United States Department of the Interior

FISH AND WILDLIFE SERVICE

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

JUL 11 2018

In Reply Refer To:
01EWFW00-2017-F-0890

Michelle Walker, Chief Regulatory Branch
Seattle District, U.S. Army Corps of Engineers
ATTN: Regulatory Branch (Printz)
P.O. Box 3755
Seattle, Washington 98124-3755

Dear Ms. Walker:

Subject: Electron Hydro, LLC (NWS-2016-350)

This letter transmits the U. S. Fish and Wildlife Service's (Service) Biological Opinion on the proposed Diversion Repair and Spillway Replacement Project located on the Puyallup River, near Electron, Pierce County, Washington, and its effects on bull trout (*Salvelinus confluentus*) and critical habitat for the bull trout. 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 May 3, 2017, request for formal consultation was received on May 8, 2017.

The enclosed Biological Opinion is based on information provided in the March 2017, Electron Hydro Project Biological Evaluation for Phase I Diversion Repair, Spillway Replacement and Bank Protection, the February 2017, Phase I Engineering Design Report for the Diversion Repair, Spillway Replacement and Bank Protection Project, 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 Biological Evaluation also included a request for the Service's concurrence with a "not likely to adversely affect" determination for certain listed resources. The enclosed document includes a section separate from the Biological Opinion that addresses your concurrence request. We included a concurrence for the marbled murrelet (*Brachyramphus marmoratus*). The rationale for this concurrence is included in the concurrence section.

The Electron Hydro Project headworks is a run-of-the-river hydropower generation facility on the Puyallup River. The headworks consists of a low-head wooden crib diversion structure and intake. Water is diverted from the Puyallup River into a 10-mile long elevated flume that conveys approximately 400 cubic feet per second of flow to a forebay where it is then transferred to several penstocks. From there, the water continues on to the powerhouse, where approximately 26 megawatts of electricity is produced. Due to the complexity of excluding fish and sediment at the diversion, listed fish are entrained into the flume and are killed at the powerhouse. Electron Hydro, LLC will address the entrainment of listed fish by a two phase approach. Phase I, the current proposed action, will address replacement of portions of the diversion structure. During Phase II, Electron Hydro, LLC will develop a Habitat Conservation Plan to address the operation and maintenance of the Electron Hydro facility which includes the entrainment of fish within the flume. As such, the proposed action addressed by this consultation does not include operation and maintenance of the facility.

If you have any questions regarding the enclosed Biological Opinion or our shared responsibilities under the ESA, please contact Jim Muck at 206-526-4740, email: jim_muck@fws.gov.

Sincerely,

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

Enclosure(s)

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
01EWFW00-2017-F-0890

Electron Hydro, LLC
Diversion Repair and Spillway
Replacement Project

Pierce County, Washington

Federal Action Agency:

U.S. Army Corps of Engineers

Consultation Conducted By:

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

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

11 July 2018
Date

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ACRONYMS AND ABBREVIATIONS

BE	Biological evaluation
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHSU	Critical habitat subunit
Corps	U.S. Army Corps of Engineers
Electron Hydro	Electron Hydro, LLC
ESA	Endangered Species Act
FMO	Foraging, Migration and Overwintering
FR	Federal Register
HCP	Habitat Conservation Plan
NTU	Nephelometric Turbidity Unit
Opinion	Biological Opinion
PBF	Physical or biological feature
PCE	Primary constituent element
PIT	Passive Integrated Transponder
RM	River mile
RPM	Reasonable and prudent measure
Service	U.S. Fish and Wildlife Service

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1 INTRODUCTION

This document represents the U. S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) based on our review of the proposed Electron Hydro, LLC, (Electron Hydro) Diversion Repair and Spillway Replacement Project located on the Puyallup River, near Electron, Pierce County, Washington, and its effects on bull trout (*Salvelinus confluentus*) and critical habitat for the bull trout in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your May 3, 2017, request for formal consultation was received on May 8, 2017.

The Electron Hydro Project headworks is a run-of-the-river hydropower generation facility on the Puyallup River. The headworks consists of a low-head wooden crib diversion structure and intake. Water is diverted from the Puyallup River into a 10-mile long elevated flume that conveys approximately 400 cubic feet per second (cfs) of flow to a forebay where it is then transferred to several penstocks. From there, the water continues on to the powerhouse where approximately 26 megawatts of electricity is produced. Due to the complexity of excluding fish and sediment at the diversion, listed fish are entrained into the flume and transported to the forebay. Once in the forebay, they are detained for significant periods of time or are furthered entrained in the penstocks and are injured or killed at the powerhouse. Small fish in the forebay are also subject to predation. Electron Hydro will address the entrainment of listed fish by a two phase approach. Phase I, the proposed action, is to repair the diversion structure, and during Phase II, Electron Hydro, LLC will develop a Habitat Conservation Plan (HCP) to cover the operation and maintenance of the facility, including the entrainment of fish within the flume.

This Opinion is based on information provided in the March 2017, Electron Hydro Project Biological Evaluation (BE) for Phase I Diversion Repair, Spillway Replacement and Bank Protection, the February 2017, Phase I Engineering Design Report for the Diversion Repair, Spillway Replacement and Bank Protection Project, and other sources of information cited in the Opinion. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey, Washington.

2 CONSULTATION HISTORY

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

The Service has been involved in the Electron Hydro facility since 2000 when we consulted with Puget Sound Energy on the construction of a fish ladder to allow fish access to over 26 miles of Puyallup River upstream of the diversion. The 2000 Opinion identified, but did not exempt, take (kill, capture, and harass) of bull trout associated with entrainment in the flume and forebay, passage through the Electron powerhouse, or capture in the smolt trapping facility in the forebay.

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Between 2003 and 2014, the Service issued a section 10(a)(1)(A) recovery permit to Puget Sound Energy (TE-072137-0) that covered the harassment, capture, and handling of bull trout during scheduled and unscheduled draining of the forebay. This recovery permit covered bull trout capture and handling in the forebay through the trap and haul and for scheduled and unscheduled maintenance draining. The permit did not cover any take associated with the operation of the Electron Hydroelectric facility.

On November 14, 2014, the Service was notified by Puget Sound Energy that the hydro facility was sold to Electron Hydro and that they were relinquishing their recovery permit.

On May 1, 2015, the Service sent Electron Hydro a letter stating that we were notified by Puget Sound Energy of the sale of the Electron Hydroelectric project to Electron Hydro, the relinquishment of their section 10(a)(1)(A) recovery permit, and a discussion on the ongoing take associated with the operation and maintenance of the project. The Service's letter stated that we welcomed the opportunity to meet with Electron Hydro to discuss their operation and maintenance of the project in a manner that is in full compliance of the ESA while also affording flexibility to operate and maintain a viable hydroelectric project.

In 2015, Electron Hydro received a one-year 10(a)(1)(A) recovery permit (TE-72942B) for maintenance outages at the Electron Hydroelectric project to line the flume. Electron Hydro's bull trout harassment, capture, handling, and transport from the trap and haul facility, scheduled and unscheduled maintenance draining of the forebay, and hook and line bull trout removal in the forebay are covered under the Puyallup Tribe's activities in the Puyallup and White River. The Puyallup Tribe is covered under the Bureau of Indian Affairs 10(a)(1)(A) recovery permit (TE-049004-10) issued in 2004/2005.

In January 2016, American Whitewater and American Rivers, Inc. filed a suit against Electron Hydro to challenge its operation of the Electron Hydroelectric project because of its continued take of listed species. Since the lawsuit, Electron Hydro has been discussing alternatives to address upgrading their facilities and fish capture of listed species.

On June 28, 2016, the Service visited the site to view the project and hear from Electron Hydro on engineering plans for the proposed upgrade to their facilities. NOAA's National Marine Fisheries Service, U.S. Army Corps of Engineers (Corps), the Puyallup Indian Tribe, and the Washington Department of Fish and Wildlife were also on site. The site visit marked the beginning of an ongoing dialog between Electron Hydro and the agencies regarding the process for updating the facility and engineering specifications to minimize adverse effects to listed fish.

On December 20, 2016, Electron Hydro sent the Service a notice of intent to prepare a HCP to address project upgrades and operations.

On May 8, 2017, the Service received a letter and BE from the Corps on the project requesting formal consultation for bull trout and critical habitat for the bull trout.

On January 18, 2018, the Service forwarded a draft of the project description and questions on the BE to the Corps and Electron Hydro.

On January 25, 2018, the Service met with Electron Hydro to discuss the project description and questions we had on the BE and tour the project site. The Service initiated consultation on January 25, 2018.

On June 1, 2018, the Service was informed during a conference call with the Corps (Jacalen Printz) and Electron Hydro (Chris Spens) that the proposed project would be constructed over two years, 2018 and 2019. This change in the project was confirmed in an email from Electron Hydro to the Corps on June 1, 2019.

3 CONCURRENCE

3.1 Marbled Murrelet

The project area is located approximately 31 miles inland from Puget Sound. Marbled murrelets may be transiting through the action area as they travel from nesting areas further inland to the marine waters to forage. The closest documented occupied murrelet nesting sites are in the eastern and southeastern edge of the action area, approximately two miles from the project site. The project area is surrounded by commercial forest lands that have been harvested in the past decade and only a few scattered, small fragments and patches of larger trees remain.

The use of heavy equipment in close proximity to suitable marbled murrelet nesting habitat can disrupt normal nesting behaviors if the activities coincide with the nesting season (April 1 to September 22). The Service has previously completed analyses for noise and visual disturbance to marbled murrelets (USFWS 2013, p. 6). In these analyses, we concluded that normal nesting behaviors are likely to be disrupted by loud noises that occur in close proximity to an active nest, or when the activity occurs within the line-of-sight of a nesting marbled murrelet (e.g., for distances out to 0.25 mile depending on the activity). For heavy equipment, we use a disturbance buffer of 111 yards to indicate the area where we consider murrelet nesting behavior could be disrupted.

The forests around the project do not exhibit the stand characteristics of suitable nesting habitat. In addition, no trees with potential platforms will be removed. Project construction will occur in 2018 and 2019 during the end (August and September) of the marbled murrelet nesting season (April 1 to September 23), and will be more than 400 yards from the closest potentially suitable habitat and two miles from known, occupied habitat, so we do not expect exposure of nesting marbled murrelets to noise or visual stressors. Given the lack of suitable habitat in the vicinity of the project site, and the distance to and isolation of the closest potential habitat, we consider the probability of occupancy at this site to be extremely unlikely. Because of the lack of suitable habitat, and the project construction methods and timing, effects of the project to nesting marbled murrelets are considered discountable. Therefore, we concur with your "not likely to adversely affect" determination.

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4 BIOLOGICAL OPINION

5 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 Corps is proposing to issue a permit under Section 404 of the Clean Water Act to Electron Hydro, LLC to repair the diversion structure, replace the spillway, add a trash rack and sluice system to the intake, and replace and reinforce the bank protection at the Electron Hydro Project headworks. The purpose of the project is to restore the integrity of the structures, keep sediment and bedload out of the intake structure, and prepare the facility for the installation of fine sediment and fish exclusion facilities. The proposed action does not include the operation of the diversion dam, and does not include the operation and maintenance of the Hydro Electron facility. The various components of the Hydro Electron facility include the fish ladder, intake structure, flume, settling basin, forebay, instream minimum flows, trap and haul operation, and powerhouse.

The existing 30-foot wide by 3-foot high Obermeyer three-gate spillway system and wooden apron will be replaced with a 70-foot wide by 12-foot high air inflated rubber bladder on a concrete foundation or slab (70 feet by 100 feet) within the existing footprint and alignment of the original diversion (200 feet by 100 feet). Approximately 35 percent of the wooden diversion/spillway structure will be permanently replaced. The remaining diversion/spillway structure will be left in place and maintained as necessary (not covered in this Opinion).

Approximately 985 feet of bank protection along the left (west) bank, extending 350 feet upstream from the intake wall, and 700 feet downstream of the diversion dam structure wall will be replaced. The existing west bank consists of 350 feet of riprap upstream of the intake wall, a 154 feet concrete intake/diversion wall (which includes the 52-foot intake), and 700 feet of riprap downstream of the diversion wall. The existing riprap both upstream and downstream of the diversion is approximately 12 feet in height. The replacement structure will be 27 feet in height, with 15 feet of riprap placed below the already existing riprap, which will be below the current riverbed elevation. The concrete wall along the diversion will be extended 150 feet downstream (304 feet total) with 50 feet placed behind the downstream riprap. The rock chutes will be extended so they discharge waterward of the riprap.

Concrete of varying depth will be placed in front of the existing intake structure to allow for the installation of a trash rack. A three-foot diameter slotted pipe will be installed along the base of the intake structure. A 3-foot radial gate will be constructed within the spillway abutment on the left wall, at the downstream end of the slotted pipe. The slotted pipe and radial gate are designed to carry up to 120 cfs and allow fine sediments to be flushed in front of the intake structure. The intention is to have this occur without deflating the bladder spillway, which would occur primarily during the glacial melt period. The discharge for the pipe is on the dissipation concrete trough below the bladder to reduce streambed scour.

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The project will be constructed over two years with all activities occurring during the approved in-water work window (July 15 through September 15). In 2018, the 350 feet of bank protection upstream of the diversion dam will be replaced. The rest of the project will be completed in 2019.

Specific project in-water activities include:

Activities constructed in 2018:

1. Isolate and dewater the left side of the river channel from the diversion structure upstream approximately 400 feet. Most of the coffer dam will be placed on a gravel bar upstream of the intake structure. Approximately 6,700 square feet of the Puyallup River in front of the intake structure will be isolated and dewatered.

2. Replace upstream bank protection structure.

Activities constructed in 2019:

1. Isolate and dewater the right side of the river channel to add a liner over the wooden apron.

    a. Supersacks, filled with onsite native gravel materials, will be placed across the upper section of the exclosure to temporarily divert river flows to the left side of the channel. In addition, gravel berms and a bulkhead (over the wooden apron) will be constructed along the side and bottom of the exclosure.

    b. Install liner over the wooden apron to reduce seepage into the construction area when the left side of river is isolated and dewatered. The liner will extend 200 feet upstream and 400 feet downstream of the diversion dam, for a total of 700 feet affected. The liner will be approximately 130 feet wide. No gravel will be placed on top of the liner except at the upstream and downstream ends to hold the liner in place. The sides of the liner will be held in place by being buried within the berms constructed to dewater the river.

2. Isolate and dewater the left side of the river and flume to repair and replace the diversion structure.

    a. Move supersacks from the right side of channel to the left side to divert flows down the right side of the channel. Extend berm upstream to enlarge area to be dewatered on left side of channel.

    b. Remove spillway, excavate, and install rubber bladder, replace intake structure, extend rock chutes, and replace downstream bank protection structure.

c. Excavate approximately 19,500 cubic yards (1.5 acres) of sediment above and below the diversion dam. Excavated material will be used to make concrete to be used for the spillway foundation, walls, and shoreline protection. Approximately 7,700 cubic yards will be used as back fill for newly replaced or repaired structures. Any remaining sediment will be stockpiled on site.

3. Remove supersacks, berms, and liner.

5.1 Conservation Measures

Conservation measures have been incorporated into the project design to avoid or minimize potential effects to listed species. Some of these conservation measures include:

1. In-water construction will be conducted between July 15 and September 15 in 2018 and 2019.

2. Fish will be excluded and removed from discrete work areas as work progresses using protocol and standards prepared by Washington Department of Transportation (2016).

3. A Stormwater Pollution Prevention Plan will be prepared to address specific actions to prevent petroleum products from being discharge into surface waters.

4. Water quality parameters will be monitored at two stations; one station upstream of the project area and one station 1,500 feet downstream.

5.2 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 action area for this proposed federal action is based on the geographic extent of increased turbidity and suspended solids generated during in-water construction (cofferdam installation and removal).

The action area is defined downstream by the distance that increased turbidity and suspended solid levels due to the in-water construction to replace the diversion attenuates to background levels, and upstream by the extent of excavation of sediments above the diversion structure. The action area is defined as 2,600 feet of the Puyallup River, extending 1,000 feet upstream, 100 feet of the diversion dam, to 1,500 feet downstream of the project area (Figure 1).

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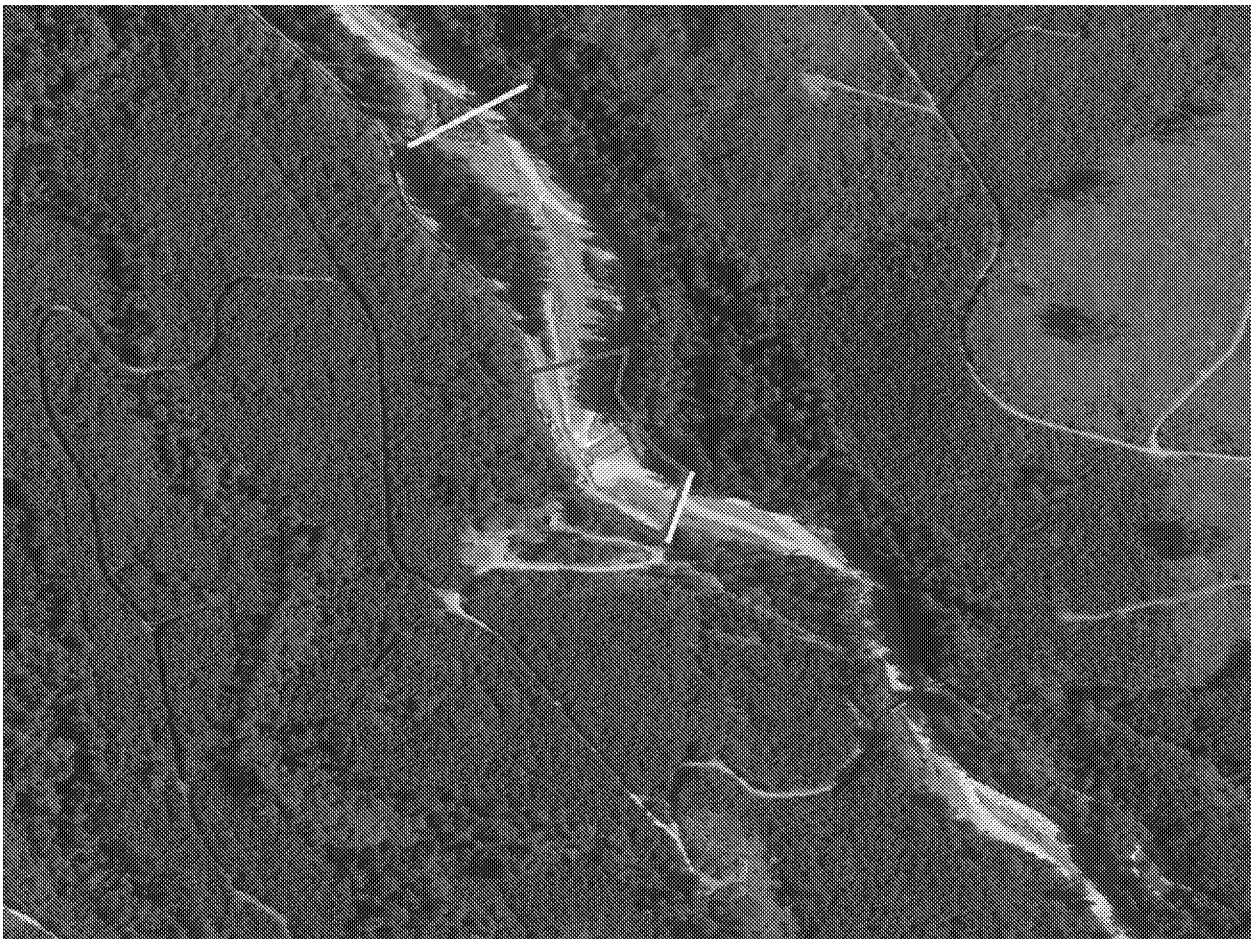

Figure 1. Project site (in red) and the action area (delineated upstream and downstream of the project in yellow)

6 ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

6.1 Jeopardy Determination

The following analysis relies on the following 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.

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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.

6.2 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 2016 critical habitat regulations (81 FR 7414) 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 the following 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

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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 bull trout.

7 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 non-native species (64 FR 58910 [Nov. 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 2015a, p. iii).

The 2015 recovery plan for bull trout identifies six recovery units of bull trout within the listed range of the species (USFWS 2015a, 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 2015a, 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 Service 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. These shared FMO areas support the viability of bull trout populations by contributing to successful overwintering survival and dispersal among core areas (USFWS 2015a, 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.

8 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 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. Overall bull trout abundance is "stable" range-wide (USFWS 2015a, p. iii). However, 81 core areas have 1,000 or fewer adults, with 24 core areas not having surveys

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conducted to determine adult abundance (USFWS 2008, p. 22; USFWS 2015b, p. 2). In addition, 23 core areas have declining populations, with 66 core areas having insufficient information (USFWS 2008, p. 25; USFWS 2015b, p. 2). These values 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 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 (*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 designated bull trout critical habitat, refer to Appendix B: Status of Designated Critical Habitat: Bull Trout.

9 ENVIRONMENTAL BASELINE

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.

9.1 Current Condition of Bull Trout and Designated Bull Trout Critical Habitat in the Action Area

The upper Puyallup River originates from glaciers on the western slope of Mt. Rainier. Flows in the Puyallup River upstream of the action area are based on glacial melt, spring snowmelt, and peak precipitation events. Extreme peak flows occur during winter months and generally result from rain on snow precipitation events. Spring snowmelt occurs from April through June and

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produces consistent moderate flows that vary with temperature and cloud cover. Glacial melt periods occur July through September and produce steady flows with sharply increased fine sediment loads. Low flows occur in early fall and during cold weather events throughout winter.

The Electron Hydro diversion structure was constructed in 1904. The diversion structure blocked all fish passage until 2000 when a concrete pool and weir-type fish ladder was constructed. The ladder requires at least 10 cfs to function properly, and it provides passage over the design flow range from 10 to 55 cfs. This range of flows through the ladder corresponds to river flows ranging from 160 to 1,100 cfs.

Up to 400 cfs of water from the Puyallup River is diverted into a 10-mile long flume for electricity production. The diversion structure entrains a large amount of sediment. Entrained rocks and cobbles are removed near the intake structure by two rock chutes. Sand and a portion of the silt are removed halfway down the flume in a settling basin. The remaining silt settles out in the forebay. Periodically, the forebay is drawn down and silt is removed from the forebay mechanically. Fish are removed at the forebay at the downstream end of the flume via a trap, hook and line, or nets during drawdowns. Captured fish are transported back to the river by truck. Fish are returned to the river downstream of the powerhouse located at river mile (RM) 31.2. Fish can be entrained in the penstocks and injured or killed as they pass through the turbines.

Fish habitat in the action area is lacking with most of the river consisting of riffles with short segments of boulder cascades. Woody debris is mobilized by high flows and deposited on gravel bars and become perched along the riverbank. Very little wood material is functioning to form habitat features at moderate to low flow conditions. Water withdrawal at the diversion dam reduces complex fish habitat by decreasing stream flows and water depths, simplifying habitat by constricting channel width, and reducing prey abundance by loss of invertebrates or spawning habitat,

The Electron Hydro facility is a run-of-the-river diversion. At the diversion dam, the Puyallup River has a naturally functioning hydrograph, with the hydrology following a glacier-dominated system. The removal of up to 400 cfs of water from the Puyallup River reduces flows within the river by up to 70 percent in late fall and winter and over 50 percent during the summer. In spring and early fall, water withdrawal can remove up to 90 percent of the river's flow. Minimum flows within the bypass reach (diversion dam to powerhouse) are 80 cfs from July 15 through November 15, and 60 cfs the rest of the year.

Nine native salmonid species (most are prey for bull trout) spawn and rear in the Puyallup River and tributaries. These species include Chinook salmon (*Oncorhychus tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), pink (*O. gorbuscha*), sockeye (*O. nerka*), steelhead/rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), mountain whitefish (*Prosopium williamsoni*), and bull trout. Non-native salmonids include brook trout (*S. fontinalis*) and brown trout (*Salmo trutta*). Within the action area, Chinook salmon, coho, steelhead/rainbow trout, cutthroat trout, and bull trout are found, and are regularly captured within, the forebay.

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Spawning habitat downstream of the diversion structure is reduced due to the removal of 400 cfs of flows to generate power. The Puyallup Tribe and Washington Department of Fish and Wildlife conduct spawning surveys within the Puyallup River watershed. Table 1 provides the number of redds found in the Puyallup River near the Electron diversion dam (RM 41.7) up to the Mowich River (RM 42.2).

Table 1. Number of salmon and steelhead redds found in the Puyallup River near the Electron diversion dam located at RM 41.7 upstream to the Mowich River at RM 42.2

Lower RM	Upper RM	Year	Species	No. of Redds
31.2	41.7	2016	Steelhead	1
35.5	41.8	2002	Steelhead	7
36	41.7	2007	Steelhead	6
36	41.7	2011	Steelhead	4
36	41.7	2016	Steelhead	1
36	41.7	2017	Steelhead	1
36	41.8	2016	Steelhead	4
36	41.9	2015	Steelhead	32
38.7	41.8	1999	Coho Salmon Steelhead	19
38.7	41.8	2000	Chinook Salmon Coho Salmon Steelhead	4
38.7	41.8	2001	Steelhead	2
39.5	41.7	2017	Steelhead	1
42	42.3	1999	Chinook Salmon	4

The removal of up to 400 cfs of flows at the diversion dam impacts prey availability for bull trout by reducing the macroinvertebrate habitat and the amount of spawning habitat available for both salmon and steelhead. Minimum flows below the diversion dam provides limited habitat for spawning and macroinvertebrate production. It is unknown whether prey availability is limiting within the action area. Lower flows are expected to limit prey availability for bull trout. Lower flows simplify in-stream habitat for prey species, resulting in changes that limit productivity.

9.2 Status of the Species in the Action Area: Bull Trout

The action area is located within the Puyallup River core area for bull trout (USFWS 2015c, p. A-151). The project is located at RM 41.7 on the Puyallup River. The project area is documented foraging, migration, and overwintering critical habitat for bull trout. The nearest spawning and early rearing habitats are located approximately a half mile upstream of the project site within the Mowich and Upper Puyallup Rivers. Bull trout get entrained in the inlet structure at the diversion dam and travel down the flume into the powerhouse forebay. A trap and haul facility captures bull trout within the forebay and transports them downstream of the powerhouse. Between 2006 and 2015, 66 bull trout, an average of 7 per year, were caught

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within the forebay (Electron Hydro 2017, p. 14). Approximately 1.1 percent of all fish captured over the ten-year period (202,987 fish) were killed at the trap and haul facility (Electron Hydro 2017, p. 14). Capture rates within the forebay in 2010 for Chinook salmon and coho ranged from 84 to 91 percent.

9.3 Puyallup River Core Area

The Puyallup core area comprises the Puyallup, Mowich, and Carbon Rivers; the White River system, which includes the Clearwater, Greenwater, and the West Fork White Rivers; and Huckleberry Creek. Glacial sources in several watersheds drain the north and west sides of Mount Rainier and significantly influence water, substrate, and channel conditions in the mainstem reaches. The location of many of the basin's headwater reaches within Mount Rainier National Park and designated wilderness areas (Clearwater Wilderness, Norse Peak Wilderness) provides relatively pristine habitat conditions in these portions of the watershed.

Anadromous, fluvial, and resident bull trout occur within local populations in the Puyallup River system (USFWS 2005a, p. 87). Bull trout occur throughout most of the system although spawning occurs primarily in the headwater reaches. Anadromous and fluvial bull trout use the mainstem reaches of the Puyallup, Carbon, and White Rivers to forage and overwinter, while the anadromous form also uses Commencement Bay and likely other nearshore areas within Puget Sound. Habitat conditions within the lower mainstem Puyallup and White Rivers are highly degraded, retaining minimal instream habitat complexity. In addition, habitat conditions within Commencement Bay and adjoining nearshore areas are severely degraded as well, with very little intact intertidal habitat remaining.

The Puyallup core area has the southernmost, anadromous bull trout population in the Coastal Recovery Unit (USFWS 2004, Vol. I p. 19). Consequently, maintaining the bull trout population in this core area is critical to maintaining the overall distribution of migratory bull trout in the Recovery Unit. In 2005, the status of this core area was the most depressed in the Puget Sound area (USFWS 2005b, p. 600). The anadromous life history form continues to be at low abundance (approximately 20 percent) based on the lack of observations in Commencement Bay since the 1980s and recent studies within the White River (Peters in litt. 2018).

The status of the bull trout core area population is based on 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, Vol. I p. 215).

9.3.1 Number and Distribution of Local Populations

Four local populations occur in the Puyallup core area: 1) Upper Puyallup and Mowich Rivers, 2) Carbon River, 3) Upper White River, and 4) West Fork White River. The Greenwater and Clearwater Rivers are not considered local populations. Occasional adult and sub-adult bull trout are observed in these river systems, but juvenile bull trout have not been reported since the early 1990s (USFWS 2015c, p. A-151). Radio Telemetry efforts have not found spawning adults in

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the Greenwater River. The Clearwater River is not considered a local population as only a single observation of bull trout has been document and telemetry data indicates lack of use (USFWS 2015, p. A-151).

Information about the distribution and abundance of bull trout in this core area is limited because observations have generally been incidental to other fish species survey work. Spawning occurs in the upper reaches of this basin where higher elevations produce the cold water temperatures required by bull trout egg and juvenile survival. Based on survey data, bull trout spawning in this core area occurs earlier in the year (i.e., September) than typically observed in other Puget Sound core areas (Marks et al. 2002). The known spawning areas in local populations are few in number and not widespread. The majority of spawning sites are located in streams within Mount Rainier National Park, with two exceptions, Silver Creek and Silver Springs (Ladley, in litt. 2006; Marks et al. 2002).

Rearing likely occurs throughout the Upper Puyallup, Mowich, Carbon, Upper White, West Fork White Rivers. However, sampling indicates most rearing is confined to the upper reaches of the basin. The mainstem reaches of the White, Carbon, and Puyallup Rivers probably provide the primary freshwater foraging, migration, and overwintering habitat for migratory bull trout within this core area.

The Puyallup River core area has an overall ranking of "at risk" for vulnerability for extirpation due to very limited and/or declining numbers, range, and/or habitat (USFWS 2008, pp. 29, 35).

9.3.2 Adult Abundance

Rigorous abundance estimates are generally not available for local populations in the Puyallup core area. Fewer than 100 adults probably occur in each of the local populations in the White River system, based on adult counts at Mud Mountain Dam's Buckley Diversion fish trap. This information is based off of bull trout numbers at the diversion dam between 1990 and 2008. However, between 1990 and 2008, adult bull trout numbers at the Buckley Diversion averaged approximately 30 bull trout per year. Since 2008, bull trout numbers have increased up to 406 in 2014 (minimum 75 in 2011, USACE 2015, p. 80, USACE 2018). Although these counts may not adequately account for fluvial migrants that do not migrate downstream of the facility, these counts do indicate that anadromous bull trout and mainstem fluvial bull trout returns to local populations in the White River system are increasing.

9.3.3 Productivity

Due to the current lack of long-term, comprehensive trend data, the bull trout population in the Puyallup core area is considered "at risk" of extirpation until sufficient information is collected to properly assess productivity (USFWS 2008, pp. 29, 35).

9.3.4 Connectivity

Migratory bull trout are likely present in most local populations in the Puyallup core area. However, the number of adult bull trout expressing migratory behavior within each local

population appears to be very low compared to other core areas. Although connectivity between the Upper Puyallup and Mowich Rivers local population and other Puyallup core area local populations was reestablished with the creation of an upstream fish ladder at Electron Dam in 2000, this occurred after approximately 100 years of isolation. The overall low abundance of migratory life history forms limits the possibility for genetic exchange and local population refounding, as well as limits more diverse foraging opportunities to increase size of spawners and therefore, overall fecundity within the population. Consequently, the bull trout population in the Puyallup core area is "at risk" of extirpation from habitat isolation and fragmentation (USFWS 2008, pp. 29, 35).

9.3.5 Changes in Environmental Conditions and Population Status

Since the bull trout listing, the Service has issued approximately 50 Opinions, including projects within Commencement Bay, that exempted incidental take in the Puyallup core area. These incidental take exemptions were in the form of harm and harassment, primarily from hydrologic impacts associated with increased impervious surface, temporary sediment increases during in-water work, habitat loss or alteration, and handling of fish. None of these projects were determined to result in jeopardy to bull trout. The combined effects of actions evaluated under these Opinions have resulted in short-term and long-term adverse effects to bull trout and degradation of bull trout habitat within the core area.

Of particular note, in 2003 the Service issued an Opinion (USFWS Ref. No. 1-3-01-F-0476) on the State Route 167 North Sumner Interchange Project. This project was located in Pierce County in the White River portion of the Puyallup watershed and was proposed by Washington State Department of Transportation. The project's direct and indirect impacts and cumulative impacts within the action area included urbanization of approximately 600 acres of land. We anticipated that conversion of this land to impervious surface would result in the permanent loss and/or degradation of aquatic habitat for bull trout and their prey species through reduced base flows, increased peak flows, increased temperatures, loss of thermal refugia, degradation of water quality, and the degradation of the aquatic invertebrate community and those species dependent upon it (bull trout prey species). These impacts will result in thermal stress and disrupt normal behavioral patterns. Incidental take of fluvial, adfluvial, and anadromous bull trout in the form of harassment due to thermal stress and the disruption of migrating and foraging behaviors was exempted for this project. These adverse effects were expected to continue in perpetuity.

Two section 10(a)(1)(B) permits have also been issued for HCPs that address bull trout in this core area. Although these HCPs may result in both short and/or long-term negative effects to bull trout and their habitat, the anticipated long-term beneficial effects are expected to maintain or improve the overall baseline status of the species. Additionally, capture and handling, and indirect mortality, during implementation of section 6 and section 10(a)(1)(A) permits have directly affected some individual bull trout in this core area. Twelve 10(a)(1)(A) permits have been issued within the Puyallup River core area and only one authorized lethal take of bull trout.

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The number of non-Federal actions occurring within the Puyallup core area since the bull trout were listed is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance affect riparian and instream habitat which typically results in negative affects to bull trout and their habitat.

9.3.6 Threats

Threats to bull trout in the Puyallup core area include (USFWS 2015c, p. A-15):

- Legacy Forest Management Practices: Extensive past and ongoing timber harvest and harvest-related activities, such as road maintenance and construction, continue to affect bull trout spawning and rearing areas. Significant impacts occur in the mid-elevation areas outside of Mount Rainier National Park, especially within the Upper Puyallup and Mowich Rivers local papulations.

- Barriers. Dams and diversions have significantly affected migratory bull trout in the core area. Until upstream passage was restored in 2000, the Electron Diversion Dam isolated bull trout in the Upper Puyallup and Mowich Rivers local population for nearly 100 years and has drastically reduced the abundance of migratory bull trout in the Puyallup River. Buckley Diversion and Mud Mountain Dam have significantly affected the White River system in the past by impeding or precluding adult and juvenile migration and degrading foraging, migration, and overwintering habitats in the mainstem. Despite improvements to these facilities, passage related impacts continue, but to a lesser degree (UWFWS 2004, pp. 150-153).

- Flood Control. Urbanization, road construction, residential development, and marine port development associated with the city of Tacoma, have significantly reduced habitat complexity and quality in the lower mainstem rivers and associated tributaries, and have largely eliminated intact nearshore foraging habitats for anadromous bull trout in Commencement Bay.

- Nonnative Fishes. The presence of brook trout in many parts of the Puyallup core area and their potential to increase in distribution, including into Mount Rainer National Park waters, are considered significant threats to bull trout. Because of their early maturation and competitive advantage over bull trout in degraded habitats, brook trout in the upper Puyallup and Mowich Rivers local population is of highest concern because of past isolation of bull trout and the level of habitat degradation in this area.

- Fisheries. Until the early 1990s, bull trout fisheries probably significantly reduced the overall bull trout population within this and other core areas in Puget Sound. Current legal and illegal fisheries in the Puyallup core area may continue to significantly limit recovery of the population because of the low numbers of migratory adults (UWFWS 2004, pp. 184-185).

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- Water Quality. Water quality has been degraded due to municipal and industrial effluent discharges resulting from development, particularly in the lower mainstem Puyallup River and Commencement Bay. Water quality has also been degraded by stormwater discharge associated with runoff from impervious surface. Impervious surface in the Puyallup watershed increased by 12 percent between 1990 and 2001 (PSAT 2007).

- Natural Events. Major flood events in November 2006 significantly impacted instream habitats within the Puyallup River system. These events are assumed to have drastically impacted bull trout brood success for the year, due to significant scour and channel changes that occurred after peak spawning. Significant impacts to rearing juvenile bull trout were also likely, further impacting the future recruitment of adult bull trout.

- Anthropogenic Events. In November 2006, an approximately 18,200 gallon diesel spill resulted in approximately 7,970 gallons entering the head waters of Spring Creek WDOE 2013, p. 1, website accessed 10/22/2013), a bull trout spawning area of the Upper White River local population, likely impacting the available instream spawning habitat. Of this, 6,974 gallons of spilled diesel were recovered by December 2006. Restoration actions have been completed as of 2012 (USFWS 2012, website accessed 10/22/2013).

9.4 Status of Critical Habitat in the Action Area: Bull Trout

The Service designated critical habitat for the Puyallup River bull trout population on October 18, 2010 (75 FR 63898). The action area is within the Puyallup River critical habitat subunit (CHSU).

The Puyallup River CHSU is essential to bull trout conservation because it represents the southernmost distribution of anadromous bull trout in Puget Sound, supports multiple life history expressions, and may represent a key climate change refugium for the species due to the extensive glacially influenced habitat (USFWS 2010a, p. 179). The action area provides FMO habitat. The action area is located approximately a half mile downstream of spawning and rearing critical habitat in the upper Puyallup and Mowich Rivers.

The final rule identified nine PCEs essential for the conservation of bull trout. Eight of the nine PCEs (all but PCE #6) are found 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 action area is assumed to contain springs, seeps, groundwater sources, and/or subsurface flow, all providing cold water to the river. However, the diversion, intake, and bank stabilization structures may prevent or reduce groundwater from the river. Most groundwater will enter the

river system from the bottom of the river or from under bank stabilization structures. The action area is located in an undeveloped, forested environment that allows infiltration of precipitation into the ground.

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

The Electron diversion dam was constructed in 1904 and was a migration barrier to bull trout until 2000 when a fish ladder was constructed along the north or right bank. It is unknown whether bull trout migrate upstream through the fish ladder. A radio-tagged bull trout was found to migrate from the White River up to the powerhouse, but did not migrate any further upstream (Peters in litt. 2018). Bull trout do get entrained within the flume and are captured and transported downstream of the powerhouse. Approximately seven bull trout per year are entrained and caught within the forebay (Electron Hydro 2017, p. 14). An unknown number get entrained in the penstocks and are injured or killed as they pass through the turbines.

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

The action area provides FMO habitat. The action area is located in the upper Puyallup River where, besides the diversion dam, the land is undeveloped, with timber harvest occurring in the surrounding areas. The riparian habitat is intact providing terrestrial organisms to the river. The action area contains forage fish (e.g. juvenile salmonids) for sub-adult and adult bull trout. Below the diversion dam, the operation of the Electron Hydro facility reduces spawning and rearing habitat for bull trout prey species, including salmon and benthic invertebrates.

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 Puyallup River upstream and downstream of the action area is a natural river system where the river is allowed to meander, resulting in natural eroding banks, sediment deposition, large wood recruitment, etc. Within the action area little complex habitat exists. The Puyallup River within the action area is mostly a riffle system with a few boulder clusters. The diversion, intake, fish ladder, and bank stabilization structures all simplify the river and limit natural river functions. The riparian habitat within the action area is intact.

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

Water temperatures within the action area are highly influenced by the glacial melt in which the Puyallup River originates. Water temperatures in the lower reaches of the Puyallup River have

only exceeded 16 °C eight times between 1971 and 2018. This long-term water quality monitoring station is location on the Puyallup River just north of Puyallup, Washington. This is approximately 30 miles downstream of the action area.

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 Electron Hydro facility is a run-of-the-river diversion. At the diversion dam, the Puyallup River has a natural hydrograph, with the hydrology following a glaciated dominated system. The operation of the Electron Hydro facility removes up to 400 cfs of water from the Puyallup River. This reduces flows within the river by up to 70 percent in late fall and winter and over 50 percent during the summer. In spring and early fall, water withdrawals can remove up to 90 percent. Minimum flows within the bypass reach (diversion dam to powerhouse) are 80 cfs from July 15 through November 15 and 60 cfs the rest of the year.

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

The water quality within the action areas is properly functioning. The action areas are not listed under the Washington Department of Ecology's 303(d) list (WDOE 2018). The Puyallup River originates from glaciers on Mount Rainier. The river has high sediment and turbidity loads during spring and summer. See PCE 5 for water temperatures within the action areas.

PCE 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.

Eastern brook trout (*S. fontinalis*) are known to occur within the Puyallup River watershed, but are mainly found within the mainstem Carbon River. Past stocking efforts introduced non-native fish species such as Yellowstone (*O. clarki bouvierri*) and West Slope (*O.clarki lewisi*) cutthroat trout. These species, if within the action areas, can compete with bull trout, especially juveniles for prey species such as macroinverterbrates. Nonnative fish species are not known to be within the action area or the upper Puyallup River.

9.5 Conservation Role of the Action Area

The action area is within the Puyallup River core area. The Puyallup River core area has the southernmost anadromous bull trout population in the Puget Sound Management Unit and within the Coastal Recovery Unit. Therefore, maintaining the bull trout population in this core area is critical to maintaining the overall distribution of migratory bull trout in the management unit. The action area provides important foraging, migration, and overwintering habitat to anadromous and fluvial bull trout life history forms. This action area provides important migratory corridors for adult bull trout migrating from the Puget Sound and Commencement Bay to spawning habitat in the upper Puyallup River watershed. In addition, the action area is immediately downstream of the Mowich and Upper Puyallup local populations.

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9.6 Climate Change

Consistent with Service 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" thus 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. These effects may be positive, neutral, or negative, and they may change over time. The nature of the effect depends on the 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.

Observations and modeling for Pacific Northwest aquatic habitats suggest that bull trout and other salmonid populations will be negatively affected by ongoing and future climate change. Rieman and McIntyre (1993, p. 8) listed several studies which predicted substantial declines of salmonid stocks in some regions related to long-term climate change. Battin et al. (2007) modeled impacts to salmon in the Snohomish River Basin related to predictions of climate change. They suggest that long-term climate impacts on hydrology would be greatest in the highest elevation basins, although site specific landscape characteristics would determine the magnitude and timing of effects. Streams which acquire much of their flows from snowmelt and rain-on-snow events may be particularly vulnerable to the effects of climate change (Battin et al. 2007, p. 6724). In the Pacific Northwest region, warming air temperatures are predicted to result in receding glaciers, which in time would be expected to seasonally impact turbidity levels, bedload, timing and volume of flows, stream temperatures, and species responses to shifting seasonal patterns. Changing climatic conditions are expected to similarly affect the Snohomish/Skykomish River basin.

Battin et al. (2007, p. 6720) suggest that salmonid populations in streams affected by climate change may have better spawning success rates for individuals that spawn in lower-elevation sites, especially where restoration efforts result in improved habitat. Higher elevation spawners would be more vulnerable to the impacts of increased peak flows on egg survival. They further note that juvenile salmonids spending less time in freshwater streams before out-migrating to the ocean would be less impacted by the higher temperatures and low flows than juveniles that rear longer in the streams. Bull trout generally spawn in cold headwater streams, and juveniles may spend one to three years rearing before moving downstream to large river reaches (such as the lower Puyallup, White, and Carbon Rivers) or estuarine/marine habitats. Therefore, bull trout would be less likely than other salmonids to be able to adjust their spawning habitat needs related to water temperature. Connectivity between lower and upper reaches of the Puyallup River

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Watershed (Puyallup, White, and Carbon Rivers) and Puget Sound may become even more critical for the growth and survival of fluvial and anadromous individuals that access the action area for foraging, migrating, and overwintering purposes.

10 EFFECTS OF THE ACTION: Bull Trout

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 primary construction-related effects of the proposed action on bull trout include: 1) disturbance from turbidity and suspended sediment, and 2) stress, capture, injury, or mortality from both stream isolation and fish handling. These effects may result in disturbance, behavioral changes, injury, or mortality of sub-adult or adult bull trout.

The project involves replacing approximately 70 feet of a 200-foot-long diversion dam, adding a trash rack and sluice system to the intake structure, and replacing and reinforcing the bank protection along the left bank of the river upstream and downstream of the diversion dam. The new diversion dam will consist of an inflatable rubber bladder on a concrete foundation.

The project will be constructed over two years. In 2018, 350 feet of bank protection upstream of the diversion dam will be replaced. Approximately 6,700 square feet of the Puyallup River in front of the intake structure will be isolated and dewatered. In 2019, the remaining portions of the project will be constructed which involves isolating and dewatering the river twice, once on each side of the river.

10.1 Suspended Sediment

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 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. A summary of effects from suspended sediment is listed in Table 2 and a more detailed discussion of effects is included in Appendix C: Determining Effects for Section 7 Consultations.

Table 2. Summary of adverse effects to fish resulting from elevated sediment levels

Sediment Impacts to Fish	Summary of Adverse Effects Related to Sediment Impacts
Gill trauma	Clogs gills which impedes circulation of water over the gills and interferes with respiration
Prey base	Disrupts both habitat for and reproductive success of macroinvertebrates and other salmonids (bull trout prey) that spawn and rear downstream of the construction activities
Feeding efficiency	Reduces visibility and impacts feeding rates and prey selection
Habitat	Fills pools, simplifies and reduces suitable habitat
Physiological	Increases stress, resulting in decreased immunological competence, growth and reproductive success
Behavioral	Results in avoidance and abandonment of preferred habitat

The project will result in increased levels of turbidity and suspended sediments during the installation and removal of the supersacks, building the berms to dewater the project areas, and when the isolated areas are rewatered after the diversion replacement is complete. Rewatering of the work area will occur slowly to allow minimize suspension of suspended solids downstream.

In 2018, the left bank protection structure will be replaced. The left bank will be isolated by installing supersacks on an existing gravel bar and within the river in front of the intake structure. Approximately 120 feet of supersacks will be placed in the river. No construction will occur within the water. The bank stabilization structure that will be replaced is all behind an existing gravel bar. The river isolation will prevent water from entering the work area while the bank protection structure is being replaced. The Service does not expect that the installation and removal of the supersacks, the rewatering of the work area, or the inundation of the work area during the first high flow event will result in a significant disruption of normal bull trout behaviors. The first high flow event after construction will result in increased turbidity and suspended sediment from construction. However, we expect the effects will be temporary and short in duration and we expect that effects are unlikely to result in injury to bull trout or to disrupt normal bull trout behaviors.

During construction in 2019, the Service expects that a significant amount of turbidity and suspended sediments will be released from the project site, particularly during the rewatering of the site, due the amount of sediment excavated from the site.

To assess the suspended sediment concentrations at which adverse effects will occur, and to determine the extent downstream to which those effects may extend, we used the Service's guidance for evaluating effects of sediment on bull trout and their habitat (USFWS 2010b; Appendix C). The guidance uses the findings of Newcombe and Jensen (1996) to evaluate the

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"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 when considering the potential effects of suspended sediment concentrations.

The framework in Appendix C requires an estimate of suspended sediment concentration (in milligrams per liter [mg/L] or Nephelometric Turbidity Units [NTUs]) and exposure duration. Turbidity in the Puyallup River can be extremely variable throughout the year because of the glaciers in which the river originates. Monitoring data collection on the Puyallup River near Orting (Station No. 10A110, located approximately 20 miles downstream) were used to determine the ratio of turbidity to suspended solids for the waterbody (1 NTU:2.6 mg/L). The Service expects that any measurable increases in turbidity will be short-term and episodic.

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

1. When background NTU levels exceed 56 NTU at any time.

2. When background NTU levels exceed 37 NTU for more than 1 hour, continuously.

3. When background NTU levels exceed 15 NTU for more than 3 hours, cumulatively, over a 10-hour workday.

4. When background NTU levels exceed 8 NTU for more than 7 hours, cumulatively, over a 10-hour workday.

Because of the location of the project site, Electron Hydro has limited access to the river. Water quality monitoring will occur upstream of the project site and approximately 1,500 feet downstream. The Service expects that suspended sediment concentrations resulting in adverse effects on bull trout are reasonably certain to occur as far as 1,500 feet downstream of the project site, which comprises the aquatic extent of the action area.

Juvenile, sub-adult, and adult bull trout may occupy the waters immediately surrounding the project area at any time of year. Sub-adult and adult bull trout are less likely to be affected by episodic increases in turbidity and suspended sediments during construction, but may exhibit a behavioral response, such as temporary avoidance of the turbid areas. Juvenile bull trout exposed to elevated turbidity and suspended sediments could experience reduced foraging efficiency and higher energetic expenditures in avoiding the turbid areas in the river. Therefore, we expect that exposure to elevated turbidity and suspended sediments will have an adverse effect on juvenile, sub-adult, and adult bull trout to the extent that it will have a measurable effect on fitness, primarily through increased energy expenditure resulting in reduction in growth and, therefore, reproduction. In addition, adult bull trout may avoid the area when suspended sediment concentrations in the area are elevated. Resulting turbidities may also impede or discourage free movement through the action area, delaying or discouraging adult bull trout from

migrating through the project area. However, bull trout will not be exposed to elevated turbidities beyond daylight hours and nocturnal movements and migration proximal to the project area will remain consistent.

Pulses of elevated turbidity are expected while work is conducted within the wetted channel during the in-water work window (July 15 through September 15, 2018), and following installation and removal of the supersacks and sediment berms. We expect the elevated turbidity and suspended sediment levels to extend as far as 1,500 feet downstream of the project site, and will result in a significant temporary disruption of normal bull trout behaviors (i.e., ability to successfully feed, migration, and/or shelter). All juvenile, sub-adult, and adult bull trout within 1,500 feet downstream of the project site will experience a significant, but temporary (between July 15 and September 15, 2018) disruption of normal bull trout behaviors during the installation and removal of the supersacks and sediment berms.

10.2 River Isolation

Work area isolation, flow diversion, and working during the approved in-water work window are conservation measures intended to reduce the risk of fish stranding and other forms of injury (e.g., exposure to intense turbidity). Electron Hydro will implement these conservation measures to avoid the more severe effects that bull trout might experience from remaining within the work area.

Bull trout may be crushed or injured during the placement of the supersacks, sediment berms, or other features in the wetted width of the waterbody during isolation of the work area. The project area is used by juvenile, sub-adults, and adults throughout the year as foraging, migration, and overwintering habitat. Juveniles and smaller sub-adult bull trout are more at risk of being injured or killed because they seek refuge in the substrate instead of swimming away. Because larger life history stages are more mobile and can easily detect and avoid activities that are conducted below the ordinary high water mark, it is extremely unlikely that larger sub-adult or adult bull trout will be crushed or injured during the placement of the supersacks, sediment berms, or other features in the river. As a result, we anticipate that the number of small (e.g., <100 mm) juvenile and sub-adult bull trout taken by the proposed methods is likely to be low.

The Service expects that a small number of juvenile and small sub-adults may be killed during the placement of the supersacks, sediment berms, or other features to isolate the project site in both 2018 and 2019. In 2018, approximately 1,000 square feet of the Puyallup River in front of the intake structure will be covered by supersacks to allow replacement of the bank protection structure upstream of the diversion dam. An approximate 30,000 square feet area (1,000 feet by 30 feet) will be covered by the supersacks and sediment berms during in-water construction from July 15 to September 15, 2019. We expect that the likelihood of crushing is low, due to the anticipated size and behavior of bull trout using the action area of the proposed projects. Based on the relatively low number of small bull trout likely to be present during the river isolation construction, we anticipate that the number of small bull trout crushed or otherwise injured during placement of the supersacks and other features would be limited to three bull trout total,

one in 2018 and two in 2019, and that this effect would be limited to 1,000 square feet in 2018 and 30,000 square feet in 2019 during placement of the supersacks and sediment berms in the river during river isolation activities.

10.3 Capture and Handling

Work area isolation and flow diversion will result in bull trout capture and handling. Work area isolation and flow diversion will occur once in 2018 and twice in 2019. In 2018, approximately 6,700 square feet of the Puyallup River in front of the intake structure will be isolated. In 2019, water will be diverted to the left side of the river, so a liner can be installed on the wooden diversion structure to minimize water seepage into the work area to install the rubber bladder. Flows will then be diverted to the right side of the river so work can occur to replace the diversion structure. Fish capture and handling will occur each time the river is isolated to the work areas.

The Service expects that with careful, full implementation of the proposed conservation measures, and considering areas where fish capture operations will be conducted, a very modest number of sub-adult and adult bull trout may be affected by fish capture and handling. All, or nearly all, of the sub-adult and adult bull trout should be removed prior to electrofishing, and the rate of injury and/or accidental (incidental) mortality should be low for sub-adult and adult bull trout. Instead, it is more likely that adverse effects to sub-adult or adult bull trout resulting from fish capture and handling will take the form of increased stress and a temporary disruption to normal bull trout behaviors. While this added stress and disruption to their normal behaviors will have measurable short-term effects, including interruption to feeding and increased energetic demands, we expect that nearly all of the exposed individuals will experience no long-term effects.

Electrofishing will be employed only as a last resort, and after all other means of fish capture and removal have been exhausted (e.g. herding with block nets, seining, dip nets in conjunction with dewatering, etc.), and only after a qualified biologist determines that all or nearly all of the sub-adult and adult-sized fish have been effectively removed. Only qualified biologists in the technique of electrofishing and familiar with equipment handling, settings, maintenance, and safety, may operate electrofishing equipment. Capture operations that utilize electrofishing equipment shall use the minimum voltage, pulse width, and rate settings necessary to immobilize fish, and shall measure water conductivity in the field before electrofishing in order to determine appropriate settings.

Electrofishing involves passing an electrical current through water to immobilize fish and facilitate their capture and removal from the in-water work area. The process of running an electrical current through the water can cause a range of effects, including annoyance, startle, or avoidance behavior; temporary immobility; physical injury; and mortality. The amount of unintentional (or incidental) injury or mortality attributable to electrofishing can vary widely, depending upon the equipment used, settings used, site conditions (e.g., clarity of water and visibility), and the expertise of the operator. Accidental contact with the electrodes is a frequent cause for physical injury or mortality. When fish capture operations use the minimum voltage, pulse width, and rate settings necessary to immobilize fish, shocked fish normally revive quickly.

Electrofishing can more severely affect adult salmonids because of their larger size and surface area. Injuries, which may cause or contribute to delayed mortality, can include spinal hemorrhages, internal hemorrhages, fractured vertebra, spinal misalignment, and separated spinal columns (Dalbey et al. 1996; Hollender and Carline 1994; Thompson et al. 1997a). Sharber and Carothers (1988) report that electrofishing killed 50 percent of the adult rainbow trout in their study. The long-term effects of electrofishing on juvenile and adult salmonids are not well understood, but it appears that most of the measurable effects of electrofishing seem to occur at the time of fish capture operations, and are of relatively short in duration.

Most studies on the effects of electrofishing have been conducted on adult fish greater than 300 millimeters in length (Dalbey et al. 1996). However, the relatively few studies that have been conducted on juvenile salmonids indicate that spinal injury rates are substantially lower than they are for large fish. Smaller fish have a smaller head-to-tail ratio than larger fish (Sharber and Carothers 1988), and therefore may experience lower injury rates (Dalbey et al. 1996; Thompson et al. 1997a; Thompson et al. 1997b). For example, McMichael et al. (1998) found a 5.1 percent injury rate for juvenile steelhead captured by electrofishing in the Yakima River.

The incidence and severity of electrofishing injury is partly related to the type of equipment used and the waveform produced (Dalbey et al. 1996; Dwyer and White 1997; Sharber and Carothers 1988). Continuous direct current or low-frequency pulsed direct current (equal or less than 30 Hz) have been recommended for electrofishing because lower spinal injury rates, particularly in salmonids, have resulted from these waveforms (Dalbey et al. 1996). Only a few studies have examined the long-term effects of electrofishing on salmonid survival and growth (Ainslie et al. 1998; Dalbey et al. 1996). These studies indicate that although some fish suffer spinal injury, few die as a result. However, severely injured fish grow at slower rates and sometimes exhibit no growth at all (Dalbey et al. 1996), resulting in a significant loss of fitness to the individual.

Sub-adult and adult salmonids, because of their larger size (i.e., older than one year and larger than 150 mm; with variation dependent on species), cannot seek refuge in gravels and are generally easier to detect, herd, seine, and/or net. Therefore, fish capture operations that exhaust other means of capture (e.g. herding with block nets, seining, dip nets in conjunction with dewatering, etc.) should not expose many sub-adult or adult salmonids to electrofishing. However, some sub-adults and adults may hide under vegetation or other cover such as undercut banks, large woody debris, or rootwads. While herding, seining, and netting are much safer means by which to capture and remove fish because they present lower risks of injury and/or incidental mortality, all forms of capture and handling result in some degree of stress to the individual, and disrupt normal behaviors for survival, such as the ability to successfully feed, move and find shelter.

Applying best professional judgment, with consideration of the timing and location of construction activities, the amount and quality of affected habitat, and methods for work area isolation and dewatering, the Service expects that no more than two juvenile, sub-adult, or adult bull trout and ten juvenile, sub-adult, or adult bull trout will be captured and handled during fish capture and handling in 2018 and 2019, respectively. Of these, one juvenile, sub-adult, or adult bull trout in 2018 and two juvenile, sub-adult, or adult bull trout in 2019 will be injured or killed (i.e., stress, injury, or mortality) due to fish capture and handling. Fish capture and handling will occur between July 15 and September 15, in both 2018 and 2019.

10.4 Effects on Bull Trout Critical Habitat

An earlier section identified the PCEs of designated bull trout critical habitat within the action area and described their baseline condition (*Environmental Baseline*). The exact location and/or features corresponding to some of the individual PCEs (e.g., location of springs, seeps, etc.) are not known. Therefore, impacts to certain PCEs can only be assumed where critical habitat overlaps with the effects of the action. The information below describes direct and indirect effects to each of the applicable PCEs and how the effects will influence the function and conservation role of the Critical Habitat Unit.

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 project maintains, and may slightly degrade the current level of function for this PCE. The project replaces 70 feet of the existing wooden diversion dam with an inflatable rubber bladder which will sit on a concrete pad. The concrete pad (700 square feet) will eliminate any groundwater source entering the Puyallup River from under the river. In addition, the project extends an existing 154-foot concrete wall along the left bank to 304 feet (adding 150 feet) and deepen the existing 1,050 feet of riprap by 15 feet (total 27 feet in height). These activities will eliminate or reduce groundwater sources from entering the Puyallup River. Because the project area is currently within an undeveloped forested environment that results in natural groundwater connectivity, the proposed activity, while maintaining or slightly degrading this PCE, will not result in a measurable impact to this PCE. There the effects to this PCE are considered insignificant.

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.

During construction, the project involves diverting flows to both sides of the river. In 2018, approximately 6,700 square feet of the Puyallup River in front of the intake structure will be isolated. In 2019, the right side of the river will be dewatered first to allow a liner to be placed on top of the existing diversion. After the liner is installed, flows will be diverted over to the right side of the river to allow replacement of the diversion with the rubber bladder. While flows are diverted to the left side of the river, the fish ladder will not be operating and the diversion will impede bull trout migration through the action area. While flows are diverted to the right side of the river, the fish ladder will be in operation and bull trout may be able to migrate above the diversion. Replacement of the diversion dam is expected to temporarily preclude bull trout from migrating through the area. We anticipate that this impediment to bull trout migration is temporary, and would not result in long-term physical, biological, or water quality impediments to bull trout migration within the action area. Overall, the project is expected to preclude migration of bull trout through the action area during construction, and therefore, will adversely affect this PCE.

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

Project construction is expected to result in short-term impacts to the food base of bull trout. Construction is anticipated to crush, smother, and/or displace prey items, such as aquatic macroinvertebrates and small fish that seek cover or are unable to escape. Placement of the supersacks and liner, construction of the berms, excavation of sediments, and strengthening and extending the bank structures on the left bank will all result in loss of prey species. The project will adversely effect this PCE.

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 proposed project will maintain the existing degraded habitat and function of this PCE along the left bank of the Puyallup River. Approximately 985 feet of bank protection consists of riprap and a concrete wall. The project will not lengthen the bank protection but will deepen the riprap 15 feet below the existing riprap. The project will not result in any measurable effect to the function of this PCE. This PCE will retain its current level of function (moderately impaired). Effects to this PCE will be insignificant.

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

The project will have no effect on this PCE. The project does not remove any riparian vegetation and will not result in any changes to the water temperature within the Puyallup River.

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 project will have no effect on this PCE. Electron Hydro operates a run-of-river hydroelectric generating facility. At the diversion dam, the Puyallup River has a natural hydrograph, with the hydrology following a glaciated dominated system. The proposed project will not affect the hydrology of the Puyallup River.

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

The proposed project will result in the localized increase in turbidity and suspended sediment during the isolation of the work areas and when flows re-enter disturbed areas between July 15 and September 15, 2018 and 2019 (years of construction). Project construction results in elevated turbidity and suspended sediments and will adversely affect this PCE.

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.

The project is not anticipated to result in the introduction of nonnative predatory, inbreeding, or competitive species into the action area. Therefore, the proposed action will have no effect to this PCE.

11 CUMULATIVE EFFECTS: Bull Trout

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.

Electron Hydro LLC operates and maintains a 26-megawatt hydroelectric power plant on the upper Puyallup River. The operation and maintenance of the hydroelectric power plant results in adverse effects to, and take of, bull trout. This includes, but is not limited to, water withdrawals and reduced flows in the 10-mile reach of the Puyallup River; entrainment of bull trout in the flume, rock chutes, settling basin, forebay, and through the powerhouse; cleaning of the sediment basin and forebay; fish capture and transport by the trap and haul and angling in the forebay; and fish ladder maintenance. The project was completed prior to the passage of the Federal Power Act and does not require a license from the Federal Regulatory Energy Commission, unless updates or improvements are made to power capacity (Spens, in litt. 2018). Thus, project operations have never been subject to a section 7 consultation.

Electron Hydro LLC has indicated in a letter that they will prepare an HCP to address take associated with proposed hydropower facility upgrades and operations and maintenance activities that is necessary to be in compliance with section 9 of the ESA (Electron Hydro LLC, in litt. 2016). The Service's approval of any HCP application requires consultation under section 7.

While most of the activities associated with the Electron Hydroelectric Facility are outside the action area, the diversion dam is an integral component for the operation of the facility and its operation results in continuing negative impacts to bull trout and take of the species and adverse effects to designated bull trout critical habitat. The Electron Hydro Project headworks is a run-of-the-river hydropower generation facility. The diversion structure and intake diverts 400 cfs of flows from the Puyallup River. The diverted water enters into a 10-mile long elevated flume that conveys water to a forebay where it is then transferred to several penstocks. The water then enters the powerhouse where approximately 26 megawatts of electricity is produced as a result.

Bull trout and other fish are entrained at the intake structure. Some fish may re-enter the Puyallup River at the rock chutes, while others travel down the flume to the forebay. A settling basin is located approximately four miles down the flume from the diversion dam and 1,650 feet from the Puyallup River. Electron Hydro pushes the sediment from the settling basin over the bank and onto the slope down towards the river. Sediment does not enter the Puyallup River.

About 1,400 feet of forest filters any sediment pushed over the bank of the settling basin. Water from the forebay then flows through the powerhouse to generate electricity and re-enters the Puyallup River at approximately RM 31.2.

Within the forebay, Electron Hydro operates a trap and haul facility to capture and relocate bull trout and other fish from the forebay into the Puyallup River. A net crosses the forebay and leads fish into a trap. Fish are loaded into a truck and transported downstream to the Puyallup River at approximately RM 31.2 where water from the powerhouse re-enters the river. Fish are also caught with hook and line within the forebay and are transferred downstream. Smaller fish are also salvaged with nets during forebay drawdown. These activities to capture bull trout within the forebay are currently covered by Bureau of Indian Affairs and Puyallup Tribe's section 10(a)(1)(A) recovery permit (TE-049004-10), but are expected to be a covered activity or conservation measure in the future HCP. Bull trout caught in the forebay are shown in Table 3. These bull trout were captured since Electron Hydro LLC purchased the facility in 2014.

Table 3. Number, size, and mortalities of bull trout caught within the forebay of the Electron hydroelectric facility

Year	Number caught	Mortalities	Sizes, if measured (mm)
2014	0	0	
2015	21	2	155, 146, 145, 154
2016	0	0	
2017	16	1	435, 445, 525, 475, 460, 400, 510, 48, 60, 40, 58, 278, 465, 470, 115, 555

The Service expects that some small bull trout are not captured in the trap and haul and are injured or killed either by predation within the forebay or when they pass through the generators in the powerhouse.

In 1997, Puget Sound Energy, who owned the Electron Powerplant prior to Electron Hydro LLC, and the Puyallup Tribe finalized a Resource Enhancement Agreement that provided for a series of resource enhancement measures to benefit fisheries resources. The Resource Enhancement Agreement provided for minimum flows downstream of the diversion dam and construction of a fish ladder around the diversion structure. The fish ladder has been in operation since 2000. Maintenance on the ladder is completed as needed, which most often includes removal of sediments. However, the ladder is located on the opposite side of the diversion dam from the intake structure. The thalweg, at times, flows within the Puyallup River along the left bank of the river, and the diversion of water re-entering the Puyallup River through the rock chutes can be more of an attraction flow for bull trout migrating up the Puyallup River than the attraction flows out of the fish ladder. This may result in bull trout entering the rock chutes and getting entrained into the forebay instead of migrating above the diversion dam by the fish ladder.

Minimum flows between the diversion dam and the powerhouse, a distance of approximately 10 miles, are 80 cfs from July 15 to November 15, and 60 cfs the rest of the year. The minimum flows downstream of the diversion dam results in a decline in bull trout prey abundance both for

spawning habitat for salmon and steelhead, and in macroinvertebrate abundance. Diverting 400 cfs out of the Puyallup River during salmon and steelhead spawning period reduces flows up to 70 percent. This diversion of water greatly reduces available spawning habitat within the river. In addition, the available habitat for spawning can be easily scoured or become too deep for eggs and alevins to survive during high flow events. Redds may also become dry and exposed to desiccation if spawning occurs when flows are high and then water is diverted. At other times of the year, minimum flows may reduce available rearing habitat for juvenile and sub-adult bull trout, increasing the risk of predation.

Replacement of the Diversion Dam includes the excavation of sediments upstream of the dam both to construct the bypass structures as well as to remove sediments that will enter the intake structure. The removal of sediment may result in a headcut during the first high flows after construction is complete. However, the Service expects that the excavated area will fill in with sediment prior to any headcutting occurring due to high flows after construction. In addition, the long-term operation of the diversion dam which includes deflating the bladder to flush sediments from above the dam to below the diversion, will also result in headcuts that will migrate upstream when the diversion dam is lowered.

The headcut results from the difference in river elevation above and below the diversion dam. The 12-foot difference in elevation will migrate upstream until either the headcut hits a hard surface, like a bedrock outcrop, or a gradient change in the river results in the headcutting stopping its upstream migration. Hydro Electron estimates the headcut will migrate upstream approximately 800 feet. The Service conducted a rough analysis based on topography maps and calculated the headcut may migrate as far as 0.5 mile upstream to the confluence with the Mowich River (Bakke, in litt. 2018). The headcut from the operation of the diversion structure may occur each time the diversion dam is lowered for the life of the operation of the Electron Hydro facility.

The headcut will occur, most often, in the fall and winter when high flows occur. Headcuts that occur after Chinook salmon, steelhead, and coho salmon have spawned will result in the loss of redds (mortality of eggs and/or alevins). The loss of Chinook salmon, steelhead, and coho salmon redds will result in an adverse effect to bull trout through a decline in the abundance of prey. In addition, the headcut will result in macroinvertebrates being flushed downstream of the action area and unavailable as forage for juvenile bull trout.

Until the development of the HCP for the operation and maintenance activities of the Electron hydroelectric facility, the adverse effects associated with activities and any resulting take under section 9 of the ESA will continue with no mitigation, conservation measures, or measures implemented to avoid, reduce, or minimize the adverse effects. These adverse effects and any resulting take of bull trout are not covered by this consultation and Opinion.

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

The Integration and Synthesis section is the final step in assessing the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action and the cumulative effects to the status of the species and critical habitat, and the environmental baseline, to formulate our biological opinion as to whether the proposed action is likely to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated critical habitat for the conservation of the species.

In the Environmental Baseline, Status of the Species, Effects of the Action, and Cumulative Effects sections of the Opinion, we established that the effects of past and ongoing activities within Puyallup River perpetuate the existing degraded habitat conditions in the action area.

12.1 Summary of the Action

Electron Hydro, LLC proposes to replace 70 feet of the existing diversion structure with an air inflated rubber bladder and dam to reduce sediment input into their intake structure. In addition, a trash rack will be added to the intake structure and bank protection along the left bank will be reinforced. This project involves isolating the river once in 2018 and twice in 2019. In 2018, 6,700 square feet of the river will be isolated in front of the intake structure. In 2019, isolating the right side of the river will occur to install a lining over the diversion dam to reduce water leaking into the work area when the left side of the river is diverted to replace the diversion dam.

12.2 Summary of the Status of Bull Trout and Designated 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 factors affecting bull trout throughout its range. The magnitude 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).

The condition of bull trout critical habitat reflects on the abundance of bull trout within each core area. The decline of bull trout is primarily due to habitat degradation, fragmentation, and blockage of migratory corridors. Human activities have and continue to impact bull trout habitat. In the Puget Sound geographic region where anadromous bull trout occur, degradation of mainstem river FMO habitat and the degradation and loss of marine nearshore habitat, results in or contributes to degraded PCEs.

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12.3 Summary of the Environmental Baseline and Status of Bull Trout and Designated Critical Habitat in the Action Area

The Electron Hydro facility diverts 400 cfs of water from the Puyallup River for hydropower generation. The removal of water entrains bull trout into the powerhouse forebay where juveniles are killed going through the generators or where bull trout are caught by hook and line or the trap and haul facility and released back into the Puyallup River near the powerhouse. Water withdrawal also limits bull trout prey availability by limiting salmon and steelhead spawning habitat and by reducing macroinvertebrate densities.

Bull trout in the Puyallup River core area are considered at intermediate risk of extirpation and adverse effects from random, naturally occurring events. The action area provides foraging, migration, and over-wintering habitat for bull trout. The action area is used by individuals from local bull trout populations upstream of the project site within the Mowich and Upper Puyallup Rivers. While bull trout are known to use the action area, data on density of occurrence are lacking.

A fish ladder was constructed at the diversion structure in 2000 to allow migration of bull trout into the upper watershed. The degree to which the ladder is effective is unknown. Further, flows out of the rock chutes (attraction flows) impede bull trout migration (PCE #2). Diversion of flows out of the Puyallup River limits bull trout prey abundance (PCE #3), simplifies habitat available for bull trout (PCE #4), and alters the natural hydrograph within the action area (PCE #7).

12.4 Effects to Bull Trout Numbers, Reproduction, and Distribution

The proposed action will adversely affect individual bull trout via several pathways. Construction will result in a significant, temporary disruption to normal bull trout foraging and migration behavior due to elevated turbidity and suspended sediments in 2019. Work area isolation will cause mortality to a small number (three total) of juvenile bull trout from crushing during placement of supersacks and sediment berms in 2018 and 2019. In addition, up to 12 bull trout, two in 2018 and ten in 2019, will be captured and handled while the project site is dewatered and we expect that three juvenile, sub-adult, or adult bull trout will be injured or killed due to fish capture and handling. One juvenile, sub-adult, or adult bull trout in 2018 and two in 2019.

The action is expected to result in the loss of a small number of bull trout individuals from the local populations within the Puyallup River core area. The loss of a small number of bull trout will have little or no measurable effect on the reproduction and distribution of bull trout within the Puyallup River core area. The impacts from the action are not expected to appreciably reduce the survival and recovery of the Puyallup River core area populations, the Coastal Recovery Unit, and the conterminous range of the species for the following reasons:

1. Behavioral effects associated with project construction are not expected to measurably reduce productivity at the scale of the Puyallup River core area because behavioral effects are temporary and will only affect a small number of bull trout.

2. Because adverse effects of the project will not be discernable at a core area scale, we do not expect effects of the project to reduce the likelihood of survival and recovery of bull trout at the Coastal Recovery Unit scale or the coterminous U.S. population.

12.5 Effects to Bull Trout Designated Critical Habitat

Eight of the nine PCEs (all but PCE #6) are found in the action area. Project construction will result in increased turbidity and suspended sediments, flow diversion, and decreases in bull trout prey abundance. This will adversely effect PCEs #2 (migratory habitat), #3 (food base), and #8 (water quality).

The anticipated direct and indirect effects of the action will not prevent the PCEs of designated bull trout critical habitat from being maintained, and will not measurably degrade the current ability to establish functioning PCEs at the scale of the action area. Within the action area, critical habitat will continue to serve the intended conservation role for the species, at the scale of the Puyallup River core area, Coastal Recovery Unit, and coterminous range.

13 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 Service's biological 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.

14 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 Service as an act which 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 Service as an intentional or negligent act or omission which 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 measures described below are non-discretionary, and must be undertaken by the Corps 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 Corps has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the Corps 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 Corps or applicant must report the progress of the action and its impact on the species to the Service as specified in this Incidental Take Statement [50 CFR 402.14(i)(3)].

15 AMOUNT OR EXTENT OF TAKE

The Service anticipates that bull trout will be taken as a result of the proposed action. The incidental take is expected to be in the form of harassment, harm, kill, and capture. Salvage operations will minimize the incidental take of individual bull trout from construction activities. The capture and handling of bull trout for salvage purposes will result in direct take (kill, capture, injury). Work area isolation, and fish capture and handling, will result in the following forms and amounts of take:

1. Incidental take in the form of capture and harm during project site isolation and dewatering. We anticipate that 12 juvenile, sub-adult, and adult bull trout, two in 2018 and ten in 2019, will be captured during work area isolation. Of the 12 captured, we anticipate that one will be harmed by being injured or killed in 2018, and two in 2019. Take is anticipated to occur between July 15 and September 15, 2018 and 2019.

The Service expects that incidental take of individuals, as described below, 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, based on the physical extent of effects, as a surrogate indicator of take. Pursuant to 50 CFR 402.14(i)(1)(i), a surrogate can be used to express the anticipated level of take in an Incidental Take Statement, provided three criteria are met: (1) measuring take impacts to a listed species is not practical; (2) a link is established between the effects of the action on the surrogate and take of the listed species; and (3) a clear standard is set for determining when the level of anticipated take based on the surrogate has been exceeded.

The Service acknowledges that in many cases the science related to the habitat requirements and behavior of the listed species informs the analytical basis for establishing a causal link between the effects of the proposed federal action to habitat and take of the listed species. A habitat-based approach to evaluating the effects of proposed federal actions on listed species is a customary practice of the Service in Opinions. For these reasons, quantifying and monitoring take impacts via project effects to the habitat of the listed species, not a surrogate species, is a scientifically credible and practical approach for expressing and monitoring the anticipated level of take for situations where use of a surrogate is warranted.

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Take of bull trout is anticipated through exposure to elevated turbidity and suspended sediments and as associated with the placement of supersacks and sediment berms to isolate the work area. Both of these exposure mechanisms will result in an unknown number of bull trout individuals taken and the surrogate can be monitored to determine the level of take. The following level of take of bull trout is anticipated:

1. Incidental take of juvenile, sub-adult, and adult bull trout in the form of harassment from exposure to elevated turbidity and suspended sediments. Take will occur within 1,500 feet downstream of in-water construction activities during the installation and removal of the supersacks and sediment berms between July 15 and September 15, 2019. Take will result when levels of turbidity reach or exceed the following:

    a. 56 NTUs above background at any time; or

    b. 37 NTUs above background for more than 1 hour, continuously, over a 10-hour workday; or

    c. 13 NTUs above background for more than 3 hours, cumulatively, over a 10-hour workday; or

    d. 8 NTUs above background for more than 3 hours, cumulatively, over a 10-hour workday.

2. Incidental take of juvenile and small sub-adult bull trout will be killed as a result of the placement of supersacks and sediment berms. Take will occur within the 1,000 square feet of substrate that will be covered by supersacks in 2018 and the 30,000 square feet of substrate that will be covered by supersacks and sediment berms in 2019. Take is anticipated to occur between July 15 and September 15, 2018 and 2019.

16 EFFECT OF THE TAKE

In the accompanying Opinion, the Service 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.

17 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 Corps will fully implement these measures, and therefore they have not been specifically identified as reasonable and prudent measures (RPMs) or terms and conditions.

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

1. Monitor incidental take of bull trout caused by elevated turbidity and suspended sediments during construction in 2019.

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2. Ensure completion of a monitoring and reporting program to confirm that the take exempted for the proposed action is not exceeded.

18 TERMS AND CONDITIONS

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

1. To implement Reasonable and Prudent Measure 1, the Corps shall ensure that:

    a. Monitor to establish background turbidity levels upstream of construction 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 1,500 feet downstream of in-water construction activities.

    c. Monitoring shall be conducted at 30-minute intervals for the first 3 hours from the start of sediment-generating activities. If the background NTU levels are exceeded by the following levels, then the amount of take authorized by the Incidental Take Statement will be exceeded and sediment-generating activities shall cease.

        i. If background NTU levels are exceeded by 56 NTU at any time.

        ii. If background NTU levels are exceeded by 37 NTU for more than 1 hour cumulatively over a 10-hour workday.

        iii. If background NTU levels are exceeded by 13 NTU for more than 3 hours cumulatively over a 10-hour workday.

        iv. If background NTU levels are exceeded by 8 NTU for more than 7 hours cumulatively over a 10-hour workday.

    d. 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 Corps will contact the Service's consulting biologist to discuss means of assuring that the authorized amount of incidental take is not exceeded.

    e. 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.

    f. If, in cooperation with other permit authorities, the Corps develops 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 Service for review and approval in lieu of the above monitoring requirements. This

strategy must be submitted to the Service 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.

2. To implement Reasonable and Prudent Measure 2, the Corps shall:

   a. Prepare a report identifying any incidental take associated with project activities and describing conservation measures implemented to minimize take. The report shall include a description of construction activities conducted, the duration of all construction activities, conservation measures implemented, and the following:

      i. Results of project site isolation and dewatering. Data shall include the following: 1) dates and description of construction related activities such as installation and removal of the in-water cofferdams; 2) area of substrate covered by supersacks and sediment berms; 3) means and methods of fish capture; 4) species and number of fish captured; 5) if electrofishing is used, provide settings and estimated duration of use; and 6) whether any sign of bull trout injury was visible.

      ii. Results of surface water quality monitoring (focused on turbidity and suspended sediments) required during construction. Data 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.

The report shall be submitted to the Service's office in Lacey, Washington, by December 31, 2019. The report shall summarize the Corps' compliance with the project description and conservation measures and the level of exempted incidental take during the implementation of the project.

The Service is to be notified within three working days upon locating a dead, injured, or sick endangered or threatened species. Initial notification must be made to the nearest U.S. Fish and Wildlife Service 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 U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the Service's Washington Fish and Wildlife Office at (360) 753-9440.

19 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA 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 Service provides the following conservation recommendations.

1. Develop an HCP to address adverse effects associated with the operation and maintenance of the hydroelectric generating facility. To facilitate development of the HCP, conduct the following studies:

    a. Develop river cross-sectional profiles to obtain river depths at various point along multiple transects upstream of the diversion dam to monitoring distance headcutting occurs from operation of the diversion dam. Monitoring and cross-section profiles include establishing permanent transects across the river upstream of the diversion dam every 100 feet. Water depths will be taken at 10 feet increments across the river. The distance upstream cross-sectional profiles will occur is based on headcutting. The objective of the monitoring is to determine the distance upstream headcutting will occur.

    b. Conduct radio telemetry studies of bull trout to determine migration patterns above and below the diversion structure, and the use of the fish ladder, rock chutes, and inflatable diversion dam.

    c. Conduct Instream Flow Incremental Methodology to calculate available fish habitat gained or lost as a result of minimum instream flows developed in the Resource Enhancement Agreement by the Puyallup Tribe and Puget Sound Energy in 1997.

    d. Conduct habitat surveys downstream of the diversion dam to the Electron powerhouse to determine habitat availability and needs for bull trout. With the minimum flows required downstream of the diversion dam, bull trout habitat may be lacking in meeting several life history parameters needed for their continued survival. Habitat surveys will provide vital information necessary to determine habitat needs in the 10 mile reach below the diversion dam.

    e. Monitor flows coming out of both the fish ladder and the rock chutes to determine whether attraction flows coming out of the fish ladder is sufficient for salmonids to use over the rock chutes.

    f. Install temperature loggers within the Puyallup River from upstream of the diversion dam to below the powerhouse to determine whether temperatures are significantly increasing due to removal of water to generate power.

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g. Install a Passive Integrated Transponder (PIT) tag reader on the fish ladder to monitor bull trout use of the ladder.

20 REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the (request/reinitiation request). 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

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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.

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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,

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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).

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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

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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 anadromous[1] 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).

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

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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

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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).

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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 resident[2] 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

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

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counterparts, resulting in greater fecundity and higher reproductive potential (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;

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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).

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Lower Mid-Columbia Region

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

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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

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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).

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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).

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Three major bull trout life history expressions are present in the Upper Snake Recovery Unit, adfluvial[3], fluvial[4], 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).

[3] Adfluvial: Life history pattern of spawning and rearing in tributary streams and migrating to lakes or reservoirs to mature.

[4] 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

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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).

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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

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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

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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

Conservation Needs

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.

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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,

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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 BULL TROUT CRITICAL HABITAT

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Appendix: B
Status of Bull Trout Critical Habitat

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).

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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

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(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.

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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.

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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).

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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
DETERMINING EFFECTS FOR SECTION 7 CONSULTATIONS

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Appendix C
Determining Effects for Section 7 Consultations

There are numerous factors that can influence project-specific sediment effects on bull trout and other salmonids. These factors include the concentration and duration of sediment input, existing sediment conditions, stream conditions (velocity, depth, etc.) during construction, weather or climate conditions (precipitation, wind, etc.), fish presence or absence (bull trout plus prey species), and best management practice effectiveness. Many of these factors are unknown.

Newcombe and Jensen (1996) and Anderson et al. (1996) provide the basis for analyzing sediment effects to bull trout and other salmonids and their habitat. Newcombe and Jensen (1996) conducted a literature review of pertinent documents on sediment effects to salmonids and nonsalmonids. They developed a model that calculated the severity of ill effect (SEV) to fish based on the suspended sediment dose (exposure) and concentration. No data on bull trout were used in this analysis. Anderson et al. (1996), using the methods used by Newcombe and Jensen (1996), developed a model to estimate sediment impacts to salmonid habitat.

A 15-point scale was developed by Newcombe and Jensen (1996, p. 694) to qualitatively rank the effects of sediment on fish (Table 1). Using a similar 15-point scale, Anderson et al. (1996) ranked the effects of sediment on fish habitat (Table 2).

We analyzed the effects on different bull trout life history stages to determine when adverse effects of project-related sediment would occur. Table 3 shows the different ESA effect calls for bull trout based on severity of ill effect.

Table 1 – Scale of the severity (SEV) of ill effects associated with excess suspended sediment on salmonids.

SEV	Description of Effect
	Nil effect
0	No behavioral effects
	Behavioral effects
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
	Sublethal effects
4	Short-term reduction in feeding rates; short-term reduction in feeding success
5	Minor physiological stress; increase in rate of coughing; increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation; impaired homing
8	Indications of major physiological stress; long-term reduction in feeding rate; long-term reduction in feeding success; poor condition
	Lethal and paralethal effects
9	Reduced growth rate; delayed hatching; reduced fish density
10	0-20% mortality; increased predation; moderate to severe habitat degradation
11	> 20 – 40% mortality
12	> 40 – 60% mortality
13	> 60 – 80% mortality
14	> 80 – 100% mortality

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The effect determination for a proposed action should consider all SEV values resulting from the action because sediment affects individual fish differently depending on life history stage and site-specific factors. For juvenile bull trout, an SEV of 5 is likely to warrant a "likely to adversely affect" (LAA) determination. However, abandonment of cover (SEV 2), or an avoidance response (SEV 3), may result in increased predation risk and mortality if habitat features are limiting in the project's stream reach. Therefore, a LAA determination may be warranted at an SEV 2 or 3 level in certain situations. For subadult and adult bull trout, however, abandonment of cover and avoidance may not be as important. A higher SEV score is more appropriate for adverse effects to subadult and adult bull trout. In all situations, we assume that SEV scores associated with adverse effects are also sufficient to represent a likelihood of harm or harass[1].

Table 2 – Scale of the severity (SEV) of ill effects associated with excess suspended sediment on salmonid habitat.

SEV	Description of Effect
3	Measured change in habitat preference
7	Moderate habitat degradation – measured by a change in invertebrate community
10	Moderately severe habitat degradation – defined by measurable reduction in the productivity of habitat for extended period (months) or over a large area (square kilometers).
12	Severe habitat degradation – measured by long-term (years) alterations in the ability of existing habitats to support fish or invertebrates.
14	Catastrophic or total destruction of habitat in the receiving environment.

When evaluating impacts to habitat as a surrogate for species effects, adverse effects may be anticipated when there is a notable reduction in abundance of aquatic invertebrates, and an alteration in their community structure. These effects represent a reduction in food for bull trout and other salmonids, and correspond to an SEV of 7 – moderate habitat degradation.

Newcombe and Jensen (1996) used six data groups to conduct their analysis. These groups were 1) juvenile and adult salmonids (Figure 1), 2) adult salmonids (Figure 2), 3) juvenile salmonids (Figure 3), 4) eggs and larvae of salmonids and non-salmonids (Figure 4), 5) adult estuarine nonsalmonids (no figure provided), and 6) adult freshwater nonsalmonids (no figure provided). No explanation was provided for why juvenile and adult salmonids were combined for group 1. As juveniles are more adapted to turbid water (Newcombe 1994, p. 5), their SEV levels are generally lower than for adult salmonids given the same concentration and duration of sediment (Figures 1-3).

[1] Harm and harass in this context refers to the FWS's regulatory definition at 50 CFR 17.3. E.g., Harm means "an act which 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."

Table 3 – ESA Effect calls for different bull trout life stages in relation to the duration of effect and severity of ill effect. Effect calls for habitat, specifically, are provided to assist with analysis of effects to individual bull trout.		
	SEV	**ESA Effect Call**
Egg/alevin	1 to 4 5 to 14	Not applicable - alevins are still in gravel and are not feeding. LAA - any stress to egg/alevin reduces survival
Juvenile	1 to 4 5 to 14	NLAA LAA
Subadult and Adult	1 to 5 6 to 14	NLAA LAA
Habitat	1 to 6 7 to 14	NLAA LAA due to indirect effects to bull trout

The figures of Newcombe and Jensen (1996) have been modified in this document. In each figure, values (in mg/L) are provided for each duration to determine when adverse effects would occur. Specific values are also given for when harm would be likely to occur. For example:

> Figure 1 – This figure is for both juveniles and adults. From Table 2, bull trout are "likely to be adversely affected" given an SEV of 5. On Figure 1, a sediment concentration of 99 mg/L for one hour is anticipated to be the maximum concentration for an SEV of 4. At 100 mg/L, an SEV of 5 occurs. In addition, one hour of exposure to 5,760 mg/L is the maximum for an SEV of 7. Exposure to 5,761 mg/L for one hour would warrant an SEV of 8. This would be the threshold between harassment and harm. An SEV of 7 would be harassment, and an SEV of 8 would be considered harm.

The following provides some guidance on use of the figures.

Definitions from Newcombe and Jensen (1996, p. 696). These definitions are provided for consultations that may have impacts to bull trout prey such as Chinook and coho salmon.

> Eggs and larvae – eggs, and recently hatched fish, including yolk-sac fry, that have not passed through final metamorphosis.
>
> Juveniles – fry, parr, and smolts that have passed through larval metamorphosis but are sexually immature.
>
> Adults – mature fish.

Bull trout use:

Newcombe and Jensen (1996) conducted their analysis for freshwater, therefore the use of the figures within this document in marine waters should be used with caution.

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Figure 1 – Juvenile and Adult Salmonids. This figure should be used in foraging, migration and overwintering (FMO) areas. In FMO areas, downstream of local populations, both subadult and adult bull trout may be found.

Figure 2 – Adult Salmonids. This figure will not be used very often for bull trout. There may be circumstances, downstream of local population spawning areas that may have just adults, but usually this would not be the case. Justification for use of this figure should be stated in your consultation.

Figure 3 – Juvenile Salmonids. This figure should be used in local population spawning and rearing areas outside of the spawning period. During this time, only juveniles and sub-adults should be found in the area. Adults would migrate to larger stream systems or to marine water. If the construction of the project would occur during spawning, then Figure 1 should be used.

Figure 4 – Eggs and Alevins. This figure should be used if eggs or alevins are expected to be in the project area during construction.

Figure 5 – Habitat. This figure should be used for all projects to determine whether alterations to the habitat may occur from the project.

Background and Environmental Baseline

In determining the overall impact of a project on bull trout, and to specifically understand whether increased sediment may adversely affect bull trout, a thorough review of the environmental baseline and limiting factors in the stream and watershed is needed. The following websites and documents will help provide this information.

1. Washington State Conservation Commission's Limiting Factors Analysis. A limiting factors analysis has been conducted on watersheds within the State of Washington. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." These documents will provide information on the current condition of the individual watersheds within the State of Washington. The limiting factors website is http://salmon.scc.wa.gov. Copies of the limiting factors analysis can be found at the Western Washington Fish and Wildlife Library.

2. Washington Department of Fish and Wildlife's (1998) Salmonid Stock Inventory (SaSI). The Washington Department of Fish and Wildlife (WDFW) inventoried bull trout and Dolly Varden (*S. malma*) stock status throughout the State. The intent of the inventory is to help identify available information and to guide future restoration planning and implementation. SaSI defines the stock within the watershed, life history forms, status and factors affecting production. Spawning distribution and timing for different life stages are provided (migration, spawning, etc.), if known. SaSi documents can be found at http://wdfw.wa.gov/fish/sasi/index.htm.

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3. U.S. Fish and Wildlife Service's (USFWS 1998a) Matrix of Diagnostics/Pathways and Indicators (MPI). The MPI was designed to facilitate and standardize determination of project effects on bull trout. The MPI provides a consistent, logical line of reasoning to aid in determining when and where adverse affects occur and why they occur. The MPI provides levels or values for different habitat indicators to assist the biologist in determining the level of effects or impacts to bull trout from a project and how these impacts may cumulatively change habitat within the watershed.

4. Individual Watershed Resources. Other resources may be available within a watershed that will provide information on habitat, fish species, and recovery and restoration activities being conducted. The action agency may cite a publication or identify a local watershed group within the Biological Assessment or Biological Evaluation. These local groups provide valuable information specific to the watershed.

5. Washington State Department of Ecology (WDOE) - The WDOE has long- and short-term water quality data for different streams within the State. Data can be found at http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html. Clicking on a stream or entering a stream name will provide information on current and past water quality data (when you get to this website, scroll down to the Washington map). This information will be useful for determining the specific turbidity/suspended sediment relationship for that stream (more information below).

6. Washington State Department of Ecology (WDOE) - The WDOE has also been collecting benthic macroinvertebrates and physical habitat data to describe conditions under natural and anthropogenic disturbed areas. Data can be found at http://www.ecy.wa.gov/programs/eap/fw_benth/index.htm. You can access monitoring sites at the bottom of the website.

7. U.S. Forest Service, Watershed Analysis Documents - The U.S. Forest Service (USFS) is required by the Record of Decision for Amendments to the USFS and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl to conduct a watershed analysis for watersheds located on FS lands. The watershed analysis determines the existing condition of the watershed and makes recommendations for future projects that move the landscape towards desired conditions. Watershed analysis documents are available from individual National Forests or from the Forest Plan Division.

8. U.S. Fish and Wildlife Service - Bull Trout Recovery Plans and Critical Habitat Designations. The draft Bull Trout Recovery Plan for the Columbia River Distinct Population Segment (DPS) (also the Jarbidge River and the St. Mary-Belly River DPS) and the proposed and final critical habitat designations provide current species status, habitat requirements, and limiting factors for bull trout within specific individual recovery units. These documents are available from the Endangered Species Division as well as the Service's web page (www.fws.gov).

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These documents and websites provide baseline and background information on stream and watershed conditions. This information is critical to determining project-specific sediment impacts to the aquatic system. The baseline or background levels need to be analyzed with respect to the limiting factors within the watershed.

Consultation Sediment Analysis

The analysis in this section only applies to construction-related physiological and behavioral impacts, and the direct effects of fine sediment on current habitat conditions. Longer-term effects to habitat from project-induced channel adjustments, post-construction inputs of coarse sediment, and secondary fine sediment effects due to re-mobilization of sediment during the following runoff season, are not included in the quantitative part of this effects determination. Those aspects are only considered qualitatively.

The background or baseline sediment conditions within the project area or watershed will help to determine whether the project will have an adverse effect on bull trout. The following method should be followed to assist in reviewing effects determinations and quantifying take in biological opinions.

1) Determine what life stage(s) of bull trout will be affected by sedimentation from the project. Life history stages include eggs and alevins, juveniles, and sub-adults and adults. If projects adhere to approved work timing windows, very few should be constructed during periods when eggs and alevins are in the gravels. However, streambed or bank adjustments may occur later in time and result in increased sedimentation during the time of the year when eggs and alevins may be in the gravels and thus affected by the project.

2) Table 4 provides concentrations, durations, and SEV levels for different projects. This table will help in analyzing similar projects and to determine sediment level impacts associated with that type of project. Based on what life history stage is in the project area and what SEV levels may result from the project, a determination may be made on effects to bull trout. (Table 4 located on the Q drive: Q:\linked Literature Materials\Species & Issues & BO Templates with RefMan\Sediment Issue Paper)

3) Once a "likely to adversely affect" determination has been made for a project, the figures in Newcombe and Jensen (1996) or Anderson et al. (1996) are used to determine the concentration (mg/L) at which adverse effects[2] and "take" will occur (see Figures 1-5). For example, if a project is located in FMO habitat, Figure 1 would be used to determine the concentrations at which adverse effects will occur. Since Figure 1 is used for both adults and juveniles, an SEV of 5 (for juveniles) is used (see Table 2). For (a.) the level when instantaneous adverse effects occur, find the SEV level of 5 in the one hour column. The corresponding concentration is the instantaneous value where adverse affects occur. In this example, it is 148 mg/L. For (b), (c), and (d), adverse effects will occur when sediment concentrations exceed SEV 4 levels. The exact concentrations for

[2] For the remainder of the document, references to "adverse effects" also refer to harm and harass under 50 CFR 17.3.

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this have been provided. For each category, find the SEV 4 levels and the corresponding concentration levels are the values used.

For impacts to individual bull trout, adverse effects would be anticipated in the following situations:

a. Any time sediment concentrations exceed 148 mg/L over background.
b. When sediment concentrations exceed 99 mg/L over background for more than one hour continuously.
c. When sediment concentrations exceed 40 mg/L over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 20 mg/L over background for over seven hours cumulatively.

For habitat effects, use Figure 5 and the same procedure as above for individual bull trout. For example, adverse effects would be expected to occur in the following situations:

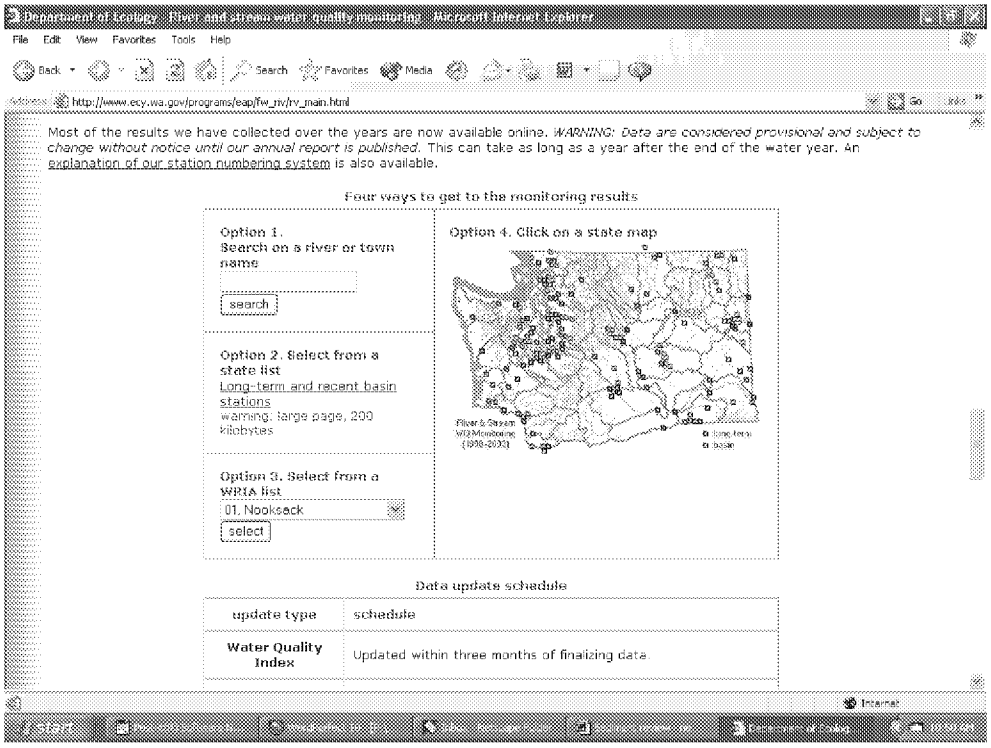
a. Any time sediment concentrations exceed 1,097 mg/L over background.
b. When sediment concentrations exceed 885 mg/L over background for more than one hour continuously.
c. When sediment concentrations exceed 345 mg/L over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 167 mg/L over background for over seven hours cumulatively.

4) Because sediment sampling for concentration (mg/L) is labor intensive, many applicants prefer to monitor turbidity as a surrogate. To do this, the sediment concentration at which adverse effects to the species and/or habitat occurs is converted to NTUs. Two methods, regression analysis and turbidity to suspended solid ratio, are available for this conversion. The regression analysis method should be used first. If not enough data are available then the turbidity to suspended solid ratio method should be used.

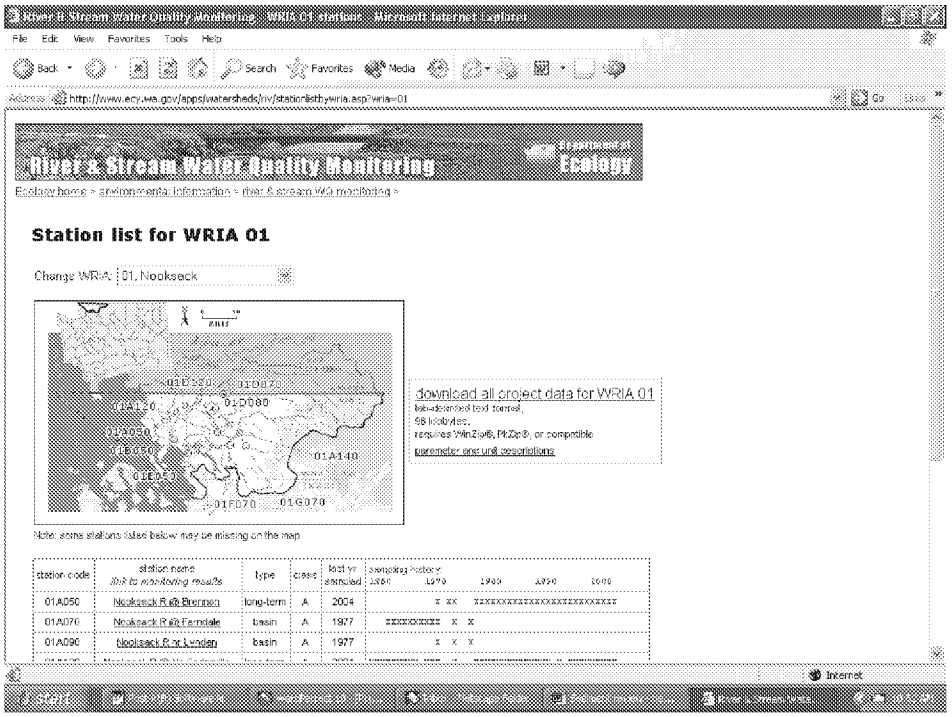
   a. Data – as described above in Background and Environmental Baseline, an attempt should be made to find turbidity and suspended solid information from the project area, action area, or the stream in which the project is being constructed. This information may be available from the Tribes, watershed monitoring groups, etc. Try to obtain information for the months in-water construction will occur, which is usually during the fish timing window (in most cases, July through September). If you are unable to find any data for the action area, use the WDOE water quality monitoring data. The following are the steps you need to go through to locate the information on the web and how to download the data:

      i. Go to the WDOE webpage (http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html).

ii. When you get to the website, the page will state "River and Stream Water Quality Monitoring." If you scroll down the page, you will see the following text and map.



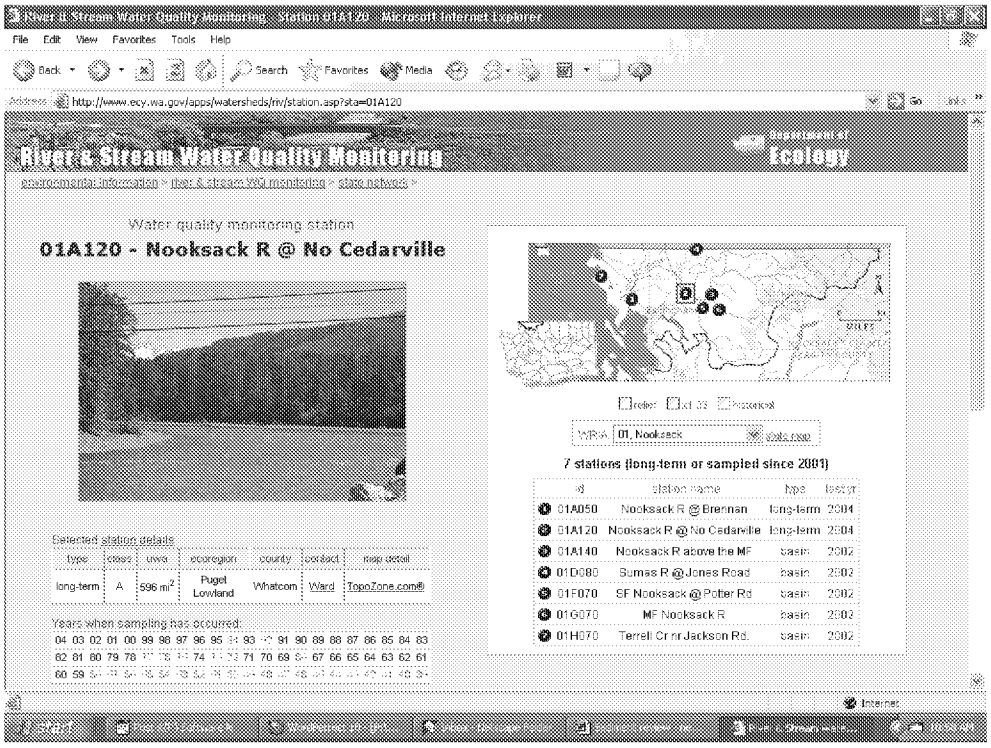
iii. The map shows all the water quality monitoring stations in Washington. You can click on a watershed, or go to Option 3, click on the down arrow and find your watershed. You will then get the following webpage. This is an example for the Nooksack River.



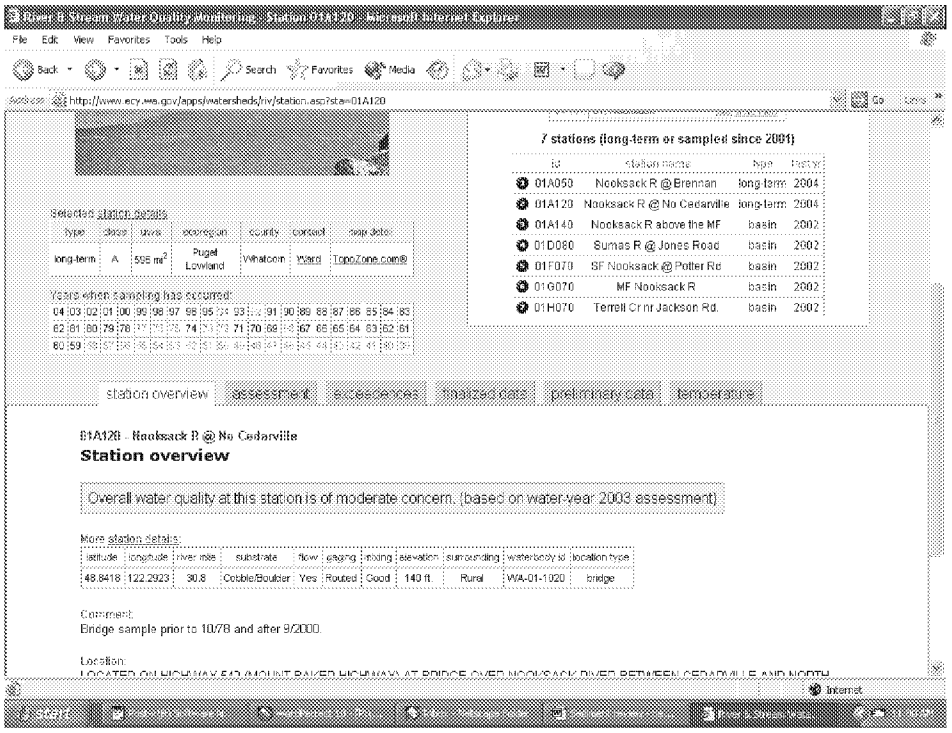
iv. This webpage shows you all the monitoring stations in this watershed. Scrolling down a little on the webpage, you get a list of the monitoring stations and the years that data were collected. The more years in which data were collected the better; however, you want to pick the monitoring station closest to the project site. If a project is located on a tributary, do not use data from the main river in the watershed. Find a monitoring station on a tributary and use that data. **Justification for the use of the data needs to be made in the BO.** The following language was used in the Anthracite Creek Bridge Scour BO. Changes to this paragraph to represent regression analysis are not italicized.

"*The guidance of Newcombe and Jensen* (1996) *requires a measurement of the existing suspended sediment concentration levels (mg/L) and duration of time that sediment impacts would occur. The Service used data available on the Washington Department of Ecology (WDOE) website to determine a ratio of turbidity (NTU) to suspended solids (mg/L)*(website to find the correlation between turbidity and suspended solids) *in Anthracite Creek. No water quality data was available for Anthracite Creek, so the Service used water quality monitoring data from a different tributary within the Snohomish River watershed. Patterson Creek, which is a tributary to the Snoqualmie River, was used to determine the ratio of turbidity to suspended solids* (correlation between turbidity and suspended solids). *The Service believes that Patterson Creek would have very comparable water quality data as Anthracite Creek. The turbidity to suspended solid ratio for Patterson Creek is 1:2.4 during the proposed months of construction (July through September).*" Delete the last sentence for regression analysis or put in the equation used for analysis and the R^2.

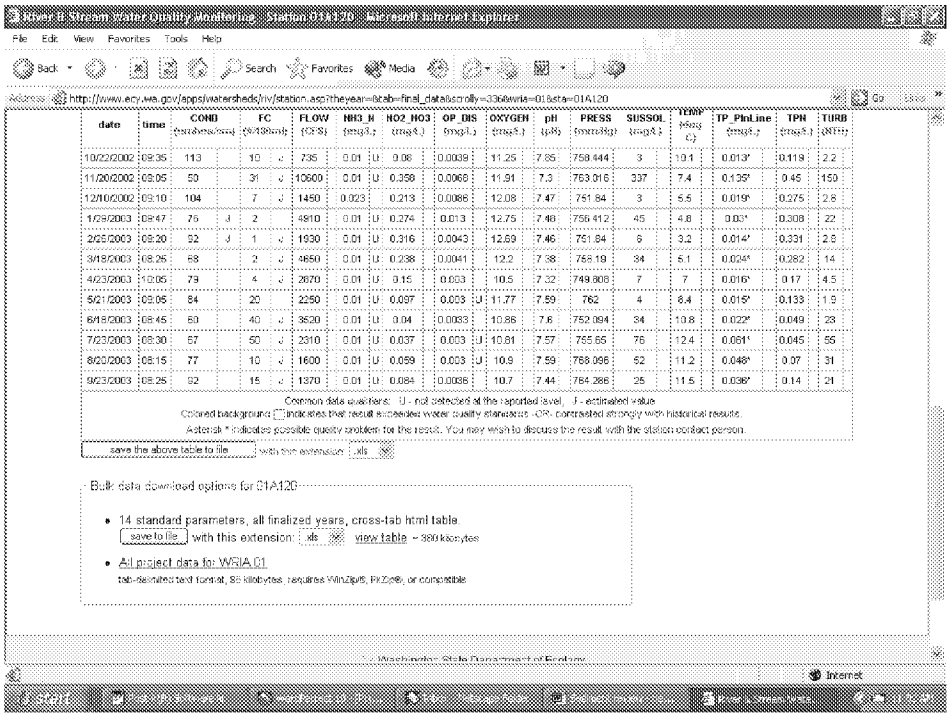
v. When you select the monitoring station, the following webpage appears. This monitoring station is on the Nooksack River at North Cedarville.



vi. Moving down the webpage, you find the following. The page shows the years data were collected and 4 to 6 tabs that provide different information. Click on the finalized data tab.



vii. Selecting the finalized data, a new page comes up; scrolling down that page you see the following. The top part of the page shows the finalized data for the most recent year data were collected. Below the data is a box that says "Bulk data download options..." Click on the "save to file" button for the 14 standardized data parameters. Follow the instructions to save this file. This saves all the data from that monitoring station so the regression analysis can be conducted.



date	time	COND		FC		FLOW	NH3_N	NO2_NO3	OP_DIS	OXYGEN	pH	PRESS	SUSSOL	TEMP	TP_PhLine	TPH	TURB
		(µmhos/cm)		(#/100ml)		(CFS)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(pH)	(mmHg)	(mg/L)	(deg C)	(mg/L)	(mg/L)	(NTU)
10/22/2002	09:35	113		10	J	735	0.01	U 0.08	0.0039	11.25	7.85	758.444	3	10.1	0.013*	0.119	2.2
11/20/2002	09:05	50		31	J	10600	0.01	U 0.358	0.0068	11.91	7.3	763.016	337	7.4	0.135*	0.45	150
12/10/2002	09:10	104		7	J	1450	0.023	0.213	0.0088	12.08	7.47	751.84	3	5.5	0.019*	0.275	2.8
1/29/2003	09:47	76	J	2		4810	0.01	U 0.274	0.013	12.75	7.48	756.412	45	4.8	0.03*	0.308	22
2/25/2003	09:20	92	J	1	J	1930	0.01	U 0.316	0.0043	12.69	7.46	751.84	6	3.2	0.014*	0.331	2.8
3/18/2003	08:25	68		2	J	9650	0.01	U 0.238	0.0041	12.2	7.38	758.19	34	5.1	0.024*	0.282	14
4/23/2003	10:05	79		4	J	2870	0.01	U 0.15	0.003	10.5	7.32	749.808	7	7	0.016*	0.17	4.5
5/21/2003	09:05	84		20		2250	0.01	U 0.097	0.003	U 11.77	7.59	762	4	6.4	0.015*	0.133	1.9
6/18/2003	08:45	60		40	J	3520	0.01	U 0.04	0.0033	10.86	7.6	752.094	34	10.8	0.022*	0.049	23
7/23/2003	08:30	67		50	J	2310	0.01	U 0.037	0.003	U 10.81	7.57	755.65	76	12.4	0.061*	0.045	55
8/20/2003	08:15	77		10	J	1600	0.01	U 0.059	0.003	U 10.9	7.59	758.096	52	11.2	0.048*	0.07	31
9/23/2003	08:25	92		15	J	1370	0.01	U 0.084	0.0038	10.7	7.44	764.286	25	11.5	0.038*	0.14	21

Common data qualifiers: U - not detected at the reported level, J - estimated value

Colored background: indicates that result exceeded water quality standards -OR- contrasted strongly with historical results.

Asterisk * indicates possible quality problem for the result. You may wish to discuss the result with the station contact person.

save the above table to file with the extension: .xls

Bulk data download options for 01A120

- 14 standard parameters, all finalized years, cross-tab html table.
  save to file with this extension: .xls view table - 380 kilobytes
- All project data for WRIA 01
  tab-delimited text format, 86 kilobytes, requires WinZip®, PKZip®, or compatible

viii. Open Excel and open the file that was just downloaded. Verify that all data appear to be available. After you have worked with these files, you will get an idea if something appears wrong. If the data looks like something is wrong, verify it by comparing the data to the finalized data on the webpage (look at each year's finalized data). After the file is open, delete all columns except the date, sussol (mg/L) and turb (NTU).

ix. Next delete the rows that do not need to be included. Only save the months in which the project will be constructed. For example, if work will be conducted during the work timing window of July 15 through August 31, delete all rows except those that contain data for July and August. The data consist of one data collection point each month. In addition, delete any values that have a "U" or "J" in the column to the right of the NTU value. This data may not be accurate; data may not be detectable at reported level or is an estimated value. The blue cells indicate the value exceeds water quality standards or contrasted strongly with historical results.

x. After deleting the unnecessary columns and rows, your data should contain 5 columns. You can now delete the columns to the right of the values. This will give you 3 columns. The first being the date, the second column contains the suspended solid data (mg/L) and the third column the turbidity (NTU) data.

b. Regression analysis. Once you have the data reduced to the months construction will occur, you can determine the relationship between turbidity and suspended

solids using regression. The following steps will provide the regression equation using the data obtained above. These steps are for Excel 2007.

i. With your mouse, highlight both columns of data (suspended solid and turbidity), but do not include the heading information.

ii. Then click on "Insert", "Scatter" and then the graph that does not have any lines on it (should be the upper left graph).

iii. The graph is placed on your Excel sheet, so move it over so you can see all the data and the graph.

iv. Now add the trendline to the graph. This is done by clicking (left button) once on any of the points on the graph. Then right click. A window pops open and click on "Add Trendline." A "Format Trendline" window appears. Make sure Linear is checked, and down on the bottom, check Display Equation on chart and Display R-squared value on chart. Click on close.

    1. The X and Y data are opposite of what you want so you need to swap the values. This is done by left clicking once anywhere on the graph and then right click and click on "select data." A window pops open and you want to click on Edit. An Edit Series window appears and you want to click on the little red arrow next to Series X values. This allows you to select the data in the table. Upon clicking the red arrow, you will see the column under sussol (mg/L) being selected by a moving line around the cells. Select the data under Turb (NTU) by left clicking and holding the button down and drag all the way down to the last cell in that column. The whole column should have the moving line around all the cells. Click on the little red arrow in the Edit Series window. That will expand out the window and you will do the same for the Series Y values. Click on the red arrow next to that, then left click and hold and select all the cells in the column under Sussol (mg/L), and then click on the red arrow again. When the Edit Series window expands, click on OK, and then click on OK.

v. The equation that you want to use for your conversion from NTUs to suspended solids is now on the graph. Hopefully, your R-squared value is also high. This gives you an indication of how well your data fits the line. A one (1) is perfect. If this number is low (and a ballpark figure is less than 0.60) then you may want to consider using the ratio method to determine your conversion from NTUs to suspended solids.

    1. Outliers – sometimes there will be data that will be far outside the norm. These values can be deleted and that will help increase your R-squared value. If you are good at statistics there are ways of

determining outliers. If not, you will probably just use the data as is, unless you think something is really not right, then you may want to delete those data points.

vi. Using the equation for the regression analysis, convert the sediment concentrations found for when adverse affects occur to bull trout and their habitat (number 3 above) to NTUs. For our example, let's say our NTU to suspended solid equation is: $y = 1.6632x - 0.5789$. Adverse effects would then occur at (solve for x):

For impacts to the species adverse effect would occur in the following situations:

a. Any time sediment concentrations exceed 89 NTU over background.
b. When sediment concentrations exceed 60 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 24 NTU over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 12 NTU over background for over seven hours cumulatively.

For impacts to habitat

a. Any time sediment concentrations exceed 660 NTU over background.
b. When sediment concentrations exceed 532 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 208 NTU over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 101 NTU over background for over seven hours cumulatively.

c. Turbidity:suspended solid ratio: To calculate the turbidity to suspended solid ratio you need to download the same data off the Ecology website as described above. Sometimes the monitoring stations have limited amount of data and by running the regression analysis it is possible to get a negative slope (an increase in turbidity results in a decrease in suspended solids). This is very unlikely to occur in a stream. Other times you have so few data points that the R^2 value shows that the correlation between suspended solid and turbidity is not very good. When R^2 values are below 0.60, determine the turbidity to suspended solid ratio. The following are the steps needed to calculate the turbidity to suspended solid ratio.

i. After you deleted all the columns and rows of data you do not need, you should have 3 columns of data. The first being the date, the second column contains the suspended solid data (mg/L) and the third column the turbidity (NTU) data.

ii. Calculate the average turbidity and suspended solid value for all data. Average the turbidity column and average the suspended solid column.

iii. Calculate the turbidity to suspended solid value for the average turbidity and average suspended solid value obtained in ii. Divide the average suspended solid value by the average turbidity value.

iv. If any outliers are identified, they should be deleted. Recalculate the turbidity:suspended solid ratio if outliers have been removed (should automatically be done when values are deleted).

vii. Using the turbidity to suspended solid ratio, convert the sediment concentrations found for when adverse effects occur to bull trout and their habitat (number 3 above) to NTUs. For our example, let's say our NTU to suspended solid ratio is 2.1. Adverse effects to the species would then occur in the following situations:

a. Any time sediment concentrations exceed 70 NTU over background.
b. When sediment concentrations exceed 47 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 19 NTU over background for more than three hours cumulatively.
d. When sediment concentrations exceeded 10 NTU over background for over seven hours cumulatively.

Adverse effects to the species through habitat impacts would occur in the following situations:

a. Any time sediment concentrations exceed 522 NTU over background.
b. When sediment concentrations exceed 421 NTU over background for more than one hour continuously.
c. When sediment concentrations exceed 164 NTU over background for more than three hours cumulatively.
a. When sediment concentrations exceeded 80 NTU over background for over seven hours cumulatively.

5) Determine how far downstream adverse effects and take will occur. There is no easy answer for determining this. Table 4 provides some sediment monitoring data for a variety of projects. These data can be used to determine the downstream extent of sediment impacts for a project. Note that in Table 4 there is not a single downstream point that can always be used because sediment conveyance and mixing characteristics are different for each stream. **An explanation of how the distance downstream was determined needs to be included in each BO.**

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Figure 1 – Severity of ill effect scores for juvenile and adult salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Juvenile and Adult Salmonids
Average severity of ill effect scores

Concentration (mg/L)	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		
162755	10	11	11	12	12	13	14	14	-	-	-
59874	9	10	10	11	12	12	13	13	14	-	-
22026	8	9	10	10	11	11	12	13	13	14	-
8103	8	8	9	10	10	11	11	12	13	13	14
2981	5760 7	8	8	9	9	10	11	11	12	12	13
1097	6	2335 7	1164 7	8	9	9	10	10	11	12	12
403	5	6	7	491 7	8	9	9	10	10	11	12
148	5	5	6	7	214 7	8	8	9	10	10	11
55	99 4	5	5	6	6	95 7	8	8	9	9	10
20	3	40 4	20 4	5	6	6	42 7	8	8	9	9
7	3	3	4	8 4	5	6	6	18 7	8 7	8	9
3	2	2	3	4	4 4	5	5	6	7	4 7	8
1	1	2	2	3	3	2 4	5	5	6	7	2 7

Figure 2 - Severity of ill effect scores for adult salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 5 and 6 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Adult Salmonids
Average severity of ill effect scores

Concentration (mg/L)	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		
162755	11	11	12	12	13	13	14	14	-	-	-
59874	10	10	11	11	12	12	13	13	14	14	-
22026	9	10	10	11	11	12	12	13	13	14	14
8103	8	9	9	10	10	11	11	12	12	13	13
2981	8	8	9	9	10	10	11	11	12	12	13
1097	2190 7	8	8	8	9	9	10	10	11	11	12
403	6	1095 7	642 7	8	8	9	9	10	10	11	11
148	156 5	6	6	331 7	175 7	8	8	9	9	10	10
55	5	78 5	6	6	7	94 7	8	8	9	9	9
20	4	4	46 5	24 5	6	6	50 7	27 7	8	8	9
7	3	4	4	5	12 5	6	6	7	14 7	8 7	8
3	2	3	3	4	4	7 5	4 5	6	6	7	4 7
1	2	2	3	3	4	4	5	2 5	1 5	6	6

Figure 3 - Severity of ill effect scores for juvenile salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for harassment, and the concentration between 7 and 8 represents the threshold for harm.

Juvenile Salmonids
Average severity of ill effect scores

Concentration (mg/L)	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		
162755	9	10	11	11	12	13	14	14	-	-	-
59874	9	9	10	11	11	12	13	14	14	-	-
22026	8	9	9	10	11	11	12	13	13	14	-
8103	13119 7	8	9	9	10	11	11	12	13	13	14
2981	6	4448 7	8	9	9	10	11	11	12	13	13
1097	6	6	1931 7	8	9	9	10	11	11	12	13
403	5	6	6	687 7	8	9	9	10	11	11	12
148	197 4	5	6	6	254 7	8	9	9	10	11	11
55	4	67 4	5	6	6	96 7	8	8	9	10	11
20	3	4	29 4	5	6	6	36 7	8	8	9	10
7	2	3	4	10 4	5	6	6	13 7	8	8	9
3	1	2	3	4	4 4	5	6	6	5 7	8	8
1	1	1	2	3	4	1 4	5	6	6	8	8

Figure 4 - Severity of ill effect scores for eggs and alevins of salmonids. The individual boxes provide the maximum concentration for that SEV. The concentration between 4 and 5 represents the threshold for both harassment and harm to eggs and alevins.

Eggs and Alevins of Salmonids
Average severity of ill effect scores

Concentration (mg/L)	Hours			Days			Weeks		Months		
	1	3	7	1	2	6	2	7	4	11	30
162755	7	9	10	11	12	13	14	-	-	-	-
59874	7	8	9	10	12	13	14	-	-	-	-
22026	7	8	9	10	11	12	13	-	-	-	-
8103	7	8	9	10	11	12	13	14	-	-	-
2981	6	7	8	10	11	12	13	14	-	-	-
1097	6	7	8	9	10	11	12	14	-	-	-
403	6	7	8	9	10	11	12	13	14	-	-
148	5	6	7	9	10	11	12	13	14	-	-
55	5	6	7	8	9	10	12	13	14	-	-
20	5	6	7	8	9	10	11	12	13	-	-
7	11 4	5	7	8	9	10	11	12	13	14	-
3	4	5	6	7	8	10	11	12	13	14	-
1	4	5	6	7	8	9	10	11	13	14	-

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Figure 5 - Severity of ill effect scores for salmonid habitat. The individual boxes provide the maximum concentration for that SEV. The concentration between 6 and 7 represents the threshold for anticipating adverse effects to bull trout through habitat modifications.

Salmonid Habitat
Average severity of ill effect scores

Concentration (mg/L)	1 Hour	3 Hours	7 Hours	1 Day	2 Days	6 Days	2 Weeks	7 Weeks	4 Months	11 Months	30 Months
162755	11	12	12	13	14	-	-	-	-	-	-
59874	10	11	12	12	13	14	-	-	-	-	-
22026	9	10	11	11	12	13	14	14	-	-	-
8103	8	9	10	11	11	12	13	14	14	-	-
2981	8	8	9	10	11	11	12	13	13	14	-
1097	7	7	8	9	10	10	11	12	13	13	14
403	885 / 6	7	7	8	9	10	10	11	12	12	13
148	5	345 / 6	167 / 6	7	8	9	9	10	11	12	12
55	4	5	6	68 / 6	7	8	9	9	10	11	11
20	3	4	5	5	29 / 6	7	8	8	9	10	11
7	2	3	4	5	5	12 / 6	7	7	8	9	10
3	2	2	3	4	5	5	5 / 6	7	8	8	9
1	1	1	2	3	4	4	5	2 / 6	7	7	8
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

EH-USA000128

ED_005624_00000038-00128

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