Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
13410-2009-F-0175

Arlington Wastewater Treatment Plan

Snohomish County, Washington

Agency:

U.S. Environmental Protection Agency

Consultation Conducted By:

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

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October 16, 2009

Date

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GLOSSARY OF TERMS

7Q10	The lowest stream flow for seven consecutive days that would be expected within a 10 year period
BA	Biological Assessment
BMP	Best management practices
BNR	Biological nutrient removal
BOD	Biochemical oxygen demand
City	City of Arlington
DO	Dissolved Oxygen
Ecology	Washington Department of Ecology
EDC	Endocrine disrupting chemicals
EEQ	Estrogenic equivalency quotient
EPA	U.S. Environmental Protection Agency
IGDO	inter-gravel dissolved oxygen
LWD	Large woody debris
LID	Low impact development
MBR	Membrane bioreactor
MDL	Maximum detection limit
Mgd	Million gallons per day
mg/L	Micrograms per liter
NPDES	National polution discharge elimination system
OHWM	Ordinary high water mark
Opinion	Biological Opinion
PCE	Primary Constituent Element
PhAC	Pharmaceutically active compounds
PPCP	Pharmaceuticals and personal care products
RM	River mile
Service	U.S. Fish and Wildlife Service
SRT	Solids retention time
TMDL	Total maximum daily load
TSS	Total suspended solids
UGA	Urban growth area
UV	Ultraviolet (radiation)
WRIA	Water resource inventory area
WWTP	Wastewater treatment plant
µg/L	Micrograms per liter

CONSULTATION HISTORY

The Wastewater treatment plant (WWTP) at Arlington is in need of capacity improvements to meet the expected population growth projected and planned for in accordance with the City of Arlington's Comprehensive Land Use Plan through 2025. Currently the WWTP has been operating near or above its capacity for influent total suspended solids (TSS). Additionally, the WWTP will soon be unable to process and store sludge generated at the current capacity.

On **March 5, 2009** the U.S. Fish and Wildlife Service (Service) received the Biological Assessment (BA) from the U.S. Environmental Protection Agency (EPA) and a request for concurrence with a "not likely to adversely affect" determination for bull trout and its critical habitat.

On **April 1, 2009,** the Service submitted comments and questions to the EPA on the BA.

On **April 23, 2009,** the Service received a response to the comments and questions from the Washington Department of Ecology (Ecology).

On **April 27, 2009,** the Service participated in a conference call with EPA, the City of Arlington, Ecology and various consultants to discuss the comments and responses on the BA.

On **April 29, 2009,** the Service provided examples of the types of analyses we expected on chemicals in WWTP effluent along with additional information to assist the applicant with the effects assessment.

On **May 5, 2009,** the Service provided follow-up comments and responses on issues discussed in the April 1, 2009 comments and questions.

On **May 7, 2009,** the Service provided research papers to assist the applicant with some of the technical issues.

On **June 6, 2009,** the Service received a response on the May 5, 2009 follow-up comments.

On **August 25, 2009,** the Service notified EPA through a letter that it could not concur with a not likely to adversely affect determination and recommended that EPA change its effect call and request formal consultation.

On **September 17, 2009,** the Service received a letter from the EPA, dated September 16, 2009, requesting formal consultation.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The City of Arlington (City) is proposing to upgrade and expand the City's existing WWTP. The purpose of the project is to provide enhanced wastewater treatment to accommodate expected population growth in the service area until the year 2017. Future project phases will provide expanded wastewater treatment capacity to accommodate projected population growth in the service area beyond the year 2025.

The City has determined that the project is necessary based on the following factors:

- Capacity-related issues in the treatment process.
- More stringent regulatory requirements as a result of total maximum daily load (TMDL) studies on the Stillaguamish River (River).
- Anticipated growth and development in the service area.

The EPA, through its authority for the State Revolving Fund Program, is funding the upgrade of the WWTP. EPA is the lead Federal agency for this consultation, due to this funding action.

Background

The WWTP site is located on a 3.91 acre site (of which 2.3 acres is occupied by the existing WWTP facilities) in the City of Arlington, Washington (Township 31 North, Range 5 East, and Section 2). The WWTP is located just downstream of the confluence of the North and South Forks of the Stillaguamish River at approximately River Mile (RM) 17.7 on the mainstem Stillaguamish River.

The current WWTP was constructed in 1959 and has undergone several expansions and upgrades throughout the years. These upgrades resulted in a treatment plant with a 2.3 acre footprint with a sequencing batch reactor treatment process, complete headworks, and ultraviolet (UV) disinfection. The WWTP currently operates at a secondary treatment capacity of 2.0 million gallons per day (mgd). Treated and disinfected effluent is discharged through a gravity outfall to the mainstem Stillaguamish River approximately 500 ft below the confluence of the North and South Forks.

Two major factors triggered the requirement for the WWTP upgrade: 1) the WWTP has been operating near or above its permitted influent TSS loading on a regular basis, and 2) sludge storage and dewatering capacity will soon be insufficient to handle projected sludge loading and there is no backup dewatering equipment available at the treatment plant.

In addition to process-related issues at the WWTP, Ecology has conducted TMDL studies of the Stillaguamish River, which necessitate more stringent regulatory requirements under future re-issuances of the National Pollutant Discharge Elimination System (NPDES) permit for the treatment plant. This will require significant upgrades to the treatment plant to achieve a higher level of treatment.

Finally, the City's wastewater service area and service population are expected to increase over the planning horizon (2005 through 2025; phase I and II), primarily due to projected population growth and a large annexation in the receiving area of a Transfer of Development Rights agreement with Snohomish County. This population growth is projected and planned for in accordance with the City of Arlington's Comprehensive Land Use Plan. The WWTP capacity improvements are needed to accommodate this planned growth.

Construction Activities

The City's WWTP will be upgraded and expanded to a membrane bioreactor (MBR) facility with aerobic sludge digestion. The construction activities include demolition, excavation, utilities installation, concrete pouring, building construction, tank conversions, paving, and landscaping. Demolition is planned for the existing post equalization basin, office building, lab building, and chlorination building. Excavation will be required for new utilities and building footprints. Grading will be required to install parking spaces and alter onsite driveways. The majority of excavation work will occur in the central and west part of the project site. Construction of additional parking spaces, a new MBR support building, lab/office building, equipment building, expanded headworks area, biofilter, and expanded solids handling building will also occur as part of this project.

Additionally, the current size and configuration of the outfall discharge to the Stillaguamish River is insufficient to hydraulically pass projected flows without water backing up into the WWTP and overflowing structures. The primary capacity limitation is due to an undersized portion of the existing outfall pipeline. Therefore, the entire 460 ft of pipe will be replaced with 24-inch ductile iron pipe. The only construction activities that will be conducted below the Ordinary High Water Mark (OHWM) are replacement of the temporary outfall and expansion of the existing outfall.

Project Timing

The treatment plant upgrades and expansion have been phased to provide a more viable project funding package, which has been affected by the current decline in the housing market, and still allow simple modular expansion of the WWTP capacity under a second construction phase to meet the anticipated growth projections.

Phase 1 improvements will upgrade the plant's treatment process and increase plant capacity to provide treatment for an average maximum month wastewater design flow of 2.69 MGD to meet projected growth through 2017. In addition to the Phase 1 improvements, the proposed action also includes a description of one element of Phase 2 work, which is the replacement of an old mid-section of 15-inch and 16-inch diameter outfall pipe with a new 24-inch pipe so that the entire outfall pipe would be a 24-inch diameter ductile iron pipe. The future Phase 2 expansion also includes increasing capacity to provide treatment for an average maximum month wastewater design flow of 4.0 MGD, equipping of a third biological treatment basin and additional MBR tanks, installation of an additional UV disinfection unit, and expansion of the Biosolids Composting Facility for the sludge produced by the new treatment plant process facilities. Due to cost considerations, the City has decided not to expand the Biosolids Composting Facility. Therefore, this element of the project will not be discussed further in this Opinion (James X. Kelly, pers. comm. 2009).

Although the City is designing this project in phases, all the actions and their direct and indirect effects are evaluated in this Biological Opinion (Opinion).

Phase 1 Activities

Construction elements for Phase 1 will occur over approximately 25 months and are expected to be completed in 2011. Implementation of Phase 1 requires the completion of the following actions:

1) Treatment Plant Upgrade Construction
    a) Treatment Plant Site Layout
    b) Treatment Plant Infrastructure
    c) Increase in Impervious Surface
    d) Clearing and Grading
    e) Temporary Erosion and Sediment Control
    f) Stormwater Treatment and Conveyance
    g) Construction and Equipment Staging Areas
    h) Discharge of Groundwater from Construction Area

2) Outfall Pipe Replacement
    a) Vegetation Clearing
    b) Excavation
    c) Temporary Effluent Bypass Pumping
    d) Construction Dewatering

According to the City (Kelly, pers. comm. 2009), all construction activities will take place within the footprint of the existing facility. Dewatering the site for construction of the MBR tanks has already taken place. Approximately 170,000 gallons of water was extracted and routed to the WWTP for treatment prior to discharge.

Some of the activities listed above will not affect the Stillaguamish River and therefore effects to bull trout and designated critical habitat for the bull trout are considered discountable. As such, these activities will not be discussed further in this Opinion, they include:

1) Treatment Plant Site Layout
2) Treatment Plant Infrastructure (utilities)
3) Clearing and Grading
4) Temporary Erosion and Sediment Control
5) Construction and Equipment Staging Areas
6) Vegetation Clearing
7) Excavation
8) Dewatering the Construction Site

The remaining Phase 1 activities will be evaluated further in this Opinion:

1) Increase in Impervious Surface
2) Stormwater Treatment and Conveyance
3) Discharge of the Treated Effluent into the Stillaguamish River (includes temporary effluent bypass pumping)

<u>Phase 2 Activities</u>

Implementation of Phase 2 requires the completion of the following actions:

1) Replace a portion of the existing outfall pipe
2) Equip a third biological treatment basin, and
3) Install an additional UV disinfection unit.

With the exception of replacing a portion of the existing outfall pipe, all construction activities will take place within the footprint of the existing facility (Kelly, pers. comm. 2009). Replacing a portion of the outfall pipe will be done during the low flow period and therefore, is anticipated to occur in the dry. Consequently, we do not expect this activity, nor any other activity planned for Phase 2, to affect the Stillaguamish River or bull trout, and therefore, Phase 2 activities will not be addressed further in this Opinion.

Conservation Measures

Conservation measures will be implemented for each component of the action including general construction of the treatment plant upgrade, the replacement of the outfall and operation of the treatment plant.

General Construction Best Management Practices

1) Develop and implement comprehensive erosion and sediment control plans for each phase of construction in accordance with the Washington State Department of Ecology's *Stormwater Management Manual for Western Washington (WDOE 2005b).*

2) Implement spill and erosion prevention and sediment control plans, as well as observe of all applicable safety and environmental regulations for handling chemicals.

3) Route all water from dewatering operations through sediment removal facilities as needed prior to eventual discharge either to infiltration trenches or designated receiving water bodies. If dissolved oxygen (DO) levels are found to be low, the water will be aerated prior to discharge into any surface water body.

4) Control the release of construction dewatering water into nearby surface water bodies to minimize erosive velocities and the potential for erosion, turbidity and sedimentation.

5) Maintain vegetation and provide adequate surface water runoff systems.

6) Limit the amount of area that is cleared and graded at any one time, and schedule construction activities soon after an area has been cleared and stripped of vegetation.

7) Revegetate or pave disturbed areas as soon as possible after construction.

8) Place straw, mulch, or commercially available erosion control blankets on slopes that require additional protection.

9) Place straw bales or silt fences to reduce runoff velocity in conjunction with collection, transport, and disposal of surface runoff generated in the construction zone.

10) All the stormwater runoff and groundwater encountered during construction will be treated through the plant and discharged through the plant outfall pipe (Mike Dawda, pers. comm. 2009). The only stormwater not routed to the WWTP comes from the roof drainage from the solids handling building (ESA Adolphson 2008b, p. 4).

11) The Stormwater Pollution Prevention Plan (ESA Adolphson 2008a) outlines several BMPs designed to reduce the discharge of sediment-laden runoff from the construction site. A variety of BMPs will be employed to enhance infiltration, reduce runoff, turbidity and contaminants in water leaving the site.

12) Covering tanks (shading)

Minimization Measures for the Outfall Replacement

1) Perform pre-construction surveys and prepare management plans for salmonid species to avoid or minimize impacts to special-status species present near construction sites.

2) Provide treatment of construction dewatering discharges, such as sediment removal or filtration, as necessary before the release of such water to the River.

3) Restore disturbed areas to the maximum extent possible.

4) Schedule construction within work windows specified by Washington Department of Fish and Wildlife, U.S. Army Corps of Engineers, NOAA Fisheries, and/or the Service to avoid critical periods (i.e., spawning, migration, overwintering) for salmonids.

Operational Conservation Measures for the WWTP

1) Any portion of the treatment facility or a discharge facility located within the flood hazard area would be designed to meet flood-proofing and/or flood-protection elevation requirements under the City of Arlington development regulations for flood hazard areas, as well as Federal Emergency Management Agency regulations.
2) The treatment plant design would include BMPs and source controls to minimize the risk of contamination from spills and leaks, in the rare event that a spill occurs. Spill containment provisions include double-walled storage facilities and emergency cleanup procedures. The site would be sloped to direct any drainage from spill-prone areas (i.e., sludge loading) back to the treatment plant for processing.
3) Stormwater generated in areas of the treatment plant site exposed to contaminants will be collected and processed through the treatment plant.

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 Service assessed the action area to be large enough to include the potential downstream extent of construction-related turbidity and effects of chemicals on aquatic organisms. Chemicals in municipal wastewater have been detected up to 13 km (8 miles) downstream from the source facilities in wastewater-dominated streams. The ability to detect chemicals and trace them directly to the source becomes more difficult with increasing distance and dilution. Most toxins remain in the system until they break down, react with other compounds, are ingested by organisms, or settle out in the substrates.

In a site-specific study, the U.S. Geological Service (USGS 2009) measured emerging contaminants in the Stillaguamish River. They collected samples approximately six miles downstream of the WWTP and did not detect contaminants at this location. They indicated that "The lack of detections in the sample does not necessarily mean that the compounds were absent; they could be present but at concentrations less than laboratory detection limits". Due to the distance from the treatment plant and the amount of flow in the River, the levels of chemicals were below detection limits.

We used the results of the Rivplum5 modeling conducted by Ecology to determine the aquatic extent of the action area. The Rivplum5 model is used to predict dilution over the entire plume width and at a particular point of interest, such as a mixing zone boundary. One of the outputs of the model is the approximate downstream distance to complete mix in feet. We used this value for the run that captured the 7Q10 for chronic conditions. According to the model output, complete mixing did not occur until the effluent was 19,302 ft (3.6 miles) from the discharge point. We therefore determined that the aquatic portion of the action area extends downstream from the plant for a distance of 3.6 miles. The upland extent of the action area includes the City of Arlington and its urban growth area.

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this Opinion relies on four components: (1) the *Status of the Species*, which evaluates the bull trout's range-wide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the bull trout in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the bull trout; (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 bull trout; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the bull trout.

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 bull trout's 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 the bull trout in the wild.

Interim recovery units were defined in the final listing rule for the bull trout for use in completing jeopardy analyses. Pursuant to Service policy, when an action impairs or precludes the capacity of a recovery unit from providing both the survival and recovery function assigned to it, that action may represent jeopardy to the species. When using this type of analysis, the Opinion describes how the action affects not only the recovery unit's capability, but the relationship of the recovery unit to both the survival and recovery of the listed species as a whole.

The jeopardy analysis for the bull trout in this Opinion uses the above approach and considers the relationship of the action area and core area (discussed below under the *Status of the Species* section) to the recovery unit and the relationship of the recovery unit to both the survival and recovery of the bull trout as a whole as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Adverse Modification Determination

This Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act) to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this Opinion relies on four components: (1) the *Status of Critical Habitat*, which evaluates the range-wide condition of designated critical habitat for the bull trout in terms of primary constituent elements (PCEs), 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 PCEs and how that will influence the recovery role of affected critical habitat units; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on bull trout critical habitat are evaluated in the context of the range-wide condition of the critical habitat, taking into account any cumulative effects, to determine if the critical habitat range-wide would remain functional (or would retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for the bull trout.

The analysis in this Opinion places an emphasis on using the intended range-wide recovery function of bull trout critical habitat, especially in terms of maintaining and/or restoring viable core areas, and the role of the action area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

STATUS OF THE SPECIES (Bull Trout)

Listing Status

The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (64 FR 58910). 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; Brewin and Brewin 1997; Cavender 1978; Leary and Allendorf 1997).

Throughout its range, the bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, entrainment (a process by which aquatic organisms are pulled through a diversion or other device) into diversion channels, and introduced non-native species (64 FR 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; Rieman et al. 2007). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

The bull trout was initially listed as three separate Distinct Population Segments (DPSs) (63 FR 31647; 64 FR 17110). The preamble to the final listing rule for the United States coterminous population of the bull trout discusses the consolidation of these DPSs with the Columbia and Klamath population segments into one listed taxon and the application of the jeopardy standard under section 7 of the Act relative to this species (64 FR 58910):

> Although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed. Formal establishment of bull trout recovery units will occur during the recovery planning process.

Current Status and Conservation Needs

In recognition of available scientific information relating to their uniqueness and significance, five segments of the coterminous United States population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: 1) Jarbidge River, 2) Klamath River, 3) Columbia River, 4) Coastal-Puget Sound, and 5) St. Mary-Belly River (USFWS 2002a; 2004b; 2004c). Each of these interim recovery units 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.

A summary of the current status and conservation needs of the bull trout within these interim recovery units is provided below and a comprehensive discussion is found in the Service's draft recovery plans for the bull trout (USFWS 2002a; 2004b; 2004c).

The conservation needs of bull trout are often generally expressed as the four "Cs": cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics (including abundant large wood and undercut banks), and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote conservation of bull trout at multiple scales ranging from the coterminous to local populations (a local population is a group of bull trout that spawn within a particular stream or portion of a stream system). The recovery planning process for bull trout (USFWS 2002a; 2004b; 2004c) has also identified the following conservation needs: 1) maintenance and restoration of multiple, interconnected populations in diverse habitats across the range of each interim recovery unit, 2) preservation of the diversity of life-history strategies, 3) maintenance of genetic and phenotypic diversity across the range of each interim recovery unit, and 4) establishment of a positive population trend. Recently, it has also been recognized that bull trout populations need to be protected from catastrophic fires across the range of each interim recovery unit (Rieman et al. 2003).

Central to the survival and recovery of bull trout is the maintenance of viable core areas (USFWS 2002a; 2004b; 2004c). A core area is defined as a geographic area occupied by one or more local bull trout populations that overlap in their use of rearing, foraging, migratory, and overwintering habitat. Each of the interim recovery units listed above consists of one or more core areas. There are 121 core areas recognized across the coterminous range of the bull trout (USFWS 2002a; 2004b; 2004c).

Jarbidge River Interim Recovery Unit

This interim recovery unit currently contains a single core area with six local populations. Less than 500 resident and migratory adult bull trout, representing about 50 to 125 spawning adults, are estimated to occur in the core area. The current condition of the bull trout in this interim recovery unit is attributed to the effects of livestock grazing, roads, incidental mortalities of released bull trout from recreational angling, historic angler harvest, timber harvest, and the introduction of non-native fishes (USFWS 2004c). The draft bull trout recovery plan (USFWS 2004c) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout within the core area, 2) maintain stable or increasing trends in abundance of both resident and migratory bull trout in the core area, 3) restore and maintain suitable habitat conditions for all life history stages and forms, and 4) conserve genetic diversity and increase natural opportunities for genetic exchange between resident and migratory forms of the bull trout. An estimated 270 to 1,000 spawning bull trout per year are needed to provide for the persistence and viability of the core area and to support both resident and migratory adult bull trout (USFWS 2004c).

Klamath River Interim Recovery Unit

This interim recovery unit currently contains three core areas and seven local populations. The current abundance, distribution, and range of the bull trout in the Klamath River Basin are greatly reduced from historical levels due to habitat loss and degradation caused by reduced water quality, timber harvest, livestock grazing, water diversions, roads, and the introduction of non-native fishes (USFWS 2002b). Bull trout populations in this interim recovery unit face a high risk of extirpation (USFWS 2002b). The draft Klamath River bull trout recovery plan (USFWS 2002b) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and strategies, 4) conserve genetic diversity and provide the opportunity for genetic exchange among appropriate core area populations.

Eight to 15 new local populations and an increase in population size from about 2,400 adults currently to 8,250 adults are needed to provide for the persistence and viability of the three core areas (USFWS 2002b).

Columbia River Interim Recovery Unit

The Columbia River interim recovery unit includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin, and presently occur in 45 percent of the estimated historical range (Quigley and Arbelbide 1997). This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in central Idaho and northwestern Montana. The Columbia River interim recovery unit has declined in overall range and numbers of fish (63 FR 31647). Although some strongholds still exist with migratory fish present, bull trout generally occur as isolated local populations in headwater lakes or tributaries where the migratory life history form has been lost. Though still widespread, there have been numerous local extirpations reported throughout the Columbia River basin. In Idaho, for example, bull trout have been extirpated from 119 reaches in 28 streams (Idaho Department of Fish and Game *in litt.* 1995). The draft Columbia River bull trout recovery plan (USFWS 2002d) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of the bull trout within core areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunities for genetic exchange.

This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in Idaho and northwestern Montana. The condition of the bull trout within these core areas varies from poor to good. All core areas have been subject to the combined effects of habitat degradation and fragmentation caused by the following activities: dewatering; road construction and maintenance; mining; grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment into diversion channels; and introduced non-native species. The Service completed a core area conservation assessment for the 5-year status review and determined that, of the 97 core areas in this interim recovery unit, 38 are at high risk of extirpation, 35 are at risk, 20 are at potential risk, 2 are at low risk, and 2 are at unknown risk (USFWS 2005a).

Coastal-Puget Sound Interim Recovery Unit

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this interim recovery unit. This interim recovery unit currently contains 14 core areas and 67 local populations (USFWS 2004b). Bull trout are distributed throughout most of the large rivers and associated tributary systems within this interim recovery unit. Bull trout continue to be present in nearly all major watersheds where they likely occurred historically, although local extirpations have occurred throughout this interim recovery unit. Many remaining populations are isolated or fragmented and abundance has declined, especially in the southeastern portion of the interim recovery unit. The current condition of the bull trout in this interim recovery unit is attributed to the adverse effects of dams, forest management practices (e.g., timber harvest and associated road building activities), agricultural practices (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation), livestock grazing, roads, mining, urbanization, poaching, incidental mortality from other targeted fisheries, and the introduction of non-native species. The draft Coastal-Puget Sound bull trout recovery plan (USFWS 2004b) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of bull trout within existing core areas, 2) increase bull trout abundance to about 16,500 adults across all core areas, and 3) maintain or increase connectivity between local populations within each core area.

St. Mary-Belly River Interim Recovery Unit

This interim recovery unit currently contains six core areas and nine local populations (USFWS 2002c). Currently, bull trout are widely distributed in the St. Mary-Belly River drainage and occur in nearly all of the waters that it inhabited historically. Bull trout are found only in a 1.2-mile reach of the North Fork Belly River within the United States. Redd count surveys of the North Fork Belly River documented an increase from 27 redds in 1995 to 119 redds in 1999. This increase was attributed primarily to protection from angler harvest (USFWS 2002c). The current condition of the bull trout in this interim recovery unit is primarily attributed to the effects of dams, water diversions, roads, mining, and the introduction of non-native fishes (USFWS 2002c). The draft St. Mary-Belly bull trout recovery plan (USFWS 2002c) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and forms, 4) conserve genetic diversity and provide the opportunity for genetic exchange, and 5) establish good working relations with Canadian interests because local bull trout populations in this interim recovery unit are comprised mostly of migratory fish, whose habitat is mostly in Canada.

Life History

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). 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 (Fraley and Shepard 1989; Goetz 1989). 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; Goetz 1989), or saltwater (anadromous form) to rear as subadults and to live as adults (Cavender 1978; McPhail and Baxter 1996; WDFW et al. 1997). 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; Leathe and Graham 1982; Pratt 1992; Rieman and McIntyre 1996).

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; Pratt 1985). The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). 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; Goetz 1989; Hoelscher and Bjornn 1989; Howell and Buchanan 1992; Pratt 1992; Rich 1996; Rieman and McIntyre 1993; Rieman and McIntyre 1995; Sedell and Everest 1991; Watson and Hillman 1997). Watson and Hillman (1997) 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), bull trout should not be expected to simultaneously occupy all available habitats (Rieman et al. 1997). Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Mike Gilpin *in litt.* 1997; Rieman et al. 1997; Rieman and McIntyre 1993). 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; Spruell et al. 1999). 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 (below 15 °C or 59 °F), and spawning habitats are generally characterized by temperatures that drop below 9 °C (48 °F) in the fall (Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1993).

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 (Baxter et al. 1997; Pratt 1992; Rieman et al. 1997; Rieman and McIntyre 1993). Optimum incubation temperatures for bull trout eggs range from 2 °C to 6 °C (35 °F to 39 °F) whereas optimum water temperatures for rearing range from about 6 °C to 10 °C (46 °F to 50 °F) (Buchanan and Gregory 1997; Goetz 1989; McPhail and Murray 1979). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 °C to 9 °C (46 °F to 48 °F), within a temperature gradient of 8 °C to 15 °C (4 °F to 60 °F). In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003) 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 (52 °F to 54 °F).

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; Fraley and Shepard 1989; Rieman et al. 1997; Rieman and McIntyre 1993; Rieman and McIntyre 1995). Availability and proximity of cold water patches and food productivity can influence bull trout ability to survive in warmer rivers (Myrick et al. 2002). For example, in a study in the Little Lost River of Idaho where bull trout were found at temperatures ranging from 8 °C to 20 °C (46 °F to 68 °F), most sites that had high densities of bull trout were in areas where primary productivity in streams had increased following a fire (Bart L. Gamett, Salmon-Challis National Forest, pers. comm. June 20, 2002).

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; Goetz 1989; Hoelscher and Bjornn 1989; Pratt 1992; Rich 1996; Sedell and Everest 1991; Sexauer and James 1997; Thomas 1992; Watson and Hillman 1997). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). 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; Pratt 1992; Pratt and Huston 1993). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

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). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992). 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; Ratliff and Howell 1992).

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) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). In a laboratory study conducted in Canada, researchers found that low oxygen levels retarded embryonic development in bull trout (Giles and Van der Zweep 1996 in Stewart et al. 2007). 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). 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). 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.

Migratory forms of bull trout may develop when habitat conditions allow movement between spawning and rearing streams and larger rivers, lakes or nearshore marine habitat where foraging opportunities may be enhanced (Brenkman and Corbett 2005; Frissell 1993; Goetz et al. 2004). 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). 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; MBTSG 1998; Rieman and McIntyre 1993). 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).

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, because this strategy can change as the fish progresses from one life stage to another (i.e., juvenile to subadult). Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994), and as fish grow, their foraging strategy changes as their food changes, in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987; Donald and Alger 1993; Goetz 1989). Subadult and adult migratory bull trout feed on various fish species (Brown 1994; Donald and Alger 1993; Fraley and Shepard 1989; Leathe and Graham 1982). Bull trout of all sizes other than fry have been found to eat fish half their length (Beauchamp and

VanTassell 2001). 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; WDFW et al. 1997).

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. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one source of food over another. For example, prey often occur in concentrated patches of abundance ("patch model" ; Gerking 1994). As the predator feeds in one patch, the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing energy acquired versus energy expended. 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). 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; Goetz et al. 2004).

Changes in Status of the Coastal-Puget Sound Interim Recovery Unit

Although the status of bull trout in Coastal-Puget Sound interim recovery unit has been improved by certain actions, it continues to be degraded by other actions, and it is likely that the overall status of the bull trout in this population segment has not improved since its listing on November 1, 1999. Improvement has occurred largely through changes in fishing regulations and habitat-restoration projects. Fishing regulations enacted in 1994 either eliminated harvest of bull trout or restricted the amount of harvest allowed, and this likely has had a positive influence on the abundance of bull trout. Improvement in habitat has occurred following restoration projects intended to benefit either bull trout or salmon, although monitoring the effectiveness of these projects seldom occurs. On the other hand, the status of this population segment has been adversely affected by a number of Federal and non-Federal actions, some of which were addressed under section 7 of the Act. Most of these actions degraded the environmental baseline; all of those addressed through formal consultation under section 7 of the Act permitted the incidental take of bull trout.

Section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans (HCP) completed in the Coastal-Puget Sound population segment. These include: 1) the City of Seattle's Cedar River Watershed HCP, 2) Simpson Timber HCP, 3) Tacoma Public Utilities Green River HCP, 4) Plum Creek Cascades HCP, 5) Washington State Department of Natural Resources HCP, 6) West Fork Timber HCP (Nisqually River), and 7) Forest Practices HCP. These HCPs provide landscape-scale conservation for fish, including bull trout. Many of the covered activities associated with these HCPs will contribute to conserving bull trout over the long-term; however, some covered activities will result in short-term degradation of the baseline. All HCPs permit the incidental take of bull trout.

Changes in Status of the Columbia River Interim Recovery Unit

The overall status of the Columbia River interim recovery unit has not changed appreciably since its listing on June 10, 1998. Populations of bull trout and their habitat in this area have been affected by a number of actions addressed under section 7 of the Act. Most of these actions resulted in degradation of the environmental baseline of bull trout habitat, and all permitted or analyzed the potential for incidental take of bull trout. The Plum Creek Cascades HCP, Plum Creek Native Fish HCP, and Forest Practices HCP addressed portions of the Columbia River population segment of bull trout.

Changes in Status of the Klamath River Interim Recovery Unit

Improvements in the Threemile, Sun, and Long Creek local populations have occurred through efforts to remove or reduce competition and hybridization with non-native salmonids, changes in fishing regulations, and habitat-restoration projects. Population status in the remaining local populations (Boulder-Dixon, Deming, Brownsworth, and Leonard Creeks) remains relatively unchanged. Grazing within bull trout watersheds throughout the recovery unit has been curtailed. Efforts at removal of non-native species of salmonids appear to have stabilized the Threemile and positively influenced the Sun Creek local populations. The results of similar efforts in Long Creek are inconclusive. Mark and recapture studies of bull trout in Long Creek indicate a larger migratory component than previously expected.

Although the status of specific local populations has been slightly improved by recovery actions, the overall status of Klamath River bull trout continues to be depressed. Factors considered threats to bull trout in the Klamath Basin at the time of listing – habitat loss and degradation caused by reduced water quality, past and present land use management practices, water diversions, roads, and non-native fishes – continue to be threats today.

Changes in Status of the Saint Mary-Belly River Interim Recovery Unit

The overall status of bull trout in the Saint Mary-Belly River interim recovery unit has not changed appreciably since its listing on November 1, 1999. Extensive research efforts have been conducted since listing, to better quantify populations of bull trout and their movement patterns. Limited efforts in the way of active recovery actions have occurred. Habitat occurs mostly on Federal and Tribal lands (Glacier National Park and the Blackfeet Nation). Known problems due to instream flow depletion, entrainment, and fish passage barriers resulting from operations of the U.S. Bureau of Reclamation's Milk River Irrigation Project (which transfers Saint Mary-Belly River water to the Missouri River Basin) and similar projects downstream in Canada constitute the primary threats to bull trout and to date they have not been adequately addressed under section 7 of the Act. Plans to upgrade the aging irrigation delivery system are being pursued, which has potential to mitigate some of these concerns but also the potential to intensify dewatering. A major fire in August 2006 severely burned the forested habitat in Red Eagle and Divide Creeks, potentially affecting three of nine local populations and degrading the baseline.

STATUS OF BULL TROUT CRITICAL HABITAT (Rangewide)

See Appendix A

ENVIRONMENTAL BASELINE

The 'environmental baseline' includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). An environmental baseline that does not meet the biological requirements of a listed species may increase the likelihood that adverse effects of the proposed action will result in jeopardy to a listed species or in destruction or adverse modification of a designated critical habitat.

The Service describes the environmental baseline in terms of the biological requirements for habitat features and processes necessary to support the life stages of each listed species within the action area. The action area serves primarily as foraging, migratory and overwintering habitat for bull trout but is used for spawning and juvenile rearing by salmon (important bull trout prey). Thus, for this action area, the biological requirements for bull trout are the habitat characteristics that support foraging, overwintering and migration.

As in most of the Puget Sound Rivers, habitat conditions and water quality in the Stillaguamish basin have been significantly altered by anthropogenic activities such as development, timber harvest, and transportation corridors. These activities have degraded habitat conditions in the River, including substrates, habitat complexity, large woody material, water temperatures, the natural hydrograph, and water quality and quantity. Logging and road construction in the upper watershed has resulted in a loss of riparian vegetation and increased occurrences of slope failures and mass wasting events. Seventy-four percent of the inventoried landslides in the Stillaguamish basin resulted from logging roads or clear cuts (WDOE 1999).

The Stillaguamish River originates in the Cascade Mountains, flows westward and drains into Puget Sound near the town of Stanwood, in Snohomish County, Washington. The Stillaguamish River is the fifth largest tributary to Puget Sound with a drainage basin of 684 square miles consisting of three sub-basins: the North Fork of the Stillaguamish River, South Fork Stillaguamish River, and the mainstem of the Stillaguamish River. The Stillaguamish River (6th Field HUC: 171100080302) is located in Washington State's Water Resource Inventory Area 5 (WRIA-5). The North Fork and South Forks of the River converge in Arlington to form the mainstem, which then flows approximately 21 miles west to Puget. The proposed action is located approximately 500 ft downstream of the confluence of the North and South Fork Stillaguamish River. The North and South Forks drain 42 percent (284 square miles) and 37 percent (255 square miles) of the watershed, respectively.

In general, upper tributaries have been adversely affected by past forest practices and lower tributaries and mainstem rivers have been degraded by agriculture and/or urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation from timber harvests and urban development are cited as problems for bull trout recovery. Blockages, water diversions, and shifts in flow regimes due to hydroelectric development and flood control projects are major habitat problems in several basins.

There are several limiting factors that negatively affect habitat for bull trout and other salmonids in the Stillaguamish watershed. Habitat degradation (both physical and chemical) has contributed to the designation of this bull trout core population as high risk. The major factors are discussed below and include:

- Changes in land use
- Loss of off channel habitat
- Loss of mature riparian forests
- Loss of pool habitat and large woody debris (LWD)
- Increasing sedimentation
- Changes in stream flow
- Degraded water quality due to point and non-point source pollution.

Land Use

Overall land use within the basin consists of 76 percent timberlands, 17 percent rural residential, five percent agricultural, and two percent urban (WSCC 1999). The dominant land uses in the upper watershed include forestry and dispersed recreation, while agricultural use is concentrated in the valley bottom along the mainstem, forks, and larger tributaries. Much of the Stillaguamish River estuary has been converted to agricultural land uses. Many side channels and sloughs within the watershed have become disconnected with the main river by the construction of levees and draining for agricultural uses, resulting in a 31 percent decrease in habitat from historic levels (USFWS 2004b). The highest stream flows occur during the fall and winter, while the lowest stream flows occur from July to September. Excess sedimentation, resulting mostly from landslides associated with human land use practices, is a limiting factor for salmonids throughout the watershed.

Habitat

Off Channel

In the floodplains of the Stillaguamish, the mainstem Stillaguamish has lost more than 31 percent of its side channel habitat (between 1933 and 1991), primarily from the construction of dikes and revetments (USFWS 2004b; WDOE 1999). The side channels of the North and South Forks have been decreased by about one third of historic levels. The losses are mainly due to filling of wetlands, and can be attributed to the combined effects of revetments, agriculture, and railroad and road construction (WDOE 1999). Side channels provide critical rearing and refuge habitat for salmonids.

Riparian Forest

The lack of mature riparian forests along the lower floodplains and upland areas are also a limiting factor. Today, only 11 percent of the Stillaguamish riparian forests are in an "intact" fully functional condition. Eleven of the 27 sub-basins identified in the Stillaguamish watershed have more than 70 percent degraded riparian forests. Eight of these sub-basins have more than 90 percent riparian degradation. Riparian zones associated with agriculture and rural residential land uses are the most severely degraded. The loss of riparian forests has resulted in a dramatic decrease in LWD and associated pool habitat, both of which are key to productive salmonid habitat. At best, only 41 percent of the Stillaguamish riparian forests bordering anadromous streams will be fully functioning to provide LWD by the end of the 21st century. The average and maximum number of pieces of wood per 100 m in agricultural stream channels is 70 percent less than what is found in forested and rural residential lands.

Pools and Large Woody Debris

The loss of pool area is associated with the removal and reduction of LWD, increases in sediment supply, and increased peak flows. Channel slope also influences the stability of the wood once it has entered the stream. Generally speaking, the spacing between pools in the Stillaguamish decreases with an increase in wood pieces and a decrease in channel slope. The mainstem has the highest average percent pool area (45 percent), followed by the South Fork (35 percent) and North Fork (28 percent).

Sedimentation

Sedimentation problems have been a concern to fish biologists in the Stillaguamish since at least the late 1950s. Landslides associated with human land uses are the primary source of sediment. A total of 1,080 landslides have been inventoried for the period from the early 1940s to the early 1990s. Seventy-four percent of the inventoried landslides in the Stillaguamish result from logging roads (22 percent) or clear cuts (52 percent), while 98 percent of the volume of sediment is associated with these two sources. A total of 851 landslides delivered sediment to stream channels, and of these, at least 40 percent delivered sediment directly to fish-bearing waters. Sixty-one percent of the 851 slides delivering sediment to streams occurred in the North Fork drainage, 36 percent in the South Fork drainage, and 3 percent in the mainstem drainage.

Stream flow

Increases in peak stream flows exacerbate sediment problems. Stream flow measurements from the North Fork show a systematic increase in peak flows. Because this trend is not found in the South Fork stream flow data, it suggests a relationship between land use activities more prevalent in the North Fork. Between 1928 and 1995, ten of the largest peak flows recorded by the North Fork gage occurred between 1980 and 1995. Peak flows can scour gravel beds containing salmon eggs. The scoured sediment may be re-deposited over downstream salmon redds, smothering the eggs. Peak flows can also flush out juvenile salmon from normally quiet rearing areas.

Low stream flows are problematic in the Stillaguamish from July through September (Table 1). The cumulative effect of groundwater withdrawals and loss of wetlands can also contribute to low flows. Known low flow problem areas include: the lower mainstem and estuary, Church Creek, North Fork (from Oso to Whitehorse), Pilchuck Creek, Harvey/Armstrong Creek, and Tributary 30. The low summer flows also permit saline waters from Puget Sound to move further upstream in the mainstem Stillaguamish than in historic times when summer flows were larger. Low flows can cause salmon to be stranded, limit or impede salmon migration, and contribute to a decrease in dissolved oxygen, an increase in water temperature, and an increase in the concentration of pollutants.

Table 1. Monthly Mean Stream Flow (cfs) from 1990 to 2008 for the Stillaguamish River at Arlington

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1990	3168	3005	2480	2682	1765	2310	649.1	442.9	357.9	2482	8008	*3151*
1991	3587	4734	1602	2415	1458	1194	606.8	468.2	399.5	283.3	3299	*2915*
1992	3417	2240	897.9	1607	1091	509.7	518.5	286.5	625.8	565.1	2020	*1432*
1993	1742	1158	2124	1944	1877	1324	779	448.1	258.7	552.7	898.8	*2599*
1994	2823	1605	2507	1826	1139	1127	604	240.1	437.1	1144	2144	*4864*
1995	2513	3936	2074	1340	1168	707.1	443.7	764.5	391	2514	6589	*3646*
1996	2878	3792	1441	2130	1827	777.8	450.6	269.4	686.6	2334	3283	*3053*
1997	5146	3074	5074	2804	4371	2432	1276	337	1381	3293	2233	*2597*
1998	3204	2109	2056	1255	1300	846	466.5	241.6	190.3	696.2	3845	*4471*
1999	3034	2209	2070	1602	2428	2454	1601	690.5	354	1293	3202	*4378*
2000	1600	1527	1774	2338	2440	2372	731.4	373.7	585.9	941.4	936.3	*1367*
2001	1595	989.2	1600	1716	2063	1278	528.9	649.5	388.1	2016	3188	*3389*
2002	3677	3544	2009	3302	2251	2287	964	381.9	335.8	305	1713	*1966*
2003	3512	1697	3438	1972	1414	840.2	380.1	207	267.2	3880	4045	*2692*
2004	3408	2023	2127	1582	1669	1443	466.8	958.2	2122	1629	3352	*3600*
2005	2947	1249	1719	2479	1345	1088	715.7	250.4	294.6	1348	2763	*2585*
2006	5592	2213	1362	2155	2263	1678	641.7	283.5	297.4	409.8	4762	*3278*
2007	3292	2571	4488	2049	1647	1236	793.1	348.4	292.2	2365	1712	*2877*
2008	1933	1889	2220	1729	3867	2597	1245	770	385.9			
Mean	***3109***	***2398***	***2266***	***2049***	***1967***	***1500***	***730***	***443***	***529.0***	***1558***	***3222***	***3048***

(USGS 2009)

Water Quality

303(d) List of Impaired Waters

Various reaches of the Stillaguamish River are on Ecology's 303(d) list of impaired waters for temperature, fecal coliform, dissolved oxygen, pH, mercury and arsenic. A number of point and potential nonpoint sources in the basin likely contribute to the Stillaguamish basin Section 303(d) listings. In the past WWTP's and dairies have been the focuses of water quality actions in the lower basin and along the upper basin valleys to control bacteria, nutrients, and oxygen demand inputs. However, land near Arlington and Stanwood are quickly converting from agricultural to rural residential land uses. Tables 2 and 3 present overviews of recent water quality data for the Stillaguamish River above the WWTP discharge at Arlington.

Table 2. Background Water Quality Monitoring Data for Metals Collected from 2005 to 2009 Upstream of the WWTP Discharge at Arlington[1].

Parameter	Unit	2005	2006	2007	2008	2009
		Min/Max/Mean	Min/Max/ Mean	Min/Max /Mean	Min/Max/ Mean	Min/Max/ Mean
Copper	µg/l	0.53/3.3/1.5	1/28/5.23	1/11/4.4	1/29/6.2	3/3/2003
Zinc	µg/l	3.2/12.3/5.1	1/46/9.6	1/46/9.6	1/51/10.9	3/3/2003
DO	mg/l	7.8/15.7/11.4	8.4/12.6/11	8.2/13.2/11.2	9.9/12.9/11.5	13.4/13.4/13.4
Temp	° C	1.3/21.3/9.16	3.6/20/9.7	3.4/19/9.3	3.4/17.7/8.6	2.4/2.4/2.4

From: Snohomish County Public works

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[1] http://www1.co.snohomish.wa.us/Departments/Public_Works/Divisions/SWM/Library/Data/default.htm

Table 3. Conventional Water Quality Monitoring Data for 2007 Through 2008 Collected from upstream of the WWTP Discharge at Arlington[2].

Date	Hardness (mg/L)	Nitrate + Nitrite (mg/L)	Phosphorus (dissolved (mg/L)		Oxygen (mg/L)	Suspended Solids (mg/L)	Temperature (°C)		Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
10/23/07	14.9	0.151	0.0043		11.5	34	7.1		0.044	0.22
11/27/07		0.294	0.0054		13.13	5	3.5		0.011	0.367
12/18/07	23.3	0.393	0.0053		12.7	17	4.7		0.039	0.431
1/29/08		0.384	0.0067		13.13	3	2.5		0.01	0.45
2/26/08	23.5	0.247	0.0047		13.16	64	5.1		0.0788	0.268
3/18/08		0.225	0.0046		12.7	33	4.9		0.0597	0.25
4/22/08	23.5	0.238	0.0039		12.33	43	5.4		0.044	0.282
5/20/08		0.1	0.0042		12.5	163	6.2		0.166	0.14
6/17/08	12.6	0.082	0.003		11.5	17	9		0.023	0.13
7/29/08		0.047	0.003	U	10.6	3	14		0.007	0.088
8/19/08	22.7	0.087	0.0032	J	9.3	2	16.9*	J	0.0058	0.12
9/23/08		0.129	0.003		11.1	4	10.5*	J	0.011	0.19

Common data qualifiers: U - not detected at the reported level, J - estimated value
Data from Washington State Department of Ecology

Point Source

According to Ecology (WDOE 2004), wastewater treatment practices and stormwater runoff in portions of the basin have resulted in increases in suspended solids, fecal coliform bacteria, and disinfection residuals. Point sources are distinct collection and discharge points where the release of pollutants is regulated and monitored under a permit. Point sources in the Stillaguamish basin include the WWTPs at Arlington, Warm Beach Christian Conference Center, Twin City Foods, and Stanwood. All facilities are self-monitored and report to Ecology under current permit requirements. Most permits require effluent monitoring of pH, temperature, biochemical oxygen demand (BOD), TSS, fecal coliform bacteria, and disinfection residuals. None of the facilities currently have permit limits on nutrient concentrations. In addition to the WWTPs, a significant number of other discharge permits have been issued in the basin (Figure 1). Many of these permits are issued to dairies located primarily in the lower River which are sources of steroid hormones, antibiotics and other veterinary medicines. The antenna cooling water discharge from the Naval Facility at Jim Creek is a source of elevated water temperatures upstream of the WWTP.

Non-point Source

Non-point sources of pollution are a major cause of water quality pollution in the Stillaguamish, with agricultural practices, onsite sewage disposal, development and urban runoff, and forest practices being the major sources. Exceedances of water quality standards for temperature, dissolved oxygen, fecal coliform and other parameters have been measured at several locations in the Stillaguamish watershed. For salmonids, high water temperature and low DO can block migration, cause stress, and can result in mortality in situations of prolonged exposure. Water temperatures above 21 °C (optimum for bull trout is 12 to 14 °C) are frequent in the action area during July and August (Table 4). High temperatures can lower DO, impair the immune system

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[2] http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

of salmon, and give non-native warm water species a competitive edge over native salmonids.

TMDL Studies and NPDES Permits

Ecology recently conducted several TMDL studies of the Stillaguamish River. In March 2004, Ecology completed a temperature TMDL study, which assigned a waste load allocation (WLA) to the Arlington WWTP for temperature (WDOE 2004). In July 2004, Ecology completed the Stillaguamish River TMDL study for fecal coliform, dissolved oxygen (DO), pH, mercury, and arsenic, which assigned a WLA to the treatment plant for fecal coliform , but did not assign a WLA for any other constituents (WDOE 2004). That TMDL study was followed by a Water Cleanup Plan for the Stillaguamish River, which was submitted to the EPA for review and approval in April 2005 (WDOE 2005a). In July 2006, Ecology also submitted a Water Quality Improvement Report pertaining to temperature to EPA for review and approval (WDOE 2006). The reports submitted to EPA summarize steps that will be taken to address water quality issues in the River and its tributaries.

As a result of these TMDL studies, more stringent regulatory requirements are expected under future re-issuances of the NPDES permit. When the upgraded and expanded WWTP is brought on line, Ecology is expected to impose limits on total phosphorus and temperature. In addition, Ecology will be holding constant the current mass load limits for 5-day BOD_5 and TSS, and reducing concentration limits for fecal coliform. Furthermore, the mixing zone study completed for the project indicates that annual limits for ammonia and seasonal limits for copper and zinc could potentially be imposed to avoid toxicity to aquatic life (Cosmopolitan 2006 as cited in ESA Adolphson 2008b). The City will be required to conduct sampling and analysis for temperature, copper and zinc to determine compliance with the water quality standards in the river for these parameters.

Table 4. Seasonal Temperature Maximum in the Stillaguamish River at Arlington

year	**Constituent**	**criterion**	**Deployment**		**max 7-day mean**		ITS[b]
			max	Date/Time[a]	max	Date[a]	
2004	Water Temp	18	25.3	7/29/2004 6:30:00 PM	24.5	8/16/2004	80.6
2003	Water Temp	18	26.1	7/30/2003 7:00:00 PM	24.9	7/29/2003	0
2002	Water Temp	18	21.68	8/14/2002 7:00:00 PM	20.9	8/14/2002	20.9
2001	Air Temp	NA	29.72	8/10/2001 4:31:04 PM	26.8	8/11/2001	NA
2001	Water Temp	18	23.47	8/12/2001 6:00:26 PM	22.6	8/12/2001	

(Ecology water monitoring station 05A090[3])

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[3] http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=notes&scrolly=0&sta=05A090

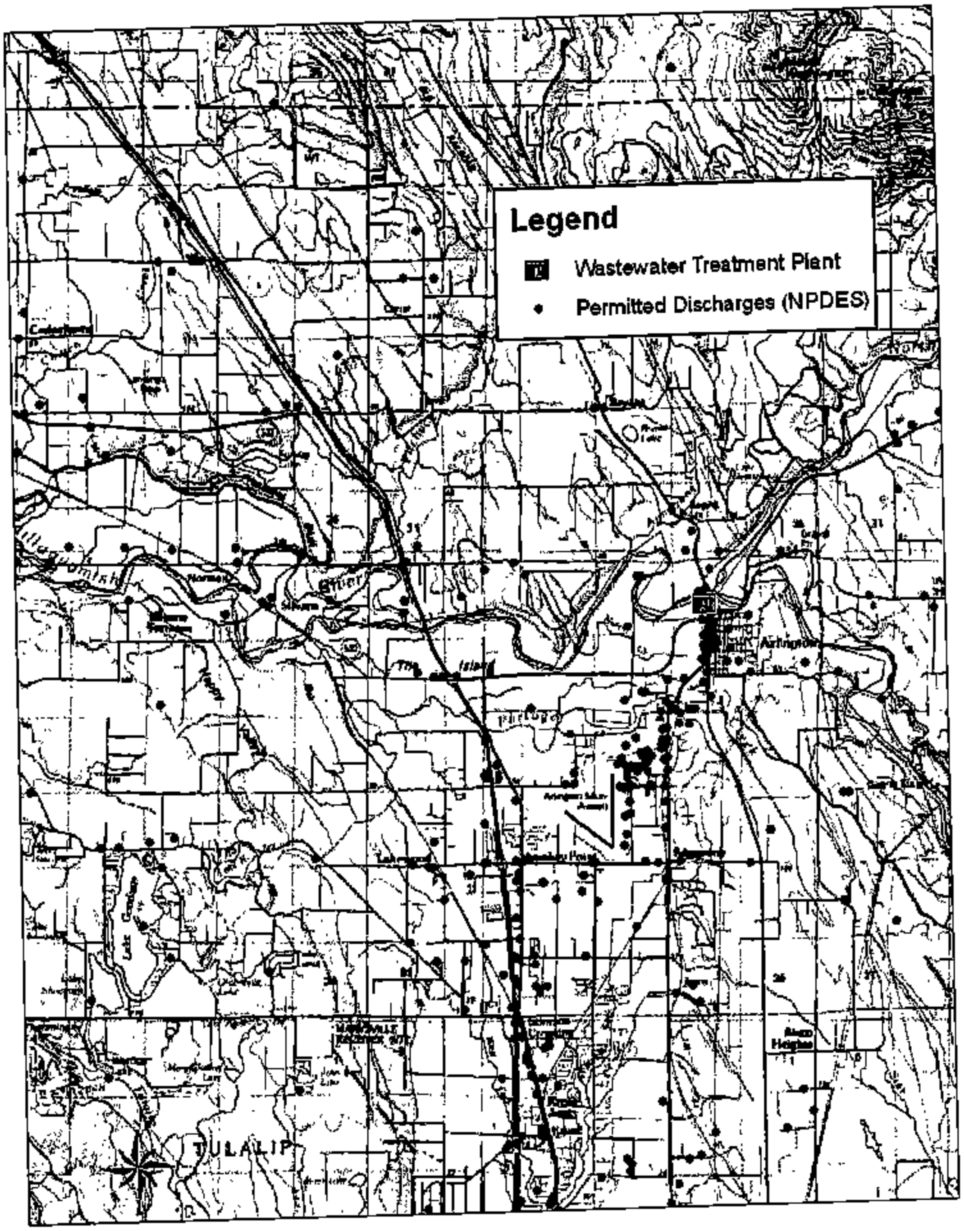

Figure 1. Permitted Discharges in the lower Stillaguamish Basin

Status of the Species in the Action Area

The discharge location for the Arlington WWTP is at the confluence of the North and South Forks of the Stillaguamish River. Depending on the water level in the River, bull trout swim through the effluent plume to reach their spawning destinations in the upper reaches of the River. The action area for the WWTP discharge covers some length of the River downstream of the outfall pipe past the allowable mixing zone (304 ft) to the point where contaminants in the effluent are diluted to the degree that they would no longer be detectable. Although the action area does not encompass the entire core area, it does impact all bull trout migrating to both forks of the River for spawning. The following section presents the status of bull trout in the entire core area.

Stillaguamish Core Area

The Stillaguamish core area comprises the Stillaguamish River basin, including the North Fork and South Forks and their tributaries. Major tributaries to the North Fork include the Boulder River and Deer, Little Deer, and Higgins Creeks. Canyon Creek, the only major tributary to the South Fork Stillaguamish River, has minor tributaries including Millardy, Deer, Coal, Palmer, Perry, and Beaver Creeks.

Bull trout that occur throughout the Stillaguamish River basin and, in the Stillaguamish core area, primarily include amphidromous and fluvial life-history forms (USFWS 2004b) . Four local populations have been identified in the Stillaguamish core area: 1) Upper Deer Creek, 2) North Fork Stillaguamish River, 3) South Fork Stillaguamish, and 4) Canyon Creek. The scarcity and spatial isolation of available spawning habitat limits the number of local populations in the Stillaguamish core area. With only four local populations, bull trout in this core area are considered to be at increased risk of extirpation and adverse effects from random naturally occurring events.

There are no known populations in the North Fork Stillaguamish River above the barrier to migration at river mile 37.5 (Kraemer 1999). No resident populations have been found above any of the natural migratory barriers on Deer or Higgins Creeks. No exclusively resident populations have been identified in this core area, but the South Fork Stillaguamish River population has a strong resident component coexisting with migratory forms.

Spawning habitat is generally limited in the Stillaguamish core area, and apparently, only the upper reaches provide adequate spawning conditions. The upper reaches of the accessible portions of the upper North Fork Stillaguamish River and its tributaries, include Deer and Higgins Creeks. There has been no extensive juvenile sampling or evaluation of spawning success in the North Fork Stillaguamish River.

Spawning areas in the South Fork Stillaguamish River and its tributaries include Canyon Creek and upper South Fork Stillaguamish. Bull trout are known to spawn and rear in Palmer, Perry, and Buck Creeks and the upper South Fork mainstem above Palmer Creek. Spawning and early rearing habitat in the South Fork Stillaguamish River is considered to be in fair condition. Although bull trout spawn in the upper South Fork Stillaguamish River and other tributaries, available habitat is partially limited by gradient and competition with coho salmon.

Upstream movement of bull trout from the lower River depends on proper functioning of the fish ladder at Granite Falls. Migratory and resident fish coexist on the spawning grounds. Recent spawning surveys identified a major spawning area above the Palmer Creek confluence. Between 50 and 100 bull trout spawn in this reach. Electrofishing surveys also documented high densities of juveniles (D Downen, *in litt.* 2003).

Bull trout in the Canyon Creek local population use the upper South Fork Stillaguamish River for spawning and rearing. Although there have been isolated and incidental observations of spawning by migratory-size bull trout, electrofishing surveys have been unable to locate any juvenile or resident bull trout from this population. Despite repeated survey efforts, very few bull trout have been located in this population because of the difficulty in locating individuals.

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 2004b).

Conservation Status of the Stillaguamish Core Area

In 2005, the Service conducted a Bull Trout Core Area Conservation Status Assessment (USFWS 2005b) and determined the core area was "at risk." This determination was based on an evaluation of numerous factors including:

- Population size, distribution and trend;
- Threats (severity, scope and immediacy); and
- Core Area extent and degree of connectivity.

Population Size, Distribution and Trend

Regarding population size, distribution, and trend, the Stillaguamish core area supports approximately 250 to 1,000 individuals occupying 620 to 3,000 river and stream miles with an unknown population trend.

Fall snorkel surveys conducted on the North Fork Stillaguamish River between 1996 and 2003 counted close to 300 migratory adults in the reach between RM 21 and 25 during fall 2001, although counts were fewer than 100 adults for the remaining sample years during this same time period (Pess 2003). Other limited snorkel survey efforts have made similar observations (Downen, *in litt.* 2003). This is the only index of abundance for this core area. These index counts are assumed to primarily represent spawners returning to two of the four identified local populations within the core area, North Fork Stillaguamish River and Upper Deer Creek. The other two identified local populations are within the South Fork Stillaguamish River.

Additional fall snorkel count data has been collected in the North Fork Stillaguamish River since 2003, and redd count data have been collected in the South Fork Stillaguamish River since 2002. Adult abundance of between 50 to 100 fish can be estimated from redd counts conducted over the last several years (Downen, *in litt.* 2003).

Based on surveys within the basin, only one functional population is likely to currently exist within the basin (South Fork Stillaguamish River local population). Therefore, current redd surveys are considered to be fairly comprehensive for the core area (Downen, *in litt.* 2003). However, surveys in Canyon and Upper Deer Creeks in 2002 and 2003 did not detect native char (Downen, *in litt.* 2003). If these systems currently maintain populations, then they do not likely contain resident individuals or juveniles in great enough abundance to sample. Adult individuals are occasionally observed in these systems. Fish holding in the North Fork Stillaguamish are suspected to be primarily foraging first-time spawners that likely originate from the Lower Skagit or Snohomish-Skykomish core areas (Downen, *in litt.* 2003).

Number and Distribution of Local Populations

Four local populations have been identified in the Stillaguamish core area: 1) Upper Deer Creek, 2) North Fork Stillaguamish River, 3) South Fork Stillaguamish, and 4) Canyon Creek. The scarcity and spatial isolation of available spawning habitat limits the number of local populations in the Stillaguamish core area. With only four local populations, bull trout in this core area are considered to be at increased risk of extirpation and adverse effects from random naturally occurring events.

Adult Abundance

The bull trout population in the Stillaguamish River basin is estimated at fewer than 1,000 adults. In the North Fork Stillaguamish River, as many as 100 adult bull trout have been observed holding near the mouth of the Boulder River. Surveys documented nearly 300 adult char between river miles 21 and 25 during fall 2001; fewer than 100 adults were counted in the remaining sample years between 1996 and 2003 (Pess 2003). Other limited snorkel surveys had similar results (Downen, *in litt.* 2003). These staging adult bull trout are assumed to spawn somewhere in the North Fork Stillaguamish River. Adult abundance in the Upper Deer Creek and Canyon Creek local populations is considered low. The Boulder River population probably has fewer than 100 adults. Approximately 50 to 100 adults are present in the South Fork Stillaguamish River, based on conservative estimates from spawning and electrofishing surveys (Downen, *in litt.* 2003). Although accurate counts are unavailable, current estimates of adult abundance suggest that Upper Deer Creek and Canyon Creek local populations have fewer than 100 adults and are considered at risk of inbreeding depression.

Threats

The analysis of threats is an indication of the degree to which bull trout in this core area are observed, inferred, or suspected to be directly or indirectly threatened. Threats considerations apply to the present and the future. The evaluation considered the impact of extrinsic threats, which typically are anthropogenic but may be natural. The impact of human activity may be direct (e.g., destruction of habitat) or indirect (e.g., invasive species introduction). Effects of natural phenomena (e.g., fire, hurricane, flooding) may be especially important when the species is concentrated in few locations. The severity of threat for this core area is considered high. High threat is characterized by loss of species population (all individuals) or destruction of species habitat in area affected, with effects essentially irreversible or requiring long-term recovery (greater than 100 years). The scope refers to the proportion of the core area that is affected. The Stillaguamish Core Area is considered moderate that is, 20 to 60 percent of the total population or area is affected. The ranking for immediacy of threat is a straightforward analysis of how timely the manifestation of the threat is likely to be. High immediacy means the threat is operational now or within a year. Moderate immediacy is a two to five year horizon. Based on this ranking system, the threat level for the Stillaguamish Core Area is considered moderate.

Threats to bull trout in the Stillaguamish core area include:

1) Channel widening and a significant reduction in primary pool abundance have seriously degraded habitat conditions in the North Fork and lower South Fork Stillaguamish Rivers.

2) Spawning habitats in Deer and Canyon Creeks have been extremely degraded.

3) Past logging and logging-related activities, such as roads, have degraded habitat in the Stillaguamish River basin. The loss of riparian cover, slope failures, stream sedimentation, increased stream temperatures, flooding, and loss of LWD have adversely affected bull trout in Deer Creek and in the South Fork Stillaguamish River (USFWS 2004b). Deer and Higgins Creeks currently violate State water quality standards for temperature.

4) Agricultural and residential development has contributed to poor water quality in the lower Stillaguamish River basin. Excessive siltation caused by mud and clay slides on the North Fork Stillaguamish River near Hazel, Washington, and on the South Fork above Robe, contribute to poor water quality (Williams et al. 1975).

5) Other limiting factors in the North Fork Stillaguamish River include loss of deep holding pools for adults and low summer flows (USFWS 2004b).

6) Low flows and high temperatures during the summer affect holding habitat for anadromous migrants in the mainstem Stillaguamish River, especially in the lower river sloughs that have slow-moving water without significant riparian cover (WDFW 1997a).

7) Water quality impairment including high stream temperature and pollution.

8) Climate change.

The Stillaguamish River Basin already suffers from temperature exceedances in the mainstem and two forks (WSCC 1999) , making it vulnerable to climate change impacts. The Upper Deer Creek local population may be particularly vulnerable since it already has noted temperature problems within several key tributaries (Deer Creek, Little Deer Creek, and Higgins Creek) as a result of past forest management practices (WSCC 1999). This watershed is still undergoing recovery from these past impacts. Compared to the Snohomish River Basin, the Stillaguamish River Basin may be even more vulnerable to climate change impacts due to the geology and limited fish distribution. This basin also lacks protected areas (e.g., Wilderness, National Park land) that might be considered more insulated from, or resistant to, climate change impacts.

Because of the historic loss of estuarine habitats within the Stillaguamish River Delta, sea-level rise associated with climate change will further reduce certain types of estuarine habitats in the future. Padilla Bay, Skagit Bay, and Port Susan Bay have significant projected losses of tidal freshwater marsh, estuarine beach, brackish marsh, tidal swamp, rocky intertidal, and riverine tidal habitats associated with anticipated sea level rise (Glick et al. 2007). The decline in marsh habitats are projected to significantly reduce rearing capacity for juvenile Chinook and are also likely to affect other salmonid species including bull trout, which depend on coastal marshes and other habitats for part of their life cycle (Glick et al. 2007).

The Core Area extent ranges from the headwaters of the Stillaguamish River to the confluence with the marine environment. In the Stillaguamish Core Area, there is unrestricted passage for bull trout to other core areas and a high degree of connectivity within the core area. "High" internal connectivity applies to core areas where connectivity between local populations is generally unimpaired, or where only minor or insignificant portions of usable habitat are currently inaccessible. The degree of connectivity with other core areas is considered moderate, meaning either "restricted passage" at both bounds, or "unrestricted passage" at one bound and "no passage" at the other. When evaluating all core areas (not just the Stillaguamish), the scoring results would suggest that current connectivity among core areas is low across the range, overall. This current lack of connectivity among core areas significantly reduces the probability of rebounding events should a core area become extirpated. It also illustrates why we consider core areas to be important biological units and why threats should be evaluated primarily at the core area level.

Connectivity

The maintenance of migratory forms of bull trout and the related connectivity requirements to support these forms are important factors in evaluating persistence of the species within core areas, as well as within regional or larger units. Connectivity of habitats within core areas, and in some cases with habitats outside of core areas, is critical for migratory bull trout to successfully complete their life history (MBTSG 1998; Rieman and McIntyre 1993). Connectivity among local populations is also important to provide the opportunity for genetic exchange within core areas and to allow populations to rebound after local extinction events (Rieman et al. 1997; Rieman and McIntyre 1993). Maintaining multiple local populations distributed throughout a watershed provides a mechanism for spreading risk because the simultaneous loss of all local populations is reduced and, if the habitat is well connected, provides for the resiliency of the core area. In some cases, connectivity among adjacent core areas is important for maintaining/restoring the original population structure that existed prior to fragmentation by artificial barriers. Connectivity among core areas also provides for the opportunity of genetic exchange (one or two-way) to maintain diversity and allows the potential for rebounding.

Primary foraging, migration, and overwintering areas in the Stillaguamish River basin include the mainstems of the North Fork and South Fork Stillaguamish Rivers and the Stillaguamish River to the estuary. Foraging sub-adults and adults may be found in nearly all reaches of the basin below migratory barriers to the basin. Rearing individuals may use nearly all accessible reaches in higher elevation and coldwater portions of the basin. Anadromous forms in the Stillaguamish core area are presumed to use nearshore marine areas in Skagit Bay, Port Susan, and Possession Sound, but may also use areas even farther from their natal basin.

Seasonal temperature impairments to migration in the South Fork Stillaguamish are still uncertain, however, bull trout have been observed gathering around the mouths of cold water inputs such as Ice Creek in summer. They may depend on these cold water refugia to over-summer in the South Fork Stillaguamish (Downen, *in litt.* 2003).

All native char habitat within the Stillaguamish River Basin generally has good connectivity. However, because the local populations are somewhat isolated from one another, maintaining connectivity among them will be critical to support life-history diversity, redounding, and genetic exchange.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, Federal actions occurring in the Stillaguamish core area have caused harm to or harassment of bull trout. These actions include statewide Federal restoration programs that include riparian restoration, restoration of fish passage at barriers, and habitat-improvement projects. In addition, federally funded transportation projects involving repair and protection of roads and bridges have been completed. Finally, section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans that address bull trout in this core area.

The number of non-Federal actions occurring in the Stillaguamish core area since the bull trout listing is unknown. However, activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout.

EFFECTS OF THE ACTION

'Effects of the action' means the direct and indirect effects of an action on the listed 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). Effects of the action that reduce the ability of a listed species to meet its biological requirements may increase the likelihood that the proposed action will result in jeopardy to that listed species or in destruction or adverse modification of its designated critical habitat.

This section addresses the direct and indirect effects of the proposed action and its interrelated and interdependent activities. The regulations implementing the Act define "effects of the action" as "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 Section 402.02).

This section includes a description of the 1) activities with insignificant and discountable effects 2) timing and duration of exposure and the life stages exposed, 3) the stressors associated with the action, and 4) the anticipated response.

Activities with Insignificant and Discountable Effects

Some of the proposed action's potential effects to bull trout are/will be insignificant or discountable. The following activities are not expected to result in direct and indirect effects due to the BMPs and minimization measures 1) replacing a section of the outfall pipe and, 2) stormwater treatment and conveyance were determined to result in insignificant effects to bull trout. The rational for these determinations is presented below.

Outfall Pipe Replacement

As required by the increased treatment capacity, a section of the outfall pipe is to be enlarged. This will involve working below the OHWM to place a temporary discharge and reroute the current discharge through a temporary pipe located very close to the original pipe. The placement of this temporary pipe may cause short term affects on water quality. Excess turbidity may be generated as the pipe is put in place. Additionally, it is also possible that some groundwater will be encountered when replacing the pipe section, so that dewatering may be necessary. If this is the case then the dewatered water will be filtered to remove sediment prior to discharging it back into the River. The replacement of the pipe is not expected to take more than one day (Kelly, pers. comm. 2009).

We don't anticipate that replacement of the outfall pipe will result in adverse effects to bull trout due to: 1) the majority of work will be done under dry conditions, 2) all dewatered water will be treated prior to discharging in back into the River resulting in low levels of turbidity, and 3) the work is only expected to take one day reducing the potential for exposure of bull trout and their prey to construction activities. Therefore, replacement of the outfall pipe will not be considered further in this Opinion.

Stormwater Treatment and Conveyance

The largest urbanized area in the action area with stormwater that directly discharges to the Stillaguamish River is an area known as "old town" Arlington, which is approximately 276 acres. The City, with funding from Ecology, is in the process of designing and constructing a stormwater wetland to detain and treat stormwater runoff from the "old town" area (USFWS and City of Arlington, pers. comm. 2009).

The expansion of the WWTP and interrelated growth are both sources of new impervious surface in the action area and within the urban growth boundary of the City. Conversion of land to impervious surface can alter the duration and frequency of runoff, can decrease both rates of infiltration and evapotranspiration, and can influence patterns of subsurface water exchange and base flows (Angermeier et al. 2004; Beyerlein 1999).

Expansion of the WWTP adjacent to the Stillaguamish River, along with the anticipated new development within the urban growth area, and redevelopment in downtown Arlington, are all expected to result in an increase in the amount of impervious surface. At completion, the WWTP expansion would create approximately 0.58 acres of new impervious surface within the footprint of the existing WWTP. This is approximately a 21 percent increase to the amount already present within the project site (ESA Adolphson 2008a) .

The new planned development known as Brekhaus-Beach will cover an area of 337 acres with 40 percent preserved as critical areas. This will result in 202 developable acres (medium and high-density housing). According to the City (USFWS and City of Arlington, pers. comm. 2009), if one were to assume that approximately 15 percent of the developable land were to become impervious, a total of 30 acres of new impervious surface would be generated from completion of the planned development.

The impact of project-related stormwater on the Stillaguamish River will be minimized by implementing BMPs. Most important are the Puget Sound Low Impact Development guidelines that require on-site storage and infiltration where possible, of stormwater for a minimum of the 2-year storm event. The BMPs for stormwater control and treatment will be employed in all new development and re-development consistent with the Western Washington 2005 Stormwater Manual [*Arlington Municipal Code 13.24 Stormwater management and Arlington Land Use Code 20.88 Environmentally Critical Areas]*. Examples of avoidance and minimization include (but are not limited to):

- High density housing and open green space
- Preservation of critical habitat area
- Porous concrete
- Rain gardens
- Infiltration basins

The City of Arlington has been meeting the requirements for on-site storage and infiltration of stormwater, as outlined in Ecology's Stormwater Management Manual, since 1995. Under the proposed action, the stormwater design will provide flow control for runoff for all flows up to the 2-year storm event. This stormwater will be either detained and/or infiltrated. Flows in excess of the 2-year storm event will be discharged consistent with flow control and water quality requirements as contained in the Western Washington 2005 Stormwater Management Manual (WDOE 2005b). Flow Control is designed to be consistent with natural predevelopment conditions. Ecology requires pretreatment of stormwater runoff before infiltration or discharge (USFWS and City of Arlington, pers. comm. 2009).

The Service expects that, the due to implementation of low impact development (LID) techniques (considered beneficial) and the amount of infiltration and pretreatment that is proposed, the stormwater design will not cause or contribute to measurable increases in peak flows or water quality. The Service expects that stormwater will not have a measurable effect on surface water temperatures (given the seasonality of storm events), and will not degrade thermal refugia within the action area. Related effects to bull trout, their habitat, and prey base will not be measurable in the short- or long-term and are therefore considered insignificant.

Bull Trout Exposure Analysis

Timing and Duration of Exposure in the Action Area

The action area provides foraging, migration, and overwintering habitat for bull trout. As such, individuals may be present in the action area throughout the year, and for extended periods of time when water temperatures are suitable. Bull trout that migrate upstream to spawn will move through the action area between the end of May and September to reach spawning grounds in the upper North and South forks of the River. Since bull trout, unlike salmon, will remain in an area and feed during migration, their presence in the action area may be influenced by the availability of prey and the quality of the habitat.

A number of salmon stocks utilize the Stillaguamish River and provide prey for bull trout. Salmon and steelhead spawn in the mainstem between September and December and again from March to June, depending on the stock. Chinook spawn in the project area, from August to November (ESA Adolphson 2008b, p. 26) and bull trout may be diverted from their upstream migration and remain in the project area during the duration of salmon spawning to feed on eggs. Salmon also rear in the action area, providing a source of prey for overwintering subadult and adult bull trout that remain for an extended period of time before moving down to marine waters.

In the Skagit River system, anadromous bull trout make migrations as long as 195 kilometers (121 miles) between marine foraging areas in Puget Sound and headwater spawning grounds, foraging on salmon eggs and juvenile salmon along their migratory route (WDFW 1997b). In the Wenatchee River, radio-tagged bull trout moved downstream after spawning to the locations of spawning Chinook and sockeye salmon and held for a few days to a few weeks, possibly to prey on dislodged eggs, before establishing an overwintering area downstream or in Lake Wenatchee (USFWS 2004b). In the Stillaguamish Core Area, five of the seven salmon stocks spawn in the mainstem River (Figure 2) and four of those spawn in the Action Area.

It is very likely that bull trout in the Stillaguamish River behave in the same manner as observed in other areas, such as the Skagit and Wenatchee. Given the level of salmon spawning in the action area, it is possible that migrating bull trout will remain for a few days to a few weeks (as they do in the Wenatchee River).

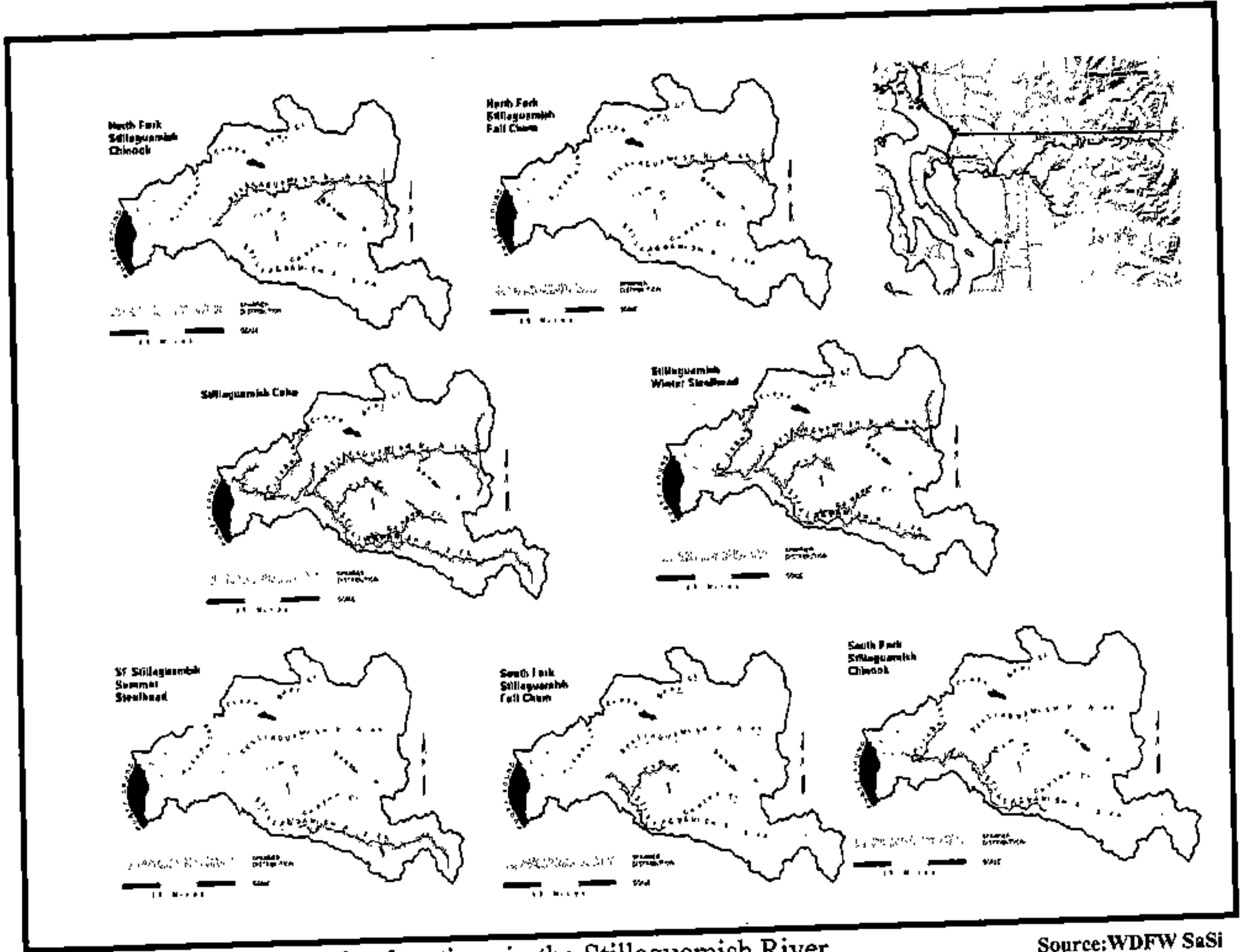

Figure 2. Salmon Spawning locations in the Stillaguamish River

Source:WDFW SaSi

Stream temperature is a limiting factor for fish (salmon and bull trout) migration. River temperatures can create a migration barrier if they are elevated above 20° C. These temperature levels have been measured in the Stillaguamish River in July and August in recent years. Consequently, bull trout that have not migrated upstream in late May and June may avoid the action area until temperature levels have dropped, most likely not before September. Adults move back downstream after spawning and both adults and subadults may be present in the action area any time that thermal conditions are suitable and prey resources are available.

Timing and Duration of Exposure in the Mixing Zone

Bull trout are likely exposed to the effluent on their upstream migration assuming they move up River with spawning salmon when water temperatures are suitable, and Chinook do indeed spawn in the project area as presented in ESA Adolphson 2008 (2008b, p. 26). We assume that bull trout will likely spend a greater amount of time in the action area during their downstream migration because such movement often coincides with salmon spawning.

The predictions of chemical concentrations in the mixing zones were developed using low flow (7Q10 and 7Q20) levels. These are clearly worst case scenario water levels used by Ecology to conservatively establish mixing zone boundaries, and determine a reasonable potential to exceed water quality criteria. We used these same parameters in our analysis in order to conservatively predict the potential for adverse effects to listed species. This conservative approach is tempered by considering surface water temperatures during these low flow periods. Bull trout and salmon are restricted in their movements when water temperatures are elevated (greater than 21 °C). We assume that during these low flow periods (when concentrations in the mixing zones are at their highest) that there is a lower likelihood of bull trout and salmon being present due to elevated water temperatures. Therefore, we have included the November to April (7Q20) flows in our analysis (Tables 8 and 9), as although these are low flow periods, they are winter low flow periods and we assume that water temperatures would not be elevated and fish would be present.

Bull trout are currently exposed to the mixing zone when they travel along the right bank of the River (Figure 3). The existing discharge is into the mainstem of the Stillaguamish River approximately 500 ft below the confluence of the north and south Forks in the thalweg (deepest part) of the channel. This area tends to be along the right (north) bank of the River. The outfall is approximately 4.11 ft below the surface and terminates approximately 45 ft south of the thalweg of the River. The single port outfall is approximately 50 ft from the left bank (north). It was demonstrated in the dye tracer study and hydrodynamic modeling that the effluent plume doesn't contact the river banks within the chronic mixing zone under the low flow conditions that occurred at that time.

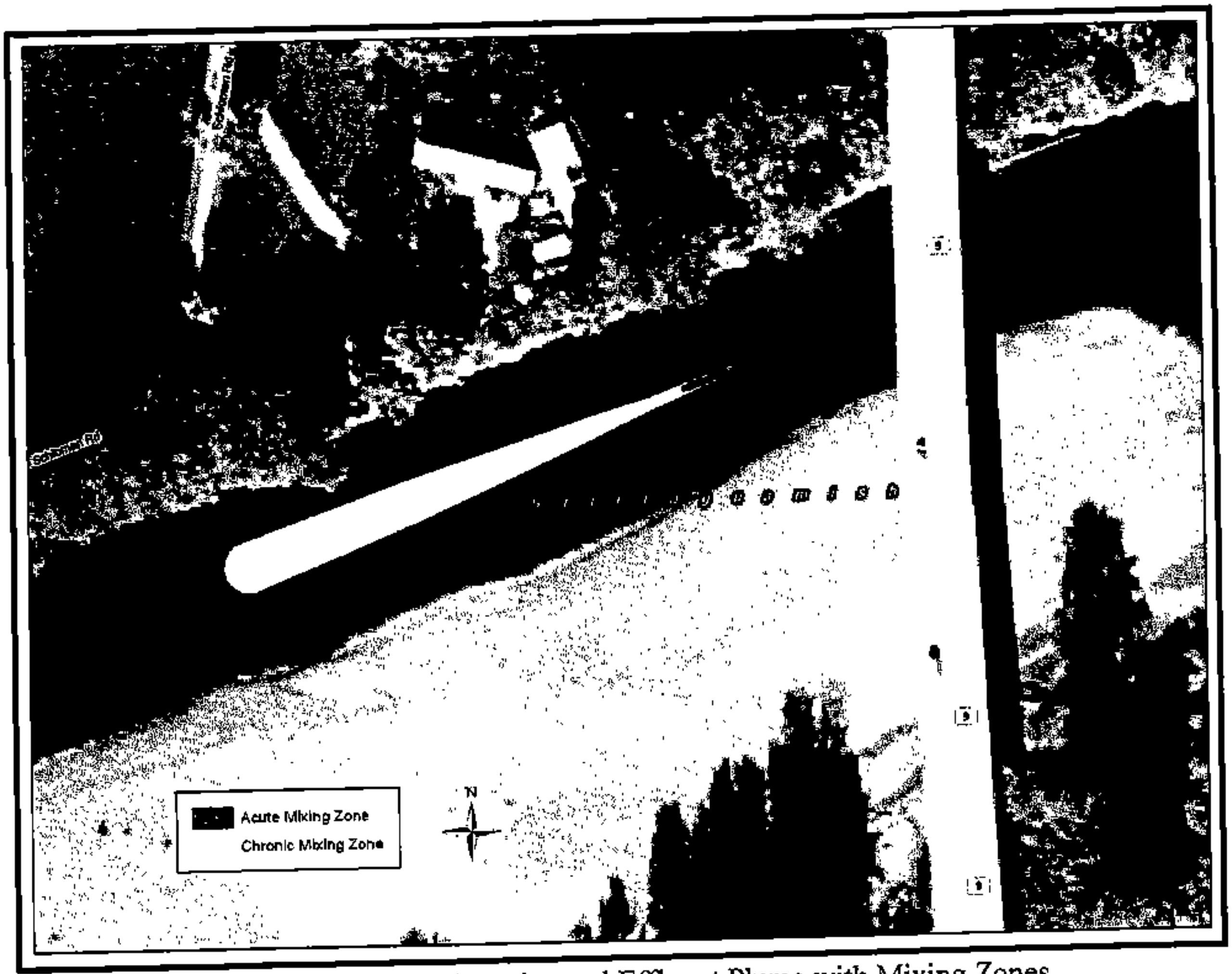

Figure 3. Approximate Discharge Location and Effluent Plume with Mixing Zones

The length of the chronic mixing zone (parallel to the shoreline) is 304 ft from the outfall port in the downstream direction. Water quality standards (WAC 173-201A-400 Mixing Zones, Subsection (7)(a)(i)) allow (chronic) mixing zone to extend upstream for a distance of 100 ft. Subsection (8)(a)(i) limits the acute mixing zone to less than 10 percent of the allowed mixing zone distance towards the upstream or downstream boundaries. Because there is no tidal effect/reversal in the River at Arlington, it is unlikely that the plume would travel upstream for more than a few feet (Dawda, pers. comm. 2009).

The maximum width of the chronic mixing zone is 30 ft (at the 304 ft mark) (Figure 3). The River is approximately 120 ft wide during low flows. Based on the maximum allowable extent of the mixing zone, bull trout that are migrating up River in presumably the deepest part of the channel (to remain in the coolest waters) are exposed to the highest concentrations of effluent. Individuals that are traveling along the north bank or midstream can currently utilize more than 45 ft of the channel without encountering the margin of the mixing zone. The area between the south bank and the plume is shallower (Figure 3) and bull trout would likely avoid this part of the channel.

Bull trout that are migrating upstream during low flow periods will be more frequently exposed to the effluent plume as it overlaps with the deepest part of the River. This is because bull trout will likely utilize the deepest part of the channel to avoid elevated water temperatures that are more common in the late summer. Depending on the surface water temperatures we wouldn't expect bull trout to remain in the action area or near the mixing zone for more than a few days during this warm time of year.

Stressors

Stressors are considered to be any physical, chemical, or biological effect on the environment resulting directly or indirectly from the proposed action, per the Service's advanced section 7 training curriculum (USFWS 2004a). Stressors, as used in the context of this analysis, may result in positive, negative, or neutral effects. The subsequent analysis will identify and characterize stressors associated with the proposed action.

As identified previously, most stressors from the proposed action are associated with changes in water quality. Water quality is routinely impacted by WWTP discharge. The remainder of this Opinion will focus on an analysis of exposure and effects on bull trout and their prey from changes to water quality from the WWTP effluent discharge.

Water Quality

Water quality will be both directly and indirectly affected by the proposed action, and these effects can be both beneficial and detrimental. The long-term effects of the action are largely beneficial due to improvement in water quality by the increased level of treatment of the wastewater effluent, implementation of LID building techniques, and stormwater infiltration. However, the facility upgrades are being conducted in response to anticipated growth in Arlington, and this increase in population will result in a doubling of the amount of effluent that will be discharged into the River as well as an increase in the amount of biosolids that are generated at the WWTP. These increases in waste material are anticipated to result in detrimental effects to the aquatic environment.

Wastewater Discharge

Measurable effects to bull trout are anticipated from this aspect of the proposed action. Wastewater contains trace amounts of numerous chemicals found in a variety of products that are disposed of via the sewer system and industrial discharges. Additionally, application of biosolids in areas adjacent to rivers and streams that are habitat for bull trout could result in indirect exposure to contaminants that may leach from biosolids and be transported into adjacent water bodies during rain events. Leaching of chemicals from biosolds is more prevalent in fall and winter when the microbial community, which usually breaks down organic chemicals, is dormant due to lower soil temperatures.

Wastewater effluent has been implicated as a source of endocrine disrupting chemicals (EDCs), pharmaceuticals and personal care products (PPCPs), persistent, bioaccumulative and toxic chemicals, polybrominated diphenyl ethers, and other compounds of anthropogenic origin in surface waters of the United States and Europe (Huang et al. 2001; Lazorchak and Smith 2004; Lee et al. 2000; Molnar et al. 2000), including Washington State (Jack and Lester 2007; Kolpin et al. 2002; Lester et al. , 2004). Wastewater effluents may also contain fragrances or musks which are common ingredients in perfumes, lotions and cosmetics.

The chemical groups listed above include antibiotics, reproductive steroids, anticoagulants, cholesterol medication, pain relievers, fire-retardants, antimicrobials, and other compounds. Some of the chemical groups identified in wastewater (EDCs and PPCPs) have been coined "emerging" since many have only recently been measured due to improved analytical methods with greater sensitivity (Daughton and Ternes 1999; Desbrow et al. 1998; McQuillan et al. 2000). There are currently no regulatory requirements for testing these emerging chemicals, although research has shown them to be frequently detected in rivers, lakes and streams (Table 5).

Table 5. Summary Statistics for EDCs detected in surface waters in King County, Washington (µg/L unless otherwise noted)

Chemical	**N**	**FOD**	**Max**	**Mean**	**Min MDL**	**Max MDL**
BenzylButyl Phthalate	37	2.7	0.011	0.01	0.0095	0.54
Bis(2-ethylhexyl)adipate	51	13.7	1.02	0.6	0.0094	0.19
Bis(2-ethylhexyl)phthalate	19	100	15.8	3.9	0.0094	0.054
Bisphenol-A	98	25.5	0.934	0.08	0.0094	0.19
Diethyl Phthalate	39	12.8	0.55	0.2	0.0095	0.54
Dimethyl Phthalate	97	11.3	0.022	0.02	0.0094	0.54
Di-N-Butyl Phthalate	34	2.94	0.31	0.31	0.24	0.54
Di-N-Octyl Phthalate	96	34.4	0.68	0.09	0.0097	0.54
Estradiol (ng/L)	184	35.9	1.1	0.4	0.2	20
Ethynylestradiol (ng/L)	183	26.2	4	00.64	0.3	30
Total 4-Nonlyphenol	130	016.2	0.836	0.19	0.019	0.19

From Jack and Lester, 2007

FOD: Frequency of Detection; MDL: Method detection Limit; N: The number of samples without blank quantification

Traditional secondary wastewater treatment does not completely remove many of these chemicals, and they are applied to agriculture lands as biosolids or discharged to receiving water bodies in the effluent. The types of treatment technologies that have proven effective at removing a majority of these compounds include ozonation and granulated or powdered activated carbon (EPA (U.S. Environmental Protection Agency) 2001; Ternes et al. 2003). These more advanced treatment processes are more costly and are primarily used in the treatment of drinking water.

Efficacy of the Proposed Wastewater Treatment Process

The treatment technology that will be utilized in the new WWTP includes MBR, biological nutrient removal (BNR) and UV radiation. The application of these technologies should result in enhanced removal efficiencies. The removal efficiency of a compound depends on many factors including its molecular weight, chemical structure, polarity (polar compounds are removed more efficiently by traditional secondary treatment) and solids retention time (SRT) in the treatment system.

Membrane Bioreactor Technology - MBR treatment has been shown to be very effective at removing suspended solids and total organic carbon, and therefore will be effective at removing chemicals that adsorb to these materials. Compounds with high solubility (such as pharmaceuticals) are more recalcitrant and their ability to move through the membranes depends on their size and structure and the SRT of the treatment system among other factors (Hu et al. 2007, p. 4099). The optimum SRT for removal of many compounds is 5 to 15 days with little additional removal by MBR (Oppenheimer and Stephenson 2006).

The behavior and fate of pharmaceutically active compounds (PhACs) is very complex in MBRs. Some of these compounds may enter the system as conjugates (metabolized form) only to be de-conjugated back to the original compound in the MBR (Hu et al. 2007, p. 4097; Panter et al. 1998). The concentration of another potent EDC nonylphenol (banned in Canada), can be amplified in MBRs through transformation of its parent compound (Hu et al. 2007, p. 4097).

Kimura et al. (2005) evaluated the effectiveness of removing PhACs using MBR. They examined the removal efficiency of MBR on four anti-inflammatory and one blood lipid regulator. The results of this study indicate that the removal efficiency depends on the presence of chlorine and the number or aromatic rings (Kimura et al. 2005, p. 138). PhACs with chlorine are not effectively removed by either conventional activated sludge; standard secondary treatment) or MBR. More complex compounds (having two or more aromatic rings) were not easily broken down in the conventional activated sludge but due to the higher SRT in the MBR these compounds were effectively degraded.

Hu et al. (2007) also investigated the removal efficiency of MBR for other known endocrine disrupting compounds and evaluated the overall estrogenicity of the mixture by summing the concentrations of the individual EDCs in the mixture. This is a logical approach when the mode of toxic action of the chemicals under investigation is the same (e.g. estrogenecity). This is commonly done with polychlorinated biphenyls and dioxin congeners using a toxic equivalency approach. The groups of compounds Hu et al., (2007) investigated included hormones (estrone and 17β estradiol), bisphenol-A (plasticizer) and nonlyphenol (non-ionic surfactant). The study found the removal efficiencies of MBR technology for these groups of compounds to be 68 to 80 percent, 69 to 90 percent and an increase to 440 percent, respectively. Hu et al., (2007, p. 4099) also found that removal efficiency was enhanced by SRT and the removal efficiencies for BPA and 4-nonlyphenol were increased by 10 to 20 percent using MBR with longer SRT (17 and 33 days).

Biological Nutrient Removal - The traditional treatment technologies widely used to treat municipal wastewater do not effectively remove many pharmaceuticals and PPCPs. However, it has recently been shown that enhanced BNR is effective at reducing a significant portion of the PPCPs contained in effluent from WWTPs (USEPA 2008, p. 82). The city is incorporating BNR along with MBR in their treatment train. This combination should effectively reduce the discharge concentrations of pharmaceuticals and PPCPs in the effluent.

A myriad of chemicals are present in wastewater effluent. The ability to remove these chemicals varies greatly, depending on the treatment technology, as well as the characteristics of the chemicals themselves. Because the current treatment technology is insufficient to remove many of these chemicals from the waste stream, they are ultimately transported to the aquatic environment. Due to the biologically active nature of the pharmaceuticals and EDCs, they have been shown to interact with the physiological systems of aquatic organisms at low part per billion concentrations. The base of knowledge on effects from exposure to aquatic species is relatively narrow but increasing, due to widespread exposure of aquatic species to these chemicals from wastewater, stormwater and other point and non-point discharges and the potential for effects on overall species health and biodiversity.

The proposed action to upgrade the WWTP to MBR and BNR should enhance the removal of many of the compounds listed above and is an improvement over the current treatment method. The removal efficiencies for these technologies should result in better water quality in the Stillaguamish River. However, some contaminants will still be present in the waste stream and the amount of chemicals that are discharged into the River will increase as the population in the service area of the WWTP increases. Complete removal (if possible) can only be done with additional measures such as including activated carbon (granulated or powdered), ozonation, reverse osmosis or some other form of ultrafiltration.

Dissolved Oxygen and Surface Water Temperature

The Stillaguamish River is on the 303(d) list for dissolved oxygen and temperature. It is unclear to what extent the WWTP contributes to degradation of water quality in the River for these parameters. In their 2004 TMDL study, Ecology attempted to determine the loading capacities for phosphorus, BOD ammonia and nitrogen for the River between Arlington and Interstate 5. They conducted a QUAL2Kw model to simulate the effects of carbon, nitrogen and phosphorus loads on DO under low-flow conditions. The nutrient and BOD loads from the Arlington WWTP and nonpoint sources were varied to compare their effects on DO changes on downstream reaches. The model simulation demonstrated that minimum DO concentrations at RM 20 (The WWTP is located at RM 17.7) were far lower than DO observed in recent field surveys. However, even simulations of natural background showed DO concentrations below the water quality criteria (8.0 mg/L).

We acknowledge that the baseline is degraded and that there is likely no significant difference in the DO levels with or without the WWTP discharge, as depicted in the Figure 4 prepared by the (USFWS and City of Arlington, pers. comm. 2009). Ecology acknowledges that when background DO levels are below the criteria, then the background level becomes the criteria (WDOE 2004, p. 102). They further state that the Arlington WWTP and other nonpoint discharges will continue to reduce the DO by at least 0.2 mg/L, which would not meet the water quality criteria. However, the margin of error in their simulation is too large to determine if the 0.2 mg/L is a significant additional loss compared to background. The model simulation predicts a potential minimum DO concentration of 6.9 to 7.2 at RM 21.7. Therefore, a minimum DO concentration of 7 mg/L should be attainable under critical conditions (e.g. low flow period) if upstream, nonpoint source and point source nutrient inputs are manager and controlled to protect beneficial uses.

An improvement in the DO levels recommended by Ecology would be in line with improvements recommended by the Stillaguamish Technical Advisory Group, (2000 as cited in (WDOE 2004, p.29). Fisheries scientists have recommended numerous habitat and channel improvements to promote salmon recovery in the Stillaguamish basin. Channel sedimentation, increased peak flows, extreme low flows, elevated temperatures, and reduced dissolved oxygen were identified as problems in the basin.

Under low DO conditions, the increase in loading of organic material from the treatment plant will not dissipate as quickly. This is because the organisms that break down these materials require oxygen. Therefore, the combination of low DO and increasing discharge between Phase I and Phase II will likely result in farther movement downstream of the organic material in the effluent.

Temperature and DO are inextricably linked. The solubility of oxygen is greater in cold water than in warm water. During the summer months, water temperatures are elevated according to the data collected by Ecology at Arlington (Table 6).

Table 6. Season Temperature in the Stillaguamish River at Arlington

Year	**Constituent**	**Criterion**	**Deployment**		**max 7-day mean**		**ITS**[b]
			Daily Max	Date/Time[a]	max	Date[a]	
2004	Water Temp	18	25.3	7/29/2004 6:30:00 PM	24.5	8/16/2004	80.6
2003	Water Temp	18	26.1	7/30/2003 7:00:00 PM	24.9	7/29/2003	0
2002	Water Temp	18	21.68	8/14/2002 7:00:00 PM	20.9	8/14/2002	20.9
2001	Air Temp	NA	29.72	8/10/2001 4:31:04 PM	26.8	8/11/2001	NA
2001	Water Temp	18	23.47	8/12/2001 6:00:26 PM	22.6	8/12/2001	

There may be other dates with the same maximum. Only the first date is shown for any given year.[b] The "Index of Thermal Stress" (ITS) is the number of degree-days temperature exceeded the criterion. The criteria became more restrictive in 2007 so ITS numbers before and after this are not comparable. All data are used so deployments with different lengths may not be comparable[4].

According to the predicted temperature data calculated using dynamic temperature simulation modeling, the temperature of the effluent ranges between 20 °C to 23 °C for the months of July, August and September (ESA Adolphson 2008b, p. 33). These temperatures are consistent or slightly below the maximum temperatures listed in Table 6 above. During the late summer, River temperatures are high and the difference between the temperatures of the effluent relative to the River temperatures is relatively low. However, the temperature of the effluent would likely be higher than the temperature of the River in the winter and spring. At these times, the temperature within the mixing zone would be elevated relative to the background temperatures of the receiving water body. It is at this time of the year when the elevated surface water within the mixing zone would create a thermal plume affecting bull trout behavior.

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[4] http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=temperature&scrolly=0&wria=05&sta=05A090

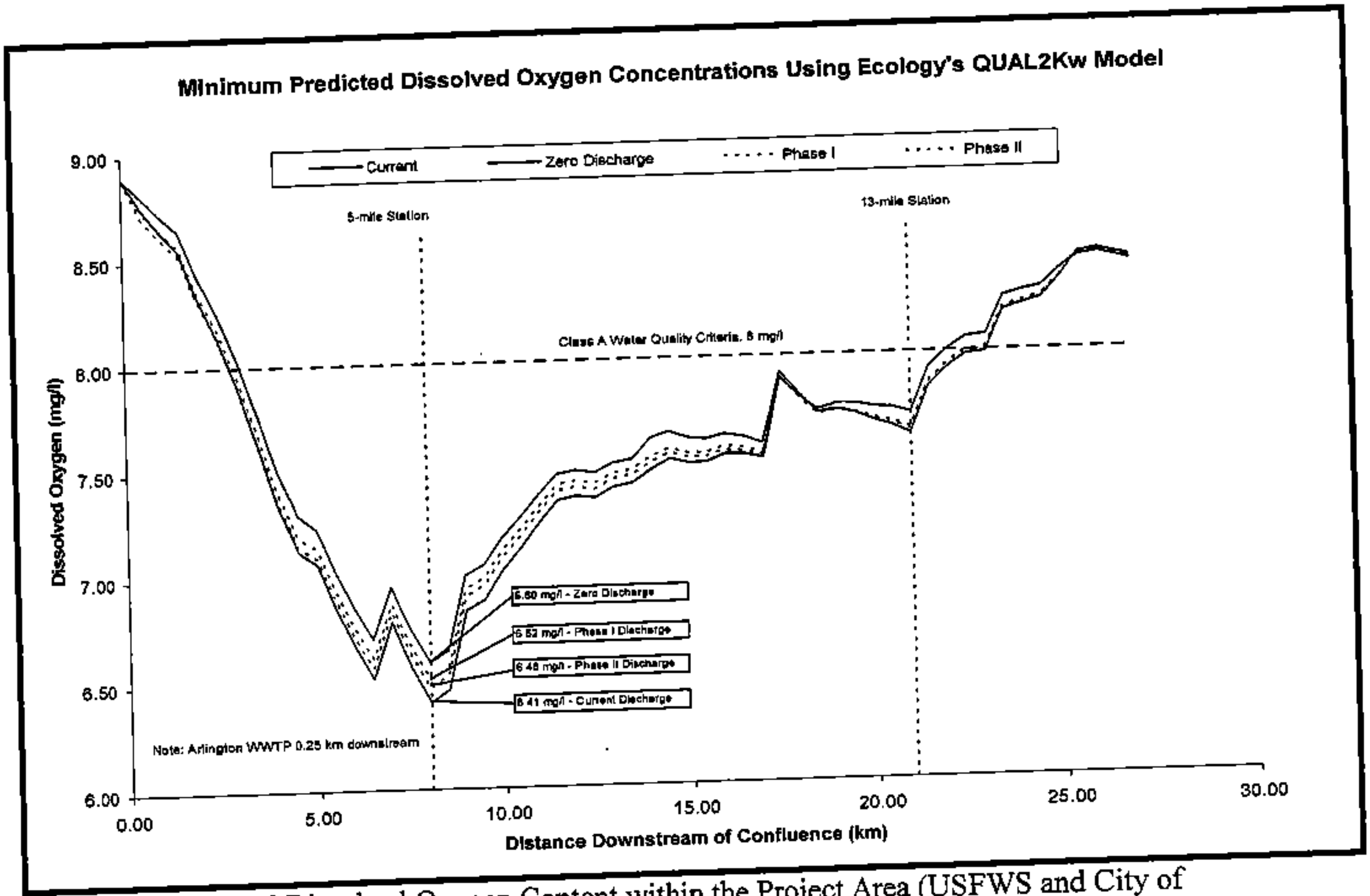

Figure 4. Estimated Dissolved Oxygen Content within the Project Area (USFWS and City of Arlington, pers. comm. 2009) (Attachment D)

Analytical Approach for Effluent Effects

It is not possible for the Service to evaluate the effects of all the chemicals anticipated to be in the Arlington WWTP effluent. No testing is required for the unregulated chemicals. Therefore, no data exist with which to predict the potential for adverse effects to bull trout. Even if monitoring data were available, toxicity data is lacking for most of the chemicals, particularly data that are based on ecologically relevant surface water concentrations and endpoints. A database containing significant information on pharmaceutical is available (Cooper et al. 2008), but the toxicity data for aquatic species was generated using part per million concentrations, orders of magnitude higher than the concentrations that exist in aquatic systems. Additionally, the toxicity data were generated for acute endpoints, and effects tend to occur at the sublethal levels, with subtle changes in behavior and reproduction not overtly apparent to the researcher who is only evaluating mortality.

Given the limitations of the available monitoring and toxicity data, we were only available to evaluate the effects of a subset of chemicals present in surface water due to stormwater and WWTP effluent. We conducted a preliminary exposure analysis in order to characterize the composition of the future wastewater effluent and estimate the chemical concentrations to which bull trout may be exposed. The purpose of this preliminary analysis was to generate data for an exposure assessment, which coupled with the effects assessment, was used to determine whether exposure to contaminants anticipated being present the Arlington WWTP effluent will result in adverse effects of bull trout.

We used information that was available from the literature to identify the chemicals and concentrations anticipated to be in the waste stream with future MBR treatment. We collected information on those chemicals which have been detected in WWTP effluent (Table 7). All of the data in Table 7 were generated from MBR facilities. Some facilities used Kubota membranes (Drewes et al. 2005; Joss et al. 2004; King County 2004b, 2005) which are consistent with the planned treatment process for Arlington. All units utilized BNR and a solids retention time of at least 10 days. Because these test parameters are consistent with the treatment system being proposed for the Arlington WWTP, we would expect similar results. The pharmaceutical data in Table 7 was also generated using US Filters (Snyder et al. 2006), and Mitsubishi-Rayon Filters with a SRT of 15 days (Kimura et al. 2005). The performance of these filters may be somewhat different than Kubota membranes, but because they were the only data we could obtain for pharmaceuticals we used them in this analysis. The SRT in these two studies was of a similar duration as anticipated for the Arlington WWTP, and since SRT is such an important factor affecting removal efficiency of organics we considered these data to be suitable.

We used these measured MBR effluent concentration data with the critical dilution ratios from ESA Adolphson (2008b, p. 5-4) to estimate the exposure concentration in the acute and chronic mixing zones during the May to October and November to April timeframes (Tables 8, 9 and 10). Dilution ratios were obtained from the modeling conducted by Ecology for the reasonable potential to exceed calculations to develop NPDES permit limits through to 2025 (ESA Adolphson 2008b, p. 5-4). Two sets of dilution ratios were used: 1) the maximum allowable dilution ratio, which is the more stringent of the two allowed by the regulation (WAC 173-201A), and 2) the centerline dilution ratio, which is the estimated dilution in the center of the effluent plume in the receiving water, where the effluent concentration is greater than the rest of the plume. These dilution ratios were used to model the condition by 2025, at which time it is anticipated that the effluent flow will double. Where available we used maximum effluent concentrations, but more frequently we used the mean, which defines both sets of dilution levels to consider a more and less conservative exposure scenario (Tables 8 and 9).

We evaluated the concentrations of chemicals in both the acute and chronic mixing zones at annual (7Q10), May through October and the November through April (7Q20) time periods.

Bull trout that enter the mixing zone will be exposed to contaminants in the effluent. The concentration of the contaminants will vary within the plume, with the highest values closest to the end of the pipe. According to the dye tracer study (ESA Adolphson 2008b, p. 4-5), the 30 ft centerline profile shows an incomplete degree of vertical mixing. Within 50 ft of the outfall the effluent volume fraction profile showed that complete vertical mixing had still not occurred, and the plume centerline was still apparent at mid-depth. The plume had risen slightly higher and the greater effluent concentrations were observed (fluorometric analysis of the dyed effluent) near the surface. The dye tracer study showed that between 100 ft and 304 ft (the edge of the chronic mixing zone) complete vertical mixing was observed with the billowing nature of the plume less apparent.

According to the output of the 2025 CORMIX1 and RIVPLUM5 model runs, depending on the river conditions and the season (dry or wet), the approximate downstream distance to complete mixing ranges from 12,000 to 19,000 ft (ESA Adolphson 2008b, Appendix D).

Table 7. Chemicals and their Concentrations measured in other MBR Systems

	Chemicals	Source	Concentration (µg/L) (mean)
Trace Metals (total)	Arsenic	King County 2004	[illegible]
	Arsenic	King County 2005	1.5
	Cadmium	King County 2004	<0.5
	Cadmium	King County 2005	ND
	Chromium (total)	King County 2005	[illegible]
	Chromium (total)	King County 2004	0.5
	Copper	Current Project	[illegible]
	Copper	King County 2004	5.4
	Copper	King County 2005	4.3
	Lead	King County 2004	[illegible]
	Lead	King County 2005	0.3
	Mercury	King County 2005	ND
	Mercury	King County 2005	ND
	Nickel	King County 2004	3.0
	Nickel	King County 2005	[illegible]
	Silver	King County 2004	ND
	Silver	King County 2005	ND
	Zinc	Current Project	[illegible]
	Zinc	King County 2004[5]	46.6
Conventionals	Ammonia (mg/L)	King County 2004	[illegible]
	Ammonia (mg/L)	King County 2005	0.6[7]
Hormones	Estradiol	King County 2004	[illegible]
	Estradiol	King County 2005	0.003 (0.005 max)
	17β Estradiol	Joss et al., 2004[8]	<0.0005
	17β Estradiol	Drewes et al., 2005	<0.0006
	Estriole	Drewes et al., 2005	<0.0004[9]
	Estrone	Joss et al., 2004	0.003
	Estrone	Drewes et al, 2005	0.006
	Ethynylestradiol	King County 2004	[illegible]
	Ethynylestradiol[2]	King County 2005	0.0008 (0.002 max)
	17–α–Ethynylestradiol	Joss et al., 2004	<0.0005
	17–α–Ethynylestradiol	Drewes et al 2005[10]	<0.0007

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[5] Did not report results from King County (2005) as they had interference from zinc leaching from pipes so values were artificially elevated

[6] This value was generated during regular operation of the MBR the startup concentration was 2.6 mg/L due to acclamation of nitrifying organisms (USFWS 2004b)

[7] 90 percentile

[8] MBR plus biological nutrient removal

[9] Analysis by ELISA method

[10] Study closely matched the proposed treatment technology: Kubota membranes, BNR, SRT

Values in blue highlight were used in the exposure calculations

	Chemicals	Source	Concentration (µg/L) (mean)
	Tetosterone	Drewes et al., 2005	<0.005[6]
Detergent Metabolites			
	4-Nonylphenol	King County 2004	<0.24
	4-Nonylphenol	King County 2005	<0.24
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
Plasticizers	Benzyl Butyl Phthalate	King County 2004	0.36
	Benzyl Butyl Phthalate	King County 2005	[illegible]
	Bis(2-ethylhexyl) Phthalate	King County 2004	1.19
	Bis(2-ethylhexyl) Phthalate	King County 2005	[illegible]
	Diethyl Phthalate	King County 2004	[illegible]
	Diethyl Phthalate	King County 2005	<0.25 (<0.28 max)
	Bis(2-ethylhexyl) adipate	King County 2004	0.29
	Bis(2-ethylhexyl) adipate	King County 2005	<0.28 (0.38 max)
	Bisphenol A	Drewes et al., 2005	0.011
	Bisphenol A	[illegible]	[illegible]
Pharmaceuticals			
	[illegible]	[illegible]	[illegible]
	Diclofenac	Snyder et al 2006[11]	<0.01
	Fluoxetine	Snyder et al 2006	<0.01
	Gemfibrozil	Snyder et al 2006	<0.01

Note: many more chemicals are found in wastewater treatment plant effluent. The list includes those for which fish toxicity information is available.
Shaded chemicals/concentrations used to calculate the Estrogenic Equivalency Quotient (EEQ) in Table 2.
ND; Not detected

Table 8. Predicted Surface Water Concentrations using Effluent Data from the Literature and Maximum Allowable Dilution Ratios

		Effluent Concentration	Annual 7Q10		May-Oct 7Q20		Nov - April 7Q20	
		µg/L	Acute	Chronic	Acute	Chronic	Acute	Chronic
Constituents								
Metals								
	Arsenic	2	1.82	0.14	1.67	0.12	1.05	0.081
	Chromium (Total)	0.5	0.45	0.003	0.42	0.03	0.26	0.020
	Copper	[illegible]	[illegible]	0.57	[illegible]	0.46	[illegible]	0.32
	Lead	0.6	0.54	0.04	0.5	0.035	0.32	0.024
	Nickel	3	2.73	0.21	2.50	0.17	1.58	0.12
	Zinc	[illegible]	[illegible]	3.7	[illegible]	3.01	[illegible]	2.11
Conventional	Ammonia	[illegible]	[illegible]	[illegible]	[illegible]	34.7	[illegible]	24.3
Endocrine Disruptors	Ehtynylestrdiol		9.09E-04	7.09E-05	8.33E-04	5.78E-05	5.26E-04	4.05E-05
	Estradiol	0.001	4.55E-03	3.55E-04	4.17E-03	2.89E-04	2.63E-03	2.02E-04
	Bisphenol-A	0.005	0.27	0.021	0.25	0.017	0.16	0.012
	Nonylphenol	0.3	0.58	0.045	0.53	0.037	0.34	0.026
	Octylphenol	0.64	0.12	9.6E-03	0.11	7.8E-03	0.07	5.47E-03

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[11] MBR by US Filters

		Effluent Concentration	Annual 7Q10		May-Oct 7Q20		Nov - April 7Q20	
	BenzylButylPhthalate	0.135	0.5	0.04	0.45	0.03	0.28	0.022
	Bis(2-ethyl)hexyl Phthalate	0.54	1.65	0.13	1.51	0.10E-01	0.95	0.073
Total EEQ (max ng/L)		[illegible]	[illegible]	0.44	[illegible]	0.36	[illegible]	0.25
Total EEQ (mean ng/L)		[illegible]	[illegible]	0.78	[illegible]	0.64	[illegible]	0.45
Pharmaceutical	Diclofenac	0.15	0.14	0.01	0.12	8.67E-03	0.08	6.07E-03

Blue Highlight indicates constituents that exceed toxicity benchmarks.

Table 9. Predicted Surface Water Concentrations using Effluent Data from the Literature and Center line Dilution Ratios

Constituents		Effluent Concentration	Annual 7Q10		May-Oct 7Q20		Nov - April 7Q20	
		µg/L	Acute	Chronic	Acute	Chronic	Acute	Chronic
Metals	Arsenic	2.0	0.25	0.1	0.25	0.08	0.253	0.066
	Chromium (Total)	0.5	0.06	0.02	0.06	0.02	0.063	0.016
	Copper	8.0	0.99	0.39	1.0	0.31	1.0	0.27
	Lead	0.6	0.07	0.03	0.076	0.02	0.076	0.020
	Nickel	3.0	0.37	0.15	0.38	0.11	0.379	0.100
	Zinc	[illegible]	[illegible]	2.27	5.89	1.8	5.89	1.55
Conventional	Ammonia	600	[illegible]	29.2	75.9	23.0	75.9	20.0
Endocrine Disruptors	Ehtynylestrdiol	0.001	1.23E-04	4.878E-05	1.27E-04	3.85E-05	1.27E-04	3.3E-05
	Estradiol	0.005	6.17E-04	2.439E-04	6.33E-04	1.92E-04	6.33E-04	1.67E-04
	Bisphenol-A	0.3	0.037	0.0146	0.038	0.011	0.038	0.010
	Nonylphenol	0.64	0.079	0.0312	0.081	0.025	0.081	0.021
	Octylphenol	0.13	0.017	6.585E-03	0.017	5.2E-03	0.017	4.5E-03
	BenzylButylPhthalate	0.54	0.667	0.0263	0.068	0.02	0.068	0.018
	Bis(2-ethyl)hexyl Phthalate	1.81	0.223	0.0883	0.229	0.07	0.229	0.060
Total EEQ (max ng/L)		[illegible]	0.77	0.3	0.79	0.24	0.79	0.21
Total EEQ (mean ng/L)		[illegible]	[illegible]	0.54	1.29	0.42	1.19	0.37
Pharmaceutical	Diclofenac	0.15	0.018	7.317E-03	0.019	5.77E-03	0.019	5.000E-03

Table 10. Predicted Estrogenicity of the WWTP Effluent

Constituent	Maximum Concentration (µg/L)	Mean Concentration (µg/L)	Maximum Potency Factors	Maximum EEQ	Mean Potency Factors	Mean EEQ
Ethynylestradiol	0.002	0.001	1.93	0.004	1.62	0.0016
Estradiol	0.005	0.003	1	0.005	1	0.003
BisA	0.3	0.3	0.0015	0.0009	0.002	0.0007
Nonlyphenol	0.64	0.64	0.003	0.0008	0.001	0.0007
4-Tert-Octylphenol	0.135	0.135	0.0013	0.0002	0.001	0.00017
			Total Max EEQ	**11.0 ng/L**		
					Total Mean EEQ	**6.2 ng/L**

Response Analysis

We estimated the concentrations of a number of constituents anticipated to be present in the effluent. We then compared these concentrations to the toxicity data to determine if the levels we predicted to be present in the acute and chronic mixing zones would elicit adverse effects in bull trout (Tables 12 and 13). Of the constituents we analyzed only ammonia, copper, zinc and total EEQ (sum of all chemicals with a common mode of action, endocrine disruption) were elevated relative to the toxicity levels. The other constituents were not anticipated to be present at concentrations (on an individual basis) that would elicit adverse effects on bull trout. Therefore, only ammonia, copper, zinc and endocrine disrupting chemicals were evaluated.

The following sub-sections address these effects: 1) existing functional impairments are a source of adverse effects to bull trout, their habitat, and their prey base, 2) improvements in water quality may still result in adverse effects from predicted presence of some constituents in the effluent plume, and 3) some effects to bull trout and their prey can be reasonably assumed and are expected to result in adverse sub-lethal effects and/or significant disruption of normal bull trout behaviors (i.e., ability to feed, move, and/or shelter).

Ammonia

Urban (e.g stormwater) runoff and agricultural and wastewater discharges are significant sources of ammonia in aquatic systems. Toxicity is expressed as total ammonia (NH_3 and NH_4^+) and increases with water pH. Ammonia toxicity is manifested in convulsions and death (Randall and Tsui 2002). The mode of action of ammonia toxicity is thought to occur because "…elevated NH_4^+ displaces K^+ and depolarizes neurons, causing excessive activation of NMDA (amino acid) type glutamate receptor, which leads to the influx of excessive Ca^{2+} and subsequent cell death in the central nervous system" (Randall and Tsui 2002).

All organisms, including fish excrete ammonia as metabolic waste to avoid accumulation in the tissues. Fish excrete NH_3 over the gills as long as a concentration gradient is present (Wicks et al. 2002). Elevated ammonia concentrations in surface water either reduce ammonia excretion or cause an uptake of ammonia from the surrounding water. Depending on the species, some fish have the physiological mechanisms to cope with elevated ammonia levels and avoid ammonia toxicity. These mechanisms include: 1) converting ammonia to less toxic substances, 2) reducing internal ammonia production, 3) volatilizing NH_3 through facultative air breathing (coming to the surface for air), and 4) excretions of ammonia ions. Species that have these abilities include goldfish (*Caurassius auratus*), common carp (*Cyprinus carpio*), talipia (*Oreochromis alcalicus*), mudskippers (*Periophthalmodon schlosseri*) and (*Boleophthalmus boddaerti*), sleeper (*Bostrichthys sinensis*), marble goby (*Oxyeleotris marmoratus*), marine toadfish (*Opsanus beta*) and Indian air breathing fish (*Heteropneustes fossilis*) (Randall and Tsui 2002).

Rainbow trout (*Oncorhynchus mykiss*) have some ability to cope with elevated ammonia. They have been shown to reduce ammonia production in high pH (greater than 10) water, and they can excrete a portion of their ammonia burden in freshwater that is elevated in ammonia (Wilson et al., 1998 and Wilson and Taylor, 1992 as cited in Randall and Tsui 2002). However, we have no species-specific data to suggest whether or not bull trout would be more or less tolerant to elevated ammonia concentrations in the environment. Since bull trout and rainbow trout are in the same family (Salmonidae), we might expect that when the surface water pH is elevated, bull trout might also reduce ammonia production and consequently avoid toxic effects. The pH in the Stillaguamish River is approximately 7.0 (ESA Adolphson 2008b, p. 6-2). We don't expect this pH level to enhance the ability of bull trout to reduce ammonia production, and anticipate bull trout to have a similar ability to excrete ammonia as rainbow trout, thereby allowing them to tolerate higher in-situ ammonia concentrations in higher pH waters. Because the pH of the Stillaguamish River at Arlington is approximately 7.0, we do not expect it would ameliorate ammonia effects to salmonids (according to the literature).

Researchers have expressed concern about the adequacy of the EPA acute ammonia criteria to protect active or stressed fish (Randall and Tsui 2002; Wicks et al. 2002). The toxicity tests used to develop ammonia criteria were based on fish that were fed and were not stressed (relative to environmental stresses). In the wild, fish must increase active swimming to compete for prey. It is precisely when fish are stressed and swimming that they produce more internal ammonia which increases their susceptibility to ammonia toxicity (i.e., elevated ambient ammonia).

Wicks et al. (2002) investigated effects on swimming performance in coho salmon (*Oncorhynchus kisutch*) and rainbow trout exposed to sublethal levels of ammonia in water with a pH of approximately 6.0. They hypothesized that swimming intensifies ammonia toxicity in fish. In order to test swimming performance the fish were made to swim to exhaustion (as migrating salmon and bull trout would do). They found that that swimming performance was significantly reduced at concentrations of 0.04 and 0.08 mg/L NH_3. Interestingly, they showed that plasma ammonia levels in exercised fish were correlated with increasing ambient ammonia concentrations. The researchers reported only one mortality in the 0.08 mg/L treatment group. Wicks et al. (2002) conducted an acute 96 hr LC_{50} (pH 6.97) with rainbow trout exposed to ammonia concentrations bracketing the EPA water quality criteria to evaluate the effects of ammonia on resting and swimming fish. They demonstrated that the mortality rates for both swimming and resting fish increased linearly; the mortality rate increased more rapidly for swimming fish than resting fish; and the LC_{50} was 174.6 mg/L higher for resting fish. The

LC_{50}'s were 32.4 ± 10.81 and 207 ± 22 mg/L for swimming and resting fish, respectively. The EPA acute criteria for ammonia is 36 mg/L and is higher than the LC_{50} for swimming fish in this study, therefore according to Wicks (2002) this acute criteria will not be protective of swimming fish.

Based on the data in tables 8 and 9, levels of total ammonia in wastewater are elevated above threshold levels in the acute mixing zone during low flow regardless of season and it is elevated in the chronic mixing zone (annual 7Q10) only using the most conservative dilution levels (maximum allowable).

Salmon will begin spawning when flow increases and water temperatures drop. We do not know where Chinook spawn relative to the acute mixing zone, but as indicated in ESA Adolphson (2008b, p. 26) they spawn in the project area, and since the project area includes the effluent discharge pipe we assume it also includes the acute and chronic mixing zones.

The predicted future levels of ammonia in the acute mixing zones are elevated regardless of the time of year or dilution levels used (Tables 8 and 9). Ammonia levels are elevated in the chronic mixing zone during the annual low flow (7Q10), using the most conservative (maximum allowable dilution ratios) only. According to the literature these levels would result in decreased swimming ability in bull trout which could affect their ability to catch prey. This would result in a significant disruption to feeding behavior and constitute an adverse effect.

Dissolved Metals

There are three known physiological pathways by which salmonids may be directly exposed to and/or be affected by metals: 1) uptake of ionic metals at the gill surfaces (Niyogi et al. 2004), 2) dietary uptake, and 3) olfaction (sense of smell) involving receptor neurons (Baldwin et al. 2003). Of these three pathways, the mechanism of dietary uptake is least understood. For dissolved metals, the most direct pathway is through the gill surfaces.

Measurements of total recoverable metal concentration include a fraction that is bound to suspended solids and/or complexed with organic matter or other ligands. This fraction is not available to bind to gill receptor sites. As such, most metal toxicity studies have examined the dissolved metal fraction which is more bioavailable and therefore of greater significance for acute exposure and toxicity. However, metals bound to sediment remain biologically relevant. The sub-sections that follow examine the significance of the particulate bound (or complexed) fraction and total metal loadings.

The relative toxicity of a metal (or metal species) can be altered by hardness, water temperature, pH, organic content, phosphate concentration, suspended solid concentration, the presence of other metals or contaminants (i.e., synergistic effects), and other factors. Eisler (1998) and (Playle 2004) found that dissolved metal mixtures exhibit greater than additive toxicity. Water hardness affects the bioavailable fraction of metals; as hardness increases, metals become less bio-available for uptake at the gill surfaces and therefore less toxic (Hansen et al. 2002d; Niyogi et al. 2004).

Copper (Cu)

Even at low concentrations, Cu is acutely toxic to fish. Effects of Cu exposure include 1) weakened immune function and impaired disease resistance, 2) impaired respiration, 3) disruptions to osmoregulation, 4) impaired function of olfactory organs and brain, 5) altered blood chemistry, 6) altered enzyme activity and function, and 7) pathology of the kidneys, liver, and gills (Eisler 1998).

The acute lethality of copper has recently been evaluated for bull trout. Hansen et al. (2002d) demonstrated the difference in sensitivity between rainbow trout fry and bull trout fry (Table 11). They analyzed acute toxicity levels only and determined that the sensitivities of these two species are similar. The levels of copper that resulted in the 96-hour and 120-hour LC50 for bull trout under test conditions (100 mg/L hardness and 8 °C) were 66.6 and 50.0 µg/L, respectively. Sublethal effects have been observed in salmonids at concentrations at or below the water quality standards for Cu. These effects include avoidance responses in coho salmon (Baldwin et al. 2003) and rainbow trout (Folmar 1976) and increased cough rates in brook trout (Drummond et al. 1973).

Table 11. Documented Effects on Fish from Exposure to Ammonia and Trace Metals

Constituent Dissolved	***Species (age class tested)***	***Concentration (µg/L)***	***Exposure Duration***	***Effect***	***Reference***
Ammonia	Fathead minnows	30 and 38.4 mg/l	24 hrs	Total mortality	(Lazorchak and Smith 2004)
	Coho	0.04 mg/l	Swimming to exhaustion	Significant reduction in swimming performance	(Wicks et al. 2002)
Arsenic^{+3}	Chum salmon (*Oncorhynchus keta*) (age not reported)	11,000	48 hrs	LC_{50}^{1}	NAS 1977 *in* (Eisler 1988)
	Rainbow trout (*Salmo gairdneri*) (adult)	23,000 to 26,600	96 hrs	LC_{50}	Spehar et al. 1980 *in* Eisler 1988
	Rainbow trout (age not reported)	130	28 days	EC_{10}^{2} mortality	EPA 1985a *in* Eisler 1988
	Brook trout (*Salvelinus fontinalis*) (age not reported)	150	96 hr	LC_{50}	EPA 1985a *in* Eisler 1988
	Rainbow trout (age not reported)	970	28 days	LC_0	Spehar et al. 1980 *in* Eisler 1988
Cadmium	Bull trout (*Salvelinus confluentus*) (juvenile)	0.786	55 days	Mortality and reduced growth	(Hansen et al. 2002b)
	Bull trout (juvenile)	0.83^{3}	120 hr	LC_{50}	(Hansen et al. 2002a)
		5.2^{4}	120 hr	LC_{50}	
	Coho salmon (*Oncorhynchus kisutch*) (age not reported)	2.3	Chronic	Reduced growth, survival, and fecundity	(USEPA 1996)

Constituent Dissolved	*Species (age class tested)*	*Concentration (µg/L)*	*Exposure Duration*	*Effect*	*Reference*
	Chinook salmon (*Oncorhynchus tshawytscha*) (age not reported)	2.7	Chronic	Reduced growth, survival, and fecundity	EPA 1996
	Brown trout (*Salmo trutta*) (age not reported)	7.4	Chronic	Reduced growth, survival, and fecundity	EPA 1996
	Brook trout (age not reported)	2.2	Chronic	Reduced growth, survival, and fecundity	EPA 1996
	Rainbow trout (complete life stage test)	3.4	Chronic	NOEC[5] Reproduction	EPA 2001
		5.5	Chronic	LOEC[6] Reproduction	
	Brown trout (complete life stage test)	9.3	Chronic	NOEC survival of F1 generation	EPA 2001
	Brown Trout (complete life stage test)	29.1	Chronic	LOEC survival of F1 generation	EPA 2001
Chromium^{+3}	Rainbow trout (juvenile)	30[7]	Chronic[8]	NOAEL[9] (un-bounded)	(Stevens and Chapman 1982)
		157[7]	Chronic[8]	LOAEL[10]	
Copper	Coho salmon (juvenile)	1.0	10 minute	NOAEL olfactory sensory responsive-ness	(Baldwin et al. 2003)
	Chinook salmon (juvenile)	25	4 hr	Neurophysio-logical and histological effects on olfactory system	(Hansen et al. 1999)
	Rainbow trout (juvenile)	25	4 hr	Neurophysio-logical and histological effects on olfactory system	(Hansen et al. 1999)
	Rainbow trout (fry)	0.1	1 hr	Avoidance by fry	(EPA 1980a in Eisler 1998)
	Rainbow trout (smolt)	7.0	LC_{10}	Lethality	EPA 1980a *in* Eisler 1998
	Rainbow trout (swim-up)	9.0	LC_{10}	Lethality	EPA 1980 *in* Eisler 1998
	Brook trout (age not reported)	9.5 -17.4[11]	Chronic	MATC	McKim and Benoit 1971 *in* Eisler 1998
Mercury (total)	Piscivorous fish or tertiary consumers	0.005[12]	NA	Adverse effect concentration (water)	USFWS 2000

Constituent Dissolved	*Species (age class tested)*	*Concentration (µg/L)*	*Exposure Duration*	*Effect*	*Reference*
Lead	Lake trout (*Salvelinus namaycush*)	48–83[13]	Lifetime	MATC[14]	EPA 1980b *in* Eisler 1988
	Brook trout (complete life cycle)	58–119	3 generations	MATC	EPA 1985b; Demayo et al. 1982; Holcombe et al. 1976 *in* Eisler 1988
	Rainbow trout (post hatch fry)	7.2 µg -14.6	Lifetime	MATC	Davies et al. 1976 *in* Eisler 1988
Lead (dissolved)	Brook trout (complete life cycle)	39–84	3 generations	MATC	Demayo et al. 1982; Holcombe et al. 1976 *in* Eisler 1988
	Rainbow trout (post hatch fry)	4.1 - 7.6	Lifetime	MATC	Davies et al. 1976 *in* Eisler 1988
	Rainbow trout (age not reported)	13	32 weeks	Anemia and reduced blood amino-levulinic acid dehydratase	EPA 1985b *in* Eisler 1988
		14	14 days	Reduced stamina	
	Rainbow trout (post hatch fry to 19 months)	7.2	19 months	NOAEL	Wong et al. 1978 *in* Eisler 1988
Zinc	Bull trout (fry)	35.6 - 80 (56.1 mean)	120 days	LC_{50}	Hansen et al. 2002b
	Brook trout (age not reported)	534-1,360	Chronic exposure	MATC	EPA 1980c; EPA 1987 *in* Eisler 1993
	Brook trout (adults)	630	14 days	LC_{17}	EPA 1980c; EPA 1987 *in* Eisler 1993
	Brook trout (adults)	960	14 days	LC_{50}	(Spear 1981); Nehring and Goettl 1974 *in* Eisler 1993
	Rainbow trout (complete life cycle)	140-547	Life cycle	MATC	EPA 1980c; EPA 1987 *in* Eisler 1993
	Rainbow trout (adults)	1,120	85 days	Reduced growth in adults	Spear 1981 *in* Eisler 1993
	Rainbow trout (juvenile)	5.6	10 minutes	Avoidance	EPA 1980c; EPA 1987 *in* Eisler 1993

Baldwin *et al.* (2003) found that short pulses of dissolved Cu (at concentrations as low as 2 µg/L) reduced olfactory sensory responsiveness by approximately 10 percent within 10 minutes, and by 25 percent within 30 minutes (Table 11). At 10 µg/L responsiveness was reduced by 67 percent within 30 minutes. Baldwin *et al.* (2003) identified a Cu concentration neurotoxic threshold of an increase of 2.3 to 3.0 µg/L, when background levels are 3.0 µg/L or less. When exceeded, this threshold is associated with olfactory inhibition. The authors also reference three other studies examining long-duration Cu exposures (i.e., exceeding 4 hours). These studies found that long-duration exposures resulted in cell (olfactory receptor neuron) death in rainbow trout and Atlantic salmon (*Salmo salar*) and Chinook. Baldwin *et al.* (2003) found that water hardness did not influence the toxicity of Cu to coho salmon sensory neurons.

More recently, Sandahl *et al.* (2007) documented sensory physiological impairment and related disruption to predator avoidance behaviors in juvenile coho at concentrations as low as 2 µg/L dissolved Cu after a 3 hour exposure period. They found a significant difference on swimming behavior and alarm stimulus reactions between at the lowest level tested (2 µg/L dissolved Cu). When alarm stimuli are reduced, fish will not recognize the presence of a predator, and as a consequence risk being preyed upon themselves.

The effects of short-term Cu exposure may persist for hours and possibly longer. Although salmonids may actively avoid surface waters containing an excess of dissolved Cu, those individuals that are exposed may experience olfactory function inhibition within minutes of exposure. Furthermore, avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

Folmar (1976) observed avoidance responses in rainbow trout fry when exposed to a lowest observed effect concentration of 0.1 µg/L dissolved Cu (hardness of 90 mg/L). The EPA (1980) also documented avoidance by rainbow trout fry of dissolved Cu concentrations as low as 0.1 µg/L during a 1 hour exposure, as well as a LC10 (lethal concentration resulting in 10 percent mortality) for smolts exposed to 7.0 µg/L for 200 hours, and a LC10 for juveniles exposed to 9.0 µg/L for 200 hours.

The predicted dissolved (assuming that approximately 98 percent of the particulate-bound copper is removed) copper concentrations in the WWTP effluent range from 7.2 µg/L to 4.2 µg/L (Table 8) and 0.99 µg/L to 0.27 µg/L (Table 9) using the maximum and centerline dilution rations, respectively.

Bull trout may avoid the plume when they detect elevated copper concentrations. Both rainbow trout and Chinook salmon avoided soft water (24 mg/L $CaCO_3$) with 1.6 µg/L and 0.7 µg/L copper in, respectively (Hansen et al. 1999, p. 1972). However, Chinook and rainbow trout did not demonstrate avoidance behavior when copper levels exceeded 44 µg/l and 180 µg/l in the test water (Hansen et al. 1999, p. 1972). Chinook salmon avoided water with copper concentrations ranging from 2.8 µg/L to 22.5 µg/L, while rainbow trout avoided concentrations ranging from 1.6 µg/L to 88 µg/L.

Chinook salmon are more sensitive than rainbow trout to the detection and avoidance of copper. When acclimated to copper (2.0 µg/L) prior to running the experiment, Chinook failed to avoid all concentrations tested. This is noteworthy as the background concentrations for total and dissolved copper are 3.6 µg/L and 0.8 µg/L in the Stillaguamish River, respectively (ESA Adolphson 2008b, Appendix I). Additionally, migrating salmon commonly encounter stormwater in late fall and winter which is often contaminated with copper. As depicted in Figure 1, there are numerous permitted discharges in the lower Stillaguamish River, many of which likely release copper. Migrating fish encounter and must swim through these discharge plumes which probably affect their subsequent copper exposure. If Chinook are exposed to concentrations of copper in excess of 2.0 µg/L prior to encountering the WWTP effluent plume, they may be somewhat desensitized and thus not avoid it. We don't have any information with which to determine whether bull trout are more, less, or equally sensitive to copper than

Chinook. Therefore, when the weight of evidence is equivocal, the Service must provide the benefit of the doubt to the species concerned when forming its biological opinion (50 CFR 402, subpart A, 19952). As such, we will assume that bull trout are as sensitive as Chinook.

The predicted future copper concentrations presented in Table 8 ranges from 7.2 μg/L to 4.2 μg/L in the acute mixing zone during annual and seasonal (May to October and November to April) low flows using the most conservative dilution ratios. Given the low effect level of 2.0 μg/L (Sandahl et al. 2007), the short exposure period of 3 hours, and the fact that fish are likely exposed to at least 2 μg/L of background copper, we anticipate that bull trout will experience adverse effects when exposed to the levels of dissolved copper in the acute mixing zone presented in Table 8. These effects would constitute a significant disruption of bull trout behaviors.

According to the BA (ESA Adolphson 2008b), Chinook spawn in the project area from August to November (p. 26), and steelhead spawn in the area from January to June. The BA also states that Steelhead rear in the action area throughout the year. If these spawning and rearing grounds are within the acute mixing zone (and we assume they are in the chronic mixing zone), bull trout may be attracted to this food source, thus prolonging their exposure to chemicals in the mixing zone.

Zinc (Zn)

Zn occurs naturally in the environment and is an essential trace element for most organisms. However, in sufficient concentrations and when bioavailable for uptake by aquatic organisms, excess Zn is toxic. Toxicity in the aquatic environment and for exposed aquatic organisms is influenced by water hardness, pH, organic matter content, levels of dissolved oxygen, phosphate, and suspended solids, the presence of mixtures (i.e., synergistic effects), trophic level, and exposure frequency and duration (Eisler 1993). Bioavailability of zinc increases under conditions of high dissolved oxygen, low salinity, low pH, and/or high levels of inorganic oxides and humic substances. Most of the Zn introduced into aquatic environments is eventually partitioned into sediments (Eisler 1993).

Effects of Zn exposure include 1) weakened immune function and impaired disease resistance (Ghanmi et al. 1989), 2) impaired respiration, including potentially lethal destruction of gill epithelium (Eisler 1993), 3) altered blood and serum chemistry, and enzyme activity and function (Hilmy et al. 1987a; Hilmy et al. 1987b); , 4) interference with gall bladder and gill metabolism (Eisler 1993), 5) hyperglycemia, and 6) jaw and branchial abnormalities (Eisler 1993).

Hansen *et al.* (2002c) determined 120-day lethal concentrations of Zn for test subjects that included bull trout and rainbow trout fry. Multiple pairs of tests were performed with a nominal pH of 7.5, hardness of 30 mg/L, and at a temperature of 8 °C. Bull trout LC50 values measured under these conditions ranged from 35.6 to 80.0 μg/L, with an average of 56.1 μg/L. Hansen *et al.* (2002c) found that rainbow trout fry are more sensitive to Zn (i.e., exhibit a lower LC50) than are bull trout fry. The authors also report that older, more active juvenile bull trout are more sensitive than younger, more docile juvenile bull trout based on observed changes in behavior at the juvenile life stage. The authors argue that the timing of Zn (and cadmium) exposure and the activity level of the exposed fish are germane to predicting toxicity in the field.

The mode of action for Zn toxicity relates to net loss of calcium. Studies suggest that exposure to Zn inhibits calcium uptake, although it appears that this effect is reversible once fish return to clean water. The apparent difference in sensitivity between rainbow trout and bull trout may be due to the lesser susceptibility of bull trout to calcium loss. Hansen *et al.* (2002d)) state that differences in sensitivity between these two salmonids may reflect different physiological strategies for regulating calcium uptake. These strategies may include gills that differ structurally, differences in the mechanisms for calcium uptake, and/or variation in resistance to or tolerance for calcium loss.

There are no known studies or data describing adult bull trout response to lethal (or near-lethal) concentrations of Zn. Active feeding and increased metabolic activity are apparently related to sensitivity. It is unknown whether sensitivity to Zn varies between adult, subadult, and juvenile bull trout. Activity level may be a better predictor of sensitivity than age.

In addition to the physiological effects of Zn exposure, studies have also documented a variety of behavioral responses. Among these are altered avoidance behavior, decreased swimming ability, and hyperactivity (Eisler 1993). The author also suggests Zn exposure has implications for growth, reproduction, and survival.

Sub-lethal endpoints have been evaluated with test subjects that include both juvenile and adult rainbow trout (Eisler 1993; EPA 19800; EPA 1987; Spear 1981). Some of these test results clearly indicate that juvenile rainbow trout are more sensitive than adult rainbow trout. Using juvenile rainbow trout as test subjects, studies have found that sub-lethal effects occur at concentrations approximately 75 percent lower (5.6 µg/L) than the concentrations that result in lethal effects (24 µg/L) (Eisler 1993; Hansen et al. 2002c). Sprague (1968) found that at concentrations as low as 5.6 µg/L juvenile rainbow trout exhibit avoidance behavior.

Although salmonids may actively avoid surface waters containing high levels of dissolved Zn, effluent contains a mixture of pollutants, including some known to affect the olfactory system (i.e., dissolved Cu). Fish are also exposed to contaminants in surface water originating from stormwater and other point and nonpoint sources. Bull trout exposed to these mixtures may not always be capable of detecting and avoiding elevated levels of dissolved Zn. Furthermore, avoidance of a chemical plume may cause fish to leave refugia or preferred habitats in favor of less suitable or less productive habitats. This can make fish more vulnerable to predation and can impair foraging success, feeding efficiency, and thereby growth.

According to the data in tables 8 and 9, total zinc is elevated above threshold levels (for avoidance) in the acute mixing zone. The season for which these levels were estimated overlaps with Chinook spawning in the project area (August to November). Therefore, when surface water temperatures are suitable, bull trout may linger in the area during Chinook spawning to feed on eggs. We don't know where Chinook spawn relative to the acute mixing zone; we assume there is direct overlap with the chronic mixing zone because of its larger size.

With the exception of avoidance, the exposure durations that elicit adverse affects in experimental fish (Table 12) are considered chronic at 14 days or longer. The effect level in Table 12 for avoidance is 5.6 µg/L for a 10 minute exposure period. If adult or subadult bull trout were not able to detect zinc and avoid the plume, due to olfactory effects from copper or some other contaminant in the effluent, they may be exposed to the acute mixing zone for an extended period of time. However, the concentrations predicted to be present ranges from 27 to 47µg/L, which is significantly higher than the 5.6µg/L that elicits an avoidance response. Given that discharges are continuous, avoidance of the acute mixing zone would reduce foraging opportunities and/or increase the risk of predation by displacing bull trout away from the deeper water towards the shallower fringes of the channel. Compromising bull trout use of a portion of the River, especially during low flow periods, can significantly impair normal behaviors.

Therefore, we anticipate that bull trout will be exposed to dissolved zinc in the WWTP effluent for a sufficient duration to experience adverse effects, and therefore effects from exposure to dissolved zinc from the Arlington WWTP are considered significant.

Total EEQ

The level of total estrogenic activity expressed as EEQ predicted to be present in the WWTP effluent is near the threshold of effects identified in Table 12 for rainbow trout (*Oncorhynchus mykiss*). In Table 9, the total EEQ ranges from 6.2 ng/L (0.006 µg/L) and 11ng/L (0.011 µg/L) depending on whether the mean or maximum constituent concentrations were used from the MBR literature. These predicted EEQs are at the threshold of effects for species evaluated in Table 12. Comparing these levels to 17β estradiol (the benchmark for relative potency of estrogenic compounds), these EEQs are at the threshold for vitellogenin induction in rainbow trout. For some of the more sensitive species, such are fathead minnows (*Pimephales promelas*), these EEQs would result in a reduced ability to compete for nests (significant effects to reproductive behavior) and reproduce. In medaka (*Oryzias latipes*), a highly sensitive species, the highest EEQ (0.11 µg/L) may result in an exclusively female population.

Table 12. Documented Effects on Aquatic Species Exposed to Wastewater-related Chemicals

Compound	Species/Lifestage/Exposure Duration	Effect	Concentration (Φg/L)	Reference
Diclofenac	Rainbow Trout/ Adult/ 28 days	Lowest observable effect level for renal lesions and alteration of the gills	5.0	(Schwaiger et al. 2004)
	Zebrafish/egg/ 48 and 96 hours	Delayed hatching but no effect on early life stage development	1000	(Hallare et al. 2004)
17V-ethinylestradiol	Medaka (*Oryzias latipes*) / Juvenile	Complete sex reversal and no egg spawned	0.1	(Scholz and Gutzeit 2000)
		reduced egg production, reduced gonadal weight	0.01	
	Medaka/ life cycle (hatch to sexual maturity)	Hepatotoxic (kidney), nephrotoxic (liver), gonadal cell death (males); possible altered breeding behavior (both sexes)	0.01	(Weber et al. 2004)
		Altered breeding behavior [reduced (males) or eliminated (females) copulation]	0.01	(Balch et al. 2004)
	Fathead Minnow (*Pimephales promelas*)/ Adult	Vitellogenin induction in males; Fibrosis and inhibition of testicular development; Enlargement of liver cells; edema in kidney tubules and other kidney-related effects	0.006 V 0.0028	(Palace et al. 2002)
	Fathead Minnow / Complete lifecycle	NOEC for growth, survival, reproduction through F_1 and secondary sex characteristics	0.001	(Lange et al. 2001)
		Failure to develop secondary sex characteristics in males; skewed F:M sex ratio (84:5)	0.004	
	Rainbow Trout (*Oncorhynchus mykiss*) / Sexually maturing males/ 62 days	Complete mortality	1.0	(Schultz et al. 2003)
		Increase in sperm density; *significant reduction in testes mass*; 50% reduction in eggs attaining the eyed stage of embryonic development	0.1	
		Increase in sperm density; 50% reduction in eggs attaining the eyed stage of embryonic development	0.01	
		Vitellogin induction in ♂;		Jobling et al. 2004
	Zebrafish(*Danio rario*)/F_0Generation/ females/10 days	Complete reproductive failure (no egg production)	0.05	(Nash et al. 2004)

Compound	Species/Lifestage/Exposure Duration	Effect	Concentration (Φg/L)	Reference
	Zebrafish /F_0 generation/40 days	No effect on reproduction	0.005	
	Zebrafish/F_1Generation/ females/Lifelong exposure	56% reduction in fecundity and complete population failure with no fertilization	0.005	
	Zebrafish/ juveniles/ 3 months	Significant reduction in total body length, body weight and increase in morphological abnormalities; reduced egg production	0.025	Van den Belt et al 2003
		Reduced number of spawning females and egg production	0.01	
	Zebrafish/adults 60 dph/	Significant reduction in viable eggs	0.01	(Hill Jr and Janz 2003)
	Sheepshead Minnow (*Cyprinodon variegates*)	Reduced hatching success in 2 reproductive trials	0.2	(Zillioux et al. 2001)
		Reduced hatching success in 1 reproductive trials	0.02	
17∃-Estradiol	Medaka / Growout phase	Production of exclusively female populations	0.01	Nimrod and Benson 1998
		Significant increase in mortality	1.66	
	Fathead Minnow / mature males/21 days	Reduced ability to compete for females, nests and reproductive success	0.025	Martinovic et al., 2003
	Rainbow Trout / Adult males/ 21 days	Threshold response of vitellogenin induction	0.001 - 0.010	(Schultz et al. 2003)
		Significant vitellogenin induction in males	0.1	
	Rainbow Trout/immature female/14days	LOEC for response in the vitellin envelope protein (biomarker response from exposure to estrogen compounds	0.005	(Thomas-Jones et al. 2003)
	Zebrafish/F_0Generation/ females/10 days	No effect on reproduction	0.005	(Nash et al. 2004)
Estrone	Rainbow Trout / Adult males/ 21 days	Threshold response of vitellogenin induction	0.025 - 0.05	(Schultz et al. 2003)
Combination of Estrone & 17β-Estradiol	Rainbow Trout / Adult males/ 21 days	Maximum obtainable vitellogenin response	0.025 of each compound	(Schultz et al. 2003)
Either Estrone or 17β-Estradiol	Rainbow Trout / Adult males/ 21 days	No significant effect on vitellogenin	0.025	
Fadrozole	Fathead minnow/ adults/≤ 21 days	Brain aromatase activity significantly decreased hormone production in females. Increased sperm production in males.	10 and 50	(Ankley et al. 2002, p. 126)

Compound	Species/Lifestage/Exposure Duration	Effect	Concentration (Φg/L)	Reference
Fluoxetine	Medaka/4 weeks	No effect on vitellogenin, plasma steroids, fecundity, egg fertilization or hatching rate	0.1 to 5	(Foran et al. 2004, p. 511)
Flutamide	Fathead minnow/adult/21 days	Fecundity reduced (lowest level tested)	651	(Jensen et al. 2004, p. 99)
Gemfibrozil	Goldfish (*Carassuis auratus*)/adult/14 days	Testosterone reduced by >50%	1.5	(Mimeault et al. 2005, p.49)
17∀-Methyltestosterone	Fathead Minnow/Adult males and female/21 days	Atretic(degenerating) follicles in ovaries	≥ 0.1	(Pawlowski et al. 2004)
		male-specific sex characteristics in females	≥ 1.0	
		Vitellogenin induction (estrogenic effect) in males	1.0	
		Concentration-dependent reduction in egg number, fertilization rate and increases in abnormal sexual behavior in females	≥ 5.0	
		Inhibitory effect on ovary growth	50	
Methoxychlor	Medaka/ Growout phase	No effect on reproductive capability	2.3	(Nimrod and Benson 1997)
Nonylphenol	Medaka /Growout phase	No effect on reproductive capability	1.9	
	Rainbow Trout / Female juvenile/exposed from hatch to 22 or 35 days, fish monitored to 86 and 431 days, respectively	OSI reduced	1 and 10	(Ashfield et al. 1998)
		Significant reduction in growth	10 and 50	
	Atlantic Salmon (*Salmo salar* L.)/ Smolt/5 day treatment; exposed for 2-24 hr continuous pulses, days 1 and 5 in fresh water	Negative effect on smolt weight and plasma insulin-like growth factor (IGF-I) concentration. Adverse effect on parr-smolt transformation (PST)	20	(Arsenault et al. 2004)
	Rainbow Trout/ adult males and females/4 months prior to spawning	Impaired reproduction, significantly reduced hatching rates, hormonal imbalances in the F_1 generation	10	(Schwaiger et al. 2002)
	Fathead minnow/larvae/64 days	Significant increase in reproductive behavior	5	(Bistodeau et al. 2006)
	Zebrafish/ Adult/ 60dph	Significant reduction in viable eggs	100	(Hill Jr and Janz 2003)
Nonylphenol/oxyphenol mixture	Fathead minnow/larvae/64 days	Significant reduction in reproductive behavior exposed males unable to hold nest	38	(Bistodeau et al. 2006)

Compound	Species/Lifestage/Exposure Duration	Effect	Concentration (Φg/L)	Reference
Nonly phenol mono-carboxylic acid	Rainbow Trout / Female juvenile/exposed from hatch to 22 or 35 days, fish monitored to 86 and 431 days, respectively	Significant reduction in length at day 55 then effect reversed through the remainder of the study. Growth induced	10	(Ashfield et al. 1998)
Nonyl phenol diethoxylate	Rainbow Trout / Female juvenile/exposed from hatch to 22 or 35 days, fish monitored to 86 and 431 days, respectively	Length and weight significantly reduced at various exposure periods. No effect on OSI	1.0 and 10	
		No effect on weight or length at any time. No effect on OSI	30	
Octylphenol	Rainbow Trout / Female juvenile/exposed from hatch to 22 or 35 days, fish monitored to 86 and 431 days, respectively	Length and weight significantly reduced at various exposure periods. No effect on OSI	1.0, 10 and 50 1.0 and 10	
4-*tert*-octylphenol	Roach (*Rutilus rutilus*)/Adult males and females/21 days	Threshold response of vitellogenin induction in males	10 - 100	(Routledge et al. 1998)
Propranolol	Fathead minnow/adult/4 week	# of eggs released was reduced	0.5 and 1.0	Huggett et al 2002 as cited in Fent et al. 2005
Wastewater effluent (17V-ethinylestradiol, estrone, 17β-Estradiol, 4-nonylphenol, bisphenol-A	Rainbow Trout Caged/males & females juvenile; fish experiment, 2 weeks	Estrogens bioaccumulating in bile and elevated vitellogenin in plasma	Order listed by compound: 4.5 ng/L, 5.8 ng/L, 1.1 ng/L, 840 ng/L 490 ng/L	(Hansen et al. 1999)

Vitellogenin production is a vital process in oviparous[12] vertebrates that is critical for oocyte[13] maturation (Larsson et al. 1999). Vitellogenin induction in male fish is one of the most common biomarkers measured in the literature. It is primarily used to indicate exposure to estrogenic compounds and has been demonstrated to occur in numerous species, including salmonids (Table 12).

Vitellogenin is a protein produced in the liver of mature female fish in response to increasing estrogen levels preceding spawning (Lintelmann et al. 2003). In female rainbow trout, vitellogenin production results in significant growth of oocytes approximately one month prior to ovulation (Lintelmann et al. 2003). Upon release from the liver the vitellogenin is incorporated into maturing oocytes and cleaved to produce primary yolk proteins (Werner et al. 2003).

Some researches maintain that some species of male fish have been documented to have low levels of vitellogenin, while other researchers state that male fish do not normally produce vitellogenin, but contain the hepatic (kidney) estrogen receptor gene that encodes for vitellogenin. When male fish are exposed to estrogenic substances the vitellogenin induction response is triggered. Because vitellogenin cannot be incorporated into the gonad, some researchers have suggested that vitellogenin accumulation in plasma leads to kidney damage (Islinger et al., 1999 as cited in Werner et al. 2003). Liver toxicity has also been observed in fish exposed to the potent xenoestrogen 17-ethynylestradiol, although the liver damage could not be attributed to either the EE_2 or the elevated vitellogenin levels (Weber et al. 2004; Weber et al. 2003; Herman and Kincaid, 1988; Gagne and Blaise, 1998; Folmar et al., 2001 as cited in Werner et al. 2003). Weber et al. (Weber et al. 2003) suggests that although hepatocytes can regenerate after liver damage, increased cell death leads to hepatocyte turnover after exposure to 17-ethynylestradiol, which may increase susceptibility to liver carcinogenesis and divert energy from reproduction.

Both juvenile and adult fish can be induced to synthesize vitellogenin after exposure to estrogenic compounds. Vitellogenin induction occurs in both juvenile and adult male rainbow trout after two to three weeks exposure to specific strogenic compounds and in-situ wastewater effluent (2004). Vitellogenin induction is also common to other species in the presence of estrogenic compounds (Table 12). Due to the similarities in teleost reproduction we have no reason to expect that bull trout would have a different physiological response than other teleost fishes noted in the literature.

Since 17β-estradiol causes the liver to produce vitellogenin in female fish in preparation for spawning, some researchers have shown that exposure to estrogenic compounds can extend the length of time that female fish remain in reproductive condition (Larsson et al. 1999; Routledge et al. 1998; Schultz et al. 2003). This is ecologically significant in that it requires the fish to expend more energy to remain in this condition, thereby reducing its fitness for other environmental challenges (e.g., escaping predation, foraging).

According to the data in tables 8 and 9, total EEQ is elevated above threshold levels in the acute

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[12] Laying of eggs in which the embryos have developed little , if at all (King County 2004a, p.20)

[13] Cell undergoing meiosis (reduction/division) (Thain and Hickman, 2000 as cited in Lintelmann et al. 2003)

mixing zone. We don't anticipate bull trout to be exposed to the acute mixing zone in the late summer or early fall for a long enough periods to experience adverse effects as reported in the literature. The exposure durations that elicits adverse effects in experimental fish (Table 12) ranges from 14 to 21 days or longer. It is extremely unlikely that bull trout would be exposed to the acute mixing zone for more than a few days during the low flow periods because 1) they would be migrating upstream to spawn, and 2) during late summer and early fall water temperatures are elevated. Additionally, it is unlikely that bull trout would remain for long in the action area because no exclusively resident populations have been identified in this core area except for the South Fork Stillaguamish River population which has a strong resident component coexisting with migratory forms.

During periods of higher flows (fall through spring), adult bull trout are migrating down from their spawning grounds and both adults and subadults are foraging and overwintering in the action area. When the water levels are high, bull trout have access to more of the channel. Because we don't anticipate that bull trout will be exposed to the estrogenic compounds in the WWTP effluent for a sufficient duration to experience adverse effects, effects from exposure to estrogenic compounds in the effluent are considered insignificant.

Water Temperature

The Service conducted an Act consultation on promulgation of the Water Quality Standards for temperature and dissolved oxygen with the EPA in 2007. The scientific rationale and basis for EPA's recommended criteria is described in the Region 10 Temperature Guidance and the supporting six Technical Issue Papers (Kramer et al. 1998; Palace et al. 2002). Two independent peer review panels provided comments and scientific issue papers on the development of the temperature standards. The data indicate the following effects to salmonids at various temperatures:

- Gamete viability in holding adults is reduced at temperatures over 13 °C
- Optimal temperatures for spawning and egg incubation are between 2 °C and 6 °C
- Optimal temperatures for juvenile rearing are in the range of 8 °C to 12 °C
- The distribution and abundance of bull trout is limited at temperatures over 15 °C
- Increased risk of disease and reduced fitness occurs during prolonged exposure at temperatures over 18 °C
- Migration is blocked at temperatures over 20 °C
- A 1-week exposure to temperatures between 21 °C and 23 °C is lethal

According to the BA (ESA Adolphson 2008b, p. 6-16), the water quality criteria for temperature is often exceeded in the project reach during the summer months (July and August). Temperatures in the Stillaguamish River at the project reach average approximately 74.8 °F (23.8 °C 7-DADMax) during warm weather (July and August). Current effluent discharge temperatures range from 20 °C to 24 °C during the summer, which is close to background levels at that time of year. This temperature range is considered a thermal barrier for salmonids and the risk of mortality would be high for individuals exposed to these elevated temperatures for a week or more.

The BA states that late July[14] through August coincides with bull trout migration and the beginning of Chinook spawning. The ambient river temperatures are not optimal to support migration or spawning during this time of year. It is clear that the baseline conditions for temperature are degraded in the project reach and the ongoing discharge of warm effluent will continue the degradation of the temperature baseline and adverse effects to salmonids including bull trout.

Indirect Effects from Reduced Water Quality

Bioaccumulation

Trace metals, such as arsenic and mercury, and persistent bioaccumulative toxins, such as fire retardants and Polychlorinated biphenyls, bioaccumulate or biomagnify in the food chain. These classes of chemicals are termed lipophylic, meaning that they do not readily dissolve in water but rather adsorb to organic particulate matter. Wastewater is a significant source of these chemicals, as well as the particulate matter that they bind to, and traditional treatment processes do not effectively remove them. However, the MBR treatment process is significantly more effective at the removal of organic matter and a substantial amount of the solids will be removed once the Arlington WWTP is upgraded.

Solids can act as both "sinks" and "sources" for metals and persistent bioaccumulative toxins. Contaminants are reversibly bound to suspended particles, and these particles can act as a "source of water column toxicity or interstitial [pore] water toxicity" (McCullough et al. 2001). Adsorption and complexation are physiochemical processes that tend to remove contaminants from the liquid-phase and sequester them in the solid-phase (Grant et al. 2003, p. 4-3). Redox potential (i.e., oxidizing or reducing conditions) and pH influence how contaminants are bound and, under varying conditions, can act to either keep contaminants bound in the solid-phase or release (or desorb) contaminants to the dissolved (liquid) phase (Bostick et al. 1998, p. 1; John and Leventhal 1995, p. 13). Some contaminated sediments constitute a persistent, continuing source of toxic contamination (Fan et al. 2004, p. 8).

Chronic effects to individuals stem from repeated exposures over time, through multiple exposure pathways, and from multiple stressors and combinations of stressors (Lloyd 1987, p. 491, 499). Ellis (Burton et al. 2000; Ellis 2000, p.86; Heintz et al. 2000, p. 214) has argued that sediment-mediated exposures and effects have not yet been given adequate attention, and furthermore that "procedures for the identification of chronic, sub-lethal no effects limits are still to be achieved". Emphasizing the tendency for accumulation in sediments, both Hodson (2000, p. 89) and Pettersson (2002, p. 1) have argued that loads (and not simply water concentrations) should be a focus for management where discharges of metals and persistent organic pollutants are concerned.

Accumulation of chemicals in sediments creates a sink for pollutants that are transferred up the food chain from benthic infauna to fish. This indirect exposure pathway is well recognized, but often not well quantified in the aquatic community. Juvenile fish rely on benthic invertebrates as a food source until such time as they are large enough to consume other fish. The action area is a

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[14] Bull trout actually start migrating at the end of May.

spawning and rearing ground for salmonids and therefore the benthic community is critical to their growth and development.

We are unable to determine the extent to which chemicals discharged from the WWTP will bioaccumulate in the aquatic food chain. The complexity of factors and interactions that combine in aquatic ecosystems to determine the ultimate significance of pollutant loadings cannot currently be resolved with a singular, measurable outcome or indicator. Loadings themselves, however, do exert a functional influence at the community level and are a reasonable indirect measure with which to gauge potential effects.

Upgrading the WWTP will allow for an increase in influent loading (due to population growth) but the TSS loading will not change because more solids will be removed by the MBR. Additionally, the MBR will remove different constituents in the effluent because of specific removal efficiencies relative to conventional treatment methods.

We anticipate that TSS loading to the Stillaguamish River will remain the same based on the future permit limits allowing for increased growth in the City (ESA Adolphson 2008b, p. 34). Assuming that a similar quantity and composition of chemicals are adsorbed to the solids, and that the TSS loading to the sediments will remain the same, we don't anticipate a measurable change in sediment quality or food web contamination as a result of the proposed project.

The Service presumes that adult and subadult bull trout that forage in the action area are currently exposed to stressors associated with bioaccumulation of chemicals via the food chain that may be affecting their growth and reproductive fitness. However, it is not possible to determine if the proposed action will incrementally change the pattern, frequency, or intensity of sediment-mediated toxic exposures. The Service cannot, at this time, determine if chronic exposures are modified from the proposed action or if implementation of the MBR will or will not affect normal bull trout behaviors, growth, or reproductive fitness.

Prey Base - Chinook and steelhead spawn and rear in the project and action area. We have already established that the levels of ammonia, copper, zinc and estrogenic compounds are elevated in the acute mixing zone relative to sublethal effect levels reported in the literature. Salmon often arrive at their spawning grounds in a weakened condition. Their migration is arduous due to the physical toll it takes on their bodies and because they do not feed along their migration route. Additionally, they are exposed to multiple anthropogenic stressors such as point and nonpoint sources discharges, elevated river temperatures and degraded habitat which likely contributes to compromising their fitness. Upon arrival at the project area, they are then exposed to elevated levels of ammonia in the chronic mixing zone, which reduces their swimming ability and reproductive fitness.

Eggs and developing embryos in redds that are constructed in or near the acute mixing zone would be exposed to estrogenic compounds at levels and durations that may affect their health and future reproductive capability (1988). The Service cannot, at this time, determine to what degree the prey abundance will be affected as a result of exposure to the WWTP effluent which would result in a significant (measurable) impairment of behavior, growth, and/or reproductive fitness of bull trout.

Summary

The Service expects that due to the enhanced level of treatment the overall the quality of the effluent will improve substantially, however contaminant loading will increase as the amount of effluent discharged effectively doubles to 4.0 mgd through 2025. As the population in Arlington continues to increase this long-term (operational) discharge of treated wastewater will further impair surface water and sediment quality in the project's receiving waters. Pollutant loadings are likely to continue and may exert measurable adverse effects on bull trout, their habitat, and prey base.

Specifically, the Service expects that the proposed action will result in measurable, adverse direct and indirect effects to bull trout, their habitat, and prey base, associated with long-term (operational) discharge of treated wastewater. Resulting effects to surface water and sediment quality will last in perpetuity. The Service expects that adult and subadult bull trout will be exposed to elevated water temperatures, dissolved copper and zinc, and ammonia which, in the immediate vicinity of wastewater outfall, are sufficient to cause adverse sub-lethal effects.

Bull Trout Critical Habitat

The final rule designating bull trout critical habitat (70 FR 56212 [September 26, 2005]) identifies eight Primary Constituent Elements (PCEs) essential for the conservation of the species. The proposed action has the potential to affect the following PCEs of designated bull trout critical habitat due to the discharge of wastewater effluent.

(1) *Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 °F (0 to 22 °C) but are found more frequently in temperatures ranging from 36 to 59 °F (2 to 15 °C). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.*

The Stillaguamish River at Arlington is on the 303(d) list of impaired waters for temperature, indicating that the baseline is degraded for this parameter. The proposed action will not improve this degraded baseline. Based on the information provided, there is very little difference between the temperature of the effluent and the temperature of the River during the warmest part of the summer (July, August). During this time of year, the 7-day average maximum temperatures in the River at Arlington can exceed 21 °C. This temperature is considered a thermal barrier for salmonids and bull trout are either forced to delay migration or swim past these areas at night when water temperatures are lower. During the cooler months, the temperature of the effluent is generally higher than the ambient temperature of the River water.

The combination of warm inflow into the WWTP, warming associated with the treatment process itself (UV radiation, biological digesters, etc), and retention time at the facility (e.g. solar heating) means that the temperature of the effluent is generally higher than the receiving water body, regardless of the time of year. Current regulations allow point source facilities to discharges pollutants at temperatures up to 30 °C (end of pipe) within the mixing zone while the temperature standards for the River are 17.5 °C most of the year (13 °C when salmon or steelhead are spawning). Although temperatures at the edge of the mixing zone must be within 0.3 °C of background levels, the mixing zone occupies up to 25 percent of the River (at low flows) and acts as a thermal plume.. The Stillaguamish River is already temperature-impaired and the discharge of warm effluent will maintain/contribute to the degraded condition in the affected reach.

Avoidance of the thermal plume reduces the amount of available habitat within the affected reach. Conversely, if bull trout do not avoid the thermal plume, they will be exposed to temperatures that are above optimal (15 °C). These responses could result in a significant impairment of normal behavior. Furthermore, temperatures in portions of the mixing zone may not support bull trout use at any time. Therefore, we have concluded that the proposed action will result in long-term (in perpetuity) adverse effects to water temperature (PCE #1) in the Stillaguamish River.

(2) *Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and in-stream structures.*

The only work to be done below the OHWM is the replacement of a potion of the existing outfall pipe. This work will be done during low flow conditions and is anticipated to be done "in the dry". If dewatering is necessary, all groundwater will be treated or filter if needed, and then returned to the River. The footprint of the pipe in the River will not change, and no effects to instream structures or hydrology are anticipated to result. Therefore, effects to PCE#2 are considered insignificant.

(3) *Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter.*

This PCE is not present in the action area.

(4) *A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.*

The City is planning for the long term protection of the Stillaguamish River valley through the Transfer of Development Rights program. This program facilitates the exchange of zoning privileges from areas with low population needs, such as farmland, to areas of high population needs, such as new development areas. The net result of implementing the rezoning will be that approximately 3,220 acres will remain as open, permeable ground while portions of other areas, such as the Brekhaus-Beach development, will be converted to impervious surface. Approximately 30 acres of the Brekhaus-Beach developable area may be impervious (buildings or roads) after development is completed (about 15 percent impervious). The area will be developed in accordance with the Western Washington Stormwater Manual and the Puget Sound LID guidelines, which require on-site storage and infiltration of stormwater where possible. The largest urbanized area in the action area with stormwater that directly discharges to the Stillaguamish River is known as "old town" Arlington. The City, with funding from Ecology, is in the process of designing and constructing a wetland to detain and treat stormwater runoff from the 276 acre site. It is also important to note that the City of Arlington has been meeting requirements for on-site storage and infiltration of stormwater since 1995, as outlined in the Ecology Stormwater Management Manual.

Measures that are or will be taken to minimize the amount of impervious surface and increasing infiltration of stormwater within the action area are not expected to result in a measurable change in the magnitude, timing or duration of flows to the Stillaguamish River. Therefore, we have concluded that direct and indirect effects to PCE #4 from the proposed action will be insignificant.

(5) *Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source.*

Some groundwater was withdrawn during installation of the MBR tanks below ground. This withdrawal was short term and all water was treated and returned to the Stillaguamish River.

The following text is from the State of the Stilly report (2007)[15]: On August 26, 2005, Ecology adopted Chapter 173-505 WAC, the Stillaguamish Instream Resources Protection and Water Resources Program, also know as the Stillaguamish instream flow rule. This rule has a significant effect on the use and availability of both surface water and groundwater in the Stillaguamish River basin. The rule establishes a water right for the River. Specifically, it requires that minimum flows must be met at various times of the year at each of 33 locations in the Stillaguamish River and its tributaries. The rule also declares that hydraulic connection between groundwater and surface water in the Stillaguamish River basin must be maintained (173-505-010). This has the effect of tying all junior water rights for both surface water and groundwater to the streamflow rights in the instream flow rule. If water rights were not available this would effectively halt development for which water cannot be obtained under an existing water right.

In order to allow some future development, Ecology included two "reservations" of water for future uses: 1) one cfs of surface water and twenty acre-feet/year (about 0.028 cfs) of groundwater for future stock watering, and 2) five cfs of permit-exempt groundwater (wells) for future domestic use. At an assumed rate of 350 gallons per day per single-family residence, the domestic use reservation would accommodate approximately 9,200 additional residences. The Snohomish County Department of Planning and Development Services determined that this would be adequate to serve development on currently undeveloped parcels outside the Urban Growth Area (UGA) boundaries. Future residential development within the UGA boundary must be provided by municipal or public water systems with water rights.

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[15] http://www1.co.snohomish.wa.us/Departments/Public_Works/Divisions/SWM/Work_Areas/Water_Quality/CWD/StateoftheStillyReport.htm

Based on the information provided on future growth and development, we anticipate a minor decline in groundwater resources associated with increased water consumption within the service area of the Arlington WWTP by the year 2025. The City proposes to use reclaimed water from the new WWTP in parks and green spaces which will reduce water consumption and offset withdrawals to some extent. Because the current regulatory mechanisms are adequate to maintain instream flows that support salmonid spawning, rearing and migration, we do not anticipate the indirect effects of growth and development associated with the Arlington WWTP upgrades to significantly affect groundwater resources, water levels in the Stillaguamish River, or the function of PCE #5.

(6) *Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.*

As described in PCE #1 above, the temperature of the effluent causes a thermal plume that may pose a partial thermal barrier within the mixing zone. However, regulations limit the size, discharges, and configuration of mixing zones specifically to prevent them from blocking up or downstream movement of fish. During the hot summer months the river temperature often exceeds 21 °C, effectively blocking migration. During the fall, winter and spring when water temperatures are cool and flows are higher, the presence of the effluent plume within the mixing zones reduces the width of the River channel that is available for bull trout but does not completely block or preclude movement through the area. Current regulations allow water quality to be degraded and temperatures to be increased within mixing zones. Although the proposed action is expected to result in improvements to water quality (due to enhanced treatment technology and greater removal efficiencies of MBR), the increase in volume of effluent that will be discharged in response to growth and development will continue to impact water quality in areas that are used by bull trout and other salmonids for migration in perpetuity. The impacts to water quality in mixing zones is additive for each permitted point source that discharges pollutants into the Stillaguamish River. The proposed action will adversely affect water quality and will affect bull trout movement through the action area in perpetuity (or the projected service life of the WWTP).

(7) *An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates and forage fish.*

Several species of salmonids spawn and rear in the Stillaguamish River providing prey for bull trout (Figure 3). According to the Washington Department of Fish and Wildlife (SaSI reports) coho, steelhead and Chinook all spawn in the action area. Spawning occurs from mid-March to June, and September to mid-January, depending on the stocks. Two of the three stocks are considered depressed, Steelhead and Chinook, and coho are considered healthy. For Chinook, total escapement for 2003 (last data were available) was 105 individuals. These stocks are not meeting their recovery goals. Winter steelhead are in a similar condition, with escapement of 660 individuals. Only coho are considered healthy, with escapement of 27,305 individuals. Coho spawn throughout the entire Stillaguamish River, including the North and South Forks. Of the stocks that spawn and rear in the action area, coho clearly provide the largest amount of prey for bull trout.

The project area includes the discharge point and associated mixing zones. Current regulations allow water quality criteria to be exceeded within mixing zones. As such, eggs in redds that are constructed in or near the acute mixing zone could be exposed to chemicals and elevated water temperatures at levels and durations that may affect their development. However, because salmon and steelhead spawning and incubation occurs during the time of year when flows are higher and stream temperatures are suitable, we do not anticipate embryos to be exposed to chemicals at levels that would be considered lethal. Because we do not anticipate mortality or a measurable reduction in the overall populations of salmon or steelhead in the action area, effects to PCE #7 are considered insignificant.

(8) *Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.*

As described in the effect analysis section of this Opinion water quality is affected by the concentrations of ammonia, copper, zinc and estrogenic chemicals discharged in the acute and chronic (ammonia only) mixing zones.

The Service concludes that effects from the proposed project will be significant and will result in adverse effects to bull trout critical habitat PCEs #1, #6 and #8.

The effects of the proposed Federal action on bull trout critical habitat are evaluated in the context of the range-wide condition of the critical habitat, taking into account cumulative effects, to determine if the critical habitat will remain functional and will continue to serve its intended recovery role for the bull trout. The analysis in this Opinion places an emphasis on using the intended range-wide recovery function of bull trout critical habitat, especially in terms of maintaining and/or restoring viable core areas, and the role of the action area relative to that intended function in making the adverse modification determination.

Baseline conditions for water quality in the Stillaguamish River are degraded, as evidence by the TMDL for temperature, dissolved oxygen, and other constituents. The WWTP discharge has and will continue to contribute to this degraded baseline into the future. The proposed action will also result in an improvement in the water quality baseline due to the enhanced treatment technologies employed. The need for the advanced treatment technologies is predicated on the existence of the TMDL and the anticipated future growth in the City, which necessitates an increase in capacity to accommodate the increased discharge volume. The enhanced treatment is anticipated to reduce the number and volume of contaminants discharged, particularly during Phase I before the anticipated growth has occurred. However, the amount of discharge will increase with growth and development, resulting in a continued incremental degradation of the water quality in the action area over the long term. Discharge temperatures will continue to be problematic, as they contribute to a thermal barrier during late summer, and a thermal plume (within the mixing zones) when the river temperatures are otherwise adequate for bull trout use.

Acknowledging the adverse effects to the PCE discussed above, we don't expect the proposed action to reduce the overall functionality of the PCEs at the scale of the action area or core area.

The upgraded WWTP is anticipated to discharge fewer contaminants, and at lower concentrations, use of reclaimed water will reduce the amount of effluent discharged and will contribute to attainment of the In Stream Flow Rule objectives for the Stillaguamish River. The increased phosphorus removal of the MBR should improve the levels of DO in the action area. The discharge volume of the Arlington WWTP represents a relatively small contribution to the overall flows in the Stillaguamish River, of approximately 0.8 percent to 1.5 percent during the high and low flow seasons, respectively. The Stillaguamish River is not considered effluent-dominated within the action area.

The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not prevent the PCEs of critical habitat from being maintained and will not degrade the current ability to establish functioning PCEs at the scale of the action and core area. Critical habitat within the action area will continue to serve the intended conservation role for the species at the scale of the core areas, Puget Sound interim recovery unit, and coterminous range.

CUMULATIVE EFFECTS

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 Biological 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 Act.

Local actions that may affect bull trout and their habitat within the action area include planned growth consistent with the land use and growth management plans of the City of Arlington. Additional residential, commercial, and industrial development (or redevelopment) is certain to occur in the action area.

According to the City's Economic Development Plan[16] lands are available for residences and businesses both within and outside the UGA. There is estimated to be 819 acres of undeveloped residential land remaining in vacant building lots and parcels, in partially used, and re-developable properties within the UGA, of which 79 percent is within the current city limits. Assuming an average of 2.60 persons per household, the additional population capacity within the service area of the WWTP is estimated to increase by 5,776 persons within the UGA by 2025 (service life of the new facility).

The total population capacity of the UGA in 2025 is estimated to be 19,383, or approximately 1,337 persons less than the population target of 20,720 persons outlined in the City's Economic Development Plan. This means that Arlington may need to add additional residential lands and/or increase allowable residential densities in order to meet these goals.

In addition to the residential areas, there are an estimated 1,411 acres of undeveloped land that

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[16] http://www.ci.arlington.wa.us/documents/Planning%20Division/Economic%20Development/EDP%20Final%20Draft%20Exec%20Sum.pdf

could be used for development of businesses in Arlington. This includes vacant building lots, parcels, and partially used and redevelopable properties within the UGA. Approximately 277.3 acres of the undeveloped lands were deemed unbuildable due to critical area restrictions. Therefore, approximately 1,133 acres of undeveloped land within the UGA are considered buildable. A total of 84 percent are within the city limits.

Regional transportation access is a problem between Interstate 5, and State Routes 530, 531, and 9, and with the various commercial and industrial areas of the city. Transportation projects have been identified to create an effective local-regional connection and to improve local and regional traffic access. These include rerouting intersections, building overpasses and interchanges, and street widening.

Planned growth consistent with the City's Comprehensive and Economic development plans will, over the long-term, result in additional effects to watershed functions, surface water quality, and instream habitat. Focusing growth within the current city limits will minimize effects as new or less infrastructure and impervious surface will be required. Additionally, fewer vehicle miles traveled will reduce effects of stormwater pollution. Currently, 79 percent of redevelopable residential and 84 percent of commercial buildable lands are with the current city limits.

Impacts to water quality and floodplain functions will be reduced through implementation of Low Impact Development (LID) and storm water management guidelines outlined in the *Arlington Municipal Code 13.24 (Stormwater management) and Arlington Land Use Code 20.88 (Environmentally Critical Areas),* adopting Critical Area Ordinances, and complying with State and County environmental permit requirements (including those requirements established for the protection of wetlands and for the regulation of private and municipal stormwater discharges).

Of the threats to bull trout in the Stillaguamish core area, the following may be exacerbated by the expected growth in Arlington:

- Low flows and high temperatures during the summer affect holding habitat for anadromous migrants in the mainstem Stillaguamish River, especially in the lower river sloughs that have slow-moving water without significant riparian cover (Balch et al. 2004; Lange et al. 2001; Weber et al. 2004), and

- Water quality impairment including high stream temperature and pollution.

Taken as a whole, future non-Federal actions are expected to adversely affect water quality and fish habitat in the Stillaguamish River and conditions in the action area. Some of these actions (e.g., implementation of the TMDL clean-up plans) are likely to improve conditions in the action area for bull trout.

INTEGRATION AND SYNTHESIS OF EFFECTS

The Service has reviewed the current status of bull trout in its coterminous range, the environmental baseline for the action area, the direct and indirect effects of the proposed Upgrade and Expansion of the Arlington WWTP, the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, Tribal, local, and private actions that are reasonably certain to occur in the action area. It is the Service's Biological Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the bull trout in its coterminous range.

The Service considers the waters within the action area to be foraging, migration, and overwintering habitat for bull trout. Foraging, migration, and overwintering habitat is important to bull trout of the Puget Sound Management Unit for maintaining diversity of life history forms and for providing access to productive foraging areas (WDFW 1997c). Adult and subadult bull trout may occupy these waters at any time of year, but information is not available to reliably estimate the number of bull trout that forage, migrate, and overwinter in the action area.

The scarcity and spatial isolation of available spawning habitat limits the number of local populations in the Stillaguamish core area. Bull trout in this core area are considered to be at increased risk of extirpation and adverse effects from random naturally occurring events. The severity of threat for this core area is considered high and the immediacy of the threat is moderate. Threats to the action area include 1) habitat degradation (including spawning), 2) agricultural and residential development and the associated water quality degradation, and 3) low flows and high surface water temperatures.

The Service expects the proposed action will result in measurable, adverse effects to bull trout associated with long-term (operational) discharge of wastewater effluent. The ongoing discharges will contribute to the existing degraded environmental baseline, specifically through reduced water and habitat quality in the action area. However, we do expect an improvement in water quality from proposed upgrades to the treatment process.

The proposed action incorporates significant permanent design elements and conservation measures that will reduce, avoid or minimize impacts to fish and habitat. Upgrade of the WWTP to MBR, with BNR and UV disinfection, is anticipated to reduce the volume and concentration of chemicals in the discharge and adverse effects to bull trout and water quality. The additional measures of incorporating LID techniques and stormwater infiltration into future development in the UGA are also significant beneficial effects of the proposed project.

Foraging, migrating, and overwintering adult and subadult bull trout will continue to be exposed to contaminants in the wastewater effluent after project implementation. The likelihood of exposure to the acute mixing zone will be greatest during low flow, elevated water temperature periods when the width of the wetted channel is at a minimum and bull trout are seeking deeper waters with lower water temperatures. Exposure to the chronic mixing zone will occur on a more frequent basis due to it size and location in the river.

Some bull trout may be exposed repeatedly as a result of regular movements through the action area. Exposure to dissolved metals and ammonia concentrations, and elevated water temperatures in the mixing zone, will result in a significant disruption of normal behavior (i.e., ability to feed, move, and/or shelter). The concentrations of contaminants evaluated in this Opinion and the duration of exposure are low enough that we do not anticipate the levels of effects to result in mortality. Exposed adult and subadult bull trout are likely to suffer sub-lethal effects, including reduced olfactory sensory responsiveness, avoidance of the mixing zone, and/or reduced foraging success. We do not have sufficient information to determine whether or to what extent the discharge of a majority of the unregulated chemicals may be affecting bull trout, their prey resources, or the PCEs.

Effects of the Action on the Stillaguamish Core Area, the Coastal-Puget Sound IRU, and the Coterminous Range of the Bull Trout

Implementation of the proposed action is not expected to result in measurable reductions in numbers, reproduction, or distribution of bull trout in the Stillaguamish Core Area. Based on our analysis effects to bull trout within the action area and core area are expected to be sublethal in nature and result in no measurable reduction in reproductive fitness. Facility upgrades will provide improved removal efficiencies that will improve water quality in the action area. The incorporation of existing regulations that limit the effects of growth and development will reduce the likelihood and magnitude of adverse effects to water quality and flows in the action area. It follows, then, that the action is also unlikely to measurably reduce numbers, reproduction or distribution of bull trout at the IRU and coterminous listing scales.

Effects of the Action on Bull Trout Critical Habitat

The conservation measures and facility upgrades will improve water quality in the action area and provide sufficient protection of the freshwater PCEs to meet the overall conservation needs of bull trout. As such, the proposed action is not likely to reduce the ability of Critical Habitat to remain functional to serve its intended recovery role for bull trout at the scale of the action area, Critical Habitat Unit, the Interim Recovery Unit, or the coterminous range.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act 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 Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The reasonable and prudent measures described below are non-discretionary, and must be undertaken by the (agency) 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 (agency) has a continuing duty to regulate the activity covered by this incidental take statement. If the (agency) 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 (agency or applicant) must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

Incidental take of adult and subadult bull trout from the Stillaguamish core area is anticipated in the form of harm and harass due to the discharge of municipal wastewater associated with the proposed action. Based on best available information, it is not possible to quantify the proportion of the core area population that will be impacted.

The take exempted in this Incidental Take Statement is associated with the City of Arlington's continued discharge of municipal wastewater. The take exemption is only applicable for discharges that are in compliance with the Federal Clean Water Act and Washington State water quality standards.

The incidental take of individual bull trout from actions that affect occupied habitat is difficult to quantify due to the indirect relationship between habitat impacts and fish injury and mortality, and the temporal variation in the distribution of potentially affected individual bull trout in the action area.

Incidental take of individual bull trout is difficult to detect for the following reasons: (1) the low likelihood of finding dead or injured juveniles or adults; (2) delayed mortality; (3) the rapid rate of fish decomposition; and (4) high probability of scavenging by predators.

In cases such as this where there is a relationship between incidental take of bull trout and adverse effects to its habitat, the amount or extent of take can be expressed in terms of the extent of affected habitat. On that basis, the Service anticipates that the following forms and amount of take will occur as a result of implementing the proposed action:

Incidental take by ***harm or harass*** of all adult and subadult bull trout exposed to the effluent plume within the acute and chronic mixing zone for the City of Arlington's discharge of municipal wastewater as a result of sub-lethal physical injury (or the likelihood of such injury) caused by prolonged exposure to harmful chemicals.

1) Incidental take of bull trout in the form of ***harm*** resulting from degraded surface water quality and acute exposure to elevated wastewater effluent contaminant concentrations. Effects will last in perpetuity, although acute exposures and effects to bull trout will be episodic. Effects resulting in subletlal injury (harm) will occur when dissolved Cu concentrations exceed the sub-lethal neurotoxic threshold of an increase of 2.0 μg/L over

background in the effluent discharge, when ammonia concentrations exceed 40 μg/L in the effluent, and when water temperature exceed water quality standards in the effluent discharge into the Stillaguamish River.

2) Because bull trout are long-lived and reside in or must pass through the action area several times over the course of their lives, the Service anticipates that all individual bull trout are likely to be exposed to chemicals at concentrations and elevated water temperatures that will result in injury or impairment of normal behavior. The area in which sub-lethal harm associated with exposure to dissolved copper to occur is limited to the acute mixing zone and ammonia in the acute and chronic mixing zones, 30.4 and 304 ft feet downstream of the outfall, respectively, and < 25 percent of the channel width). Because the discharge of municipal wastewater occurs on a continual basis, exposure may occur any time a bull trout enters the mixing zone, for as long as the facility is operating.

3) Incidental take by ***harassment*** of all adult and subadult bull trout that avoid the mixing zone and are precluded from using a portion of the river. Take of individual bull trout that will occur through the disruption of normal migration and foraging behavior when exposed to concentrations of at least 5.6 μg/L dissolved zinc in the acute mixing zone. The duration of incidental take of bull trout that avoid the mixing zone as a result of exposure to chemicals or elevated water temperatures may be as little as a few days for adults that are migrating through the action area or indefinitely for individuals that are foraging or overwintering in the action area and will be precluded from using the portion of the river that is affected by the mixing zone on a continual basis.

Please note that this Incidental Take Statement does not address incidental take that may result from future facility upgrades or activities that exceed Clean Water Act permit limitations; such take must be addressed under a section 10(a)(1)(B) permit or section 7 of the Act, as appropriate.

EFFECT OF THE TAKE

In the accompanying Biological Opinion, the Service has determined that the level of anticipated take is not likely to result in jeopardy to the bull trout.

The proposed action incorporates design elements and conservation measures which the Service expects will reduce permanent effects to habitat and avoid and minimize impacts during construction and operation. The Service assumes the EPA will fully implement these measures and therefore they have not been specifically identified as Reasonable and Prudent Measures or Terms and Conditions

REASONABLE AND PRUDENT MEASURES (RPM) — CITY OF ARLINGTON

The Service believes the following RPM is necessary and appropriate to minimize the impact of incidental take on the bull trout caused by the proposed action:

Minimize the potential for injury to bull trout resulting from exposure to chemicals in the effluent at levels that exceed the toxicity benchmarks.

TERMS AND CONDITIONS — CITY OF ARLINGTON

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

1) The City of Arlington shall provide an annual report to the Service, due January 1 each year, as noted below, that includes the following water quality monitoring requirements:

2) Basic effluent monitoring as outlined in section S 2 of the NPDES permit, including priority pollutant tests (metals and organics):
    a) Whole effluent toxicity test results;
    b) Report on combined sewer overflow events;
    c) Any exceedances of the water quality standards; and
    d) Variances obtained by Ecology.

3) Any additional monitoring of chemicals that occurs, including results and reports of any and all studies conducted that relate to the WWTP effluent.

The water quality monitoring report shall be submitted to the Service's Washington Fish and Wildlife Office (Attn: Andrea LaTier).

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs the Federal agencies to utilize their authorities to further the purposes of the Act 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 recommends the following conservation measures to the EPA and the City of Arlington:

1) Implement enhanced treatment through attainable, cost-effective technologies, such as the use of granular or powdered activated carbon, which will have greater long-term benefits and significantly reduces risks to aquatic ecosystems.
2) Work towards achieving water quality standards as close to the end of the pipe as possible and reduce or eliminate the need for mixing zones, particularly for chemicals that bioaccumulate in the aquatic food web.
3) Implement measures to reducing the temperature of the effluent.
4) Implement whole effluent toxicity test that measure endpoints targeting endocrine disruption to determine the risk of effluent exposure to fish.

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

This Biological Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service (No. 03-35279) to complete the following analysis with respect to critical habitat.

Legal Status

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on September 26, 2005 (70 FR 56212); the rule became effective on October 26, 2005. The scope of the designation involved the Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments (also considered as interim recovery units). Rangewide, the Service designated 143,218 acres of reservoirs or lakes and 4,813 stream or shoreline miles as bull trout critical habitat (Table X).

Table X. Stream/shoreline distance and acres of reservoir or lakes designated as bull trout critical habitat by state.

	Stream/shoreline Miles	Stream/shoreline Kilometers	Acres	Hectares
Idaho	294	474	50,627	20,488
Montana	1,058	1,703	31,916	12,916
Oregon	939	1,511	27,322	11,057
Oregon/Idaho	17	27		
Washington	1,519	2,445	33,353	13,497
Washington (marine)	985	1,585		

Although critical habitat has been designated across a wide area, some critical habitat segments were excluded in the final designation based on a careful balancing of the benefits of inclusion versus the benefits of exclusion (see Section 3(5)(A) and Exclusions under Section 4(b)(2) in the final rule). This balancing process resulted in all proposed critical habitat being excluded in 9 proposed critical habitat units: Unit 7 (Odell Lake), Unit 8 (John Day River Basin), Unit 15 (Clearwater River Basin), Unit 16 (Salmon River Basin), Unit 17 (Southwest Idaho River Basins), Unit 18 (Little Lost River), Unit 21 (Upper Columbia River), Unit 24 (Columbia River), and Unit 26 (Jarbidge River Basin). The remaining 20 proposed critical habitat units were designated in 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.

Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (70 FR 56212). 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. Critical habitat units generally encompass one or more core areas and may include foraging, migration, and overwintering (FMO) areas, outside of core areas, that are important to the survival and recovery of bull trout.

Because there are numerous exclusions that reflect land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments. These individual critical habitat segments are expected to contribute to the ability of the stream to support bull trout within local populations and core areas in each critical habitat unit.

The primary function of individual critical habitat units 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); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (Rieman and McIntyre 1993; MBTSG 1998); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Rieman and McIntyre 1993; Hard 1995; Healey and Prince 1995; MBTSG 1998); and 4) are distributed throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Rieman and McIntyre 1993; Hard 1995; MBTSG 1998; Rieman and Allendorf 2001).

The Olympic Peninsula and Puget Sound critical habitat units are essential to the conservation of amphidromous bull trout, which are unique to the Coastal-Puget Sound bull trout population. These critical habitat units contain nearshore and freshwater habitats, outside of core areas, that are used by bull trout from one or more core areas. These habitats, outside of core areas, contain Primary Constituent Elements (PCEs) that are critical to adult and subadult foraging, overwintering, and migration.

Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Note that only PCEs 1, 6, 7, and 8 apply to marine nearshore waters identified as critical habitat; and all except PCE 3 apply to FMO habitat identified as critical habitat.

The PCEs are as follows:

> (1) Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32° to 72 °F (0° to 22 °C) but are found more frequently in temperatures ranging from 36° to 59 °F (2° to 15 °C). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.
>
> (2) Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures.

(3) Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter.

(4) A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.

(5) Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source.

(6) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.

(7) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

(8) Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

Critical habitat includes the stream channels within the designated stream reaches, the shoreline of designated lakes, and the inshore extent of marine nearshore areas, including tidally influenced freshwater heads of estuaries.

In freshwater habitat, critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high-water line. In areas where ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. For designated lakes, the lateral extent of critical habitat is defined by the perimeter of the water body as mapped on standard 1:24,000 scale topographic maps.

In marine habitat, critical habitat includes the inshore extent of marine nearshore areas between mean lower low-water (MLLW) and minus 10 meters (m) mean higher high-water (MHHW), including tidally influenced freshwater heads of estuaries. This refers to the area between the average of all lower low-water heights and all the higher high-water heights of the two daily tidal levels. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone, which is the layer of water in which organisms are exposed to light. Critical habitat extends offshore to the depth of 33 ft (10 m) relative to the MLLW.

Adjacent stream, lake, and 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 altering the PCEs to such an extent that critical habitat would not remain functional to serve the intended conservation role for the species (70 FR 56212, USFWS 2004). 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). Therefore, 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, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments.

Current 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 (67 FR 71240). This condition reflects the condition of bull trout habitat.

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 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 (Rieman and McIntyre 1993; Dunham and Rieman 1999); 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; MBTSG 1998); 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; Rieman et al. 2006); 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.

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