United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
Lacey, Washington 98503

MAR 19 2018

In Reply Refer To:
01EWFW00-2017-F-1500

Daniel Mathis
U.S. Department of Transportation
Federal Highway Administration
Suite 501 Evergreen Plaza
711 South Capitol Way
Olympia, WA 98501-1284

Dear Mr. Mathis:

This letter transmits the U.S. Fish and Wildlife Service's (USFWS) Biological Opinion on the proposed US 101 Elwha Bridge Replacement Project located in Clallam County, Washington, and its effects on bull trout (*Salvelinus confluentus*) and bull trout critical habitat. Formal consultation on the proposed action was conducted in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your September 11, 2017, request for formal consultation was received on September 13, 2017.

The enclosed Biological Opinion is based on information provided in the September 11, 2017, Biological Assessment (BA), telephone conversations, field investigations, and other sources of information cited in the Biological Opinion. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey Washington.

The BA also included a request for USFWS concurrence with "not likely to adversely affect" determinations for certain listed species. The enclosed document includes a section separate from the Biological Opinion that addresses your concurrence requests. We included a concurrence for the northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), and Taylor's checkerspot butterfly (*Euphydryas editha taylori*). The rationale for these concurrences is included in the concurrence section.

If you have any questions regarding the enclosed Biological Opinion, our response to your concurrence request(s), or our shared responsibilities under the ESA, please contact George Ritchotte at 206-356-0511 or Martha Jensen at 360-753-9000.

Sincerely,

Tim Romanski

Eric V. Rickerson, State Supervisor
Washington Fish and Wildlife Office

Enclosure

cc:
FHWA, Olympia, WA (C. Callahan)
USFWS, Lacey, WA (D. Jones)
Herrera Inc., Seattle, WA (G. Richotte)

Endangered Species Act – Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
01EWFW00-2017-F-1500

US101/Elwha River Bridge Replacement Project

Clallam County, Washington

Federal Action Agency:

Federal Highway Administration

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, Washington

Tim Romanski for

Eric V. Rickerson, State Supervisor
Washington Fish and Wildlife Office

3-19-2018

Date

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

BA	Biological Assessment
BMP	best management practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
dbh	diameter at breast height
DCu	dissolved copper
DZn	dissolved zinc
ESA	Endangered Species Act of 1973, as amended (16 U.S.C. l531 *et seq*.)
FHWA	Federal Highway Administration
FMO	foraging, migration and overwintering
FR	Federal Register
mg/L	milligrams per liter
NAVD88	North American Vertical Datum of 1988
NMFS	National Marine Fisheries Service
NTU	nephelometric turbidity units
OHWM	ordinary high water mark
Opinion	Biological Opinion
PBF	physical or biological features
PCE	Primary Constituent Element
PGIS	pollution-generating impervious surface
RM	river mile
RPM	reasonable and prudent measure
Services	U.S. Fish and Wildlife Service and National Marine Fisheries Service
spotted owl	northern spotted owl
TCu	total copper
TSS	total suspended solids
TZn	total zinc
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation
μg/L	micrograms per liter

INTRODUCTION

This document represents the U.S. Fish and Wildlife Service's (USFWS) Biological Opinion (Opinion) on the proposed US101/Elwha River Bridge – Bridge Replacement Project (also referred to herein as the proposed federal action). The project site is in Clallam County, Washington. This Opinion is based on our review of the proposed project and its effects on bull trout (*Salvelinus confluentus*) and bull trout critical habitat. This Opinion was prepared in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.) (ESA). Your September 11, 2017, request for formal consultation was received on September 11, 2017.

The Federal Highway Administration (FHWA) is requesting our concurrence with "may affect, not likely to adversely affect" determinations for the northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), and Taylor's checkerspot butterfly (*Euphydryas editha taylori*).

The FHWA determined the project would have "no effect" on northern spotted owl (*Strix occidentalis caurina*) (spotted owl) critical habitat, marbled murrelet (*Brachyramphus marmoratus*) critical habitat, streaked horned lark (*Eremophila alpestris strigata*) and streaked horned lark critical habitat, western yellow-billed cuckoo (*Coccyzus americanus*) and yellow-billed cuckoo critical habitat, Taylor's checkerspot butterfly (*Euphydryas editha taylori*) critical habitat, and golden paintbrush (*Castilleja levisecta*). The USFWS has no regulatory or statutory authority for concurring with a "no effect" determination, and no consultation with the USFWS is required. We recommend that the action agency document their analysis on effects to listed species and maintain that documentation as part of the project file.

This Opinion is based on information provided in the September 11, 2017, Biological Assessment (BA) and associated updates, telephone conversations, field investigations, and other sources of information as detailed below. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey Washington.

CONSULTATION HISTORY

The following is a summary of important events associated with this consultation:

- An early coordination meeting was held in Port Angeles on April 11, 2017, followed by a site visit. The meeting was attended by Washington State Department of Transportation (WSDOT) and USFWS representatives.

- A pre-consultation meeting was held via conference call with WSDOT biologists and USFWS liaisons on May 24, 2017.

- Another pre-consultation meeting with USFWS species leads, USFWS liaisons, and WSDOT representatives was held at the USFWS office in Lacey, Washington, on July 10, 2017.

- On July 13, 2017, WSDOT biologists met onsite with Bill Vogel (USFWS) to look at potential marbled murrelet habitat in the action area. No trees with suitable nest platforms were observed. Based on the lack of suitable habitat, the USFWS determined the probability of exposure of nesting marbled murrelets to noise or tree removal would be discountable.

- The BA was received on September 13, 2017.

- Additional information necessary to initiate consultation was received on October 3, 2017, and November 13, 2017.

- Formal consultation was initiated on October 12, 2017.

CONCURRENCES

Please see the "Description of the Proposed Action" within the Opinion, below, regarding specific activities associated with the proposed action.

Northern Spotted Owl

Project activities will result in short-term elevated noise and activity levels associated with the use of heavy equipment that could result in disturbance to spotted owls. The project also involves clearing a small area (6.7 acres) of vegetation along the roadside and riparian corridor, including the removal of 21 trees (conifer or hardwood) that are greater than 30 inches in diameter at breast height (dbh). Approximately 5.7 acres will be revegetated following completion of project work.

The project area falls within the Olympic Peninsula Demographic Study Area, where spotted owl territories have been monitored since the 1990s, including annual visits to spotted owl activity centers (active and historical) in the action area. Monitoring efforts have documented a steady decline in the proportion of sites with detections of spotted owls and an increase in occupancy rates by barred owls (*Strix varia*) (Gremel 2015). Sites where spotted owls persist on the Olympic Peninsula, in general, are in steep terrain at relatively high elevations (2,900 feet above sea level, on average). Low-elevation areas are now dominated by barred owls (Gremel, pers. comm. 2017). The action area is located in the Elwha River valley at an elevation of approximately 240 feet, which is below the elevation range where most spotted owl territories remain.

The nearest spotted owl activity center to the project site is approximately 1 mile northeast of the Elwha River bridge (WDFW 2017) and is monitored on an annual basis. Since 2002, only barred owls have been observed during monitoring visits to that activity center. The nearest spotted owl activity center with recent spotted owl detections is near Barnes Creek, approximately 6 miles west of the action area, where a pair of spotted owls was detected in 2016 (Gremel, pers. comm. 2017). The field assessment of forested habitat in the vicinity of the project site determined that there are no suitable nest trees within 195 feet of the project site (the distance within which noise from ground-based motorized activity could have significant adverse effects on spotted owls [USFWS 2015a]), and the forested habitat present is of marginal quality for use by spotted owls.

Based on the lack of suitable nesting/roosting habitat, the distance to the nearest active spotted owl territory, and the predominance of barred owls in most low-elevation habitat on the Olympic Peninsula, it is extremely unlikely that a spotted owl pair would be nesting close to the proposed project site. Therefore, effects to spotted owls are considered discountable. We also expect that spotted owls are unlikely to use adjacent forested habitats for foraging or dispersal near the project site, and that project activities are unlikely to result in short-term noise or visual disturbance to spotted owls. The project will result in the clearing of a small area of potential marginal-quality spotted owl foraging or dispersal habitat. Given the current degraded quality of the habitat and that the majority of the vegetation removed will be replanted following project completion, we consider the effects to spotted owl habitat to be insignificant.

Marbled Murrelet

The project will result in short-term elevated noise and activity levels associated with the use of heavy equipment that could result in disturbance to marbled murrelets. Vegetation clearing includes the removal of 21 trees (conifer or hardwood) that are greater than 30 inches dbh, which could potentially provide suitable nesting habitat for marbled murrelets.

Surveys for marbled murrelets were conducted in potential nesting habitat in the action area in the 1990s and early 2000s. Results of those surveys indicated that marbled murrelets were not nesting in forest stands near the project site, but that the river corridor in the project area serves as a flight corridor between the marine environment and nesting stands along the upper reaches of the Elwha valley or tributaries (NPS 1996a). The nearest known occupied site is approximately 4.2 miles south of the project site (WDFW 2017). Surveys conducted in 1995 and 1996 near the former Elwha Dam and Glines Canyon Dam found low numbers of marbled murrelets traveling along the river corridor daily. Those surveys produced no evidence of nesting near either dam (NPS 1996b). Other surveys conducted in the area have documented behaviors associated with nesting in forested habitat, such as flying through the canopy or landing in trees. All such observations were more than 1 mile from the project site (WDFW 2017).

The field assessment of forested habitat near the project site determined that there are no suitable nest trees within 328 feet of the project site (the distance within which ground-based motorized activities could have adverse effects on marbled murrelets [USFWS 2015a]). Seven or eight platform-like structures were observed in trees southwest of the bridge, but they lacked the overhead cover that would render them suitable as nesting platforms for marbled murrelets (Vogel, in litt. 2017). Based on the lack of suitable nest trees and the distance to the nearest documented marbled murrelet occupied site (over 4 miles from the project footprint), it is extremely unlikely that marbled murrelets would be nesting near the proposed project site. Therefore, project-related effects that could cause disturbance to nesting marbled murrelets are considered discountable.

The project will require the clearing of a small area of forested habitat. Given the lack of nesting platforms, the current degraded quality of the habitat, and the fact that most of the vegetation removed will be replanted following project completion, we consider the effects to marbled murrelet habitat to be insignificant. The nearest marbled murrelet foraging habitat is in the Strait of Juan de Fuca, more than 5 miles from the project site. Potential effects on foraging marbled murrelets, marine habitat, or prey resources are considered discountable.

No designated marbled murrelet critical habitat occurs within the construction limits. The nearest unit of designated critical habitat for marbled murrelets is approximately 0.2 mile east of the project footprint.

Taylor's Checkerspot Butterfly

The project will impact a small area (6.7 acres) of vegetation along the roadside and riparian corridor. Land cover in the project footprint consists of roadways, disturbed soils, closed-canopy forest, and the river channel, none of which provide suitable habitat for Taylor's checkerspot butterfly. Taylor's checkerspot butterfly populations on the northeastern Olympic Peninsula are primarily associated with shallow-soil balds and grasses within a forested landscape, although some have been found in clearcut areas and along roadsides (Stinson 2005). Grosboll (2011) found that within areas of broadly suitable grassland vegetation structure, Taylor's checkerspot butterfly adults lay their eggs in areas with very high densities of host plants. Of 31 oviposition locations studied, the volume of host plants in all but one exceeded 10,000 cubic centimeters per square meter. Site visits conducted in July 2017 for the project found no areas with sufficient densities of host plant species.

The area of ground disturbance for the project includes some of the plant species that serve as nectar plants for adult Taylor's checkerspot butterflies, particularly invasive Canada thistle (*Cirsium arvense*). However, the area lacks a sufficient density of larval host plants (such as paintbrush or plantain species) to provide suitable habitat for Taylor's checkerspot butterflies.

The nearest location where Taylor's checkerspot butterflies have been observed is more than 1 mile from any areas where ground-disturbing activities are proposed (WDFW 2017; Grosboll 2011). Dispersal of adults from occupied habitats occurs only as random events and is limited to few individuals (Stinson 2005). Taylor's checkerspot butterflies are unlikely to disperse from currently occupied habitat to the project site.

Given the lack of suitable habitat and larval host plants, and the distance to the nearest documented Taylor's checkerspot butterfly location, the USFWS considers the likelihood of removing or degrading potential habitat or killing individual butterflies to be highly unlikely and, therefore, discountable.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

A federal action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas (50 CFR 402.02).

The WSDOT is proposing to construct a new bridge and roadway over the Elwha River, and to remove the existing US 101 Elwha River Bridge. The existing three-span, 388-foot-long concrete arch bridge was built in 1926. Following the removal of the Elwha Dam in 2012 and the Glines Canyon Dam in 2014, the Elwha River dramatically changed its course and flow, leading to severe erosion around the bridge pier foundations. Between 2012 and 2016, the riverbed at the bridge lowered 14 feet due to the erosive forces of the now free-flowing river, undermining one bridge pier and exposing another. Geotechnical borings conducted in October 2016 discovered that the bridge pier foundations were built on river bed gravel, not bedrock, as was indicated in the 1926 engineering plans. Emergency scour repairs were conducted in October 2016 and August 2017 to provide short-term protection of the bridge infrastructure; however, replacement of the existing bridge is required to protect public safety and provide long-term multimodal transportation across the Elwha River.

<u>Project Elements</u>
Beginning in 2019, the WSDOT will replace the Elwha River Bridge with a new bridge located approximately 250 feet north of the existing bridge. The new bridge will be 502.35 feet long and will consist of four piers and three concrete girder spans. The existing bridge will be removed, and a parking lot and trail access will be constructed along the right bank. Each of the project elements are shown in Figure 1 and described in more detail below. The proposed construction schedule and sequence of in-water work for major elements of the project are shown in Figure 22. Additional detail is described under each project element section below.

<u>Site Preparation and Staging Areas</u>

Project construction activities will be confined to construction limits, which will be staked or flagged to mark the project edges, clearing limits, and right-of-way. Construction areas will be cleared of vegetation and obstructions to provide adequate work space. Approximately 6.7 acres of land outside the proposed roadway limits will be cleared and grubbed, up to 2.9 acres of which will be within the 200-foot riparian buffer zone of the Elwha River and Indian Creek. Vegetation clearing will include removing branches and tree trunks, but will leave the soil intact. Grubbing will include removing all vegetative matter (roots and debris) from the load-bearing surface of the soil. Temporary erosion and sediment control measures (see Conservation Measures) will be implemented before any clearing or grubbing activities.

Land-based construction staging areas will be used for delivering and storing construction materials and equipment, contractor offices and storage trailers, and employee parking. Such areas are typically located adjacent to the construction site. Temporary driveways may need to be established from the staging areas to the roadway network. Construction staging areas could require grading or excavation to level the site and install drainage improvements, depending on site conditions. Drainage conveyance systems to convey stormwater from a collection point to an outfall may consist of drainage pipes and temporary stormwater facilities (such as ponds, vaults, and catch basins), and the use of gravity flow or pumps. Office trailers, placed on temporary foundations, will be connected to available utilities, including power, telephone, water, and sewer, as needed. Connecting to those utilities may involve the installation of temporary poles for power lines and excavating trenches for underground utility hookups. After construction is completed, the staging areas will be restored and disconnected from any utilities.

Construction Access Pads

The new bridge construction will require the construction of temporary access pads adjacent to and within the river channel to enable equipment to reach pier and superstructure construction areas. On the right bank of the Elwha River, the construction access pad will originate north of the existing bridge and extend southward along the channel margin to the proposed Pier 3 location (Figure 3). On the left bank, the landward access will originate from both sides of US 101 approximately 300 feet west of the existing bridge abutment, extending down to near the confluence of the Elwha River and Indian Creek, where it will continue into the channel to the proposed Pier 2 location (Figure 3). The access pads will be constructed to withstand the range of river flows for 1 year and the loads of heavy construction equipment. The access pad dimensions will match the size of equipment that will be used for constructing the bridge superstructure. The pads will be high enough to allow for work in the dry, except in flow conditions that exceed the 2-year flow. During such events, all equipment and materials will be moved off the access pads until waters levels have subsided.

The construction access pads will cover an area of approximately 61,200 square feet, of which 29,500 square feet will be below the ordinary high water mark (OHWM). The pads will be composed of 11,700 cubic yards of 6-man riprap (54 to 60 inches in diameter) and will require up to 1,500 cubic yards of excavation to level existing surfaces and key into the channel bed. Once the large rock has been positioned, streambed gravel will be used to fill the interstitial spaces within the riprap foundation to solidify the structure. The excavated streambed substrate will be used for fill material. Additional fill material may need to be borrowed from adjacent gravel bars outside of the wetted perimeter of the river.

The access pads will take approximately 3 weeks to construct, beginning in July 2019. The landward access will be completed within the first 2 weeks of July, and the waterward access areas (temporary waterward construction access in Figure 2) will be completed during the proposed first-year in-water work window from July 15 to August 30, 2019. The pads will remain in the river through the second in-water work window in 2020 to enable subsequent column and pier cap construction and girder placement. To alleviate potential velocity and scour effects between the construction access pads, the WSDOT proposes to remove a portion of each pad on the waterward side of the new piers in late September. This work will be conducted outside of the in-water work window.

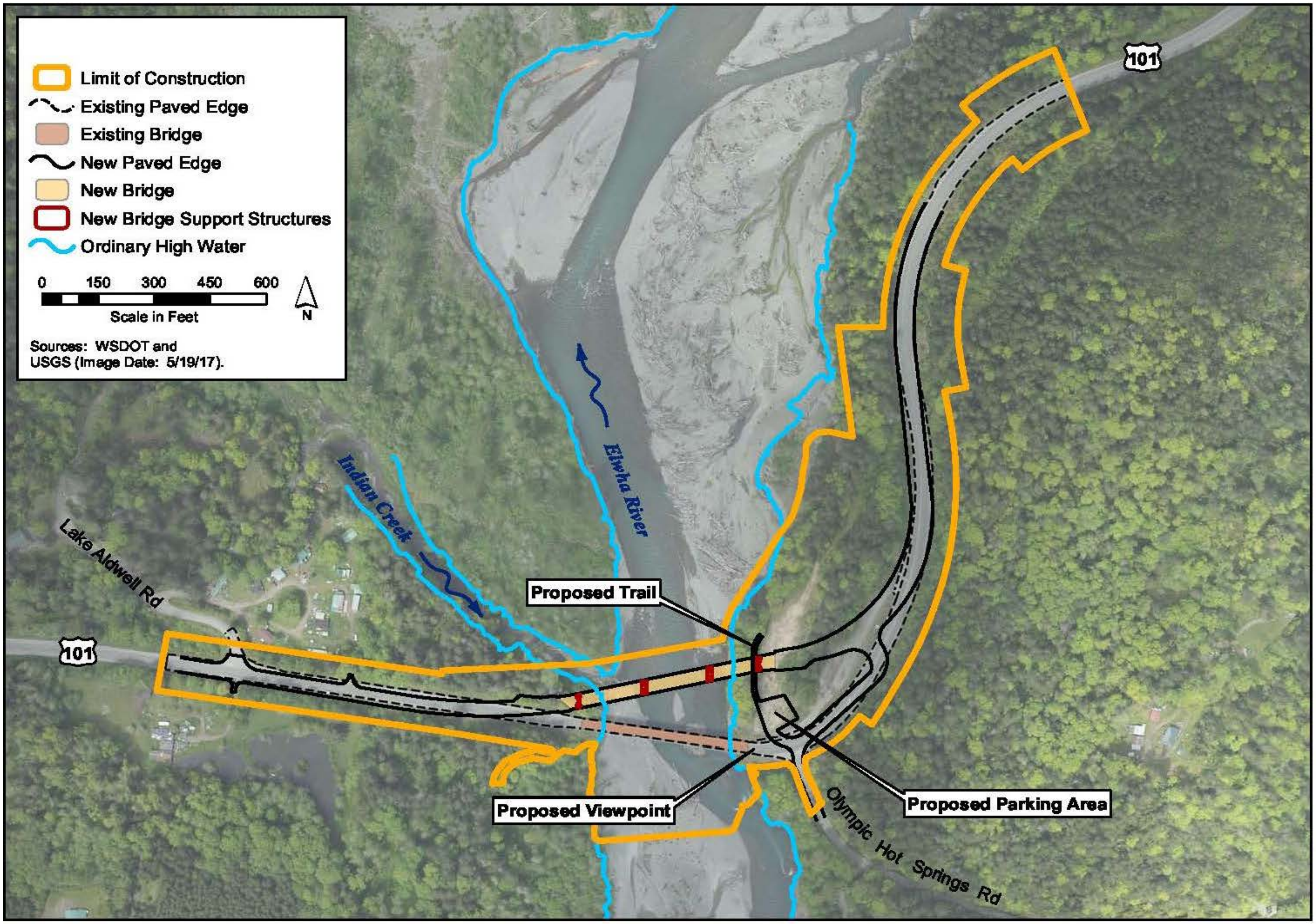

Figure 1. Project Overview of the US 101 Elwha Bridge Replacement Project

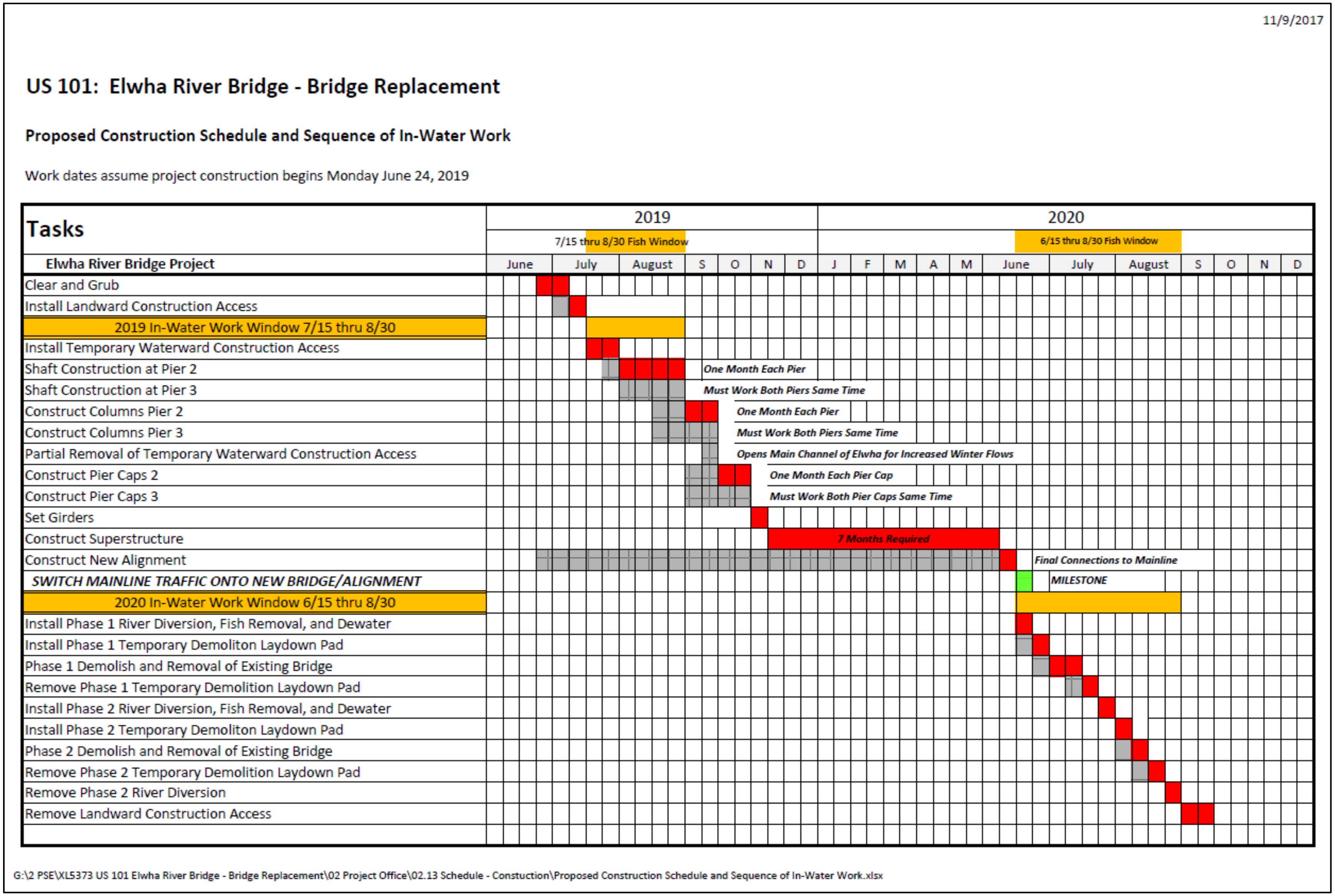

Figure 2. Proposed Construction Schedule and sequence of In-water Work for the US 101 Elwha Bridge Replacement Project

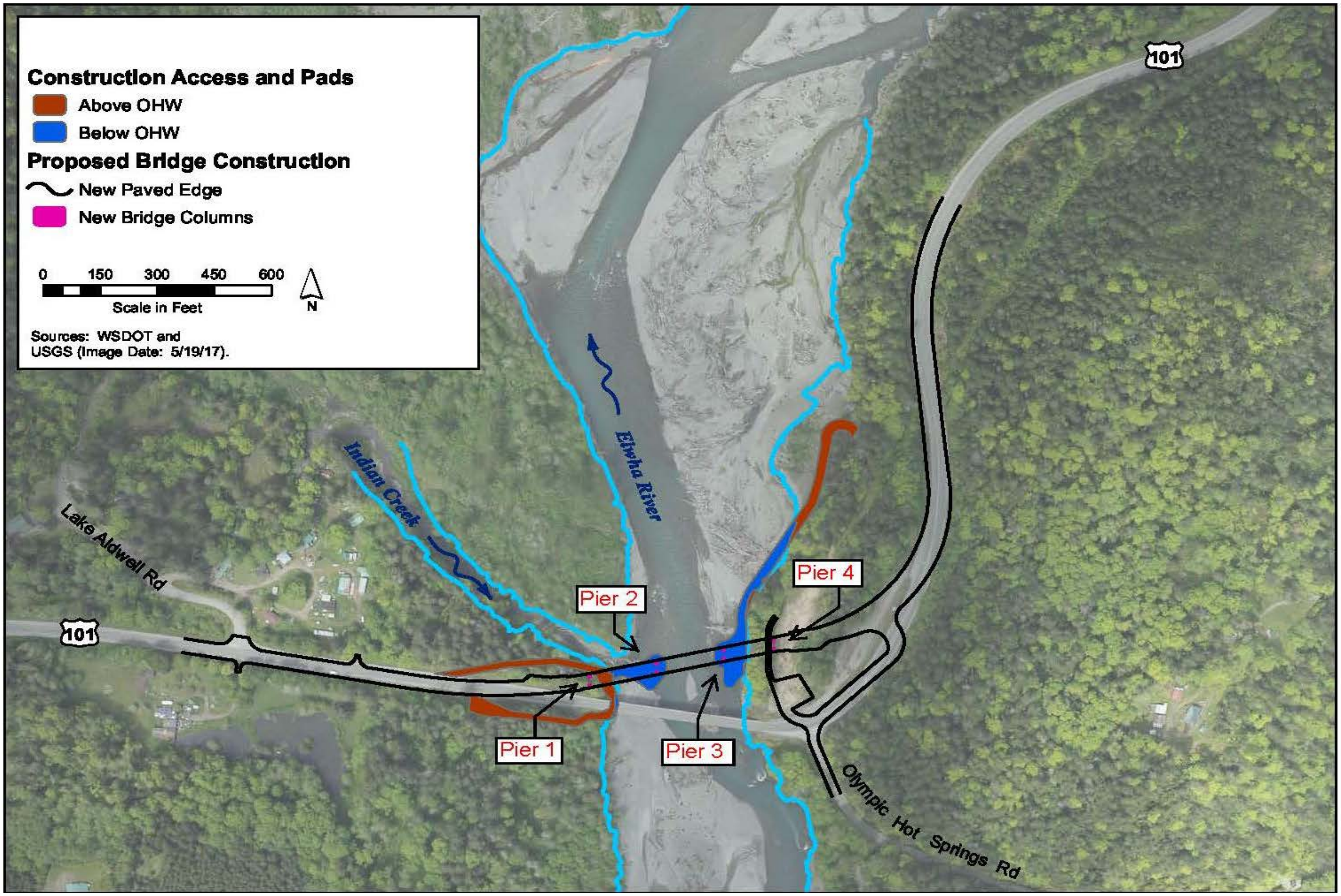

Figure 3. Location of Construction Access Pads for the US 101 Elwha Bridge Replacement Project

Replacement Bridge

The new bridge will be a higher and wider fixed-span concrete girder bridge supported on concrete drilled shafts piers/footings. The new east abutment (right bank of the Elwha River) will be located approximately 250 feet north of the existing abutment; and the new west abutment (left bank of the Elwha River) will be located approximately 60 feet north of the existing west abutment.

The new bridge will be supported by four piers, each composed of two concrete drilled shafts with concrete support columns attached to the top of the drilled shafts. Piers 1 and 4 are located at the west and east abutments, respectively, and are completely outside the OHWM (Figure 3). Piers 2 and 3 are both located within the Elwha River channel, and are designed at a 12-degree skew to the bridge alignment to correlate to river flow (Figure 3). Drilled casings for the new piers will be installed using a crane-mounted casing oscillator to advance the steel casing through the substrate until reaching bedrock, likely at a depth of approximately 10 to 12 feet below the river channel. After the casing has been installed to bedrock, a crane will lower an auger and begin to drill into and remove the substrate and soil material. Once bedrock depth is achieved and material is removed, a conventional rock-drilling crane will take over, continuing into bedrock to a depth of approximately 50 feet.

After the shaft excavation is completed, a prefabricated reinforcing steel shaft cage will be lowered into the excavation. Concrete will be pumped into the casing, and the displaced water and slurry will be transferred to holding tanks or land-based facilities for treatment and reuse or disposal. Drilled shafts will extend above the 100-year flood elevation. For Piers 2 and 3, a single 8-foot-diameter concrete column will extend from the top of each shaft to a cross beam that will connect both columns of the pier. Piers 1 and 4 will not have columns. Instead, the contractor or the WSDOT will construct cast-in-place concrete retaining walls around the north, south, and waterward sides of the shafts to complete the bridge abutments.

The bridge superstructure will be constructed on top of the support columns or retaining walls. The precast-concrete girders will be set by cranes operating from either landward approach sections or the in-channel construction access pads. Roadway deck soffit forms will be supported from the precast girders and will support the reinforcing steel and fresh concrete for the roadway deck. Concrete forms, including the soffit support system, will be removed after the roadway concrete deck has cured and achieved adequate strength. Cast-in-place approach slabs will be constructed landward of each bridge abutment to tie into the roadway alignment. The bridge superstructure will be completed with the installation of barriers and rails.

The substructure construction is proposed from August through October 2019. It will take approximately 8 to 10 weeks to complete the four in-channel bridge support shafts. Construction of the superstructure is expected to begin in November 2019 and to continue through the early part of June 2020.

Roadway Construction

The new bridge alignment will require approximately 0.6 mile of US 101 to be reconstructed, including approximately 0.2 mile west of the new bridge and 0.4 mile east of the new bridge. The roadway improvements will also relocate the intersection of US 101 and Olympic Hot Springs Road approximately 400 feet east and north of its current location to accommodate the new bridge alignment (Figure 1). The new roadway will generally consist of a 12-foot wide travel lane in each direction, with 8-foot wide shoulders on the outer edge of each travel lane. The revised configuration will create approximately 3.27 acres of new or replaced pollution-generating impervious surface (PGIS), resulting in a net increase of 0.38 acre of PGIS. The area of new and replaced PGIS is within the 6.7 acres that will be cleared for the project.

Roadway construction will involve excavation and fills; temporary shoring; embankment and retaining wall construction; reconstruction of existing driveway accesses; and drainage, stormwater, and culvert installations. Embankments will be constructed for the roadway approaches. Retaining walls are proposed at two locations along the proposed roadway and around the bridge abutments. One of the retaining walls is needed to minimize the roadway width and to avoid impacts on a tributary to Indian Creek that passes through a culvert under the roadway. That wall will consist of soldier piles that will be installed using vibratory pile driving methods approximately 1 foot from the OHWM of the tributary. The wall will be approximately 49 feet long and will be outside the flood zone of the creek. Vibratory pile driving will take place over 3 to 4 days during the spring or summer of 2019.

The other retaining wall is needed to stabilize the roadway in an area of steep topography east of the new bridge. Once the embankments and retaining walls are complete, compacted layers of gravel will complete the subgrade before the road is paved with an asphalt surface and the surface is painted. The roadways embankments beyond the shoulders will be vegetated by hydroseeding or other appropriate means. Overall, roadway construction is anticipated to require approximately 8,000 cubic yards of excavation and 46,000 cubic yards of fill. Material removed during excavation may be used as fill at other project construction locations if the materials meet the required standards.

Roadway construction will occur contemporaneously with the new bridge construction, from June 2019 through June 2020. US 101 through traffic will be shifted to the new alignment once the new bridge and roadway have been completed.

Bridge Demolition

After traffic has been shifted to the new alignment (scheduled for mid-June 2020), the existing bridge and remaining roadway sections will be demolished. To ensure that all of the demolition work can be completed within a single in-water construction period, the WSDOT has requested an expanded work window of June 15 to August 30. Demolition will occur in two phases: the first phase (phase 1) involves the demolition of Arches 1 and 2, as well as Piers 5 and 6, from the left-bank side of the river; the second phase (phase 2) involves demolition of Arch 3 and Piers 7 and 8 from the right-bank side of the river (Figure 4). To complete the demolition, portions of the channel will be dewatered, corresponding to the phases.

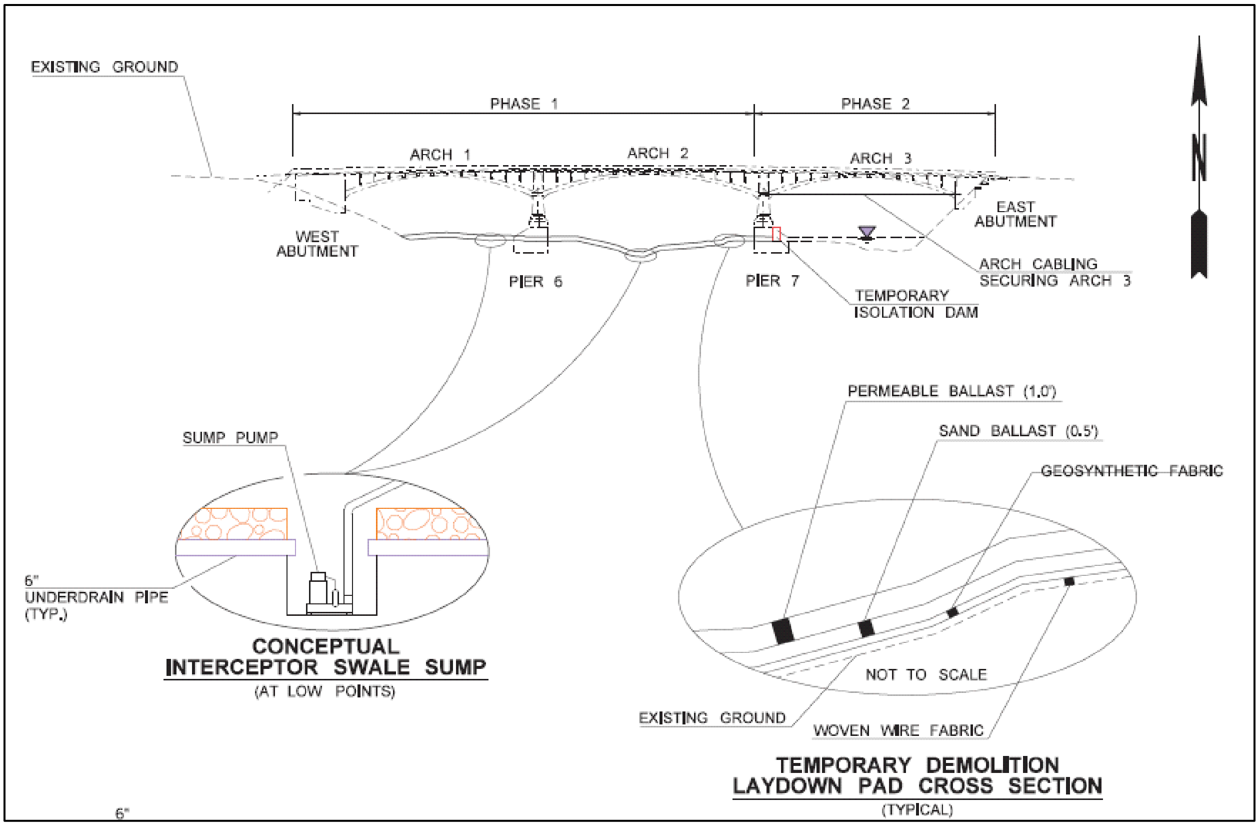

Figure 4. Existing bridge demolition phases for the US 101 Elwha Bridge Replacement Project

For phase 1, a 5,000-cubic-yard bulk bag (e.g., “supersack”) dam, or similar product filled with clean 1- to 3-inch gravel and buttressed with riverbed material, will be used to dewater portions of the channel. The phase 1 cofferdam will be constructed approximately 295 feet upstream of the existing bridge out into the Elwha River channel, around Pier 7, and back to the new Pier 2 construction access pad (Figure 55). The access pad will be designed to accommodate a 10 percent exceedance flow calculated based on flow gage history upstream of the site. The phase 1 cofferdam will be approximately 9 feet wide and 9 feet tall at the tallest location, 860 feet long, and will occupy 2,600 square feet of the channel bed. The cofferdam will dewater an area of approximately 110,000 square feet (2.6 acres) of channel. While the cofferdam is in place, the Elwha River will flow between Pier 7 and the east abutment (Pier 8).

After the cofferdam is in place and the river diversion has stabilized, the area behind the cofferdam will be completely dewatered. Pumps with intake hoses fitted with fish-compliant screening will be installed into the low points of any remaining isolated pool areas. Outlet hoses will be routed to a point downstream of the demolition work activities and back into the Elwha River. Discharge rates will be controlled to meet water quality requirements. The pools will then be dewatered at a maximum rate of 2 inches per hour, allowing aquatic life to migrate with the receding water level, thereby reducing the risk of stranding. Qualified personnel will capture and release any fish, or other remaining aquatic life, back into the natural flow of the Elwha River, pursuant to the WSDOT’s Fish Exclusion Protocols and Standards. The river diversion and dewatering will take 1 week and is planned to begin June 15, 2020.

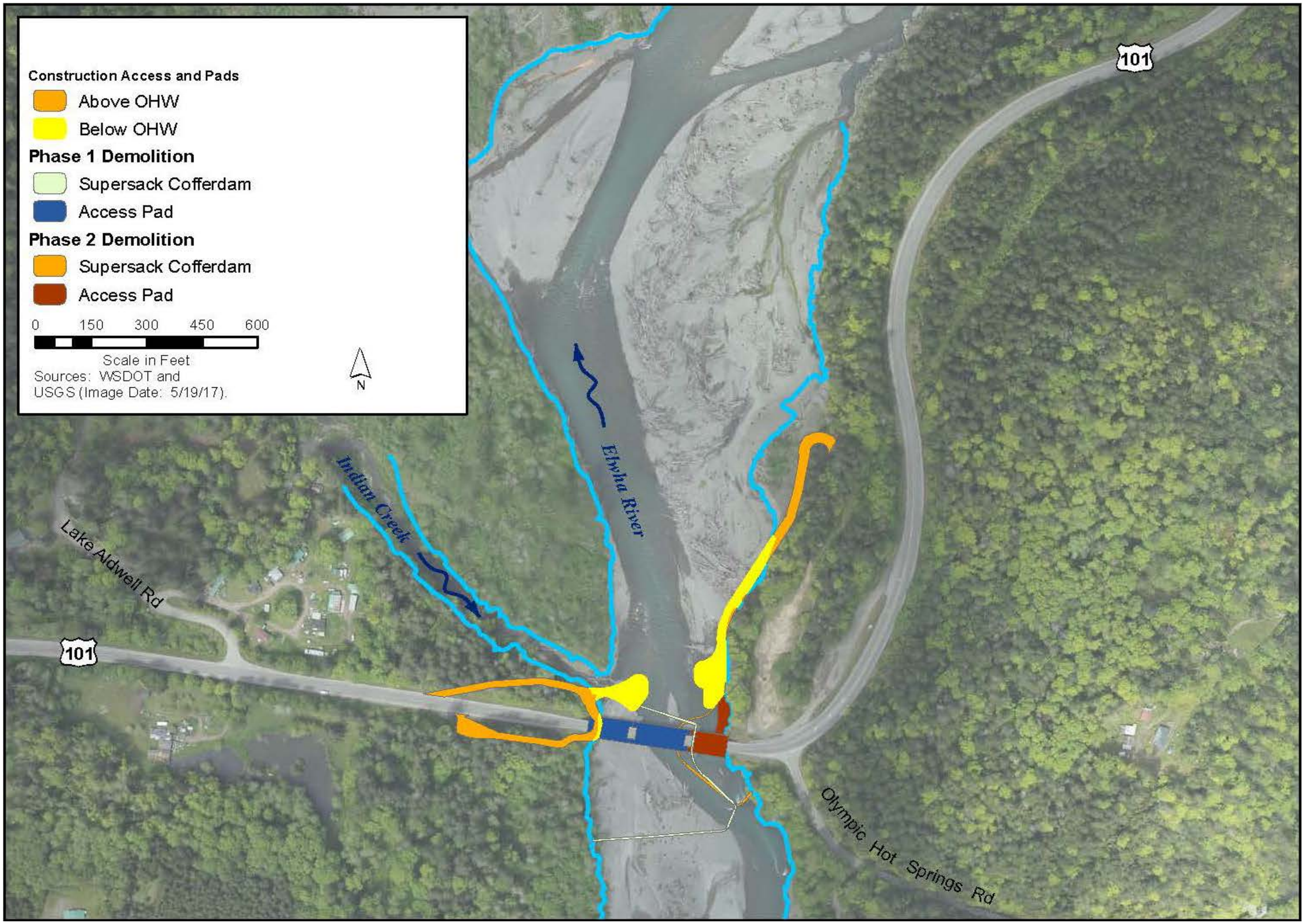

Figure 5. Demolition access for the US 101 Elwha Bridge Replacement Project

An access pad will be constructed in the channel behind the cofferdams for each demolition phase in order to provide equipment access and a surface to capture heavy pieces of concrete debris so they do not enter the river. Once the area is dewatered, a woven wire fabric overlain with a geosynthetic fabric will be installed under the drop zone to provide separation between the native riverbed and the foreign debris. The woven wire layer will also help to ensure complete removal of the geosynthetic fabric and all concrete particulate with no loss of debris into the river, or loss of riverbed material from over-excavating to remove concrete debris. Approximately 900 cubic yards of ballast rock will be used to create a 1.5-foot layer over the woven fabric to provide a work surface for construction workers and equipment, and absorb the impact of falling concrete without damaging the geosynthetic fabric. A construction stormwater interceptor swale will be integrated into the demolition laydown pad that will route runoff to a sump to be pumped to an upland storage tank. Construction of the demolition laydown pad is also expected to take 1 to 2 weeks, beginning the third week of June 2020 (Figure 2).

Following the completion of the phase 1 demolition laydown pad, phase 1 of the bridge demolition can occur, beginning with the bridge deck. Arches 1 and 2 will be removed to facilitate the collapse of the structure, and the remaining arches, piers, and pier footings will be demolished, allowing rubble to free fall onto the demolition laydown pad. The Pier 6 footing and the rock installed during prior emergency repairs will be fully broken down as necessary and removed from the channel bed. The concrete rubble will be transported off site for disposal at an approved upland facility. Phase 1 of the bridge demolition is expected to take 2 to 3 weeks, beginning the last week of June 2020.

The phase 1 temporary demolition laydown pad and the Pier 2 construction access pad will be removed. The materials will either be reused for phase 2 demolition or hauled off site for disposal. The cofferdam will then be dismantled by opening the supersacks and releasing the gravel to the channel bed. The material will be released in a manner that allows for natural redistribution of sediment under normal flows, or strategically placed to fill large voids in the channel bed, such as where the Pier 6 footing will be removed. Removal of the phase 1 temporary demolition structures is expected to last 1 to 2 weeks, beginning the second week of July 2020 (Figure 2).

Phase 2 of the bridge demolition includes removing Pier 7 and Arch 3 on the right bank of the Elwha River. Similar to phase 1, a 400-cubic-yard supersack cofferdam will be constructed out from the right bank, located approximately 160 feet upstream of the bridge, around Pier 7, terminating at the construction access pad for the new bridge Pier 3 (Figure 55). The phase 2 cofferdam will be approximately 9 feet wide, 9 feet tall at the tallest location, and will extend for 480 feet to occupy approximately 1,400 square feet of the channel bed. The area within the cofferdam will be approximately 30,000 square feet (0.7 acre). The phase 2 cofferdam will be constructed and dewatered, and will undergo fish exclusion in the same manner as phase 1. To accommodate streamflow while the cofferdam is in place, the channel will be deepened in an area approximately 600 feet long and 80 feet wide. Channel deepening will reduce stream velocities, reduce scour, and provide a low-flow channel for the river during demolition and removal of the bridge debris. Channel excavation is expected to result in the removal of approximately 4,600 cubic yards of streambed materials. Most of the excavation will occur while the work area is isolated during phase 1 of the demolition. During and after installation of the cofferdam for phase 2, additional excavation may be required. This work is expected to take 1 week to complete and is proposed in the last week of July 2020 (Figure 2).

The remaining phase 2 demolition activities will be similar to those of phase 1. A demolition laydown pad will be constructed along the right bank from the Pier 3 construction access pad, beneath the existing Arch 3, and out to Pier 7. The phase 2 demolition pad ballast material is expected to total 600 cubic yards. Once the demolition laydown pad is in place, demolition of the remaining bridge elements will be conducted in the same manner as phase 1. The demolition work is expected to last 2 weeks, beginning the first week of August 2020.

The total area affected by cofferdam installation, including the area behind the cofferdam, is 144,000 square feet (4,000 square feet of cofferdam area, and 140,000 square feet of area behind the cofferdams). The demolition laydown pad, cofferdam, and construction access pad will be removed from the river following the bridge demolition. Like in phase 1, the supersacks used to create the cofferdam will be opened and the clean gravel used to fill them will be deposited in the channel bed. The gravel either will be placed to fill large voids in the channel bed, or it will be released in a manner that allows for its natural redistribution under normal flows. Angular rock used for ballast or the construction access pad will be completely removed and hauled off site for recycling or disposal. Removal of the laydown pad, cofferdam, and construction access pad is expected to take 4 to 5 weeks, between mid-August and late September 2020 (Figure 2).

Roadway Demolition

The roadway approach sections on either side of the existing bridge will also be demolished in conjunction with the bridge demolition (mid-June to late September 2020). This work will likely consist of saw cutting and/or impact breaking the roadway surface, then removing the asphalt and subgrade with heavy earth-moving machinery. Approximately 28,200 square feet of the existing roadway will be removed, within roughly 150 feet on either side of the existing bridge (Figure 6). Demolished roadway material will be hauled off site for disposal at an approved upland facility.

River Access Features

The eastern abutment of the old bridge, including the foundation, will be removed. Approximately 8,000 square feet of the existing cleared area northeast of the existing bridge will be paved and will serve as a parking area for potential river access and a pedestrian trail. The trail will extend northward approximately 200 feet from the parking area, along the top of the bluff above the right bank of the river. The paved trail will be approximately 14 feet wide and will have 13 feet of vertical clearance beneath the new bridge, to allow access by emergency response vehicles. Access to the trail will be from Olympic Hot Springs Road, approximately 350 feet southwest of the new intersection with US 101 (Figure 1). This work will take approximately 1 to 2 weeks and will be completed towards the end of the project (July 2020).

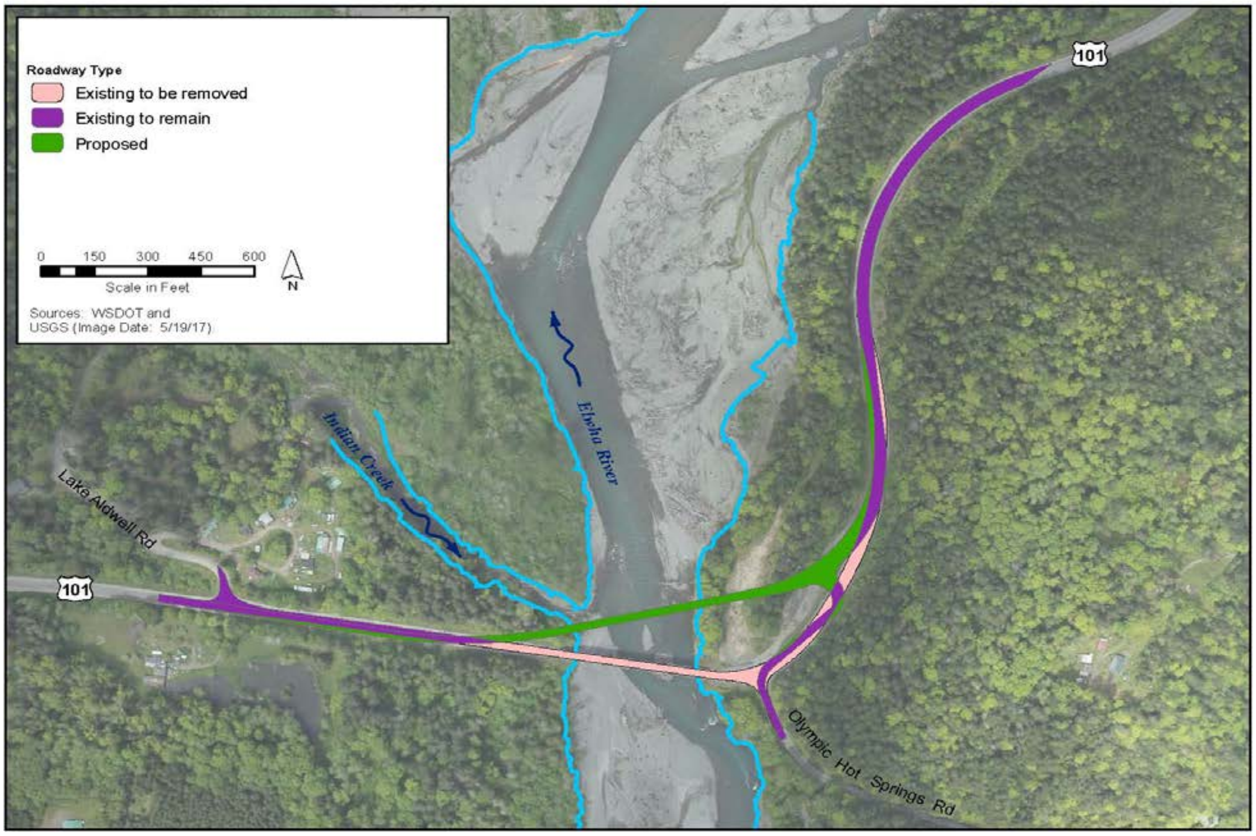

Figure 6. Existing and proposed roadway for the US 101 Elwha Bridge Replacement Project

Restoration and Site Cleanup

The final elements of work will be restoration of temporarily disturbed areas, site cleanup, and demobilization. Temporarily cleared areas will be revegetated with native plant species similar to those removed. Restoration of temporarily disturbed areas will generally follow the standards contained in the WSDOT's Standard Specifications (WSDOT 2016a) for roadside restoration and the Roadside Policy Manual (WSDOT 2015a). These standards include placing topsoil, compost, and soil amendments; planting native species; and adhering to the weed and pest control and plant establishment plans. At the project site, restoration will be based on zones categorized by roadside activities. Zones 1 and 2 closest to the roadway will require some level of ongoing maintenance and will be restored primarily with hydroseeding and planting of low-growing woody vegetation. Outside of those zones, vegetation will be restored with native plant species appropriate to the setting, using standards designed to replace the lost functions of the pre-project conditions.

Of the 6.7 acres cleared for the project, approximately 5.7 acres will be revegetated following completion of project work. Approximately 2 acres of the restoration area will consist of roadway zones 1 and 2 (hydroseeding and planted low-growing vegetation), while the remaining 3.7 acres will consist of native forested plantings sourced from the Olympic National Park Native Plant Nursery. Of the total 5.7 acres that will be revegetated, 2.5 acres are within the riparian buffer (1.8 acres will be planted with native stock; 0.7 acre will consist of roadway zones 1 and 2). Site revegetation will take place during the first planting window following construction (October 1, 2020, to March 1, 2021).

As a final element of construction in conjunction with site restoration, all remaining construction materials, debris, and equipment will be removed from the site. All construction debris will be hauled to an approved disposal facility. Site restoration and cleanup will take place in September 2020 and is expected to last 2 to 3 weeks.

Stormwater Management

The project will result in a net increase of 0.38 acre of PGIS for a total of 3.27 acres of new and replaced PGIS. Approximately 1.49 acres (46 percent) of new and replaced PGIS will receive water quality treatment. The WSDOT will install water quality treatment facilities along new roadway segments and will construct stormwater conveyance structures to carry stormwater to planned discharge points. Stormwater will sheet flow off the roadway into roadside swales, ditches, and filter strips, where runoff treatment methods will be installed. Cross culverts will be used where needed to convey water across the roadway. Treatment options will consist primarily of biofiltration best management practices (BMPs), such as vegetated filter strips, biofiltration swales, media filter drains, or bioswales. There are currently no established stormwater BMPs providing water quality treatment within the project limits. Approximately 1.78 acres (54 percent) of the 3.27 acres will continue to have no water quality treatment BMPs after the project.

Conservation Measures

The WSDOT's standard conservation measures are described in detail in the USFWS' Programmatic Biological Opinion for WSDOT Projects in Washington State (USFWS 2015a), the WSDOT's Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT 2016a), and the WSDOT's Roadside Policy Manual (WSDOT 2015a), and they are incorporated here by reference. Additional BMPs that will be incorporated into the project are listed on pages 24 through 28 of the BA, and are also hereby incorporated by reference.

Many of the conservation measures described in the BA will minimize the impacts of delivering sediment to waterbodies, introducing pollutants to waterbodies, and disturbance or removal of riparian habitat. Conservation measures specifically related to the listed species in the Concurrence and Opinion sections of this report include:

- Disturbance to riparian vegetation from the operation of heavy equipment will be minimized as much as practicable by straddling the vegetation with heavy equipment or by pruning it without damaging the roots. Existing riparian vegetation outside of the work area will not be removed or disturbed.

- Temporary erosion and sediment control measures will be implemented before any clearing or grubbing activities.

- The contractor will designate at least one employee as the erosion and spill control lead. That person will be responsible for installing and monitoring erosion control measures and maintaining spill containment and control equipment. The erosion and spill control lead will also be responsible for ensuring compliance with all local, state, and federal erosion and sediment control requirements, including discharge monitoring reporting for the Washington State Department of Ecology.

- Erosion control blankets or an equally effective BMP will be installed on steep slopes that are susceptible to erosion and where ground-disturbing activities have occurred. Doing so will prevent erosion and assist with establishment of native vegetation.

- Project staging and material storage areas will be located a minimum of 150 feet from surface waters or in currently developed areas such as parking lots or previously developed sites.

- Erodible material that may be temporarily stored for use in project activities will be covered with plastic or other impervious material during rain events to prevent sediments from being washed from the storage area to surface waters.

- Exposed soils will be seeded and covered with straw mulch or an equally effective BMP after construction is complete. Any temporary construction impact areas will be revegetated with native plants following final grading activities.

- All exposed soils will be stabilized during the first available opportunity, and no soils shall remain exposed for more than 2 days from October 1 to April 30, and for more than 7 days from May 1 to September 30.

- Any areas disturbed on a temporary basis will be permanently stabilized and restored in a manner consistent with the WSDOT's Roadside Policy Manual (WSDOT 2015). The WSDOT will remove any temporary fills and till-compacted soils, and restore woody and herbaceous vegetation according to an engineer-approved restoration or planting plan.

- A minimum 1-year plant establishment plan will be implemented to ensure survival, or replacement, of vegetation by stem count at the end of 1 year.

- Elwha River flows will be monitored throughout construction using the Northwest River Forecast Center station at McDonald Bridge, upstream of the project site. During flow events approaching the 2-year discharge, equipment and materials will be moved off the access pads until water levels subside.

- During flow events approaching the 2-year discharge, equipment and materials will be moved off the demolition laydown pads until waters subside. Portions of the cofferdam may be selectively removed to provide flow relief and prevent catastrophic failure.

- River diversion for phase 2 of the bridge demolition will occur prior to August 15 to minimize potential effects on early Chinook salmon (*Oncorhynchus tshawytscha*) spawning.

- The channel bed and gravel borrow areas will be inspected and large depressions or voids will be filled with bulk bag streambed material to smooth out unnatural grades.

- Fish use and timing will be monitored during the 2019 in-water work window (July 15 to August 31) to validate the adequacy of proposed flexibility of the 2020 in-water work window (June 15 to August 30).

- Before, during, and immediately after isolation and dewatering of the in-water work area, fish from the isolated area will be captured and released using methods that minimize the risk of fish injury, in accordance with the WSDOT protocols for such activities (WSDOT 2012).

Action Area

The action area is defined as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment. The terrestrial extent of the action area is based on the geographic extent of in-air sound from construction and demolition activities, as depicted in Figure 7. The loudest project-related noise levels will be associated with the vibratory driving of soldier piles (approximately 101 A-weighted decibels), which will attenuate background levels approximately 2.6 miles from the project site.

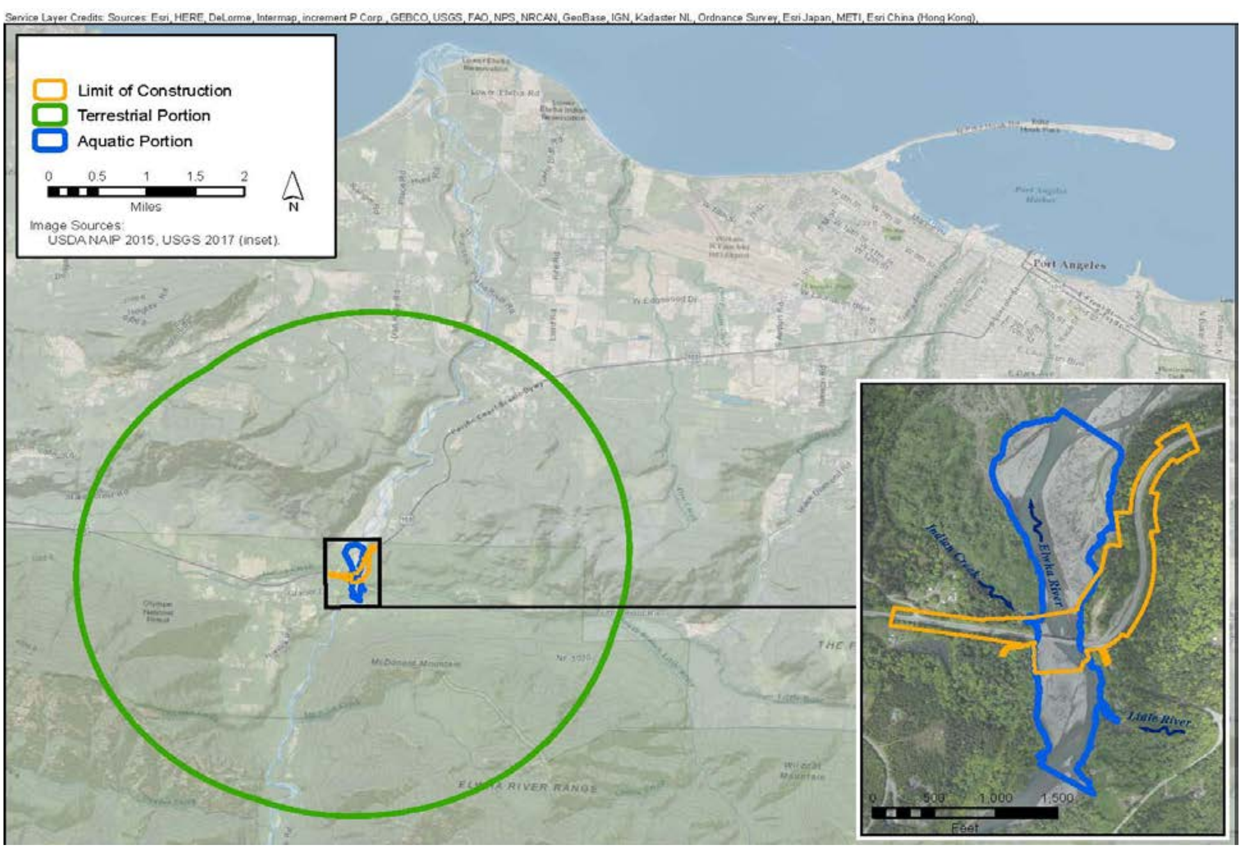

Figure 7. Project Action Area for the US 101 Elwha Bridge Replacement Project

The aquatic extent of the action area is a smaller area encompassed within the action area, and is also shown in Figure 7. The aquatic extent of the action area is composed of a combined area of 2,400 feet downstream of the existing bridge and 1,300 feet upstream of the existing bridge. Even with the implementation of BMPs, in-water construction will generate suspended sediment and turbidity effects, conservatively estimated to extend up to 2,400 feet downstream from the existing bridge. Based on the results of a two-dimensional hydraulic modelling analysis, the hydraulic effect of the action with the greatest upstream spatial extent is derived from backwater conditions formed by the river diversion and cofferdams during construction. Under a worst-case flow scenario, the backwater conditions associated with the river diversion and cofferdams will extend approximately 1,300 feet upstream of the planned cofferdam, 200 feet into the lower reach of the Little River, and 150 feet into the lower reach of Indian Creek. Stormwater runoff from the project will discharge to the Elwha River, Indian creek, and an unnamed tributary to Indian Creek

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

The following analysis relies on four components: 1) the *Status of the Species*, which evaluates the rangewide condition of the listed species addressed, the factors responsible for that condition, and the species' survival and recovery needs; 2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; 3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed federal action and the effects of any interrelated or interdependent activities on the species; and 4) *Cumulative Effects*, which evaluates the effects of future, non-federal activities in the action area on the species.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed federal action in the context of the species' current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of listed species in the wild.

The jeopardy analysis in this Opinion emphasizes the rangewide survival and recovery needs of the listed species and the role of the action area in providing for those needs. It is within this context that we evaluate the significance of the proposed federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Adverse Modification Determination

Section 7(a)(2) of the ESA requires that federal agencies insure that any action they authorize, fund, or carry out is not likely to destroy or to adversely modify designated critical habitat. A final rule revising the regulatory definition of "destruction or adverse modification of critical habitat" was published on February 11, 2016 (81 FR 7214). The final rule became effective on March 14, 2016. The revised definition states: "Destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features."

Past designations of critical habitat have used the terms "primary constituent elements" (PCEs), "physical or biological features" (PBFs) or "essential features" to characterize the key components of critical habitat that provide for the conservation of the listed species. The new critical habitat regulations (79 FR 27066) discontinue use of the terms "PCEs" or "essential features," and rely exclusively on use of the term "PBFs" for that purpose because that term is contained in the statute. However, the shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs or essential features. For those reasons, in this Opinion, references to PCEs or essential features should be viewed as synonymous with PBFs. All of these terms characterize the key components of critical habitat that provide for the conservation of the listed species.

Our analysis for destruction or adverse modification of critical habitat relies on four components: 1) the Status of Critical Habitat, which evaluates the range-wide condition of designated critical habitat for the bull trout in terms of essential features, PCEs, or PBFs, depending on which of these terms was relied upon in the designation, the factors responsible for that condition, and the intended recovery function of the critical habitat overall; 2) the Environmental Baseline, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; 3) the Effects of the Action, which determines the direct and indirect impacts of the proposed federal action and the effects of any interrelated or interdependent activities on the essential features, PCEs, or PBFs and how those effects are likely to influence the recovery role of affected critical habitat units; and 4) Cumulative Effects, which evaluates the effects of future, non-federal activities in the action area on the essential features, PCEs, or PBFs and how those effects are likely to influence the recovery role of affected critical habitat units.

For purposes of making the destruction or adverse modification finding, the effects of the proposed federal action, together with any cumulative effects, are evaluated to determine if the critical habitat rangewide would remain functional (or retain the current ability for the PBFs to be functionally re-established in areas of currently unsuitable but capable habitat) to serve its intended conservation/recovery role for the species.

STATUS OF THE SPECIES: Bull Trout

The bull trout was listed as a threatened species in the coterminous United States in 1999. Throughout its range, the bull trout is threatened by the combined effects of habitat degradation, fragmentation, and alteration (associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, and poor water quality), incidental angler harvest, entrainment, and introduced nonnative species (64 FR 58910 [November 1, 1999]). Since the listing of bull trout, there has been very little change in the general distribution of bull trout in the coterminous United States, and we are not aware that any known, occupied bull trout core areas have been extirpated (USFWS 2015b, p. iii).

The 2015 recovery plan for bull trout identifies six recovery units of bull trout within the listed range of the species (USFWS 2015b, p. 34). Each of the six recovery units are further organized into multiple bull trout core areas, which are mapped as non-overlapping watershed-based polygons, and each core area includes one or more local populations. Within the coterminous United States, we currently recognize 109 currently occupied bull trout core areas, which comprise 600 or more local populations (USFWS 2015b, p. 34). Core areas are functionally similar to bull trout metapopulations, in that bull trout within a core area are much more likely to interact, both spatially and temporally, than are bull trout from separate core areas.

The USFWS has also identified a number of marine or mainstem riverine habitat areas outside of bull trout core areas that provide foraging, migration and overwintering (FMO) habitat that may be shared by bull trout originating from multiple core areas. The shared FMO areas support the viability of bull trout populations by contributing to successful overwintering survival and dispersal among core areas (USFWS 2015b, p. 35).

For a detailed account of bull trout biology, life history, threats, demography, and conservation needs, refer to Appendix A: Status of the Species: Bull Trout.

STATUS OF CRITICAL HABITAT: Bull Trout

Bull trout critical habitat was designated in the coterminous United States in 2010. The condition of bull trout critical habitat varies from poor too good across the species' range. Although still relatively widely distributed across their historical range, bull trout occur in low numbers in many areas. Overall bull trout abundance is "stable" rangewide (USFWS 2015b, p. iii). However, 81 core areas have 1,000 or fewer adults, with 24 core areas not having surveys conducted to determine adult abundance (USFWS 2008, p. 22; USFWS 2015c, p. 2). In addition, 23 core areas have declining populations, with 66 core areas having insufficient information (USFWS 2008, p. 25; USFWS 2015c, p. 2). These numbers reflect the condition of bull trout habitat. The decline of bull trout is primarily due to habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, impoundments, dams, water diversions, and the introduction of nonnative species (63 FR 31647, June 10, 1998; 64 FR 17112, April 8, 1999).

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded the PCEs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Dunham and Rieman 1999, p. 652; Rieman and McIntyre 1993, p. 7); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989, p. 141; MBTSG 1998, pp. ii–v, 20–45); 3) the introduction and spread of nonnative fish species, particularly brook trout (*Salvelinus fontinalis*) and lake trout (*S. namaycush*), as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, p. 857; Rieman et al. 2006, pp. 73–76); 4) in the Puget Sound and Olympic Peninsula geographic regions where anadromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

For a detailed account of the status of the designated bull trout critical habitat, refer to Appendix B: Status of Designated Critical Habitat: Bull Trout.

ENVIRONMENTAL BASELINE: Bull Trout and Designated Bull Trout Critical Habitat

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the past and present impacts of all federal, state, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed federal projects in the action area that have undergone section 7 consultation, and the impacts of state and private actions which are contemporaneous with the consultation in progress.

The action area for the project encompasses an area over 25 square miles, which includes lands within Olympic National Park, Olympic National Forest, private ownership, and about 7 river miles (RM) of the Elwha River. The aquatic portion of the action area includes a 3,700-foot reach of the Elwha River and the lower portions of Indian Creek and the Little River where they join the Elwha River (Figure 7).

The Elwha River watershed is a dynamic system currently in a state of flux because of the recent removal of two hydroelectric dams. The Elwha and Glines Canyon Dams (dams) were constructed on the Elwha River without fish passage facilities: the Elwha Dam at RM 4.9 in 1912 (approximately 1.5 miles downstream from the project site) and the Glines Canyon Dam at RM 13.4 in 1925 (approximately 5 miles upstream from the project site). The dams limited anadromous salmonids to the lower 4.9 river miles of the Elwha River, a short reach accessible to the ocean but lacking tributaries. In 1992, the Elwha River Ecosystem and Fisheries Restoration Act (PL 102-495) was passed, delegating the National Park Service to remove the dams and to fully restore the Elwha River ecosystem and native anadromous fisheries. Removal of the Elwha dam began in September 2011 and was completed in March 2012, followed by the removal of the Glines Canyon Dam, which was completed in August 2014.

The Elwha River originates in Olympic National Park. Roughly 83 percent of the watershed occurs within the park's wilderness area. The river drains nearly 322 square miles, flowing 48 miles from glaciers and ice fields at the headwaters, down to its confluence with the Strait of Juan de Fuca in the Pacific Ocean (Pess et al. 2008). The highest elevation in the watershed is 7,320 feet (relative to the North American Vertical Datum of 1988 [NAVD88]) and the mean basin elevation is 3,570 feet (NAVD88). The elevation at the US 101 crossing is approximately

190 feet (NAVD88). Land use in most of the drainage basin is a combination of forests and pasture with some rural residential development near US 101. Forest covers approximately 71 percent of the watershed (WSDOT 2016b).

The geomorphology of the Elwha River Basin is a series of alternating canyons and floodplains. The depositional reaches between the canyons are generally lower in gradient, contain wide gravel bars, and are braided channels with pool-riffle morphology (Brenkman et al. 2012). There are 34 named tributaries that flow into the Elwha River, 33 of which are upstream of the former dam sites and were not accessible to anadromous salmonids during the over 100-year period of dam operation (Brenkman et al. 2012).

The climate within the Elwha River basin is characterized by cool, wet winters and dry, warm summers, with most precipitation at higher elevations falling as snow (Duda et al. 2008). River discharges follow a bi-modal pattern, with a spring peak when the accumulated snow pack melts, followed by a dry summer period before a second peak when rainfall increases in late autumn (Duda et al. 2008). Average annual rainfall ranges from 100 centimeters per year near the mouth to over 550 centimeters per year in the headwaters (Duda et al. 2008), with a mean annual precipitation of approximately 83 inches within the contributing basin (WSDOT 2016b).

The US 101 bridge crosses the Elwha River at approximately RM 7.7. Prior to dam removal this area was near the upper limits of Lake Aldwell, the impoundment above the Elwha Dam. When the dams were constructed, the dam reservoirs inundated former riverine and riparian habitat, trapped sediments and woody debris from upstream sources, and increased downstream water temperatures in late summer and early fall because of heat storage in the reservoirs (Wunderlich et al. 1994). These changes caused the river to form a single, wandering, gravel-bed channel downstream of the dams, with predominately cobble grain size bed material (East et al. 2015). Mature riparian vegetation developed on stable river bars in the regulated portion of the river.

Removal of the dams released more than 10.5 million metric tons of sediment in the first 2 years following removal (East et al. 2015). The natural annual sediment load would have been 217,000 to 513,000 metric tons (Curran et al. 2009; Czuba et al. 2011). The release of that large volume of sediment produced extensive physical responses in the Elwha River. Initial stages of dam removal resulted in the release of fine sediment, followed by coarser sediment near the completion of dam removal, particularly after the removal of the Glines Canyon Dam (East et al. 2015). In the first 2 years following dam removal, the river bed rose by more than 3 feet, aggrading riffle crests, shifting the river towards a braided morphology, and decreasing the gradient of the lower Elwha River (East et al. 2015). Sediment filled in pools, and as mainstem bed aggradation forced flow through floodplain channels, sediment was deposited in the side channels of the Elwha River floodplain, which acted as sediment sinks, particularly in the middle reach (East et al. 2015; Peters et al. 2017). Near the former reservoirs, tree cover that had developed within the floodplain was mobilized and incorporated into the river as large woody debris.

In later stages, the concentration of flow in the mainstem channel (as floodplain side channels filled) led to scour of the accumulated sediment in the mainstem, followed by incision of the mainstem channel. Currently, conditions in the mainstem indicate the bed has degraded back to its original elevation and is re-exposing the cobble substrates and newly deposited gravel substrates (Peters et al. 2017). Wood has begun accumulating on newly developed gravel bars. Recent studies estimate that most (nearly 70 percent) of the sediment stored in the reservoirs behind the former Elwha River dams had been transported downstream by April 27, 2015 (the date of the last significant winter storm of that year). Much of the remaining sediment is anticipated to be retained given the channel incision that has occurred, which resulted in a well-developed channel being reestablished through both former reservoirs (Ritchie et al. 2016). Data on distribution of flows and sediment production collected between April 2015 and April 2016 indicate that low flow concentrations have returned to normal levels consistent with a natural river. Those data also indicate that turbidities are quite high during flood events (higher than 5,000 nephelometric turbidity units [NTU] during winter flood events and less than 20 NTU during summer low flows) and are likely to remain so for the foreseeable future (Herrera 2016).

The geomorphic evolution of the Elwha River represents conditions greatly exceeding natural flood conditions in the past. Changes in topography, grain size, and channels are the result of the artificial imbalance in sediment supply and transport capacity conditions created by dam removal (East et al. 2015). The data on distribution of flows and sediment production collected for the year April 2015 to April 2016 can reasonably be assumed to represent annual average existing conditions and can be used as an estimation of future river conditions, although significant variability from year to year is expected, dependent on the amount and timing of annual precipitation (Herrera 2016).

Based on site-specific information provided in the BA, the Elwha River has undergone dramatic change in the project vicinity since the dam removal, consistent with the large-scale changes in the river. Between 2013 and 2015, a large section of riparian forest on the left bank upstream of the bridge was washed away, exposing a large gravel bar. That channel adjustment also resulted in the relocation of the confluence of Indian Creek by several hundred feet downstream of its former location. The movement of the Indian Creek confluence has occurred as the left bank eroded and the confluence moved up the former Indian Creek channel (WSDOT 2017).

In its current condition, the Elwha River within the action area can generally be characterized as a pool-riffle type of channel, with laterally oscillating bars, pools, and riffles. Downstream of the existing bridge, the channel becomes braided as it continues to adjust to sediment deposition and mobilization in the former Lake Aldwell reservoir, which is now largely unconfined floodplain. The channel bed is composed of well-sorted sediments, ranging from boulder-sized particles to finer sands and silts. Large woody debris accumulations are prevalent on the gravels bars, particularly downstream on the former Lake Aldwell delta. The right bank of the Elwha River near the bridge consists of bedrock, and a bedrock outcrop occurs mid-channel upstream of the bridge (WSDOT 2017).

The Little River flows into the Elwha River roughly 900 feet upstream from the existing bridge. The river drains an area of approximately 47.5 square miles. The Washington State Department of Ecology lists water quality as extraordinary (WDOE 2016). Bull trout redds have been documented in the lower reaches of the river near the confluence with the Elwha River. Brook trout spawning has also been documented in the Little River, and the USFWS has identified potential competition and hybridization with brook trout in this area as a concern (USFWS 2015c).

Indian Creek has a drainage basin of 18.6 square miles. Compared to the Elwha River, Indian Creek has a more uni-modal hydrograph, with peak flows mainly in the rainy winter months and flows decreasing throughout the summer. Monthly flows vary between approximately 10 and 240 cubic feet per second (cfs) (WSDOT 2017). A tributary to Indian Creek flows through a culvert underneath US 101 on the west side of the existing bridge within the action area. That culvert is a partial barrier to fish passage due to slope (WSDOT 2018).

Current Condition of Bull Trout in the Action Area

The range of the bull trout is divided into six recovery units based on major watersheds, genetic relationships, and the physical and environmental factors that influence the biogeographical distribution of the bull trout (USFWS 2015b, p. 36). The action area for the project is in the Coastal Recovery Unit for the bull trout, which encompasses the Olympic Peninsula, Puget Sound, and Lower Columbia River basins, and 21 bull trout core areas (USFWS 2015b).

Bull trout use the action area primarily for foraging and migration. Spawning and rearing occur in the upper watershed. Spawning has also recently been documented in the lower reaches of the Little River. Adult upstream migration occurs in the fall (September to November), with peak spawning in late October. Eighty-six bull trout were as part of a radio telemetry study in the Elwha River following dam removal (Geffre et al. 2016). The majority of fish migrated downstream to the river mouth after release, and did not move back upstream. Eighteen tagged fish ascended the former Elwha dam site during flow rates ranging from 283 to 2,160 cfs. In 2016, another 13 bull trout ascended the Glines canyon Dam site during discharges of 291 to 2,570 cfs. Most individuals in the action area would be adult or subadult fish, but some juveniles could be present. Juvenile, subadult, and non-spawning adult bull trout could occur in low densities in the action area throughout the year (Geffre et al. 2016).

Elwha River Core Area

The Elwha River core area, part of the Coastal Recovery Unit, includes the Elwha River and its tributaries including Boulder, Cat, Prescott, Stony, Hayes Godkin, Buckinghorse, and Delabarre Creeks; the former locations of Lake Mills and Lake Aldwell; and the estuary of the Elwha River. The Elwha River core area is one of two core areas on the Olympic Peninsula that drain to the Strait of Juan de Fuca.

Anadromous, fluvial, and resident bull trout life-history forms are all present within the Elwha River core area. With the removal of the Elwha River dams and resulting elimination of the reservoirs, the adfluvial life-history form that was present is reverting back to the historical fluvial and anadromous forms (Crain and Brenkman 2010, p. 16; DeHaan et al. 2011, p. 472). Prior to the dam removals, bull trout were documented spawning in the area directly above Lake Mills (approximately RM 25) (Crain and Brenkman 2009). Dam removal likely altered that known spawning site (Crain and Brenkman 2010). Another suspected spawning location may occur in the Elwha River near the confluence of the Hayes River (Crain and Brenkman 2009). New spawning habitat/sites for bull trout likely will develop over time in the restored reaches. There is little habitat suitable for bull trout spawning and incubation downstream of the former dam locations.

The Elwha River core area population is considered “at risk” for extirpation (USFWS 2008a). The status of a bull trout core area population can be summarized by four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004).

Number and Distribution of Local Populations

Two local populations and one potential local population are recognized within the Elwha River core area (USFWS 2015c). One local population is in the Elwha headwaters (upstream of Carlson Canyon) and appears to consist mainly of the resident life-history form (DeHaan et al. 2011). The other local population occupies the area downstream of Carlson Canyon and primarily contains the migratory life-history form. The Little River has been identified as a potential local population, based on the availability of suitable habitat and the likelihood that the high quality spawning habitat would be used by migratory bull trout once the dams were removed. With only two local populations, bull trout in the Elwha River core area are considered at increased risk of extirpation and adverse effects from random naturally occurring events (USFWS 2004).

Adult Abundance

Bull trout abundance in the Elwha River system is not known (USFWS 2008a). Prior to the dam removals, the numbers were assumed to be moderately low. Prior to the species’ listing, bull trout observations were limited in the Elwha River below the Elwha Dam at the Washington Department of Fish and Wildlife (WDFW) Chinook rearing channel (Travers, in litt. 2002). Thirty-one bull trout, ranging in size from 250 to 620 millimeters, were documented in this section of the river during snorkel surveys in 2003 (Pess, in litt. 2003). In 2007, 215 bull trout were observed during snorkel surveys from RM 41 to the mouth of the Elwha River (USFWS 2008b). There is no information on trends in abundance of Elwha River bull trout. Core areas with fewer than 1,000 spawning adults per year are at risk from genetic drift, and local populations with fewer than 100 spawning adults per year are at risk from inbreeding depression (USFWS 2004). Bull trout in the Elwha River core area are considered at risk from such effects until more is known about adult abundance.

The bull trout population in the Elwha River core area is considered at risk of extirpation (USFWS 2008a). The Elwha River core area showed reduced levels of within-population genetic variation when compared to larger populations from other core areas; there was no indication that the fragmentation caused by the Elwha River dams has led to the evolution of genetically distinct spawning populations within the Elwha River core area (DeHaan et al. 2011).

Productivity

There has been only limited monitoring of the bull trout in the Elwha River, so no trend data are currently available. Low bull trout abundance in the Elwha River core area indicates that this population is at risk of extirpation.

Connectivity

In August 2014, the removal of the Elwha and Glines Canyon Dams was finished. With full restoration of fish passage complete with the removal of the dams, future studies will indicate bull trout movement throughout the watershed. No barriers exist within the mainstem Elwha River and the lower reaches of its tributaries. The removal of the dams on the Elwha River has provided connectivity between the local populations within the Elwha River core area.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, federal actions occurring in the Elwha River core area have resulted in harm to or harassment of bull trout, much of which was specifically related to construction activities. The federal actions have included: statewide federal restoration programs with riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and Section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. The removal of Elwha and Glines Canyon Dams, as part of the Elwha River Restoration Project, represents a federal action with long-term improvement of bull trout habitat and core population. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have also directly affected bull trout in the Elwha River core area (e.g., Crain and Hugunin 2012).

The number of non-federal actions occurring in the Elwha River core area since the bull trout listing is unknown. However, because most of the core area is in federal ownership, few non-federal actions likely have occurred in this core area.

Threats

There are four primary threats to bull trout in the Elwha River core area: limits to fish passage, low instream flows, limited prey availability, and competition from nonnative fish (USFWS 2015c).

Instream Impacts: Fish Passage Issues – Fish passage difficulty at former dam sites.

Water Quality: Instream Flows – Adequate water quantity within the lower river will need to be maintained into the future, as municipal water rights currently exceed summer flows. Exercising full water rights will seasonally alter instream habitat and impair connectivity for migration; ongoing loss of glaciers associated with climate change is expected to exacerbate low instream flows.

Forage Fish Availability: Prey base – Although dam removal has been completed, salmon and steelhead populations are only in the early rebuilding phase and may require additional habitat and/or fish management intervention to fully restore the freshwater prey base in the Elwha River watershed.

Nonnative Fishes: Competition and Hybridization – With the removal of the dams, brook trout now overlap tributary spawning areas for bull trout in Indian, Griff, and Hughes Creeks, and in the Little River, creating significant potential for species competition and hybridization.

Additional threats to bull trout in the Elwha River core area include (USFWS 2016):

- Past logging on private lands in the Elwha River core area, outside of Olympic National Park, has affected water quality through the release of fine sediment, which potentially affects bull trout egg incubation success and juvenile rearing.

- Impacts from residential and urban development occur mainly in the lower Elwha River. Dike construction has constricted the channel and severely affected nearshore and estuary habitat and processes.

- Bull trout are susceptible to incidental mortality associated with fisheries that target commercially desirable species such as coho (*Oncorhynchus kisutch*) and steelhead (*O. mykiss*) in the lower river and recreational fishing in Olympic National Park. A moratorium on all fishing in the Elwha River was put in place between March 1, 2012, and June 1, 2019, to assist with the recovery and colonization of the Elwha River watershed following dam removal.

- Stranding and crushing of bull trout occurs during the Port Angeles Water District's routine maintenance and repair operations.

Most of the Elwha River watershed (85 percent) is within Olympic National Park, which minimizes outside stressors to bull trout and their habitat. The watershed is identified as a "transient" watershed because it is currently a snowmelt-dominated system that is projected to become a rain-dominated system due to climate change (Halofsky et al. 2011). This change will result in modifications to stream flow and temperature, which will cause a decline in the quality and quantity of bull trout habitat. Simulations of the monthly and average total base flows based on global climate models indicate that average total runoff and base flow depths will increase during the fall through early spring and will decrease in the summer compared to simulated historical conditions (Halofsky et al. 2011). The lower summer flows will allow streams to be more influenced by increased air temperatures (ISAB 2007). With projected increases in air temperature, especially in the lower elevations of this core area (Halofsky et al. 2011), water temperatures are also anticipated to increase.

Current Condition of Bull Trout Critical Habitat in the Action Area

In 2010, the USFWS identified the Elwha core area as a critical habitat subunit within the Olympic Peninsula critical habitat unit (75 FR 200). In mapping critical habitat, the USFWS identified a total of 78.41 river miles of known occupied bull trout streams within the Elwha River critical habitat subunit, including 58.53 river miles of spawning and rearing habitat, and 19.88 river miles identified as FMO habitat. Of those, 66.91 river miles were designated as bull trout critical habitat; the rest of the area known to be occupied by bull trout was excluded from the final designation because of protections provided by existing Habitat Conservation Plans or Tribal ownerships. In the action area, all portions of the Elwha River, the Little River, and Indian Creek are designated bull trout critical habitat.

The aquatic extent of the action area provides suitable FMO habitat. The quality and distribution of those habitat types are expected to be quite variable as the channel continues to stabilize after dam removal. Geomorphic alterations of the channel and changing bed-sediment grain size are likely to continue to affect aquatic habitat structure, benthic fauna, salmonid spawning and rearing potential, and riparian vegetation (East et al. 2015).

The PCEs provided by bull trout critical habitat in the action area, and their existing conditions, are described below.

PCE 1: Springs, seeps, ground water sources and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Springs or seeps occur in the Elwha River basin, for example, near the water treatment facility in the lower basin. Groundwater-fed, off-channel habitats occur in the lower river (Crain and Brenkman 2010). Wells are used to provide some of the water used by the Lower Elwha Klallam Tribe and WDFW fish facilities, as well as local land owners. The effect of groundwater withdrawal on the function of PCE 1 is not fully known. Withdrawal using shallow wells (e.g., 25 feet deep) has a greater potential to influence groundwater quantity and, therefore, flows and temperature in the river. Such effects are most likely a potential for concern during the low-flow periods of the summer and early fall when water temperatures are higher and instream flows are lower. We anticipate that this PCE may be negatively affected seasonally by groundwater withdrawals; however, the function of PCE 1 is not precluded.

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

The Elwha Dam and the Glines Canyon Dam were built without fish-passage capability, blocking passage of anadromous and fluvial bull trout. Since the dams were removed, major barriers to bull trout migration are no longer present. Bull trout presence has been documented above the previous locations of the Elwha and Glines Canyon Dams (Geffre et al. 2016).

A tributary to Indian Creek flows through a culvert underneath US 101 on the west side of the existing bridge within the action area. That culvert is a partial barrier to fish passage due to slope (WSDOT 2018).

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

Bull trout feed almost exclusively on other fish, including eggs and fry. In fresh water, prey species include various trout and salmon species (*Oncorhynchus* spp.), sculpin (*Cottus* spp.), whitefish (*Prosopium* spp.), and suckers (*Catostomus* spp.), as well as aquatic invertebrates and plankton. Juveniles feed primarily on aquatic invertebrates, including mayflies, stoneflies, caddisflies, and beetles, and shift to fish prey as they grow larger. In nearshore marine areas and the ocean, bull trout feed on forage fish including Pacific herring (*Clupea pallasii*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (USFWS 2015b).

Snorkel surveys conducted prior to dam removal found several non-salmonid taxa below Elwha Dam including sculpins, threespine stickleback (*Gasterosteus aculeatus*), Pacific lamprey (*Lampetra tridentata*), redside shiner (*Richardsonius balteatus*), eulachon (*Thaleichthys pacificus*), starry flounder (*Platichthys stellatus*) and surf smelt (Brenkman et al. 2012). Pacific lamprey have been documented in Indian Creek following dam removal (Jolley et al. 2016), and various species of anadromous salmonids have been observed in the middle and upper reaches of the Elwha River (Lower Elwha Klallam Tribe 2017; McHenry et al. 2017; Moses et al. 2015).

Depressed populations of anadromous salmon and steelhead in the Elwha River watershed significantly limited the prey base available to bull trout in the Elwha core area prior to dam removal. Elwha River bull trout were found to be of poor fitness throughout the watershed prior to dam removal as a result of the limited food supply (Crain and Brenkman 2010). Following dam removal, more than 70 miles of usable habitat in the middle and upper Elwha River became accessible for bull trout prey species, such as Chinook salmon, which could be present in the action area year-round. Dam removal led to an increase in the proportion of Chinook salmon spawning in the mainstem, rather than tributary habitat, and the majority of the redds (73 percent) were observed above the former Elwha Dam. Although Chinook salmon have been observed spawning in the larger tributaries (Indian Creek, Little River, and Hughes Creek), they are not known to spawn in the smaller tributaries (McHenry et al. 2015). Bull trout prey availability in the Elwha River system is expected to increase as salmonid populations continue to respond to the beneficial effects of dam removal.

Since dam removal, riparian vegetation and its associated macroinvertebrates, while still present along the Elwha River, are much farther from the water in the middle and lower river and in the reaches where the lakes were impounded behind the dams. New vegetation is emerging in the old lake beds, but it will be limited for many years as the river moves. In the lower and middle Elwha River, the amount of overhanging vegetation is more limited than in the upper river, thereby reducing the availability of terrestrial invertebrates available to bull trout in the lower and middle reaches.

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

The Elwha Dam and the Glines Canyon Dam precluded the movement of large wood and gravels downstream of the dams. With dam removal, as well as restoration actions that have been carried out and are planned to install large wood in the lower river, the amount of complexity in the river is likely to improve in the long term.

The condition of pools below the dams is unknown. However, it likely is in transition as pools fill with sediment from material stored behind the dams and form again as greater amounts of large woody debris are distributed throughout the system.

PCE 5: Water temperatures ranging between 2 °C to 15 °C (36 °F to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

The Elwha River flows from glaciers and ice fields, providing a reliable source of cold water. However, until recently, the reservoirs behind the dams increased downstream water temperatures by 4 °C to 8 °C above normal (McHenry 2002) during some parts of the late summer and early fall (FERC 1993). With dam removal, water temperatures are anticipated to decrease below the former dam sites. The current lack of overhanging riparian vegetation will limit the cooling effect provided by shading. In time, we anticipate that the riparian conditions will improve to assist in maintaining cool water temperatures in the lower and middle reaches of the river.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions.

Bull trout spawning has not been documented in the action area. Spawning and rearing habitat for bull trout occurs primarily in the reaches of the Elwha River within Olympic National Park. Bull trout in the Little River have been designated as a potential local population. The Little River may support spawning, and bull trout redds were observed near the river mouth in October 2014 (upstream of the action area; Moses et al. 2015). The Little River has over 7 miles of accessible habitat suitable for bull trout spawning and juvenile rearing, based on temperature data collected in 1996 by the Lower Elwha Klallam Tribe (McHenry, in litt. 2003). The temperature profile is similar to other systems where very cold groundwater is the major factor influencing stream temperatures in late summer, with very little diurnal variation (McHenry, in litt. 2003).

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

The Elwha River has been restored to a natural hydrograph by removal of the Elwha and Glines Canyon Dams. River discharge is influenced by winter storms, spring snowmelt, and base flow conditions during summer and fall. Mean annual discharge is approximately 1,500 cfs at the McDonald Bridge stream gage (U.S. Geological Survey gage #12045500) and 1,650 cfs at the river mouth (NPS 2005). Mean winter flow is about 2,000 cfs, and mean summer flows is about 600 cfs. Peak flood events have exceeded 40,000 cfs, while base summer low flows may be as low as 200 cfs (Elwha-Dungeness Planning Unit 2005).

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

The Washington State Department of Ecology has classified the Elwha River and its tributaries as a “salmon and trout spawning, core rearing, and migration” area, which signifies “extraordinary” quality (WDOE 2016). There are no industrial discharges into the river. Discharges that may negatively affect the water quality of the river are associated with stormwater runoff from roads, treated effluent from the hatchery and fish rearing facilities, and septic systems. Water withdrawals for domestic and hatchery-related facilities may reduce the instream flows to some extent.

Mobilized stream sediments following dam removal resulted in periods of high turbidity within the mainstem. Episodic events, such as an event between April 6 and 8, 2013, have resulted in turbidity levels exceeding 4,000 NTU; such high levels of turbidity have likely contributed to salmonid mortality, possibly from stranding, disorientation, or choking (Pess 2014). High levels of fine sediment deposition are also associated with reductions in drift invertebrates and up to 95 percent reductions in benthic invertebrates (Pess 2014). Although most sediment stored behind the dams has been removed from the system, turbidity is high during flood events and is likely to remain so for the foreseeable future (Herrera 2016).

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

Nonnative brook trout have been planted in Olympic National Park, and are known to occur in Elwha River tributaries (USFWS 2000). Snorkel surveys conducted prior to dam removal detected brook trout below Glines Canyon Dam and above the Elwha Dam (Brenkman et al. 2012). Although brook trout distribution was limited within the Elwha core area before the removal of the dams, the species is now likely to expand its distribution and abundance. Brook trout overlap tributary spawning areas for bull trout in Indian, Griff, and Hughes Creeks and the Little River, creating significant potential for species competition and hybridization (USFWS 2015c). The highest abundances of brook trout are documented in Indian Creek and a small groundwater-fed channel in the Elwha Campground, roughly 2 miles upstream of the project footprint (Crain and Brenkman 2010).

Conservation Role of the Action Area

The action area includes a small area of the Elwha River, which provides essential FMO habitat for bull trout. All waters accessible to anadromous fish within bull trout core areas provide a necessary contribution to the forage base important to the seasonal habitat needs, survival, and growth of individual migratory fish. Bull trout habitat in the action area is essential for maintaining the connectivity, distribution, and overall abundance of bull trout in the Elwha core area.

Previously Consulted-On Effects

The USFWS has consulted on previous projects in the Elwha River, such as the Elwha River Restoration Project (USFWS 2000), the Elwha River Salmon and Steelhead Hatchery Programs (USFWS 2012), and the Elwha Valley and Quinault Valley Storm Damage Road Repairs (USFWS 2016).

Climate Change

Consistent with USFWS policy, our analyses under the ESA include consideration of ongoing and projected changes in climate. The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2014a, pp. 119–120). The term “climate change” refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2014a, p. 119). Various types of changes in climate can have direct or indirect effects on species and critical habitats. Such effects may be positive, neutral, or negative, and they may change over time. The nature of the effect depends on a species’ life history, the magnitude and speed of climate change, and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2014b, pp. 64, 67–69, 94, 299). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change and its effects on species and their critical habitats. We focus in particular on how climate change affects the capability of species to successfully complete their life cycles, and the capability of critical habitats to support that outcome.

Across the western United States, increasing temperatures over the last 50 years have led to more precipitation falling as rain rather than snow, earlier snowmelt, and reduced spring snowpack, all of which affect streamflow (Halofsky et al. 2011). Bull trout are vulnerable to the effects of warming climates, changing precipitation, and hydrologic regimes, and are considered a useful indicator species of the effects climate change (USFWS 2015b). Climate change presents a major challenge to natural resource managers because of the magnitude of potential effects of climate change on ecosystem structure, processes, and function, and because of the uncertainty associated with those potential ecological effects (Halofsky et al. 2011). During the next 20 to 40 years, the climate of the Pacific Northwest is projected to change significantly with predicted changes to include warmer, drier summers and warmer, wetter autumns and winters (Mote and Salathe 2010).

An analysis of climate change impacts on the Olympic Peninsula summarized the following projected climate change effects (Halofsky et al. 2011):

- Climate models project increases in annual average temperature of +0.6 °C to +1.9 °C by the 2020s; +0.9 °C to +2.9 °C by the 2040s; and +1.6 °C to +5.4 °C by the 2080s for the Pacific Northwest.

- Warming is expected to occur during all seasons, with most models projecting the largest temperature increases in summer.

- Ensemble means of models for precipitation suggest wetter winters (+3.3 percent in the 2040s; +7.6 percent in the 2080s) and drier summers (-8.5 percent in the 2040s; -12.8 percent in the 2080s).

- Winter precipitation on the Olympic Peninsula is likely to increase by 4.5 to 5 percent, on average and depending on location.

- In addition to increased rain precipitation quantity, regional climate models show significant increases in the intensity of winter precipitation in the western portion of the Olympic Peninsula.

Warming trends are expected to reduce winter snowpack and cause shifts in the timing of snowmelt and streamflow. On the Olympic Peninsula, such shifts will likely lead to increased winter and early spring peak flows, lower summer low flows, and more frequent winter floods (Halofsky et al. 2011). Existing road systems on the Olympic Peninsula will likely be at increased risk of flood damage, potentially resulting in more road failures and increased impacts on aquatic habitats (Halofsky et al. 2011).

All salmonids, including bull trout, are highly sensitive to changes in temperature. The current distribution of bull trout is linked to broad-scale stream temperature gradients, with spawning and rearing areas constrained to streams with appropriate temperature regimes (Dunham et al. 2003). Maximum summer water temperatures in many low elevation rivers on the Olympic Peninsula are currently exceeding optimal levels for salmonids (Halofsky et al. 2011). Recently developed stream temperature models for the Pacific Northwest indicate the warming trends on the western Olympic Peninsula will likely continue over the next 40 years (Isaak et al. 2015). Projected increases in winter peak flows, increases in summer stream temperatures, and lower summer streamflows suggest there will be declines in freshwater habitat quality and quantity for salmon, steelhead, bull trout, and resident fish on the Olympic Peninsula (Halofsky et al. 2011). Increased stream temperatures and reduced summer stream flows could particularly affect bull trout by reducing the quantity and quality of spawning and rearing habitat (Halofsky et al. 2011).

The likely degradation of aquatic habitats due to predicted climate change impacts highlights the importance of maintaining and improving functional riparian zones to naturally regulate stream temperature and water quality, and to provide for large wood recruitment to aquatic systems.

EFFECTS OF THE ACTION: Bull Trout and Designated Bull Trout Critical Habitat

The effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action includes the placement of temporary construction pads in the river, operation of heavy equipment operation below the OHWM, and excluding fish from the in-water work zone. The proposed action will result in temporary hydraulic changes through the work area during bridge construction and removal. Therefore, the proposed action will result in both direct and indirect effects on bull trout and designated bull trout critical habitat. For the reasons discussed in the following sections, effects resulting from pollutants in stormwater runoff and elevated levels of underwater sound are not likely to result in adverse effects on bull trout or bull trout critical habitat. Adverse effects are likely to result from:

- Impacts on benthic habitat
- Exposure to elevated levels of turbidity and suspended sediments
- Fish handling and stranding during dewatering of the work area
- Impeded migration from increased water velocity
- Removal of riparian vegetation

Effects will be temporary and will persist only during and shortly after construction. Construction activities have the potential to kill or injure a limited number of juvenile, subadult, or adult bull trout and to significantly disrupt their normal behaviors. Seasonal timing of in-water work and implementation of other BMPs will minimize impacts on individual fish. Indirect effects on bull trout habitat may last for several months after construction as the disturbed streambed adjusts to the new conditions.

Insignificant and Discountable Effects

Several project actions are not likely to adversely affect bull trout, either because the scope and scale of the action is too small to affect bull trout in the action area, or because bull trout are not likely to be exposed to potential stressors of the action. The effects of pollutants in stormwater runoff and elevated levels of underwater sound are discussed below.

<u>Stormwater</u>

Stormwater runoff generated by roadways contains pollutants that can be detrimental to aquatic life. The primary constituents of concern are total suspended solids (TSS), total copper (TCu), dissolved copper (DCu), total zinc (TZn), and dissolved zinc (DZn). The USFWS and National Marine Fisheries Service (NMFS; collectively referred to as the Services) have established freshwater behavioral threshold levels for fish of 2 micrograms per liter (μg/L) above background concentrations of 3.0 μg/L or less for DCu, and 5.6 μg/L above background concentrations between 3.0 μg/L and 13 μg/L for DZn (WSDOT 2015b). There are two pathways for possible adverse effects of chemicals in stormwater on bull trout: 1) direct exposure to water column pollutant concentrations in excess of the freshwater behavioral thresholds; and 2) indirect adverse effects resulting from the accumulation of pollutants in the environment over time, altered food web productivity, and possible dietary exposure.

There are five threshold discharge areas[1] in the action area that discharge to three waterbodies: the Elwha River, Indian Creek, and an unnamed tributary to Indian Creek. The existing stormwater system collects runoff in ditches and culverts, and discharges it, untreated, to receiving water bodies. The project will result in an increase of 0.38 acre of PGIS. The WSDOT will provide enhanced water quality treatment for approximately 1.49 acres of new and replaced PGIS, substantially increasing the amount of water quality treatment in the action area. Approximately 1.78 of 3.27 acres will continue to have no water quality treatment BMPs after the project. Based on the results of analysis using the WSDOT's HI-RUN tool (WSDOT 2011), loads and concentrations of TSS, TCu, DCu, TZn, and DZn in stormwater runoff will all be reduced by 18 to 34 percent (Table 1), which will reduce the potential exposure of bull trout to pollutants in stormwater runoff.

Table 1. Summary of stormwater pollutant loads for the US 101 Elwha Bridge Replacement Project.

			Median Predicted Values from WSDOT HI-RUN				
	PGIS (acre)	**Acres with Stormwater Treatment**	**TSS Load (lb/yr)**	**Total Copper (lb/yr)**	**Dissolved Copper (lb/yr)**	**Total Zinc (lb/yr)**	**Dissolved Zinc (lb/yr)**
Pre-project	2.89	0	2,879	0.739	0.172	4.5	1.28
Post-project	3.27	1.49	1,907	0.51	0.14	3	0.98
Change	+0.38	+1.49	-972	-0.229	-0.032	-1.5	-0.3

lb/year = pounds per year

PGIS = pollution-generating impervious surface

TSS = total suspended solids

Elevated Underwater Sound

The retaining wall adjacent to the tributary to Indian Creek will be installed by vibratory pile driving the soldier piles. As of June 2008, the USFWS, FHWA, WSDOT, and other signatory agencies have endorsed application of interim criteria (thresholds) for estimating onset of injury developed by the Fisheries Hydroacoustic Working Group (FHWG 2008). Vibratory drivers produce underwater peak pressures that are lower than those thresholds (Nedwell and Edwards 2002; Teachout 2010). No documented fish kills are associated with the use of vibratory hammers. Therefore, the USFWS does not consider elevated sound pressure levels associated with vibratory pile drivers to result in injurious effects on bull trout or forage fish. Bull trout could exhibit behavioral effects due to elevated underwater sound levels, such as avoidance of the area and associated disruption of feeding. However, bull trout are not likely to occur in the small tributary to Indian Creek during the in-water work window, when low summer flows and high temperatures likely preclude bull trout presence. The effects of elevated underwater sound associated with the project are, therefore, considered insignificant.

[1] A threshold discharge area is an onsite area draining to a single natural discharge location or multiple natural discharge locations that combine within 0.25 mile downstream.

Adverse Effects of the Action – Bull Trout

Effects on Bull Trout Associated with Impacts on Benthic Habitat and Juvenile Salmonids

Benthic areas provide habitat for forage fish and aquatic macroinvertebrates that serve as a food source for bull trout. Although the action area does not provide spawning habitat for bull trout, the Elwha River provides spawning habitat for other salmon species. Juvenile salmonids and salmonid eggs are also food resources for bull trout.

Project activities will directly affect the Elwha riverbed through the installation and removal of the temporary construction access pads, which will cover approximately 29,500 square feet of streambed, elevating the area so equipment can access the work area. The pads will be composed of 6-man riprap (54- to 60-inch-diameter angular rock) and filled with streambed gravel to fill the interstitial spaces in the riprap foundation and solidify the structure. The fill material will be excavated from nearby gravel bars. The access pads will take approximately 3 weeks to construct, beginning in July 2019, and will remain in place until bridge demolition is completed in mid- to late August 2020 (approximately 13 months total). Removal of the access pads is expected to take another 4 to 5 weeks.

Rock placement and excavation, and the presence of in-water structures will smother and reduce the production of benthic and epibenthic macroinvertebrates that juvenile bull trout and salmonids prey upon in the action area. The effects on aquatic macroinvertebrates will be temporary. The riverbed will return to natural contours soon after construction, and macroinvertebrates are expected to rapidly recolonize disturbed areas (within approximately 2 weeks to 2 months) after the access pads are removed (Merz and Chan 2005). Rock placement may also reduce Chinook and steelhead spawning in the action area, potentially limiting eggs and juvenile salmon that provide a bull trout food source.

The construction pads and cofferdams (for bridge demolition) will narrow the river channel, increasing river velocities. Higher velocities will result in sheer stresses on materials that will cause scour and deposition. Hydraulic modeling identified several areas that could be subject to potential scour and depositional effects (Table 2). Because of the large volumes of streambed material being transported in the Elwha River, it is likely that any remaining areas of deposition or scour would be mobilized or filled after the construction access pads and temporary protection areas are removed from the river.

We expect that the temporary benthic impacts and impacts to salmonid spawning habitat will adversely affect bull trout and their prey base by temporarily reducing foraging efficiency and availability of food sources to an extent that could have a measurable effect on fitness. This adverse impact will occur over an area of 372,500 square feet (29,500 square feet of construction access pads, 4,000 square feet of cofferdam, 140,000 square feet behind the cofferdams, 93,000 square feet of increased scour area, and 106,000 square feet of increased depositional area) for a duration of approximately 14 months (including time from construction to removal of access pads, time while cofferdams are in place, and recovery time for macroinvertebrate production).

Table 2. Summary of potential scour and depositional effects

Construction Stage	Area of Increased Scour (square feet)	Primary Scour Locations	Area of Increased Deposition (square feet)	Deposition Locations
Construction Access Pads	45,000	Area around and between access pads, extending downstream	65,000	Indian Creek mouth, upstream of existing bridge
Demolition Phase I (Left Bank)	29,000	Around existing Pier 7, extending downstream	16,000	Little River mouth; mainstem Elwha River upstream of isolation cofferdam
Demolition Phase II (Right Bank)	19,000	Mainstem Elwha River, beginning near existing bridge and extending downstream.	25,000	Little River Mouth, upstream of isolation cofferdam
Total	93,000	---	106,000	---

The footprint of the new bridge piers will permanently impact benthic habitat. The area of permanent benthic displacement for the four 10-foot-diameter piers is approximately 314 square feet, a reduction of 1,094 square feet compared to the piers of the existing bridge. We do not expect that permanent features of the project will prevent or discourage migration through the area or expose bull trout to heightened predation risk or other acute or chronic stressors. Furthermore, because of the small amount of affected foraging habitat and the overall gains in potential foraging habitat compared to the existing condition, and because productive, alternative foraging opportunities are readily available upstream and downstream of the work area, we conclude that these adverse effects to habitat will not significantly disrupt normal bull trout behaviors over the long term after construction.

In summary, impacts on benthic habitat and salmonid spawning areas resulting from the project will have adverse short-term effects that are likely to significantly reduce the fitness of a few individual bull trout. There will be a slight increase in available habitat and habitat quality within the action area in the long term, but the increase is not expected to measurably affect bull trout, their prey base, or the key functions provided by bull trout critical habitat.

Temporary Exposure to Elevated Turbidity and Sedimentation

Project construction includes activities below the OHWM that will temporarily degrade water quality and result in measurable, adverse effects on bull trout and their habitat. These activities include equipment operation, installation of construction access pads, installation of drilled shafts for the new bridge piers, and installation and removal of supersack cofferdams during bridge demolition phases 1 and 2.

Although few studies have specifically examined the effects of suspended sediment on bull trout, increases in suspended sediment affect salmonids in several recognizable ways. The effects of suspended sediment may be characterized as lethal, sublethal, or behavioral (Bash et al. 2001;

Newcombe and MacDonald 1991; Waters 1995). Lethal effects include gill trauma (physical damage to the respiratory structures), severely reduced respiratory function and performance, and smothering and other effects that can reduce egg-to-fry survival (Bash et al. 2001). Sublethal effects include physiological stress reducing the ability of fish to perform vital functions (Cederholm and Reid 1987), increased metabolic oxygen demand and susceptibility to disease and other stressors (Bash et al. 2001), and reduced feeding efficiency (Bash et al. 2001; Berg and Northcote 1985; Waters 1995). Sublethal effects can act separately or cumulatively to reduce growth rates and increase fish mortality over time. Behavioral effects include avoidance, loss of territoriality, and related secondary effects to feeding rates and efficiency (Bash et al. 2001). Fish may be forced to abandon preferred habitats and refugia, and may enter less favorable conditions and/or be exposed to additional hazards (including predators) when seeking to avoid elevated concentrations of suspended sediment. The severity of effect of suspended sediment increases as a function of the sediment concentration and exposure time (Newcombe and Jensen 1996; Bash et al. 2001). Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991).

To assess the suspended sediment concentrations at which adverse effects will occur, and to determine the downstream extent to which those effects may extend as a result of the proposed project, we used the USFWS guidance for evaluating effects of sediment on bull trout and their habitat (Muck 2010; Appendix C). That guidance uses the findings of Newcombe and Jensen (1996) to evaluate the “severity-of-effect” based on suspended sediment concentration, exposure, and duration. Factors influencing suspended sediment concentration, exposure, and duration include waterbody size, volume of flow, the nature of the construction activity, construction methods, erosion controls, and substrate and sediment particle size. Factors influencing the severity-of-effect include duration and frequency of exposure, concentration, and life stage. Availability and access to refugia are other important considerations.

The framework in Appendix C requires an estimate of suspended sediment concentration (in milligrams per liter [mg/L] or NTUs) and exposure duration. Turbidity in the Elwha River can be extremely high (greater than 5,000 NTU) during winter floods but is generally low (less than 20 NTU) during the dry season, when in-water work will occur. Monitoring data collection on the Elwha River near Port Angeles (Station No. 18B070) were used to determine the ratio of turbidity to suspended solids for the waterbody (1 NTU:1.41 mg/L). During monitoring near the bridge in 2015, turbidity varied between approximately 0.5 and 138 NTU (WDOE 2017). To determine exposure duration, we assumed that work below the OHWM would occur 10 hours per day, for as many as 124 working days (2 weeks during the in-water work window in 2019, and 9 weeks during the in-water work window in 2020). Note that we expect that any measurable increases in turbidity will be short-term and episodic.

Using this approach, we expect that adverse effects on adult, subadult, and juvenile bull trout are likely to occur under the following circumstances.

1. When background NTU levels are exceeded by 105 NTU at any time.

2. When background NTU levels are exceeded by 70 NTU for more than 1 hour, continuously.

3. When background NTU levels are exceeded by 28 NTU for more than 3 hours, cumulatively, over a 10-hour workday.

4. When background NTU levels are exceeded by 13 NTU for more than 7 hours, cumulatively, over a 10-hour workday.

To assess the potential extent of such effects, we relied on a limited set of monitoring data collected to determine the effectiveness of BMPs and compliance with Washington surface water quality standards. We also considered the nature and extent of the proposed in-water work, and the Elwha River's seasonal hydrological conditions. Based on this information, we expect that suspended sediment concentrations resulting in adverse effects on bull trout are reasonably certain to occur as far as 2,400 feet downstream of the existing bridge, the aquatic extent of the action area.

Juvenile, adult, and subadult bull trout may occupy the waters immediately surrounding the project area at any time of year. Adult and subadult bull trout are less likely to be affected by episodic increases in turbidity during construction, but may exhibit a behavioral response (likely temporary avoidance of turbid areas). Juvenile bull trout exposed to elevated turbidity and suspended sediments could experience reduced foraging efficiency and higher energetic expenditures as they are forced to avoid turbid areas. We expect that exposure to temporary elevated turbidity and suspended sediments will have an adverse effect on adult, subadult, and juvenile bull trout to an extent that will have a measurable effect on fitness. Some bull trout will avoid the area when suspended sediment concentrations area elevated. Resulting turbidities may also impede or discourage free movement through the action area, delaying or discouraging adult bull trout from migrating through and around the project area. However, bull trout will not be exposed to elevated turbidities outside daylight hours; therefore, nocturnal movements and migration through and around the project area will be unimpeded during certain times of the day.

Pulses of elevated turbidity are expected to occur for 48 days in 2019 and 78 days in 2020 while work is conducted within the wetted channel during the in-water work window (July 15 through September 30, 2019, and June 15 through August 31, 2020) following removal of the cofferdams and when heavy equipment is working below the OHWM removing material from the work access pads. Temporary increases in turbidity may prevent individuals from exploiting preferred habitats, and/or may expose individuals to less favorable conditions. We expect that elevated turbidity and sedimentation extending as far as 2,400 feet downstream of the existing bridge will result in a significant temporary disruption of normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter).

Fish Stranding and Handling during Dewatering

Demolition of the existing US 101 bridge will require isolation of the work area extending across the Elwha River channel. Isolation of that area will occur in two stages, with the left (west) bank isolated during the first stage and the right (east) bank isolated in the second stage of bridge demolition, affecting a total of 2.8 acres and 0.6 acre of habitat below the OHWM, respectively. Isolation of the work area will require dewatering of the area, and capture and removal of any fish remaining in the area using WSDOT-approved methods or by appropriately adapting the approved methods (WSDOT 2012).

Stream flow diversion and dewatering could harm individual bull trout by concentrating or stranding them in residual wetted areas, or by entrapping them within the interstices of channel substrate where they may not be seen by fish relocation personnel. Construction activity on and adjacent to gravel bars on the left and right banks may result in localized depressions, which can create ponding features that can pose a stranding risk for bull trout as river elevations decrease. Juvenile bull trout that avoid capture in the project work area will likely die due to desiccation, thermal stress, or crushing during placement of supersacks and/or equipment operation. Fish relocation efforts are expected to be effective at removing most fish from the area, but a small number of juvenile bull trout may be missed and have the potential to be stranded and killed within the dewatered area.

Fish trapping, handling, and transport are reasonably certain to harm some bull trout, disrupt their normal behavior, and cause short-term stress, fatigue, some injury, and, possibly, mortality. Fish may suffer from thermal stress during handling or may receive subtle injuries such as de-scaling and loss of their protective mucus coating on the skin. Handling can contribute directly or indirectly to disease transmission and susceptibility or increased post-release predation because fish that have been stressed are more vulnerable to predation (Mesa et al. 1994; Mesa and Schreck 1989). Death can result if fish are handled roughly or kept out of water for extended periods of time (Nielsen and Johnson 1983). Increasing stress levels can reduce disease resistance, increase osmotic-regulatory problems, decrease growth, decrease reproductive capacity, and increase chances of mortality (Kelsch and Shields 1996). The WSDOT protocols for fish handling stipulate ways to minimize harm associated with handling fish, which include minimizing the amount and duration of handling, using clean hands free of sunscreen and insect repellent, and using specific types of containers for transferring bull trout.

The actual numbers of fish adversely affected by handling is difficult to anticipate. Fish that avoid capture (primarily juveniles) will go unnoticed. A small number of subadult and adult bull trout may be captured during fish exclusion. In most cases, the handled fish will be released shortly after their capture, minimizing stress. Depending on the number of fish that need to be handled during the operation, some fish may be injured or even killed during the handling and/or transfer process or may die later (delayed mortality due to handling).

The WSDOT reviewed 25 projects that involved stream isolation and fish handling. Only five bull trout were captured during those projects, an average of one bull trout for every five projects. Most of the projects analyzed were smaller scale than the proposed action, with much smaller in-water work zones and isolation areas. Based on the size of the river and fish distribution studies conducted after the dams were removed, we estimate that as many as five bull trout could be captured during the project. Studies indicate that 95 percent of fish captured and handled survive with no long-term effects, and up to 5 percent are expected to be injured or killed, including delayed mortality (USFWS 2015a). Of the five bull trout expected to be captured during the project, we estimate that one bull trout may be injured or killed. Compared to juvenile bull trout, adult and subadult bull trout are more visible and more likely to be herded out of the dewatered work area prior to handling. Juvenile bull trout are harder to detect and are more likely to be present during dewatering and electrofishing; the juvenile age class is likely to experience the greatest effects from fish handling.

In summary, we expect an unknown but small number juvenile bull trout to escape fish exclusion and handling and become stranded during dewatering, leading to injury and death. We estimate that as many as five juvenile, subadult, or adult bull trout will be captured and handled during fish exclusion, and one of those individuals (likely a juvenile) could experience injury or mortality as a result of handling.

<u>Impeded Migration from Temporary Increases in Stream Velocities</u>

Bull trout forage in and migrate through the action area to reach headwater streams in the middle and upper Elwha River. Upstream migration occurs primarily from early summer to late fall, which overlaps the in-water work window. Increased water velocities during construction could temporarily delay upstream migration of small numbers of adult bull trout.

Temporary in-channel features may create localized increases in stream velocities, which could delay the upstream migration of bull trout during peak stream flows. Increased velocities would occur for 13 months while the construction access pads and demolition pads are in the river and while cofferdams are installed for demolition of the existing bridge. Based on modeling conducted by the WSDOT (2017), the effects of changes in flow velocities could extend as far as 1,500 feet downstream of the existing bridge. To alleviate potential velocity and scour effects between the construction access pads, the WSDOT proposes to remove a portion of each pad on the waterward side of the new piers in between the in-water work windows. During the second phase of bridge demolition, WSDOT contractors will deepen the channel in an area approximately 600 feet long and 80 feet wide to reduce stream velocities while the work area is isolated.

Effects on the PCEs of Designated Bull Trout Critical Habitat

An earlier section identified the PCEs that define designated bull trout critical habitat and described their baseline condition in the action area. The following section discusses the effects of the proposed action with reference to the PCEs present in the action area.

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The proposed action will have no measurable effect on this PCE. Any temporary or permanent effect to this PCE will be insignificant. Within the action area, this PCE will retain its current level of function (not impaired).

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

The proposed action will have measurable adverse effects on this PCE. Construction activities will temporarily impair the function of the migratory corridor for 2 years during the course of in-water work. The temporary work access pads and cofferdams used to isolate the work site during demolition will constrict flows through the work area, creating higher stream velocities and blocking off portions of the channel. Water quality will be degraded during in-water work, potentially impeding bull trout migration through the aquatic portion of the action area. Such effects will be temporary, and the function of this PCE is expected to be restored once in-water work is complete.

The proposed action is also expected to create an improvement over existing conditions, resulting in fewer detrimental effects on this PCE. The longer span of the new bridge and the new alignment will allow the river to move more freely in the channel at this narrow section in the river. The proposed action will not create or contribute to any existing impediments to migration. Instead, it will reduce a significant, long-standing constraint on the channel migration zone and will restore channel-forming processes and floodplain and riparian processes that will restore natural flows and improve the condition of the migratory corridor. Within the action area, this PCE will achieve an enhanced level of function following construction.

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

The proposed action will have temporary measurable adverse effects on benthic habitats and salmonid spawning areas. The Elwha River in the action area provides suitable spawning habitat for Chinook salmon and steelhead, both of which are bull trout prey species. The installation and removal of the construction access pads is likely to reduce fish abundance in the action area for the duration of construction (two in-water work windows). Substrates will return to pre-project conditions during high flows in the first winter after construction, and fish abundance in the action area is expected to recover 1 year after construction is complete. Placement and removal of fill in the river, as well as elevated levels of suspended sediment, will also reduce levels of aquatic macroinvertebrates in the action area. Macroinvertebrate will recolonize disturbed areas within 2 weeks to 2 months following construction.

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

The proposed action includes the removal of 2.9 acres of riparian vegetation within 200 feet of the Elwha River or Indian Creek during construction. Approximately 21 trees (both conifer and hardwood) greater than 30 inches dbh will be cut down. Riparian vegetation removal can affect listed bull trout by reducing streambank stability, which leads to erosion and sedimentation; increasing water temperatures; reducing leaf litter and organic input for aquatic insect production; and reducing large woody debris recruitment (Lowrance et al. 1985; Welsch 1991; Mitchell 1999; Opperman and Merenlender 2004). Elevated water temperatures may adversely affect salmonid physiology, growth, and development, alter life history patterns, induce disease, and exacerbate competitive predator-prey interactions (Spence et al. 1996).

At least 1.8 acres of native riparian vegetation will be replanted throughout the disturbed riparian area to minimize impacts from project construction. An additional 0.7 acre will be replanted in the roadway zone with hydroseeding and planting of low-growing woody vegetation. The remaining 0.4 acre of riparian area to be cleared will consist of new roadway.

The proposed action will have significant, unavoidable, long-term impacts on riparian buffers associated with clearing and grading in the riparian area. Removing mature conifers in the riparian area will preclude their potential future recruitment into the channel as large wood and their contribution to formation of pools and other complex habitat features. In temporarily cleared areas, impacts will last for several decades until planted trees have matured. Impacts will be permanent in the portion of the riparian buffer zone converted to new roadway.

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

The proposed action will have no measurable effect on this PCE. The area of riparian vegetation removal is too small to affect this PCE. Any temporary or permanent effect on this PCE will be insignificant. Within the action area, this PCE will retain its current level of function (i.e., not impaired).

PCE 6: Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount (e.g., less than 12 percent) of fine substrate less than 0.85 mm (0.03 inch) in diameter and minimal embeddedness of these fines in larger substrates are characteristic of these conditions.

Suitable bull trout spawning habitats are not present in the action area, and, therefore, the proposed action will have no effect on bull trout spawning habitats. The nearest documented bull trout spawning habitat is in the Little River, just upstream of the bridge. The proposed action will have no measurable temporary or permanent effect on this PCE. Within the action area, this PCE will retain its current level of function (i.e., functioning).

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, they minimize departures from a natural hydrograph.

The proposed action will have measurable short-term adverse effects on this PCE. Constricting the channel with cofferdams during removal of the old bridge will result in increased flow velocities during the time of year when in-water construction activities are occurring. Increased velocities would occur for 13 months while the construction access pads and cofferdams are in the river. The effects of changes in flow velocities could extend up to 1,500 feet downstream. To alleviate potential velocity and scour effects, a portion of each access pad on the waterward side of the new piers will be removed during the time of year when no inwater work is being done. During the second phase of bridge demolition, contractors will deepen the channel to reduce stream velocities while the work area is isolated.

In the long-term, the USFWS expects that the action will improve the storage and attenuation of flood flows and will increase channel and floodplain roughness, thereby reducing hydraulic forces and resulting bed and bank erosion. Any permanent or long-term effect on this PCE will be insignificant and/or beneficial. Within the action area, this PCE will retain its current level of function (i.e., not impaired).

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

The proposed action will have measurable adverse effects on this PCE. Temporary, construction-related increases in turbidity may extend as far as 2,400 feet downstream of the bridge. We expect that measurable, construction-related increases in turbidity will be short-term and episodic. We expect that the channel will adjust and resume natural patterns of bedload and sediment transport within 2 years following construction.

Stormwater treatment for the new bridge will result in a slight improvement of water quality in the project area over current conditions. The proposed action will have no measurable, permanent, or long-term effects on this PCE. The proposed action will not permanently degrade or impair water quality or quantity within the action area and the PCE will retain its current level of function (i.e., not impaired).

Indirect Effects

Indirect effects are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. Indirect effects may occur outside of the area directly affected by the action (USFWS and NMFS 1998). Indirect effects could occur as a result of riparian vegetation removal, the effects of which will persist for several decades.

The USFWS expects that the proposed action will maintain a diverse and complex assemblage of instream habitats along the affected reach, including a range of channel depths, complex cover, and resting and refuge habitat from stream velocities and forces. We expect that the resulting conditions will provide good rearing, foraging, and overwintering opportunities for bull trout. For a fuller discussion of such indirect effects, see the preceding sub-sections.

The proposed action will not result in changes in the use or function of the road infrastructure. The action will not construct new points of access or increase traffic or visitor capacity. No future development proposals or other major actions are contingent or dependent upon the proposed action. The USFWS expects that no discernible changes in the rate or pattern of land use conversion will result, in whole or in part, from the action. We also expect that no discernable changes in long-term public use or management will result from the proposed action. There are no other foreseeable indirect effects on bull trout or designated bull trout critical habitat that might occur later in time.

Effects of Interrelated and Interdependent Actions

Interrelated actions are defined as actions “that are part of a larger action and depend on the larger action for their justification;” interdependent actions are defined as actions “that have no independent utility apart from the action under consideration” (50 CFR Section 402.02).

Previous emergency actions linked to the proposed action likely adversely affected bull trout and bull trout critical habitat. While conducting fish habitat surveys in September 2016, Lower Elwha Klallam Tribe staff observed that Pier 7 was undermined and Pier 6 was becoming exposed. The WSDOT confirmed the observed erosion and conducted geotechnical borings in October 2016. The geotechnical borings discovered that, contrary to the depiction in the 1926 engineering plans, the bridge pier foundations were built on river bed gravel, not bedrock. Damage to the bridge due to shifts in flows, velocities, sediment transport and the river migrating in the channel led to the decision to replace the existing bridge with a new bridge, which is the proposed action being addressed in this consultation.

In October 2016, the WSDOT requested and received emergency authorization from the NMFS, USFWS, WDFW, and the U.S. Army Corps of Engineers to place 700 cubic yards of large rock around Piers 6 and 7 in the Elwha River. The repair work was accomplished by end-dumping large riprap down the incline and onto the gravel bar immediately northeast of the bridge and then using three excavators to relay the rock across the river. This system minimized stream crossings and kept equipment out of the water to the greatest extent possible. Approximately 1,185 cubic yards of large riprap was placed at Pier 7 and approximately 975 cubic yards of large riprap was placed at Pier 6, for a total of 2,160 cubic yards. Work at Pier 6 was done in the dry. The surface area covered by riprap placed around each pier was approximately 4,400 square feet Minor excavation was performed around the pier foundations to key in the riprap; the excavated material was used to solidify the structure by filling the interstitial spaces within the riprap foundation. In-water work lasted 5 days.

Due to unusually high flows following the initial repair, the WSDOT conducted additional scour protection in January 2017. It was accomplished by placing 6-man rock (5 to 5.5 feet in diameter) at the bases of the west abutment and Piers 6 and 7, and placing riverbed material to fill the spaces in the rock at the perimeter of each location. The large boulders came from an approved WSDOT site. The rock was end-dumped at the location (northeast of the bridge) that was used for feeding rock to the river's edge during the October 2016 scour repair work. Excavators used a pre-existing river access to reach the work location. Approximately 740 cubic yards of rock was placed at the west abutment and at Piers 6 and 7, affecting an area of approximately 4,000 square feet below the OHWM of the Elwha River. An additional 200 cubic yards of streambed material was excavated from the area near the piers. Approximately 100 cubic yards of streambed material was removed upstream of the bridge, and another 100 cubic yards of streambed material was removed downstream of the bridge. The excavated streambed material was placed on or near the 6-man rock to fill voids and prevent the erosion of the rock under the piers. Excess streambed material was spread to blend with existing streambed contours and to fill work-related depressions that could entrain fish.

Similar to the method employed for the October 2016 work, rock was collected by an excavator, handed off to another excavator where the rock was to be placed, and placed by a third excavator. The riverbed was excavated to key the rock into the substrate. Interstitial spaces in each course were filled with native riverbed material. Work began at the west abutment, proceeded to Pier 6, then to Pier 7. Work below the OHWM of the Elwha River took place over the course of 3 days. The contractor restricted the stockpile on the Elwha River bank to limit the amount of rock to only what could be installed during a work shift.

Before starting work on initial emergency scour repairs in October 2016, the WSDOT consulted with the Services. The Services recommended the following conservation measures, all of which were implemented by the WSDOT:

- Minimize equipment within or crossing the stream
- Do not leave anything in the stream that will block bull trout movement upstream
- Locate salmonid redds on a plan sheet and stay as far away from them as possible
- Identify and minimize ingress/egress paths; minimize the amount of equipment the stream and keep stream crossings to a minimum
- Use biodegradable hydraulic fluid in equipment working below the OHWM
- Clean and conduct frequent checks of equipment working below the OHWM
- Ensure that temporary erosion and sediment control measures and containment booms are in place when work is underway
- Minimize the number of trips below the OHWM
- Conduct turbidity monitoring during in-water work and stay in compliance with Washington State Department of Ecology requirements.

<u>Effects</u>

Placement of fill in the river during the October 2016 emergency repairs occurred prior to winter high flows and after the peak migration period for bull trout. Construction likely disturbed individual fish for the duration of in-water work, delaying migration or causing fish to avoid the area for 5 days during daylight hours when equipment was operating below the OHWM.

Follow-up work in January 2017 occurred well after peak migration (September to November) during winter high flows. Although bull trout can be found in the Elwha River year-round, it is unlikely that fish would have been present in the high-energy flows at the base of the bridge piers during in-water work, and very few fish would have been exposed to the effects of project activities.

Placement of rock during emergency repairs may have damaged Chinook and steelhead redds, or limited available spawning sites. Damage to redds may have temporarily reduced the availability of eggs and juvenile salmonids on which bull trout forage. All of the riprap installed for the emergency scour repairs will be removed during the demolition of the existing bridge.

CUMULATIVE EFFECTS: Bull Trout and Designated Bull Trout Critical Habitat

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Future actions that are: 1) reasonably certain to occur in the action area, and 2) not expected to include a federal nexus that would trigger ESA Section 7 compliance requirements include commercial or residential development projects without federal funding or federal permit requirements, timber harvest operations on state or private lands, and recreational activities. Timber harvest operations on state trust lands in the action area are covered under the habitat conservation plan that was developed to support issuance of a section 10(a)(1)(B) permit for incidental take of spotted owls and marbled murrelets, among other species (WDNR 1997). Because section 7 consultation for that permit has been completed, timber harvest activities on state trust lands is considered to be part of the environmental baseline for those species, and are not addressed as cumulative effects (USFWS and NMFS 1998). Any of the reasonably certain future activities identified above have the potential to contribute to adverse cumulative effects on the species and critical habitats addressed in this analysis.

Lands in the action area are zoned for timber production and very-low-density residential development. As such, it is extremely unlikely that any development projects with significant impacts on the environment will be proposed in the action area. Moreover, the potential for future development projects to adversely affect ESA-listed species and critical habitat will be minimized through compliance with the critical areas rules of Clallam County. As stated in Chapter 27.12 of the Clallam County Code, it is the policy of Clallam County that the beneficial functions of critical areas be protected, and potential dangers or public costs associated with the inappropriate use of such areas be minimized by reasonable regulation of uses within, adjacent to, or directly affecting such areas. Also, future projects that involve work within the area defined by the OHWM of any streams in the action area will be required to comply with the provisions of hydraulic project approvals issued by WDFW and would also require a U.S. Army Corps of Engineers permit. Through the implementation of measures to avoid, minimize, and mitigate impacts on ecosystem resources, compliance with these and other review and permitting processes are expected to minimize the risk of adverse effects on the species and habitats addressed in this analysis.

INTEGRATION AND SYNTHESIS OF EFFECTS: Bull Trout and Designated Bull Trout Critical Habitat

Summary of the Action

The WSDOT is proposing to replace the existing US 101 Bridge over the Elwha River with a new bridge. Construction access pads and bridge piers will be installed below the OHWM of the Elwha River, reducing benthic habitat, increasing levels of turbidity and suspended sediment, and narrowing the river channel (thereby increasing river flow velocities). Fish will be excluded from the in-water work zone prior to construction. The existing bridge and roadway approach sections will be demolished. The new bridge will be wider, and US 101 will be realigned and widened to match the new bridge alignment, increasing the amount of PGIS in the action area. The WSDOT will provide stormwater treatment for some new and replaced PGIS, reducing pollutant loads discharged to Indian Creek and the Elwha River from stormwater runoff. Temporarily cleared areas will be restored once construction is complete. Approximately 0.4 acre of riparian vegetation will be permanently cleared.

Summary of the Status of Bull Trout and Bull Trout Critical Habitat

Based on our most recent status review (USFWS 2015b), historical habitat loss and fragmentation, interaction with nonnative species, and fish passage issues are widely regarded as the most significant threat factors affecting bull trout throughout its range. The order of those threats and their potential synergistic effects vary greatly by core area and among local populations (USFWS 2015b). The primary strategy for bull trout recovery is to conserve bull trout so that they are geographically widespread across representative habitats and demographically stable in six recovery units; and to effectively manage and ameliorate the primary threats at the core area scale such that bull trout are not likely to become endangered in the foreseeable future (USFWS 2015b).

Summary of the Environmental Baseline

The proposed action is within portions of the Elwha core area, which is in the Coastal Recovery Unit. The Coastal Recovery Unit encompasses 21 bull trout core areas located in western Washington and western (USFWS 2015b). The primary threats identified in the *Coastal Recovery Unit Implementation Plan for Bull Trout* (USFWS 2015c) for the Elwha River core area include fish passage difficulty at the two former dam sites, threats to instream flows associated with municipal and tribal water rights and withdrawals, forage fish availability, and competition/hybridization with brook trout. Considering the predicted effects of climate change to hydrology and stream temperature on the Olympic Peninsula, the primary threats identified above are likely to be exacerbated by increased summer temperatures and increased frequency and intensity of winter floods, which will likely lead to more road failures and increased sediment loading to streams.

Effects to Bull Trout Numbers, Reproduction, and Distribution

Population viability analysis has been applied to assess the long-term persistence of bull trout populations (Rieman and Mclntyre 1993, Post et al. 2003, Staples et al. 2005). Sensitivity analyses in those models have pointed to the importance of survival of older age classes to population persistence. Post et al. (2003) found that populations of migratory bull trout may be highly susceptible to declines from increased mortality of larger, older fish due to angling. Bull trout generally do not attain maturity until at least 5 years of age. Thus, in bull trout populations, survival of older juveniles and adults appears to be a critical factor influencing population persistence (Dunham et al. 2008).

The action area contains FMO habitat for migratory (fluvial and anadromous) bull trout, and supports adult, subadult, and juvenile bull trout. Current information suggests that the two known local populations in the Elwha River have experienced significant variation in numbers (abundance) since the time of listing. However, with the removal of the dams and increase in abundance of naturally spawning salmonids, it is expected that the abundance and distribution of bull trout will improve in the Elwha River core area.

The proposed action incorporates conservation measures which will reduce effects on habitat and will avoid and minimize impacts during construction. The action's temporary adverse effects are limited in both physical extent and duration. With full implementation of the proposed conservation measures, we expect low numbers of adult, subadult, and juvenile bull trout will be adversely affected by construction activities. Exposure to construction and fish removal activities may injure or kill a limited number of bull trout. Construction activities will also significantly disrupt normal bull trout behaviors (feeding, moving, and sheltering). Construction activities may temporarily delay or discourage adult migration through the action area, but will have no effect on bull trout spawning habitat or essential spawning behaviors.

Based on location, extent of impacts and proximity to bull trout core areas and local populations, it is reasonable to conclude that a few individuals will be exposed to the action's short- or long-term effects. Except for the number of fish that will be handled during dewatering (estimated as five fish), we are unable to quantify a specific number of individuals. Instead, we use a habitat surrogate to describe the extent of project related effects on bull trout and bull trout critical habitat.

In the Elwha River core area, the proposed action will result primarily in short-term, sublethal effects associated with impacts on benthic habitat and prey abundance, which will encompass an area of 372,500 square feet; short-term, sublethal effects associated with turbidity plumes (extending 2,400 feet downstream from the existing bridge); and short-term, sublethal effects associated with impeded migration due to increased river velocities, which could extend up to 1,500 feet downstream from the existing bridge. Adverse effects on bull trout and bull trout critical habitat are limited to approximately 2,400 feet (0.45 river mile) of habitat in the lower reaches of the core area. These effects are limited in scale and are minor relative to the major fluvial processes that affected the Elwha River as a result of dam removal in 2014 and 2015. Because the effects of the action are short-term, small-scale, and highly localized, we do not expect the effects of the action to permanently influence bull trout distribution or habitat use within the Elwha River core area.

Up to five juvenile or subadult bull trout could be captured and handled during fish exclusion; of those five individuals, one could experience injury or mortality as a result of handling. Direct mortality associated with stranding or crushing is limited to an unknown, but a very low number of juvenile bull trout associated with habitat along the channel margins within the action area. As described above, bull trout demography is most sensitive to adult mortality and habitat connectivity within and between core areas. The effects of the action will be limited to a small number of individual bull trout. Such a low level of anticipated mortality is not measurable in the context of the Elwha local population, which is distributed over 78 miles of river habitat within the basin. Likewise, effects on designated critical habitat are so localized that the effects of the proposed action on critical habitat PCEs to provide for the conservation and recovery of bull trout will be minor in the context of the larger critical habitat network in the Elwha critical habitat subunit. Suitable bull trout rearing and spawning habitats are not present in the immediate vicinity of the bridge, but are present in the Little River, the mainstem and several tributaries upstream of the project site; therefore, project activities will have no effect on eggs or juvenile bull trout rearing or spawning habitat, or these essential behaviors.

Although we anticipate localized adverse effects on individual bull trout and designated bull trout critical habitat will occur from implementation of the proposed action, none of those effects are expected to result in any measurable reduction in the numbers, distribution, or reproduction of bull trout in the Elwha River core area, the Coastal Recovery Unit, or within the listed range of the species. The recovery objectives outlined in the USFWS' recovery plan for bull trout are to conserve bull trout and to effectively manage and ameliorate the primary threats at the core area scale (USFWS 2015b). Considering the localized nature of the effects of the proposed action, we conclude that the conservation role of the action area (and the function of designated bull trout critical habitat) to provide for the connectivity, distribution, and overall abundance of bull trout, will be maintained at the scale of the action area, the core area and critical habitat subunit, the Coastal Recovery Unit for bull trout, and range-wide.

CONCLUSION: Bull Trout and Designated Bull Trout Critical Habitat

After reviewing the current status of bull trout, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the USFWS' Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the bull trout and is not likely to destroy or adversely modify designated critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. *Harm* is defined by the USFWS as an act that actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). *Harass* is defined by the USFWS as an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The USFWS is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest USFWS Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the USFWS Law Enforcement Office at (425) 883-8122, or the USFWS' Washington Fish and Wildlife Office at (360) 753-9440.

The measures described below are non-discretionary, and must be undertaken by the FHWA so that they become binding conditions of any grant or permit issued to the (applicant), as appropriate, for the exemption in section 7(o)(2) to apply. The FHWA has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the FHWA 1) fails to assume and implement the terms and conditions or 2) fails to require the (applicant) to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the FHWA must report the progress of the action and its impact on the species to the USFWS as specified in this Incidental Take Statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

The USFWS anticipates that incidental take in the form of harm and harassment of juvenile, subadult, and adult bull trout from the Elwha core area will result from the project. The capture and handling of bull trout during fish exclusion could cause direct injury or mortality. However, the direct take resulting from salvage operations will minimize the incidental take of individual bull trout from stream diversion/dewatering activities.

The USFWS expects that incidental take of bull trout due to other adverse effects of the action will be difficult to detect or quantify for the following reasons: 1) the low likelihood of finding dead or injured individuals; 2) delayed mortality, and 3) losses may be masked by seasonal fluctuations in numbers. Where this is the case, we use a description of the affected habitat (i.e., physical extent, frequency, and duration) and the intensity of temporary exposures as a surrogate indicator of take. The USFWS exempts take from the following:

1. Incidental take of juvenile, subadult, and adult bull trout in the form of *harm* from impacts on benthic habitat over an area of 372,500 square feet for the duration of construction (15 months—from July 2019 to August 2020 and including 2 months for recovery). The Service anticipates sublethal effects associated with reduced prey availability and foraging efficiency in foraging habitat.

2. Incidental take in the form of *harm* and *harassment* resulting from handling related to fish capture and removal operations during bridge demolition (10 weeks between June 15 and August 31, 2020).

    a. Five adult, subadult bull trout, or juvenile bull trout will be harassed as a result of fish capture operations.

b. One juvenile bull trout will be injured or killed as a result of fish capture and removal operations and installation of supersacks prior to bridge demolition. Dewatering and supersack installation will occur over an area of approximately 144,000 square feet between June 15 and August 31, 2020.

c. Incidental take in the form of *harm* of juvenile or subadult bull trout due to stranding during dewatering and installation of supersacks prior to bridege demolition. Dewatering and supersack installation will occur over an area approximately 144,000 square feet in size between June 15 and August 31, 2020.

3. Incidental take of juvenile bull trout in the form of *harassment* of juvenile, subadult, and adult bull trout from exposure to episodic periods of elevated turbidity up to 2,400 feet downstream of the existing bridge. The potential for elevated turbidity may occur during the 10-hour workday, for as many as many as 126 working days (two in-water construction seasons; July 15 through August 31, 2019, and June 15 through August 31, 2020). The sublethal effects are considered to be a significant disruption of normal behaviors that creates a likelihood of injury to exposed individuals caused by avoidance behaviors. Take will result when levels of turbidity reach or exceed the following:

   a. 105 NTUs above background at any time; or

   b. 70 NTUs above background for more than 1 hour, continuously; or

   c. 28 NTUs above background for more than 3 hours, cumulatively, over a 10-hour workday; or

4. Incidental take in the form of *harassment* of all bull trout due to impeded migration due to higher water velocities in an area extending from the existing bridge to 1,500 feet downstream of the bridge while construction access and demolition pads are in place (13 months between July 2019 and August 2020).

EFFECT OF THE TAKE

In the accompanying biological Opinion, the USFWS determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

The project incorporates design elements and conservation measures that we expect will reduce permanent effects to habitat and avoid and minimize impacts during construction. We expect that the FHWA will fully implement these measures, and therefore they have not been specifically identified as Reasonable and Prudent Measures (RPMs) or Terms and Conditions.

The USFWS believes the following RPMs are necessary and appropriate to minimize the impacts (i.e., the amount or extent) of incidental take of bull trout:

1. Minimize and monitor incidental take of bull trout caused by elevated turbidity during construction.

2. Minimize and monitor incidental take of bull trout caused by fish stranding, worksite isolation and fish removal/handling.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the FHWA must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

The following terms and conditions are required for the implementation of RPM 1:

1. The FHWA or WSDOT shall monitor turbidity levels in the Elwha River during sediment-generating activities.

   a. Monitoring shall be conducted to establish background turbidity levels upstream and away from the influence of sediment-generating activities. Background turbidity shall be monitored at least twice daily during sediment-generating activities. In the event of a visually appreciable change in background turbidity, an additional sample shall be taken.

   b. Turbidity monitoring shall be conducted at a distance of 300 feet downstream of in-water construction activities or every 300 feet to the end of any visible sediment plume up to a distance of 2,400 feet downstream of the project site.

   c. Monitoring shall be conducted at 30-minute intervals for the first 3 hours from the start of sediment-generating activities. If turbidities measured over the course of three consecutive 30-minute sampling intervals do not exceed 5 NTUs over background, then monitoring of sediment-generating activities will be conducted for the remainder of the workday at a frequency of once every 6 hours, or if there is a visually appreciable increase in turbidity.

      If the background NTU levels are exceeded by the following levels, then the amount of take authorized by the Incidental Take Statement will have been exceeded and sediment-generating activities shall cease.

      1. If background NTU levels are exceeded by 105 NTU at any time.
      2. If background NTU levels are exceeded by 70 NTU for more than 1 hour cumulatively over a workday.

    3. If background NTU levels are exceeded by 28 NTU for more than 3 hours cumulatively over a workday.

    4. If background NTU levels are exceeded by 13 NTU for more than 7 hours cumulatively over a workday.

    The FHWA/WSDOT shall contact the USFWS consulting biologist at the Washington Fish and Wildlife Office in Lacey, Washington, to determine what additional measures may be necessary to reduce turbidity levels and to reinitiate consultation.

  d. If levels of turbidity do not exceed the above levels during the first hour, then monitoring may be reduced to once every hour during sediment-generating activities.

  e. If turbidity levels approach the above-listed NTU values, work shall cease and the sediment control procedures shall be reevaluated. Sediment and erosion control measure shall be modified to reduce turbidity levels. The FHWA or WSDOT will contact the USFWS consulting biologist to discuss means of assuring that the authorized amount of incidental take is not exceeded.

2. The FHWA/WSDOT will submit a surface water quality monitoring report (focused on turbidity and suspended sediment) to the USFWS Washington Fish and Wildlife Office in Lacey, Washington, by April 1 following each construction season. The report shall include, at a minimum, the following: 1) dates, times, and locations of construction activities; 2) monitoring results, sample times, locations, and measured turbidities (in NTUs; 3) a summary of construction activities and measured turbidities associated with those activities; and 4) a summary of corrective actions taken to reduce turbidity.

   If, in cooperation with other permit authorities, the FHWA/WSDOT develop a functionally equivalent monitoring strategy (e.g., intensive monitoring by project area or activity, followed by validation and routine monitoring), they may submit this plan to the USFWS for review and approval in lieu of the above monitoring requirements. This strategy must be submitted to the USFWS a minimum of 60 days prior to construction. In order to be approved for use in lieu of the above requirements, the plan must meet each of the same objectives.

The following term and condition is required for the implementation of RPM 2:

1. The FHWA, or WSDOT shall ensure that all fish capture and removal operations are conducted by a qualified biologist, and that all staff participating in the operation have the necessary knowledge, skills, and abilities to ensure safe handling of fish. Fish capture and removal operations shall take all appropriate steps to minimize the amount and duration of handling.

2. During installation of cofferdams, dewatering of the work area and fish removal efforts, the FHWA/WSDOT shall ensure that the substrates are level to minimize ponding that pose a stranding risk.

The USFWS believes that the amount of extent of incidental take described above will not be exceeded as a result of the proposed action. The RPMs, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The FHWA must immediately provide an explanation of the causes of the taking and review with the USFWS the need for possible modification of the reasonable and prudent measures.

The USFWS is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest USFWS Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the USFWS Law Enforcement Office at (425) 883-8122, or the USFWS' Washington Fish and Wildlife Office at (360) 753-9440.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The USFWS recommends the following to the FHWA:

1. The FHWA and WSDOT should monitor plantings of trees and shrubs for at least 3 years in restored areas to ensure plant survival. Plantings should meet the following minimum requirements:

    a. 100 percent survival for trees and shrubs for the first year, with replacements as needed to achieve this value.

    b. At least 80 percent survival of trees and shrubs at the end of 3 years, with replacements as needed to achieve this value.

2. The FHWA/WSDOT should replace the fish passage barrier on Indian Creek to provide unimpeded passage for all fish species and life stages at all times of year.

3. To retain mature trees that will be cut within the river system, all large trees removed from upland and riparian areas associated with the project should be stockpiled and placed on gravel bars or within the river following the completion of construction.

In order for the USFWS to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the USFWS requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the request for formal consultation. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: 1) the amount or extent of incidental take is exceeded; 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or 4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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APPENDIX A
STATUS OF THE SPECIES: BULL TROUT

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Appendix A
Status of the Species: Bull Trout

Taxonomy

The bull trout (*Salvelinus confluentus*) is a native char found in the coastal and intermountain west of North America. Dolly Varden (*Salvelinus malma)* and bull trout were previously considered a single species and were thought to have coastal and interior forms. However, Cavender (1978, entire) described morphometric, meristic and osteological characteristics of the two forms, and provided evidence of specific distinctions between the two. Despite an overlap in the geographic range of bull trout and Dolly Varden in the Puget Sound area and along the British Columbia coast, there is little evidence of introgression (Haas and McPhail 1991, p. 2191). The Columbia River Basin is considered the region of origin for the bull trout. From the Columbia, dispersal to other drainage systems was accomplished by marine migration and headwater stream capture. Behnke (2002, p. 297) postulated dispersion to drainages east of the continental divide may have occurred through the North and South Saskatchewan Rivers (Hudson Bay drainage) and the Yukon River system. Marine dispersal may have occurred from Puget Sound north to the Fraser, Skeena and Taku Rivers of British Columbia.

Species Description

Bull trout have unusually large heads and mouths for salmonids. Their body colors can vary tremendously depending on their environment, but are often brownish green with lighter (often ranging from pale yellow to crimson) colored spots running along their dorsa and flanks, with spots being absent on the dorsal fin, and light colored to white under bellies. They have white leading edges on their fins, as do other species of char. Bull trout have been measured as large as 103 centimeters (41 inches) in length, with weights as high as 14.5 kilograms (32 pounds) (Fishbase 2015, p. 1). Bull trout may be migratory, moving throughout large river systems, lakes, and even the ocean in coastal populations, or they may be resident, remaining in the same stream their entire lives (Rieman and McIntyre 1993, p. 2; Brenkman and Corbett 2005, p. 1077). Migratory bull trout are typically larger than resident bull trout (USFWS 1998, p. 31668).

Legal Status

The coterminous United States population of the bull trout was listed as threatened on November 1, 1999 (USFWS 1999, entire). The threatened bull trout generally occurs in the Klamath River Basin of south-central Oregon; the Jarbidge River in Nevada; the Willamette River Basin in Oregon; Pacific Coast drainages of Washington, including Puget Sound; major rivers in Idaho, Oregon, Washington, and Montana, within the Columbia River Basin; and the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Bond 1992, p. 4; Brewin and Brewin 1997, pp. 209-216; Cavender 1978, pp. 165-166; Leary and Allendorf 1997, pp. 715-720).

Throughout its range, the bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, entrainment (a process by which aquatic organisms are pulled through a diversion or other device) into diversion channels, and introduced non-native species (USFWS 1999, p. 58910). Although all salmonids are likely to be affected by climate change, bull trout are especially vulnerable given that spawning and rearing are constrained by their location in upper watersheds and the requirement for cold water temperatures (Battin et al. 2007, entire; Rieman et al. 2007, entire; Porter and Nelitz. 2009, pages 4-8). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

Life History

The iteroparous reproductive strategy of bull trout has important repercussions for the management of this species. Bull trout require passage both upstream and downstream, not only for repeat spawning but also for foraging. Most fish ladders, however, were designed specifically for anadromous semelparous salmonids (fishes that spawn once and then die, and require only one-way passage upstream). Therefore, even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route. Additionally, in some core areas, bull trout that migrate to marine waters must pass both upstream and downstream through areas with net fisheries at river mouths. This can increase the likelihood of mortality to bull trout during these spawning and foraging migrations.

Growth varies depending upon life-history strategy. Resident adults range from 6 to 12 inches total length, and migratory adults commonly reach 24 inches or more (Goetz 1989, p. 30; Pratt 1985, pp. 28-34). The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982, p. 95).

Bull trout typically spawn from August through November during periods of increasing flows and decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989, p. 141). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989, pp. 15-16; Pratt 1992, pp. 6-7; Rieman and McIntyre 1996, p. 133). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992, p. 1). After hatching, fry remain in the substrate, and time from egg deposition to emergence may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992, p. 1; Ratliff and Howell 1992, p. 10).

Early life stages of fish, specifically the developing embryo, require the highest inter-gravel dissolved oxygen (IGDO) levels, and are the most sensitive life stage to reduced oxygen levels. The oxygen demand of embryos depends on temperature and on stage of development, with the greatest IGDO required just prior to hatching.

A literature review conducted by the Washington Department of Ecology (WDOE 2002, p. 9) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). Normal oxygen levels seen in rivers used by bull trout during spawning ranged from 8 to 12 mg/L (in the gravel), with corresponding instream levels of 10 to 11.5 mg/L (Stewart et al. 2007, p. 10). In addition, IGDO concentrations, water velocities in the water column, and especially the intergravel flow rate, are interrelated variables that affect the survival of incubating embryos (ODEQ 1995, Ch 2 pp.

23-24). Due to a long incubation period of 220+ days, bull trout are particularly sensitive to adequate IGDO levels. An IGDO level below 8 mg/L is likely to result in mortality of eggs, embryos, and fry.

Population Dymanics

Population Structure

Bull trout exhibit both resident and migratory life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993, p. 2). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Goetz 1989, p. 15). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989, p. 138; Goetz 1989, p. 24), or saltwater (anadromous form) to rear as subadults and to live as adults (Brenkman and Corbett 2005, entire; McPhail and Baxter 1996, p. i; WDFW et al. 1997, p. 16). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime). Repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Fraley and Shepard 1989, p. 135; Leathe and Graham 1982, p. 95; Pratt 1992, p. 8; Rieman and McIntyre 1996, p. 133).

Bull trout are naturally migratory, which allows them to capitalize on temporally abundant food resources and larger downstream habitats. Resident forms may develop where barriers (either natural or manmade) occur or where foraging, migrating, or overwintering habitats for migratory fish are minimized (Brenkman and Corbett 2005, pp. 1075-1076; Goetz et al. 2004, p. 105). For example, multiple life history forms (e.g., resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002, pp. 96, 98-106). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams, lakes, and marine waters; greater fecundity resulting in increased reproductive potential; and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Frissell 1999, pp. 861-863; MBTSG 1998, p. 13; Rieman and McIntyre 1993, pp. 2-3). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbances make local habitats temporarily unsuitable. Therefore, the range of the species is diminished, and the potential for a greater reproductive contribution from larger size fish with higher fecundity is lost (Rieman and McIntyre 1993, p. 2).

Whitesel et al. (2004, p. 2) noted that although there are multiple resources that contribute to the subject, Spruell et al. (2003, entire) best summarized genetic information on bull trout population structure. Spruell et al. (2003, entire) analyzed 1,847 bull trout from 65 sampling locations, four located in three coastal drainages (Klamath, Queets, and Skagit Rivers), one in the Saskatchewan River drainage (Belly River), and 60 scattered throughout the Columbia River Basin. They concluded that there is a consistent pattern among genetic studies of bull trout, regardless of whether examining allozymes, mitochondrial DNA, or most recently microsatellite loci. Typically, the genetic pattern shows relatively little genetic variation within populations, but substantial divergence among populations. Microsatellite loci analysis supports the existence of at least three major genetically differentiated groups (or evolutionary lineages) of bull trout (Spruell et al. 2003, p. 17). They were characterized as:

i. "Coastal", including the Deschutes River and all of the Columbia River drainage downstream, as well as most coastal streams in Washington, Oregon, and British Columbia. A compelling case also exists that the Klamath Basin represents a unique evolutionary lineage within the coastal group.

ii. "Snake River", which also included the John Day, Umatilla, and Walla Walla rivers. Despite close proximity of the John Day and Deschutes Rivers, a striking level of divergence between bull trout in these two systems was observed.

iii. "Upper Columbia River" which includes the entire basin in Montana and northern Idaho. A tentative assignment was made by Spruell et al. (2003, p. 25) of the Saskatchewan River drainage populations (east of the continental divide), grouping them with the upper Columbia River group.

Spruell et al. (2003, p. 17) noted that within the major assemblages, populations were further subdivided, primarily at the level of major river basins. Taylor et al. (1999, entire) surveyed bull trout populations, primarily from Canada, and found a major divergence between inland and coastal populations. Costello et al. (2003, p. 328) suggested the patterns reflected the existence of two glacial refugia, consistent with the conclusions of Spruell et al. (2003, p. 26) and the biogeographic analysis of Haas and McPhail (2001, entire). Both Taylor et al. (1999, p. 1166) and Spruell et al. (2003, p. 21) concluded that the Deschutes River represented the most upstream limit of the coastal lineage in the Columbia River Basin.

More recently, the U.S. Fish and Wildlife Service (Service) identified additional genetic units within the coastal and interior lineages (Ardren et al. 2011, p. 18). Based on a recommendation in the Service's 5-year review of the species' status (USFWS 2008a, p. 45), the Service reanalyzed the 27 recovery units identified in the draft bull trout recovery plan (USFWS 2002a, p. 48) by utilizing, in part, information from previous genetic studies and new information from additional analysis (Ardren et al. 2011, entire). In this examination, the Service applied relevant factors from the joint Service and National Marine Fisheries Service Distinct Population Segment (DPS) policy (USFWS 1996, entire) and subsequently identified six draft recovery units that contain assemblages of core areas that retain genetic and ecological integrity across the range of bull trout in the coterminous United States. These six draft recovery units were used to inform designation of critical habitat for bull trout by providing a context for deciding what habitats are essential for recovery (USFWS 2010, p. 63898). The six draft recovery units identified for bull trout in the coterminous United States include: Coastal, Klamath, Mid-Columbia, Columbia Headwaters, Saint Mary, and Upper Snake. These six draft recovery units were also identified in the Service's revised recovery plan (USFWS 2015, p. vii) and designated as final recovery units.

Population Dynamics

Although bull trout are widely distributed over a large geographic area, they exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993, p. 4). Increased habitat fragmentation reduces the amount of available habitat and increases isolation from other populations of the same species (Saunders et al. 1991, entire). Burkey (1989, entire) concluded that when species are isolated by fragmented habitats, low rates of population growth are typical in local populations and their probability of extinction is directly related to the degree of isolation and fragmentation. Without sufficient immigration, growth for local populations may be low and probability of extinction high (Burkey 1989, entire; Burkey 1995, entire).

Metapopulation concepts of conservation biology theory have been suggested relative to the distribution and characteristics of bull trout, although empirical evidence is relatively scant (Rieman and McIntyre 1993, p. 15; Dunham and Rieman 1999, entire; Rieman and Dunham 2000, entire). A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1994, pp. 189-190). For inland bull trout, metapopulation theory is likely most applicable at the watershed scale where habitat consists of discrete patches or collections of habitat capable of supporting local populations; local populations are for the most part independent and represent discrete reproductive units; and long-term, low-rate dispersal patterns among component populations influences the persistence of at least some of the local populations (Rieman and Dunham 2000, entire). Ideally, multiple local populations distributed throughout a watershed provide a mechanism for spreading risk because the simultaneous loss of all local populations is unlikely. However, habitat alteration, primarily through the construction of impoundments, dams, and water diversions has fragmented habitats, eliminated migratory corridors, and in many cases isolated bull trout in the headwaters of tributaries (Rieman and Clayton 1997, pp. 10-12; Dunham and Rieman 1999, p. 645; Spruell et al. 1999, pp. 118-120; Rieman and Dunham 2000, p. 55).

Human-induced factors as well as natural factors affecting bull trout distribution have likely limited the expression of the metapopulation concept for bull trout to patches of habitat within the overall distribution of the species (Dunham and Rieman 1999, entire). However, despite the theoretical fit, the relatively recent and brief time period during which bull trout investigations have taken place does not provide certainty as to whether a metapopulation dynamic is occurring (e.g., a balance between local extirpations and recolonizations) across the range of the bull trout or whether the persistence of bull trout in large or closely interconnected habitat patches (Dunham and Rieman 1999, entire) is simply reflective of a general deterministic trend towards extinction of the species where the larger or interconnected patches are relics of historically wider distribution (Rieman and Dunham 2000, pp. 56-57). Recent research (Whiteley et al. 2003, entire) does, however, provide genetic evidence for the presence of a metapopulation process for bull trout, at least in the Boise River Basin of Idaho.

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993, p. 4). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989, entire; Goetz 1989, pp. 23, 25; Hoelscher and Bjornn 1989, pp. 19, 25; Howell and Buchanan 1992, pp. 30, 32; Pratt 1992, entire; Rich 1996, p. 17; Rieman and McIntyre 1993, pp. 4-6; Rieman and McIntyre 1995, entire; Sedell and Everest 1991, entire; Watson and Hillman 1997, entire). Watson and Hillman (1997, pp. 247-250) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993, pp. 4-6), bull trout should not be expected to simultaneously occupy all available habitats.

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993, p. 2). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed or stray to nonnatal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a long time (Rieman and McIntyre 1993, p. 2; Spruell et al. 1999, entire). Migration also allows bull trout to access more abundant or larger prey, which facilitates growth and reproduction. Additional benefits of migration and its relationship to foraging are discussed below under "Diet."

Cold water temperatures play an important role in determining bull trout habitat quality, as these fish are primarily found in colder streams, and spawning habitats are generally characterized by temperatures that drop below 9 °C in the fall (Fraley and Shepard 1989, p. 137; Pratt 1992, p. 5; Rieman and McIntyre 1993, p. 2).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992, pp 7-8; Rieman and McIntyre 1993, p. 7). Optimum incubation temperatures for bull trout eggs range from 2 °C to 6 °C whereas optimum water temperatures for rearing range from about 6 °C to 10 °C (Buchanan and Gregory 1997, p. 4; Goetz 1989, p. 22). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996, entire) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 °C to 9 °C, within a temperature gradient of 8 °C to 15 °C. In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003, p. 900) found that the probability of juvenile bull trout occurrence does not become high (i.e., greater than 0.75) until maximum temperatures decline to 11 °C to 12 °C.

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Buchanan and Gregory 1997, p. 2; Fraley and Shepard 1989, pp. 133, 135; Rieman and McIntyre 1993, pp. 3-4; Rieman and McIntyre 1995, p. 287). Availability and proximity of cold water patches and food productivity can influence bull trout ability to survive in warmer rivers (Myrick 2002, pp. 6 and 13).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989, p. 137; Goetz 1989, p. 19; Hoelscher and Bjornn 1989, p. 38; Pratt 1992, entire; Rich 1996, pp. 4-5; Sedell and Everest 1991, entire; Sexauer and James 1997, entire; Thomas 1992, pp. 4-6; Watson and Hillman 1997, p. 238). Maintaining bull trout habitat requires natural stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993, pp. 5-6). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997, p. 364). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989, p. 141; Pratt 1992, p. 6; Pratt and Huston 1993, p. 70). Pratt (1992, p. 6) indicated that increases in fine sediment reduce egg survival and emergence.

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Fish growth depends on the quantity and quality of food that is eaten, and as fish grow their foraging strategy changes as their food changes, in quantity, size, or other characteristics (Quinn 2005, pp. 195-200). Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987, p. 58; Donald and Alger 1993, pp. 242-243; Goetz 1989, pp. 33-34). Subadult and adult migratory bull trout feed on various fish species (Donald and Alger 1993, pp. 241-243; Fraley and Shepard 1989, pp. 135, 138; Leathe and Graham 1982, pp. 13, 50-56). Bull trout of all sizes other than fry have been found to eat fish half their length (Beauchamp and VanTassell 2001, p. 204). In nearshore marine areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (Goetz et al. 2004, p. 105; WDFW et al. 1997, p. 23).

Bull trout migration and life history strategies are closely related to their feeding and foraging strategies. Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. For example, in the Skagit River system, anadromous bull trout make migrations as long as 121 miles between marine foraging areas in Puget Sound and headwater spawning grounds, foraging on salmon eggs and juvenile salmon along their migration route (WDFW et al. 1997, p. 25). Anadromous bull trout also use marine waters as migration corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Brenkman and Corbett 2005, pp. 1078-1079; Goetz et al. 2004, entire).

Status and Distribution

Distribution and Demography

The historical range of bull trout includes major river basins in the Pacific Northwest at about 41 to 60 degrees North latitude, from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada to the headwaters of the Yukon River in the Northwest Territories, Canada (Cavender 1978, pp. 165-166; Bond 1992, p. 2). To the west, the bull trout's range includes Puget Sound, various coastal rivers of British Columbia, Canada, and southeast Alaska (Bond 1992, p. 2). Bull trout occur in portions of the Columbia River and tributaries within the basin, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River basin of south-central Oregon. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta and Montana and in the MacKenzie River system in Alberta and British Columbia, Canada (Cavender 1978, pp. 165-166; Brewin et al. 1997, entire).

Each of the following recovery units (below) is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions. No new local populations have been identified and no local populations have been lost since listing.

Coastal Recovery Unit

The Coastal Recovery Unit is located within western Oregon and Washington. Major geographic regions include the Olympic Peninsula, Puget Sound, and Lower Columbia River basins. The Olympic Peninsula and Puget Sound geographic regions also include their associated marine waters (Puget Sound, Hood Canal, Strait of Juan de Fuca, and Pacific Coast), which are critical in supporting the anadromous2 life history form, unique to the Coastal Recovery Unit. The Coastal Recovery Unit is also the only unit that overlaps with the distribution of Dolly Varden (*Salvelinus malma*) (Ardren *et al*. 2011), another native char species that looks very similar to the bull trout (Haas and McPhail 1991). The two species have likely had some level of historic introgression in this part of their range (Redenbach and Taylor 2002). The Lower Columbia River major geographic region includes the lower mainstem Columbia River, an important migratory waterway essential for providing habitat and population connectivity within this region. In the Coastal Recovery Unit, there are 21 existing bull trout core areas which have been designated, including the recently reintroduced Clackamas River population, and 4 core areas have been identified that could be re-established. Core areas within the recovery unit are distributed among these three major geographic regions (Puget Sound also includes one core area that is actually part of the lower Fraser River system in British Columbia, Canada) (USFWS 2015a, p. A-1).

The current demographic status of bull trout in the Coastal Recovery Unit is variable across the unit. Populations in the Puget Sound region generally tend to have better demographic status, followed by the Olympic Peninsula, and finally the Lower Columbia River region. However, population strongholds do exist across the three regions. The Lower Skagit River and Upper Skagit River core areas in the Puget Sound region likely contain two of the most abundant bull trout populations with some of the most intact habitat within this recovery unit. The Lower Deschutes River core area in the Lower Columbia River region also contains a very abundant bull trout population and has been used as a donor stock for re-establishing the Clackamas River population (USFWS 2015a, p. A-6).

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2 Anadromous: Life history pattern of spawning and rearing in fresh water and migrating to salt water areas to mature.

Puget Sound Region

In the Puget Sound region, bull trout populations are concentrated along the eastern side of Puget Sound with most core areas concentrated in central and northern Puget Sound.

Although the Chilliwack River core area is considered part of this region, it is technically connected to the Fraser River system and is transboundary with British Columbia making its distribution unique within the region. Most core areas support a mix of anadromous and fluvial life history forms, with at least two core areas containing a natural adfluvial life history (Chilliwack River core area [Chilliwack Lake] and Chester Morse Lake core area). Overall demographic status of core areas generally improves as you move from south Puget Sound to north Puget Sound. Although comprehensive trend data are lacking, the current condition of core areas within this region are likely stable overall, although some at depressed abundances. Two core areas (Puyallup River and Stillaguamish River) contain local populations at either very low abundances (Upper Puyallup and Mowich Rivers) or that have likely become locally extirpated (Upper Deer Creek, South Fork Canyon Creek, and Greenwater River). Connectivity among and within core areas of this region is generally intact. Most core areas in this region still have significant amounts of headwater habitat within protected and relatively pristine areas (e.g., North Cascades National Park, Mount Rainier National Park, Skagit Valley Provincial Park, Manning Provincial Park, and various wilderness or recreation areas) (USFWS 2015a, p. A-7).

Olympic Peninsula Region

In the Olympic Peninsula region, distribution of core areas is somewhat disjunct, with only one located on the west side of Hood Canal on the eastern side of the peninsula, two along the Strait of Juan de Fuca on the northern side of the peninsula, and three along the Pacific Coast on the western side of the peninsula. Most core areas support a mix of anadromous and fluvial life history forms, with at least one core area also supporting a natural adfluvial life history (Quinault River core area [Quinault Lake]). Demographic status of core areas is poorest in Hood Canal and Strait of Juan de Fuca, while core areas along the Pacific Coast of Washington likely have the best demographic status in this region. The connectivity between core areas in these disjunct regions is believed to be naturally low due to the geographic distance between them.

Internal connectivity is currently poor within the Skokomish River core area (Hood Canal) and is being restored in the Elwha River core area (Strait of Juan de Fuca). Most core areas in this region still have their headwater habitats within relatively protected areas (Olympic National Park and wilderness areas) (USFWS 2015a, p. A-7).

Lower Columbia River Region

In the Lower Columbia River region, the majority of core areas are distributed along the Cascade Crest on the Oregon side of the Columbia River. Only two of the seven core areas in this region are in Washington. Most core areas in the region historically supported a fluvial life history form, but many are now adfluvial due to reservoir construction. However, there is at least one core area supporting a natural adfluvial life history (Odell Lake) and one supporting a natural, isolated, resident life history (Klickitat River [West Fork Klickitat]). Status is highly variable across this region, with one relative stronghold (Lower Deschutes core area) existing on the Oregon side of the Columbia River. The Lower Columbia River region also contains three watersheds (North Santiam River, Upper Deschutes River, and White Salmon River) that could potentially become re-established core areas within the Coastal Recovery Unit. Although the South Santiam River has been identified as a historic core area, there remains uncertainty as to whether or not historical observations of bull trout represented a self-sustaining population. Current habitat conditions in the South Santiam River are thought to be unable to support bull trout spawning and rearing. Adult abundances within the majority of core areas in this region are relatively low, generally 300 or fewer individuals.

Most core populations in this region are not only isolated from one another due to dams or natural barriers, but they are internally fragmented as a result of manmade barriers. Local populations are often disconnected from one another or from potential foraging habitat. In the Coastal Recovery Unit, adult abundance may be lowest in the Hood River and Odell Lake core areas, which each contain fewer than 100 adults. Bull trout were reintroduced in the Middle Fork Willamette River in 1990 above Hills Creek Reservoir. Successful reproduction was first documented in 2006, and has occurred each year since (USFWS 2015a, p. A-8). Natural reproducing populations of bull trout are present in the McKenzie River basin (USFWS 2008d, pp. 65-67). Bull trout were more recently reintroduced into the Clackamas River basin in the summer of 2011 after an extensive feasibility analysis (Shively et al. 2007, Hudson et al. 2015). Bull trout from the Lower Deschutes core area are being utilized for this reintroduction effort (USFWS 2015a, p. A-8).

Klamath Recovery Unit

Bull trout in the Klamath Recovery Unit have been isolated from other bull trout populations for the past 10,000 years and are recognized as evolutionarily and genetically distinct (Minckley et al. 1986; Leary et al. 1993; Whitesel et al. 2004; USFWS 2008a; Ardren et al. 2011). As such, there is no opportunity for bull trout in another recovery unit to naturally re- colonize the Klamath Recovery Unit if it were to become extirpated. The Klamath Recovery Unit lies at the southern edge of the species range and occurs in an arid portion of the range of bull trout.

Bull trout were once widespread within the Klamath River basin (Gilbert 1897; Dambacher et al. 1992; Ziller 1992; USFWS 2002b), but habitat degradation and fragmentation, past and present land use practices, agricultural water diversions, and past fisheries management practices have greatly reduced their distribution. Bull trout abundance also has been severely reduced, and the remaining populations are highly fragmented and vulnerable to natural or manmade factors that place them at a high risk of extirpation (USFWS 2002b). The presence of nonnative brook trout (*Salvelinus fontinalis*), which compete and hybridize with bull trout, is a particular threat to bull trout persistence throughout the Klamath Recovery Unit (USFWS 2015b, pp. B-3-4).

Upper Klamath Lake Core Area

The Upper Klamath Lake core area comprises two bull trout local populations (Sun Creek and Threemile Creek). These local populations likely face an increased risk of extirpation because they are isolated and not interconnected with each other. Extirpation of other local populations in the Upper Klamath Lake core area has occurred in recent times (1970s). Populations in this core area are genetically distinct from those in the other two core areas in the Klamath Recovery Unit (USFWS 2008b), and in comparison, genetic variation within this core area is lowest. The two local populations have been isolated by habitat fragmentation and have experienced population bottlenecks. As such, currently unoccupied habitat is needed to restore connectivity between the two local populations and to establish additional populations. This unoccupied habitat includes canals, which now provide the only means of connectivity as migratory corridors. Providing full volitional connectivity for bull trout, however, also introduces the risk of invasion by brook trout, which are abundant in this core area.

Bull trout in the Upper Klamath Lake core area formerly occupied Annie Creek, Sevenmile Creek, Cherry Creek, and Fort Creek, but are now extirpated from these locations. The last remaining local populations, Sun Creek and Threemile Creek, have received focused attention. Brook trout have been removed from bull trout occupied reaches, and these reaches have been intentionally isolated to prevent brook trout reinvasion. As such, over the past few generations these populations have become stable and have increased in distribution and abundance. In 1996, the Threemile Creek population had approximately 50 fish that occupied a 1.4-km (0.9-mile) reach (USFWS 2002b). In 2012, a mark-resight population estimate was completed in Threemile Creek, which indicated an abundance of 577 (95 percent confidence interval = 475 to 679) age-1+ fish (ODFW 2012). In addition, the length of the distribution of bull trout in Threemile Creek had increased to 2.7 km (1.7 miles) by 2012 (USFWS unpublished data). Between 1989 and 2010, bull trout abundance in Sun Creek increased approximately tenfold (from approximately 133 to 1,606 age-1+ fish) and distribution increased from approximately 1.9 km (1.2 miles) to 11.2 km (7.0 miles) (Buktenica et al. 2013) (USFWS 2015b, p. B-5).

Sycan River Core Area

The Sycan River core area is comprised of one local population, Long Creek. Long Creek likely faces greater risk of extirpation because it is the only remaining local population due to extirpation of all other historic local populations. Bull trout previously occupied Calahan Creek, Coyote Creek, and the Sycan River, but are now extirpated from these locations (Light et al. 1996). This core area's local population is genetically distinct from those in the other two core areas (USFWS 2008b). This core area also is essential for recovery because bull trout in this core area exhibit both resident3 and fluvial life histories, which are important for representing diverse life history expression in the Klamath Recovery Unit. Migratory bull trout are able to grow larger than their resident counterparts, resulting in greater fecundity and higher reproductive potential

3 Resident: Life history pattern of residing in tributary streams for the fish's entire life without migrating.

(Rieman and McIntyre 1993). Migratory life history forms also have been shown to be important for population persistence and resilience (Dunham et al. 2008).

The last remaining population (Long Creek) has received focused attention in an effort to ensure it is not also extirpated. In 2006, two weirs were removed from Long Creek, which increased the amount of occupied foraging, migratory, and overwintering (FMO) habitat by 3.2 km (2.0 miles). Bull trout currently occupy approximately 3.5 km (2.2 miles) of spawning/rearing habitat, including a portion of an unnamed tributary to upper Long Creek, and seasonally use 25.9 km (16.1 miles) of FMO habitat. Brook trout also inhabit Long Creek and have been the focus of periodic removal efforts. No recent statistically rigorous population estimate has been completed for Long Creek; however, the 2002 Draft Bull Trout Recovery Plan reported a population estimate of 842 individuals (USFWS 2002b). Currently unoccupied habitat is needed to establish additional local populations, although brook trout are widespread in this core area and their management will need to be considered in future recovery efforts. In 2014, the Klamath Falls Fish and Wildlife Office of the Service established an agreement with the U.S. Geological Survey to undertake a structured decision making process to assist with recovery planning of bull trout populations in the Sycan River core area (USFWS 2015b, p. B-6).

Upper Sprague River Core Area

The Upper Sprague River core area comprises five bull trout local populations, placing the core area at an intermediate risk of extinction. The five local populations include Boulder Creek, Dixon Creek, Deming Creek, Leonard Creek, and Brownsworth Creek. These local populations may face a higher risk of extirpation because not all are interconnected. Bull trout local populations in this core area are genetically distinct from those in the other two Klamath Recovery Unit core areas (USFWS 2008b). Migratory bull trout have occasionally been observed in the North Fork Sprague River (USFWS 2002b). Therefore, this core area also is essential for recovery in that bull trout here exhibit a resident life history and likely a fluvial life history, which are important for conserving diverse life history expression in the Klamath Recovery Unit as discussed above for the Sycan River core area.

The Upper Sprague River core area population of bull trout has experienced a decline from historic levels, although less is known about historic occupancy in this core area. Bull trout are reported to have historically occupied the South Fork Sprague River, but are now extirpated from this location (Buchanan et al. 1997). The remaining five populations have received focused attention. Although brown trout (*Salmo trutta*) co-occur with bull trout and exist in adjacent habitats, brook trout do not overlap with existing bull trout populations. Efforts have been made to increase connectivity of existing bull trout populations by replacing culverts that create barriers. Thus, over the past few generations, these populations have likely been stable and increased in distribution. Population abundance has been estimated recently for Boulder Creek (372 + 62 percent; Hartill and Jacobs 2007), Dixon Creek (20 + 60 percent; Hartill and Jacobs 2007), Deming Creek (1,316 + 342; Moore 2006), and Leonard Creek (363 + 37 percent; Hartill and Jacobs 2007). No statistically rigorous population estimate has been completed for the Brownsworth Creek local population; however, the 2002 Draft Bull Trout Recovery Plan reported a population estimate of 964 individuals (USFWS 2002b). Additional local populations need to be established in currently unoccupied habitat within the Upper Sprague River core area, although brook trout are widespread in this core area and will need to be considered in future recovery efforts (USFWS 2015b, p. B-7).

Mid-Columbia Recovery Unit

The Mid-Columbia Recovery Unit (RU) comprises 24 bull trout core areas, as well as 2 historically occupied core areas and 1 research needs area. The Mid-Columbia RU is recognized as an area where bull trout have co-evolved with salmon, steelhead, lamprey, and other fish populations. Reduced fish numbers due to historic overfishing and land management changes have caused changes in nutrient abundance for resident migratory fish like the bull trout. The recovery unit is located within eastern Washington, eastern Oregon, and portions of central Idaho. Major drainages include the Methow River, Wenatchee River, Yakima River, John Day River, Umatilla River, Walla Walla River, Grande Ronde River, Imnaha River, Clearwater River, and smaller drainages along the Snake River and Columbia River (USFWS 2015c, p. C-1).

The Mid-Columbia RU can be divided into four geographic regions the Lower Mid-Columbia, which includes all core areas that flow into the Columbia River below its confluence with the 1) Snake River; 2) the Upper Mid-Columbia, which includes all core areas that flow into the Columbia River above its confluence with the Snake River; 3) the Lower Snake, which includes all core areas that flow into the Snake River between its confluence with the Columbia River and Hells Canyon Dam; and 4) the Mid-Snake, which includes all core areas in the Mid-Columbia RU that flow into the Snake River above Hells Canyon Dam. These geographic regions are composed of neighboring core areas that share similar bull trout genetic, geographic (hydrographic), and/or habitat characteristics. Conserving bull trout in geographic regions allows for the maintenance of broad representation of genetic diversity, provides neighboring core areas with potential source populations in the event of local extirpations, and provides a broad array of options among neighboring core areas to contribute recovery under uncertain environmental change USFWS 2015c, pp. C-1-2).

The current demographic status of bull trout in the Mid-Columbia Recovery Unit is highly variable at both the RU and geographic region scale. Some core areas, such as the Umatilla, Asotin, and Powder Rivers, contain populations so depressed they are likely suffering from the deleterious effects of small population size. Conversely, strongholds do exist within the recovery unit, predominantly in the Lower Snake geographic area. Populations in the Imnaha, Little Minam, Clearwater, and Wenaha Rivers are likely some of the most abundant. These populations are all completely or partially within the bounds of protected wilderness areas and have some of the most intact habitat in the recovery unit. Status in some core areas is relatively unknown, but all indications in these core areas suggest population trends are declining, particularly in the core areas of the John Day Basin (USFWS 2015c, p. C-5).

<u>Lower Mid-Columbia Region</u>

In the Lower Mid-Columbia Region, core areas are distributed along the western portion of the Blue Mountains in Oregon and Washington. Only one of the six core areas is located completely in Washington. Demographic status is highly variable throughout the region. Status is the poorest in the Umatilla and Middle Fork John Day Core Areas. However, the Walla Walla River core area contains nearly pristine habitats in the headwater spawning areas and supports the most abundant populations in the region. Most core areas support both a resident and fluvial life history; however, recent evidence suggests a significant decline in the resident and fluvial life history in the Umatilla River and John Day core areas respectively. Connectivity between the core areas of the Lower Mid-Columbia Region is unlikely given conditions in the connecting FMO habitats. Connection between the Umatilla, Walla Walla and Touchet core areas is uncommon but has been documented, and connectivity is possible between core areas in the John Day Basin. Connectivity between the John Day core areas and Umatilla/Walla Walla/Touchet core areas is unlikely (USFWS 2015c, pp. C-5-6).

Upper Mid-Columbia Region

In the Upper Mid-Columbia Region, core areas are distributed along the eastern side of the Cascade Mountains in Central Washington. This area contains four core areas (Yakima, Wenatchee, Entiat, and Methow), the Lake Chelan historic core area, and the Chelan River, Okanogan River, and Columbia River FMO areas. The core area populations are generally considered migratory, though they currently express both migratory (fluvial and adfluvial) and resident forms. Residents are located both above and below natural barriers (*i.e.*, Early Winters Creek above a natural falls; and Ahtanum in the Yakima likely due to long lack of connectivity from irrigation withdrawal). In terms of uniqueness and connectivity, the genetics baseline, radio-telemetry, and PIT tag studies identified unique local populations in all core areas. Movement patterns within the core areas; between the lower river, lakes, and other core areas; and between the Chelan, Okanogan, and Columbia River FMO occurs regularly for some of the Wenatchee, Entiat, and Methow core area populations. This type of connectivity has been displayed by one or more fish, typically in non-spawning movements within FMO. More recently, connectivity has been observed between the Entiat and Yakima core areas by a juvenile bull trout tagged in the Entiat moving in to the Yakima at Prosser Dam and returning at an adult size back to the Entiat. Genetics baselines identify unique populations in all four core areas (USFWS 2015c, p. C-6).

The demographic status is variable in the Upper-Mid Columbia region and ranges from good to very poor. The Service's 2008 5-year Review and Conservation Status Assessment described the Methow and Yakima Rivers at risk, with a rapidly declining trend. The Entiat River was listed at risk with a stable trend, and the Wenatchee River as having a potential risk, and with a stable trend. Currently, the Entiat River is considered to be declining rapidly due to much reduced redd counts. The Wenatchee River is able to exhibit all freshwater life histories with connectivity to Lake Wenatchee, the Wenatchee River and all its local populations, and to the Columbia River and/or other core areas in the region. In the Yakima core area some populations exhibit life history forms different from what they were historically. Migration between local populations and to and from spawning habitat is generally prevented or impeded by headwater storage dams on irrigation reservoirs, connectivity between tributaries and reservoirs, and within lower portions of spawning and rearing habitat and the mainstem Yakima River due to changed flow patterns, low instream flows, high water temperatures, and other habitat impediments. Currently, the connectivity in the Yakima Core area is truncated to the degree that not all populations are able to contribute gene flow to a functional metapopulation (USFWS 2015c, pp. C-6-7)

Lower Snake Region

Demographic status is variable within the Lower Snake Region. Although trend data are lacking, several core areas in the Grande Ronde Basin and the Imnaha core area are thought to be stable. The upper Grande Ronde Core Area is the exception where population abundance is considered depressed. Wenaha, Little Minam, and Imnaha Rivers are strongholds (as mentioned above), as are most core areas in the Clearwater River basin. Most core areas contain populations that express both a resident and fluvial life history strategy. There is potential that some bull trout in the upper Wallowa River are adfluvial. There is potential for connectivity between core areas in the Grande Ronde basin, however conditions in FMO are limiting (USFWS 2015c, p. C-7).

Middle Snake Region

In the Middle Snake Region, core areas are distributed along both sides of the Snake River above Hells Canyon Dam. The Powder River and Pine Creek basins are in Oregon and Indian Creek and Wildhorse Creek are on the Idaho side of the Snake River. Demographic status of the core areas is poorest in the Powder River Core Area where populations are highly fragmented and severely depressed. The East Pine Creek population in the Pine-Indian-Wildhorse Creeks core area is likely the most abundant within the region. Populations in both core areas primarily express a resident life history strategy; however, some evidence suggests a migratory life history still exists in the Pine-Indian-Wildhorse Creeks core area. Connectivity is severely impaired in the Middle Snake Region. Dams, diversions and temperature barriers prevent movement among populations and between core areas. Brownlee Dam isolates bull trout in Wildhorse Creek from other populations (USFWS 2015c, p. C-7).

Columbia Headwaters Recovery Unit

The Columbia Headwaters Recovery Unit (CHRU) includes western Montana, northern Idaho, and the northeastern corner of Washington. Major drainages include the Clark Fork River basin and its Flathead River contribution, the Kootenai River basin, and the Coeur d'Alene Lake basin. In this implementation plan for the CHRU we have slightly reorganized the structure from the 2002 Draft Recovery Plan, based on latest available science and fish passage improvements that have rejoined previously fragmented habitats. We now identify 35 bull trout core areas (compared to 47 in 2002) for this recovery unit. Fifteen of the 35 are referred to as "complex" core areas as they represent large interconnected habitats, each containing multiple spawning streams considered to host separate and largely genetically identifiable local populations. The 15 complex core areas contain the majority of individual bull trout and the bulk of the designated critical habitat (USFWS 2010).

However, somewhat unique to this recovery unit is the additional presence of 20 smaller core areas, each represented by a single local population. These "simple" core areas are found in remote glaciated headwater basins, often in Glacier National Park or federally-designated wilderness areas, but occasionally also in headwater valley bottoms. Many simple core areas are upstream of waterfalls or other natural barriers to fish migration. In these simple core areas bull trout have apparently persisted for thousands of years despite small populations and isolated existence. As such, simple core areas meet the criteria for core area designation and continue to be valued for their uniqueness, despite limitations of size and scope. Collectively, the 20 simple core areas contain less than 3 percent of the total bull trout core area habitat in the CHRU, but represent significant genetic and life history diversity (Meeuwig et al. 2010). Throughout this recovery unit implementation plan, we often separate our analyses to distinguish between complex and simple core areas, both in respect to threats as well as recovery actions (USFWS 2015d, pp. D-1-2).

In order to effectively manage the recovery unit implementation plan (RUIP) structure in this large and diverse landscape, the core areas have been separated into the following five natural geographic assemblages.

Upper Clark Fork Geographic Region

Starting at the Clark Fork River headwaters, the *Upper Clark Fork Geographic Region* comprises seven complex core areas, each of which occupies one or more major watersheds contributing to the Clark Fork basin (*i.e.*, Upper Clark Fork River, Rock Creek, Blackfoot River, Clearwater River and Lakes, Bitterroot River, West Fork Bitterroot River, and Middle Clark Fork River core areas) (USFWS 2015d, p. D-2).

Lower Clark Fork Geographic Region

The seven headwater core areas flow into the *Lower Clark Fork Geographic Region*, which comprises two complex core areas, Lake Pend Oreille and Priest Lake. Because of the systematic and jurisdictional complexity (three States and a Tribal entity) and the current degree of migratory fragmentation caused by five mainstem dams, the threats and recovery actions in the Lake Pend Oreille (LPO) core area are very complex and are described in three parts. LPO-A is upstream of Cabinet Gorge Dam, almost entirely in Montana, and includes the mainstem Clark Fork River upstream to the confluence of the Flathead River as well as the portions of the lower Flathead River (*e.g.*, Jocko River) on the Flathead Indian Reservation. LPO-B is the Pend Oreille lake basin proper and its tributaries, extending between Albeni Falls Dam downstream from the outlet of Lake Pend Oreille and Cabinet Gorge Dam just upstream of the lake; almost entirely in Idaho. LPO-C is the lower basin (*i.e.*, lower Pend Oreille River), downstream of Albeni Falls Dam to Boundary Dam (1 mile upstream from the Canadian border) and bisected by Box Canyon Dam; including portions of Idaho, eastern Washington, and the Kalispel Reservation (USFWS 2015d, p. D-2).

Historically, and for current purposes of bull trout recovery, migratory connectivity among these separate fragments into a single entity remains a primary objective.

Flathead Geographic Region

The *Flathead Geographic Region* includes a major portion of northwestern Montana upstream of Kerr Dam on the outlet of Flathead Lake. The complex core area of Flathead Lake is the hub of this area, but other complex core areas isolated by dams are Hungry Horse Reservoir (formerly South Fork Flathead River) and Swan Lake. Within the glaciated basins of the Flathead River headwaters are 19 simple core areas, many of which lie in Glacier National Park or the Bob Marshall and Great Bear Wilderness areas and some of which are isolated by natural barriers or other features (USFWS 2015d, p. D-2).

Kootenai Geographic Region

To the northwest of the Flathead, in an entirely separate watershed, lies the *Kootenai Geographic Region*. The Kootenai is a uniquely patterned river system that originates in southeastern British Columbia, Canada. It dips, in a horseshoe configuration, into northwest Montana and north Idaho before turning north again to re-enter British Columbia and eventually join the Columbia River headwaters in British Columbia. The *Kootenai Geographic Region* contains two complex core areas (Lake Koocanusa and the Kootenai River) bisected since the 1970's by Libby Dam, and also a single naturally isolated simple core area (Bull Lake). Bull trout in both of the complex core areas retain strong migratory connections to populations in British Columbia (USFWS 2015d, p. D-3).

Coeur d'Alene Geographic Region

Finally, the *Coeur d'Alene Geographic Region* consists of a single, large complex core area centered on Coeur d'Alene Lake. It is grouped into the CHRU for purposes of physical and ecological similarity (adfluvial bull trout life history and nonanadromous linkage) rather than due to watershed connectivity with the rest of the CHRU, as it flows into the mid-Columbia River far downstream of the Clark Fork and Kootenai systems (USFWS 2015d, p. D-3).

Upper Snake Recovery Unit

The Upper Snake Recovery Unit includes portions of central Idaho, northern Nevada, and eastern Oregon. Major drainages include the Salmon River, Malheur River, Jarbidge River, Little Lost River, Boise River, Payette River, and the Weiser River. The Upper Snake Recovery Unit contains 22 bull trout core areas within 7 geographic regions or major watersheds: Salmon River (10 core areas, 123 local populations), Boise River (2 core areas, 29 local populations), Payette River (5 core areas, 25 local populations), Little Lost River (1 core area, 10 local populations), Malheur River (2 core areas, 8 local populations), Jarbidge River (1 core area, 6 local populations), and Weiser River (1 core area, 5 local populations). The Upper Snake Recovery Unit includes a total of 206 local populations, with almost 60 percent being present in the Salmon River watershed (USFWS 2015e, p. E-1).

Three major bull trout life history expressions are present in the Upper Snake Recovery Unit, adfluvial[4], fluvial[5], and resident populations. Large areas of intact habitat exist primarily in the Salmon drainage, as this is the only drainage in the Upper Snake Recovery Unit that still flows directly into the Snake River; most other drainages no longer have direct connectivity due to irrigation uses or instream barriers. Bull trout in the Salmon basin share a genetic past with bull trout elsewhere in the Upper Snake Recovery Unit. Historically, the Upper Snake Recovery Unit is believed to have largely supported the fluvial life history form; however, many core areas are now isolated or have become fragmented watersheds, resulting in replacement of the fluvial life history with resident or adfluvial forms. The Weiser River, Squaw Creek, Pahsimeroi River, and North Fork Payette River core areas contain only resident populations of bull trout (USFWS 2015e, pp. E-1-2).

Salmon River

The Salmon River basin represents one of the few basins that are still free-flowing down to the Snake River. The core areas in the Salmon River basin do not have any major dams and a large extent (approximately 89 percent) is federally managed, with large portions of the Middle Fork Salmon River and Middle Fork Salmon River - Chamberlain core areas occurring within the Frank Church River of No Return Wilderness. Most core areas in the Salmon River basin contain large populations with many occupied stream segments. The Salmon River basin contains 10 of the 22 core areas in the Upper Snake Recovery Unit and contains the majority of the occupied habitat. Over 70 percent of occupied habitat in the Upper Snake Recovery Unit occurs in the Salmon River basin as well as 123 of the 206 local populations. Connectivity between core areas in the Salmon River basin is intact; therefore it is possible for fish in the mainstem Salmon to migrate to almost any Salmon River core area or even the Snake River.

Connectivity within Salmon River basin core areas is mostly intact except for the Pahsimeroi River and portions of the Lemhi River. The Upper Salmon River, Lake Creek, and Opal Lake core areas contain adfluvial populations of bull trout, while most of the remaining core areas contain fluvial populations; only the Pahsimeroi contains strictly resident populations. Most core areas appear to have increasing or stable trends but trends are not known in the Pahsimeroi, Lake Creek, or Opal Lake core areas. The Idaho Department of Fish and Game reported trend data from 7 of the 10 core areas. This trend data indicated that populations were stable or increasing in the Upper Salmon River, Lemhi River, Middle Salmon River-Chamberlain, Little Lost River, and the South Fork Salmon River (IDFG 2005, 2008). Trends were stable or decreasing in the Little-Lower Salmon River, Middle Fork Salmon River, and the Middle Salmon River-Panther (IDFG 2005, 2008).

4 Adfluvial: Life history pattern of spawning and rearing in tributary streams and migrating to lakes or reservoirs to mature.
5 Fluvial: Life history pattern of spawning and rearing in tributary streams and migrating to larger rivers to mature.

Boise River

In the Boise River basin, two large dams are impassable barriers to upstream fish movement: Anderson Ranch Dam on the South Fork Boise River, and Arrowrock Dam on the mainstem Boise River. Fish in Anderson Ranch Reservoir have access to the South Fork Boise River upstream of the dam. Fish in Arrowrock Reservoir have access to the North Fork Boise River, Middle Fork Boise River, and lower South Fork Boise River. The Boise River basin contains 2 of the 22 core areas in the Upper Snake Recovery Unit. The core areas in the Boise River basin account for roughly 12 percent of occupied habitat in the Upper Snake Recovery Unit and contain 29 of the 206 local populations. Approximately 90 percent of both Arrowrock and Anderson Ranch core areas are federally owned; most lands are managed by the U.S. Forest Service, with some portions occurring in designated wilderness areas. Both the Arrowrock core area and the Anderson Ranch core area are isolated from other core areas. Both core areas contain fluvial bull trout that exhibit adfluvial characteristics and numerous resident populations. The Idaho Department of Fish and Game in 2014 determined that the Anderson Ranch core area had an increasing trend while trends in the Arrowrock core area is unknown (USFWS 2015e).

Payette River

The Payette River basin contains three major dams that are impassable barriers to fish: Deadwood Dam on the Deadwood River, Cascade Dam on the North Fork Payette River, and Black Canyon Reservoir on the Payette River. Only the Upper South Fork Payette River and the Middle Fork Payette River still have connectivity, the remaining core areas are isolated from each other due to dams. Both fluvial and adfluvial life history expression are still present in the Payette River basin but only resident populations are present in the Squaw Creek and North Fork Payette River core areas. The Payette River basin contains 5 of the 22 core areas and 25 of the 206 local populations in the recovery unit. Less than 9 percent of occupied habitat in the recovery unit is in this basin. Approximately 60 percent of the lands in the core areas are federally owned and the majority is managed by the U.S. Forest Service. Trend data are lacking and the current condition of the various core areas is unknown, but there is concern due to the current isolation of three (North Fork Payette River, Squaw Creek, Deadwood River) of the five core areas; the presence of only resident local populations in two (North Fork Payette River, Squaw Creek) of the five core areas; and the relatively low numbers present in the North Fork core area (USFWS 2015e, p. E-8).

Jarbidge River

The Jarbidge River core area contains two major fish barriers along the Bruneau River: the Buckaroo diversion and C. J. Strike Reservoir. Bull trout are not known to migrate down to the Snake River. There is one core area in the basin, with populations in the Jarbidge River; this watershed does not contain any barriers. Approximately 89 percent of the Jarbidge core area is federally owned. Most lands are managed by either the Forest Service or Bureau of Land Management. A large portion of the core area is within the Bruneau-Jarbidge Wilderness area. A tracking study has documented bull trout population connectivity among many of the local populations, in particular between West Fork Jarbidge River and Pine Creek. Movement between the East and West Fork Jarbidge River has also been documented; therefore, both resident and fluvial populations are present. The core area contains six local populations and 3 percent of the occupied habitat in the recovery unit. Trend data are lacking within this core area (USFWS 2015e, p. E-9).

Little Lost River

The Little Lost River basin is unique in that the watershed is within a naturally occurring hydrologic sink and has no connectivity with other drainages. A small fluvial population of bull trout may still exist, but it appears that most populations are predominantly resident populations. There is one core area in the Little Lost basin, and approximately 89 percent of it is federally owned by either the U.S. Forest Service or Bureau of Land Management. The core area contains 10 local populations and less than 3 percent of the occupied habitat in the recovery unit. The current trend condition of this core area is likely stable, with most bull trout residing in Upper Sawmill Canyon (IDFG 2014).

Malheur River

The Malheur River basin contains major dams that are impassable to fish. The largest are Warm Springs Dam, impounding Warm Springs Reservoir on the mainstem Malheur River, and Agency Valley Dam, impounding Beulah Reservoir on the North Fork Malheur River. The dams result in two core areas that are isolated from each other and from other core areas. Local populations in the two core areas are limited to habitat in the upper watersheds. The Malheur River basin contains 2 of the 22 core areas and 8 of the 206 local populations in the recovery unit. Fluvial and resident populations are present in both core areas while adfluvial populations are present in the North Fork Malheur River. This basin contains less than 3 percent of the occupied habitat in the recovery unit, and approximately 60 percent of lands in the two core areas are federally owned. Trend data indicates that populations are declining in both core areas (USFWS 2015e, p. E-9).

Weiser River

The Weiser River basin contains local populations that are limited to habitat in the upper watersheds. The Weiser River basin contains only a single core area that consists of 5 of the 206 local populations in the recovery unit. Local populations occur in only three stream complexes in the upper watershed: 1) Upper Hornet Creek, 2) East Fork Weiser River, and 3) Upper Little Weiser River. These local populations include only resident life histories. This basin contains less than 2 percent of the occupied habitat in the recovery unit, and approximately 44 percent of lands are federally owned. Trend data from the Idaho Department of Fish and Game indicate that the populations in the Weiser core area are increasing (IDFG 2014) but it is considered vulnerable because local populations are isolated and likely do not express migratory life histories (USFWS 2015e, p.E-10).

St. Mary Recovery Unit

The Saint Mary Recovery Unit is located in northwest Montana east of the Continental Divide and includes the U.S. portions of the Saint Mary River basin, from its headwaters to the international boundary with Canada at the 49th parallel. The watershed and the bull trout population are linked to downstream aquatic resources in southern Alberta, Canada; the U.S. portion includes headwater spawning and rearing (SR) habitat in the tributaries and a portion of the FMO habitat in the mainstem of the Saint Mary River and Saint Mary lakes (Mogen and Kaeding 2001).

The Saint Mary Recovery Unit comprises four core areas; only one (Saint Mary River) is a complex core area with five described local bull trout populations (Divide, Boulder, Kennedy, Otatso, and Lee Creeks). Roughly half of the linear extent of available FMO habitat in the mainstem Saint Mary system (between Saint Mary Falls at the upstream end and the downstream Canadian border) is comprised of Saint Mary and Lower Saint Mary Lakes, with the remainder in the Saint Mary River. The other three core areas (Slide Lakes, Cracker Lake, and Red Eagle Lake) are simple core areas. Slide Lakes and Cracker Lake occur upstream of seasonal or permanent barriers and are comprised of genetically isolated single local bull trout populations, wholly within Glacier National Park, Montana. In the case of Red Eagle Lake, physical isolation does not occur, but consistent with other lakes in the adjacent Columbia Headwaters Recovery Unit, there is likely some degree of spatial separation from downstream Saint Mary Lake. As noted, the extent of isolation has been identified as a research need (USFWS 2015f, p. F-1).

Bull trout in the Saint Mary River complex core area are documented to exhibit primarily the migratory fluvial life history form (Mogen and Kaeding 2005a, 2005b), but there is doubtless some occupancy (though less well documented) of Saint Mary Lakes, suggesting a partly adfluvial adaptation. Since lake trout and northern pike are both native to the Saint Mary River system (headwaters of the South Saskatchewan River drainage draining to Hudson Bay), the conventional wisdom is that these large piscivores historically outcompeted bull trout in the lacustrine environment (Donald and Alger 1993, Martinez et al. 2009), resulting in a primarily fluvial niche and existence for bull trout in this system. This is an untested hypothesis and additional research into this aspect is needed (USFWS 2015f, p. F-3).

Bull trout populations in the simple core areas of the three headwater lake systems (Slide, Cracker, and Red Eagle Lakes) are, by definition, adfluvial; there are also resident life history components in portions of the Saint Mary River system such as Lower Otatso Creek (Mogen and Kaeding 2005a), further exemplifying the overall life history diversity typical of bull trout. Mogen and Kaeding (2001) reported that bull trout continue to inhabit nearly all suitable habitats accessible to them in the Saint Mary River basin in the United States. The possible exception is portions of Divide Creek, which appears to be intermittently occupied despite a lack of permanent migratory barriers, possibly due to low population size and erratic year class production (USFWS 2015f, p. F-3).

It should be noted that bull trout are found in minor portions of two additional U.S. watersheds (Belly and Waterton rivers) that were once included in the original draft recovery plan (USFWS 2002) but are no longer considered core areas in the final recovery plan (USFWS 2015) and are not addressed in that document. In Alberta, Canada, the Saint Mary River bull trout population is considered at "high risk," while the Belly River is rated as "at risk" (ACA 2009). In the Belly River drainage, which enters the South Saskatchewan system downstream of the Saint Mary River in Alberta, some bull trout spawning is known to occur on either side of the international boundary. These waters are in the drainage immediately west of the Saint Mary River headwaters. However, the U.S. range of this population constitutes only a minor headwater migratory SR segment of an otherwise wholly Canadian population, extending less than 1 mile (0.6 km) into backcountry waters of Glacier National Park. The Belly River population is otherwise totally dependent on management within Canadian jurisdiction, with no natural migratory connection to the Saint Mary (USFWS 2015f, p. F-3).

Current status of bull trout in the Saint Mary River core area (U.S.) is considered strong (Mogen 2013). Migratory bull trout redd counts are conducted annually in the two major SR streams, Boulder and Kennedy creeks. Boulder Creek redd counts have ranged from 33 to 66 in the past decade, with the last 4 counts all 53 or higher. Kennedy Creek redd counts are less robust, ranging from 5 to 25 over the last decade, with a 2014 count of 20 (USFWS 2015f, p. F-3).

Generally, the demographic status of the Saint Mary River core area is believed to be good, with the exception of the Divide Creek local population. In this local population, there is evidence that a combination of ongoing habitat manipulation (Smillie and Ellerbroek 1991, F-5 NPS 1992) resulting in occasional historical passage issues, combined with low and erratic recruitment (DeHaan et al. 2011) has caused concern for the continuing existence of the local population.

While less is known about the demographic status of the three simple cores where redd counts are not conducted, all three appear to be self-sustaining and fluctuating within known historical population demographic bounds. Of the three simple core areas, demographic status in Slide Lakes and Cracker Lake appear to be functioning appropriately, but the demographic status in Red Eagle Lake is less well documented and believed to be less robust (USFWS 2015f, p. F-3).

Reasons for Listing

Bull trout distribution, abundance, and habitat quality have declined rangewide (Bond 1992, pp. 2-3; Schill 1992, p. 42; Thomas 1992, entire; Ziller 1992, entire; Rieman and McIntyre 1993, p. 1; Newton and Pribyl 1994, pp. 4-5; McPhail and Baxter 1996, p. 1). Several local extirpations have been documented, beginning in the 1950s (Rode 1990, pp. 26-32; Ratliff and Howell 1992, entire; Donald and Alger 1993, entire; Goetz 1994, p. 1; Newton and Pribyl 1994, pp. 8-9; Light et al. 1996, pp. 6-7; Buchanan et al. 1997, p. 15; WDFW 1998, pp. 2-3). Bull trout were extirpated from the southernmost portion of their historic range, the McCloud River in California, around 1975 (Rode 1990, p. 32). Bull trout have been functionally extirpated (i.e., few individuals may occur there but do not constitute a viable population) in the Coeur d'Alene River basin in Idaho and in the Lake Chelan and Okanogan River basins in Washington (USFWS 1998, pp. 31651-31652).

These declines result from the combined effects of habitat degradation and fragmentation, the blockage of migratory corridors; poor water quality, angler harvest and poaching, entrainment (process by which aquatic organisms are pulled through a diversion or other device) into diversion channels and dams, and introduced nonnative species. Specific land and water management activities that depress bull trout populations and degrade habitat include the effects of dams and other diversion structures, forest management practices, livestock grazing, agriculture, agricultural diversions, road construction and maintenance, mining, and urban and rural development (Beschta et al. 1987, entire; Chamberlain et al. 1991, entire; Furniss et al. 1991, entire; Meehan 1991, entire; Nehlsen et al. 1991, entire; Sedell and Everest 1991, entire; Craig and Wissmar 1993pp, 18-19; Henjum et al. 1994, pp. 5-6; McIntosh et al. 1994, entire; Wissmar et al. 1994, entire; MBTSG 1995a, p. 1; MBTSG 1995b. pp. i-ii; MBTSG 1995c, pp. i-ii; MBTSG 1995d, p. 22; MBTSG 1995e, p. i; MBTSG 1996a, p. i-ii; MBTSG 1996b, p. i; MBTSG 1996c, p. i; MBTSG 1996d, p. i; MBTSG 1996e, p. i; MBTSG 1996f, p. 11; Light et al. 1996, pp. 6-7; USDA and USDI 1995, p. 2).

Emerging Threats

Climate Change

Climate change was not addressed as a known threat when bull trout was listed. The 2015 bull trout recovery plan and RUIPs summarize the threat of climate change and acknowledges that some extant bull trout core area habitats will likely change (and may be lost) over time due to anthropogenic climate change effects, and use of best available information will ensure future conservation efforts that offer the greatest long-term benefit to sustain bull trout and their required coldwater habitats (USFWS 2015, p. vii, and pp. 17-20, USFWS 2015a-f).

Global climate change and the related warming of global climate have been well documented (IPCC 2007, entire; ISAB 2007, entire; Combes 2003, entire). Evidence of global climate change/warming includes widespread increases in average air and ocean temperatures and accelerated melting of glaciers, and rising sea level. Given the increasing certainty that climate change is occurring and is accelerating (IPCC 2007, p. 253; Battin et al. 2007, p. 6720), we can no longer assume that climate conditions in the future will resemble those in the past.

Patterns consistent with changes in climate have already been observed in the range of many species and in a wide range of environmental trends (ISAB 2007, entire; Hari et al. 2006, entire; Rieman et al. 2007, entire). In the northern hemisphere, the duration of ice cover over lakes and rivers has decreased by almost 20 days since the mid-1800's (Magnuson et al. 2000, p. 1743). The range of many species has shifted poleward and elevationally upward. For cold-water associated salmonids in mountainous regions, where their upper distribution is often limited by impassable barriers, an upward thermal shift in suitable habitat can result in a reduction in range, which in turn can lead to a population decline (Hari et al. 2006, entire).

In the Pacific Northwest, most models project warmer air temperatures and increases in winter precipitation and decreases in summer precipitation. Warmer temperatures will lead to more precipitation falling as rain rather than snow. As the seasonal amount of snow pack diminishes, the timing and volume of stream flow are likely to change and peak river flows are likely to increase in affected areas. Higher air temperatures are also likely to increase water temperatures (ISAB 2007, pp. 15-17). For example, stream gauge data from western Washington over the past 5 to 25 years indicate a marked increasing trend in water temperatures in most major rivers.

Climate change has the potential to profoundly alter the aquatic ecosystems upon which the bull trout depends via alterations in water yield, peak flows, and stream temperature, and an increase in the frequency and magnitude of catastrophic wildfires in adjacent terrestrial habitats (Bisson et al. 2003, pp 216-217).

All life stages of the bull trout rely on cold water. Increasing air temperatures are likely to impact the availability of suitable cold water habitat. For example, ground water temperature is generally correlated with mean annual air temperature, and has been shown to strongly influence the distribution of other chars. Ground water temperature is linked to bull trout selection of spawning sites, and has been shown to influence the survival of embryos and early juvenile rearing of bull trout (Baxter 1997, p. 82). Increases in air temperature are likely to be reflected in increases in both surface and groundwater temperatures.

Climate change is likely to affect the frequency and magnitude of fires, especially in warmer drier areas such as are found on the eastside of the Cascade Mountains. Bisson et al. (2003, pp. 216-217) note that the forest that naturally occurred in a particular area may or may not be the forest that will be responding to the fire regimes of an altered climate. In several studies related to the effect of large fires on bull trout populations, bull trout appear to have adapted to past fire disturbances through mechanisms such as dispersal and plasticity. However, as stated earlier, the future may well be different than the past and extreme fire events may have a dramatic effect on bull trout and other aquatic species, especially in the context of continued habitat loss, simplification and fragmentation of aquatic systems, and the introduction and expansion of exotic species (Bisson et al. 2003, pp. 218-219).

Migratory bull trout can be found in lakes, large rivers and marine waters. Effects of climate change on lakes are likely to impact migratory adfluvial bull trout that seasonally rely upon lakes for their greater availability of prey and access to tributaries. Climate-warming impacts to lakes will likely lead to longer periods of thermal stratification and coldwater fish such as adfluvial bull trout will be restricted to these bottom layers for greater periods of time. Deeper thermoclines resulting from climate change may further reduce the area of suitable temperatures in the bottom layers and intensify competition for food (Shuter and Meisner 1992. p. 11).

Bull trout require very cold water for spawning and incubation. Suitable spawning habitat is often found in accessible higher elevation tributaries and headwaters of rivers. However, impacts on hydrology associated with climate change are related to shifts in timing, magnitude and distribution of peak flows that are also likely to be most pronounced in these high elevation stream basins (Battin et al. 2007, p. 6720). The increased magnitude of winter peak flows in high elevation areas is likely to impact the location, timing, and success of spawning and incubation for the bull trout and Pacific salmon species. Although lower elevation river reaches are not expected to experience as severe an impact from alterations in stream hydrology, they are unlikely to provide suitably cold temperatures for bull trout spawning, incubation and juvenile rearing.

As climate change progresses and stream temperatures warm, thermal refugia will be critical to the persistence of many bull trout populations. Thermal refugia are important for providing bull trout with patches of suitable habitat during migration through or to make feeding forays into areas with greater than optimal temperatures.

There is still a great deal of uncertainty associated with predictions relative to the timing, location, and magnitude of future climate change. It is also likely that the intensity of effects will vary by region (ISAB 2007, p 7) although the scale of that variation may exceed that of States. For example, several studies indicate that climate change has the potential to impact ecosystems in nearly all streams throughout the State of Washington (ISAB 2007, p. 13; Battin et al. 2007, p. 6722; Rieman et al. 2007, pp. 1558-1561). In streams and rivers with temperatures approaching or at the upper limit of allowable water temperatures, there is little if any likelihood that bull trout will be able to adapt to or avoid the effects of climate change/warming. There is little doubt that climate change is and will be an important factor affecting bull trout distribution. As its distribution contracts, patch size decreases and connectivity is truncated, bull trout populations that may be currently connected may face increasing isolation, which could accelerate the rate of local extinction beyond that resulting from changes in stream temperature alone (Rieman et al. 2007, pp. 1559-1560). Due to variations in land form and geographic location across the range of the bull trout, it appears that some populations face higher risks than others. Bull trout in areas with currently degraded water temperatures and/or at the southern edge of its range may already be at risk of adverse impacts from current as well as future climate change.

The ability to assign the effects of gradual global climate change to bull trout or to a specific location on the ground is beyond our technical capabilities at this time.

Conservation

<u>*Conservation Needs*</u>

The 2015 recovery plan for bull trout established the primary strategy for recovery of bull trout in the coterminous United States: 1) conserve bull trout so that they are geographically widespread across representative habitats and demographically stable1 in six recovery units; 2) effectively manage and ameliorate the primary threats in each of six recovery units at the core area scale such that bull trout are not likely to become endangered in the foreseeable future; 3) build upon the numerous and ongoing conservation actions implemented on behalf of bull trout since their listing in 1999, and improve our understanding of how various threat factors potentially affect the species; 4) use that information to work cooperatively with our partners to design, fund, prioritize, and implement effective conservation actions in those areas that offer the greatest long-term benefit to sustain bull trout and where recovery can be achieved; and 5) apply adaptive management principles to implementing the bull trout recovery program to account for new information (USFWS 2015, p. v.).

Information presented in prior draft recovery plans published in 2002 and 2004 (USFWS 2002a, 2004) have served to identify recovery actions across the range of the species and to provide a framework for implementing numerous recovery actions by our partner agencies, local working groups, and others with an interest in bull trout conservation.

The 2015 recovery plan (USFWS 2015) integrates new information collected since the 1999 listing regarding bull trout life history, distribution, demographics, conservation successes, etc., and integrates and updates previous bull trout recovery planning efforts across the range of the single DPS listed under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

The Service has developed a recovery approach that: 1) focuses on the identification of and effective management of known and remaining threat factors to bull trout in each core area; 2) acknowledges that some extant bull trout core area habitats will likely change (and may be lost) over time; and 3) identifies and focuses recovery actions in those areas where success is likely to meet our goal of ensuring the certainty of conservation of genetic diversity, life history features, and broad geographical representation of remaining bull trout populations so that the protections of the Act are no longer necessary (USFWS 2015, p. 45-46).

To implement the recovery strategy, the 2015 recovery plan establishes categories of recovery actions for each of the six Recovery Units (USFWS 2015, p. 50-51):

1. Protect, restore, and maintain suitable habitat conditions for bull trout.
2. Minimize demographic threats to bull trout by restoring connectivity or populations where appropriate to promote diverse life history strategies and conserve genetic diversity.
3. Prevent and reduce negative effects of nonnative fishes and other nonnative taxa on bull trout.
4. Work with partners to conduct research and monitoring to implement and evaluate bull trout recovery activities, consistent with an adaptive management approach using feedback from implemented, site-specific recovery tasks, and considering the effects of climate change.

Bull trout recovery is based on a geographical hierarchical approach. Bull trout are listed as a single DPS within the five-state area of the coterminous United States. The single DPS is subdivided into six biologically-based recover units: 1) Coastal Recovery Unit; 2) Klamath Recovery Unit; 3) Mid-Columbia Recovery Unit; 4) Upper Snake Recovery Unit; 5) Columbia Headwaters Recovery Unit; and 6) Saint Mary Recovery Unit (USFWS 2015, p. 23). A viable recovery unit should demonstrate that the three primary principles of biodiversity have been met: representation (conserving the genetic makeup of the species); resiliency (ensuring that each population is sufficiently large to withstand stochastic events); and redundancy (ensuring a sufficient number of populations to withstand catastrophic events) (USFWS 2015, p. 33).

Each of the six recovery units contain multiple bull trout core areas, 116 total, which are non-overlapping watershed-based polygons, and each core area includes one or more local populations. Currently there are 109 occupied core areas, which comprise 611 local populations (USFWS 2015, p. 3). There are also six core areas where bull trout historically occurred but are now extirpated, and one research needs area where bull trout were known to occur historically, but their current presence and use of the area are uncertain (USFWS 2015, p. 3). Core areas can be further described as complex or simple (USFWS 2015, p. 3-4). Complex core areas contain multiple local bull trout populations, are found in large watersheds, have multiple life history forms, and have migratory connectivity between spawning and rearing habitat and FMO habitats. Simple core areas are those that contain one bull trout local population. Simple core areas are small in scope, isolated from other core areas by natural barriers, and may contain unique genetic or life history adaptations.

A local population is a group of bull trout that spawn within a particular stream or portion of a stream system (USFWS 2015, p. 73). A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. For most waters where specific information is lacking, a local population may be represented by a single headwater tributary or complex of headwater tributaries. Gene flow may occur between local populations (e.g., those within a core population), but is assumed to be infrequent compared with that among individuals within a local population.

Recovery Units and Local Populations

The final recovery plan (USFWS 2015) designates six bull trout recovery units as described above. These units replace the 5 interim recovery units previously identified (USFWS 1999). The Service will address the conservation of these final recovery units in our section 7(a)(2) analysis for proposed Federal actions. The recovery plan (USFWS 2015), identified threats and factors affecting the bull trout within these units. A detailed description of recovery implementation for each recovery unit is provided in separate recovery unit implementation plans (RUIPs)(USFWS 2015a-f), which identify conservation actions and recommendations needed for each core area, forage/ migration/ overwinter areas, historical core areas, and research needs areas. Each of the following recovery units (below) is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions.

Coastal Recovery Unit

The coastal recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015a). The Coastal Recovery Unit is located within western Oregon and Washington. The Coastal Recovery Unit is divided into three regions: Puget Sound, Olympic Peninsula, and the Lower Columbia River Regions. This recovery unit contains 20 core areas comprising 84 local populations and a single potential local population in the historic Clackamas River core area where bull trout had been extirpated and were reintroduced in 2011, and identified four historically occupied core areas that could be re-established (USFWS 2015, pg. 47; USFWS 2015a, p. A-2). Core areas within Puget Sound and the Olympic Peninsula currently support the only anadromous local populations of bull trout. This recovery unit also contains ten shared FMO habitats which are outside core areas and allows for the continued natural population dynamics in which the core areas have evolved (USFWS 2015a, p. A-5). There are four core areas within the Coastal Recovery Unit that have been identified as current population strongholds: Lower Skagit, Upper Skagit, Quinault River, and Lower Deschutes River (USFWS 2015, p.79). These are the most stable and abundant bull trout populations in the recovery unit. The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, loss of functioning estuarine and nearshore marine habitats, development and related impacts (e.g., flood control, floodplain disconnection, bank armoring, channel straightening, loss of instream habitat complexity), agriculture (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation, livestock grazing), fish passage (e.g., dams, culverts, instream flows) residential development, urbanization, forest management practices (e.g., timber harvest and associated road building activities), connectivity impairment, mining, and the introduction of non-native species. Conservation measures or recovery actions implemented include relicensing of major hydropower facilities that have provided upstream and downstream fish passage or complete removal of dams, land acquisition to conserve bull trout habitat, floodplain restoration, culvert removal, riparian revegetation, levee setbacks, road removal, and projects to protect and restore important nearshore marine habitats.

Klamath Recovery Unit

The Klamath recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015b). The Klamath Recovery Unit is located in southern Oregon and northwestern California. The Klamath Recovery Unit is the most significantly imperiled recovery unit, having experienced considerable extirpation and geographic contraction of local populations and declining demographic condition, and natural re-colonization is constrained by dispersal barriers and presence of nonnative brook trout (USFWS 2015, p. 39). This recovery unit currently contains three core areas and eight local populations (USFWS 2015, p. 47; USFWS 2015b, p. B-1). Nine historic local populations of bull trout have become extirpated (USFWS 2015b, p. B-1). All three core areas have been isolated from other bull trout populations for the past 10,000 years (USFWS 2015b, p. B-3. The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, habitat degradation and fragmentation, past and present land use practices, agricultural water diversions, nonnative species, and past fisheries management practices. Conservation measures or recovery actions implemented include removal of nonnative fish (e.g., brook trout, brown trout, and hybrids), acquiring water rights for instream flows, replacing diversion structures, installing fish screens, constructing bypass channels, installing riparian fencing, culver replacement, and habitat restoration.

Mid-Columbia Recovery Unit

The Mid-Columbia recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015c). The Mid-Columbia Recovery Unit is located within eastern Washington, eastern Oregon, and portions of central Idaho. The Mid-Columbia Recovery Unit is divided into four geographic regions: Lower Mid-Columbia, Upper Mid-Columbia, Lower Snake, and Mid-Snake Geographic Regions. This recovery unit contains 24 occupied core areas comprising 142 local populations, two historically occupied core areas, one research needs area, and seven FMO habitats (USFWS 2015, pg. 47; USFWS 2015c, p. C-1–4). The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, agricultural practices (e.g. irrigation, water withdrawals, livestock grazing), fish passage (e.g. dams, culverts), nonnative species, forest management practices, and mining. Conservation measures or recovery actions implemented include road removal, channel restoration, mine reclamation, improved grazing management, removal of fish barriers, and instream flow requirements.

Columbia Headwaters Recovery Unit

The Columbia headwaters recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015d, entire). The Columbia Headwaters Recovery Unit is located in western Montana, northern Idaho, and the northeastern corner of Washington. The Columbia Headwaters Recovery Unit is divided into five geographic regions: Upper Clark Fork, Lower Clark Fork, Flathead, Kootenai, and Coeur d'Alene Geographic Regions (USFWS 2015d, pp. D-2 – D-4). This recovery unit contains 35 bull trout core areas; 15 of which are complex core areas as they represent larger interconnected habitats and 20 simple core areas as they are isolated headwater lakes with single local populations. The 20 simple core areas are each represented by a single local population, many of which may have persisted for thousands of years despite small populations and isolated existence (USFWS 2015d, p. D-1). Fish passage improvements within the recovery unit have reconnected some previously fragmented habitats (USFWS 2015d, p. D-1), while others remain fragmented. Unlike the other recovery units in Washington, Idaho and Oregon, the Columbia Headwaters Recovery Unit does not have any anadromous fish overlap. Therefore, bull trout within the Columbia Headwaters Recovery Unit do not benefit from the recovery actions for salmon (USFWS 2015d, p. D-41). The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, mostly historical mining and contamination by heavy metals, expanding populations of nonnative fish predators and competitors, modified instream flows, migratory barriers (e.g., dams), habitat fragmentation, forest practices (e.g., logging, roads), agriculture practices (e.g. irrigation, livestock grazing), and residential development. Conservation measures or recovery actions implemented include habitat improvement, fish passage, and removal of nonnative species.

Upper Snake Recovery Unit

The Upper Snake recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015e, entire). The Upper Snake Recovery Unit is located in central Idaho, northern Nevada, and eastern Oregon. The Upper Snake Recovery Unit is divided into seven geographic regions: Salmon River, Boise River, Payette River, Little Lost River, Malheur River, Jarbidge River, and Weiser River. This recovery unit contains 22 core areas and 207 local populations (USFWS 2015, p. 47), with almost 60 percent being present in the Salmon River Region. The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, dams, mining, forest management practices, nonnative species, and agriculture (e.g., water diversions, grazing). Conservation measures or recovery actions implemented include instream habitat restoration, instream flow requirements, screening of irrigation diversions, and riparian restoration.

St. Mary Recovery Unit

The St. Mary recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015f). The Saint Mary Recovery Unit is located in Montana but is heavily linked to downstream resources in southern Alberta, Canada. Most of the Saskatchewan River watershed which the St. Mary flows into is located in Canada. The United States portion includes headwater spawning and rearing habitat and the upper reaches of FMO habitat. This recovery unit contains four core areas, and seven local populations (USFWS 2015f, p. F-1) in the U.S. Headwaters. The current condition of the bull trout in this recovery unit is attributed primarily to the outdated design and operations of the Saint Mary Diversion operated by the Bureau of Reclamation (e.g., entrainment, fish passage, instream flows), and, to a lesser extent habitat impacts from development and nonnative species.

Tribal Conservation Activities

Many Tribes throughout the range of the bull trout are participating on bull trout conservation working groups or recovery teams in their geographic areas of interest. Some tribes are also implementing projects which focus on bull trout or that address anadromous fish but benefit bull trout (e.g., habitat surveys, passage at dams and diversions, habitat improvement, and movement studies).

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APPENDIX B
STATUS OF DESIGNATED CRITICAL HABITAT: BULL TROUT

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Appendix B
Status of Designated Critical Habitat: Bull Trout

Past designations of critical habitat have used the terms "primary constituent elements" (PCEs), “physical and biological features” (PBFs) or "essential features" to characterize the key components of critical habitat that provide for the conservation of the listed species. The new critical habitat regulations (81 FR 7214) discontinue use of the terms “PCEs” or “essential features” and rely exclusively on use of the term PBFs for that purpose because that term is contained in the statute. To be consistent with that shift in terminology and in recognition that the terms PBFs, PCEs, and essential habit features are synonymous in meaning, we are only referring to PBFs herein. Therefore, if a past critical habitat designation defined essential habitat features or PCEs, they will be referred to as PBFs in this document. This does not change the approach outlined above for conducting the ‘‘destruction or adverse modification’’ analysis, which is the same regardless of whether the original designation identified PCEs, PBFs or essential features.

Current Legal Status of the Critical Habitat

Current Designation

The U.S. Fish and Wildlife Service (Service) published a final critical habitat designation for the coterminous United States population of the bull trout on October 18, 2010 (USFWS 2010, entire); the rule became effective on November 17, 2010. A justification document was also developed to support the rule and is available on the Service’s website: (http://www.fws.gov/pacific/bulltrout). The scope of the designation involved the species’ coterminous range, which includes the Coastal, Klamath, Mid-Columbia, Upper Snake, Columbia Headwaters and St. Mary’s Recovery Unit population segments. Rangewide, the Service designated reservoirs/lakes and stream/shoreline miles as bull trout critical habitat (Table 1). Designated bull trout critical habitat is of two primary use types: 1) spawning and rearing, and 2) foraging, migration, and overwintering (FMO).

Table 1. Stream/Shoreline Distance and Reservoir/Lake Area Designated as Bull Trout Critical Habitat.

State	Stream/Shoreline Miles	Stream/Shoreline Kilometers	Reservoir/ Lake Acres	Reservoir/ Lake Hectares
Idaho	8,771.6	14,116.5	170,217.5	68,884.9
Montana	3,056.5	4,918.9	221,470.7	89,626.4
Nevada	71.8	115.6	-	-
Oregon[1]	2,835.9	4,563.9	30,255.5	12,244.0
Oregon/Idaho[2]	107.7	173.3	-	-
Washington	3,793.3	6,104.8	66,308.1	26,834.0
Washington (marine)	753.8	1,213.2	-	-
Washington/Idaho	37.2	59.9	-	-
Washington/Oregon	301.3	484.8	-	-
Total[3]	19,729.0	31,750.8	488,251.7	197,589.2

[1] No shore line is included in Oregon
[2] Pine Creek Drainage which falls within Oregon
[3] Total of freshwater streams: 18,975

The 2010 revision increases the amount of designated bull trout critical habitat by approximately 76 percent for miles of stream/shoreline and by approximately 71 percent for acres of lakes and reservoirs compared to the 2005 designation.

The final rule also identifies and designates as critical habitat approximately 1,323.7 km (822.5 miles) of streams/shorelines and 6,758.8 ha (16,701.3 acres) of lakes/reservoirs of unoccupied habitat to address bull trout conservation needs in specific geographic areas in several areas not occupied at the time of listing. No unoccupied habitat was included in the 2005 designation. These unoccupied areas were determined by the Service to be essential for restoring functioning migratory bull trout populations based on currently available scientific information. These unoccupied areas often include lower main stem river environments that can provide seasonally important migration habitat for bull trout. This type of habitat is essential in areas where bull trout habitat and population loss over time necessitates reestablishing bull trout in currently unoccupied habitat areas to achieve recovery.

The final rule continues to exclude some critical habitat segments based on a careful balancing of the benefits of inclusion versus the benefits of exclusion. Critical habitat does not include: 1) waters adjacent to non-Federal lands covered by legally operative incidental take permits for habitat conservation plans (HCPs) issued under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act), in which bull trout is a covered species on or before the publication of this final rule; 2) waters within or adjacent to Tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the Tribes indicated that inclusion would impair their relationship with the Service; or 3) waters where impacts to national security have been identified (USFWS 2010, p. 63903). Excluded areas are approximately 10 percent of the stream/shoreline miles and 4 percent of the lakes and reservoir acreage of designated critical habitat. Each excluded area is identified in the relevant Critical Habitat Unit

(CHU) text, as identified in paragraphs (e)(8) through (e)(41) of the final rule. It is important to note that the exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation. Because exclusions reflect the often complex pattern of land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments.

The Physical and Biological Features

Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (USFWS 2010, p. 63898). The core areas reflect the metapopulation structure of bull trout and are the closest approximation of a biologically functioning unit for the purposes of recovery planning and risk analyses. CHUs generally encompass one or more core areas and may include FMO areas, outside of core areas, that are important to the survival and recovery of bull trout.

Thirty-two CHUs within the geographical area occupied by the species at the time of listing are designated under the revised rule. Twenty-nine of the CHUs contain all of the physical or biological features identified in this final rule and support multiple life-history requirements. Three of the mainstem river units in the Columbia and Snake River Basins contain most of the physical or biological features necessary to support the bull trout's particular use of that habitat, other than those physical biological features associated with physical and biological features (PBFs) 5 and 6, which relate to breeding habitat.

The primary function of individual CHUs is to maintain and support core areas, which 1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993, p. 19); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Hard 1995, pp. 314-315; Healey and Prince 1995, p. 182; MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); and 4) are distributed throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Hard 1995, pp. 321-322; MBTSG 1998, pp. 13-16; Rieman and Allendorf 2001, p. 763; Rieman and McIntyre 1993, p. 23).

Physical and Biological Features for Bull Trout

Within the designated critical habitat areas, the PBFs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Based on our current knowledge of the life history, biology, and ecology of this species and the characteristics of the habitat necessary to sustain its essential life-history functions, we have determined that the PBFs, as described within USFWS 2010, are essential for the conservation of bull trout. A summary of those PBFs follows.

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
5. Water temperatures ranging from 2 °C to 15 °C, with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The revised PBF’s are similar to those previously in effect under the 2005 designation. The most significant modification is the addition of a ninth PBF to address the presence of nonnative predatory or competitive fish species. Although this PBF applies to both the freshwater and marine environments, currently no non-native fish species are of concern in the marine environment, though this could change in the future.

Note that only PBFs 2, 3, 4, 5, and 8 apply to marine nearshore waters identified as critical habitat. Also, lakes and reservoirs within the CHUs also contain most of the physical or biological features necessary to support bull trout, with the exception of those associated with PBFs 1 and 6. Additionally, all except PBF 6 apply to FMO habitat designated as critical habitat.

Critical habitat includes the stream channels within the designated stream reaches and has a lateral extent as defined by the bankfull elevation on one bank to the bankfull elevation on the opposite bank. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. If bankfull elevation is not evident on either bank, the ordinary high-water line must be used to determine the lateral extent of critical habitat. The lateral extent of designated lakes is defined by the perimeter of the waterbody as mapped on standard 1:24,000 scale topographic maps. The Service assumes in many cases this is the full-pool level of the waterbody. In areas where only one side of the waterbody is designated (where only one side is excluded), the mid-line of the waterbody represents the lateral extent of critical habitat.

In marine nearshore areas, the inshore extent of critical habitat is the mean higher high-water (MHHW) line, including the uppermost reach of the saltwater wedge within tidally influenced freshwater heads of estuaries. The MHHW line refers to the average of all the higher high-water heights of the two daily tidal levels. Marine critical habitat extends offshore to the depth of 10 meters (m) (33 ft) relative to the mean low low-water (MLLW) line (zero tidal level or average of all the lower low-water heights of the two daily tidal levels). This area between the MHHW line and minus 10 m MLLW line (the average extent of the photic zone) is considered the habitat most consistently used by bull trout in marine waters based on known use, forage fish availability, and ongoing migration studies and captures geological and ecological processes important to maintaining these habitats. This area contains essential foraging habitat and migration corridors such as estuaries, bays, inlets, shallow subtidal areas, and intertidal flats.

Adjacent shoreline riparian areas, bluffs, and uplands are not designated as critical habitat. However, it should be recognized that the quality of marine and freshwater habitat along streams, lakes, and shorelines is intrinsically related to the character of these adjacent features, and that human activities that occur outside of the designated critical habitat can have major effects on physical and biological features of the aquatic environment.

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to “destroy or adversely modify” critical habitat by no longer serving the intended conservation role for the species or retaining those PBFs that relate to the ability of the area to at least periodically support the species. Activities that may destroy or adversely modify critical habitat are those that alter the PBFs to such an extent that the conservation value of critical habitat is appreciably reduced (USFWS 2010, pp. 63898:63943; USFWS 2004a, pp. 140-193; USFWS 2004b, pp. 69-114). The Service’s evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS and NMFS 1998, Ch. 4 p. 39). Thus, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes the critical habitat designated for the Klamath River, Jarbidge River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments. However, we consider all 32 CHUs to contain features or areas essential to the conservation of the bull trout (USFWS 2010, pp. 63898:63901, 63944). Therefore, if a proposed action would alter the physical or biological features of critical habitat to an extent that appreciably reduces the conservation function of one or more critical habitat units for bull trout, a finding of adverse modification of the entire designated critical habitat area may be warranted (USFWS 2010, pp. 63898:63943).

Current Critical Habitat Condition Rangewide

The condition of bull trout critical habitat varies across its range from poor to good. Although still relatively widely distributed across its historic range, the bull trout occurs in low numbers in many areas, and populations are considered depressed or declining across much of its range (Ratliff and Howell 1992, entire; Schill 1992, p. 40; Thomas 1992, p. 28; Buchanan et al. 1997, p. vii; Rieman et al. 1997, pp. 15-16; Quigley and Arbelbide 1997, pp. 1176-1177). This condition reflects the condition of bull trout habitat. The decline of bull trout is primarily due to habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, impoundments, dams, water diversions, and the introduction of nonnative species (USFWS 1998, pp. 31648-31649; USFWS 1999, p. 17111).

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PBFs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Dunham and Rieman 1999, p. 652; Rieman and McIntyre 1993, p. 7); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989, p. 141; MBTSG 1998, pp. ii - v, 20-45); 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, p. 857; Rieman et al. 2006, pp. 73-76); 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

Effects of Climate Change on Bull Trout Critical Habitat

One objective of the final rule was to identify and protect those habitats that provide resiliency for bull trout use in the face of climate change. Over a period of decades, climate change may directly threaten the integrity of the essential physical or biological features described in PBFs 1, 2, 3, 5, 7, 8, and 9. Protecting bull trout strongholds and cold water refugia from disturbance and ensuring connectivity among populations were important considerations in addressing this potential impact. Additionally, climate change may exacerbate habitat degradation impacts both physically (e.g., decreased base flows, increased water temperatures) and biologically (e.g., increased competition with non-native fishes).

Many of the PBFs for bull trout may be affected by the presence of toxics and/or increased water temperatures within the environment. The effects will vary greatly depending on a number of factors which include which toxic substance is present, the amount of temperature increase, the likelihood that critical habitat would be affected (probability), and the severity and intensity of any effects that might occur (magnitude).

The ability to assign the effects of gradual global climate change bull trout critical habitat or to a specific location on the ground is beyond our technical capabilities at this time.

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APPENDIX C
BIOLOGICAL EFFECTS OF SEDIMENT ON BULL TROUT AND THEIR HABITAT

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Appendix C
Biological Effects of Sediment on Bull Trout and Their Habitat

Introduction

As a stream or river flows downslope, it transports sediment and dissolved matter (Skinner and Porter 2000, p. 252). A stream has a natural amount of sediment that is transported through the system that varies throughout the year in response to natural hydrological changes (Galbraith et al. 2006, p. 2488). The amount of sediment that a stream can transport annually is based on numerous factors: precipitation, surface water transport, erosion, topography, geology, streamflow, riparian vegetation, stream geomorphologic characteristic, human disturbance, atmospheric deposition, etc. (Bash et al. 2001, p. 7; Berry et al. 2003, p. 7). Therefore, different watersheds will have different levels or concentrations of turbidity and suspended sediment. A glaciated stream will have higher sediment levels than a spring fed stream (Ahearn 2002, p .2; Uehlinger et al. 2002, p. 1).

Many watersheds are subject to anthropogenic disturbances that can produce substantial inputs of sediments into streams (Barrett et al. 1992, p. 437). Turbidity, suspended solids, sediment, and siltation have been consistently listed as impairments in the U.S. Environmental Protection Agency's (EPA) 305(b) water quality reports in rivers and streams, lakes, reservoirs, ponds, wetlands, and oceans shoreline waters (Berry et al. 2003, p. 4). The EPA's 305(b) list provides the U.S. Congress and the public a means of determining or assessing the current condition of water quality within each individual state. Excessive sedimentation, natural and anthropogenic, has been estimated to occur in 46 percent of all streams and rivers in the U.S. and is considered the most important factor limiting fish habitat and causing water quality impairment (Berry et al. 2003, pp. 4, 7; Judy et al. 1985 as cited in Henley et al. 2000, p. 126). One of the most pervasive influences of land-use activities on stream ecosystems is an increase in sediment yield resulting from point source discharges associated with in-stream activities (Suren and Jowett 2001, p. 725).

Aquatic organisms have adapted to the natural variation in sediment load that occurs seasonally within the stream (Birtwell 1999, p. 7; FAO 1976, pp. 13, 15). Field experiments have found a thirty-fold increase in salmonids' (coho salmon) tolerance to suspended solids between August and November when naturally occurring concentrations are expected to be high (Cederholm and Reid 1987, p. 388).

The introduction of sediment in excess of natural amounts can have multiple adverse effects on bull trout and their habitat (Berry et al. 2003, p. 7; Rhodes et al. 1994, pp. 16-21). The effect of sediment beyond natural background conditions can be fatal at high levels. Embryo survival and subsequent fry emergence success have been highly correlated to percentage of fine material within the streambed (Shepard et al. 1984, pp. 146, 152). Low levels of sediment may result in sublethal and behavioral effects such as increased activity, stress, and emigration rates; loss or reduction of foraging capability; reduced growth and resistance to disease; physical abrasion; clogging of gills; and interference with orientation in homing and migration (Barrett et al. 1992, p. 437; Bash et al. 2001, p. 9; Berry et al. 2003, p. 33; Lake and Hinch 1999, p. 865; McLeay et al. 1987, p. 671; Newcombe and MacDonald 1991, pp. 72, 76, 77; Vondracek et al. 2003, p.

1005; Watts et al. 2003, p. 551). The effects of increased suspended sediments can cause changes in the abundance and/or type of food organisms, alterations in fish habitat, and long-term impacts to fish populations (Anderson et al. 1996, pp. 1, 9, 12, 14, 15; Reid and Anderson 1999, pp. 1, 7-15). No threshold has been determined in which fine-sediment addition to a stream is harmless (Suttle et al. 2004, p. 973). Even at low concentrations, fine-sediment deposition can decrease growth and survival of juvenile salmonids.

Aquatic systems are complex interactive systems, and isolating the effects of sediment to fish is difficult (Castro and Reckendorf 1995, pp. 2-3). The effects of sediment on receiving water ecosystems are complex and multi-dimensional, and further compounded by the fact that sediment flux is a natural and vital process for aquatic systems (Berry et al. 2003, p. 4). Environmental factors that affect the magnitude of sediment impacts on salmonids include duration of exposure, frequency of exposure, toxicity, temperature, life stage of fish, angularity and size of particle, severity/magnitude of pulse, time of occurrence, general condition of biota, and availability of and access to refugia (Bash et al. 2001, p. 11). Potential impacts caused by excessive suspended sediments are varied and complex and are often masked by other concurrent activities (Newcombe 2003, p. 530). The difficulty in determining which environmental variables act as limiting factors has made it difficult to establish the specific effects of sediment impacts on fish (Chapman 1988, p. 2). For example, excess fines in spawning gravels may not lead to smaller populations of adults if the amount of juvenile winter habitat limits the number of juveniles that reach adulthood. Often there are multiple independent variables with complex inter-relationships that can influence population size.

The ecological dominance of a given species is often determined by environmental variables. A chronic input of sediment could tip the ecological balance in favor of one species in mixed salmonid populations or in species communities composed of salmonids and nonsalmonids (Everest et al. 1987, p. 120). Bull trout have more spatially restrictive biological requirements at the individual and population levels than other salmonids (USFWS 1998, p. 5). Therefore, they are especially vulnerable to environmental changes such as sediment deposition.

Bull trout are apex predators that prey on a variety of species including terrestrial and aquatic insects and fish (Rieman and McIntyre 1993, p. 3). Fish are common in the diet of individual bull trout that are over 110 millimeters or longer. Large bull trout may feed almost exclusively on fish. Therefore, when analyzing impacts of sediment on bull trout, it is very important to consider other fish species that are part of their prey base. While sediment may not directly impact bull trout, the increased sediment input may affect the spawning and population levels of Chinook and coho salmon, cutthroat trout, and steelhead, or other species that are potential prey for bull trout. The following effects of sediment are not specific to bull trout alone. All salmonids can be affected similarly.

This document identifies the biological effects of sediment on fish and their habitat including the different life stage(s) affected by sediment input.

Sediment Classifications and Definitions

Sediment within a stream can be classified into a variety of categories: turbidity, suspended sediment, bedload, deposited sediment, and wash load (Bash et al. 2001, pp. 3-4; Waters 1995, pp. 13-14). Sediment category definitions include:

- Turbidity - Optical property of water which results from the suspended and dissolved materials in the water. This causes light to be scattered rather than transmitted in straight lines. Turbidity is measured in nephelometric turbidity units (NTUs). Measurements of turbidity can quickly estimate the amount of sediment within a sample of water.
- Suspended sediment - Represents the actual measure of mineral and organic particles transported in the water column. Suspended sediment is measured in mg/L and is an important measure of erosion, and is linked to the transport of nutrients, metals, and industrial and agricultural chemicals through the river system.
- Bedload - Consists of larger particles on the stream bottom that move by sliding, rolling, or saltating along the substrate surface. Bedload is measured in tons/day, or tons/year.
- Deposited sediment - The intermediate sized sediment particles that settle out of the water column in slack or slower moving water. Based on water velocity and turbulence, these intermediate size particles may be suspended sediment or bedload.
- Wash load - Finest particles in the suspended load that are continuously maintained in suspension by the flow turbulence. Therefore, significant quantities are not deposited in the bed.

Suspended sediment, turbidity, and deposited sediment are not associated with specific particle sizes, as there will be considerable overlap depending on velocity, turbulence, and gradient (MacDonald et al. 1991, p. 98; Waters 1995, p. 14). Turbidity cannot always be correlated with suspended solid concentrations due to the effects of size, shape and refractive index of particles (Bash et al. 2001, p. 5). Turbidity and suspended sediment affect the light available for photosynthesis, visual capability of aquatic animals, gill abrasion, and physiology of fish. Suspended and deposited sediment affect the habitat available for macroinvertebrates, the quality of gravel for fish spawning, and the amount of habitat for fish rearing (Waters 1995, p. 14).

The size of particles within the stream is also important. The quantity of “fines” within a stream ecosystem is usually associated with the degree of fish population declines (Castro and Reckendorf 1995, p. 2). Particle diameters less than 6.4 mm are generally defined as “fines” (Bjornn et al. 1977, p. 1; Bjornn and Reiser 1991, p. 103; Castro and Reckendorf 1995, p. 2; Chapman 1988, p. 14; Hillman et al. 1987, p. 185; MBTSG 1998, p. 8; Rieman and McIntyre 1993, p. 6; Shepard et al. 1984, p. 148).

Biological Effects of Sediment on Bull Trout

Classification of Sediment Effects

In the absence of detailed local information on population dynamics and habitat use, any increase in the proportion of fines in substrates should be considered a risk to the productivity of an environment and to the persistence of associated bull trout populations (Rieman and McIntyre 1993, p. 6). Specific effects of sediment on fish and their habitat can be put into three classes that include (Bash et al. 2001, p. 10; Newcombe and MacDonald 1991, pp. 72-73; Waters 1995, pp. 81-82)

Lethal: Direct mortality to any life stage, reduction in egg-to-fry survival, and loss of spawning or rearing habitat. These effects damage the capacity of the bull trout to produce fish and sustain populations.

Sublethal: Reduction in feeding and growth rates, decrease in habitat quality, reduced tolerance to disease and toxicants, respiratory impairment, and physiological stress. While not leading to immediate death, may produce mortalities and population decline over time.

Behavioral: Avoidance and distribution, homing and migration, and foraging and predation. Behavioral effects change the activity patterns or alter the kinds of activity usually associated with an unperturbed environment. Behavior effects may lead to immediate death or population decline or mortality over time.

Direct Effects

Gill trauma

High levels of suspended sediment and turbidity can result in direct mortality of fish by damaging and clogging gills (Curry and MacNeill 2004, p. 140). Fish gills are delicate and easily damaged by abrasive silt particles (Bash et al. 2001, p. 15). As sediment begins to accumulate in the gill filaments, fish excessively open and close their gills to expunge the silt. If irritation continues, mucus is produced to protect the gill surface, which may impede the circulation of water over the gills and interfere with fish respiration (Bash et al. 2001, p. 15). Gill flaring or coughing abruptly changes buccal cavity pressure and is a means of clearing the buccal cavity of sediment. Gill sediment accumulation may result when fish become too fatigued to continue clearing particles via the cough reflex (Servizi and Martens 1991, p. 495).

Fish are more susceptible to increased suspended sediment concentrations at different times of the year or in watersheds with naturally high sediment such as glaciated streams. Fish secrete protective mucous to clean the gills (Erman and Ligon 1985, p. 18). In glaciated systems or during winter and spring high flow conditions when sediment concentrations are naturally high, the secretion of mucous can keep gills clean of sediment. Protective mucous secretions are inadequate during the summer months, when natural sediment levels are low in a stream system. Consequently, sediment introduction at this time may increase the vulnerability of fish to stress and disease (Bash et al. 2001, p. 12).

Spawning, redds, eggs, and alevins

The effects of suspended sediment, deposited in a redd and potentially reducing water flow and smothering eggs or alevins or impeding fry emergence, are related to sediment particle sizes of the spawning habitat (Bjornn and Reiser 1991, p. 98). Sediment particle size determines the pore openings in the redd gravel. With small pore openings, more suspended sediments are deposited and water flow is reduced compared to large pore openings.

Survival of eggs is dependent on a continuous supply of well oxygenated water through the streambed gravels (Anderson et al. 1996, p. 13; Cederholm and Reid 1987, p. 384). Eggs and alevins are generally more susceptible to stress by suspended solids than are adults. Accelerated sedimentation can reduce the flow of water and, therefore, oxygen to eggs and alevins. This can decrease egg survival, decrease fry emergence rates (Bash et al. 2001, pp. 17-18; Cederholm and Reid 1987, p. 384; Chapman 1988, pp. 12-16), delay development of alevins (Everest et al. 1987, p. 113), reduce growth and cause premature hatching and emergence (Birtwell 1999, p. 19). Fry delayed in their emergence are also less able to compete for environmental resources than fish that have undergone normal development and emergence (intra- or interspecific competition) (Everest et al. 1987, p. 113). Sedimentation fills the interstitial spaces and can prevent alevins from emerging from the gravel (Anderson et al. 1996, p. 13; Suttle et al. 2004, pp. 971-972).

Several studies have documented that fine sediment can reduce the reproductive success of salmonids. Natural egg-to-fry survival of coho salmon, sockeye and kokanee has been measured at 23 percent, 23 percent and 12 percent, respectively (Slaney et al. 1977, p. 33). Substrates containing 20 percent fines can reduce emergence success by 30-40 percent (MacDonald et al. 1991, p. 99). A decrease of 30 percent in mean egg-to-fry survival can be expected to reduce salmonid fry production to extremely low levels (Slaney et al. 1977, p. 33).

<u>Indirect Effects</u>

Macroinvertebrates

Sedimentation can have an effect on bull trout and fish populations through impacts or alterations to the macroinvertebrate communities or populations (Anderson et al. 1996, pp. 14-15). Increased turbidity and suspended sediment can reduce primary productivity by decreasing light intensity and periphytic (attached) algal and other plant communities (Anderson et al. 1996, p. 14; Henley et al. 2000, p. 129; Suren and Jowett 2001, p. 726). This results in decreased macroinvertebrates that graze on the periphyton.

Sedimentation also alters the habitat for macroinvertebrates, changing the species density, diversity and structure of the area (Anderson et al. 1996, pp. 14-15; Reid and Anderson 1999, pp. 10-12; Shaw and Richardson 2001, p. 2220; Waters 1995, pp. 61-78). Certain groups of macroinvertebrates are favored by salmonids as food items. These include mayflies, caddisflies, and stoneflies. These species prefer large substrate particles in riffles and are negatively affected by fine sediment (Everest et al. 1987, p. 115; Waters 1995, p. 63). Increased sediment can affect macroinvertebrate habitat by filling of interstitial space and rendering attachment sites unsuitable. This may cause invertebrates to seek more favorable habitat (Rosenberg and Snow 1975, p. 70). With increasing fine sediment, invertebrate composition and density changes from available, preferred species (i.e., mayflies, caddisflies, and stoneflies) to non-preferred, more unavailable species (i.e., aquatic worms and other burrowing species) (Henley et al. 2000, pp. 126, 130; Reid and Anderson 1999, p. 10; Shaw and Richardson 2001, p. 2219; Suren and Jowett 2001, p. 726; Suttle et al. 2004, p. 971). The degree to which substrate particles are surrounded by fine material was found to have a strong correlation with macroinvertebrate abundance and composition (Birtwell 1999, p. 23). At an embeddedness of one-third, insect abundance can decline by about 50 percent, especially for riffle-inhabiting taxa (Waters 1995, p. 66).

Increased turbidity and suspended solids can affect macroinvertebrates in multiple ways through increased invertebrate drift, feeding impacts, and respiratory problems (Berry et al. 2003, pp. 8, 11; Cederholm and Reid 1987, p. 384; Shaw and Richardson 2001, p. 2218). The effect of turbidity on light transmission has been well documented and results in increased invertebrate drift (Birtwell 1999, pp. 21, 22; Waters 1995, p. 58). This may be a behavioral response associated with the night-active diel drift patterns of macroinvertebrates. While increased turbidity results in increased macroinvertebrate drift, it is thought that the overall invertebrate populations would not fall below the point of severe depletion (Waters 1995, p. 59). Invertebrate drift is also an important mechanism in the repopulation, recolonization, or recovery of a macroinvertebrate community after a localized disturbance (Anderson et al. 1996, p. 15; Reid and Anderson 1999, pp. 11-12).

Increased suspended sediment can affect macroinvertebrates by abrasion of respiratory surface and interference with food uptake for filter-feeders (Anderson et al. 1996, p. 14; Berry et al. 2003, p. 11; Birtwell 1999, p. 21; Shaw and Richardson 2001, p. 2213; Suren and Jowett 2001, pp. 725-726). Increased suspended sediment levels tend to clog feeding structures and reduce feeding efficiencies, which results in reduced growth rates, increased stress, or death of the invertebrates (Newcombe and MacDonald 1991, p. 73). Invertebrates living in the substrate are also subject to scouring or abrasion which can damage respiratory organs (Bash et al. 2001, p. 25).

Feeding Efficiency

Increased turbidity and suspended sediment can affect a number of factors related to feeding for salmonids, including feeding rates, reaction distance, prey selection, and prey abundance (Barrett et al. 1992, pp. 437, 440; Bash et al. 2001, p. 21; Henley et al. 2000, p. 133). Changes in feeding behavior are primarily related to the reduction in visibility that occurs in turbid water. Effects on feeding ability are important as salmonids must meet energy demands to compete with other fishes for resources and to avoid predators. Reduced feeding efficiency would result in lower growth and fitness of bull trout and other salmonids (Barrett et al. 1992, p. 442; Sweka and Hartman 2001, p. 138).

Distance of prey capture and prey capture success both were found to decrease significantly when turbidity was increased (Berg and Northcote 1985, pp. 1414-1415; Sweka and Hartman 2001, p. 141; Zamor and Grossman 2007, pp. 168, 170, 174). Waters (1995, p. 83) states that loss of visual capability, leading to reduced feeding, is one of the major sublethal effects of high suspended sediment. Increases in turbidity were reported to decrease reactive distance and the percentage of prey captured (Bash et al. 2001, pp. 21-23; Klein 2003, pp. 1, 21; Sweka and Hartman 2001, p. 141). At 0 NTUs, 100 percent of the prey items were consumed; at 10 NTUs, fish frequently were unable to capture prey species; at 60 NTUs, only 35 percent of the prey items were captured. At 20 to 60 NTUs, significant delay in the response of fish to prey was observed (Bash et al. 2001, p. 22). Loss of visual capability and capture of prey leads to depressed growth and reproductive capability.

To compensate for reduced encounter rates with prey under turbid conditions, prey density must increase substantially or salmonids must increase their active searches for prey (Sweka and Hartman 2001, p. 144). Such an increase in activity and feeding rates under turbid conditions reduces net energy gain from each prey item consumed (Sweka and Hartman 2001, p. 144).

Sigler et al. (1984, p. 150) found that a reduction in growth occurred in steelhead and coho salmon when turbidity was as little as 25 NTUs. The slower growth was presumed to be from a reduced ability to feed; however, more complex mechanisms such as the quality of light may also affect feeding success rates. Redding et al. (1987, p. 742) found that suspended sediment may inhibit normal feeding activity, as a result of a loss of visual ability or as an indirect consequence of increased stress.

Habitat Effects

Compared to other salmonids, bull trout have more specific habitat requirements that appear to influence their distribution and abundance (Rieman and McIntyre 1993, p. 7). All life history stages are associated with complex forms of cover including large woody debris, undercut banks, boulders, and pools. Other habitat characteristics important to bull trout include channel and hydrologic stability, substrate composition, temperature, and the presence of migration corridors (Rieman and McIntyre 1993, p. 5).

Increases in sediment can alter fish habitat or the utilization of habitats by fish (Anderson et al. 1996, p. 12). The physical implications of sediment in streams include changes in water quality, degradation of spawning and rearing habitat, simplification and damage to habitat structure and complexity, loss of habitat, and decreased connectivity between habitats (Anderson et al. 1996, pp. 11-15; Bash et al. 2001, pp. 1, 12, 18, 30). Biological implications of this habitat damage include underutilization of stream habitat, abandonment of traditional spawning habitat, displacement of fish from their preferred habitat, and avoidance of habitat (Newcombe and Jensen 1996, p. 695).

As sediment enters a stream it is transported downstream under normal fluvial processes and deposited in areas of low shear stress (MacDonald and Ritland 1989, p. 21). These areas are usually behind obstructions, near banks (shallow water) or within interstitial spaces. This episodic filling of successive storage compartments continues in a cascading fashion downstream until the flow drops below the threshold required for movement or all pools have reached their storage capacities (MacDonald and Ritland 1989, p. 21). As sediment load increases, the stream compensates by geomorphologic changes in increased slope, increased channel width, decreased depths, and decreased flows (Castro and Reckendorf 1995, p. 21). These processes contribute to increased erosion and sediment deposition that further degrade salmonid habitat.

Loss of acceptable habitat and refugia, as well as decreased connectivity between habitats, reduces the carrying capacity of streams for salmonids (Bash et al. 2001, p. 30). This loss of habitat or exclusion of fish from their habitat, if timed inappropriately, could impact a fish population if the habitat within the affected stream reach is critical to the population during the period of the sediment release (Anderson et al. 1996, p. 12; Reid and Anderson 1999, p. 13). For example, if summer pool habitat used by adults as holding habitat prior to spawning is a limiting factor within a stream, increased sediment and reduced pool habitat during the summer can decrease the carrying capacity of the stream reach and decrease the fish population. In systems lacking adequate connectivity of habitats, fish may travel longer distances or use less desirable habitats, increasing biological demands and reducing their fitness.

The addition of fine sediment (less than 6.4 mm) to natural streams during summer decreased abundance of juvenile Chinook salmon in almost direct proportion to the amount of pool volume lost to fine sediment (Bjornn et al. 1977, p. 31). Similarly, the inverse relationship between fine sediment and densities of rearing Chinook salmon indicates the importance of winter habitat and high sediment loads (Bjornn et al. 1977, pp. 26, 38, 40). As fine sediments fill the interstitial spaces between the cobble substrate, juvenile Chinook salmon were forced to leave preferred habitat and to utilize cover that may be more susceptible to ice scouring, predation, and decreased food availability (Hillman et al. 1987, p. 194). Deposition of sediment on substrate may lower winter carrying capacity for bull trout (Shepard et al. 1984, p. 153). Food production in the form of aquatic invertebrates may also be reduced.

Juvenile bull trout densities are highly influenced by substrate composition (MBTSG 1998, p. 9; Rieman and McIntyre 1993, p. 6; Shepard et al. 1984, p. 153). During the summer, juvenile bull trout hold positions close to the stream bottom and often seek cover within the substrate itself. When streambed substrate contains more than 30 percent fine materials, juvenile bull trout densities drop off sharply (Shepard et al. 1984, p. 152). Any loss of interstitial space or streambed complexity through the deposition of sediment would result in a loss of summer and winter habitats (MBTSG 1998, p. 9). The reduction of rearing habitat will ultimately reduce the potential number of recruited juveniles and therefore reducing population numbers (Shepard et al. 1984, pp. 153-154). In fact, Johnston et al. (2007, p. 125) found that density-dependent survival during the earliest of the juvenile stages (between egg and age-1) regulated recruitment of adult bull trout in the population.

Although an avoidance response by fish to increased sediment may be an initial adaptive survival strategy, displacement from cover could be detrimental. It is possible that the consequences of fish moving from preferred habitat, to avoid increasing levels of suspended sediment, may not be beneficial if displacement is to sub-optimal habitat, because they may be stressed and more vulnerable to predation (Birtwell 1999, p. 12).

In addition to altering stream bed composition, anthropogenic input of sediment into a stream can change channel hydrology and geometry (Owens et al. 2005, pp. 694-695). Sediment release can reduce the depth of pools and riffle areas (Anderson et al. 1996, p. 12). This can reduce available fish habitat, decrease fish holding capacity, and decrease fish populations (Anderson et al. 1996, pp. 12, 14).

Physiological Effects

Sublethal levels of suspended sediment may cause undue physiological stress on fish, which may reduce the ability of the fish to perform vital functions (Cederholm and Reid 1987, pp. 388, 390). Stress is defined as a condition perceived by an organism which threatens a biological function of the organism, and a set of physiological and behavioral responses is mounted to counteract the condition (Overli 2001, p. 7). A stressor is any anthropogenic or natural environmental change severe enough to require a physiological response on the part of a fish, population, or ecosystem (Anderson et al. 1996, pp. 5-6; Jacobson et al. 2003, p. 2; USEPA 2001, pp. 1-2). At the individual level, stress may affect physiological systems, reduce growth, increase disease, and reduce the individual's ability to tolerate additional stress (Anderson et al. 1996, p. 7; Bash et al. 2001, p. 17). At the population level, the effects of stress may include reduced spawning success, increased larval mortality, and reduced recruitment to succeeding life stages and, therefore, overall population declines (Bash et al. 2001, p. 17).

Upon encountering a stressor, the fish responds through a series of chemical releases in its body. These primary chemical and hormonal releases include catecholamine (e.g. epinephrine, norepinehprine) in the circulatory system, corticosteroids (e.g. cortisol) from the interregnal tissue, and hypothalamic activation of the pituitary gland (Barton 2002, p. 517; Davis 2006, p. 116; Gregory and Wood 1999, p. 286; Schreck et al. 2001, p. 5). Primary chemical releases result in secondary releases or changes in plasma, glucose, tissue ion, metabolite levels, and hematological features. These secondary responses relate to physiological adjustments in metabolism, respiration, immune and cellular function (Barton 2002, p. 517; Haukenes and Buck 2006, p. 385; Mazeaud et al. 1977, p. 201). After secondary responses, continued stress results in tertiary stress responses which affect whole-animal performance such as changes in growth, condition, resistance to disease, metabolic scope for activity, behavior, and ultimately survival (Barton 2002, p. 517; Pickering et al. 1982, p. 229; Portz et al. 2006, pp. 126-127).

Stress in a fish occurs when the homeostatic or stabilizing process in the organism exceed the capability of the organism to compensate for the biotic or abiotic challenge (Anderson et al. 1996, p. 5). The response to a stressor is an adaptive mechanism that allows the fish to cope with the real or perceived stressor in order to maintain its normal or homeostatic state (Barton 2002, p. 517). Acclimation to a stressor can occur if compensatory physiological responses by the fish are able to re-establish a satisfactory relationship between the changed environment and the organism (Anderson et al. 1996, p. 5). The ability of an individual fish to acclimate or tolerate the stress will depend on the severity of the stress and the physiological limits of the organism (Anderson et al. 1996, p. 5). In a natural system, fish are exposed to multiple chemical and physical stressors which can combine to cause adverse effects (Berry et al. 2003, p. 4). The chemical releases from each stressor results in a cumulative or additive response (Barton et al. 1986, pp. 245, 247; Cobleigh 2003, pp. 16, 39, 55; Milston et al. 2006, p. 1172; USEPA 2001, pp. 3-25).

Stress in fish results in extra cost and energy demands. Elevated oxygen consumption and increased metabolic rate result from the reallocation of energy to cope with the stress (Barton and Schreck 1987, pp. 259-260; Contreras-Sanchez et al. 1998, pp. 439, 444; McCormick et al. 1998, pp. 222, 231). An approximate 25 percent increase in metabolic cost, over standard metabolism requirements, is needed to compensate for a perceived stress (Barton and Schreck 1987, p. 260; Davis 2006, p. 116). Stressed fish would thus have less energy available for other life functions such as seawater adaptation, disease resistance, reproduction, or swimming stamina (Barton and Schreck 1987, p. 261; Contreras-Sanchez et al. 1998, p. 444).

Tolerance to suspended sediment may be the net result of a combination of physical and physiological factors related to oxygen availability and uptake by fish (Servizi and Martens 1991, p. 497). The energy needed to perform repeated coughing (see Gill trauma section) increases metabolic oxygen demand. Metabolic oxygen demand is related to water temperature. As temperatures increase, so does metabolic oxygen demand, but concentrations of oxygen available in the water decreases. Therefore, a fish's tolerance to suspended sediment may be primarily related to the capacity of the fish to perform work associated with the cough reflex. However, as sediment increases, fish have less capability to do work, and therefore less tolerance for suspended sediment (Servizi and Martens 1991, p. 497).

Once exposed to a stressor, the primary chemical releases can take one-half to twenty-four hours to peak (Barton 2002, p. 520; Quigley and Hinch 2006, p. 437; Schreck 1981, p. 298). Recovery or return of the primary chemical release to normal or resting levels can take two hours to two weeks (Mazeaud et al. 1977, pp. 205-206; Schreck et al. 2001, p. 313). In a study of handling stress, chemical release of cortisol peaked at two hours and returned to normal in four hours. However, complete recovery took 2 weeks (Pickering et al. 1982, pp. 236, 241). Fish exposed to two or more stresses require longer recovery times than fish exposed only to one stressor indicating the cumulative effects of stress (Sigismondi and Weber 1988, pp. 198-199).

Redding el al. (1987, pp. 740-741) observed higher mortality in young steelhead trout exposed to a combination of suspended sediment (2500 mg/L) and a bacteria pathogen, than when exposed to the bacteria alone. Physiological stress in fishes may decrease immunological competence, growth, and reproductive success (Bash et al. 2001, p. 16).

Behavioral effects

Increased turbidity and suspended sediment may result in behavior changes in salmonids. These changes are the first effects evoked from increased levels of turbidity and suspended sediment (Anderson et al. 1996, p. 6). These behavioral changes include avoidance of habitat, reduction in feeding, increased activity, redistribution and migration to other habitats and locations, disruption of territoriality, and altered homing (Anderson et al. 1996, p. 6; Bash et al. 2001, pp. 19-25; Suttle et al. 2004, p. 971). Many behavioral effects result from changes in stream habitat (see Habitat effects section). As suspended sediment concentration increases, habitat may be lost which results in abandonment and avoidance of preferred habitat. Stream reach emigration is a bioenergetic demand that may affect the growth or reproductive success of the individual fish (Bash et al. 2001, p. 12). Pulses of sediment result in downstream migration of fish, which disrupts social structures, causes downstream displacement of other fish and increases intraspecific aggression (Bash et al. 2001, pp. 12, 20; McLeay et al. 1987, pp. 670-671; Suttle et al. 2004, p. 971). Loss of territoriality and the breakdown of social structure can lead to secondary effects of decreased growth and feeding rates, which may lead to mortality (Bash et al. 2001, p. 20; Berg and Northcote 1985, p. 1416).

Downstream migration by bull trout provides access to more prey, better protection from avian and terrestrial predators, and alleviates potential intraspecific competition or cannibalism in rearing areas (MBTSG 1998, p. 13). Benefits of migration from tributary rearing areas to larger rivers or estuaries may be increased growth potential. Increased sedimentation may result in premature or early migration of both juveniles and adults or avoidance of habitat and migration of nonmigratory resident bull trout.

High turbidity may delay migration back to spawning sites, although turbidity alone does not seem to affect homing. Delays in spawning migration and associated energy expenditure may reduce spawning success and therefore population size (Bash et al. 2001, p. 29).

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