MILLENNIUM BULK TERMINALS—LONGVIEW NEPA ENVIRONMENTAL IMPACT STATEMENT

NEPA FISH TECHNICAL REPORT

PREPARED FOR:

U.S. Army Corps of Engineers, Seattle District
4735 East Marginal Way South
Seattle, WA 98134

PREPARED BY:

ICF International
710 Second Avenue, Suite 550
Seattle, WA 98104

September 2016

ICF International. 2016. *Millennium Bulk Terminals—Longview, NEPA Environmental Impact Statements, NEPA Fish Technical Report*. September. (ICF 00264.13.) Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

Contents

Tables

Figures

Acronyms and Abbreviations

ACM	Active Channel Margin
Applicant	Millennium Bulk Terminals—Longview, LLC
bgs	below ground surface
BNSF	Burlington Northern Santa Fe Railway
CDID	Consolidated Diking Improvement District
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
CRC	Columbia River Crossing
CRD	Columbia River Datum
DART	Data Access in Real Time
dB	decibels
DPSs	Distinct Population Segments
dwt	dead weight tons
DWZ	Deep Water Zone
Ecology	Washington Department of Ecology
EFH	essential fish habitat
ESA	Endangered Species Act
ESUs	Evolutionary Significant Units
FR	Federal Register
g/m^2	grams per square meter
HEA	habitat equivalency analysis
HPA	Hydraulic Project Approval
IPaC	Information, Planning, and Conservation
LVSW	Longview Switching Company
mg/L	milligrams per liter
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NTUs	nephelometric turbidity units
OHW	ordinary high water
PAHs	polycyclic aromatic hydrocarbons
PCE	primary constituent elements
PHS	Priority Habitats and Species
Port	Port of Longview
ppm	parts per million
PTS	permanent threshold shifts
RCW	Revised Code of Washington
Reynolds facility	Reynolds Metal Company facility
RM	river miles
RMS	root mean square
SEL	sound exposure level
SEPA	State Environmental Policy Act

SPL	sound pressure level
SWZ	Shallow Water Zone
TEEC	trace elements of environmental concern
TTS	temporary threshold shift
UP	Union Pacific
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

Chapter 1
Introduction

This technical report assesses the potential fish and fish habitat impacts of the proposed Millennium Bulk Terminals—Longview project (On-Site Alternative), Off-Site Alternative, and No-Action Alternative. This report describes the regulatory setting, establishes the method for assessing potential fish and fish habitat impacts, presents the historical and current fish and fish habitat conditions in the study area, and assesses potential impacts.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate an export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail shipment, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean to overseas markets in Asia. The export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the export terminal would begin in 2018. For the purpose of this analysis, it is assumed the export terminal would operate at full capacity by 2028. The following subsections present a summary of the On-Site Alternative, Off-Site Alternative, and No-Action Alternative.

1.1.1 On-Site Alternative

Under the On-Site Alternative, the Applicant would develop an export terminal on 190 acres (project area). The project area is located within an existing 540-acre area currently leased by the Applicant at the former Reynolds Metals Company facility (Reynolds facility), and land currently owned by Bonneville Power Administration. The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview city limits (Figure 2).

The Applicant currently and separately operates at the Reynolds facility, and would continue to separately operate a bulk product terminal on land leased by the Applicant. Industrial Way (State Route 432) provides vehicular access to the Applicant's leased land. The Reynolds Lead and the BNSF Spur rail lines, both operated by Longview Switching Company (LVSW),[1] provide rail access to the Applicant's leased area from the BNSF Railway Company (BNSF) main line (Longview Junction) located to the east in Kelso, Washington. Ships access the Applicant's leased area including the bulk product terminal via the Columbia River and berth at an existing dock (Dock 1) operated by the Applicant in the Columbia River.

Under the On-Site Alternative, BNSF or Union Pacific Railroad (UP) trains would transport coal in rail cars from the BNSF main line at Longview Junction to the project area via the BNSF Spur and Reynolds Lead. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks 2 and 3) on the Columbia River for export to Asia.

[1] LVSW is jointly owned by BNSF Railway Company (BNSF) and Union Pacific Railroad (UP).

Figure 1. Project Vicinity

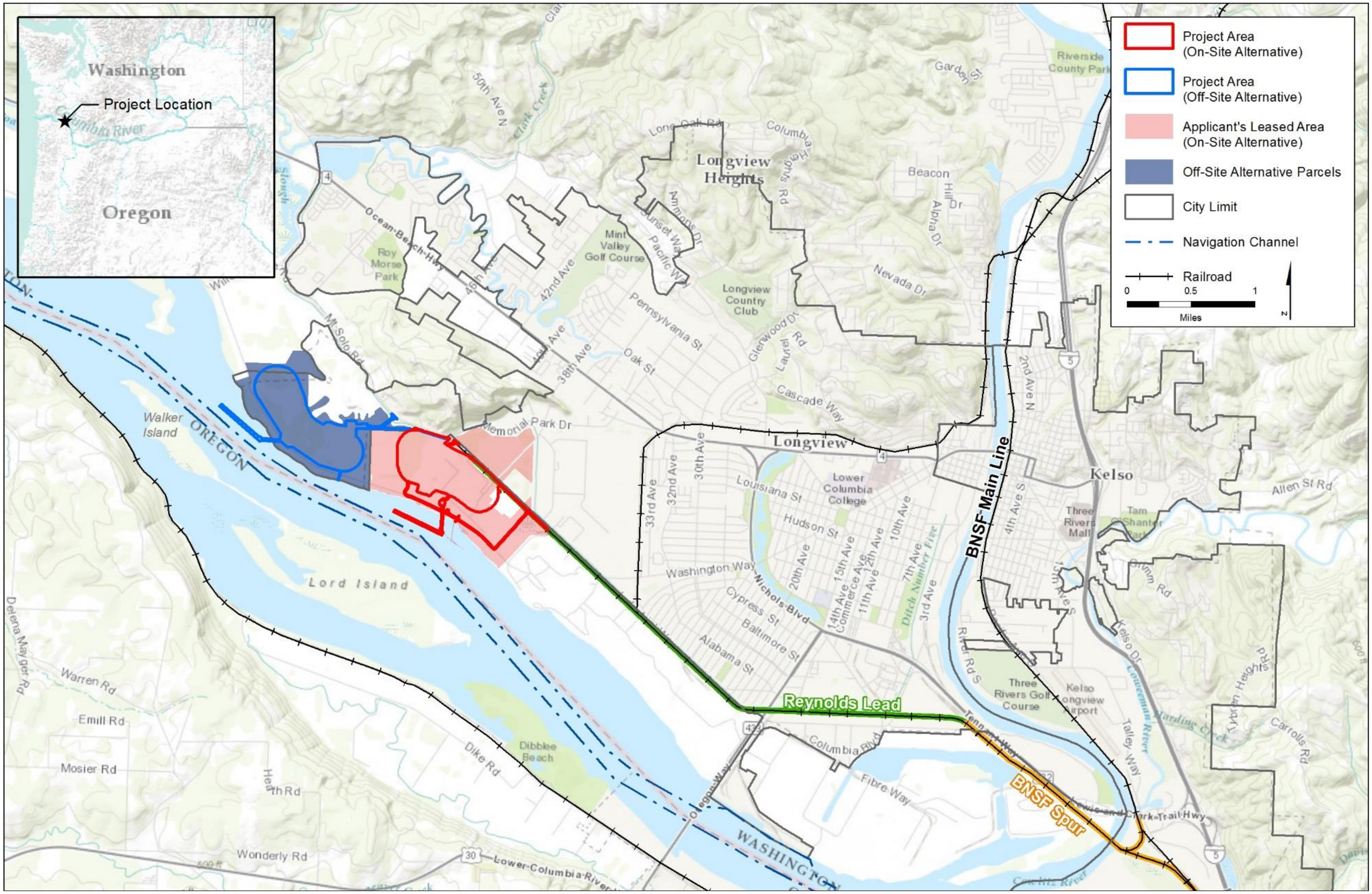
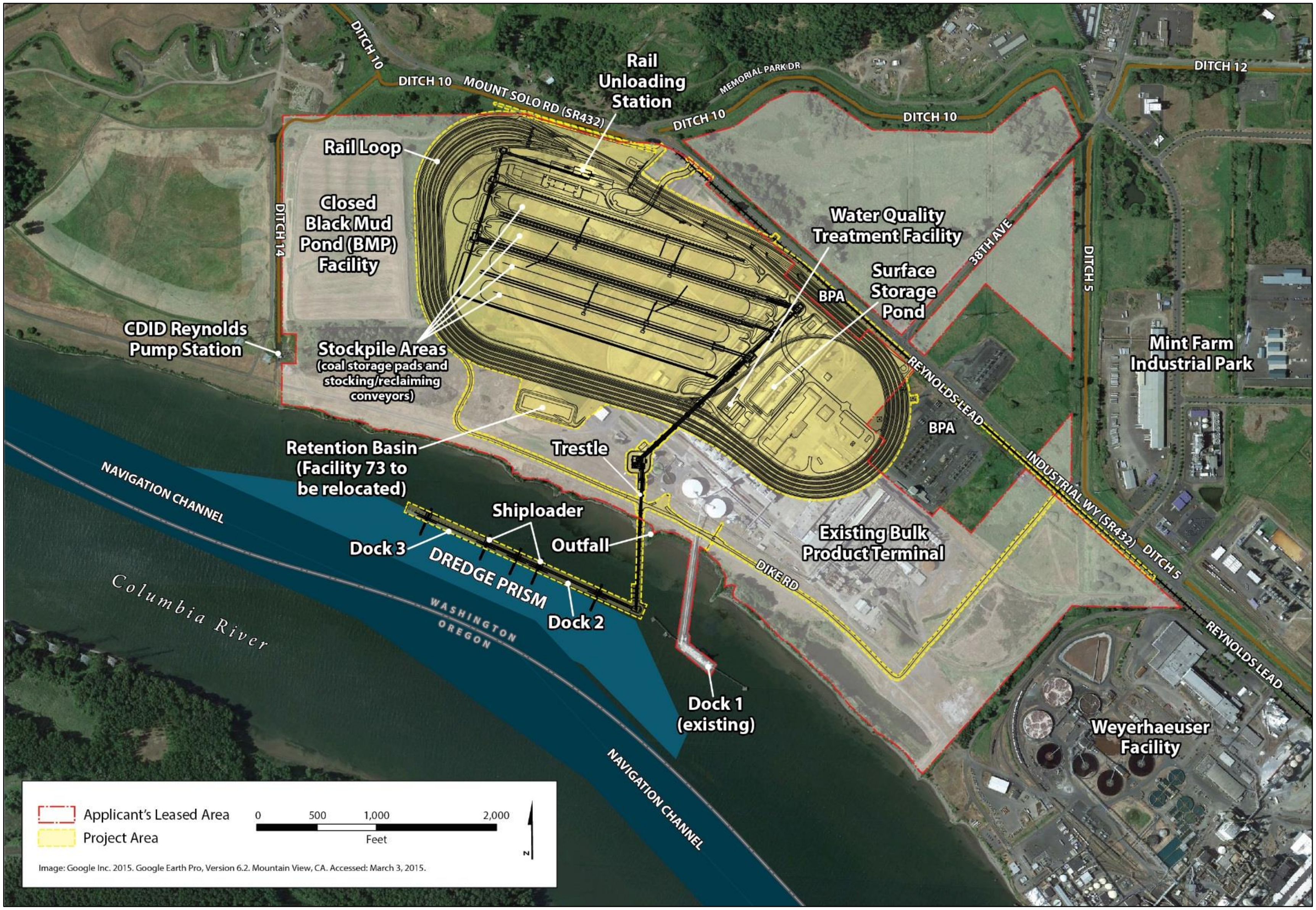


Figure 2. On-Site Alternative



Once construction is complete, the export terminal would have an annual throughput capacity of up to 44 million metric tons of coal.[2] The export terminal would consist of one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432). Ships would access the project area via the Columbia River and berth at one of the two new docks. Trains would access the export terminal via the BNSF Spur and the Reynolds Lead. Terminal operations would occur 24 hours per day, 7 days per week. The export terminal would be designed for a minimum 30-year period of operation.

1.1.2 Off-Site Alternative

Under the Off-Site Alternative, the export terminal would be developed on an approximately 220-acre site adjacent to the Columbia River, located in both Longview, Washington, and unincorporated Cowlitz County, Washington, in an area commonly referred to as Barlow Point (Figure 3). The project area for the Off-Site Alternative is west and downstream of the project area for the On-Site Alternative. Most of the project area for the Off-Site Alternative is located within Longview city limits and owned by the Port of Longview. The remainder of the project area is within unincorporated Cowlitz County and privately owned.

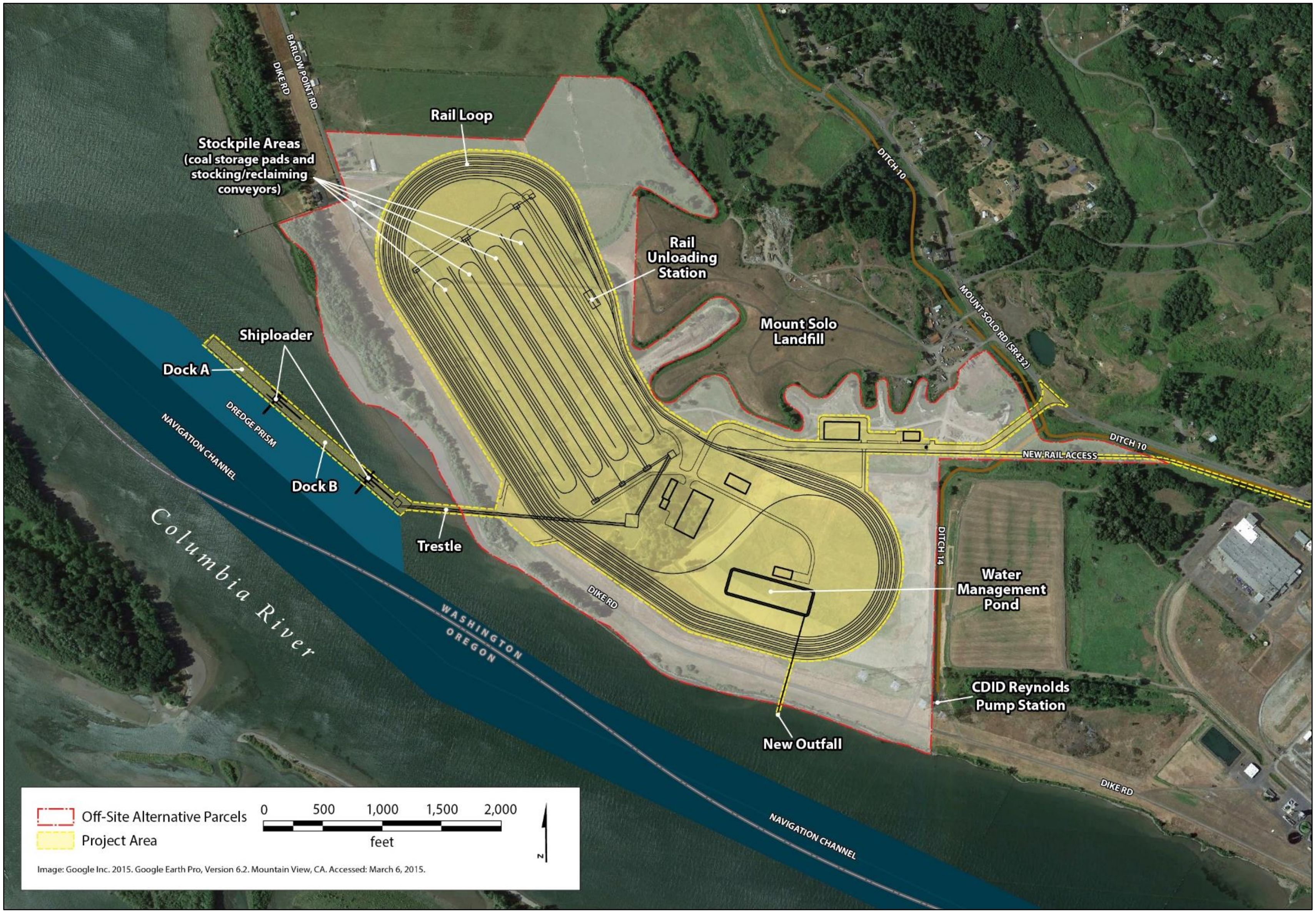
Under the Off-Site Alternative, BNSF or UP trains would transport coal from the BNSF main line at Longview Junction over the BNSF Spur and the Reynolds Lead, which would be extended approximately 2,500 feet to the west. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks A and B) on the Columbia River. The Off-Site Alternative would serve the same purpose as the On-Site Alternative.

Once construction is complete, the Off-Site Alternative would have an annual throughput capacity of up to 44 million metric tons of coal. The export terminal would consist of the same elements as the On-Site Alternative: one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks A and B), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area via a new access road extending from Mount Solo Road (State Route 432) to the project area. Trains would access the terminal via the BNSF Spur and the extended Reynolds Lead. Ships would access the project area via the Columbia River and berth at one of the two new docks. Terminal operations would occur 24 hours per day, 7 days per week. The export terminal would be designed for a minimum 30-year period of operation.

[2] A metric ton is the U.S. equivalent to a tonne per the International System of Units, or 1,000 kilograms or approximately 2,204.6 pounds.

Figure 3. Off-Site Alternative



1.1.3 No-Action Alternative

Under the No-Action Alternative, the U.S. Army Corps of Engineers would not issue the requested Department of the Army permit under the Clean Water Act Section 404 and the Rivers and Harbors Act Section 10. This permit is necessary to allow the Applicant to construct and operate the proposed export terminal.

The Applicant plans to continue operating its existing bulk product terminal located adjacent to the On-Site Alternative project area, as well as expand this business whether or not a Department of the Army permit is issued. Ongoing operations would include storing and transporting alumina and small quantities of coal, and continued use of Dock 1. Maintenance of the existing bulk product terminal would continue, including maintenance dredging at the existing dock every 2 to 3 years. Under the terms of an existing lease, expanded operations could include increased storage and upland transfer of bulk products utilizing new and existing buildings. The Applicant would likely undertake demolition, construction, and other related activities to develop expanded bulk product terminal facilities.

In addition to the current and planned activities, if the requested permit is not issued, the Applicant would intend to expand its bulk product terminal business onto areas that would have been subject to construction and operation of the proposed export terminal. In 2014, the Applicant described a future expansion scenario under No-Action Alternative that would involve handling bulk materials already permitted for off-loading at Dock 1. Additional bulk product transfer activities could involve products such as a calcine pet coke, coal tar pitch, cement, fly ash, and sand or gravel. While future expansion of the Applicant's bulk product terminal business might not be limited to this scenario, it was analyzed to help provide context to a No-Action Alternative evaluation and because it is a reasonably foreseeable consequence of a Department of the Army denial.

1.2 Regulatory Setting

The jurisdictional authorities and corresponding regulations, statutes, and guidance for determining potential impacts on fish are summarized in Table 1.

Table 1. Regulations, Statutes, and Guidance for Fish

Regulation, Statute, Guideline	Description
Federal	
National Environmental Policy Act (42 USC 4321 et seq.)	Requires the consideration of potential environmental effects. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).
U.S. Army Corps of Engineers NEPA Environmental Regulations (33 CFR 230)	Provide guidance for implementing the procedural provisions of NEPA for the Corps. It supplements CEQ regulations 40 CFR 1500–1508.

Regulation, Statute, Guideline	Description
Endangered Species Act (16 USC 1531 et seq.)	The federal Endangered Species Act of 1973, as amended, provides for the conservation of species that are listed as threatened and endangered and the habitat upon which they depend. Section 7 of the federal Endangered Species Act requires that federal agencies initiate consultation with the USFWS and/or NMFS. This will ensure the federal action is not likely to jeopardize the continued existence of any listed threatened or endangered animal species or result in the destruction or adverse modification of designated critical habitat.
Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267)	Requires fishery management councils to include descriptions of essential fish habitat and potential threats to essential fish habitat in all federal fishery management plans. Also requires federal agencies to consult with NMFS on activities that may adversely affect essential fish habitat.
State	
Washington State Environmental Policy Act (WAC 197-11, RCW 43.21C)	Requires state and local agencies in Washington to identify potential environmental impacts that could result from governmental decisions.
Washington State Growth Management Act (RCW 36.70A)	Defines a variety of critical areas, which are designated and regulated at the local level under city and county critical areas ordinances.
Washington State Shoreline Management Act (90.58 RCW)	Requires cities and counties (through their Shoreline Master Programs) to protect shoreline natural resources.
Washington State Hydraulic Code (WAC 220-660)	Under the Hydraulic Code, WDFW issues a hydraulic project approval for certain construction projects or activities in or near state waters. The hydraulic code was specifically designed to protect fish life.
Clean Water Act Section 401 Water Quality Certification	Ecology issues Section 401 Water Quality Certification for in-water construction activities to ensure compliance with state water quality standards and other aquatic resources protection requirements under Ecology's authority as outlined in the federal Clean Water Act.
Local	
Cowlitz County SEPA Regulations (CCC Code 19.11)	Provide for the implementation of SEPA in Cowlitz County.
Cowlitz County Critical Areas Code (19.15)	Regulates activities within and adjacent to critical areas, including those that support fish and fish habitat.
Cowlitz County Shoreline Master Program	Regulates development within shoreline jurisdiction, including the shores of the Columbia River, a Shoreline of Statewide Significance.
City of Longview Shoreline Master Program (Off Site-Alternative only)	Adopts Cowlitz County Shoreline Master Program by reference. The program must be updated to be consistent with Ecology's Shoreline Master Program Guidelines. This update must be completed by July 2015.
City of Longview Critical Areas Ordinance (17.10.140) (Off-Site Alternative only)	Regulates activities within and adjacent to critical areas, including those that support fish and fish habitat.

Notes:
NEPA = National Environmental Policy Act; CFR = Code of Federal Regulations; Corps = U.S. Army Corps of Engineers; CEQ = Council on Environmental Quality; USFWS = U.S. Fish and Wildlife Service; NMFS = National Marine Fisheries Service; ESA = Endangered Species Act; USC = United States Code; WAC = Washington Administrative Code; RCW = Revised Code of Washington; WDFW = Washington Department of Fish and Wildlife; Ecology = Washington State Department of Ecology.

1.3 Study Area

The study areas for the On-Site Alternative and Off-Site Alternative are described below.

1.3.1 On-Site Alternative

The On-Site Alternative project area would be located 63 river miles (RM) upstream of the Pacific Ocean on the northern shoreline of the Columbia River Estuary in Cowlitz County, Washington. The Columbia River estuary extends upstream from the mouth of the Columbia River to the Bonneville Dam (USGS 2011). The study area accounts for the area where potential underwater noise impacts would likely extend. Underwater noise disturbance thresholds have been established by the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) for fish, primarily salmonids, which occur in the Columbia River adjacent to the On-Site Alternative; therefore, these thresholds were used to help establish the study area relative to fish. The underwater noise study area includes the Columbia River in which construction noise could disturb fish and extends between the following approximate boundaries: downstream boundaries are near the downstream end of Walker Island (RM 60.4) on the Oregon side and Barlow Point (RM 61.6) on the Washington side, and upstream boundaries are near the City of Rainier (RM 67.0) on the Oregon side and the Lewis and Clark Bridge (RM 66.0) on the Washington side (Grette 2014a) (Figure 4). This area extends a distance of approximately 3.92 miles upstream and downstream of the project area in the Columbia River (measured respectively, from the upstream and downstream extents of the proposed docks at the On-Site Alternative). The study area for direct impacts is based on the distances at which underwater noise generated during project related in-water pile driving is estimated to reach noise disturbance thresholds (i.e., 150 decibels [dB] root mean square[3] [RMS]) for fish from impact and vibratory pile driving (Grette 2014b).

At full build out, the On-Site Alternative would load 70 vessels (Panamax and/or Handymax) per month. Vessels of this size generate wakes, which in certain circumstances can strand fish on shallow sloping beaches. Therefore, the study area for indirect impacts on fish extends from the project area downstream to the landward line of the territorial sea (i.e., a line between the western-most end of the north and south jetties), from here on referred to as the mouth of the Columbia River (Figure 5). This study area includes shallow-sloping beaches along the river on which fish could be stranded by the wakes of passing vessels.

[3] Root Mean Square (RMS) is the square root of the energy divided by the impulse duration. This level is the mean square pressure level of the pulse.

Figure 4. Study Area Boundaries for the On-Site Alternative

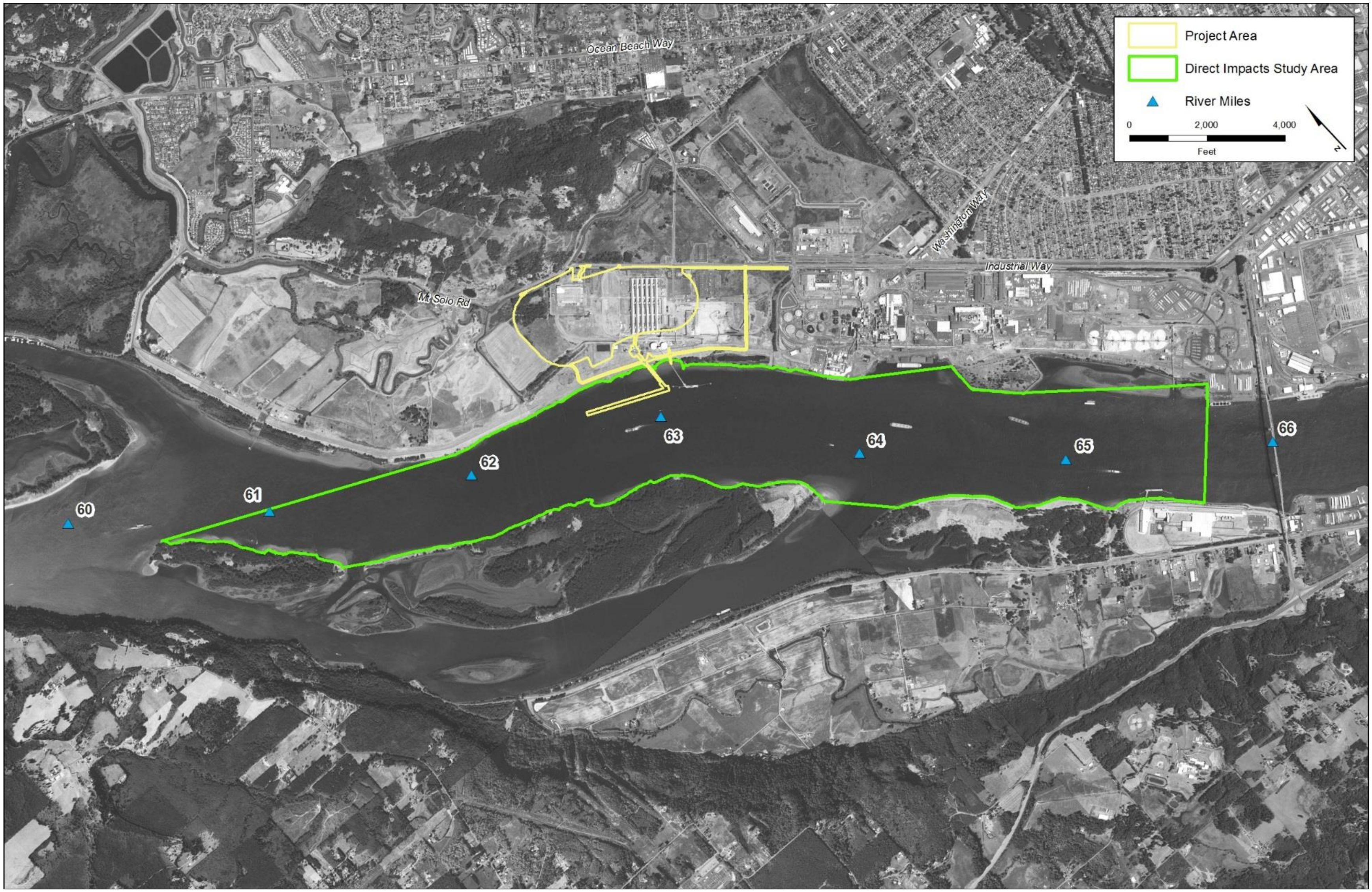
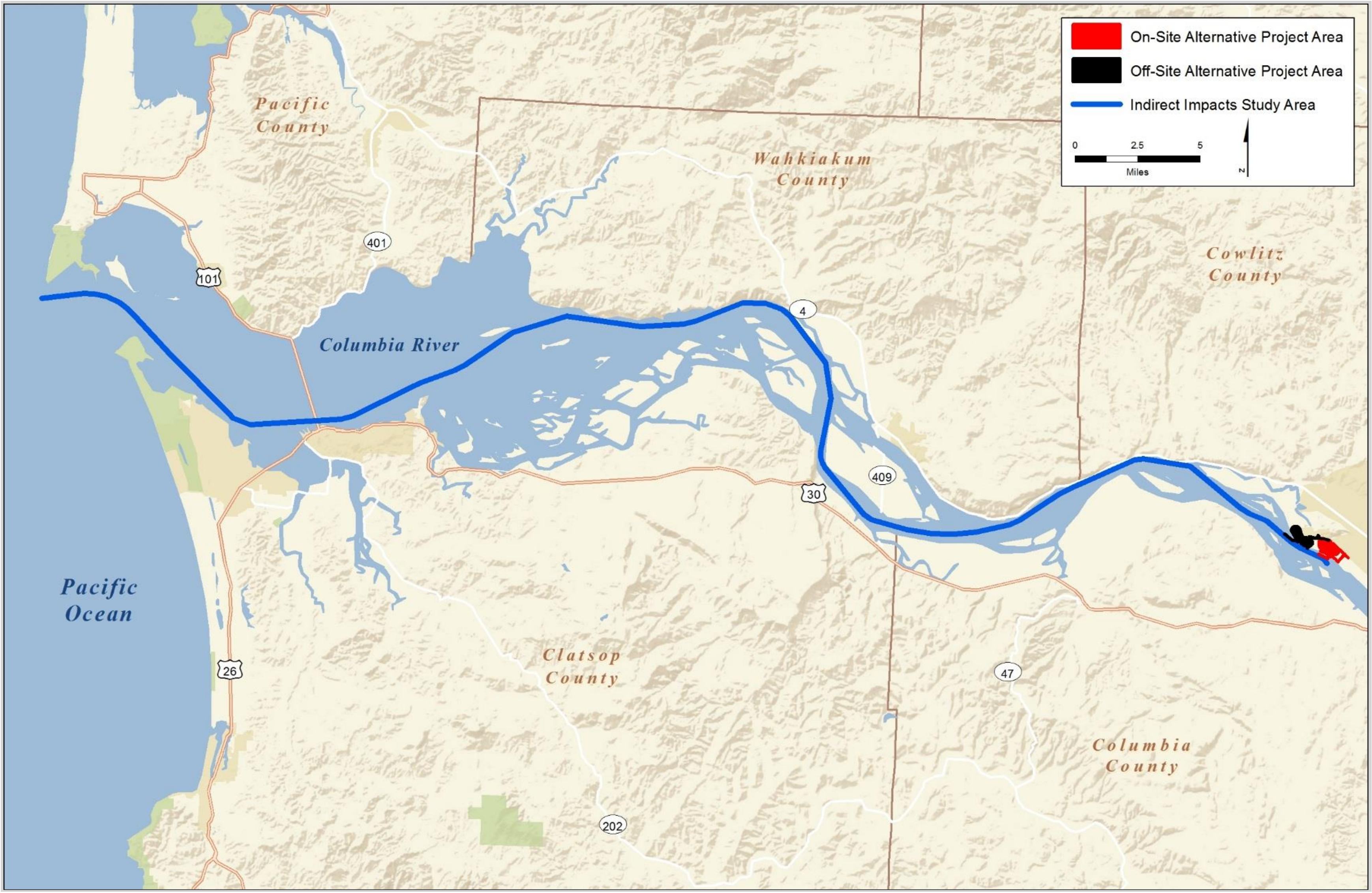


Figure 5. Aquatic Study Area for Project-Related Vessel Traffic

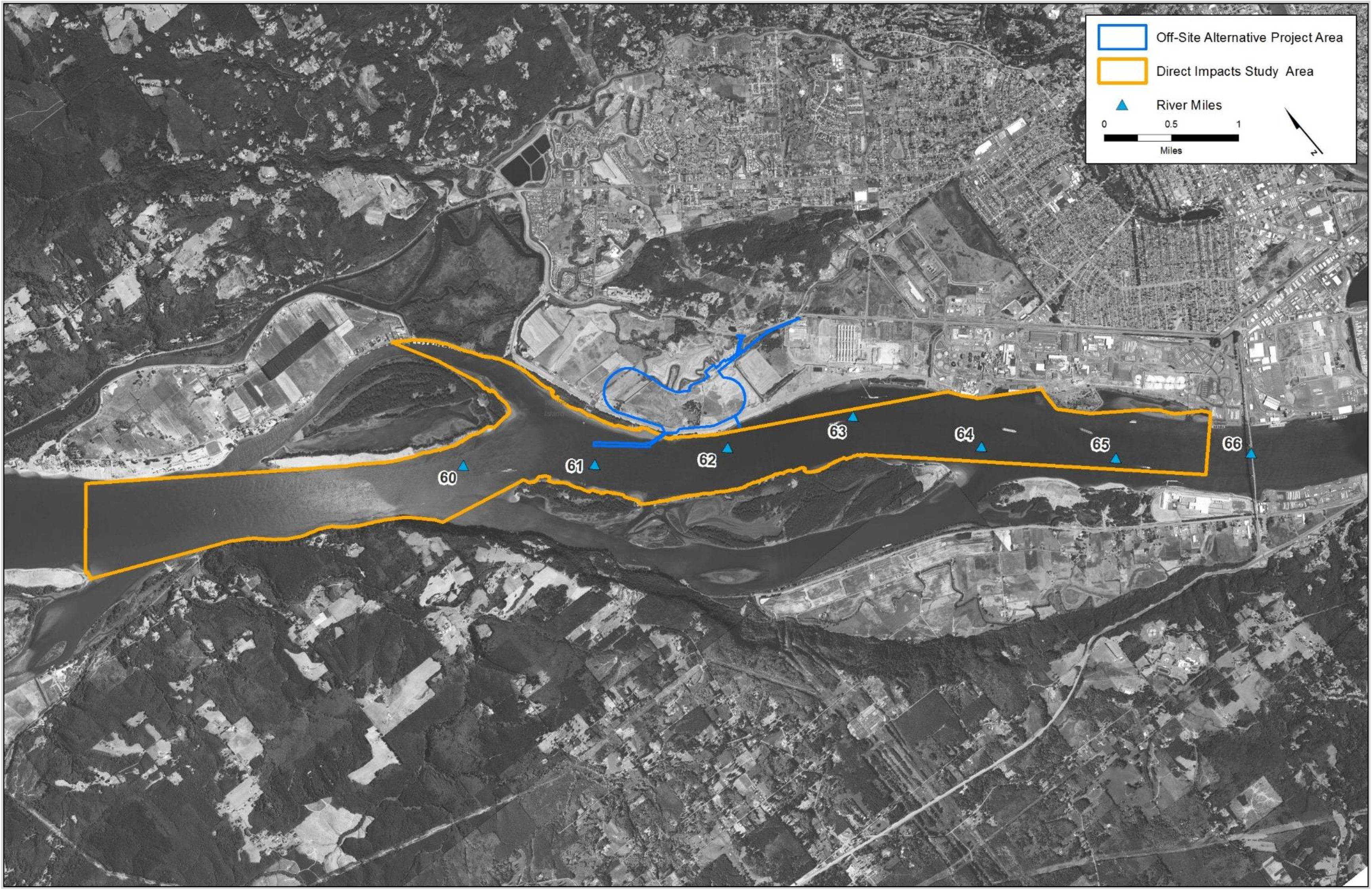


1.3.2 Off-Site Alternative

The study area for Off-Site Alternative is similar to that described for the On-Site Alternative. The study area includes the main channel of the Columbia River and a small section of the Fisher Island Slough side channel (located between Fisher Island and Washington) in which construction noise could disturb fish. The extent of the main channel study area extends between the following approximate boundaries: downstream boundary is near the upstream end from Crims Island (RM 57.0), and upstream boundary is downstream from the Lewis and Clark Bridge (RM 65.7) (Grette 2014b) (Figure 6). This area extends a distance of approximately 3.92 miles upstream and downstream in the Columbia River (measured, respectively, from the upstream and downstream extents of the proposed docks at the Off-Site Alternative). As mentioned for the On-Site Alternative, the study area is based on the distances at which underwater noise is estimated to reach noise disturbance thresholds (i.e., 150 dB_{RMS}) for fish from impact and vibratory pile driving (Grette 2014b).

Similar to the On-Site Alternative, the study area for fish has been expanded to include the Columbia River downstream from the Off-Site Alternative to the Columbia River mouth to accommodate an analysis of the potential effects of fish stranding on shallow sloping beaches. This portion of the study area is not depicted on Figure 6 due to the scale, but is similar to the aquatic study area shown on Figure 5.

Figure 6. Study Area Boundaries for the Off-Site Alternative



Chapter 2
Affected Environment

This chapter describes the methods for assessing the affected environment and determining impacts, and the affected environment in the study areas as it pertains to fish and fish habitat.

2.1 Methods

This section describes the sources of information and methods used to characterize the affected environment and assess the potential impacts of the proposed export terminal on fish and fish habitat.

This assessment is based on information collected specifically for this technical report, as well as available information concerning fish and aquatic resources in the Columbia River. It specifically addresses existing aquatic and shoreline habitat conditions within the project areas, as well as areas adjacent to the project areas potentially affected directly and indirectly by construction and operation. This includes the shoreline and offshore areas associated with the proposed deepwater terminals, aquatic habitats subject to temporary impacts during construction, aquatic habitats affected by construction and maintenance dredging to create and maintain vessel access to the export terminal, and impacts of vessels transiting within the Columbia River between the project areas and the mouth of the Columbia River.

2.1.1 Data Sources

The following sources were used to evaluate fish and fish habitat characteristics of the study area.

- One site visit conducted by ICF fish biologists on January 29, 2014.
- Reports prepared by Grette Associates for the Applicant as part of the permit application supporting materials.
    - *Docks 2 and 3 and Associated Trestle Direct Effects of Construction* (Grette 2014a).
    - *Off-Site Alternative – Barlow Point Pile Driving and Underwater Sound* (Grette 2014b).
    - *Affected Environment Biological Resources. Technical Report* and associated appendices (Grette 2014c).
    - *Docks 2 and 3 and Associated Trestle: Proposed Mitigation Measures to Minimize Construction and Long-Term Effects* (Grette 2014d).
    - *Off-Site Alternative – Barlow Point Permanent Impacts to Aquatic Habitat* (Grette 2014e).
    - *Permanent Impacts to Aquatic Habitat* (Grette 2014f).
- National Oceanic and Atmospheric Administration (NOAA) Fisheries West Coast Region species list (2014a).
- NOAA Fisheries listing packages (2014a, b).
- USFWS (2014) Information, Planning, and Conservation (IPaC) system online database.

- Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species (PHS) geographic information system (GIS) data for the study area (2015a). The Priority Habitat and Species Program is fulfilled by WDFW to provide important fish, wildlife and habitat information to local governments, state and federal agencies, private landowners, consultants, and tribal biologists for land use planning purposes.
- Washington Department of Fish and Wildlife (2015b) SalmonScape data for the study area and vicinity.
- Washington State Department of Natural Resources, Natural Heritage Program, February 2014 database (accessed by ICF on April 7, 2014).
- Washington State Department of Ecology (Ecology) 303(d) /305(b) Integrated Report Viewer (accessed by ICF in December 2014).
- Fish Passage and Timing Data Columbia River Data Access in Real Time (DART), Columbia Basin Research, University of Washington (juvenile and adult fish passage) (Columbia River Basin 2013).
- Fish Passage Center. Query of adult passage at Bonneville Dam: graph with current year, last year, and 10-year average (Fish Passage Center 2014).
- Comments received from interested parties during the scoping period relative to fish and wildlife, as summarized in the NEPA Scoping Report (February 10, 2014).
- Other scientific literature and sources of technical information as cited in the text.

2.1.2 Impact Analysis

The following methods were used to evaluate the potential impacts of the On-Site Alternative, Off-Site Alternative, and No-Action Alternative on fish and fish habitat. For the purposes of this analysis, construction impacts are based on peak construction period and operations impacts are based on maximum throughput capacity (up to 44 million metric tons per year). For direct impacts, the analysis assumes best management practices were incorporated into the design, construction, and operations of the export terminal. More information about best management practices can be found in the NEPA Draft Environmental Impact Statement (Volume 1), Chapter 8, *Minimization* and *Mitigation*, and Appendix H, *Export Terminal Design Features*.

Potential impacts on fish and fish habitat were determined by considering the species that are likely to occur in the study area based on field surveys, site visits, the presence of suitable habitat and geographic range, and documented species occurrences and habitat conditions. For documented occurrences, focus was on fish species identified in the WDFW PHS database. The PHS program provides comprehensive information on important fish, wildlife, and habitat resources in Washington. It is the principal means by which WDFW provides fish, wildlife, and habitat information to public and private entities for planning purposes. In addition, the USFWS list of federally listed species in Cowlitz County and the NMFS West Coast Region species list of fish (which are also included in the PHS database) were also considered.

WDFW maintains a PHS geospatial database that maps likely locations of priority species occurrences and priority habitats. Priority species in the PHS program include fish and wildlife species classified under state law (WAC 232-12-297) as threatened, endangered, or sensitive, as well as species that are candidates for such classification. Other PHS species include vulnerable aggregations of species or groups of animals that are susceptible to significant population declines due to their inclination to aggregate, and species of recreational, commercial, and/or tribal importance. The PHS database also includes state-monitored species, which are not considered special-status but are monitored for status and distribution trends. Geospatial PHS data containing mapped locations of priority species occurrences and priority habitats was obtained from WDFW (Washington Department of Fish and Wildlife 2015a). This PHS data was overlaid with the study area to determine presence of documented priority fish species and habitat occurrences.

A list of special-status fish species was compiled for the study area, consisting of those species federally listed as threatened, endangered, proposed, or candidate species, and fish species listed in the WDFW PHS database.

A list of federally listed fish species for Cowlitz County was generated from the USFWS IPaC online planning tool (U.S. Fish and Wildlife Service 2014).

A list of state priority species that occur in Cowlitz County was obtained from the WDFW PHS program website (Washington Department of Fish and Wildlife 2015a).

A list of federally protected fish and their habitat, including essential fish habitat, that could occur in the study area was also compiled from the NMFS (2015) West Coast Region website.

The impact analysis for fish habitat is quantitative; however, the impact analysis for fish species is qualitative because fish are generally mobile and their presence and abundance within the study area cannot be quantitatively predicted at any one location or time. In addition, a species reaction to an impact mechanism, such as construction-generated noise, can be different for each species given the variability in species' hearing frequencies, mobility, vision, and overall sensitivity (e.g., juvenile fish may be more sensitive and susceptible to potential impacts than adult fish). Therefore, impact mechanisms are identified and a qualitative impact discussion describes the potential effect an impact mechanism could have on species that may be in the study area during construction and operations.

2.2 Affected Environment

The affected environment related to fish and fish habitat in the study areas are described below.

2.2.1 On-Site Alternative

The project area for the On-Site Alternative is located along the north side of the Columbia River at river mile 63, within unincorporated Cowlitz County and adjacent to the City of Longview.

2.2.1.1 Project Area

The project area was once productive marsh and riparian floodplain habitat used by many species of fish for spawning, foraging, and rearing. It is now extensively modified for flood control, industrial development, and deep draft vessel traffic, and its value for fisheries is now primarily as a migratory corridor from upstream spawning areas to downstream rearing and foraging areas in the estuary and marine environments.

Adjacent lands to the north and west are largely undeveloped and are used for a combination of agricultural and recreation activities. Lands to the south and east are heavily industrialized and include a large Weyerhaeuser Lumber processing and export terminal and the Port of Longview (Port). The Port is a multipurpose deep-draft terminal encompassing 478 acres and over one mile of waterfront at RM 66 on the Columbia River. The marine terminal includes nine berths handling bulk, break bulk, and cargoes for or from domestic barge and international (Panamax sized) ocean vessels. During 2010, the Port had 154 vessel calls, totaling 2.3 million metric tons of cargo (Port of Longview 2010). In 2012, this number increased to 225 vessel calls, reflecting the increased capacity provided by a new bulk export grain terminal capable of handling more than 8 million metric tons annually (Kulisch 2013).

In the 1920s, Consolidated Diking Improvement District (CDID) #1 constructed a levee along the Columbia River shoreline to protect Longview area properties from Columbia River flooding. In conjunction with the levees, the CDID also excavated a series of ditches to facilitate development of low-lying properties. These ditches, which lie north and west of the project area, drain both stormwater and shallow groundwater from properties within CDID #1. The ditch water is ultimately discharged to the Columbia River through pump stations. The topography of the 540-acre Applicant's leased area varies by location, although overall it is generally flat. Current topography on the property south of Industrial Way indicates the majority of the upland portion of the site is in the range of elevation +5 to +12 feet above the Columbia River Datum (CRD).[4]

This area is currently developed with a variety of facilities and structures associated with the former Reynolds facility. Most of the approximately 540-acre site that is located south of Industrial Way is paved with asphaltic concrete and Portland cement concrete pavements. The western portion of the site extends into wooded areas and grass-covered fields.

2.2.1.2 Study Area

The hydrology of the region, as described in the NEPA Groundwater Technical Report (ICF International 2016a) is characterized by two major aquifers: the upper alluvial aquifer (i.e., shallow groundwater) and a deeper confined aquifer. Shallow groundwater is present in the upper 75 to 100 feet of alluvium, and is in direct communication with the Columbia River. Multiple groundwater zones are present in the upper alluvial aquifer due to the interbedded nature of the alluvium. A deeper confined aquifer is present below approximately 300 feet below ground surface (bgs) in coarser sands and gravels where production and supply wells draw groundwater. Both aquifers are in direct communication with the Columbia River.

The average annual rainfall recorded between 1931 and 2005 for Longview, Washington, is 46.17 inches. Approximately 44% of the total precipitation falls between November and January during winter storms. The average annual snowfall is just less than 5 inches. July and August are typically the two driest months of the year (Western Region Climate Center 2011, as cited in URS 2014).

The study areas have been moderately to highly modified as a result of historical and ongoing human activities that have altered natural habitat conditions. The mainstem Columbia River is deeper than it was historically because of construction and periodic dredging of the Federal navigation channel and the berthing areas along the river. The hydrologic regime and water

---

[4] Columbia River Datum (CRD) is a vertical datum that is the adopted fixed low water reference plane for the lower Columbia River. It is the plane of reference from which river stage is measured on the Columbia River form the lower Columbia River up to Bonneville Dam, and on the Willamette River up to Willamette Falls. .

temperature conditions have been altered by the operation of the Federal Columbia River Power System throughout the Columbia River Basin. Floodplain habitats have been disconnected from the riverine environment and in some cases eliminated. Extensive shoreline armoring and protection, overwater structures, and development in adjacent upland and riparian zones have substantially degraded habitat conditions and altered habitat-forming processes, resulting in corresponding changes to the biological communities associated with these habitats. A more thorough discussion of the changes in the vegetation zones can be found in the NEPA Vegetation Technical Report (ICF International 2016b).

By the mid-20th century a significant portion of the study area had been diked, dredged, and filled (Graves et al. 1995 in Johnson et al. 2003). Alteration of the natural hydrograph by the operation of upstream dams and reservoirs, surface water diversions, and other water uses have decreased seasonal and annual flow variability and altered the timing of the hydrograph peak discharge and base discharge. Peak spring flows are now smaller, begin earlier, and last longer than they did historically. Winter flows are generally higher on average, but periodic peaks have been dampened or eliminated (Bottom et al. 2008). Overall, the average daily discharge in the Lower Columbia and the study area has decreased by approximately 16% relative to the historical norm (Bottom et al. 2008). The average annual flow for the Columbia River at Beaver Army Terminal near Quincy, Oregon, is approximately 236,600 cubic feet per second (cfs). The river's annual discharge rate fluctuates with precipitation and ranges from 63,600 cfs in a low water year to 864,000 cfs in a high water year (U.S. Geological Survey 2014). The change in flow conditions has altered estuarine dynamics in the study area. River flows can reverse direction during periods when river flows are low and incoming tides are large, and these reversal events now occur more frequently because the magnitude and timing of minimum flows has changed. Although the flow may reverse in response to tidal fluctuation, salt water does not intrude as far upstream as the study area and the water remains fresh through the tidal cycle. The study area can be considered a high-energy environment, characterized by strong currents, active bedload transport, and variable patterns of sediment of deposition and erosion (Grette 2014c).

2.2.1.3 Aquatic Habitat Types

The aquatic habitat for the study area is discussed in terms consistent with the habitat equivalency analysis (HEA) model, which provides a framework for describing habitat quality in the context of habitat availability and suitability as a function of water depth and physical attributes. The aquatic portion of the study area adjacent to the project area is composed of three broad habitat types (Grette 2014c): the Active Channel Margin (ACM), the Shallow Water Zone (SWZ), and the Deep Water Zone (DWZ). Although not technically an aquatic habitat, the riparian zone is discussed because of its interaction with aquatic habitats, as the riparian zone is the transition zone between aquatic and upland/terrestrial habitats. A cross-section of the aquatic habitat adjacent to the project area is provided in Figure 7, showing the maximum widths and typical depth profiles of each of these habitat types adjacent to the project area near the proposed new docks. Habitat type locations associated with the On-Site Alternative are provided in Figure 8.

Figure 7. Cross Section of Shoreline Habitats adjacent to the Project Area

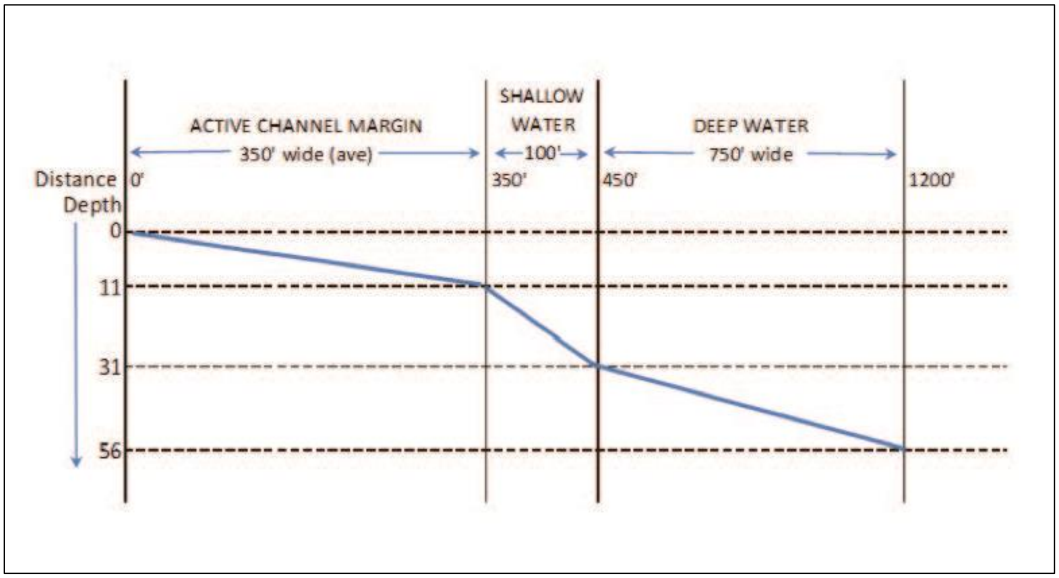


Figure 8. Aquatic Habitat Types Potentially Affected by the On-Site Alternative

Riparian Zone

The discussion of the riparian zone here is focused on those elements relevant to aquatic habitat important to fish and fish habitat. The riparian zone includes lands less than 200 feet landward from ordinary high water (OHW) (+11.1 feet CRD). Shoreline armoring and CDID dikes have contributed to what is typically low habitat complexity, artificially steepened upper shoreline, and largely cut off floodplain connectivity. Landward of the shoreline, most of the riparian area has been so heavily modified there is little remaining function (Grette 2014c). There is a small area of intact riparian assemblage, immediately upstream of Dock 1; however, it consists primarily of nonnative and invasive species (ICF International 2016b). There is little potential for a remnant area of riparian habitat to contribute biological material (e.g., leaf litter, woody material, and insects) to the aquatic areas, nor does it provide shade or other physical function. In comparison to shoreline areas with intact riparian habitat, the HEA[5] model would rank shoreline habitat at a relatively lower value, especially when compared to similar areas with intact riparian habitat (e.g., Lord Island, immediately across the river) (Grette2014c).

Active Channel Margin

The ACM is defined as the shoreline and nearshore edge habitat, extending from the OHW line to CRD 0 feet. For comparison purposes, the mean low water line is at approximately +2.7 feet CRD and OHW is at approximately +7.0 feet CRD (National Oceanic and Atmospheric Administration 2013, U.S. Army Corps of Engineers 2004a).[6] Water levels in the ACM fluctuate continuously and portions are periodically dewatered because of tidal influence and river flow conditions, with the extent and duration of exposure dependent on site-specific topography. The ACM in the vicinity of the proposed docks covers approximately 25 acres and extends from 25 to 350 feet offshore with a typical maximum depth of about 11 feet (Figures 7 and 8), based on Ordinary High Water (OHW) of +11.1 feet CRD. The shoreline portion of the ACM (less than 1.5 acres) is sparsely vegetated and consists of sandy substrate with little organic matter (Grette 2014c). Habitat functions in the ACM are strongly influenced by the condition of the shoreline and adjacent riparian zone. The shoreline in this area is highly modified by dikes and riprap armoring that includes scattered large woody debris.

Generally the ACM provides foraging and rearing habitat for juvenile salmonids, particularly those expressing a stream-type life history (National Marine Fisheries Service 2011). Steelhead trout (*Onchorhyncus mykiss*), lamprey, adult eulachon (*Thaleichthys pacificus*), and sturgeon are less likely to be found in the ACM because these species generally prefer deeper open water habitats (Carter et al. 2009, Gustafson et al. 2010, Independent Scientific Review Panel 2013). However, periodic occurrence of these species cannot be discounted. Larval and juvenile sturgeon may drift or move incidentally into inundated habitats in the ACM. Larval eulachon dispersal into the ACM is also probable.

Shallow Water Zone

The SWZ includes the fully inundated near-shore zone extending from the ACM at 0 feet CRD out to -20 feet CRD. The SWZ is adjacent to the proposed docks and covers approximately 34 acres extending from approximately 25 to 500 feet offshore with maximum depths ranging from 11 to 31

[5] HEA is a tool that can be used to estimate habitat gains and losses across a range of habitat types

[6] The OHW line is equivalent to the mean higher high water line in the tidally influenced Lower Columbia River.

feet across this zone, based on OHW of +11.1 feet CRD. The bottom is primarily (90%) flat or shallow sloping substrate, with some moderate slopes out to depths of about 25 feet, where the habitat becomes markedly steeper. There are two pile dikes and one overwater dock that extends into the SWZ that likely provide both cover and refuge for prey and predator species, but they are not likely to substantially inhibit migration past the site. The substrate consists primarily of silty river sand with little organic matter (Grette 2014c).

Deep Water Zone

The third major habitat type in the study area is the DWZ. The DWZ habitat type encompasses about 115 acres in the project area, adjacent to the proposed docks, extending from the edge of the SWZ, beyond 31 feet deep, based on OHW of +11.1 feet CRD. At approximately 450 feet from the shore, this zone is about 31 feet deep, outward to a maximum depth of 56 feet deep approximately 1,200 feet from shore. The DWZ is used as an upstream migration corridor by adult salmonids returning to their spawning grounds and as a downstream corridor by juvenile salmonids of sufficient size to avoid predators and forage in open water. Steelhead are likely to be present periodically throughout the year in the DWZ as different summer and winter-run populations migrate through the area as juveniles and adults. Adult and subadult bull trout (*Salvelinus confluentus*) may also be found foraging in these deepwater habitats, particularly when eulachon, migrating juvenile salmonids, and other potential prey species are present in abundance. Eulachon (adults and larvae) are likely to be present during adult migration and larval dispersal. White sturgeon (*Acipenser transmontanus*) (adults, subadults, larvae, and juveniles) and green sturgeon (*Acipenser medirostris*) (adults and subadults) are likely to occur in the DWZ. Adult and juvenile lamprey may be present in the DWZ in the spring, summer, and fall during migration between freshwater and marine habitats

There are a two pile dikes and one dock that extend into the DWZ. These structures are likely to influence but not inhibit the migration of juvenile salmonids, and they are likely to provide both resting and ambush habitats for predatory species including pikeminnow, bass, and piscivorous birds.

2.2.1.4 Columbia River Downstream of Project Area

The Columbia River downstream of the project area are considerably degraded compared to 200 years ago. The estuary tidal prism has been reduced by about 20% due mostly to dike and filling practices used to convert the floodplain to agricultural, industrial, commercial, and residential uses. Changes to flow volume and timing are attributed to hydrosystem regulation; water withdrawal for agricultural, municipal, and industrial purposes; and climate fluctuations. The near elimination of overbank flood events and the separation of the river from its floodplain have altered the food web and reduced floodplain habitats of particular importance to ocean-type salmon runs (salmonids that typically rear for a shorter time in tributaries and a longer time in the estuary) (National Marine Fisheries Service 2011).

The estuary also is influenced by a number of physical structures (jetties, pilings, pile dikes, bulkheads, revetments, docks, etc.) that contribute to its overall degradation, but the extent of their impacts is poorly understood. Over-water and instream structures in the estuary number in the thousands and alter river circulation patterns, sediment deposition, and light penetration; they also form microhabitats that often benefit predators. In some cases, structures reduce juvenile access to low-velocity habitats (National Marine Fisheries Service 2011).

Habitat forming processes in the lower river and estuary have also been altered by loss of upstream sediment input (now constrained behind upriver dams), changes in flow patterns that move sediments and modify landforms, and channel deepening and dredging. The full impact of these changes is unknown. Some of the concerns about impacts on sediment transport and channel forming processes have been addressed by the use of instream dredge disposal alternatives and disposal methods to help sustain in-channel islands and shallow water habitats (National Marine Fisheries Service 2011).

Stranding associated with existing ship wakes is an example of another threat to salmon and steelhead in the estuary. A study completed by ENTRIX (2008) identified 217 beach segments (out of 1,046 beach segments assessed) between the project area and the river mouth on which there is more than a minimal likelihood of fish stranding. Seventy of these sites occur in three clusters: Puget Island (RM 43–47), near Pt. Barlow (RM 61–62), and Walker and Lord Islands (RM 61–65) (Figure 9).

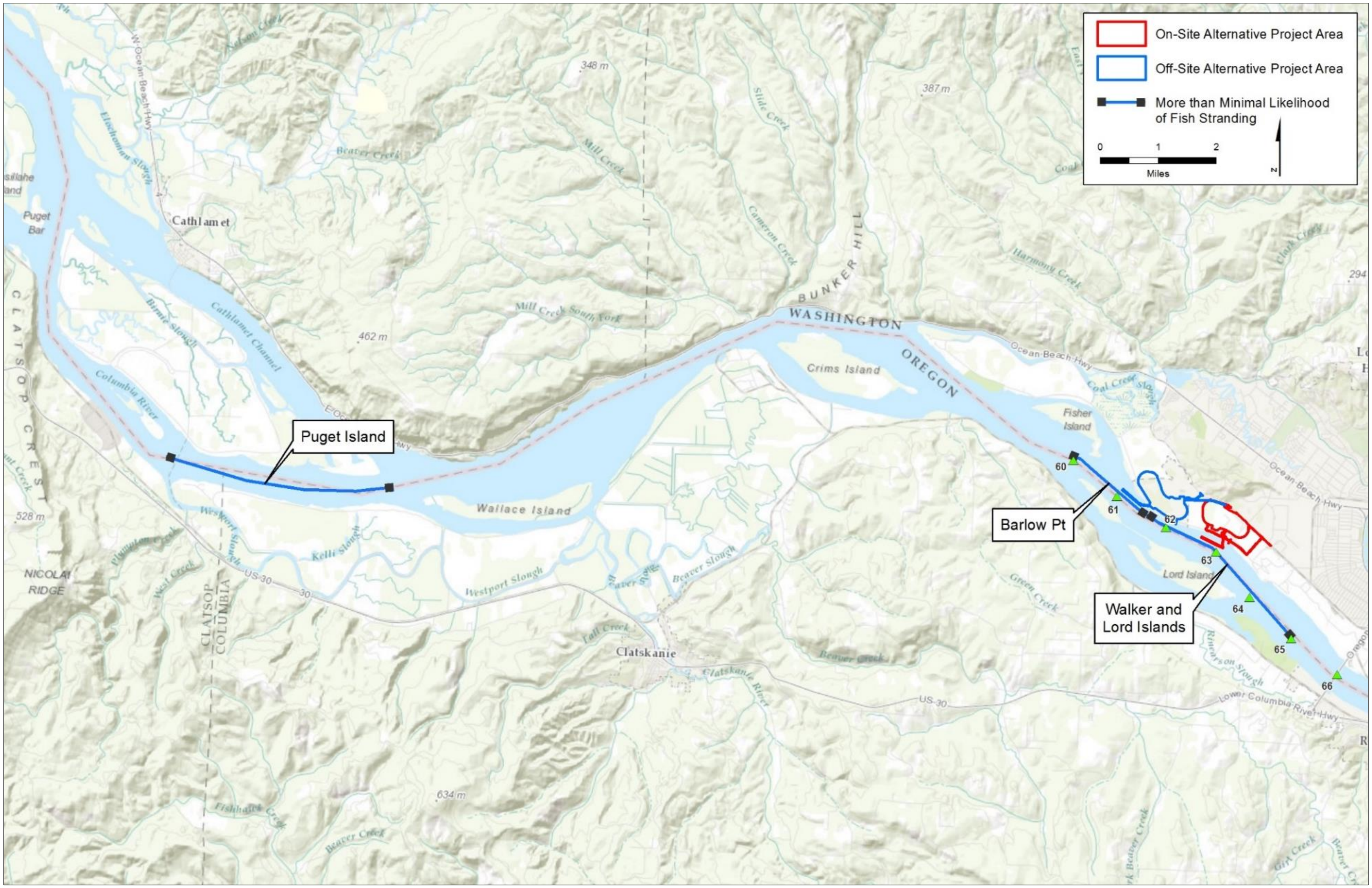
2.2.1.5 Focus Fish Species

This summary focuses primarily on fish species of special interest/concern, including federally and state-listed threatened and endangered species, and their designated critical habitat, as well as species of commercial, recreational, or cultural importance. Table 2 outlines the focus fish species, the status of the species (i.e., state and federal), habitat types these species typically occupy, and their seasonal occurrence in the study area. Affected environment and habitat use by focus fish species are described by habitat type in the following sections and summarized in Table 2.

The study area provides habitat for a variety of anadromous and resident fish species found in the Columbia River. Anadromous salmonids occurring within the study area include the following species: Chinook (*Onchorhyncus tshawytscha)*, coho (*Onchorhyncus kisutch*), pink (*Onchorhyncus gorbuscha*), sockeye (*Onchorhyncus nerka*), and chum (*Onchorhyncus keta*) salmon; steelhead; bull trout; and coastal cutthroat trout (*Oncorhynchus clarkii clarkii*). Due to variable migration timing and duration of estuarine habitat use, one or more of these anadromous salmonid species are present in the Lower Columbia River throughout the year, as adults migrating upstream to spawning habitats, outmigrating juveniles, juveniles rearing in the estuary for extended periods, or, in the case of cutthroat trout and bull trout, as foraging subadults and adults. The study area also supports a variety of additional native and introduced fish species. Other anadromous or estuarine migrant species include green and white sturgeon, eulachon, shad (subfamily Alosinae), striped bass (*Morone saxatilis*), starry flounder (*Platichthys stellatus*), and Pacific lamprey (*Entosphenus tridentatus*) and river lamprey (*Lampetra ayresi*).

Resident freshwater fish expected to occur in the study area and vicinity include both coldwater (trout) and warmwater (bass, crappie, and bluegill [*Lepomis macrochirus*]) species, and locally migratory species (three spine sticklebacks (*Gasterosteus aculeatus*), peamouth chub [*Mylocheilus caurinus*]). Several resident fish species are predatory, feeding on a variety of small fish, including juvenile salmonids. These predators include the native northern pikeminnow (*Ptychocheilus oregonensis*), and introduced species such as walleye (*Sander vitreus*), crappie, and largemouth bass (*Micropterus salmoides*) and bass (*Micropterus dolomieui*).

Figure 9. Fish Stranding Sites



Salmon and Trout

Eight threatened or endangered salmon Evolutionary Significant Units (ESUs), five threatened steelhead Distinct Population Segments (DPSs), one threatened bull trout DPS, and their designated critical habitats occur in the Lower Columbia River and the study area (Table 2) (Bottom et al. 2008, National Marine Fisheries Service 2011). An ESU is defined as a population of organism that is considered distinct for purposes of conservation. A DPS is defined as the smallest division of a taxonomic species permitted to be protected under the ESA. In addition, essential fish habitat (EFH) has been designated for Chinook and coho salmon in the Lower Columbia River. EFH includes those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity, per the 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act. The Columbia River estuary is used primarily as migratory and rearing habitat, and no salmonid spawning takes place in the study area. Adult anadromous salmonids travel through the estuary and lower river relatively quickly during their migration to upstream spawning grounds, remaining primarily in offshore deepwater habitats (Table 2 provides seasonal presence in the study area). In contrast, juvenile salmonids use a wider variety of habitats and exhibit more variable downstream migration speed, taking advantage of shallow water and ACM for foraging and seeking cover.

General salmon reproductive strategies can be divided into two groups: stream-rearing and ocean-rearing (noted in Table 2). Stream-rearing fish tend to spend extended periods, usually more than a year, rearing in fresh water before emigrating to the ocean. Examples of stream-type fish are steelhead, coho, and spring-run Chinook salmon. In contrast, ocean-type juvenile salmonids tend to return to the ocean in the same year they were spawned. Examples of ocean-type fish are chum salmon, and fall-run Chinook salmon. These strategies affect how each population uses the estuary and how it may be affected by the On-Site Alternative. Because stream-type salmon spend more time rearing in their natal streams and associated rivers, they arrive in the estuary at a relatively larger size than ocean-type salmon and therefore use the estuary differently and are affected by different factors. For example, stream-type salmon arrive in the estuary as larger fish and generally use the estuary as a migration route rather than rearing habitat, and are affected mostly by predation and flow. Ocean-type salmon move into the estuary at a smaller size and use the estuary as rearing habitat before entering the ocean. They are also affected by flow, but are more affected by habitat conditions in the estuary than are stream-type fish (Fresh et al. 2005). Salmonid occurrence by species and season are summarized in Table 2 (Bottom et al. 2008, Johnson et al. 2003, Fresh et al. 2005).

Habitat use and timing patterns of nonlisted salmon and steelhead populations are similar to the listed salmonid species (Table 2). Other salmonids, such as cutthroat trout, have complex life histories, consisting of both anadromous and resident populations that make extensive use of the lower river and estuary for foraging (Trotter 1989). Given the diverse run timing and life-history strategies exhibited by salmonids (Fresh et al. 2005) some life stage of salmon or trout could be present in the study area at any time. Salmon and steelhead use of the study area is described in the following sections by aquatic habitat type.

Table 2. Status of Focus Species and Seasonal Presences in the Study Area[a]

Species, ESU/DPS	Federal Status[a]	Life Stage	Sept			Oct			Nov			Dec		
			A[b]	S[b]	D[b]	A	S	D	A	S	D	A	S	D
Chinook Salmon														
Snake River fall-run ESU	T	Adults			X[c]			…						
		Subyr		…[d]	…		…	…		…	…			
Lower Columbia River ESU	T	Adults			X			X						
		Yrlng												…
		Subyr		…	…		…	…		…	…	…		
Upper Willamette River ESU	T	Yrlng												…
		Subyr		…	…		…	…		…	…	…		
Coho Salmon														
Lower Columbia River ESU	T	Adults			X			X			X			X
		Subyr		…			…			…		…	…	
Chum Salmon														
Columbia River ESU	T	Adults						X			X			
		Subyr										…	…	
Steelhead Trout														
Snake River DPS	T	Adults			X			…						
Upper Columbia River DPS	T	Adults			X			…						
Middle Columbia River DPS	T	Adults			X			…[e]						
Lower Columbia River DPS	T	Adults			X			X			X			X
Bull Trout														
Columbia River DPS	T	Adults		…	…		…	…		…	…		…	…
Cutthroat Trout														
Columbia River DPS	NL	Adults/Juveniles		X	X		X	X		X	X		X	X
Green Sturgeon														
Southern DPS	T	Adults/Sub-Adults		X	X		X	X						
Northern DPS	SOC	Adults		X	X		X	X						
		Sub-Adults		X	X		X	X						

Species, ESU/DPS	Federal Status[a]	Life Stage	Sept			Oct			Nov			Dec		
			A[b]	S[b]	D[b]	A	S	D	A	S	D	A	S	D
White Sturgeon														
Lower Columbia River		Adults		X	X		X	X		X	X		X	X
		Sub-Adults		X	X		X	X		X	X		X	X
Eulachon														
Southern DPS	T	Adults								…	…		X	X
		Eggs/Larvae								…	…		X	X
Pacific & River Lamprey														
Multiple populations	NL	Adults		X	X		X	X						
		Ammoceotes		X	X		X	X		X	X		X	X

[a] "T" denotes federally threatened (no Endangered in this table), "NL denotes Not Listed, SOC denotes Species of Concern.

[b] A, S, and D represent the HEA habitat categories of ACM, SWZ, and DWZ; see Grette (2014c) Section 3.2.3.1 for additional information.

[c] "X" denotes expected or potential presence; see Grette Associates (2014c), Section 3.3 for additional information.

[d] "…" denotes expected presence but low relative abundance; see Grette Associates (2014c), Section 3.3 for additional information.

[e] The Middle Columbia River DPS includes a very small proportion of winter-run fish (Klickitat River, Fifteen Mile Creek); because passage data at Bonneville Dam indicate that the vast majority of steelhead have passed the dam by early October, it is assumed that this includes winter steelhead spawning above it.

ESU = Evolutionary Significant Unit; DPS = Distinct Population Segment; Subyr = subyearling; Yrlng = yearling.

Designated critical habitat for federally protected salmonids within the study area consists of two primary constituent elements; migration corridors and estuarine areas. Migration corridors must be free of obstruction with healthy water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channel, and undercut banks to support juvenile and adult mobility and survival. Estuarine areas must be free of obstruction with water quality and salinity conditions to support juvenile and adult physiological transitions between fresh and saltwater; with natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and with juvenile and adult forage, including aquatic invertebrates and fishes to support growth and maturation.

Additionally, the Columbia River is also Essential Fish Habitat (EFH), as defined by the Magnuson-Stevens Fishery and Management Conservation Act for Chinook salmon and coho salmon. EFH for Pacific salmon is defined as those waters and substrate necessary to support salmon production, a long-term sustainable salmon fishery, and salmon contributions to a healthy ecosystem. To achieve that level of production, EFH must include those streams, lakes, ponds, wetlands and other currently viable water bodies and most of the habitat historically accessible to salmon in Washington, Oregon, Idaho and California. Thus, any discussion regarding the existing fish habitat conditions as well as potential impacts on fish habitat is applicable to EFH for Pacific salmon (i.e., Chinook salmon and coho salmon).

Active Channel Margin Use by Salmon and Steelhead

A fully functioning ACM provides natural cover, shoreline complexity, shade, submerged and overhanging large woody debris, logjams, and aquatic vegetation. All of these elements are identified in the primary constituent elements (PCEs) of critical habitat for Endangered Species Act (ESA)-listed salmon and steelhead, as well as bull trout (Grette 2014c). The ACM provides important habitat for juvenile salmon, with different species using different habitat types at different life stages. PCEs are defined as those physical and biological features of a landscape that a species needs to survive and reproduce. Table 2 identifies the salmon and steelhead species and season when individuals may be present in the ACM affected by the On-Site Alternative.

Use of the ACM varies both between and within species depending on locally specific adaptation for some life stages. Some salmonid species and populations rear in the lower river and estuary for extended periods (weeks to months) prior to entering the ocean; others spend very little time in the estuary and are unlikely to be present in the ACM for extended periods (Bottom et al. 2008, Johnson et al. 2003). Roegner and Sobocinski (2008) found that subyearling Chinook and chum salmon are the most likely species to be found in the shallow nearshore habitats that compose the ACM. Juvenile chum salmon are abundant in shallow nearshore areas from March through May. Subyearling Chinook (likely ocean-type) are commonly found in the shallow margins of the ACM from March through July. Healthy ACM provides abundant macroinvertebrate forage and cover for protection from predation supporting increased growth, survival, and fitness. Information on use of the Columbia River estuary by the less abundant anadromous salmonid species (cutthroat and bull trout) and those species having life histories with limited freshwater rearing and migration (pink and chum salmon) is limited (Carter et al. 2009), although Carter et al. (2009) do report juvenile cutthroat trout use backwater and channel margin habitats during presmolt and smolt life stages in the Columbia River estuary. In contrast, steelhead and stream-type Chinook salmon are typically larger when they reach the estuary and are more likely to be found farther offshore in the SWZ or DWZ.

As stated above, the ACM near the proposed docks has been extensively modified. As a consequence, it does not provide high-quality habitat for juvenile salmonids and other species that prefer shallow water habitats. These species are nonetheless likely to occur in the study area as they migrate downstream to better quality rearing in the lower river and estuary and/or during outmigration to the ocean (Table 2).

Shallow Water Zone Use by Salmon and Steelhead

The SWZ is used by adult salmon and steelhead as a migratory corridor and as foraging habitat by larger juveniles that are more capable swimmers in open water environments. Juvenile Chinook salmon, and sockeye salmon and steelhead smolts are typically found in deeper open water areas in the SWZ foraging on phytoplankton, invertebrates, and small fish (Bottom et al. 2008, Carter et al. 2009). Juvenile Chinook salmon are most commonly present from March through July but may be found in the SWZ during any month of the year. Juvenile coho salmon and steelhead are less likely to be found in the shallower areas but are abundant in deep water offshore habitats during their outmigration period (Roegner and Sobocinski 2008), indicating a likelihood of occurrence in the deeper areas of the SWZ.

Subyearling and yearling salmonids typically move offshore into the SWZ as temperatures increase in late spring and summer and as juveniles gain sufficient size to forage within the open water column (Carter et al. 2009). In general, survival and growth of juvenile salmonids is dependent upon habitats with ample food resources, resting areas (i.e., areas of slow current), refuge from predation, shoreline relief, side channels, and overhanging cover and banks. The SWZ near the proposed docks is made up of relatively high-energy habitat, with a sandy and silt bottom, and little organic matter, and is subject to erosion and deposition (National Marine Fisheries Service 2011). Consequently, this area is unlikely to provide substantial forage habitat for juvenile fish within the water column or along the bottom.

Generally, juvenile salmonids do not reside in specific habitats in the Lower Columbia River for extended periods, remaining in a given area for just a day or two before moving downstream to new suitable habitats (Bottom et al. 2008, Johnson et al. 2003). Carter et al. (2009) reported migration rates for tagged yearling and sub-yearling salmon of tens of kilometers per day. Given the simplicity of the shallow water habitat near the proposed docks and poor quality of the adjacent ACM, migratory fish are likely to move quickly through the area.

Deepwater Zone Use by Salmon and Steelhead

The DWZ zone provides a migratory corridor for adult salmon and steelhead and foraging and migratory habitat for larger juvenile Chinook salmon, coho salmon, and sockeye salmon and steelhead smolts pursuing phytoplankton, invertebrates, and small fish (Bottom et al. 2008, Carter et al. 2009, Roegner and Sobocinski 2008). Generally, juvenile salmonids do not reside in specific habitats in the Lower Columbia River for extended periods, remaining in a given area for just a day or two before moving downstream to new suitable habitats (Bottom et al. 2008, Johnson et al. 2003). Juvenile and adult salmon and steelhead are likely to be found in the DWZ during their respective migration and rearing periods (Table 2) as outmigrating salmonids (particularly stream type) tend to use deep water (Carter et al. 2009). The DWZ is also a dynamic environment, characterized by high flows and sediment transport. Sediment type is composed mostly of fine grain sands with little to no gravel or cobble for structure (Grette 2014c).

Bull Trout (Char)

Columbia River bull trout are listed as threatened, and there is one extant population in a subbasin that drains to the Lower Columbia River below Bonneville Dam; the Lewis River. Bull trout migrate to the mainstem Columbia River to rear, overwinter, or migrate to and from spawning areas. This indicates the possibility that more distant populations (e.g., Klickitat, Deschutes, Willamette) may migrate to and forage in the project vicinity or could in the future, but the extent to which different bull trout populations use the Lower Columbia River is uncertain (Carter et al. 2009). The Lower Columbia Recovery Team considers the mainstem Columbia River to contain core habitat that may be important for full recovery of Columbia River bull trout (U.S. Fish and Wildlife Service 2002). Bull trout have occasionally been observed in the Lower Columbia River as foraging or migrating adults and subadults, most likely originating from accessible Lower Columbia River tributaries with extant bull trout populations. Subadults may occur in the study area throughout the year in shallow rearing habitats of the ACM and SWZ while adults are more likely to occur in the deeper areas of the SWZ and the DWZ (U.S. Army Corps of Engineers 2004b). However, bull trout are opportunistic predators and routinely move between aquatic habitat types in search of prey so they could be present anywhere in the study area during periods when they are likely to occur in the Lower Columbia River (Table 2).

Eulachon

Eulachon are small anadromous fish in the smelt family (*Osmeridae*), sometimes known as Columbia River smelt (among other names), that spawn in coastal rivers and migrate to the ocean to rear to adulthood. The historical range of this species extends from northern California to Bristol Bay, Alaska. NMFS has classified all extant eulachon populations from the southern end of the range in northern California to the Nass River in British Columbia (exclusive) as belonging to the Southern DPS of the species, and has listed this DPS as threatened under the ESA (*Federal Register* [FR], Volume 75, page 13012). Eulachon are a migratory anadromous species that spend the majority of their lives (2 to 5 years) in marine habitats but return to natal tributary rivers to spawn after reaching adulthood (75 FR 13012).

Eulachon reach sexual maturity and typically spawn in mid- to late-winter, spawning may also occur from November to April (Gustafson et al. 2010). Adults congregate in open water and scatter their fertilized eggs over a variety of substrates. The eggs are adhesive, remaining attached to the substrate through a relatively short incubation period lasting about two weeks at typical water temperatures; eggs survive best in pea-sized gravel and coarse sandy substrates. The newly hatched larvae are captured by currents immediately after hatching and are transported rapidly downstream to estuarine and ocean habitats. Larvae that are dispersed into low current areas may remain in the estuary for weeks or months before growing into juveniles large enough to migrate to marine waters on their own. Most larvae are carried directly to the ocean where they rear to adulthood (Carter et al. 2009).

Prior to construction of dams in the Columbia River, eulachon may have migrated as far as Hood River to spawn. Currently eulachon migrate to the base of Bonneville Dam and spawn in the main river channel and many of the downstream tributaries, including the Grays, Elochoman, Kalama, Cowlitz, Lewis, and Sandy Rivers (Washington Department of Fish and Wildlife and Oregon

Department of Fish and Wildlife 2001). The Lower Columbia River up to Bonneville Dam and the lower reaches of those tributary streams that provide potential spawning habitats (i.e., Grays, Elochoman, Cowlitz, Kalama, Lewis, and Sandy Rivers) have been designated as critical habitat (76 FR 65324). Currently, the lower mainstem Columbia River and the Cowlitz River support the majority of eulachon production in the system (Gustafson et al. 2010). However, in years of relative abundance, spawning occurs broadly in the tidally influenced portions of the Columbia River and its tributaries (Grette 2014c). Adult migration in the Columbia River system is likely related to river temperature reaching 39.2°F and may begin in December, usually peaking in February and continuing through May (Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife 2001). In 2001, Howell et al. (2001) reported on spawning and distribution of larval eulachon, noting that, while spawning occurred widely in the mainstem and in tributaries as far upstream as the Sandy River (RM 120), the majority of the spawning likely occurred in the Cowlitz River and at a location just downstream of Barlow Point (RM 59.6). During the same spawning season, Romano et al. (2002) used artificial substrates to collect eulachon eggs as a way of identifying spawning sites in the main stem (based on the assumption that if eggs are collected spawning must have occurred nearby). They sampled locations between RM 30 and RM 85 near the mouth of the Lewis River. They collected the greatest number of eggs between RM 56 and RM 61 (Germany Creek to Barlow Point), and to a lesser extent RM 67 through RM 69 (mouth of the Cowlitz River to Cottonwood Island). Howell et al. (2001) took samples at several stations at seven fixed transects to assess the distribution of larvae across the river. They showed larvae were distributed nearer the Washington Shore at transects 7 downstream from Sandy River, and at transects 6 (downstream side of Lewis and Clark Bridge) and transect 5 downstream of Barlow Point. This likely reflects larvae moving downstream from spawning areas in the tributaries. Cross-channel distribution at transects farther downstream was more uniform, reflecting cross channel dispersion of larvae spawned in the tributaries and more intense mainstem spawning between Germany Creek and Barlow Point.

WDFW and ODFW conducted plankton tows to sample for eulachon eggs and larvae between the Port of Longview above Barlow Point and the channel below the Cowlitz River mouth including four sample sites offshore in the vicinity of the project area (Mallette 2014). Peak larval abundance occurred in mid-March during two of the three survey years and from late April to early May in the third (Mallette 2014). As part of a related on-time sampling effort, eulachon eggs/larvae were documented in plankton tows at six sample sites (inshore and offshore) near the proposed Project between RM 62.8 and 64.0 in February 2012 (Report B in Mallette 2014).

Adults deposit eggs in areas where the substrate consists of coarse sand/fine gravel (National Marine Fisheries Service 2010). Eggs are spherical and have a double membrane that, upon fertilization, peels back to form an adhesive peduncle (Howell et al. 2001). Eggs adhere to the surface of the substrate and incubate over a period of about 30 to 40 days, depending on temperature. Upon hatching, the larvae become part of the drift as (presumably) passive plankters and are rapidly transported out to sea (Howell et al. 2001). Larval fish, particularly from spawning aggregations in the Cowlitz River, are likely to pass through the study area as they are transported downstream. Eggs attached to large sand grains and pea-sized gravel may be disbursed from the spawning area flows in the Columbia River. The river channel in the study area is dynamic, with sand waves present in the area indicative of bedload movement. Given that incubation can be 30 to 40 days, there could be regular movement of eggs through the SWZ and DWZ of the study area conveyed by moving currents and bedload transport. Eggs could be present from December through April; however, peak of spawning season is usually in February or March. Larval eulachon, particularly from spawning aggregations in the Cowlitz River, likely pass through the study area as they are transported downriver. Further, it is likely that at least limited spawning occurs in the mainstem Columbia River, as documented on the Oregon side of the Columbia River by Mallette (2014). Mallette (2014) found the greatest numbers of eulachon larvae were found in samples collected well downstream of the Lewis, Kalama, and Cowlitz rivers and upstream of the Elochoman (rivers with known eulachon spawning). While the relatively distant proximity of sampling events to known spawning areas does not discount the possibility that larvae in samples may be the product of spawning in these tributaries, Mallette (2014) concluded that these findings highlight the potential for at least limited spawning in the mainstem Columbia River.

Sturgeon

Both green and white sturgeon may be present in the deepwater component of the study area as adults and subadults. Two green sturgeon DPSs occur in in the Lower Columbia River. The northern DPS, currently listed as a federal species of concern, includes spawning populations from the Eel River in California to the Umpqua River in Oregon. The southern DPS, currently listed as threatened under the ESA, includes spawning populations from the Sacramento River basin. While this species does not spawn in the Columbia River or its tributaries, subadult and adult green sturgeon originating from all major spawning populations are known to use the Lower Columbia River and other coastal estuaries in Oregon and Washington for holding habitat in the summer and early fall (Adams et al. 2002, Lindley et al. 2011, Moser and Lindley 2007). Lindley et al. (2008 and 2011) investigated migration patterns of green sturgeon tagged with acoustic transmitters on their spawning grounds and in known nonspawning aggregation sites. They discovered that green sturgeon undertake long season migrations from spawning grounds to overwinter in marine waters off of the coast of Vancouver Island, British Columbia. In the late spring and summer green sturgeon enter and inhabit a number of estuarine and coastal sites, including the Columbia River estuary, Willapa Bay, Grays Harbor, and the estuaries of certain smaller rivers in Oregon, especially the Umpqua River estuary. Moser and Lindley (2007) suggested that growth opportunities for green sturgeon are higher in estuaries because they are warmer than shelf waters and food is abundant. Green sturgeon from different natal rivers use the Columbia River estuary from May through October (peak in July and August). The most prevalent tags reported by Lindley et al. (2011) were from fish tagged in the Klamath and Rogue Rivers, but fish from the Sacramento River (southern DPS) were also present. Based on the size of green sturgeon and the number of tagged fish reported in the estuary, the Columbia River estuary appears to be an important component of foraging habitat for adult and juvenile green sturgeon belonging to the northern and southern DPSs.

Sturgeon are most commonly found in association with the bottom, where they feed on a mixture of aquatic insects and benthic (i.e., bottom-dwelling) invertebrates (Adams et al. 2002, Independent Scientific Review Panel 2013). Fish become a larger component of the diet as sturgeon increase in size. This species is known to spawn in the mainstem Columbia River in fast flowing waters near Bonneville Dam and in deepwater areas of the lower river (Independent Scientific Review Panel 2013, Parsley et al. 1993). Spawning lasts from 38 to 48 days extending from late April through early July during high runoff periods when water is turbid and turbulent. Adults are broadcast spawners, releasing their adhesive eggs over boulder and cobble substrate in areas with strong currents. Incubation lasts 7 to 14 days. Upon hatching the free-swimming embryos are broadly dispersed by currents as far as 100 miles downstream before settling. Post-settlement embryos seek out deep habitats with low light and large cobble or boulder substrates, remaining in cover for 20 to 25 days before they emerge as actively feeding larvae (Independent Scientific Review Panel 2013).

The DWZ near the proposed docks does not provide suitable substrates for white sturgeon spawning or larval rearing so these life stages are unlikely to occur for extended periods in this area.

In contrast, juvenile white sturgeon are found throughout the Lower Columbia River and use a wide variety of habitats, including both main-channel and off-channel areas. They are most commonly found at depths greater than 33 feet (Independent Scientific Review Panel 2013). White sturgeon adults, sub adults, and young of the year are usually found at depths greater than 36 feet (McCabe and Tracy 1994), but habitat use can vary considerably. For example, Parsley et al. (2008) tracked the movement patterns of subadult and adult white sturgeon ranging from 20 to 48 inches in length in the Columbia River estuary and observed complex daily and seasonal patterns of habitat selection. Tagged sturgeon were readily observed in the study area in summer but virtually absent in winter. When present they exhibited diurnal movement patterns, occupying habitats deeper than 33 feet during the day and moving to shallower waters, sometimes less than 15 feet deep, at night. The tagged fish were broadly distributed across available suitable habitat, but individuals demonstrated strong site fidelity, restricting their daytime and nighttime movements to the same general area. The depth preferences of white sturgeon indicate this species is most likely to be found in the DWZ, but individuals may also be present in the SWZ and, infrequently, in the ACM.

The white sturgeon population in the Columbia River downstream from Bonneville Dam has been among the most productive sturgeon populations in North America. Abundance and biomass have been estimated at 36.1 fish/acre and 88 pounds/acre, respectively (DeVore et al. 1995, cited in Independent Scientific Review Panel 2013). Current white sturgeon biomass in the unimpounded lower mainstem appears to be less than levels seen during pristine conditions before significant exploitation in the late 1800s (Jones et al. 2011). Where habitat is relatively homogenous, such as in marine waters, estuaries, low gradient mainstem areas of the lower basin, and reservoirs, white sturgeon move frequently and range widely, presumably in search of scattered or mobile food resources. Many white sturgeon movement and migration patterns appear to be associated with feeding. Primary prey items appear to be the benthic amphipod *Corophium salmonis* and the opossum shrimp *Neomysis mercedis* (Romano and Rien 2001). In the Lower Columbia River below Bonneville Dam, white sturgeon have been observed migrating upstream in the fall and downstream in the spring (Parsley et al. 2008). During early life stages, white sturgeon in the Lower Columbia River use a variety of habitats. Age-0 fish in the Lower Columbia River prefer deep (30–125 feet), low velocity areas where substrate particle sizes are small (e.g., sand; Parsley et al. 1993). Juvenile and sub-adult white sturgeon occupy a wide variety of depths (7–130 feet; Parsley et al. 1993 and 2008). Some juvenile white sturgeon preferentially used low velocity areas over sandy substrates at depths ranging from 7 to 190 feet in the Columbia River (Fisheries and Oceans Canada 2014), while others exhibited diel depth preferences Parsley et al. (2008). Given the abundance and mobility of white sturgeon in the Lower Columbia River, there likely would be some present during construction and operation of the On-Site Alternative.

Lamprey

Lamprey in general are a primitive anadromous fish species that spend their adult lives in the ocean but return to freshwater habitats for spawning and larval rearing. Two species, Pacific and river lamprey, are known to spawn in tributaries to the Columbia River and therefore migrate through the study area as adults and juveniles. Adults pass through the Lower Columbia River from March through October on their return migration to spawning tributaries (Columbia River Research 2014). Lamprey ascend rivers by swimming upstream briefly, then sucking to rocks, resting, and then proceeding.

Pacific lamprey populations may include mature adults that spawn within a few weeks of entering their spawning tributaries and immature adults that hold in freshwater overwinter and spawn between March and July the following spring (Clemens et al. 2013). Spawning takes place in the spring in low-gradient sections of water, with gravel and sandy bottoms, when water temperatures are between 50 and 60°F. Females are very fecund, depositing between 10,000 and 100,000 extremely small eggs. Adults die within 3 to 36 days after spawning (Clemens et al. 2013).

The young (ammocoetes larvae) hatch in 2 to 3 weeks and are dispersed by currents to slack-water areas with soft substrates, where they settle in sediments, which are soft and rich in dead plant materials. They quickly burrow into the muddy bottom where they live for a period of 3 to 8 years as filter feeders consuming microscopic plants (mostly diatoms) and animals. As filter feeders, they are susceptible to pollutants in the water column and sediments, which originate from various sources such as urban and agricultural runoff. Because this species depends on muddy bottoms, backwater areas, and low gradient areas during its juvenile life stage, it is susceptible to loss or modification of wetlands, side channels, back eddies, and beaver ponds resulting from agricultural, forestry, or urban development practices or channelization for flood control. Late in the ammocoetes life stage, unknown factors trigger a metamorphosis, from which lamprey juveniles emerge. During high water periods, in late winter or early spring, the juveniles migrate to the ocean where they mature. During their ocean phase, Pacific lamprey are scavengers, predators, and/or parasites on larger animals such as salmon and marine mammals. They may undertake migrations in the Pacific Ocean, considerable distances from their natal river (Beamish 1980). After 2 to 4 years in the ocean they return to freshwater to spawn.

River lampreys are associated with large river systems such as the Fraser, Columbia, Klamath, Eel, and Sacramento Rivers. They exhibit a similar life history to the Pacific lamprey, including an ammocoete larval stage lasting 4 to 6 years. River lamprey ammocoetes also settle in slack water areas with muddy sediments and filter feed on microscopic organism (Moyle 2002). They differ from Pacific lamprey in that they are smaller in size, a bit less fecund, with females laying between 12,000 and 37,000 eggs, and they are shorter lived. The length of adult life from the onset of metamorphosis until death following spawning is 2 years (Beamish 1980). The difference in longevity stems from their shorter ocean phase. River lamprey spend only 3 to 4 months in salt water, remaining close to the mouths of their natal rivers and foraging on smaller prey, such as herring and smelt (Beamish 1980).

The study area lacks suitable spawning substrates for either species. Therefore, adults are likely to be present only during upstream migration. Silver et al. (2007) and Jolley et al. (2012) investigated the presence and distribution of larval Pacific lamprey in the Willamette and Columbia Rivers. They found ammocoetes of several age classes in the Willamette River and at a few locations in the Columbia River. They observed anecdotally that larvae were more often found along underwater ledges at relatively steep drop-offs to deep water; and that shallow, flat, and sandy areas that appeared to present suitable habitat, were devoid of larvae. They speculate that those apparently suitable areas may have been dry during the summer months preceding the study because of lower regulated flows. They captured Pacific lamprey ammocoetes at two sites in the Columbia River near the mouth of the Cowlitz River. These ammocoetes were likely spawned in tributaries and either transported or migrated to the Columbia River. Their presence in the study area indicates the possibility that some ammocoetes could settle near the On-Site Alternative. The ACM and SWZ near the proposed docks generally lack the slack water environments required for ammocoete rearing, and the sediments in this area are mobile and lacking in the organic matter associated with suitable ammocoetes rearing habitat. The distribution of ammocoetes reported by Silver et al. (2007)

indicates that ammocoetes may be transported through the area or migrate through the study area to suitable habitat downstream. Juvenile and adult lamprey may be present in the SWZ and DWZ during their respective migration periods (Table 2).

Nonfocus Fish

The nonfocus fish (Table 3) are a mix of fish of interest because they are important food fish (harvested commercially and recreationally), game fish (harvested recreationally only), or on Washington's PHS list. Two of the species, mountain whitefish (*Prosopium williamsoni*) and leopard dace (*Rhinichthys falcutus*), are on Washington's PHS list as state candidate species. Both species are widely distributed in the Columbia and Frasier River basins. The other species in this group are important as commercial or recreational species. Most are abundant and widely distributed in the system, including several introduced species. Some are known predators of juvenile salmonid, such as largemouth bass, northern pikeminnow, smallmouth bass, striped bass, and walleye.

Table 3. Nonfocus Fish Species that May Occur in the Study Area

Species	Reason for Interest	Native or Introduced
Channel catfish (*Ictalurus punctatus*)	WDFW game fish	I
Common carp (*Cyprinus carpio*)	WDFW food fish	I
Largemouth bass (*Micropterus salmoides*)	WDFW game fish	I
Leopard dace (*Rhinichthys falcutus*)	WDFW PHS	N
Mountain sucker (*Catostomus platyrhuchus*)	WDFW PHS, WDFW game fish	N
Mountain whitefish (*Prosopium williamsoni*)	WDFW game fish	N
Northern pikeminnow (*Ptychocheilus oregonensis*)	WDFW game fish	N
Peamouth (*Mylocheilus caurinus*)	WDFW game fish	N
Perch (family Percidae)	WDFW game fish	I
Shad (subfamily Alosinae)	WDFW food fish	I
Smallmouth bass (*Micropterus dolomieu*)	WDFW game fish	I
Suckers (family Catostomidae)	WDFW game fish	N
Sunfish (family Centrarchidae)	WDFW game fish	I
Striped bass (*Morone saxatilis*)	WDFW game fish	I
Walleye (*Sander vitreus*)	WDFW game fish	I

Notes:
Source: Grette 2014c.
WDFW = Washington Department of Fish and Wildlife; PHS = Priority Habitats and Species

2.2.1.6 Commercial and Recreational Fishing

Commercial and recreational fisheries in the lower Columbia River are managed by the states of Washington and Oregon and tribes, subject to the terms of the 2008-2017 *United States v. Oregon* Management Agreement (Management Agreement). The Management Agreement establishes tribal harvest allocations and upholds the right of tribes to fish for salmon in their usual and accustomed fishing grounds. Commercial fisheries in these waters are managed under the Columbia River Compact, a congressionally mandated process that adopts seasons and rules for Columbia River commercial fisheries (National Marine Fisheries Service 2015).

In Washington, commercial fishing seasons and rules are established by the Columbia River Compact, which comprises the Washington and Oregon Departments of Fish and Wildlife Directors, or their delegates, acting on behalf of the Oregon and Washington Fish and Wildlife Commission. The Columbia River Compact is charged by congressional and statutory authority to adopt seasons and rules for Columbia River commercial fishers. When addressing commercial seasons for salmon, steelhead and sturgeon, the Columbia River Compact must consider the effect of the commercial fishery on escapement, treaty rights, and sport fisheries, as well as the impact on species listed under the federal ESA. Although the Columbia River Compact has no authority to adopt sport fishing seasons or rules, it is their inherent responsibility to address the allocation of limited resources among users (National Marine Fisheries Service 2015).

In Washington State, recreational fishing seasons and rules are updated annually and presented in the Washington Sport Fishing Rules pamphlet. Sport fishing seasons are generally established from July 1 through June 30 of the following year. The pamphlet covers all fresh waters and marine waters in Washington State, including the lower Columbia River. It establishes the seasons and rules for recreational fishing for finfish and shellfish/seaweed.

Commercial and recreational fishers primarily target hatchery-produced salmon and steelhead, as well as sturgeon and other game fish.

2.2.1.7 Sediment and Water Quality Conditions

Sediment conditions in the study area are generally uniform with slight variations between aquatic habitat types. ACM sediments are primarily sand mixed with silt, SWZ sediments are primarily sand, and DWZ sediments are primarily silt mixed with sand (Grette 2014c). Sediments within the dredge prism meet sediment disposal guidelines and are considered clean by the U.S. Army Corps of Engineers (Corps), EPA, and Ecology (U.S. Army Corps of Engineers Dredged Material Management Office 2010 in Grette 2014c). Recent sediment characterization indicates less than 0.2% organic matter in deep areas and typically less than 0.3% in shallow areas. Eulachon eggs usually settle into coarse sands and gravels in relatively deep water, while the shallow and DWZs are largely made up of silty river sand and therefore not considered high quality habitat for eulachon eggs.

The Lower Columbia River is listed as a Washington State 303(d) impaired water and is classified by Ecology as a Category 5 polluted water for dissolved oxygen, Dieldrin, PCB, and 2,3,7,8 TCDD, and 4,4,4 DDE (Grette 2014c). The nearest measured water quality impairment (for dioxin and bacteria) occurs approximately 2.5 miles upstream of the project area (Washington State Department of Ecology 2014). Turbidity in the study area is variable based on a number of factors. For example, over five days of water quality monitoring for dredging, background levels (upstream of active dredging) ranged from the mid-20s to the mid-60s nephelometric turbidity units (NTUs) at all depths (U.S. Army Corps of Engineers Dredged Material Management Office 2010 in Grette 2014c). Water temperature in the study area ranges from low 40s to low 70s (°F), and while this is slightly warmer than historic values (Bottom et al. 2008), the area is not listed as a Washington State 303(d) impaired water for temperature. Salmonids typically move from habitat areas as temperatures approach 66°F, and the study area habitat within the ACM and upper SWZ likely reaches this threshold and may become unsuitable for juveniles salmonids in the summer months. Refer to the NEPA Water Quality Technical Report (ICF International 2016c) for further information regarding water quality conditions near the project area.

2.2.1.8 Fish Predators

Several bird, mammal, and fish species present in the Columbia River estuary are known to prey on one or more of the focus fish species. For example, cormorants and Caspian terns are significant avian predators that are known to target juvenile salmonids and eulachon. Osprey and bald eagles are also known fish predators, capable of taking both juvenile and smaller adult salmonids. Steller and California sea lions are primary predators on adult fish, including salmon, steelhead, and sturgeon in the Lower Columbia River (National Marine Fisheries Service 2013). However, the study area does not currently or historically support sea lion congregations, and it is unknown whether terns congregate in these areas (Jefferies et al. 2000). Native and nonnative fish species, including northern pikeminnow, smallmouth bass, and walleye, are known to be significant predators on juvenile fish and are capable of exploiting habitats present in the study area. Specifically, pikeminnow and smallmouth bass are known to associate with shoreline and channel modifications like riprap armoring, revetments, and pile dikes, which provide suitable holding habitat for lie-in-wait predation (Pribyl et al. 2004). In contrast, walleye use deeper, open water habitats but they are also known to associate with artificial and natural structures when they are present (Pribyl et al. 2004). The existing dock, pile dikes, and other shoreline and channel modifications are likely to provide suitable habitat for these predatory fish species.

2.2.1.9 Fish Stranding

A growing body of evidence indicates that juvenile salmon and other fish are at risk of stranding on wide, gently sloping beaches because of wakes generated by deep draft vessel passage (Bauersfeld 1977; Hinton and Emmett 1994; Pearson et al. 2006;, ENTRIX 2008). Depending on the slope and breadth of a beach, wakes from passing vessels can travel a considerable distance, carrying fish and depositing them on the beach where they are susceptible to stress, suffocation, and predation.

Pearson et al. (2006) published the most detailed study of Columbia River fish stranding completed to date. They evaluated stranding at three sites in the Lower Columbia River: Sauvie Island, Barlow Point (adjacent to the project area), and County Line Park. The sites were chosen because prior work had established them as sites with high risk of stranding (Bauersfield 1977). Pearson et al. (2006) observed 126 vessel passages, 46 of which caused stranding. From the study, certain sites appear to be more susceptible to stranding than others. For example, the highest occurrence of stranding was at Barlow Point, where 53% of the observed passages resulted in stranding. Stranding occurred less frequently at Sauvie Island (37% of the observed passages resulted in stranding) and County Line Park (15% of observed passages resulted in stranding) (Person et al. 2006). The proposed terminal would add 840 vessel calls, or round-trips to and from the proposed terminal, or 1,680 one-way transits to Columbia River vessel traffic annually at full capacity, which would introduce additional permanent risk of fish stranding in the Columbia River. Many factors affect the risk of fish stranding in the lower Columbia River, including but not limited to vessel size, draft and speed, and beach slope and permeability.

2.2.2 Off-Site Alternative

The affected environment relative to the Off-Site Alternative is similar to the On-Site Alternative based on the proximity of the two sites. The discussion below highlights differences that exist at the Off-Site Alternative.

2.2.2.1 Aquatic Habitat Types

The aquatic portion of the Off-Site Alternative is a functioning, although somewhat modified, habitat complex (riparian, ACM, SWZ, and DWZ) (Figure 10) with varying water-level regimes on daily (tidal) and seasonal (discharge) scales. Modifications (e.g., diking, shoreline armoring) and simplifications (e.g., lack of vegetation) limit habitat development, but functional habitat is present within the ACM and SWZ portions of the study area (Grette 2014b).

Riparian

Shoreline armoring and the CDID dike have contributed to what is typically low-complexity and artificially steepened upper shoreline and no floodplain connectivity in the upstream two-thirds of the Off-Site Alternative. Additionally, landward of the shoreline, dike maintenance has removed and continues to prevent the establishment of riparian habitat (Grette 2014b).

However, the Off-Site Alternative includes relatively intact riparian habitat below the toe of the dike. Approximately the middle one-third of the property contains a band of riparian/wetland habitat, varying from approximately 20 to 140 feet in width, and the downstream one-third contains wide, dense (approximately 250 feet) riparian/wetland habitat. Thus, relative to the dike portion of the Lower Columbia River, much of the Off-Site Alternative contributes moderate to high levels of biological material (e.g., leaf litter, woody material, insects) to the aquatic areas, as well as shade and other physical function (Grette 2014b).

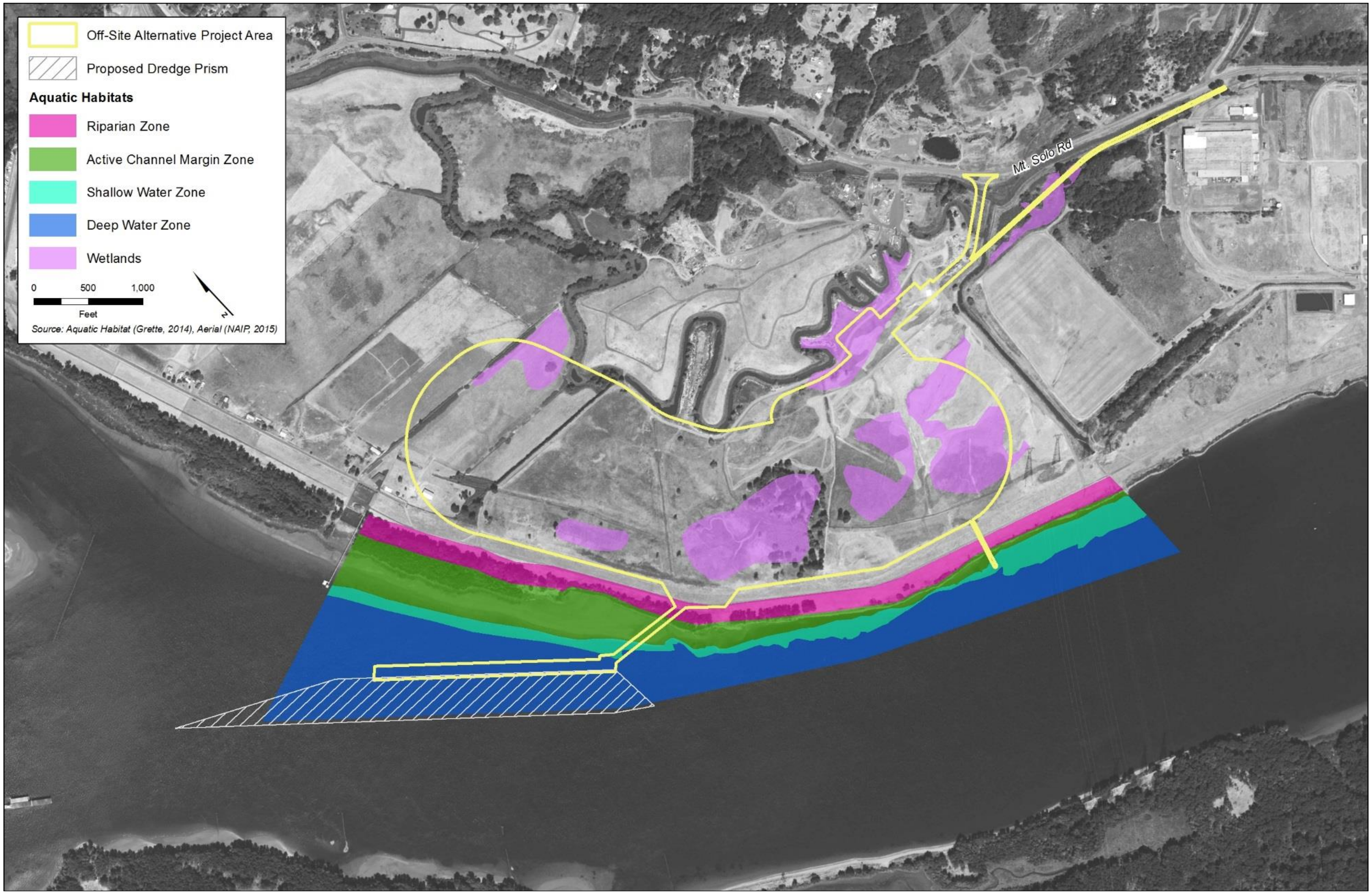
Active Channel Margin

The middle and lower portions of the ACM consist largely of unvegetated, silty sands that provide shallow (e.g., 2 to 6 feet deep) water habitat during high and low water-level seasons. Specifically, the flats in the ACM provide shallow water foraging and refuge opportunities for small salmonids during the early part of the outmigration period (high water levels). This shallow, flat ACM habitat occurs almost exclusively in the downstream portion of the study area, and primarily in the ACM. During low water periods when the ACM is dewatered or very shallow, similar flat habitat in the upper SWZ that provides similar function is scarce because the SWZ is much more steeply sloped (Grette 2014b).

Shallow Water Zone

The HEA model considers shallow-water areas to provide inherently higher biological function than DWZ habitat. In areas with poor quality riparian habitat (e.g., the upstream one-third of the Off-Site Alternative), the overall habitat function of the ACM—and to a lesser extent the SWZ—at the Off-Site Alternative is expected to be relatively less than similar areas with intact riparian habitat (Grette 2014b).

Figure 10. Aquatic Habitat Types Potentially Affected by the Off-Site Alternative



Deepwater Zone

Because depth reduces light penetration, the HEA model considers the quality of benthic habitat in DWZ areas to rank at least ten times lower than that of ACM or SWZ habitats. Though no studies have been conducted at the Off-Site Alternative, it was found at the On-Site Alternative that the quality of DWZ habitat is further reduced due to the highly dynamic nature of currents acting upon it (Grette Associates 2014c). Based on the similar settings and proximity of the sites, this conclusion likely applies to the Off-Site Alternative as well. Areas with dynamic bedload typically express reduced biological productivity due to limited sediment stability and the insufficient buildup of detritus and fine material (McCabe et al. 1997). In addition, the potential for benthic invertebrates to colonize areas exposed to strong currents is challenged by the risk of burial due to accretion and the risk of scouring due to erosion. Therefore, in the context of the HEA model, the quality of DWZ portions of the Off-Site Alternative would rank low in comparison to both SWZ areas and areas of the DWZ that are not exposed to strong downstream flow.

2.2.2.2 Columbia River

The affected environment in the Columbia River at the Off-Site Alternative is the same or similar to that of the On-Site Alternative as described in Section 2.2.1.4, *Columbia River Downstream of Project Area*.

2.2.2.3 Focus Fish Species

The affected environment relative to the focus fish species at the Off-Site Alternative is the same or similar to that of the On-Site Alternative as described in Section 2.2.1.5, *Focus Fish Species*.

2.2.2.4 Commercial and Recreational Fishing

The affected environment relative to the commercial and recreational fishing at the Off-Site Alternative is the same or similar to that of the On-Site Alternative as described in Section 2.2.1.6, *Commercial and Recreational Fishing.*

2.2.2.5 Sediment and Water Quality Conditions

The affected environment relative to sediment and water quality at the Off-Site Alternative is the same or similar to that of the On-Site Alternative as described in Section 2.2.1.7, *Sediment and Water Quality Conditions.*

2.2.2.6 Fish Predators

The affected environment relative to fish predators at the Off-Site Alternative is the same or similar to that of the On-Site Alternative as described in Section 2.2.1.8, *Fish Predators.*

2.2.2.7 Fish Stranding

The affected environment relative to fish stranding associated with the Off-Site Alternative is the same or similar to that of the On-Site Alternative as described in Section 2.2.1.9, *Fish Stranding.*

Chapter 3
Impacts

This chapter describes the impacts on fish and fish habitat that would result from construction and operation of the proposed export terminal.

3.1 On-Site Alternative

Potential impacts on fish from the proposed terminal at the On-Site Alternative location are described below.

3.1.1 Construction: Direct Impacts

Construction of the On-Site Alternative would occur on currently developed and disturbed lands and within the Columbia River. Potential construction impacts on fish and fish habitat would include permanent removal or temporary alteration of habitat, elevated underwater noise associated with pile driving, temporary overwater shading, and spills and leaks of hazardous material.

Aquatic Habitat

Construction would result in the alteration and removal of aquatic habitat in the Columbia River adjacent to the On-Site Alternative. Riparian vegetation at the project area is sparse and riparian habitat conditions are degraded. Project construction would not result in measurable impacts to riparian vegetation or habitat conditions at the project area.

Habitat in the Columbia River would be permanently altered and removed by the placement of piles. A total of 603 of the 622 36-inch-diameter steel piles required for the trestle and docks would be placed below the OHW mark, permanently removing an area equivalent to 0.10 acre (4,263 square feet) of benthic habitat. The majority of this habitat is located in DWZ (Grette 2014a). The placement of piles would displace benthic habitat, and the areas within each pile footprint would cease to contribute toward primary or secondary productivity. Individual pile footprints are relatively small (7.07 square feet) and are spaced throughout the dock and trestle footprint. Benthic, epibenthic (i.e. living at the water-substrate interface), or infaunal (i.e., beneath the surface of the river floor) organisms within the pile footprint at the time of pile driving would likely perish.

Creosote-treated piles would be removed from the deepest portions of two existing timber pile dikes. In total, approximately 225 lineal feet of the dikes would be removed. Overall, the removal of creosote-treated woodpiles from the Columbia River would be a beneficial impact, as any remaining creosote in those piles would be removed from the aquatic environment. However, removal of the piles could result in temporary increases in suspended sediments, short-term contamination of water, and long-term contamination of sediments from creosote released during extraction. Creosote contains a mixture 200 to 250 compounds, with primary components composed of polycyclic aromatic hydrocarbons (PAHs) (Brooks 1995), which are known to be toxic to aquatic organisms including invertebrates and fish and can cause sublethal and lethal effects (Eisler 1987, Brooks 1995).

Creosote and associated chemicals are known to bioconcentrate in many aquatic invertebrates (Eisler 1987, Brooks 1995). This could expose higher trophic level species such as fish to creosote/PAH compounds through the food chain. Many vertebrates, including fish, however, metabolize PAHs and excrete them, reducing the potential risk to higher trophic level species (National Marine Fisheries Service 2009).

Most of the components of creosote are heavier than water and sink in the water column. PAHs from creosote accumulate in sediments and are likely to persist at the site of pile removal or wherever they settle after suspension until they degrade (National Marine Fisheries Service 2009). However, PAHs from sediment are less bioavailable to aquatic species and thus these organisms are not likely to bioaccumulate PAHs from sediments (Brooks 1995).

Over the long term, the source of creosote would be removed or capped by the sediment falling into the hole left by the extracted pile. Water quality would improve over time; the concentration of creosote in the sediment would be expected to decrease, and the potential pathway of exposure for wildlife through contamination of prey would be reduced.

The in-water work windows would be defined by the permits that may be issued for the construction of the project. The in-water work windows presented here are consistent with WAC 220-110-206, which was repealed effective July 1, 2015 by Washington State Rule 15-02-029. No new in-water work windows have been defined and the project specific in-water work periods would be defined during permitting. Dredging is proposed between August 1 and December 31, per the recently repealed WAC 220-110-206) and would permanently alter a 48-acre area of benthic habitat in the DWZ (below -20 feet CRD) by removing approximately 500,000 cubic yards of benthic sediment to achieve a depth of -43 feet CRD, with a 2-foot overdredge allowance. Within the proposed dredge prism (i.e., extent of the area to be dredged), the amount of deepening would vary based on existing depths, from no removal up to approximately 16 feet of removal. The majority of the area of the proposed dredge prism is at or below a depth of -31 feet CRD. Hydrodynamic modeling and sediment transport analysis performed by WorleyParson (2012) evaluated the potential effects that could result from dredging, sediment deposition and maintenance dredging. Overall, WorleyParsons (2012) found that the accretion rate would be approximately 12,000 cubic yards per year within the dredge prism; however, accretion rates could fluctuate significantly year-over-year based on flow conditions. Maintenance dredging would likely only be required on a multi-year basis, or following special extreme flow events (WorleyParsons 2012). The preferred method for disposing of dredge material is flow-lane disposal so those sediments are not removed from the river, but remain in the river and are transported and deposited in areas where they can provide habitat for benthic species and benthic dependent species. Thus dredged materials are expected to be disposed of within the flow lane, adjacent to the navigation channel, allowing these sediments to support the downstream sediment transport system (Grette 2014a, 2014d). This area would be located within an area of approximately 80 to 110 acres between approximately RM 60 and RM 66. However, it could be that some or all of the dredged materials could be used for pre-loading of the stockpile pads and then disposed of at an appropriate off-site upland facility. Specific disposal methods for dredged materials would be determined during permitting and federal ESA Section 7 consultation.

The majority of benthic, epibenthic, and infaunal organisms are nonmotile or slow-moving and become entrained during dredging. Benthic, epibenthic, and infaunal organisms within the proposed dredge prism above -43 feet CRD would be removed during dredging, resulting in likely mortality. These organisms often serve as prey for larger animal species. Most of the habitat within the proposed dredge prism is in deep water where benthic productivity is expected to be low relative to shallower habitat. Deepwater channels are subjected to higher water velocities that periodically scour bottom sediments, limiting the standing crop of invertebrates and the buildup of detritus and fine materials that support these invertebrates (McCabe et al. 1997) Dredging activities are not typically associated with long-term reductions in the availability of prey resources, and impacts on benthic productivity are expected to be temporary. Disturbed habitats are expected to return to reference conditions with rapid recolonization by benthic organisms (McCabe et al. 1996). Benthic organisms typically recolonize disturbed environments within 30 to 45 days.

Much of the scientific literature evaluating the effects of turbidity on fish is discussed in relation to turbidity concentrations associated with dredging. The dredging that would occur for the On-Site Alternative would remove approximately 500,000 cubic yards of sediments, and temporary increases in turbidity associated with other related activities (e.g., pile driving and pile dike removal) would generally be lower than those associated with larger dredging activities (i.e., dredging of the navigation channel). Several studies indicate that suspended sediment concentrations occurring near dredging activity do not cause gill damage in salmonids. Servizi and Martens (1992) found that gill damage was absent in under yearling coho salmon exposed to concentrations of suspended sediments lower than 3,143 milligrams per liter (mg/L). A negligible risk of gill tissue damage is also expected for adult and subadult salmonids exposed to turbidity generated by dredging activities because salmonids in these life stages are generally more tolerant of elevated suspended sediment levels (Stober et al. 1981) and are generally able to avoid localized areas of elevated turbidity associated with construction activities.

Suspended sediments have been shown to cause stress in salmonids but at concentrations higher than those typically measured during dredging. Subyearling coho salmon exposed to suspended sediment concentrations above 2,000 mg/L were physiologically stressed as indicated by elevated blood plasma cortisol levels (Redding et al. 1987). Although turbidity may cause stress to salmonid species, studies by Redding et al. (1987) found that relatively high suspended sediment loads (2,000–2,500 mg/L) did not appear to be severely stressful to yearling salmon.

As stated previously, the Applicant has proposed to do the in-water work between August 1 and February 28. The Applicant has proposed to do impact pile driving between September 1 and December 31; dredging, including flow lane disposal of dredged material, would be performed between August 1 and December 31. While the specific times dredging activities would be allowed by the permitting agencies has not be determined and would not be defined until permits would be issued for the project, the Applicant proposed timing for performing the dredging activities would avoid and minimize impacts to spawning adult, egg, and larval eulachon. Adult eulachon typically enter the Columbia River and tributaries (i.e., Cowlitz, Kalama, Lewis, Sandy, Elochoman), in December and January. Peak spawning migration occurs in February and March. Peak larval abundance occurred in mid-March during two of three survey years and in late April/early May in the third (Mallette 2014). Eggs could be present from December through April, however. Dredging activities that occur between August 1 and December 31 would minimize potential impacts to adult eulachon that may spawn within 300 feet of the dredge prism. Limiting dredging activities to August 1 and November 30 would further reduce the potential to impact eulachon spawning or migrating adults.

Dredging and dock construction associated with the proposed terminal could impact habitat that may be suitable for eulachon spawning. Spawning substrates include sand, course gravel, and detrital substrates. Sand substrate occurs within the dredge prism, and is assumed to provide suitable habitat for eulachon spawning. Project-related dredging would impact approximately 48-acres for the On-Site Alternative. Trestle and Dock construction would install 603 piles below OHW, affecting an additional 0.10 acre (4,263 square feet). The dock, with two Panamax size vessels being loaded simultaneously, would shade approximately 9.83 acres (refer to Section 3.1.3, *Operations: Direct Impacts*). The direct impact study area for the On-Site Alternative is approximately 1,549 acres (Figure 5.7-1). Thus, project-related dredging would modify approximately 3% of the direct impact study area, while dock construction would permanently affect approximately 0.6% of the direct impact study area. The extent of this area that may be used by eulachon for spawning is unknown.

During eulachon spawning eggs are deposited through broadcast spawning and attach to the substrate. After approximately 1 month of incubating the eggs hatch into larvae that drift passively downstream to salt water. It is likely that much of the dredge prism area is used for egg incubation and larval transport/rearing, either from spawning within the dredge prism area or egg drift from areas upstream within the Columbia River, or the Cowlitz River, located approximately 5 miles upstream of the project area.

Eulachon are assumed to occur in the Columbia River adjacent to the project area from December through May. Any project-related work that would occur between December and May could directly impact eulachon. Potential mitigation measures identified in the Draft EIS would reduce the potential impact by confirming the presence/absence of eulachon, and, if present, coordinating with the fish and wildlife agencies (i.e., NMFS and WDFW) on the appropriate course of action to avoid and minimize potential impacts to eulachon. Although it is difficult to determine exactly how much of a temporary increase in turbidity would result from the covered activities, increases in suspended sediments are expected to be relatively short term, occurring during in-water construction activities and maintenance dredging. Thus in-water construction and maintenance activities would not result in chronic sediment delivery to adjacent waters, because sediments would be disturbed only during in-water work. Construction related dredging is proposed to occur from August 1 through December 31, when many fish species would be present within the study area (Table 2). It is assumed that dredging would occur between 7:00 a.m. and 10:00 p.m., Monday through Friday, per the Cowlitz County Code Chapter 10.25, which restricts construction noise to these hours, unless the activity is authorized by a valid conditional use permit, a SEPA determination, or a permit approval condition.

Those fish that are present in the construction area when the effects are manifest are likely to avoid the area until the effects dissipate. Carlson et al (2001) observed out-migrating salmon smolts moving in-shore when encountering either a dredge or discharge plume before resuming their prior distribution a short distance downstream. An evaluation of dredge disposal in the lower Columbia River found that white sturgeon may slightly shift habitat use toward disposal areas during disposal, possibly in response to prey items associated with dredged materials (Parsley et al. 2011). Hence, short-term, localized increases in turbidity associated with the On-Site Alternative dredging and dredge disposal activities would not likely result in significant physiological impacts on fish, their habitat, or their prey.

Behavioral effects related to increased turbidity are another consideration. Some of the documented behavioral effects of turbidity on fish include avoidance, disorientation, decreased reaction time, increased or decreased predation and increased or decreased feeding activity. However, many fish species (especially estuarine species) have been documented to prefer higher levels of turbidity for cover from predators and for feeding strategies. For example, increased foraging rates for juvenile Chinook salmon were attributable to increase in cover provided by increased turbidity, while juvenile steelhead and coho salmon had reduced feeding activity and prey capture rates at relatively low turbidity levels. Juvenile Chinook salmon were also found to have reduced predator-avoidance recovery time after exposure to turbid water. (ECORP Consulting, Inc. 2009). Thus, while there may be some beneficial behavioral effects from increased turbidity, it is expected that for many of the focus fish species and native non-focus fish species behavior effects from increased turbidity would generally be negative.

The On-Site Alternative would permanently affect approximately 48 acres of benthic habitat due to dredging activities (i.e., removal of benthic habitat and benthic organisms) and construction of the docks (i.e., construction of new in-water structure and related shading of the aquatic environment). Water quality could be affected as a result of coal dust. These potential impacts are discussed below. Other elements of these two PCEs, such as water quantity, natural cover, and salinity would not be impacted by the project.

Response to Underwater Noise during Pile Driving

The following analysis is a summary of the Grette (2014a) evaluation of the potential impacts on fish from underwater noise generated during pile-driving activities. The Grette (2014a) analysis was reviewed and evaluated by ICF, and the approach taken for the analysis is consistent with the current approach for evaluating the effects of underwater noise on fish, specifically underwater noise generated by pile-driving activities.

Docks 2 and 3 and their associated trestle would be supported by 622 36-inch steel piles, 603 of which would be installed in aquatic areas below OHW. The Dock 2 and 3 structures would be located completely within DWZ habitat (below -20 feet CRD) and would comprise the majority of the pile to be installed. Each pile would be installed using a vibratory driver until it meets practical resistance, at which point an impact pile driver would be used to proof the pile and complete installation to the necessary weight-bearing capacity.

Most piles would be driven to a depth of 140 to 165 feet below the mudline to provide the necessary resistance to support the overwater structures (i.e., Docks 2 and 3, the ship loaders, and conveyors) (Grette 2014a) The duration of vibratory and impact pile driving required to install each pile would be dependent upon the depth at which higher density materials (e.g., volcanic ash or dense sand and gravels) are encountered; shallower resistance would require less vibratory and more impact driving, while deeper resistance would require more vibratory and less impact driving.

Sound generated by impact pile driving has the potential to affect fish in several ways, ranging from alteration of behavior to physical injury or mortality, depending on the intensity and characteristics of the sound, the distance and location of the fish in the water column relative to the sound source, the size and mass of the fish, and the fish's anatomical characteristics (Hastings and Popper 2005). Refer to the NEPA Noise and Vibration Technical Report (ICF International and Wilson Ihrig Associates 2016) for further information regarding noise and vibration.

Both peak sound pressure level (SPL) and sound exposure level (SEL) can affect fish hearing through auditory tissue damage or temporary shifts in sensitivity to sounds (referred to as a temporary threshold shift [TTS]). Exposure to very loud noise or loud noise for extended periods may result in permanent reductions in sensitivity or permanent threshold shifts (PTS). Generally TTS would occur at lower levels than those resulting in auditory tissue damage, which result in PTS. The effects of hearing loss in fish may relate to the fish's reduced fitness, which may increase the vulnerability to predators and/or result in a reduced ability to locate prey, inability to communicate, or inability to sense their physical environment (Hastings and Popper 2005). Popper et al. (2005) found fish experiencing TTS were able to recover from varying levels of TTS, including substantial TTS, in less than 18 hours post exposure. Meyers and Corwin (2008) reported evidence that fish can replace or repair sensory hair cells that have been damaged in both the inner ear and lateral line, indicating that fish may be able to recover from PTS over a period of days to weeks.

In June 2008, NMFS, USFWS, the U.S. Federal Highway Administration, and several state transportation agencies agreed to interim criteria intended to protect fish from underwater noise generated by pile driving during bridge construction and retrofitting (Fisheries Hydroacoustic Working Group 2008). In general, the interim criteria establish thresholds for injury and behavioral effects from pile-driving generated underwater noise. There are three criteria for injury related to underwater noise: the first is based on peak pressure levels of 206 dB_{PEAK}[7] for impulse-type noise (e.g., pile driving), and the other two are based on accumulated sound exposure levels (i.e., sound energy integrated over time), the first of which is 187 dB cumulative $_{SEL}$ [8]for fish greater than or equal to 2 grams (e.g., most juvenile salmon and trout), and the other is 183 dB cumulative $_{SEL}$ for fish less than 2 grams (e.g., larval lamprey). Underwater noise levels of 150 dB_{RMS} may cause behavioral effects in fish species, such as startle response, disruption of feeding, or avoidance of an area. Depending on site-specific conditions, construction timing, duration, and other factors, exposure to these levels may cause behavioral changes that result in potential injury (Washington State Department of Transportation 2015). Potential adverse behavioral affects include interruption of foraging activities, avoidance of feeding or spawning areas, or movement away from cover, impaired predator avoidance (Washington State Department of Transportation 2015).

This analysis assumes that in-water pile driving would occur over two proposed construction seasons. In order to accomplish impact pile driving during limited work windows, multiple pile-driving rigs are expected to be in use simultaneously on the same day. The simultaneous use of multiple rigs may reduce the total duration of pile driving sound as some overlap in active driving may occur.

Considering the large number of piles to be driven, and the potential for multiple rigs to operate simultaneously, this analysis assumes that vibratory and/or impact pile driving may occur continuously during each working day of the Applicant-proposed in-water construction window (September 1 through December 31). Local Ordinance (Cowlitz County Code: Chapter 10.25) restricts construction noise to the hours of 7 a.m. to 10 p.m. unless the activity is authorized by a valid conditional use permit, a SEPA determination, or a permit approval condition. Various

---

[7] dB_{PEAK} is the instantaneous maximum overpressure or underpressure observed during each pulse. When evaluating potential injury impacts to fish, peak sound pressure (dB_{PEAK}) is often used.

[8] dB cumulative SEL is a metric for acoustic events and is often used as an indication of the energy does. SEL is calculated by summing the cumulative pressure squared (p^2), integrating over time, and normalizing to 1 second.

underwater reference noise values were reviewed, in order to select the appropriate noise values that would likely be generated by pile-driving activities. Of the various reference pile data available (ICF Jones & Stokes and Illingworth and Rodkin 2009, Washington State Department of Transportation 2015), sound levels from the Columbia River Crossing (CRC) 48-inch diameter steel test piling (David Evans Associates 2011) were selected as reference levels for the 36-inch-diameter steel piling proposed for the analysis. Although the pilings were larger for the CRC project, the proximity of the two sites and the similar conditions (i.e., depth, currents, and substrates) are expected to be more comparable than more distant locations such as Puget Sound or areas of California, where other reference data has been obtained for 36-inch-diameter steel piling (Grette 2014a).

Substrate characteristics between the CRC site and the project area are relatively similar, and pile driving conditions and underwater noise levels generated are anticipated to be similar. The greatest per-pile levels for each type of sound (i.e., single strike at 217 dB_{PEAK}, 201 dB_{RMS}, and 185 dB_{SEL}) were selected. These values are generally greater than reference values recorded for 36-inch-diameter piling at various other locations, and thus represent the potential worst-case for noise levels generated during pile driving (Grette 2014a).

Further, the hydroacoustic monitoring conducted for the CRC test pile also tested the efficacy of both confined and unconfined bubble curtains for attenuation of underwater noise from pile driving (David Evans Associates 2011). For 48-inch-diameter steel piling, both confined and unconfined bubble curtains consistently attenuated sound levels by 10 dB or more, measured at a distance of 33 feet from the source. At another Washington State Department of Transportation project completed downstream at Puget Island, the confined bubble curtain attenuated sound levels by 13 dB (measured at 43 feet) after on-site modifications (Washington State Department of Transportation 2010). Thus, the assumption that sound values would be attenuated by 9 dB during use of a confined bubble curtain in this analysis is considered realistic, achievable, and likely conservative (Grette 2014a).

Both the NMFS and the USFWS are concerned with potential impacts of elevated underwater noise levels during pile driving on federally protected fish species, such as salmonids, green sturgeon, and eulachon. NMFS and the USFWS have developed standard thresholds for disturbance/behavioral changes and injury (Table 4). Sound at or above these thresholds is evaluated on a site- and project-specific basis to determine whether potential impacts could occur, and whether any impacts on individuals resulting from underwater noise generated by pile driving could occur. Injury threshold values typically result from impact pile driving, as opposed to vibratory pile driving because sound- or pressure-related injuries, such as barotraumas, are thought to result from the rapid rise times and fluxes in over- versus under-pressure during a pile strike (Grette 2014a).

It is standard practice to use the Practical Spreading Loss model to evaluate the potential effects of pile driving and determine the distance at which sound associated with pile driving would attenuate to specific levels (i.e., effect thresholds), except where cumulative sound is being considered.

Table 4. Underwater Sound-Level Thresholds for Endangered Species Act-Listed Fish

Species	Effect Type	Threshold
All Listed Fish[a]	Injury, cumulative sound (fish ≥2 grams): onset of TTS (auditory response), with onset of auditory tissue damage and nonauditory tissue damage with increasing cumulative sound	$187 dB_{SELcum}$
	Injury, cumulative sound (fish <2 grams): similar to above, onset of nonauditory tissue damage occurs at lower sound levels with smaller fish	$183 dB_{SELcum}$
	Injury, single strike: onset of TTS and auditory tissue damage from single strike	$206 dB_{PEAK}$
	Behavioral Disruption	$150 dB_{RMS}$

Notes:

[a] Injury thresholds are based on interim criteria that were developed for salmonids based on data specific to hearing generalists with swim bladders (Carlson et al. 2007). NMFS also applied these thresholds to other listed fish with swim bladders (e.g., green sturgeon) and sometimes conservatively to fish without swim bladders (e.g., eulachon). Injury descriptions are based on information summarized in Carlson et al. (2007).

TTS = temporary threshold shift; dB = decibel; SEL = sound exposure level; cum = cumulative; RMS = root mean square.

Source: Grette 2014a.

The Practical Spreading Loss model is defined as:

$TL = 15 * Log (R_1/R_2)$

where:

TL = Transmission Loss, the difference between SPLs in dBs at distances R_1 and R_2; also $SPL_2 – SPL_1$

R_1 = distance at which transmission loss is estimated

R_2 = distance from source at which sound is known or measured (typically 10m)

In order to solve for R_1, the distance required for SPLs to attenuate to a desired level (e.g., threshold or ambient condition) based on reference SPLs at a known distance (R_2, typically at 10m), the terms are rearranged as follows:

$R_1 = R_2 * 10^{(TL/15)}$

In this case, the Practical Spreading Loss model was used to solve for R_1 in order to calculate distance to injury (single strike, 206 dB_{PEAK}) and distance to disturbance (150 dB_{RMS}) for federally protected fish during impact pile driving (Grette 2014a).

In addition to thresholds for single pile strikes, NMFS has established injury thresholds for fish based on cumulative sound exposure to account for the potential effects of impact pile driving over the course of a workday. Cumulative sound exposure is calculated using the NMFS Stationary Fish model (available at http://www.wsdot.wa.gov/Environmental/Biology/BA/BAguidance.htm#noise) (Grette 2014a).

The Stationary Fish model requires the number of pile strikes over an entire work day to determine the potential cumulative injury for fish based on dB_{SEL}. However, NMFS incorporated the concept of "effective quiet" into the model, which assumes that sound cannot accumulate and contribute toward cumulative injury below 150 dB_{SEL}. Because of this, one can calculate the maximum distance possible for cumulative injury independent of pile strikes. This can be accomplished either using the Practical Spreading Loss model to determine the distance required to attenuate sound at the source to 150 dB_{SEL}, or by iteratively increasing the pile strikes in the Stationary Fish model until it returns a consistent (rather than increasing) distance value because it is basing the calculation on effective quiet (Grette 2014a).

Rather than predicting daily pile strikes (which are anticipated to be highly variable), the Stationary Fish model was used to determine the distance to cumulative injury based on effective quiet. The maximum distance of potential cumulative effects occurred at approximately 5,000 strikes for fish greater than or equal to 2 grams (threshold 187dB_{SELcum}) and at approximately 2,000 strikes for fish less than 2 grams (threshold 183 dB_{SELcum}). This represents a distance of 1,775 feet for both size classes (Grette 2014a).

The model predicts that impacts on fish would not increase for more than approximately 2,000 pile strikes in a day for fish less than 2 grams or 5,000 pile strikes in a day for larger fish. This is because additional pile strikes do not result in additional cumulative energy. Furthermore, this predicted cumulative injury area is a liberal estimate (the largest possible) of the potentially injury area for fish based on the Stationary Fish model. This conservative approach protects fish because, should fewer pile strikes occur on any given day, the area of potentially injurious sound would be smaller. Because there is no assumed upper limit on pile strikes, this approach includes scenarios where multiple pile-driving rigs are used simultaneously on a single day.

NMFS currently assumes a 12-hour recovery period where fish are not exposed to sound from pile driving in order to reset daily accumulated $_{SEL}$ calculations (Stadler and Woodbury 2009). As is standard practice, this analysis assumes that this 12-hour recovery period of nonexposure would occur between pile driving work periods (i.e., 12-hour pile driving days) (Grette 2014a).

Distances to Injury and Disturbance Thresholds

The results of the Practical Spreading Loss and Stationary Fish models using the reference levels for injury and disturbance are summarized in Table 5. Noise attenuation and fish movement models predicted that underwater noise thresholds would be exceeded, resulting in injury or behavior impacts, at distances ranging from 45 feet (single sound strike) to 3.92 miles (cumulative sound). The specific distances and effects for listed fish are provided in Table 5. Because the number of pile strikes per day would be variable, it was assumed that a minimum of 5,000 strikes would occur. Increasing pile strikes beyond 5,000 would not affect the distance at which thresholds would be exceeded for all federally protected fish. Predicted noise reduction using confined or unconfined bubble curtains or similar attenuation devices would be at least 9 dB, based on observations at the Columbia River Crossing (David Evans Associates 2011) and at Puget Island (Washington State Department of Transportation 2010).

Table 5. Underwater Noise Thresholds and Distances to Threshold Levels

Species	Effect Type	Threshold	Distance to Effect Threshold[a]
All Federally Protected Fish	Injury, cumulative sound (≥2 grams)	187 dB_{SEL}	1,775 feet[b]
	Injury, cumulative sound (<2 grams)	183 dB_{SEL}	1,775 feet[b,c]
	Injury, single strike	206 dB_{PEAK}	45 feet[d]
	Behavior	150 dB_{RMS}	3.92 miles

[a] Impact Pile Driver Operation, 36-inch steel pile with 9 dB attenuation from use of confined bubble curtain.

[b] This represents the point at which the model for distance to threshold for cumulative sound no longer increases with increased pile strikes. For 187 dB $_{SELcum}$ (fish ≥ 2 grams), this is at 5,003 strikes; for 187dB_{SELcum} (fish >2 grams), this is at 1,992 strikes. The concept of effective quiet makes the 1,775-foot distance applicable to both thresholds and therefore is applicable to fish both greater than and less than 2 grams.

[c] Given the On-Site Alternative location and adherence to the proposed in-water work window, most salmonids in the area during construction are assumed to be > 2 grams (187 dB_{SELcum} threshold), except possibly for very early subyearling chum salmon in December

[d] Because the distance to cumulative sound thresholds are greater than the distance to the single-strike sound threshold, this analysis follows the NMFS dual criteria guidance and moves forward solely considering the larger values.

Impact pile driving could occur from September 1 through December 31. To install 603 piles in-water would require two years, based on the proposed in-water work window for impact pile driving. Pile driving would occur during working days, Monday through Friday. Each pile is expected to take between 20 and 120 minutes to set using an impact pile driver, depending on when the resistant layer is met during installation. The contractor would determine the sequencing of the pile driving and the overall number of driving rigs to be used; this analysis assumes that multiple pile-driving rigs may be used simultaneously. It is possible that impact pile driving could occur at any time, as permitted by Cowlitz County Code, during the proposed in-water work window for impact pile driving (September 1 through December 31), and that it could be continuous over some working days, particularly if multiple rigs are operating in areas of shallow practical resistance. However, given variable subsurface conditions, it is expected there would be days where periods of impact driving are shorter and/or intermittent throughout the workday. Pile-driving activities could affect federally protected salmon, steelhead and trout, eulachon and green sturgeon, as well as nonprotected fish species.

Impacts on Salmon and Steelhead

Based on the proposed September 1 through December 31 in-water work window for impact pile driving, all life-history stages of the following ESUs/DPSs are expected to be absent from study area during this period:

Snake River spring-/summer-run ESU Chinook salmon

Upper Columbia River spring-run ESU Chinook salmon

Snake River ESU sockeye salmon

Upper Willamette River DPS steelhead

The potential for pile-driving activities to affect these species is considered negligible, and thus they are not considered further with respect to potential impacts from pile-driving activities.

Sub-adult and adult bull trout are occasionally observed within the Columbia River mainstem within the study area and could be present during any season. However, bull trout are expected to occur infrequently and in very low numbers relative to all other salmonids, and the likelihood of bull trout presence at any given time is very low, and the potential for pile-driving activities to affect bull trout is considered negligible. According to USFWS (2002), bull trout in the Lower Columbia Recovery Unit could have migrated seasonally from tributaries downstream into the Columbia River to overwinter and feed. However, the extent to which bull trout in the Lower Columbia Recovery Unit currently use the mainstem Columbia River is unknown. Therefore, bull trout are not considered further with respect to potential impacts from pile-driving activities.

Federally protected adult and juvenile salmon and steelhead that could be present in the study area during the proposed in-water work windows include juvenile fish from five ESUs and adult fish from eight ESUs/DPSs, as summarized in Table 6.

Table 6. Summary of Salmonid ESUs/DPSs for which Presence is not Discountable during the Impact Pile Driving Proposed Work Window (September 1–December 31) by Life Stage, Month, and Habitat Zone

Species, ESU/DPS	Federal Status[a]	Life Stage	Sept			Oct			Nov			Dec		
			A[b]	S[b]	D[b]	A	S	D	A	S	D	A	S	D
Chinook Salmon														
Snake River fall-run ESU	T	Adults			X[c]			...						
		Subyr		...[d]	...		...	...		...	...			
Lower Columbia River ESU	T	Adults			X			X						
		Yrlng												...
		Subyr		...	...		...	...		...	...	...		
Upper Willamette River ESU	T	Yrlng												...
		Subyr		...	...		...	...		...	...	...		
Coho Salmon														
Lower Columbia River ESU	T	Adults			X			X			X			X
		Subyr		...			...			...		...	...	
Chum Salmon														
Columbia River ESU	T	Adults						X			X			
		Subyr										...	...	
Steelhead Trout														
Snake River DPS	T	Adults			X			...						
Upper Columbia River DPS	T	Adults			X			...						
Middle Columbia River DPS	T	Adults			X			...[e]						
Lower Columbia River DPS	T	Adults			X			X			X			X

a "T" denotes federally threatened (no Endangered in this table).
b A, S, and D represent the HEA habitat categories of ACM, SWZ, and DWZ; see Grette (2014c) Section 3.2.3.1 for additional information.
c "X" denotes expected presence; see Grette Associates (2014c), Section 3.3 for additional information.
d "..." denotes expected presence but low relative abundance; see Grette Associates (2014c), Section 3.3 for additional information.
e The Middle Columbia River DPS includes a very small proportion of winter-run fish (Klickitat River, Fifteen Mile Creek); because passage data at Bonneville Dam indicate that the vast majority of steelhead have passed the dam by early October, it is assumed that this includes winter steelhead spawning above it.
ESU = Evolutionary Significant Unit; DPS = Distinct Population Segment; Subyr = subyearling; Yrlng = yearling.

Juvenile Chinook Salmon Habitat Use and Timing

In general, juvenile Chinook salmon outmigrate through the study area within SWZ and DWZ habitat during some or all of the September 1–December 31 in-water proposed work window. Overall habitat use and timing for juvenile Chinook salmon is summarized as follows (Grette 2014a).

- Juvenile Chinook salmon from the Snake River fall-run ESU exhibit multiple rearing strategies, but the majority of juveniles outmigrate as yearlings or large subyearlings during a well-defined period between late spring and early fall. These fish move through the tidal freshwater region at a large size and occur primarily in deeper water rather than the shallow margin.
- Juvenile Chinook salmon from the Upper Willamette River ESU exhibit multiple rearing strategies, but the majority of juveniles outmigrate as yearlings or large subyearlings during a well-defined period in late winter and spring. These fish move through the tidal freshwater region at a large size and occur primarily in deeper water rather than the shallow margin.
- Juvenile Chinook salmon from the Lower Columbia River ESU are associated with multiple runs and are thus associated with multiple rearing strategies. However, the majority of juveniles from this ESU outmigrate either as spring-run yearlings during the late winter and spring or as fall-run fry and fingerlings between the late winter and early summer. Any late-season fall-run subyearlings are expected to outmigrate through the tidal freshwater region at a large size and occur primarily in deeper water rather than the shallow margin.

Subyearling coho salmon from the Lower Columbia River ESU and subyearling chum salmon from the Columbia River ESU are expected to occur in the estuary during the proposed in-water work window; however, presence of individuals would represent low relative abundance in comparison to annual outmigration periods for each ESU. Subyearling coho salmon present in the estuary between September and December would represent individuals moving amongst off-channel rearing areas. Any subyearling coho salmon present within the estuary are expected to overwinter in low-velocity tributaries or off-channel habitats prior to outmigrating the following spring as yearlings. Subyearling chum outmigrate soon after emergence and rear in the lower estuary. Any subyearling chum present in the river mainstem of the tidal freshwater region during the in-water work period would therefore be expected to move rapidly through the study area. Mainstem Columbia River habitats are considered to be used by juvenile salmon as a migratory corridor where presence in any given location is temporary and relatively short-term.

Potential Injury Impacts on Juvenile Salmon

Because the distance to cumulative sound thresholds are greater than the distance to the single-strike sound threshold, this analysis follows the NMFS dual criteria guidance and moves forward solely considering the larger values. Sound above the potential cumulative injury threshold (183/187 dB_{SELcum}) may occur within 1,775 feet of impact pile driving (both upstream and downstream), for a maximum distance of 1.1 miles along the shoreline (1,775 feet upstream and downstream, along the 2,300-foot length of Docks 2 and 3 for a total distance 5,850 feet). This is approximately 0.44 square miles.

Approximately 21% (0.09 square mile) of this area is above -20 feet CRD, inclusive of the ACM and SWZ. This area provides relatively low-quality habitat for small (< 4 inches) subyearling salmon. Areas across the river and downstream provide greater (and more diverse) natural cover as well as floodplain connectivity, contributing to higher-quality critical habitat for rearing juvenile salmon.

Any subyearling salmon present in the 0.09-square-mile area during impact pile driving would be susceptible to sound-related injury due to cumulative exposure. The risk of injury for some individual smaller subyearling salmon is low based on relative abundance expected in the study area (Table 5), but not discountable for the following salmon (in decreasing order of likelihood based on timing and relative abundance).

- Lower Columbia River Chinook salmon
- Upper Willamette River Chinook salmon
- Snake River fall-run Chinook salmon
- Lower Columbia River coho salmon
- Columbia River chum salmon

The mainstem Columbia River (Deep Water) comprises the remaining 79% of the aquatic area exposed to potentially injurious sound from impact pile driving. Any yearling or larger (> 4 inches) subyearling salmon present in this area would be susceptible to sound-related injury during pile driving due to cumulative exposure. The risk of injury for some individual yearling and larger subyearling salmon is low but not discountable for the following salmon (in decreasing order of likelihood based on timing and relative abundance).

- Lower Columbia River Chinook salmon (larger subyearlings and yearlings)
- Upper Willamette River Chinook salmon (larger subyearlings and yearlings)
- Snake River Fall-run Chinook salmon (larger subyearlings only)

It is possible that juvenile fish could leave areas of potentially injurious sound, either as an avoidance response or during the course of normal outmigration behavior, in which case they may not experience sufficient cumulative sound to cause injury.

Adult Salmon Habitat Use and Timing

Adult from eight ESUs/DPSs of salmon and steelhead may migrate upstream through the study area within DWZ habitat during some or all of the proposed September 1–December 31 impact pile driving work window.

Adults from three of the eight ESUs/DPSs are expected to be in the Lower Columbia River each of the four months when pile-driving activities are anticipated to occur.

- Adult steelhead from the Lower Columbia River DPS migrate year-round (winter- and summer-run fish); therefore, individuals are expected to be present from September 1to December 31.
- Adult coho from the Lower Columbia River ESU may migrate through the tidal freshwater region from August through February, and are also expected to be present from September 1 to December 31.
- Adult chum from the Columbia River ESU migrate through the tidal freshwater region during October and November, which is entirely within the September 1–December 31 period.

Adults from the remaining five ESUs/DPSs are expected only in September and October.

- Lower Columbia River Chinook (fall-run component only)
- Snake River fall-run Chinook (in low abundance after September)

- Snake River steelhead (in low abundance after September)
- Upper Columbia River steelhead (in low abundance after September)
- Middle Columbia River steelhead (in low abundance after September)

Based on historical run-timing data from Bonneville Dam, 95% of adult Chinook and steelhead migrating upstream past the dam have done so by the end of the first week of October (inclusive of hatchery fish and nonlisted populations). For Chinook, typically 50% of adults have migrated past the Bonneville Dam by the end of August. For steelhead, that number is closer to 60%.

None of these ESUs/DPSs spawn in the mainstem of the river within the area of elevated sound (Table 5), adult salmonids do not forage in freshwater, and migrating fish are not expected to hold in this section of the river (versus holding near the confluence to a spawning tributary). Therefore, all migrating adult salmon and steelhead are expected to move quickly through the study area.

Migrating Chinook salmon in the Columbia River travel approximately 23 miles per day (median, from Keefer et al. 2004). Migrating steelhead in the Columbia River travel 19–25 miles per day in reaches not adjacent to spawning tributaries (English et al. 2006). Migration rates for coho and chum specific to the Columbia River are not available, but surrogates can be used to estimate them. As reviewed in Sandercock (1991), upstream migration rates for coho may be 0.8–1.7 miles per hour, which results in approximately 9–20 miles per day assuming fish actually migrated 12 hours in each day (see Sandercock 1991). Chum salmon in the Yukon River averaged migration rates of 23 miles per day (Buklis and Barton 1984). In general, Chinook, chum, and steelhead would be expected to travel most swiftly through this section of the river (approximately 23 miles per day), with coho travelling somewhat slower (approximately 9–20 miles per day).

Overall, the proportion of adults from each of the eight ESUs/DPSs that could be present during some or all of the impact pile-driving period would move through the study area rapidly; none are expected to hold within or occupy the study area for extended periods of time.

Potential Injury Impacts on Adult Salmon

Based on habitat use and timing, adult salmonids potentially migrating through the tidal freshwater region during the proposed September through December impact pile-driving work window would include all of the adults from the Columbia River chum salmon ESU, many of the adults from the fall-run component of the Lower Columbia River Chinook salmon ESU, many of the adults from the Lower Columbia River coho salmon ESU, and some of the adults from the Snake River, Upper Columbia River, Middle Columbia River, and Lower Columbia River steelhead DPSs. These fish would be actively migrating upstream at an estimated rate of 9–22 miles per day. The relative amounts (all, many, some) are based on the proportion of the total migration period that occurs within the impact pile-driving period (September through December) for each ESU/DPS (Grette 2014a).

Active pile driving would not occur continuously (all hours, all days) between September 1 and December 31; therefore, not all of the adults migrating upstream during this time would experience sound from pile driving. However, those adult salmon and steelhead that do migrate through the study area during active pile driving could experience potentially injurious sound. Assuming fish were to travel through the entire area (as opposed to avoiding portions of it) this distance traveled would be between 0.67 and 1.1 miles, depending on whether driving occurred at closely or widely spaced locations. Based on the migration speeds reviewed above, adult fish migrating upstream could pass through these areas in approximately 20 to 90 minutes. It is therefore not discountable that some adult salmonids from these ESUs/DPSs could be susceptible to sound-related injury while actively migrating through the study area, depending on the actual duration of sound exposure and proximity to pile driving for individual fish (Grette 2014a).

Current NMFS guidance is to apply the 187dB_{SELcum} injury threshold to all salmonids greater than 2 grams; however, this is an overly conservative approach (see Carlson et al. 2007). Carlson et al. (2007) conclude that for fish greater than 200 grams (applicable to all adult salmonids considered in this assessment), the threshold for nonauditory tissue injury (including injuries resulting from rapid oscillations in gas-filled spaces) is 213 dB_{SELcum}. The conservative approach used to model sound in this assessment predicts 214 dB_{SELcum} at 10 meters from pile driving. Therefore, because cumulative sound above 214 dB_{SELcum} would be limited to such a small area, it is extremely unlikely that adult fish would experience enough sound to result in injury to nonauditory tissues. However, adult fish could be susceptible to auditory injury (hair cell damage) and hearing effects from TTS from cumulative sound exposure, should sufficient exposure occur (Grette 2014a).

Potential Risk for Behavioral Effects on Salmon

As described in ICF Jones & Stokes and Illingworth and Rodkin (2009), 150 dB_{RMS} is a conservative threshold that is applied in most Biological Opinions to evaluate when impact pile driving/proofing could result in temporary behavioral responses in fish, which could in turn result in such effects as reduced predator avoidance and reduction in foraging efficiency. Also as described in ICF Jones & Stokes and Illingworth and Rodkin (2009), NMFS and USFWS do not provide scientific support for this threshold. Therefore, whether behavioral effects actually occur and then subsequently result in injury through behavioral changes or significant disruption of normal behavioral patterns must be evaluated on a project-specific basis dependent upon factors such as site characteristics, project details, and species life history and habitat use within the potential exposure area (Grette 2014a).

SPLs (not cumulative) may exceed the behavioral disturbance threshold of 150 dB_{RMS} up to 3.92 miles from the site during active pile driving. Underwater noise would only propagate into areas that are within line-of-site of the noise source, therefore the area affected is less than 3.92 miles because islands and bends in the river prevent sound propagation beyond this distance. As mentioned previously, juvenile salmon from five ESUs and adult salmon and steelhead from eight ESUs/DPSs may migrate through the Columbia River adjacent to the On-Site Alternative during the impact pile-driving period (Table 5). However, juvenile and adult fish are expected to move through the study area relatively quickly as a function of active migratory behavior Grette 2014a).

Nonlisted Salmon and Steelhead

Several nonlisted salmon ESUs and steelhead DPSs also migrate within the Columbia River through the study area and could be impacted by pile-driving activities, similar to listed salmon and steelhead described above. These include Chinook salmon from three ESUs (Deschutes River summer/fall-run, Middle Columbia River spring-run, and Upper Columbia River summer/fall-run), sockeye salmon from two ESUs (Okanogan River and Lake Wenatchee), as well as a number of artificial propagation programs (e.g., coho salmon re-introduction and/or hatchery programs established by member tribes of the Columbia River Inter-Tribal Fish Commission) (Grette 2014a).

During impact pile driving, adults and subyearlings from the Deschutes River summer-/fall-run and Upper Columbia River summer-/fall-run ESUs may be present in the study area, with timing and presence most similar to Snake River fall-run Chinook. Some adults are expected to be present in the study area during September, and adult migration through the area could continue into October. Subyearling fish may be present in very small numbers through November (Grette 2014a).

Presence, timing, and use of fish from artificial propagation programs are similar to listed ESUs by species and life-history types. Based on the timing and use summarized in Table 5, during impact pile driving, presence of some adults from these programs is expected; juveniles (subyearling and yearlings) are expected in relatively low numbers with variable timing and use by species and life history (Grette 2014a).

Based on similarities in presence, timing, and use, the analyses for listed salmonids can be generally applied to the nonlisted salmon and steelhead (Grette 2014a).

Impacts on Eulachon

The areas of potentially disturbing and injurious sound described previously for salmonids also can be applied to eulachon. However, because many of the cumulative injuries associated with underwater sound are related to the interaction between SPLs and a fish's swim bladder, the application of the cumulative injury threshold to eulachon is conservative (and therefore protective) as eulachon lack a swim bladder. As described above, the distances to thresholds are 1,775 feet for cumulative injury and 3.92 miles for disturbance. Impact driving would likely occur on most working days (Monday through Friday) within the proposed in-water work window (September 1–December 31). On some days impact driving may occur over most or even all of the day, but during much of the construction period, it would be for shorter durations and at times may be discontinuous (Grette 2014a).

Adult eulachon could arrive in the study area as early as November, although most adults would migrate through the study area later, coincident with peak spawn timing between February and March. Eggs from early spawners could be distributed from the tributaries downstream to portions of the study area where suitable incubation conditions occur (i.e., sand waves) shortly thereafter. Emergent larvae could be present in the study area as early as December. However, based on the timing of peak spawning, and because incubation occurs for one to two months, peak larval transport would not be expected until February or later (Grette 2014a).

Little information exists upon which to base assumptions about eulachon habitat use within the area of potentially elevated sound, such as preferential depths and migration behavior versus spawning for adults. Therefore, in order to present a conservative evaluation that is protective of the species, it is assumed that adult eulachon may be distributed anywhere throughout this area, and that not all adult fish are actively migrating through it. It is also assumed that eggs and incubating larvae, whether spawned in the area or delivered from upstream locations, may be distributed throughout areas where sand wave bed forms occur. As reviewed in Gustafson et al. (2010), larvae in the water column are quickly transported downstream and therefore are assumed to be moving with the current (Grette 2014a).

Potential Injury Impacts on Eulachon

The area of potentially injurious sound is assumed to be the same as that delineated for salmon and steelhead (1,775 feet from pile-driving activities, which would include an area covering approximately 0.44 square mile). Any adult eulachon present during pile driving would be at risk of sound-related injury; therefore, although the risk of injury to individual fish is low, based on relative abundance in the study area during pile driving activities (Table 2), it is not discountable. Some fish may be moving through the area, reducing their risk of exposure to cumulative sound injury, or adult fish could leave and/or avoid areas of potentially injurious sound, as part of an avoidance response or during the course of normal behavior, in which case they may not experience sufficient cumulative sound to cause injury. However, some adult eulachon present in the area of impact may experience cumulative injury from pile driving in November and December. Nevertheless, based on the timing of adult returns to the Columbia River, this would probably be a very low number of fish relative to the entire annual eulachon run.

Eulachon eggs and larvae could experience sound that is potentially injurious for adult and juvenile fish, but based on the proposed timing for impact pile driving this would be an extremely low proportion of eggs and larvae produced in any given spawning year. Further, it is not appropriate to directly apply the same thresholds to larval fish and eggs. There is little information available on the effects of sound in general on fish eggs and larvae (Popper and Hastings 2009), and almost nothing specific to the effect of sound from pile driving (Bolle et al. 2012). As reviewed by Popper and Hastings (2009), there is some indication in the literature that sound (e.g., broadband noise) or sound pressure (e.g., blasts or even mechanical simulations such as drops) can affect egg, embryo, and larval survival and development. Because eulachon eggs adhere to sediments and therefore stay within or move slowly through areas of elevated sound, they may be more susceptible to prolonged exposure to cumulative sound from pile driving regardless of the distance at which injury may occur. Larvae are more likely to be transported quickly through areas of elevated sound, and may therefore be less susceptible to any cumulative effects. Common sole (*Solea solea*) larvae exposed to cumulative sound in excess of the standard injury threshold exhibited no increase in mortality (Bolle et al. 2012). The risk of injury generally applies to the earliest part of the run, and over a relatively small area of the potential incubation and migration area (Grette 2014a).

Potential Risk of Behavioral Effects on Eulachon

Potentially disturbing sound from impact pile driving may extend up to 3.92 miles from the site during active pile driving; this represents an approximately three square-mile area within which adult eulachon could be affected. As indicated previously, little is known about the behavioral effects of pile driving sound on fish, but it is possible that adult eulachon present in this area could be at greater risk of predation as a result of underwater sound generated during pile-driving activities. This risk is low but not discountable for adult eulachon (Grette 2014a).

Similar to injury thresholds, it is not appropriate to apply the behavioral threshold to larval eulachon, particularly given the paucity of information of the effects of sound in general, and from pile driving specifically. Should sound from impact pile driving affect these fish at any distance from the On-Site Alternative, active behavioral responses would not be expected based upon their small size and weak swimming behavior (Grette 2014a).

Impacts on Green and White Sturgeon

The areas of potentially disturbing and injurious sound described for salmonids can be applied to green and white sturgeon, which also have a swim bladder. Based on the calculations and assumptions described for salmonids, including the maximum pile strike assumptions in the cumulative sound model and use of an attenuation device, the distances to thresholds are 1,775 feet for cumulative injury and 3.92 miles for disturbance (Figure 4).

To minimize the potential for impacts on other fish, impact pile driving would occur between September 1 and December 31. Based on this timing, it is expected that some green sturgeon may be present in the Lower Columbia River during the early part of the work period but that numbers of fish would decline thereafter as they leave the estuary to winter in the Pacific Ocean. White sturgeon are expected to be present throughout the work period. When present in the Columbia River, green sturgeon are known to occur as far upstream as Bonneville Dam but are predominately present below RM 37 (Adams et al. 2002). The project area is at RM 63. Therefore, while some green sturgeon may be generally present within the area of potentially elevated sound, it is expected that their number would be small. There is a relatively low likelihood of these fish being present in the area of potentially elevated sound during the summer, and that likelihood would further decline throughout the pile-driving period.

White sturgeon on the other hand, are found throughout the lower Columbia River and are expected to be within the study area during pile driving activities.

Potential Injury Impacts on Green and White Sturgeon Threshold

Green sturgeon have been observed swimming at speeds of 1.3–3.9 feet per second in tidal environments in the San Francisco Bay estuary (Kelly and Klimley 2012). White sturgeon are assumed to have similar swimming speeds as green sturgeon. Based on this swimming speed, Southern DPS green sturgeon and white sturgeon would pass through areas of potentially elevated sound within 20 and 75 minutes, depending on speed and distance, and some green and white sturgeon could be susceptible to sound-related injury while actively migrating through the study area. However, given the low number of green sturgeon expected to use areas upstream of the study area and the proposed timing for pile driving, this is expected to be a very low proportion of the Southern DPS green sturgeon using the Columbia River in any given year. White sturgeon are expected to be more abundant and would be likely to occur within the study area throughout the proposed timing for pile driving.

Application of the $187dB_{SELcum}$ injury threshold to fish > 200 grams is an overly conservative approach (see Carlson et al. 2007). As with salmonids, adult and subadult green and white sturgeon at this location would be expected to be > 200 grams and are expected to have a much higher threshold for nonauditory tissue injury. It is extremely unlikely that subadult or adult green and white sturgeon would experience cumulative sound sufficient to result in injury to nonauditory tissues. However, they could be susceptible to auditory injury (hair cell damage) and hearing effects from TTS from cumulative sound exposure, should sufficient exposure occur (Grette 2014a).

Potential Risk of Behavioral Effects on Green and White Sturgeon

Potentially disturbing sound from impact pile driving may extend up to 3.92 miles from the site. Adult or subadult Southern DPS green sturgeon may move downstream through this area, particularly early in the in-water work period. White sturgeon may occur within the study area and may be moving upstream or downstream. Using the same analysis of distances and swimming speeds, those fish would pass through the study area in less than one day but could experience potentially disturbing sound from pile driving during this migration period. However, the risk that individual adult and subadult green and white sturgeon would experience elevated sound and potentially be at greater risk of predation is considered low (Grette 2014a).

Pacific Lamprey and River Lamprey

It is well documented that hydroacoustic impacts can be significant, causing injury or mortality, for fish with swimbladders. Lampreys do not have swimbladders and it is therefore difficult to determine the extent of this impact. Fish without swimbladders are thought to be at lower risk from underwater noise than fishes with swimbladders (Hastings and Popper 2005 in Lord 2011). No thresholds for disturbance or injury have been established for such fish. Therefore, hydroacoustic impacts to lamprey should not be discounted, but they cannot be quantified or analyzed with any level of certainty (Lord 2011). Impacts on lampreys from project related pile driving would be expected to be less harmful than impacts to salmon and sturgeon and other fish species with swimbladders.

Temporary Shading

Overwater structures (i.e., docks and large vessels) can increase shading to the aquatic environment beneath and adjacent to the structure, which can result in changes to productivity as well as fish behavior, predation, and migration. Barges necessary for construction of in-water elements of the On-Site Alternative would create temporary overwater structure, which would reduce the amount of light entering the water. This temporary reduction in light level is not anticipated to result in changes to aquatic habitat conditions and therefore would not change the ambient light in the environment.

Juvenile and subadult salmonids use the nearshore areas for feeding and rearing, and as a migratory corridor. As small individuals, they stay in shallow waters to avoid large fish predators found in deeper water. As these fish grow larger, they will feed on the forage fish, such as herring (family Clupeidae), sand lance (family Ammodytidae), and surf smelt (*Hypomesus pretiosus*), that spawn and rear in shallow intertidal areas.

The use of a barge or other similar large vessel could affect juvenile and subadult salmonid migration within the shallow water habitat areas. However, their use would primarily be during the in-water construction period (September 1–December 31) and would be mostly required for installation of support piling for Docks 2 and 3. Pile-driving activities would be expected to be much more disruptive to fish than the shading created by construction-related barges and vessels, and would likely affect migration and foraging opportunities within the study area to a greater extent (i.e., fish migrating within the study area would not be expected to be near construction barges during pile driving due to the elevated noise levels, thus fish would not be expected to be affected by shading associated with construction barges). Barges and similar large vessels may also be used for construction of Docks 2 and 3, which could occur outside of the proposed in-water window and thus could affect juvenile and subadult salmonid migration in the shallow water habitat. However, specific timing and methods for construction of Docks 2 and 3 would be determined during permitting.

Spills and Leaks

Construction activities would occur on land as well as in and over waters of the Columbia River. During all construction-related activities there is the potential risk of temporary water quality impacts resulting from the release of hazardous materials such as fuels, lubricants, hydraulic fluids, or other chemicals as described in the NEPA Hazardous Materials Technical Report (ICF International 2016d). Overall, it is assumed that a spill would be relatively small (e.g., less than 50 gallons) because limited quantities of potentially hazardous materials would be stored and used during construction at the project area. These materials could enter surface waters of the Columbia River or drainage ditches near the On-Site Alternative. Such spills could affect aquatic habitat or fish that could be near the discharge point, resulting in toxic acute or subacute impacts that could affect the respiration, growth, or reproduction of the affected fish. Over-water and in-water work increases this risk as well as the potential for construction debris or materials to enter the Columbia River. The potential for these types of impacts would be avoided or greatly reduced given protective measures to guard against these risks, including: construction best management practices, avoidance and minimization measures, in-water work restrictions, and regulatory requirements, such as those associated with 401 Water Quality Certification. The NEPA Water Quality Technical Report (ICF International 2016c) includes a detailed discussion on the potential risks to and impacts on water quality associated with the On-Site Alternative.

3.1.2 Construction—Indirect Impacts

Construction of the proposed export terminal would not result in indirect impacts on fish because no construction impacts would occur later in time or farther removed in distance than the direct impacts.

3.1.3 Operations: Direct Impacts

Operations associated with the proposed terminal would occur on land and on dock and trestle structures in the Columbia River. Potential direct impacts related to operations of the On-Site Alternative are discussed below.

Shading

Overwater structures (i.e., docks and large vessels) can increase shading to the aquatic environment beneath and adjacent to the structure, which can result in changes to productivity as well as fish behavior, predation, and migration. The trestle would result in approximately 0.3 acre of new overwater coverage in shallow-water areas above -20 feet CRD (SWZ), while Docks 2 and 3 and a portion of the trestle would result in 4.83 acres of new overwater coverage in DWZ habitat below -20 feet CRD. Vessels loaded at Docks 2 and 3 during project operations would further increase the shading beyond Docks 2 and 3 in DWZ habitat. At full build out, the Applicant anticipates serving 70 vessels per month; thus, it is expected that there would be two vessels at Docks 2 and 3 at all times. The worst case would be two Panamax vessels being loaded simultaneously. Panamax vessels are approximately 965 feet in length with a beam of 106 feet, for an overall area of 102,290 square feet (2.35 acres). Two Panamax ships would add 204,580 square feet (4.7 acres) of overwater surface area located over DWZ habitat, for a total of 9.83 acres being shaded. The study area encompasses approximately 1,300 acres, primarily DWZ habitat. Docks 2 and 3 as well as vessels being loaded at the docks would shade approximately 0.8%. As mentioned above, juvenile salmonids tend to migrate in SWZ habitat, thus shading of DWZ habitat would likely affect juvenile salmonids to a lesser extent than adults or larger juveniles that tend to migrate in DWZ habitat. Overall shading of DWZ habitat would be less likely to affect primary productivity, as primary productivity tends to be higher in SWZ habitat. Based on the location of Docks 2 and 3 over DWZ habitat and the relatively small area shaded in relation to the overall study area, the shading impact would be relatively low.

As reviewed in Carrasquero (2001), light attenuation from overwater structures in freshwater environments can lead to lowered primary productivity (phytoplankton and macrophyte producers). Reduced primary productivity, including reduced stock of algae and macrophytes, can in turn influence the epibenthic community on which other organisms depend. Reduction of primary productivity in DWZ habitat would not likely translate to reductions of epibenthic communities, which are more prevalent in SWZ habitat.

Light attenuation could affect fish migration, prey capture and predation. Salmon fry are known to use darkness and turbidity for refuge. However, they tend to migrate along the edges of shadows rather than penetrate them (Simenstad et al. 1999). Studies in the northwest have documented this behavioral tendency to use shadow edges for cover during migration (Shreffler and Moursund 1999). The underwater light environment also affects the ability of fishes such as bass, to see and capture their prey, including juvenile salmonids. Foraging opportunities for juvenile fish are generally associated with SWZ habitat (areas above -20 feet CRD), which are expected to provide greater availability of benthic organisms as compared to DWZ habitat (areas below -20 feet CRD). Juvenile salmon primarily migrate in SWZ habitat, although larger juveniles do migrate in DWZ habitat. Juveniles migrating in DWZ habitat are likely migrating relatively quickly and not rearing for extended periods in any particular area. The trestle is the only structure that would generate shade in SWZ habitat. The potential shading created by the trestle would be relatively low because the trestle is elevated over the water surface elevation of OHW by approximately eight feet, allowing light to penetrate beneath the trestle, which would not be expected to have a measurable effect on primary productivity or fish behavior, migration, or predation in SWZ habitat.

The design and orientation of the trestle would further minimize the potential effects of shading. The elevation of the trestle combined with the relatively narrow width of the deck (24 feet), the height, and the width would allow natural light to partially pass beneath the structure during all seasons. In addition, the north–south orientation of the trestle relative to the path of the sun overhead would reduce the amount of shading cast beneath it, as compared to if the structure were oriented east–west.

The docks and vessels would be located over the DWZ, but could provide shaded habitat for larger predatory fishes, such as bass, northern pikeminnow, as well as piscivorous birds (Carrasquero 2001). Support piling for the docks could also create flow shears (i.e. back-eddies), which could increase the potential predation of juvenile salmonids and other fish migrating or otherwise occurring within the SWZ and DWZ (Carrasquero 2001). The extent or magnitude to which an increase in overwater surface area may alter the predator-prey relationship at the On-Site Alternative is unknown, but it is assumed that the relationship would change and an increase in predation would be likely. The extent or magnitude to which an increase in overwater surface area could alter the predator-prey relationship in the study area is unknown, but it is assumed that the relationship would change and an increase in predation would be likely.

Spills or Leaks

Routine operations could result in spills or leaks at the On-Site Alternative from vehicles, trains, or equipment that could affect water quality and the condition of aquatic habitat in the Columbia River and drainage ditches in the vicinity. Overall, it is assumed that a spill would be relatively small (e.g., less than 50 gallons) because limited quantities of potentially hazardous materials would be stored and used during operations at the project area. Refueling of vehicles during operations would occur off site at approved refueling stations, or fuel would be delivered to the project area by a refueling truck (capacity of 3,000 to 4,000 gallons). Refueling trucks are required to carry appropriate spill response equipment, thereby reducing the potential risk and impact associated with a fuel spill. Vessel bunkering (i.e., a vessel receiving fuel while at the dock) would not occur at the project area. Thus, the risk of spills from vessel transfers would not increase. Potential impacts on fish and fish habitat are similar to those described for construction leaks and spills in Section 3.1.1.1. Appropriate training and implementation of prevention and control measures would guard against these risks, greatly reducing the potential for these types of impacts. Further information is contained in the NEPA Water Quality Technical Report (ICF International 2016c) and NEPA Hazardous Materials Technical Report (ICF International 2016d).

Coal Spills

Direct impacts on the natural environment from a coal spill during operations of the proposed terminal could occur. Direct impacts resulting from a spill during coal handling at the export terminal would likely be minor because the amount of coal that could be spilled would be relatively small. Also, impacts would be minor because of the absence of aquatic environments in the project area and the contained nature and features of the terminal (e.g., fully enclosed belt conveyors, transfer towers, and shiploaders). Potential physical and chemical effects of a coal release on the aquatic environments that occur adjacent to the terminal are described below.

Aquatic environments could potentially be affected by a coal spill both physically and chemically. A coal spill could have physical effects on aquatic environments, including abrasion, smothering, diminished photosynthesis, alteration of sediment texture and stability, reduced availability of light, temporary loss of habitat, and diminished respiration and feeding for aquatic organisms. The magnitude of these potential impacts would depend on the amount and size of coal particles suspended in the water, duration of coal exposure, and existing water clarity (Ahrens and Morrisey 2005). Therefore, the circumstances of a coal spill, the conditions of a particular aquatic environment (e.g., pond, stream, wetland), and the physical effects on aquatic organisms and habitat from a coal spill would vary. Similarly, cleanup of coal released into the aquatic environment could result in temporary impacts on habitat, such as smothering, altering sediment composition, temporary loss of habitat, and diminished respiration and feeding for aquatic organisms. The recovery time required for aquatic resources would depend on the amount of coal spill and the extent and duration of clean-up efforts, as well as the environment in which the incident occurred. It is unlikely that coal handling in the upland portions of the export terminal would result in a spill of coal that would affect the Columbia River. This is unlikely because the rail loop and stockpile areas would be contained, and other areas adjacent to the export terminal are separated from the Columbia River by an existing levee, which would prevent coal from being conveyed from upland areas adjacent to the rail loop to the Columbia River. Coal could be spilled during shiploading operations as a result of human error or equipment malfunction. However, such a spill would likely result in a limited release of coal into the environment due to safeguards to prevent such operational errors, such as start-up alarms, dock containment measures (i.e., containment “gutters” placed beneath the docks to capture water and other materials that may fall onto and through the dock surface) to contain spillage /rainfall/runoff, and enclosed shiploaders.

The chemical effects on aquatic organisms and habitats would depend on the circumstances of a coal spill and the conditions of a particular aquatic environment (e.g., stream, lake, wetland). Some research suggests that physical effects are likely to be more harmful than the chemical effects (Ahrens and Morrisey 2005).

A recent coal train derailment and coal spill in Burnaby, British Columbia, in 2014, and subsequent cleanup and monitoring efforts provide some insight into the potential impacts of coal spilled in the aquatic environment. Findings from spill response and cleanup found there were potentially minor impacts in the coal spill study area, and that these impacts were restricted to a localized area (Borealis Environmental Consulting 2015).

3.1.4 Operations: Indirect Impacts

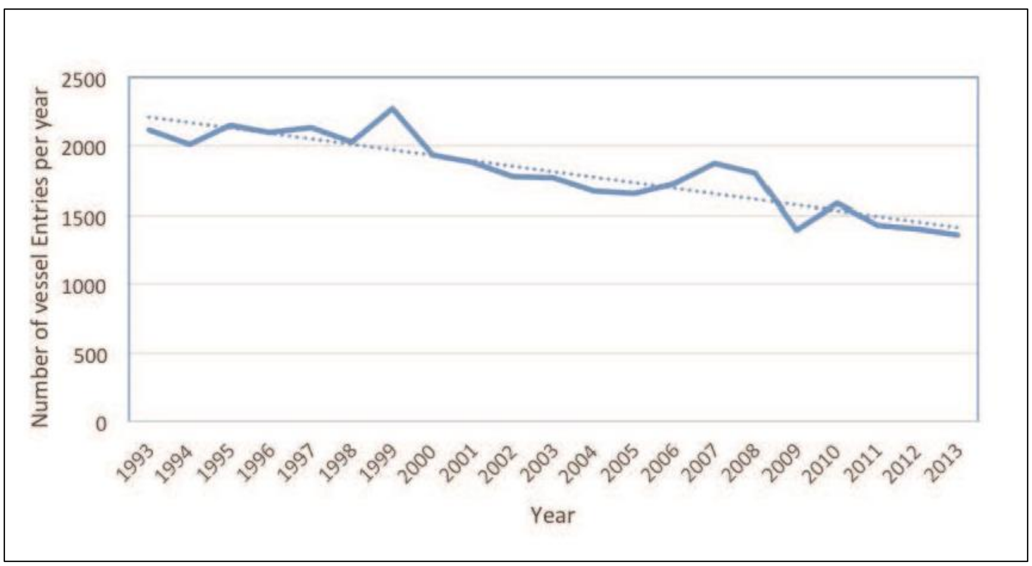
Potential indirect impacts associated with operation of the proposed terminal could occur as a result of vessel traffic in the Columbia River between the proposed terminal and the confluence with the Pacific Ocean. These potential impacts include fish stranding associated with vessel wakes. Periodic maintenance dredging could result in removal of benthic habitat and associated impacts on aquatic invertebrates. Also, coal dust could indirectly affect fish and fish habitat.

Fish Stranding from Vessel Wakes

Ecology has monitored the number of vessel entries into the Columbia River of commercial cargo and passenger vessels of 300 gross tons or larger and tank vessels carrying oil products of all sizes since 1993. Over that period there has been about a 2% per year decline in the number of vessels crossing the Columbia River Bar (Figure 11). This is in part due the completion of the Columbia River Federal Navigation Channel Improvements Project, which dredged the Columbia River Ship Channel from near the entrance to the Port of Portland near RM 106 to a depth of 43 feet. This allowed the newer and larger Panamax and Handymax vessels to navigate the river and call at Columbia River ports, thereby reducing the number of smaller vessels navigating the Columbia River.

At full build out, the proposed terminal would have the capacity to serve up to 70 vessels per month (840 per year) with a throughput capacity of 44 million metric tons per year of coal.

Figure 11. Number of Vessels Entering the Columbia River per Year



The fleet serving the On-Site Alternative would consist of the newer Panamax and Handymax vessels. Panamax vessels anticipated to use the export terminal average about 65,000 dead weight tons (dwt) and measure approximately 738 feet long by 105 feet wide with a draft of 43 feet. They are designed to fit snuggly, but safely in the lock chambers of the Panama Canal. Handymax vessels are the workhorses of the dry bulk market. They are usually less than 60, 000 dwt and measure approximately 490 to 655 feet long by 105 feet wide with a draft of 36 feet.

A growing body of evidence indicates that juvenile salmon and other fish are at risk of stranding on wide, gently sloping (i.e., less than 5% slope) beaches as a consequence of wakes generated by deep draft vessel passage (Bauersfeld 1977; Hinton and Emmett 1994; Pearson et al. 2006; ENTRIX 2008). Depending on various factors such as the slope and breadth of a beach, river stage, tidal stage, depth of water vessels are transiting in, and vessel size and speed, wakes from passing vessels can travel a considerable distance. When these wakes meet the shoreline, they can carry fish and deposit them, essentially "stranding" them on the beach where they are susceptible to stress, suffocation, and predation before than can return to the water.

The precise factors that contribute to stranding risk are not well understood. Bauersfeld (1977) observed that "stranded fish are often concentrated along the high-water line, in and around obstructions or debris which impedes return flow, and along the path of return flow. Ship-wash stranding is generally confined to sand beaches with a low slope angle or coves which constrict the waves and force the water onshore." He also identified a number of sites where stranding was observed. In all, Bauersfeld (1977) observed the passage of 216 ships, and found 2,397 stranded fish, 2,297 of them juvenile Chinook salmon. Hinton and Emmett (1994) sampled eight sites along the reach extending from the upper estuary to Sauvie Island from April through September 1992 and from March through July 1993. They observed the passage of 145 ships, and found five stranded fish. They did not identify factors contributing to stranding, other than those previously noted by Bauersfeld (1977).

Pearson et al. (2006) published the most detailed study of Lower Columbia River fish stranding completed to date. They evaluated stranding at three sites in the Lower Columbia River: Sauvie Island, Barlow Point (adjacent to the On-Site Alternative and the proposed Off-Site Alternative), and County Line Park. The sites were chosen because prior work (primarily Bauersfeld's work) had established them as sites with high risk of stranding. Pearson et al. (2006) observed 126 vessel passages, 46 of which caused stranding. They also measured numerous site variables including fish density (measured via beach seining), site topography, river stage, current velocity, tidal stage, tidal height, and a variety of vessel variables including direction of movement, velocity, ship type, ship size, and draft. Although the study provides an understanding of the factors that contribute to standing, it does not create a predictive model because it was limited to analysis of known or suspected high-risk sites.

To address this limitation, ENTRIX (2008) conducted a spatial analysis from RM 0 to RM 104 in which a total of 1,634 transects spaced at intervals of 656 feet along both river banks were identified and various risk factors were modeled.

The results of the ENTRIX (2008) analysis supported the statements of Bauersfeld (1977) that not all Lower Columbia River beaches pose a risk of stranding juvenile salmon by ship wakes and of Pearson and Skalski (2006) that their three study sites were not representative of all Lower Columbia River beaches. The ENTRIX (2008) analysis demonstrated that a minimal stranding risk exists along 175 of the 208 miles of shoreline found on the Lower Columbia River.

A more than minimal stranding risk exists along 33 miles of the river, with a high stranding risk (comparable to the risk found at Barlow Point, County Line Park, and Sauvie Island) found along about 8 miles of the river (Figure 9). ENTRIX cautions that this study is best viewed as a systematic analysis using objective, quantitative criteria to identify physically based susceptibility to stranding because it did not include information about nearshore fish density.

Fish stranded by passing deep-draft vessels on the Lower Columbia River have been inventoried by Bauersfeld (1977), Hinton and Emmett (1994), and Pearson et al. (2006). Each of these researchers relied primarily on beach seine data collected at sites where stranding was observed to determine fish species presence adjacent to the sites. Results consistently demonstrated that stranded fish primarily consist of subyearling salmonids. Bauersfeld (1977) found that 86% of all fish collected were in the 1.2 to 2.0 inch size range and of these, 78% were Chinook salmon and 20% were chum salmon. Hinton and Emmett (1994) provide two anecdotal reports of ship wake stranding observed by Earl Dawley in 1977 (Hinton and Emmett 1994) and 1984 (Dawley et al. 1984); in both instances the stranded fish were nearly all subyearling Chinook salmon. Pearson et al. (2006) observed stranding of 520 fish, of which 426 (82%) were subyearling Chinook salmon. Pearson et al. (2006) also performed beach seines to develop an index of fish available for stranding; they found that subyearling Chinook salmon comprised only 49% of the beach seine catch, indicating that these fish are more susceptible to stranding than other salmonid species. This difference was statistically significant at 98% confidence. All salmonids other than subyearling Chinook salmon (yearling Chinook, coho, and chum salmon, and mountain whitefish) collectively comprised only 5% of the stranded fish and 3.3% of the fish sampled by beach seine (Pearson et al. 2006), suggesting that the effects of wake stranding fall primarily upon subyearling Chinook salmon (i.e., ocean-type Chinook salmon).

Although the On-Site Alternative would result in an increase in deep-draft vessel traffic, which characteristically produce wakes that contribute to stranding, many of the sites in the study area where fish stranding could occur are located near the project area; for example, Lord Island is just across the channel from the project area, and Barlow Point is about 1.2 miles downstream (and has also been identified as the project area for the Off-Site Alternative). Vessels maneuvering in the study area would be either slowing to stage nearby if the docks are full, or slowing to prepare for docking. Once vessels are loaded, they would maneuver back to the navigation channel and then proceed downstream toward the Pacific Ocean. Such maneuvering would be unlikely to result in a risk of stranding near the proposed docks, as very little wake would be generated by vessels moving at slow speeds. Sites farther downstream, such as near Puget Island, would be more likely to have a higher risk of fish stranding from vessel wakes because vessels are transiting those areas at higher speeds.

In the Lower Columbia River fish stranding appears to be associated with various factors, as mentioned previously. In general, fish stranding appears to be an issue when wakes produced by deep-draft vessels (those with a draft of 26 feet or more) transiting the river during low tides encounter shorelines with shallow sloping beaches (i.e., less than 5% slope), and particularly on those beaches that are highly permeable (high rates of infiltration due to unconsolidated substrate material). Such conditions appear to increase the potential for fish stranding. However, it should be noted that beaches are not necessarily always conducive to stranding. For example, stranding may occur less frequently or not at all during high tide or during periods when the river is at a certain stage, when the beaches are more inundated and less exposed. Thus, the potential for fish stranding to occur on any given beach is not constant, but likely changes as tides and river stage changes, and as fish migrations change. It is recognized, however, that in 2028 at full build out, project-related vessels would represent approximately 27% of the expected total vessel traffic in the Lower Columbia River annually. This increase would result in an increased risk in fish stranding.

It is also worth noting that vessel operations in the Lower Columbia River are federally regulated, including; the size, speed, and navigation. Additionally, in the Lower Columbia River, large vessels are required to be operated by pilots licensed by the Coast Guard. The navigation channel is managed and regulated at the federal level, including maintenance dredging and dredged material disposal.

Physical or Behavioral Responses to Vessel Noise

Vessels transit the Columbia River each year carrying oil, freight, and materials to and from ports along the river. Approximately 3,980 commercial vessel transits occurred on the Columbia River in 2014 including approximately 2,750 by cargo and passenger vessel transits above 300 gross tons (Washington State Department of Ecology 2015). Mean source sound levels of bulk carrier vessels were calculated in Puget Sound at between 187.9 and 198.2 dB re 1uPA at 1 meter when vessels were travelling at between 9.0 and 11.1 knots (Hemmera Envirochem et al. 2014). These source sound levels exceed identified thresholds for potential behavioral disturbance for fish and may cause avoidance or other behavioral responses (Fisheries Hydroacoustic Working Group 2008). Therefore, fish in the immediate vicinity of transiting vessels may experience behavioral responses to the vessel noise, but would not likely be injured.

Maintenance Dredging and Aquatic Habitat

Maintenance dredging would likely occur every few years, as needed, to maintain required depths at Docks 2 and 3 and to allow access from the docks to the navigation channel, especially in the years following the initial dredging work (WorleyParsons 2012). Maintenance dredging would require additional permitting, beyond any permits that may be issued to construct the project. It is assumed that flow lane disposal would be the preferred method for disposal of dredge material, provided the sediments were clean.

Sediment accretion in the proposed dredge prism would most likely occur as a result of bedload transport due to river currents, and local scour and sediment redistribution from propeller wash. Hydrodynamic modeling and sediment transport analysis was conducted for the proposed Docks 2 and 3 berthing/navigation basin. Sedimentation is complex in a newly dredged basin. Specific morphologic data is unavailable for the proposed new dredging basin; therefore, the rate of accretion can only be estimated roughly. Based on current accretion estimates, rough estimates for annual accretion height is approximately 0.16 foot (0.07–0.26 foot range), and annual accretion volume is approximately 11,675 cubic yards (4,670–23,350 cubic yard range) (WorleyParsons 2012). WAC 220-660-160 provides general design considerations for new terminals, to minimize impacts fish life that the project would generally comply with, whenever feasible.

Impacts on the benthic invertebrate community would be similar to those described for initial dredging associated with construction activities. Compared to the initial dredging effort, maintenance dredging would remove a relatively small amount of material, including benthic, epibenthic, and infaunal organisms, resulting in some mortality of invertebrate organisms and temporary disruption of benthic productivity. Habitat within the proposed dredge prism is in

DWZ habitat where benthic productivity is expected to be relatively low compared to shallow water habitats (McCabe et al. 1997).

Maintenance-related dredging activities could affect fish in a manner similar to the initial dredging associated with construction activities. Fish could be affected by increased turbidity and noise associated with dredging activities (Todd et al. 2014). Turbidity would be elevated during maintenance dredging and impacts would be similar to those described above for construction under Section 3.1.1.1. Noise could cause masking and behavioral changes in fish but is unlikely to cause auditory damage (Central Dredging Association 2011, Dickerson et al. 2001, Todd et al. 2014).

Coal Dust

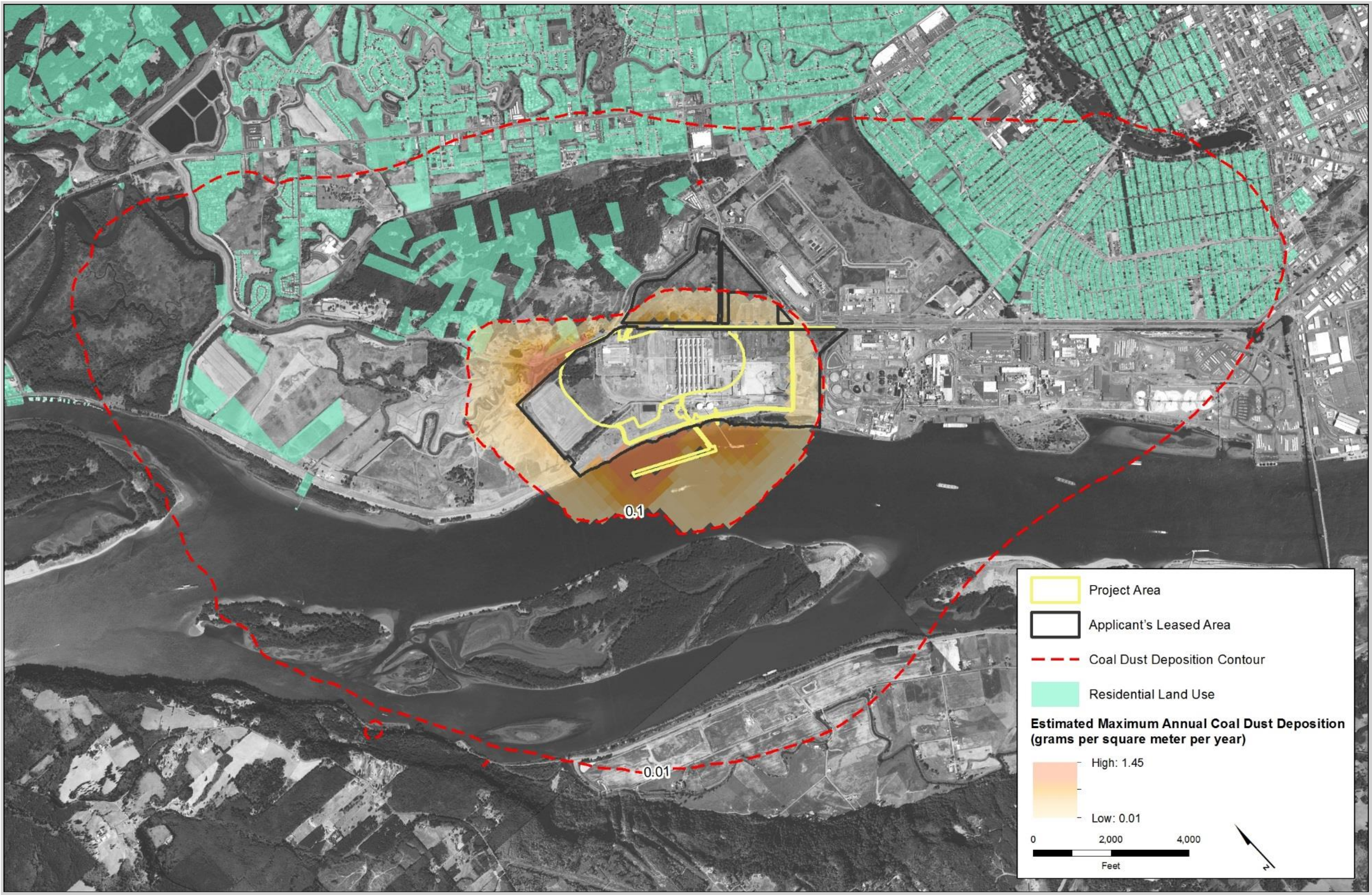
Coal dust would be generated during operation of the proposed terminal through the movement of coal into the site, around the site, and onto vessels. Coal dust could also become airborne from the large stockpiles that would be located within the site.

The potential extent and deposition rate of coal dust particles less than 75 microns was modeled as part of the analysis conducted relative to air quality and human health during the preparation of the environmental impact statement as described in the NEPA Air Quality Technical Report (ICF International 2016e) for additional details. Based on this modeling, the highest rate of coal dust deposition would be expected in the immediate area surrounding the export terminal, but smaller particles would also be expected to deposit in a zone extending around and downwind of the export terminal. Deposition rates could range from 1.45 grams per square meter (g/m^2) per year closest to the export terminal, gradually declining to less than 0.01 g/m^2/year approximately 2.41 miles from the export terminal, as described in the SEPA Coal Technical Report (ICF International 2016g).

Based on the models, the zone of deposition would extend primarily northwest of the On-Site Alternative and over the Columbia River, encompassing the Off-Site Alternative and forested hills at the northern extent of the Off-Site Alternative, riparian habitat along the shoreline, and extending across the Columbia River to Lord and Walker Islands. Deposition rates ranging from 0.4 g/m^2/year in the Columbia River adjacent to the project area to 0.1 g/m^2/year in the Columbia River at Lord Island (Figure 12), with declining concentrations moving away from the project area.

Although concerns regarding coal dust are commonly expressed relative to air quality and human health concerns, wind-born coal dust could affect fish through physical or toxicological means. Ahrens and Morrisey (2005) conducted a literature review on the biological effects of unburnt coal in the marine environment. The following discussion is distilled from that review. Coal particles could affect aquatic wildlife in a manner comparable to any form of suspended particulates, such as tissue abrasion, smothering, obstruction, or damage to feeding or respiratory organs, and other effects resulting from reduced quantity or quality of light. Another potential manner in which coal could affect aquatic wildlife is through coal leachates. Unburnt coal can be a source of acidity, salinity, trace metals, hydrocarbons, chemical oxygen demand, and potentially macronutrients if they leach from the coal matrix into aquatic habitats. Toxic constituents of coal include PAHs and trace metals, which are present in coal in variable amounts and combinations dependent on the type of coal. The coal type, the mineral impurities in the coal, and environmental conditions determine whether these compounds can be leached from the coal. Some PAHs are known to be toxic to aquatic animals and humans.

Figure 12. Modeled Average Annual Coal Dust Deposition (On-Site Alternative)



Metals and PAHs could also potentially leach from coal to the pore water of sediments and be ingested by benthic-feeding organisms, providing a mechanism for subsequent ingestion by other organisms throughout the food chain. However, the low aqueous extractability and bioavailability of the contaminants minimizes the potentially toxic effects (Ahrens and Morrisey 2005). The type of coal anticipated to be exported from the On-Site Alternative is alkaline, low in sulfur and trace metals. Furthermore, because the Columbia River is a dynamic riverine system the constituents of the coal dust would be distributed and diluted to even lower concentrations as they are transported downstream.

Coal has a heterogeneous chemical composition and specific impacts related to its toxic contaminants are highly dependent on the specific coal composition and source (Ahrens and Morrisey 2005). The majority of coal transported to and from the site would be from the Powder River basin. A 2007 U.S. Geological Survey (USGS) report investigated the quality of coal from the Powder River basin, including the concentrations of trace elements of environmental concern, which include: antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, and uranium. According to the study conducted by the USGS (2007), trace elements of environmental concern (TEEC) are generally low in the Powder River basin coals in comparison to other mining regions, although exact concentrations were not known at the time of this report. Table 7 presents the average concentrations of each TEEC sampled in parts per million. However, at a maximum coal deposition rate of 1.45 g/m^2/year, a coal density of 0.83 grams per cubic centimeter, and at the minimum flow recorded over the 23-year period of record for one day, TEEC deposition directly into the river assumed to be an area of approximately 3,000,000 square meters would result in a change in concentration for each of the elements of concern on the order of $1x10^{-13}$ to $1x10^{-15}$ g/L. If coal dust generated at the project area accumulated without being disturbed throughout the summer dry season (assuming 120 days duration), the anticipated change in TEEC concentration for the minimum recorded flow over one day would be on the order of $1x10^{-10}$ to $1x10^{-12}$ g/L. Again, this change would not be measureable and is not anticipated to affect human health or affect aquatic organism functions (i.e., respiration, feeding).

The concentration of PAHs in Power River basin coal was not investigated for this report because PAHs are only released during combustion. Because the rate of coal dust deposition is so low it is likely unmeasurable and the concentration of trace elements of environmental concern are considered low, impacts on water quality are anticipated to be low.

Table 7. Average Concentration of Trace Elements in Wyodak and Big George Coal Beds, Powder River Basin, Wyoming

Trace Element of Environmental Concern	Average Concentration in Sampled Coal (ppm)
Antimony	0.10
Arsenic	1.43
Beryllium	0.18
Cadmium	0.06
Chromium	2.63
Cobalt	1.93
Lead	1.26
Manganese	10.05
Nickel	1.58
Selenium	0.57
Uranium	0.46

Source: U.S. Geological Survey 2007.
ppm = parts per million

Research suggests that the bioavailability of contaminants in coal is limited, and that at levels of coal contamination at which estimates of bioavailable concentrations of contaminants might give cause for concern, the acute physical effects are likely to be more harmful than the chemical effects (Ahrens and Morrisey 2005). However, the variable chemical properties of coal could conceivably result in contaminant mobility and enhanced bioavailability in the aquatic environment. Coal can be a source of acidity, salinity, trace metals, PAHs, and chemical oxygen demand (a measure of organic pollutants found in water). Interactions between coal and water could alter pH and salinity, release trace metals and PAHs, and increase chemical oxygen demand. However, if and how much these alterations occur in the aquatic environment and whether the alterations are significant enough to be potentially toxic to aquatic organisms depends on many factors, including the type of coal, the relative amount of time the coal is exposed to water, dilution, and buffering.

In summary, fugitive coal dust from project operations is not expected to increase suspended solids in the Columbia River to the point that there would be a demonstrable effect on fish distribution, abundance, survival, or acute physical effects. Additionally, the potential risk for exposure to toxic chemicals contained in coal (e.g., PAHs and trace metals) would be relatively low because these chemicals tend to be bound in the matrix structure and not quickly/easily leached. Further, any coal particles would be transported downstream by the flow of the river and either carried out to sea or distributed over a broad area further reducing the potential for adverse impacts on fish from suspended solids.

Commercial and Recreational Fishing

Project-related increases in vessel traffic in the lower Columbia River and associated underwater noise could affect fishing in the study area. Increases in vessel traffic could cause behavioral responses including quicker migration or avoidance of the navigation channel. An average of 70 large commercial vessels would be loaded at the terminal each month. If adult fish targeted in commercial and recreational fishing were to alter behavior in response to increased underwater noise, they may avoid or migrate quickly through the navigation channel.

Commercial and recreational fishing vessels would not likely be fishing in the navigation channel when large vessels are present. Therefore, the On-Site Alternative would be unlikely to significantly reduce commercial or recreational fishing catches or limit access for fishing activities. The potential impacts of the On-Site Alternative on commercial and recreational fishing vessels associated with project-related vessels are addressed in the NEPA Vessel Transportation Technical Report (ICF International 2016f).

3.2 Off-Site Alternative

Potential impacts on fish from the proposed terminal at the Off-Site Alternative location are described below.

3.2.1 Construction: Direct Impacts

Construction of the Off-Site Alternative would occur at the alternate project area, and would affect fish and fish habitats in the Columbia River. The types of construction impacts would be similar to those described under Section 3.1.1, *On-Site Alternative*. Construction of the proposed terminal at the Off-Site Alternative location would result in the following direct impacts.

Aquatic Habitat

Project construction would result in the alteration or removal of aquatic habitat. Aquatic habitat would be permanently removed by the placement of piles for the trestle and docks. A total of 597 36-inch-diameter steel piles would be placed below the OHW mark for the trestle and docks, removing an area equivalent to 0.10 acres of benthic habitat. Approximately 94% of this habitat (3,980 square feet) is located in deep water (Grette 2014e). As with the On-Site Alternative, the placement of piles would displace benthic habitat and the areas within each pile footprint would no longer contribute toward primary or secondary productivity. Individual pile footprints would be relatively small (36 inches in diameter) and would be spaced throughout the dock and trestle footprint. The Off-Site Alternative would require fewer piles (597 compared to 603) below OHW and the area of benthic habitat permanently lost would be less (3,980 square feet compared to 4,263). Benthic, epibenthic, and infaunal organisms within the pile footprint at the time of pile driving would likely perish.

Dredging would permanently alter a 15-acre area of deepwater habitat (below -20 feet CRD) by removing approximately 50,000 cubic yards of benthic sediment to achieve a depth of -43 feet CRD, with a 2-foot overdredge allowance (Grette 2014e). The amount of deepening required to reach target depth would be three feet or less, as the proposed dredge prism is at or below -42 feet CRD (Grette 2014e). Required sediment removal at the Off-Site Alternative site would be approximately 50,000 cubic yards, ten times less than would be required at the On-Site Alternative site, which would involve the removal of approximately 500,000 cubic yards or sediment over an area more than three times larger (48 acres). As with the On-Site Alternative, dredged materials would likely be disposed of within the flow lane in or adjacent to the navigation channel, allowing these sediments to support the downstream sediment transport system (Grette 2014d, 2014e, 2014f). This would be within an area of approximately 80 to 110 acres between approximately RM 60 and RM 66 (Figure 4).

Potential impacts on fish and fish habitat resulting from dredging activities would be similar to those described for the On-Site Alternative in Section 3.1.1.1; however, the extent of the potential impacts would be less than those at the On-Site Alternative because the dredge prism at the Off-Site Alternative is approximately one-third the size of the On-Site Alternative dredge prism and the quantity of sediments that would be removed at the Off-Site Alternative would be approximately one-tenth of what would be removed for the On-Site Alternative.

The majority of benthic, epibenthic, and infaunal organisms are nonmotile or slow-moving and become entrained during dredging. Benthic, epibenthic, and infaunal organisms within the proposed dredge prism above -43 feet CRD would be removed during dredging, resulting in likely mortality. These organisms often serve as prey for larger animal species, such as fish. The habitat within the proposed dredge prism is in deep water where benthic productivity is expected to be low relative to shallower habitat habitats. Deepwater channels are subjected to higher water velocities, which periodically scour bottom sediments, limiting the standing crop of invertebrates and the buildup of detritus and fine materials that support these invertebrates (McCabe et al. 1997, as cited in Grette 2014f). Dredging activities are not typically associated with long-term reductions in the availability of prey resources, and impacts on benthic productivity are expected to be temporary. Disturbed habitats are expected to return to reference conditions with rapid recolonization by benthic organisms (Grette 2014f).

The overall impacts of dredging activities on fish would be the same as or similar to those described for the On-Site Alternative (Section 3.1.1.1).

Potential mitigation measures presented in the NEPA Draft Environmental Impact Statement (Volume 1), Chapter 8, *Minimization* and *Mitigation* addresses impacts on fish caused by permanently removing or temporarily altering habitat.

Physical or Behavioral Response from Elevated Turbidity during Pile Driving and Dredge Material Disposal

Potential impacts on fish resulting from elevated turbidity from pile driving and dredged material disposal would be the same as or similar to those described for the On-Site Alternative (Section 5.7.2.5.1). However, the Off-Site Alternative would require driving 597 piles, 13 fewer than for the On-Site Alternative. This difference in terms of turbidity from driving 13 fewer piles would be negligible.

Physical or Behavioral Response to Underwater Noise during Pile Driving

Potential impacts on fish resulting from underwater construction noise would be very similar to those described for the On-Site Alternative (Section 3.1.1.1). The Off-Site Alternative would require 597 piles be driven in-water, as opposed to 603 in-water piles for the On-Site Alternative.

Compared to the On-Site Alternative, the overall areas where in-water noise thresholds for fish are exceeded are unchanged, however the duration of pile driving may be slightly reduced due to the reduced number of piles to be driven (13 fewer piles). Potential mitigation measures presented in the NEPA Draft Environmental Impact Statement (Volume 1), Chapter 8, *Minimization and Mitigation* address impacts on fish caused by increased underwater noise during pile driving.

Temporary Shading

Potential impacts on fish resulting from shading would be very similar to those described for the On-Site Alternative (Section 3.1.1.1). The surface area of the docks and trestle for Off-Site Alternative would be 0.01-acres less than the On-Site Alternative. The shading created by the vessels would be the same (4.7 acres for two Panamax vessels) for both alternatives.

Spills and Leaks

Potential impacts on fish resulting from construction-related spills and leaks would be the same as or similar to those described for the On-Site Alternative (Section 3.1.1.1).

3.2.2 Construction: Indirect Impacts

Construction of the proposed terminal would not result in indirect impacts on fish because no construction impacts would occur later in time or farther removed in distance than the direct impacts.

3.2.3 Operations: Direct Impacts

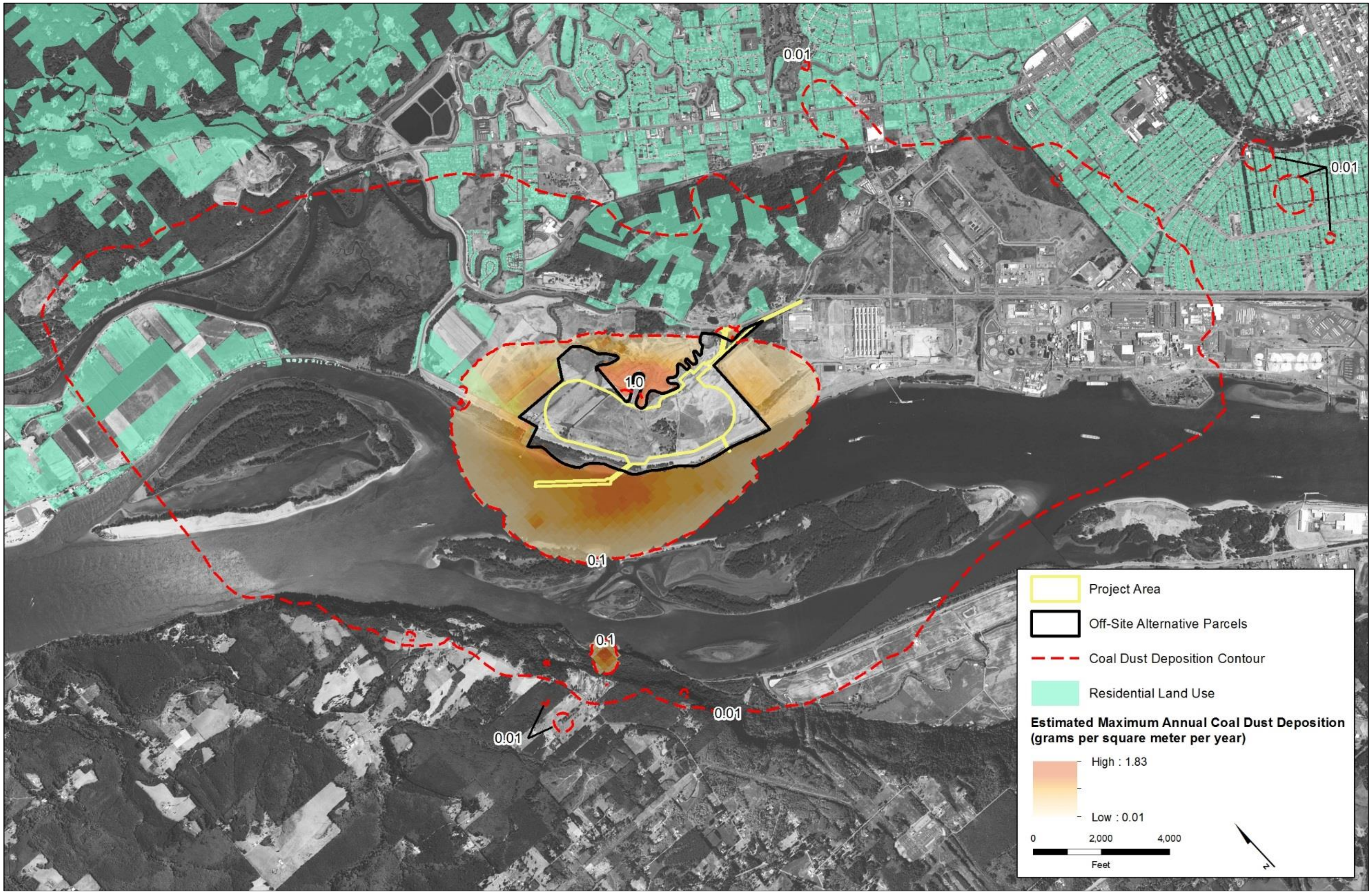
Direct operational impacts of the Off-Site Alternative would result in impacts very similar to those described for the On-Site Alternative (Section 3.1.1.2).

3.2.4 Operations: Indirect Impacts

Overall, indirect operational impacts of the Off-Site Alternative would result in impacts very similar to those described for the On-Site Alternative (Section 3.1.1.3).

However, modeled fugitive coal dust concentrations for the Off-Site Alternative (Figure 13) indicate that deposition rates would range from 1.83 grams per square meter per year (g/m^2/year) adjacent to the proposed export terminal to 0.01 g/m^2/year approximately 2.98 miles from the terminal, compared to the On-Site Alternative.

Figure 13. Modeled Average Annual Coal Dust Deposition (Off-Site Alternative)



3.3 No-Action Alternative

Under the No Action Alternative, the Applicant would not construct the On-Site Alternative or the Off-Site Alternative. Current operations would presumably continue. The existing bulk product terminal could be expanded onto the on-site alternative project area. Expansion activities could require a permit from the U.S. Army Corps of Engineers if they result in a discharge of dredged or fill material into onsite wetlands or other waters of the United States. New construction, demolition, or related activities to expand the bulk terminal could occur on previously developed upland portions of the On-Site Alternative. This could affect upland areas and habitats that do not provide suitable fish habitat.

It is assumed that growth in the region would continue, which would allow continued operation of the export terminal site and the adjacent bulk terminal site within the 20-year analysis period (2018–2038). Cleanup activities, relative to past industrial uses, would continue to occur. This could impact developed areas and associated disturbed upland habitats. Vessel traffic volumes are expected to continue and any fish disturbance or injury associated with vessel movements would continue at levels similar to current conditions; however, additional impacts on fish or fish habitat could occur under the No-Action Alternative because in-water work could occur.

Chapter 4
Required Permits

The On-Site Alternative or Off-Site Alternative would require the following permits in relation to fish and fish habitat.

The On-Site Alternative would require the following permits related to fish and fish habitat.

- **Shoreline Management Act Authorization—Cowlitz County**. Cowlitz County administers the Shoreline Management Act (SMA) through its Shoreline Management Master Program (SMP). The On-Site Alternative site would have elements and impacts within SMA jurisdiction (see WAC 90.58.030 for definition of SMA jurisdiction which includes "Shorelands," "Shorelines," and "Shorelines of Statewide Significance") and would thus require a Shoreline Substantial Development and Conditional Use permit from Cowlitz County and the Department of Ecology.
- **Local Critical Areas and Construction Permits—Cowlitz County**. Either Alternative would require local permits related to clearing and grading of the site and relative to impacts to regulated critical areas. Chapter 19.15 of the Cowlitz County Code regulates activities within and adjacent to critical areas and in so doing regulates fish and wildlife habitat conservation areas (including streams and their buffers), frequently flooded areas, and other sensitive areas. Cowlitz County would require an application for Planning Clearance, a Fill and Grade Permit, Building Permits, Shoreline Permit, Floodplain Permit, and Critical Area Permit, and would review the Environmental Impact Statements for consistency with the County's critical areas ordinance.
- **Construction and Development Permits—Cowlitz County.** Both Alternatives would require fill and grade permits (CCC 16.35) and construction permits (CCC 16.05) for clearing and grading and other ground disturbing activities, as well as construction of structures and facilities associated with the On-Site Alternative.
- **Clean Water Act Authorization-U.S. Army Corps of Engineers.** Construction and operation of the export terminal would involve discharges of dredged and fill material into waters of the United States, including wetlands. Department of the Army Authorization from the U.S. Army Corps of Engineers would be required under Section 404 of the Clean Water Act.

  An Individual Water Quality Certification from the Washington State Department of Ecology under Section 401 of the Clean Water Act and a National Pollution Discharge Elimination System permit under Section 402 of the Clean Water Act would also be required. Additional details regarding the permitting process related to the Clean Water Act can be found in the NEPA Water Quality Technical Report (ICF International 2016c).
- **Rivers and Harbors Act—U.S. Army Corps of Engineers.** Construction and operation of the export terminal would take place in navigable waters of the United States (i.e., the Columbia River). The Rivers and Harbors Act authorizes the Corps to protect commerce in navigable streams and waterways of the United States by regulating various activities in such waters. Section 10 of the RHA (33 USC 403) specifically regulates construction, excavation, or deposition of materials into, over, or under navigable waters, or any work that would affect the course, location, condition, or capacity of those waters

- **Hydraulic Project Approval—Washington Department of Fish and Wildlife.** Both Alternatives would require a Hydraulic Project Approval (HPA) from the WDFW due to project elements that would affect and cross the shoreline of the Columbia River. The HPA would consider effects on riparian and shoreline/bank vegetation in issuance and conditions of the permit, including for the installation of the proposed docks and pilings, as well as for project-related dredging activities and other project-related work.
- **Local Critical Areas and Construction Permits—City of Longview (Off-Site Alternative only).** The Off-Site Alternative would require permits from the City of Longview. Chapter 17.10 of the City of Longview Municipal Code regulates activities within and adjacent to critical areas and in so doing regulates vegetation occurring in wetlands and their buffers, fish and wildlife habitat conservation areas (including streams and their buffers), frequently flooded areas, and geological hazard areas. The City of Longview would require Critical Areas and Floodplain permits, as well as a Building Permit for clearing, grading, and construction.
- **Shoreline Substantial Development—City of Longview (Off-Site Alternative only)**. A Shoreline Substantial Development permit from the City of Longview would also be required. The City of Longview administers the Shoreline Management Act through its Shoreline Management Master Program. The project area would have elements and impacts within jurisdiction of the act and would thus require a Shoreline Substantial Development permit from the City of Longview. The Off-Site Alternative would not require a Shoreline Substantial Development Permit or Conditional Use Permit from Cowlitz County.

Chapter 5
References

5.1 Written References

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, and M. L. Moser. 2002. *Status Review for North American Green Sturgeon,* Acipenser mediorstris*.* National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA.

Ahrens, M. J., and D. J. Morrisey. 2005. Biological Effects of Unburnt Coal in the Marine Environment. National Institute of Water and Atmospheric Research Ltd. *Oceanography and Marine Biology: An Annual Review* 43:69–122.

Bauersfeld, K. 1977. *Effects of Peaking (Stranding) of Columbia River Dams on Juvenile Anadromous Fishes below The Dalles Dam, 1974 and 1975*. Report by the State of Washington Department of Fisheries, Olympia, Washington, for the U.S. Army Corps of Engineers, Portland District, Portland, OR.

Beamish, R. J. 1980. Adult Biology of the River Lamprey (*Lampetra ayresi*) and the Pacific Lamprey (*Lampetra tridentate*) from the Pacific Coast of Canada. *Canadian Journal of Fisheries and Aquatic Sciences* 37(11):1906–1923.

BergerABAM. 2016. *Millennium Bulk Terminal Longview: Land and Shoreline Use Technical Report*. Prepared for ICF International.

Bolle, L. J., C. A. De Jong, S. M. Bierman, P. J. Van Beek, O. A. Van Keeken, P. W. Wessels, and R. P. Dekeling. 2012. Common Sole Larvae Survive High Levels of Pile-Driving Sound in Controlled Exposure Experiments*. PLoS One*7(3):e33052.

Bottom, D. L., G. Anderson, A. Baptista, J. Burke, M. Burla, M. Bhuthimethee, L. Campbell, E. Casillas, S. Hunton, K. Jacobson, D. Jay, R. McNatt, P. Moran, G. G. Roegner, C. A. Simenstad, V. Stamatiou, D. Teel, and J. E. Zamon. 2008. *Salmon Life Histories, Habitat, and Food Webs in the Columbia River Estuary: An Overview of Research Results, 2002–2006*. Report of the National Marine Fisheries Service to the U.S. Army Corps of Engineers and Bonneville Power Administration, Portland, OR.

Brooks, K. M. 1995. Literature Review, Computer Model, and Assessment of the Environmental Risks Associated with Creosote Treated Wood Products Used in Aquatic Environments. August 30, 1994. *Aquatic Environmental Sciences,* Port Townsend, Washington (reissued in 1997).

Buklis, L. S. and L. H. Barton. 1984. *Yukon River Fall Chum Biology and Stock Status*. Alaska Department of Fish and Game, Division of Commercial Fisheries. Anchorage, Alaska. Available: http://www.sf.adfg.state.ak.us/FedAidPDFs/afrbil.239.pdf. Accessed: September 2014.

Carlson, T., M. Hastings, and A. N. Popper. 2007. *Update on Recommendations for Revised Interim Sound Exposure Criteria for Fish during Pile Driving Activities*. Memorandum to Suzanne Theiss at California Department of Transportation and Paul Wagner at Washington Department of Transportation.

Carlson TJ, Ploskey G, Johnson RL, Mueller RP, Weiland MA, Johnson PN. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigation channel and channel maintenance activities. Pacific Northwest National Laboratory, Richland, p 35.

Carrasquero, J. 2001. *Over-Water Structures: Freshwater Issues*. Herrara Environmental Consultants. White Paper submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology, Washington Department of Transportation. April 12, 2001.

Carter, J. A., G. A. McMichael, I. D. Welch, R. A. Harnish, and B. J. Bellgraph. 2009. *Seasonal Juvenile Salmonid Presence and Migratory Behavior in the Lower Columbia River*. PNNL-18246, Pacific Northwest National Laboratory, Richland, WA.

Central Dredging Association. 2011. *Underwater Sound in Relation to Dredging.* Central Dredging Association (CEDA), CEDA position paper, November 7. Available: http://www.dredging.org/media/ceda/org/documents/resources/cedaonline/2011-11_ceda_positionpaper_underwatersound_v2.pdf.

Clemens, B. J., S. van de Wetering, S. A. Sower, and C. B. Schreck. 2013. Maturation Characteristics and Life-History Strategies of the Pacific Lamprey, *Entosphenus tridentatus*. *Canadian Journal of Zoology* 91:775–788.

Columbia River Research. 2013. *DART Smolt Index 10 Year Historical Run Timing*. Columbia Basin Research, University of Washington (juvenile fish passage). Available: http://www.cbr.washington.edu/dart/query/smolt_hrt. Queried: September 2013.

Columbia River Research. 2014. *DART Adult Passage 10 Year Historical Run Timing.* Columbia Basin Research, University of Washington. Available: http://www.cbr.washington.edu/dart/query/adult_hrt. Queried: September 2014.

David Evans and Associates, Inc. 2011. *Columbia River Crossing Test Pile Project Hydroacoustic Monitoring Final Report*. August 2011. Prepared by James Coleman, David Evans and Associates, Inc.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, R. A. Kirn, and A. E. Rankis. 1984. *Migrational Characteristics and Survival of Juvenile Salmonids Entering the Columbia River Estuary during 1983*. Annual Report of Research Financed by Bonneville Power Administration, Agreement DE-A179-83BP39652 and Coastal Zone and Estuarine Studies Division of Northwest and Alaska Fisheries Center, National Oceanic and Atmospheric Administration. Seattle, WA.

DeVore, J. D., B. W. James, C. A. Tracy, and D. H. Hale. 1995. Dynamics and Potential Production of White Sturgeon in the Unimpounded Lower Columbia River. *Transactions of the American Fisheries Society* 124:845–856.

Dickerson, C., K. J. Reine, and D. G. Clark. 2001. *Characterization of Underwater Sounds Produced by Bucket Dredging Operations*. DOER Technical Notes Collection (ERDC TN-DOER-E14), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

ECORP Consulting, Inc. 2009. Literature review (for studies conducted prior to 2008): Fish behavior in response to dredging and dredged material placement activities (Contract No. W912P7-07-P-0079). Prepared for the U.S. Army Corps of Engineers, San Francisco District. 69pp.

Eisler, R. 1987. *Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. U.S. Fish and Wildlife Service, Biological Report 85.

English, K. K., D. Robichaud, C. Sliwinski, R. F. Alexander, W. R. Koski, T. C. Nelson, B. L. Nass, S. A. Bickford, S. Hammond, and T. R. Mosey. 2006. Comparison of Adult Steelhead Migrations in the Mid-Columbia Hydrosystem and in Large Naturally Flowing British Columbia Rivers. *Transactions of the American Fisheries Society* 135:739–754.

ENTRIX. 2008. *Spatial Analysis of Beach Susceptibility for Stranding of Juvenile Salmon by Ship Wakes*. Final Report. Prepared for: The Port of Vancouver. Vancouver, WA 98660.

Fish Passage Center. 2014. Query of Adult Passage at Bonneville Dam: Graph with Current Year, Last Year, and 10-Year Average. Available: http://www.fpc.org/adultsalmon/adultqueries/Adult_Table_Species_Graph.html.

Fisheries Hydroacoustic Working Group. 2008. Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities.

Fisheries and Oceans Canada. 2014. Recovery Strategy for White Sturgeon (*Acipenser transmontanus*) in Canada [Final]. In *Species at Risk Act Recovery Strategy Series*. Ottawa: Fisheries and Oceans Canada.

Fresh, K. L., E. Casillas, L. L. Johnson, and D. L. Bottom. 2005. *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability*. U.S. Dept. Commerce, Seattle, WA. NOAA Tech. Memo. NMFS-NWFSC-69.

Graves, J. K., J. A. Christy, P. J. Clinton, and P. L. Britz. 1995. *Historic Habitats of the Lower Columbia River*. Report by the Columbia River Estuary Study Taskforce, Astoria, Oregon. In Johnson et al. 2003.

Grette Associates, LLC. 2014a. *Millennium Coal Export Terminal Longview, Washington: Affected Environment Biological Resources. Technical Report.* January 2014, revised March 2014. Wenatchee, WA. Prepared for Millennium Bulk Terminals – Longview, LLC. Longview, WA.

Grette Associates, LLC. 2014b. *Millennium Coal Export Terminal Longview, Washington: Docks 2 and 3 and Associated Trestle Direct Effects of Construction*. September 2014. Wenatchee, WA. Prepared for Millennium Bulk Terminals – Longview, LLC. Longview, WA.

Grette Associates, LLC. 2014c. *Millennium Coal Export Terminal Longview, Washington: Off-Site Alternative – Barlow Point Pile Driving and Underwater Sound*. September 2014. Wenatchee, WA. Prepared for Millennium Bulk Terminals – Longview, LLC. Longview, WA.

Grette Associates, LLC. 2014d. *Millennium Coal Export Terminal Longview, Washington: Docks 2 and 3 and Associated Trestle: Proposed Mitigation Measures to Minimize Construction and Long-Term Effects*. September 2014. Wenatchee, WA. Prepared for Millennium Bulk Terminals – Longview, LLC. Longview, WA.

Grette Associates, LLC. 2014e. *Millennium Coal Export Terminal Longview, Washington: Off-Site Alternative – Barlow Point Permanent Impacts to Aquatic Habitat*. September 2014. Wenatchee, WA. Prepared for Millennium Bulk Terminals – Longview, LLC. Longview, WA.

Grette Associates, LLC. 2014f. *Millennium Coal Export Terminal Longview, Washington: Permanent Impacts to Aquatic Habitat*. September 2014. Wenatchee, WA. Prepared for Millennium Bulk Terminals – Longview, LLC. Longview, WA.

Gustafson, R. G., M. J. Ford, D. Teel, and J. S. Drake. 2010. *Status Review of Eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California*. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-105. Available: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/other_species/eulachon/7092_06162010_142619_eulachontm105webfinal.pdf. Accessed: September 2014.

Hastings, M. C. and A. Popper. 2005. *Effects of Sound on Fish*. Final Report #CA05-0537. Project P476 Noise Thresholds for Endangered Fish. California Department of Transportation. Sacramento, CA 95811

Hemmera Environchem Inc., SMRU Canada Ltd., and JASCO Applied Sciences (Canada) Ltd. 2014. Roberts Bank Terminal 2 Technical Data Report: Underwater Noise Ship Sound Signature Analysis Study. Prepared for Port Metro Vancouver. December 2014.

Hinton, S. A. and R. L. Emmett. 1994. *Juvenile Salmonid Stranding in the Lower Columbia River, 1992 and 1993*. NOAA Technical Memorandum NMFS-NWFSC-20. Prepared by the National Marine Fisheries Service, Northwest Fisheries Science Center, Coast Zone and Estuaries Studies Division, Seattle, WA.

Howell, M. D., M. D. Romano, and T. A. Rien. 2001. *Draft Outmigration Timing and Distribution of Larval Eulachon,* Thaleichthys pacificus*, in the Lower Columbia River, Spring 2001*. Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife, Olympia, Washington.

ICF Jones & Stokes and Illingworth and Rodkin. 2009. *Final Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish.* February 2009. Prepared for California Department of Transportation. ICF Jones & Stokes and Illingworth and Rodkin, Inc., Sacramento, CA. *Appendix I: Compendium of Pile Driving Sound Data*, updated October 2012.

ICF International. 2016a. *Millennium Bulk Terminals— Longview, NEPA Environmental Impact Statement, NEPA Groundwater Technical Report*. September. Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

ICF International. 2016b. *Millennium Bulk Terminals— Longview, NEPA Environmental Impact Statement, NEPA Vegetation Technical Report*. September. Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

ICF International. 2016c. *Millennium Bulk Terminals— Longview, NEPA Environmental Impact Statement, NEPA Water Quality Technical Report*. September. Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

ICF International. 2016d. *Millennium Bulk Terminals— Longview, NEPA Environmental Impact Statement, NEPA Hazardous Materials Technical Report*. September. Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

ICF International. 2016e. *Millennium Bulk Terminals— Longview, NEPA Environmental Impact Statement, NEPA Air Quality Technical Report*. September. Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

ICF International. 2016f. *Millennium Bulk Terminals—Longview, NEPA Environmental Impact Statements, NEPA Vessel Transportation Technical Report.* September. Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

ICF International. 2016g. *Millennium Bulk Terminals— Longview, SEPA Environmental Impact Statements, SEPA Coal Technical Report; Coal Dust Exposure, Coal Spill Analysis and Sulfur Dioxide and Mercury Analysis.* April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

ICF International and Wilson Ihrig Associates. 2016. *Millennium Bulk Terminals—Longview, NEPA Environmental Impact Statement, NEPA Noise and Vibration Technical Report.* September. Seattle, WA. Prepared for U.S. Army Corps of Engineers, Seattle District.

Independent Scientific Review Panel. 2013. *Review of the Draft Columbia Basin White Sturgeon Planning Framework*.

Jefferies, S. J., P. J. Gearin, H. R. Huber, D. L. Saul, and D. A. Pruett. 2000. *Atlas of Seal and Sea Lion Haulout Sites in Washington*. Washington Department of Fish and Wildlife, Wildlife Science Division, 600 Capitol Way North, Olympia, WA.

Johnson, G. E., B. D. Ebberts, R. M. Thom, N. M. Ricci, A. H. Whiting, J. A. Southard, G. B. Sutherland, J. D. Wilcox, T. Berquam. 2003. *An Ecosystem-Based Approach to Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary*. Final Report. November 2003. Prepared for the U.S. Department of Energy under Contract DE-AC06-76RL01830. PNNL-14412

Jolley, J. C., G. S. Silver, and T. A. Whitesel. 2012. *Occurrence, Detection, and Habitat Use of Larval Lamprey in Columbia River Mainstem Environments: Bonneville Tailwater and Tributary Mouths*. 2011 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. Available: http://www.fws.gov/columbiariver/publications/2011AR_Bonneville_lamprey.pdf.

Jones, T., C. Kern, C. Mallette, and T. Rien. 2011. Lower Columbia River and Oregon Coast White Sturgeon Conservation Plan. Oregon Department of Fish and Wildlife, Ocean Salmon and Columbia River Program. 192pp.

Keefer, M. L., C. A. Perry, M. A. Jepson, and L. C. Struhrenberg. 2004. Upstream Migration Rates of Radio-Tagged Adult Chinook Salmon in Riverine Habitats of the Columbia River Basin. *Journal of Fish Biology*. 64:1126–1141.

Kelly, J. T., and A. P. Klimley. 2012. Relating the Swimming Movements of Green Sturgeon to the Movement of Water Currents. *Environmental Biology of Fishes* 96(2):151–167.

Kulisch, E. 2013, Expanding the Pie for Containerized Exports. *American Shipper* 55(3):8–9.

Lindley, S. T., M. L. Moser, D. L. Erickson, M. Belchik, D. W. Welch, E. L. Rechisky, J. T. Kelly, J. Heublein, and P. Klimley. 2008. Marine Migration of North American Green Sturgeon. *Transactions of the American Fisheries Society* 137:182–194.

Lindley, S. T., D. L. Erickson, M. L. Moser, G. Williams, O. P. Langness, B. W. McCovey, M. Belchik, D. Vogel, W. Pinnix, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2011. Electronic Tagging of Green Sturgeon Reveals Population Structure and Movement among Estuaries. *Transactions of the American Fisheries Society* 140:108–122.

Lord, J. 2011. Interstate 5 Columbia River Crossing—Pacific lamprey and the Columbia River Crossing Project: A white paper. 304pp.

Mallette, C. 2014, Studies of Eulachon Smelt in Oregon and Washington. Project Completion Report Prepared by Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. C. Mallette (editor).

McCabe, G. T., and C. A. Tracy. 1994. Spawning and Early Life History of White Sturgeon, *Acipenser transmontanus,* in the Lower Columbia River. Seattle, Washington. *Fisheries Bulletin* 92:760–772.

McCabe, G.T., S.A. Hinton, R.L. Emmett. 1996. Benthic invertebrates and sediment characteristics in Wahkiakum County Ferry Channel, Washington, before and after dredging. Final Report to U.S. Army Corps of Engineers and NMFS, Seattle, WA. 32pp.

McCabe, G.T., S.A. Hinton, R.L. Emmett, and B.P. Sanford. 1997. Benthic Invertebrates and Sediment Characteristics in Main Channel Habitats in the Lower Columbia River. Northwest Science, Volume 71, Number 1, 1997. 11pp.

Meyers, J. R. and J. T. Corwin. 2008. Morphological Correlates of Regeneration and Repair in the Inner Ear. Pages 39–75 in R. J. Salvi, A. N. Popper, and R. R. Fay (eds.), *Springer Handbook of Auditory Research, Vol. 33: Hair Cell Regeneration, Repair, and Protection.*

Moser, M. L. and S. T. Lindley. 2007. Use of Washington Estuaries by Subadult and Adult Green Sturgeon. *Environmental Biology of Fishes* 79:243–253.

Moyle, P. B. 2002. Lampreys, Petromyzontidae – River Lamprey, (*Lampetra ayresi*). Pages 101–103 in *Inland Fishes of California*. Los Angeles, California: University of California Press.

National Marine Fisheries Service. 2010. *Status Review of Eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California.* NOAA Technical Memorandum NMFS-NWFSC-105

National Marine Fisheries Service. 2011. *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead.* NMFS Northwest Region. Portland, OR. January. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc., subcontractor. January.

National Marine Fisheries Service. 2013. *ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead.* NMFS Northwest Region. June 2013.

National Marine Fisheries Service. 2015. *Status of ESA Listings & Critical Habitat Designations for West Coast Salmon & Steelhead*. Updated October 31, 2012. Available: http://www.westcoast.fisheries.noaa.gov/publications/protected_species/salmon_steelhead/status_of_esa_salmon_listings_and_ch_designations_map.pdf. Accessed: March 19, 2015.

National Oceanic and Atmospheric Administration. 2013. Datums for 9440422, Longview WA. Elevations on station datum for NOAA tide gage 9440422. Available: <http://tidesandcurrents.noaa.gov/datums.html?id=9440422>. Last revised: October 15, 2013.

National Oceanic and Atmospheric Administration. 2014a*.* *West Coast Region*. Available: http://www.westcoast.fisheries.noaa.gov/. Accessed on April 17, 2014.

National Oceanic and Atmospheric Administration. 2014b. *West Coast Region, Chinook Salmon*. Available: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chinook/chinook_salmon.html. Accessed on April 14, 2014.

Parsley, M. J., L. G. Beckman, and G. T. McCabe, Jr. 1993. Spawning and Rearing Habitat Use by White Sturgeons in the Columbia River Downstream from McNary Dam. *Transactions of the American Fisheries Society* 122:217–227.

Parsley, M. J., Popoff, N. D., & Romine, J. G. (2011). Short-term response of subadult white sturgeon to hopper dredge disposal operations. North American Journal of Fisheries Management, 31(1), 1-11.

Parsley, M. J., N. D. Popoff, C. D. Wright, C. D., and B. K. van der Leeuw. 2008. Seasonal and Diel Movements of White Sturgeon in the Lower Columbia River. *Transactions of the American Fisheries Society* 137(4):1007–1017.

Pearson, W. H., and J. R., Skalski. 2006. *Assessing Loss of Juvenile Salmon to Stranding by Ship Wakes at Three Sites along the Lower Columbia River.* Draft Report.

Pearson, W. H., J. R. Skalski, K. L. Sobocinski, M. C. Miller, G. E. Johnson, G. D. Williams, J. A. Southard, and R. A. Buchanan. 2006. *A Study of Stranding of Juvenile Salmon by Ship Wakes along the Lower Columbia River Using a Before-and-After Design: Before-Phase Results*. Pacific Northwest National Laboratory.

Popper, A. N. and M. C. Hastings. 2009. Review Paper: The Effects of Anthropogenic Sources of Sound on Fishes. *Journal of Fish Biology* 75:455–489.

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. MacGillivray, M. E. Austin, and D. A. Mann. 2005. Effects of Exposure to Seismic Airgun Use on Hearing of Three Fish Species. *Journal of the Acoustical Society of America* 117:3958–3971.

Port of Longview. 2010. *Port of Longview 2010 Annual Report.*

Pribyl, A. L., J. S. Vile, and T. A. Friesen. 2004. Population Structure, Movement, Habitat Use, and Diet of Resident Piscivorous Fishes in the Lower Willamette River. Paper #3 in T.A. Friesen (ed.), *Biology, Behavior, and Resources of Resident and Anadromous Fish in the Lower Willamette River - Final Report of Research, 2000–2004.* Prepared for the City of Portland Bureau of Environmental Services by the Oregon Department of Fish and Wildlife. March 2005.

Redding, J. M., C. B. Schreck, and F. H. Everest. 1987. Physiological Effects on Coho Salmon and Steelhead of Exposure to Suspended Solids. *Transactions of the American Fisheries Society* 116:737–744.

Roegner, G. C., and K. Sobocinski. 2008. Ecology of Juvenile Salmonids in Tidal Fresh and Estuarine Waters. *Proceedings to the Columbia River Estuary Conference on Ecosystem Restoration*. Astoria, OR. August.

Roegner, G. C., R. McNatt, D. J. Teel, and D. L. Bottom. 2012. Distribution, Size, and Origin of Juvenile Chinook Salmon in Shallow-Water Habitats of the Lower Columbia River and Estuary, 2002–

2007. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 4(1):450–472. DOI: 10.1080/19425120.2012.675982.

Roegner, G. C., E. A. Daly, and R. D. Brodeur. 2013. Surface Distribution of Brachyuran Megalopae and Ichthyoplankton in the Columbia River Plume during Transition from Downwelling to Upwelling Conditions. *Continental Shelf Research* 60:70–86.

Romano, M. D., M. D. Howell, and T. A. Rien. 2002. *Use of an Artificial Substrate to Capture Eulachon Eggs in the Lower Columbia River*. Draft Report by the Oregon Department of Fish and Wildlife to the U. S. Army Corps of Engineers, Portland, OR.

Sandercock, F.K. 1991. Life history of Coho Salmon (*Oncorhynchus kisutch*). Pages 395–446 in C. Groot and L. Margolis (eds.), *Pacific Salmon Life Histories.* Vancouver, Canada: UBC Press. (Reprinted 1998.)

Servizi, J. A., and D. W. Martens. 1992. Sublethal Responses of Coho Salmon (*Oncorhynchus kisutch*) to Suspended Sediments. *Canadian Journal of Aquatic Sciences* 49:1389–1395.

Shreffler, D. K. and R. A. Moursund. 1999. *Impacts of Ferry Terminals on Juvenile Salmon Migrating along Puget Sound Shorelines. Phase II: Field Studies at Port Townsend Ferry Terminals.* Washington State Transportation Center, University of Washington, Seattle, WA. WA-RD 480.1.

Silver, G. S., C. W. Luzier, and T. A. Whitesel. 2007. *Investigation of Larval Pacific Lamprey Occupancy of the Mainstem Columbia River and Willamette River.* 2007 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. Available: http://www.fws.gov/columbiariver/publications/2007_Mainstem_Lamprey_AR.pdf.

Simenstad, C. A., B. J. Nightingale, R. M. Thom, and D. K. Shreffler, D. K. 1999. *Impacts of Ferry Terminals on Juvenile Salmon Migration along Puget Sound Shorelines, Phase I; Synthesis of State of Knowledge*. Prepared for the Washington State Transportation Commission, Research Project, 9903.

Stadler, J. H., and D. P. Woodbury. 2009 *Assessing the Effects to Fishes from Pile Driving: Application of New Hydracoustic Criteria.* Inter-noise 2009, Ottawa, Ontario, Canada.

Stober, Q. J., B. D. Ross, C. L Melby, P. A. Dinnel, T. H. Jagielo, and E. O. Salo. 1981. *Effects of Suspended Sediment on Coho and Chinook Salmon in the Toutle and Cowlitz Rivers*. FRI-UW-8124, Fisheries Research Institute, University of Washington, Seattle, WA.

Todd, V. L. G., I. B. Todd, J. C. Gardiner, E. C. N. Morrin, N. A. MacPherson, N. A. DiMarzio, and F. Thomsen. 2014. A Review of Impacts of Marine Dredging Activities on Marine Mammals. *ICES Journal of Marine Science* 72:328–340.

Trotter, P. 1989. Coastal Cutthroat Trout: A Life History Compendium. *Transactions of the American Fisheries Society* 118:463–473.

URS Corporation. 2014. *Millennium Coal Export Terminal Longview, Washington; Water Resource Report*. September.

U.S. Army Corps of Engineers. 2004a. *Portland-Vancouver Harbor Information Package*. Second Edition. Portland District, Reservoir Regulation and Water Quality Section. November.

U.S. Army Corps of Engineers. 2004b. *Biological Assessment, Columbia River Channel Operations and Maintenance, Mouth of the Columbia to Bonneville Dam*. Prepared by the U.S. Army Corps of Engineers, Portland District. September.

U.S. Army Corps of Engineers, Dredged Material Management Office. 2010. *Memorandum for Record: Determination Regarding the Suitability of Proposed Dredged Material from Berth 1 of the Chinook Ventures Facility, Longview, Washington for Flowlane Disposal in the Columbia River*. November.

U.S. Fish and Wildlife Service. 2002. Lower Columbia Recovery Unit, Washington. Chapter 20 in U.S. Fish and Wildlife Service, *Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan*. Portland, OR.

U.S. Fish and Wildlife Service. 2014. *IPaC-Information, Planning, and Conservation System.* Environmental Conservation Online System. Available: http://ecos.fws.gov/ipac/. Accessed: April 15, 2014.

U.S. Geological Survey. 2007. *Coal Quality and Major, Minor, and Trace Elements in the Powder River, Green River, and Williston Basins, Wyoming and North Dakota*. Open-File Report 2007-1116. U.S. Department of the Interior, U.S. Geological Survey.

U.S. Geological Survey. 2014. *USGS 14246900 Columbia River at Beaver Army Terminal near Quincy, OR.* Available: http://wdr.water.usgs.gov/wy2013/pdfs/14246900.2013.pdf?1423677243767.

Washington Department of Fish and Wildlife. 2015a. *Priority Habitats and Species (PHS) – PHS Statewide List and Distribution by County*. Available: http://wdfw.wa.gov/conservation/phs/list/ Accessed: January 29, 2015.

Washington Department of Fish and Wildlife. 2015b. *Salmonscape*. Available: http://apps.wdfw.wa.gov/salmonscape/map.html. Accessed: January 29, 2015.

Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. 2001. *Washington and Oregon Eulachon Management Plan*. November.

Washington State Department of Ecology. 2015. Vessel Entries and Transits for Washington Waters: VEAT 2014. Ecology Publication 15-08-012. Olympia, WA.

Washington State Department of Ecology. 2014. Washington State Proposed Draft Assessment Database – Review Tool. 303(d) /305(b) Integrated Report Viewer. Available: http://apps.ecy.wa.gov/wats/Default.aspx, on-line mapper: https://fortress.wa.gov/ecy/wqamapviewer/default.aspx. Queried December 2014

Washington State Department of Transportation (WSDOT). 2010. Underwater Sound Levels Associated with Driving Steel Piles at the Wahkiakum County Ferry Terminal. Prepared by Jim Laughlin, Office of Air Quality and Noise, Seattle, Washington. Available at: http://www.wsdot.wa.gov/environment/air/piledrivingreports.htm. Accessed: September 2014.

Washington State Department of Transportation. 2015. *Biological Assessment Preparation for Transportation Projects – Advanced Training Manual* – Version 2015. Available at: http://www.wsdot.wa.gov/Environment/Biology/BA/BAguidance.htm#manual. Accessed: March 20, 2015.

WorleyParsons. 2012. *Hydrodynamic Modeling and Sediment Transport Analysis*. Prepared for Millennium Bulk Terminals Longview, LLC.