Boundary Hydroelectric Project (FERC No. 2144)

Study No. 14
Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats
Interim Report

Prepared for
Seattle City Light

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1 INTRODUCTION

Study No. 14, Assessment of Factors Affecting Aquatic Productivity in Tributary Habitats, is being conducted in support of the relicensing of the Boundary Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 2144, as identified in the Revised Study Plan (RSP; SCL 2007) submitted by Seattle City Light (SCL) on February 14, 2007, and approved by the FERC in its Study Plan Determination letter dated March 15, 2007. This is the interim report for the 2007 study efforts of the Tributary Habitat Aquatic Productivity Assessment.

Tributary streams contribute to river or reservoir systems by providing physical support as a source of nutrients, sediment, woody debris, and water. In addition, they support biological processes by providing refuge, foraging areas, and recruitment habitat to fish residing within the tributaries year-round, as well as to those fish that migrate between the reservoir and tributary streams. Fish that demonstrate this type of adfluvial life history pattern utilize both a mainstem river or lake system and tributary streams during their life cycle. As such, the success of fluvial and adfluvial salmonid populations within the Project area may depend on tributary streams that meet those physical and biological needs.

Several factors have been identified in recent studies that may have contributed to the decline of bull trout populations in the Pend Oreille River and its tributaries. Among those factors known to be of great consequence are habitat degradation, fish passage barriers (including three hydroelectric facilities on the Pend Oreille River that were constructed without fish passage facilities) and competition with non-native species of fish (Andonaegui 2003). In addition, available habitat that could sustain native salmonids may be limited to holding pools in tributary streams, pockets of cooler water in the vicinity of tributary mouths, and areas of groundwater influence along the shoreline of the mainstem Pend Oreille River. These conditions make it difficult for native salmonids to compete with non-native species that are more resilient to variations in water temperature.

The operation of Boundary Dam results in fluctuations in water surface elevation that may cause changes in tributary conditions, and as a result, may have an effect on fish populations within the system. To fully evaluate the effects of Project operations on seasonal distribution and abundance of native salmonids and other fish species, it is necessary to understand the factors affecting aquatic productivity, or limiting factors, in the tributaries draining into Boundary Reservoir. This information will also be useful in identifying locations where factors limiting productivity can be modified through human intervention to mitigate impacts to aquatic resources that may be associated with Project operations or other basin activities.

Limiting factors have been defined as "conditions that limit the ability of habitat to fully sustain populations of salmon" (Salmon Recovery Act codified as RCW 77.85 in the 1998 Washington State legislative Engrossed Substitute House Bill 2496). Study No. 14 focuses on assessing limiting factors, or factors that affect productivity, in tributaries of the Project area. This will, in turn, identify those factors that affect the tributaries' ability to sustain populations of native salmonids. Relevant information from other studies being conducted in support of the relicensing effort, sediment transport and tributary delta habitats—Study 8, Sediment Transport and Tributary Delta Habitats (SCL 2008a) and the potential movement of fish between mainstem and tributary habitats—Study No. 9 Fish Distribution, Timing and Abundance (SCL 2008b)—will also be evaluated. The information collected in all of these studies will provide a greater understanding of the effects of Project operations on tributary habitat conditions.

Twenty-eight tributaries were identified in the RSP (SCL 2007) as providing between 0 and 5 miles of adfluvial habitat associated directly with Boundary Reservoir. The watersheds comprising these 28 tributaries provide areas of habitat utilization, or potential utilization, for bull trout, westslope cutthroat, and mountain whitefish. An evaluation of the factors affecting productivity in those tributaries can help identify ways in which human intervention may benefit native salmonid habitats.

While bull trout have been observed in a few tributaries between Albeni Falls Dam and Boundary Dam in recent years, no known healthy populations appear to exist (USFWS 2005). Available literature suggests that habitat alteration and degradation as a result of forest management practices, hydroelectric development, water supply development, flood control, livestock grazing, and road construction have affected fish populations within the reservoir and tributaries within the area (WDFW 1998, USFWS 2005). In addition, the presence of non-native fish species, such as brook trout, has been suggested as a serious threat to native salmonids as a result of interbreeding, which produces sterile offspring, and competition for habitat and food resources (Andonaegui 2003). Andonaegui concluded that with the fragmentation of habitat caused by impassable dams on the Pend Oreille River, such as Box Canyon Dam and Boundary Dam, suitable rearing habitat for juvenile bull trout could only be found in the tributaries. However, Andonaegui (2003) also noted that access by bull trout to those tributaries may be restricted by natural and artificial barriers, as well as degraded conditions, such as high temperatures and lack of thermal refugia, that result in less than suitable habitat (R2 Resource Consultants 1998; McLellan 2001).

Bull trout distribution and abundance is thought to be positively correlated with availability of pools and complex cover such as large woody debris (Reiman and McIntyre 1993; Jakober 1995; MBTSG 1998 as cited in USFWS 2005). The land use activities occurring in the vicinity of the Boundary Reservoir and its many tributaries likely contribute to a reduction in the number of pools and quantity of large woody debris (LWD) in the system through timber harvest, which reduces the amount of LWD supplied to streams and riparian canopy providing shade, and can promote the destabilization of banks resulting in sediment sloughing into streams. In addition, the removal of woody material from streams following timber harvest reduces pool frequency, quality, and channel complexity (Bisson et al. 1987; House and Boehne 1987), thus reducing the amount of viable habitat available to native salmonids, including bull trout.

Studies have shown that resident westslope cutthroat trout are found in numerous tributary streams to the Boundary Reservoir (POSRT 2005). The widespread introduction of hatchery cutthroat trout since the early 1900s has led to an expanded range within Washington state, but hybridization of wild and hatchery stocks has been considered a threat to wild cutthroat trout populations (50 CFR Part 17). It is also thought that diversity within the cutthroat trout population decreased from historic levels following the construction of multiple dams on the Pend Oreille River (Scholz 2000 in Wydoski and Whitney 2003), at which time fluvial stocks of cutthroat trout were apparently unable to adapt to an adfluvial life history and disappeared from many of the watersheds (C. Vail, WDFW, pers. comm. 2004 as cited in POSRT 2005).

This study was designed to inventory available information about physical habitats and fish populations within the Boundary Reservoir tributaries to allow a thorough evaluation of factors affecting aquatic productivity in the tributaries associated with the Project. This study compiles available literature and data sources to develop an initial list of factors affecting productivity. Any critical gaps or needs for additional information are identified; field collection of these data will be conducted in 2008. The additional information obtained through field collection will be incorporated and the list of factors affecting productivity will be refined. In addition, critical data gaps associated with factors affecting productivity will be re-evaluated in 2008 to determine if they may be modified through human intervention. This interim report addresses the first phase of the study which includes compiling information, identifying data gaps, and developing next steps for field data acquisition in 2008.

2 STUDY OBJECTIVES

The primary goal of the Tributary Habitat Aquatic Productivity Assessment Study, as defined in the RSP, is to compile information on the hydrology, water quality, fish habitat, fish presence and abundance, and migration barriers to determine factors affecting tributary productivity. This information will be used to evaluate the feasibility of modifying those factors through human intervention.

Specific objectives of the study are to:

- Document and summarize existing information on tributary habitat available between the Box Canyon Hydroelectric Project and the Boundary Hydroelectric Project.
- Develop an initial list of factors affecting productivity of tributary habitats.
- Create a spreadsheet containing available information on tributary habitat. Specific information provided in the spreadsheet consists of migration barriers, riparian conditions, channel conditions and dynamics, habitat elements, water quality, water quantity, and fish presence.
- Based on the developed list of factors affecting productivity of tributary habitats and the spreadsheet containing available information on tributary habitats, prepare a matrix of factors limiting the productivity of native species in Boundary Reservoir tributaries.
- Identify and document data gaps based on reviewing the initial list of factors affecting productivity in tributary habitats, the spreadsheet containing available information on tributary habitats, and the matrix of factors limiting productivity.

- Based on identifying and documenting all data gaps, determine which are critical to fill through field acquisition in 2008.

3 STUDY AREA

The study area includes only streams that drain directly into Boundary Reservoir (Table 3.0-1). These streams are grouped by watersheds that comprise Watershed Administrative Units (WAUs) defined by the Washington State Department of Natural Resources (DNR). Those streams that either drain directly into Boundary Reservoir or into a WAU connected to a Boundary Reservoir tributary are located within four WAUs: Slate Creek WAU, Sullivan Creek WAU, Harvey Creek WAU, and Box Canyon WAU (Figure 3.0-1). Within each of these four WAU's drainage networks reside multiple creeks (Table 3.0-2) potentially providing habitats utilized by native salmonids and other fish species.

Distances upstream from tributary stream mouths are designated in river miles (RM), whereas the location where a tributary enters Boundary Reservoir is designated in Project river miles (PRM) and indicates the approximate distance from the Pend Oreille River mouth to the tributary mouth.

Table 3.0-1. Project river mile designations of tributaries draining into Boundary Reservoir.

Watershed Administrative Unit (WAU)	Tributary Name	Side of Pend Oreille River (West Bank / East Bank)	Project River Mile (PRM) Designation
Slate Creek	**Boundary Dam**		17.0
Slate Creek	Unnamed No. 1	EB	17.2
Slate Creek	Pewee Creek	WB	17.9
Slate Creek	Unnamed No. 2	WB	17.9
Slate Creek	Lime Creek	EB	19.0
Slate Creek	Everett Creek	WB	21.9
Slate Creek	Whiskey Gulch	WB	21.9
Slate Creek	Slate Creek	EB	22.2
Slate Creek	Three Mile Creek	EB	24.3
Slate Creek	Beaver Creek	WB	24.3
Slate Creek	Unnamed No. 3	WB	25.4
Slate Creek	Flume Creek	WB	25.8
Sullivan Creek	Sullivan Creek	EB	26.9
Box Canyon	Unnamed No. 4	WB	27.1
Box Canyon	Linton Creek	WB	28.1
Box Canyon	Unnamed No. 5	WB	28.9
Box Canyon	Unnamed No. 6	WB	29.2
Box Canyon	Pocahontas Creek	EB	29.4
Box Canyon	Unnamed No. 7	WB	29.6
Box Canyon	Unnamed No. 8	WB	30.1
Box Canyon	Wolf Creek	EB	30.3
Box Canyon	Sweet Creek	WB	30.9
Box Canyon	Unnamed No. 9	EB	31.1
Box Canyon	Sand Creek	EB	31.7
Box Canyon	Lost Creek	WB	32.2

Table 3.0-1. Project river mile designations of tributaries draining into Boundary Reservoir (continued).

Watershed Administrative Unit (WAU)	Tributary Name	Side of Pend Oreille River (West Bank / East Bank)	Project River Mile (PRM) Designation
Box Canyon	Unnamed No. 10	WB	33.5
Box Canyon	Unnamed No. 11	WB	33.6
Box Canyon	Unnamed No. 12	WB	34.0
Box Canyon	Unnamed No. 13	WB	34.3
Box Canyon	**Box Canyon Dam**		34.5

Table 3.0-2. Confluence river mile designations within Boundary Reservoir tributaries.

Tributary/Creek/Waterbody Name	River Mile (RM) Designation
Slate Creek WAU	
Pewee Creek	
Fence Creek	1.1
Slate Creek	
Slumber Creek	2.0
Uncas Gulch	2.75
Styx Creek	4.9
South Fork Slate Creek	6.2
North Fork Slate Creek	6.2
Flume Creek	
South Fork Flume Creek	1.1
Middle Fork Flume Creek	3.3
Sullivan Creek WAU	
Sullivan Creek	
North Fork Sullivan Creek	2.35
Elk Creek	3.7
Outlet Creek	5.3
Pass Creek	8.9
Stony Creek	11.6
Kinyon Creek	12.65
Copper Creek	13.35
Gypsy Creek	13.8
Leola Creek	17.6
Leola Creek	
Deemer Creek	0.32
Harvey Creek WAU	
Outlet Creek	
Sullivan Lake	0.5
Sullivan Lake	
Noisy Creek	3.8
Harvey Creek	4.0
Harvey Creek	
Middle Fork Harvey Creek	10.0
Middle Fork Harvey Creek	
North Fork Harvey Creek	0.5
Box Canyon WAU	
Sweet Creek	
Lunch Creek	1.5

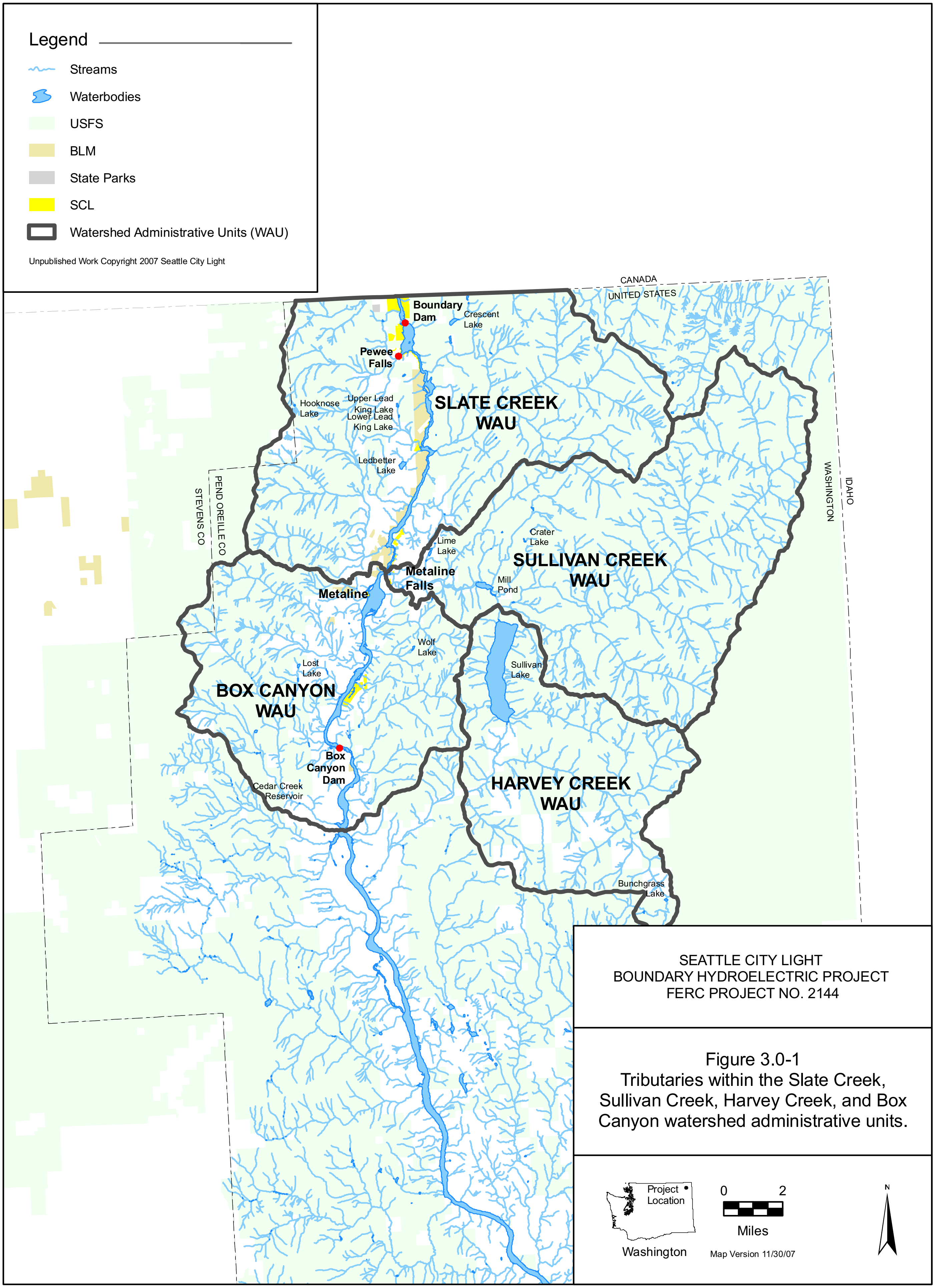

Figure 3.0-1
Tributaries within the Slate Creek, Sullivan Creek, Harvey Creek, and Box Canyon watershed administrative units.

3.1. Slate Creek WAU

Eleven of the 28 tributaries identified in the RSP are in the Slate Creek WAU (Figure 3.1-1). The Slate Creek WAU is located in the northeastern corner of Washington state, in Pend Oreille County (Figure 3.0-1). Slate Creek flows into the Boundary Reservoir reach of the Pend Oreille River at PRM 22.2 and includes the Pewee, Lime, Everett, Whiskey Gulch, Slate, Threemile, Beaver, and Flume creek drainages. The aforementioned drainages enter the Boundary Reservoir at PRM 17.9, 19.0, 21.9, 21.9, 22.2, 24.3, 24.3, and 25.8, respectively (Table 3.0-1). Andonaegui (2003) documented that the Slate Creek WAU drainage encompassed approximately 73.1 square miles (189.4 square kilometers); however, this was prior to revised WAU boundaries designated by DNR in 2007. Based on the geographic information system (GIS) layers available from the DNR (2007), the Slate Creek WAU drainage size is 95.4 square miles (247.1 square kilometers).

Slate Creek has four main tributaries and two forks: Slumber Creek, Uncas Gulch, Styx Creek, an unnamed creek, and North and South Fork Slate Creek (Figure 3.1-1). Slumber Creek enters Slate Creek north of U.S. Forest Service (USFS) Road 3155, near State Highway 31. Uncas Gulch flows into Slate Creek south of USFS Road 3155. Styx Creek enters Slate Creek just west of Lead Hill Mountain, near the junction of USFS Road 3155 and USFS Road 3160. The unnamed tributary enters Slate Creek west of the Lead Hill Mine and south of USFS Road 3155. USFS Road 3155 runs northerly along North Fork Slate Creek. South Fork Slate Creek and North Fork Slate Creek join at RM 6.2 to form the Slate Creek mainstem.

The majority of the Slate Creek WAU falls within the Colville National Forest, with a small section in the eastern portion of the WAU within the Salmo-Priest Wilderness. There is a small amount of privately owned land in the WAU, located adjacent to the Pend Oreille River, north of Metaline Falls. Additionally, a few privately owned, 40-acre timber holdings exist in the Slate Creek drainage. There is no assessor-designated Agriculture Open Space in the Slate Creek WAU (K. Kuhn, Pend Oreille County Planning, pers. comm., 2002 as cited in Andonaegui 2003). Literature on the geology and hydrology of Slate Creek WAU is limited; however, published information suggests that lead and zinc have been mined in the area (USFS 1998; Andonaegui 2003). In a large portion of the WAU, the bedrock is overlain by younger materials such as glacial drift, glacial till, glacial outwash, alluvium, and volcanic ash. Some of the alluvial and outwash material can be quite sandy (USFS 1998).

Within the Slate Creek WAU, the historic relative abundance and distribution of bull trout is not known. Bull trout have been observed at the mouth of Slate Creek (Andonaegui 2003), but no observations of bull trout upstream of the mouth have been documented. In 2002 the United States Fish and Wildlife Service (USFWS) proposed designating 10.1 miles of Slate Creek, from the confluence with the Pend Oreille River upstream, "Critical Habitat" (USFWS 2002). Based on the final rule, as published in the Federal Register (2005), 0.15 mile of Slate Creek, from the confluence with the Pend Oreille River upstream, was ruled "Critical Habitat." Within the Pend Oreille River Core Area, Slate Creek was identified as containing a local population of bull trout with a numeric recovery goal for migratory adults of 25 to 75 fish (USFWS 2002). To obtain this goal it will be necessary to ensure that the productivity of aquatic habitat in Slate Creek is optimal.

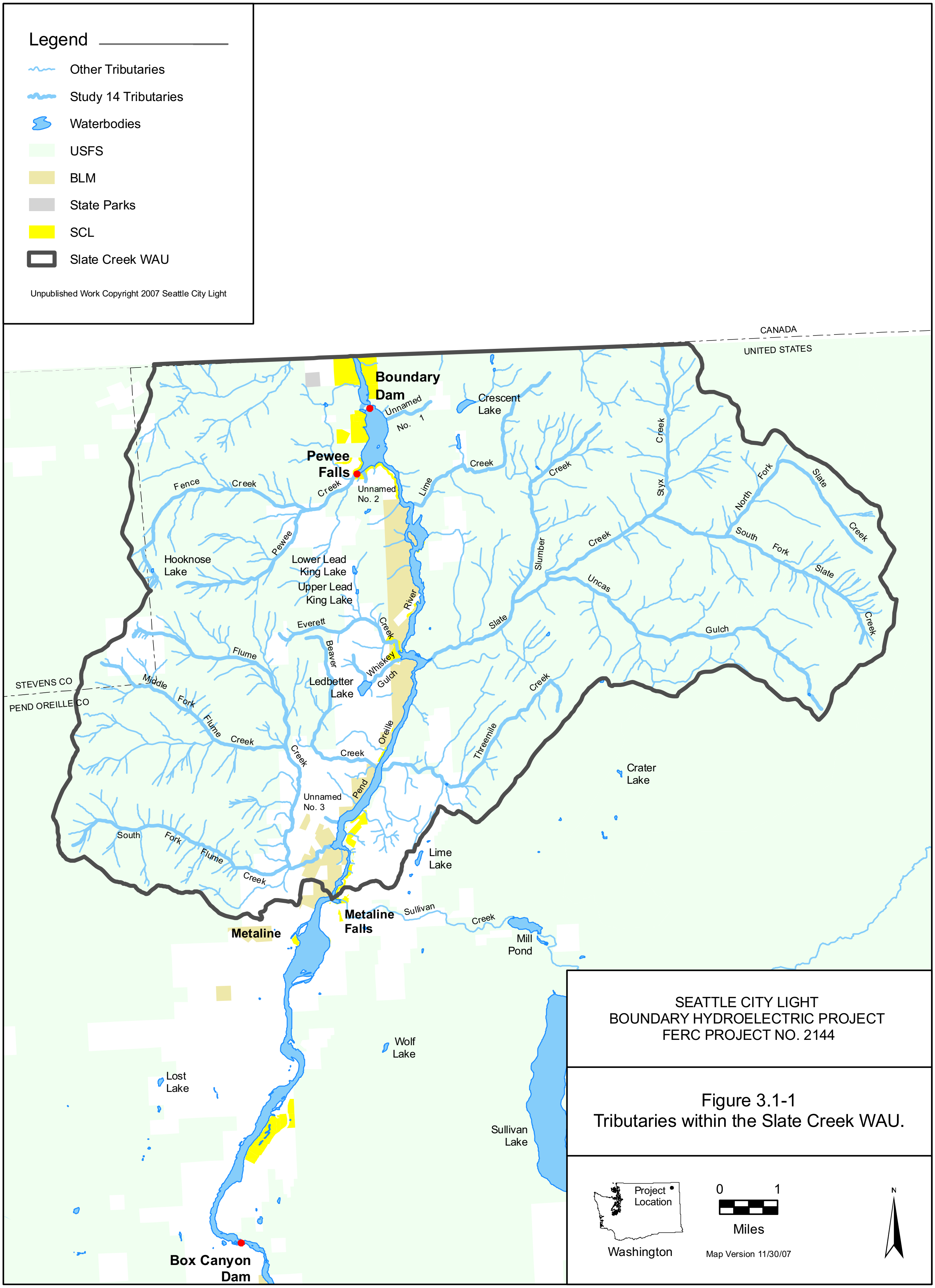

Figure 3.1-1
Tributaries within the Slate Creek WAU.

3.2. Sullivan Creek WAU

Sullivan Creek is one of the 28 tributaries identified in the RSP (Figure 3.2-1). The Sullivan Creek WAU is located in the northeastern part of Washington state, within Pend Oreille County (Figure 3.0-1). Within the Sullivan Creek WAU, the USFS manages 97.4 percent of drainage, with 25.3 percent of it located within the Salmo-Priest Wilderness (USFS 1996; Andonaegui 2003). Sullivan Creek flows 21.4 miles westerly and enters the Pend Oreille River at PRM 26.9, near the town of Metaline Falls (Figure 3.2-1). North Fork Sullivan, Elk, Outlet, Pass, Stony, Kinyon, Copper, Gypsy, and Leola creeks are the primary contributing drainages to the Sullivan Creek WAU (Table 3.0-2). Available literature from various sources (CES 1996; USFS 1996; Andonaegui 2003; and DNR 2007) suggests slight differences in the estimated size of the Sullivan Creek WAU. Based on available GIS layers from the DNR (2007), and for the purpose of this report, the Sullivan Creek WAU basin size is estimated to be 91 square miles (235.7 square kilometers). The average annual precipitation over the WAU is about 40 inches (in) (CES 1996). The system is snow-pack dominated, and spring runoff is the major channel-forming hydrologic event (USFS 1996).

The cultural history of the Sullivan Creek drainage area is rich in many ways. Literature suggests that the Sullivan Creek drainage has historically been utilized, to some extent, by people since the end of the last ice age. Archeological evidence uncovered at the north end of Sullivan Lake confirmed human presence in the area for at least 3,000 years (Andonaegui 2003). The Sullivan Creek drainage, with its abundant plant and animal resources, was traditionally used by the Kalispell people to hunt and gather food. The town of Metaline was established in the 1800s as a mining camp in support of gold mining activities largely on Sullivan Creek and was the earliest community to be established in Pend Oreille County. Currently, residential development within the drainage is very limited. The Sullivan Creek watershed is accessed by Sullivan Lake Road, which follows the west shore of Sullivan Lake. A network of USFS roads (233.7 total miles) and approximately 4.4 miles of private roads provide access to other areas of the Sullivan Creek drainage (USFS 1996).

Two dams are present within the Sullivan Creek WAU, with a third dam controlling flow released from the Harvey Creek WAU into Sullivan Creek (Table 3.2-1). The first dam is located in North Fork Sullivan Creek. The North Fork Sullivan Creek mouth is located at RM 2.35 on Sullivan Creek. Upstream from the mouth at RM 0.25 is the North Fork Sullivan Creek Dam, which provides water to the town of Metaline Falls. Between the confluence of North Fork Sullivan Creek and Outlet Creek is Mill Pond Dam (RM 3.25). Outlet Creek is 0.5 mile long and is the outlet of Sullivan Lake, which is located in the Harvey Creek WAU (Figure 3.0-1).

Near the mouth of Sullivan Creek, two bull trout have been documented (Andonaegui 2003). Local agency biologists, studies on resident fish stock status, and surveys conducted throughout the tributary suggests there is suitable habitat to support populations of native salmonids throughout the Sullivan Creek watershed (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). In 2005 the USFWS designated the lower 0.66 mile of Sullivan Creek as "Critical Habitat" (Federal Register 2005). Within the Pend Oreille River Core Area, Sullivan Creek was identified as containing a local population of bull trout with a numeric recovery goal for migratory adults of 600 to 850 fish (USFWS 2002). To obtain this goal it will be necessary to ensure that the productivity of aquatic habitat in Sullivan Creek is optimal.

Table 3.2-1. Dams within the Sullivan Creek and Harvey Creek WAUs.

Dam Name	Tributary/ Creek Name	River Mile Designation	Hydraulic Height (feet)	Year Built	Jurisdictional Agency	Licensee/ Operator	Fish Passage Facilities
Mill Pond Dam	Sullivan Creek	3.25	55	1923	FERC[1]	POPUD	No
Sullivan Lake Dam	Outlet Creek	0.5	29	1931	FERC[1]	POPUD	No
North Fork Sullivan Creek Dam	North Fork Sullivan Creek	0.25 on North Fork Sullivan Creek	13.1	late 1950s	N/A	POPUD	No

Notes:

1 On July 18th, 2007, the Federal Energy Regulatory Commission (FERC) denied a petition for a declaratory order that the existing FERC license is void and accepted that the license is no longer required (FERC 2007a). However, as of August 16 and 17, 2007, American Whitewater and the Washington Department of Fish and Wildlife (WDFW), respectively, submitted requests for a hearing (FERC 2007b).

NA – not applicable

POPUD – Pend Oreille Public Utility District

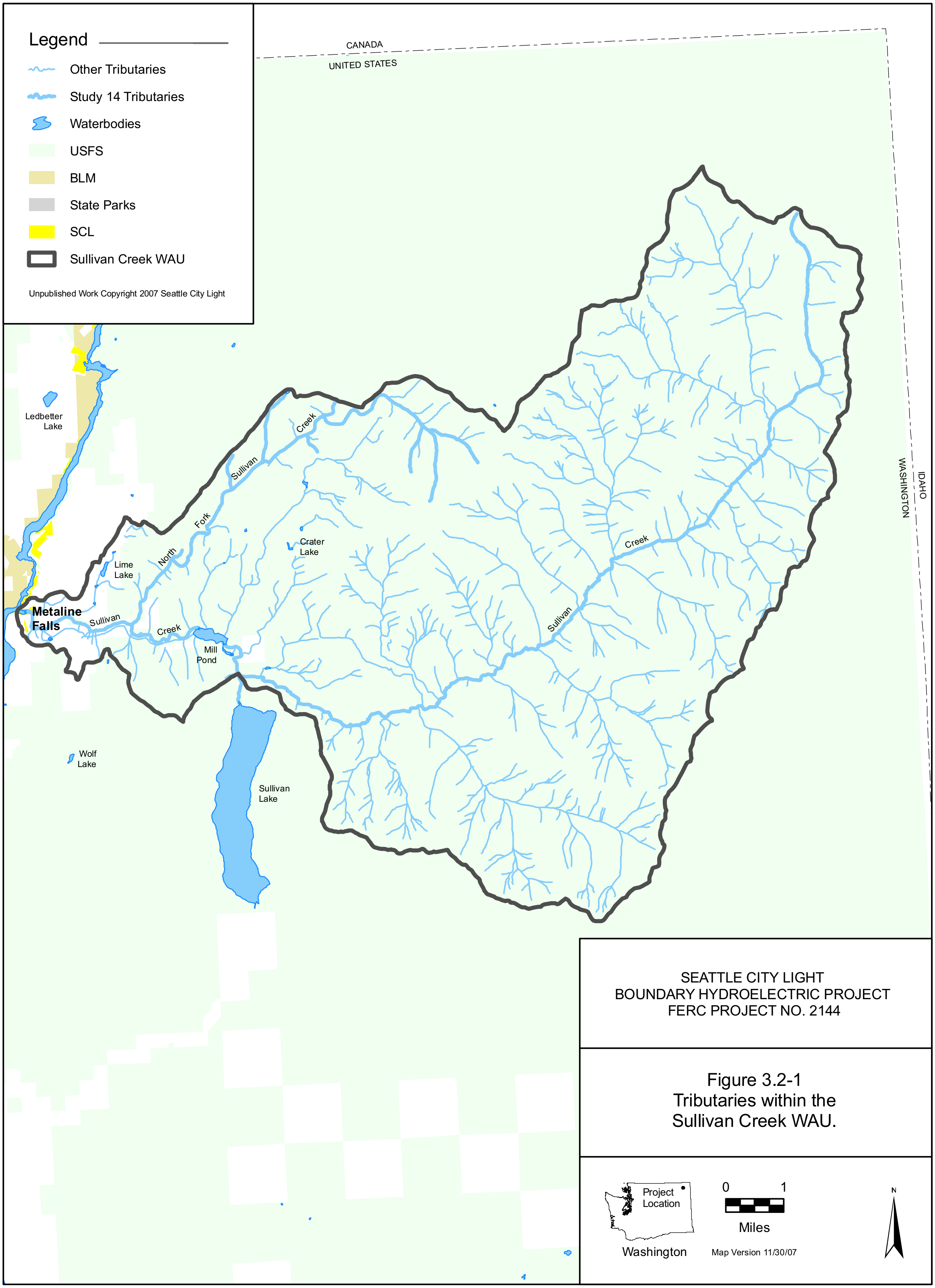

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Figure 3.2-1
Tributaries within the
Sullivan Creek WAU.

3.3. Harvey Creek WAU

There are no tributaries within the Harvey Creek WAU that are specifically identified in the RSP. Although no tributaries were specifically identified in the RSP, the entire Harvey Creek WAU drainage flows into Sullivan Lake, which ultimately drains into the Sullivan Creek WAU.

As with the other WAUs located in the study area, the Harvey Creek WAU is located in the northeastern corner of Washington state, in Pend Oreille County, just south of Sullivan Creek WAU (Figures 3.0-1 and 3.3-1). The Harvey Creek WAU is estimated to encompass approximately 51.5 square miles (138.4 square kilometers). Harvey Creek originates at the peaks of Monumental and Salmon Mountains, primarily comprises a middle and north fork (Table 3.0-2), and flows approximately 15 miles north-northwesterly from its headwaters before flowing into Sullivan Lake, a natural lake (Andonaegui 2003). In 1931, Sullivan Lake Dam was built (Table 3.2-1) which increased the holding capacity of Sullivan Lake (Andonaegui 2003). Outlet Creek, located on the edges of the Harvey Creek WAU and the Sullivan Creek WAU, flows out of Sullivan Lake at Sullivan Lake Dam and converges with Sullivan Creek at RM 5.3. In the vicinity of the Sullivan Creek/Outlet Creek confluence, there are about nine residences and a small store on private land (Andonaegui 2003).

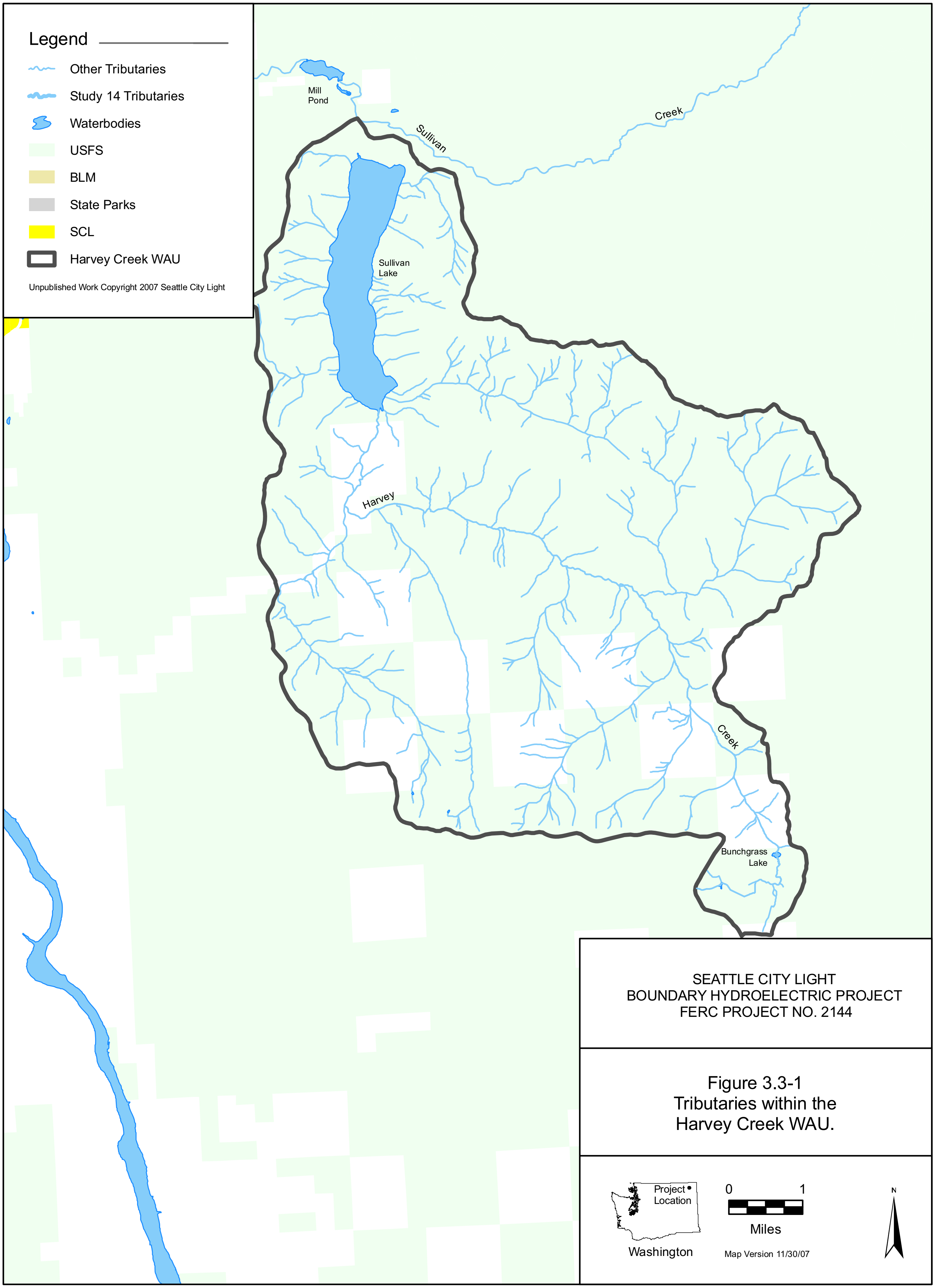

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Figure 3.3-1
Tributaries within the
Harvey Creek WAU.

3.4. Box Canyon WAU

Sixteen of the 28 tributaries identified in the RSP are in the Box Canyon WAU (Figure 3.4-1). The Box Canyon WAU is located in northeastern Washington State, just south of the Slate Creek WAU, in Pend Oreille County (Figure 3.0-1). In 2006, the DNR reassessed many of the state's watersheds and, as a result, renamed Box Canyon WAU to Cedar Creek WAU. Due to the recent nature of the renaming, most of the available literature regarding this WAU refers to it as Box Canyon WAU; therefore, it will be referred to as the Box Canyon WAU for the purpose of this study.

The Box Canyon WAU includes the Sweet and Sand creek drainages, which flow into the Boundary Reservoir reach of the Pend Oreille River at PRM 30.9 and 31.7, respectively (Table 3.0-1). The WAU area is approximately 87.8 square miles (227.3 square kilometers) and encompasses several tributaries that flow into the Pend Oreille River, including Linton, Pocahontas, Wolf, Sweet, Sand, Lost, and 10 unnamed creeks (Table 3.0-1) identified in the RSP.

Within the Box Canyon WAU, Sweet Creek and Sand Creek are the largest tributaries with watershed areas of 11.1 square miles (28.7 square kilometers) and 8.2 square miles (21.2 square kilometers), respectively. Lunch Creek, defined as a tributary to Sweet Creek for the purposes of this study, converges with Sweet Creek at RM 1.5 (Table 3.0-2). At least 50 percent of the Sweet Creek drainage is located on privately-owned property; however, a portion of it is located on USFS-managed lands (Figure 3.4-1). Within the USFS boundary there are no roads, and management of the area focuses on semi-primitive, non-motorized recreation (USFS 1999c).

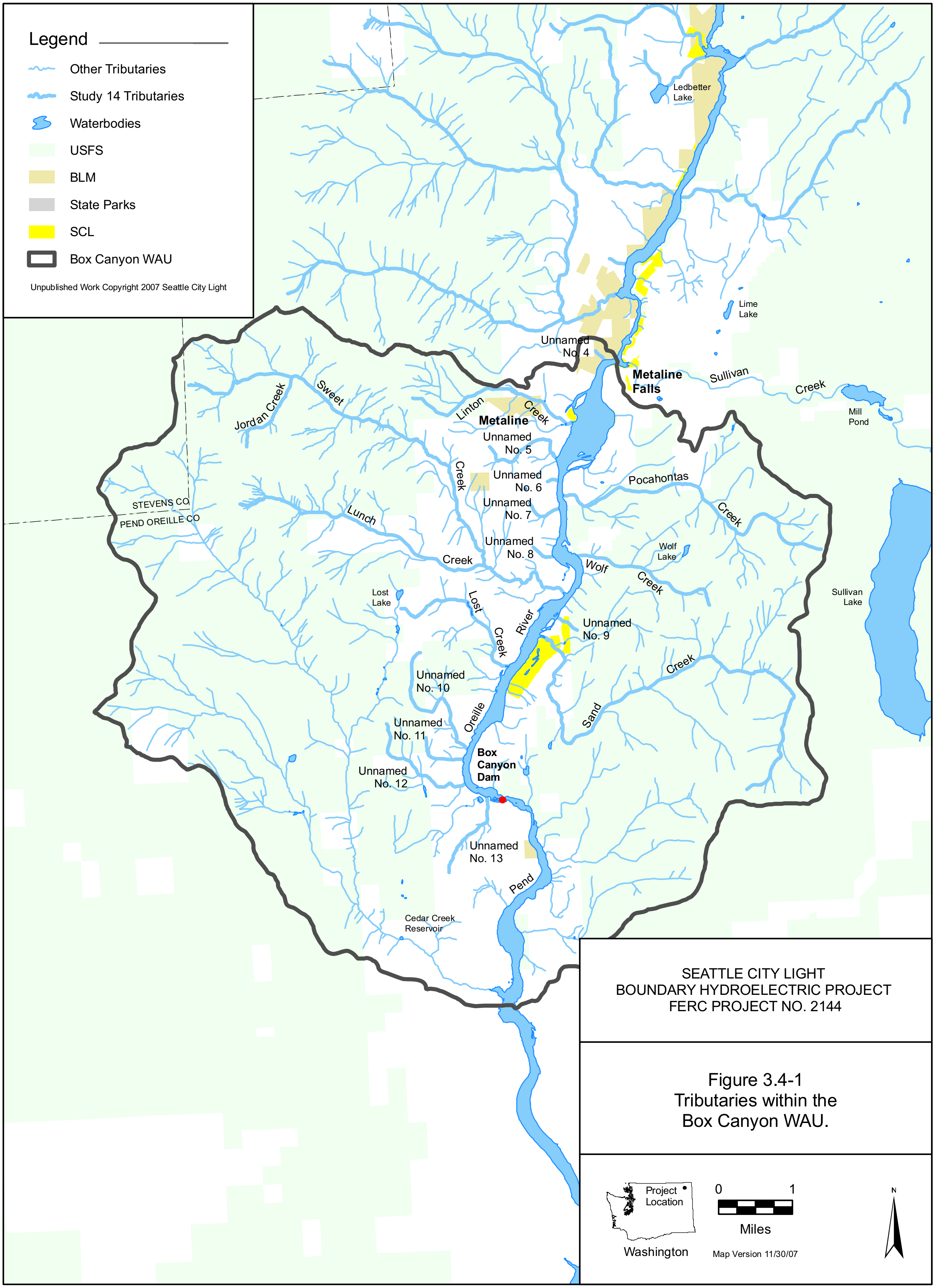

Figure 3.4-1
Tributaries within the
Box Canyon WAU.

4 METHODS

Four tasks have been identified as part of this study. The methodologies for each are described in the following sections.

4.1. Review and Compile Available Information

Available hydrology, water quality, fish habitat, fish presence and abundance, and migration barrier information for tributaries draining to Boundary Reservoir was obtained from the following sources:

- Andonaegui (2003)
- Cascade Environmental Services (1996)
- Connor et al. (2005)
- Entrix (2001, 2002)
- McLellan (2001)
- R2 Resource Consultants (1998)
- Terrapin Environmental (2000)
- USFS (1996)
- USFS (1998)
- USFS (2005)

Only content specific to each of the tributaries draining into Boundary Reservoir was extracted from these sources. Information on available migration barriers (natural and artificial), riparian conditions, channel conditions (streambank condition, floodplain connectivity, channel stability), habitat elements (channel substrate [embeddedness and fines], large woody debris [LWD], pool frequency and quality, pool depth, wetted width), water quality (7-day maximum temperature), water quantity (discharge, changes in flow regime, gradient), and native and non-native fish species information was reviewed and compiled from information sources for Boundary Reservoir tributaries. This information was organized based on its content and grouped by tributary name. All tributaries were grouped within respective WAUs for discussion purposes.

The format, method, content, and evaluation utilized by Andonaegui (2003) provided information and a template to follow for this study. The limiting factors evaluation by Andonaegui (2003), which presents bull trout limiting factors, was the primary template used to organize and review available information.

The SMART database (USFS 2005) provided information from sampling points or reaches for creeks flowing through Colville National Forest (CNF) land. Information from the SMART database was used to address data gaps for tributaries lacking information from other literature sources.

The review of all available relevant information from the previously listed sources was completed in September 2007; any additional information obtained post-review will be assessed for inclusion in the final report. After reviewing and compiling all available relevant information from the previously listed sources for the tributaries identified as draining into Boundary Reservoir, criteria were developed to identify those tributaries possessing major factors limiting productivity that could be addressed through human intervention. These criteria are discussed in the next section.

4.2. Stream Categorization and Productivity Factors

This task has two purposes: 1) to narrow the selection of streams to evaluate those that have potential to provide at least moderate benefits to native salmonids, primarily adfluvial populations, through human intervention if habitat or other conditions could be improved; and 2) to identify productivity factors and their status within the selected tributaries.

Criteria were developed to categorize streams into three levels of opportunity: primary (areas with high opportunity), secondary (areas with some opportunity), and excluded from evaluation (areas with little to no opportunity). The descriptions in Table 4.2-1 outline the criteria used and the logic behind each of the criteria.

Table 4.2-1. Stream level of opportunity categorization and criteria.

Category	Criteria	Reason
Primary	Adfluvial habitat greater than 250 feet and watershed area is more than 1 square mile.	Streams of this size, at a minimum, have the greatest potential to influence Boundary Reservoir native adfluvial fish resources, and, therefore, if a limiting factor can be improved through human intervention, it may be considered for future enhancement. These streams have both a moderate to large basin to help increase flow and increase overall habitat quality in the reaches accessible to adfluvial fish with the ability to enhance more life stages and sizes of adfluvial species, as well the potential to enhance native fish species.
Secondary	Containing either a watershed area greater than 1 square mile or adfluvial habitat length greater than 250 feet. If a tributary meets either of these criteria, and a natural barrier at the mouth is present and native salmonid species are known to occur in the basin, it will be included.	The larger basins, without adfluvial habitat, may be worth evaluating further because there may be potential for watershed improvements that could enhance native salmonid species populations. The smaller basins, with adfluvial habitat length greater than 250 feet, may have some potential for human-aided improvement, possibly improving available habitat for Boundary-reservoir native species. They are not considered prime streams because of the low amount of drainage area limiting overall habitat, and/or limited adfluvial stream length, restricting the potential to benefit adfluvial habitat through human intervention. Tributaries that have natural barriers occurring at the mouth, but have native salmonids known to be present in the basin, are included because these creeks may have opportunities to improve aquatic habitat without the need to supplement existing populations.
Excluded	Less than 1 square mile and less than 250 feet adfluvial habitat. Has a natural barrier occurring at the mouth of the tributary and no native salmonid populations	These streams, because of their small size and very limited adfluvial habitat, have a low potential to benefit either adfluvial or resident trout under existing conditions, or with any human intervention to current conditions.

After primary and secondary tributaries were identified, data tables were created for primary tributaries with available information on migration barriers, riparian conditions, channel conditions and dynamics, habitat elements, water quality, water quantity, and fish species. No data tables were created for the secondary or excluded tributaries. The data tables created for the primary tributaries were compared to salmonid habitat rating standards for identifying preliminary factors limiting productivity in primary tributaries. Specifically, the bull trout habitat rating criteria for Water Resource Inventory Area (WRIA) 62 (Andonaegui 2003) were used to assist in identifying preliminary limiting factors in primary tributaries. In addition, the Washington Conservation Commission (WCC) WRIA habitat limiting factors ratings standards (Smith 2005)[1] were cross-referenced with the bull trout habitat rating criteria to assess the comparability with Washington State standards. Based on the results from comparing the data tables to the bull trout rating criteria, and assessing the limiting factors reported by Andonaegui (2003) for the identified primary tributaries, a preliminary limiting factors matrix was developed. After the preliminary limiting factors matrix had been developed for the primary tributaries, a preliminary limiting factors matrix for the secondary tributaries was developed from the limiting factors matrix reported by Andonaegui (2003).

4.3. Limiting Factors Matrix

Limiting factors are "conditions that limit the ability of habitat to fully sustain populations of salmon," as defined in the Salmon Recovery Act (codified as RCW 77.85 in the 1998 Washington State legislative Engrossed Substitute House Bill 2496) (Andonaegui 2003). Within RCW 77.85, salmon are defined as "all members of the family Salmonidae which are capable of self-sustaining, natural production." RCW 77.85 directed state and local government agencies, tribes, and other personnel with appropriate expertise, within each WRIA, to act as a technical advisory group (TAG) to study and identify limiting factors for salmonids. The studies in each WRIA focused on evaluating factors limiting the productivity of native biota in streams and rivers. In general, information was organized by productivity level into categories, and this information was displayed in the form of a matrix (see Andonaegui 2003 and Smith 2005). Types of categories used include poor quality habitat (not properly functioning), fair habitat (at risk), and good quality habitat (properly functioning). These categories provide a ranking structure for habitat for use in prioritizing which streams and rivers require the greatest attention in order to hinder the factors limiting the productivity for native species.

The first step in creating a limiting factors matrix for the primary tributaries was to compare the data tables (described in Section 4.2) to the bull trout habitat rating criteria. Limiting factors identified in this first step were used to update the bull trout limiting factors matrix for WRIA 62 reported in Andonaegui (2003) for the primary tributaries. The final step was to compare these results to other efforts focused on assessing habitat productivity in these tributaries (Table 4.3-1). Specifically, the limiting factors results from the Northwest Power and Conservation Council (NPCC 2005; see Appendix 1) and the Pend Oreille Salmonid Recovery Team (POSRT 2005; see Appendix 2) were used to reinforce the evaluation and identification of limiting factors

[1] The WCC habitat limiting factors ratings standards were only used for cross-reference purposes, and not specifically used to evaluate Boundary Reservoir Tributaries. As the WCC criteria is used by the state of Washington to evaluate limiting factors throughout the state, it was necessary to assess these standards with the criteria used in Andonaegui (2003).

determined from the primary tributary data tables and from the Andonaegui (2003; Appendix 3) bull trout limiting factors matrix. The limiting factors matrix for secondary tributaries (see Appendix 4) was developed in a similar fashion, except the preliminary matrix was derived exclusively from Andonaegui (2003) without any updates from data tables.

Table 4.3-1. Other major sources used for Boundary Reservoir tributary information.

Tributary, Watershed Drainage, or Waterbody Name	Individual Bull Trout Observation only (WCC mapping)	Resident Fish Stock Status Project (WDFW)	WRIA 62 Bull Trout Limiting Factors (Andonaegui 2003)	Subbasin Planning Report (NPCC 2005)	Pend Oreille Salmonid Recovery Team (POSRT 2005)	Contains USFWS Critical Habitat
Pewee Creek		X		X	X	
Lime Creek		X		X	X	
Slate Creek		X	X	X	X	X
Flume Creek		X	X	X	X	
Threemile Creek				X	X	
Sullivan Creek	X (only below Mill Pond)	X	X	X	X	X
Sullivan Creek tributaries			X	X	X	
Sullivan Lake			X	X	X	
Sullivan Lake tributaries			X	X	X	
Pocahontas Creek				X	X	
Sweet Creek	X (only below the falls at RM 0.6)	X	X	X	X	
Sand Creek		X	X	X	X	

Notes:
NPCC – Northwest Power and Conservation Council
POSRT – Pend Oreille Salmonid Recovery Team
WCC – Washington Conservation Commission
WDFW – Washington Department of Fish and Wildlife
WRIA – Water Resource Inventory Area
USFWS – U.S. Fish and Wildlife Service

4.4. Identification of Data Gaps and Proposed Data Collection Areas for 2008

Data gaps were identified by reviewing information, organizing available information into the primary tributaries data sheets, determining factors limiting the productivity of native species, and developing the primary and secondary tributaries limiting factors matrices. Each method described in the previous sections (4.1, 4.2, and 4.3) provided a mechanism to identify data gaps. Identified data gaps for each of the categories in the limiting factors matrices were noted in the appropriate matrix and documented. Data gaps identified in Andonaegui (2003) and by the CNF (2007) were also included.

Although a data gap in the limiting factors matrices may describe a complete evaluation of aquatic conditions for a particular tributary, not all data gaps were critical for determining which areas may be improved through human intervention for streams of interest relative to the Project. To determine which data gaps for the primary and secondary tributaries were critical to address, the following decision criteria were developed. A data gap was considered critical to address if:

- It was from a primary tributary.
- It was related to restoration goals from regional groups.
- It was related to stream section adfluvial habitat for Boundary Reservoir.
- Addressing the data gap(s) or surveying the area would facilitate in determining whether modification through human intervention is necessary, and if intervention actions would benefit adfluvial and native trout.
- It occurred in a tributary that has been identified as a priority by the POSRT (2005) or the CNF (2007).

5 PRELIMINARY RESULTS

As of July 31, 2007, available information on important physical, chemical, and biological conditions of the tributaries has been compiled and reviewed, with an initial focus on all tributaries draining into Boundary Reservoir. The drainage upstream of Mill Pond Dam in the Sullivan Creek WAU and the entire drainage of the Harvey Creek WAU were considered secondary streams because Mill Pond Dam and Sullivan Lake Dam are complete barriers to fish passage, which limit these areas to resident fish production. Consequently, documentation on the habitat conditions within the Sullivan Creek drainage upstream of Mill Pond Dam and the Harvey Creek WAU is limited in this report. This section presents the preliminary results of this study, discussed by task.

5.1. Review and Compile Available Information

Information gathered from compiling and reviewing sources for tributaries draining to Boundary Reservoir, excluding the drainage upstream of Mill Pond Dam in Sullivan Creek and the Harvey Creek WAU, resulted in a wide range of data. The majority of this information was from surveys and biological evaluations that occurred in the 1990s, and between 2000 and 2005. This information facilitated the development of a list of productivity factors for Boundary Reservoir tributaries (Section 5.2).

5.2. Stream Categorization and Productivity Factors

The information obtained from compiling and reviewing sources was catalogued into several categories affecting productivity including barriers, riparian conditions, channel conditions and dynamics, habitat elements, water quality, water quantity and characteristics, and fish species. Subsequently, the catalogued information was organized by WAU and tributary within a WAU, respectively, and provided a detailed list of productivity factors (see Appendix 5).

All Boundary Reservoir tributaries, including the Sullivan Creek drainage upstream of Mill Pond Dam and the Harvey Creek WAU, were categorized as primary, secondary, or excluded (see

Section 4.2) to determine levels of opportunity within these areas (Table 5.2-1). Although the Sullivan Creek drainage upstream of Mill Pond Dam and the Harvey Creek WAU were not a key focus during development of the list of productivity factors, information needed to determine if these areas were primary, secondary, or excluded was obtained from McLellan (2001), Andonaegui (2003), and WDFW SalmonScape (2007).

Pertinent information on aquatic conditions was captured for primary tributaries. A data table of migration barriers, riparian conditions, channel conditions and dynamics, habitat elements, water quality, water quantity, and fish species was developed for the primary tributaries (see Appendix 6). The data table facilitated construction of an overview of the aquatic conditions in Boundary Reservoir primary tributaries and documenting the function of those tributaries in the reservoir.

Tributary streams play an integral part in the conditions of river or reservoir systems by contributing nutrients, sediment, woody debris, and water. In addition, tributary streams support biological processes by providing food and refuge habitat to adfluvial and resident fish populations such as bull trout, westslope cutthroat trout, and mountain whitefish. Due to the connections between native salmonids, tributaries, and river or reservoir systems, it is imperative that the streams draining into Boundary Reservoir be capable of providing physical and biological conditions that assist in maintaining healthy salmonid populations.

Andonaegui (2003) stated that artificial structures, habitat degradation, high water temperatures, changes in the natural flow regime, and species competition have been associated with the decline of bull trout populations in the Pend Oreille River and its tributaries. Based on reviewing available sources and developing the list of productivity factors and the spreadsheet of data, it was determined that these same factors are potential conditions limiting aquatic productivity in Boundary Reservoir primary tributaries.

The following discussion, which is presented by WAU, summarizes the general status of productivity factors for many of the streams in each of the WAUs. The emphasis of the discussion is on primary tributaries because these are the water bodies with the greatest potential for human interventions that would supply the most benefit to mainly adfluvial salmonids. The Harvey WAU is not presented here because no primary streams are present in that region and because the area has limited potential as adfluvial habitat. A complete summary of the productivity factors and their status by streams within the Slate Creek, Sullivan Creek, and Box Canyon WAUs, including all tributaries, is presented in Appendix 5.

Table 5.2-1. Determination of primary, secondary, and excluded tributaries.

WAU	Tributary Name	Watershed Area (mi^2)	Length of Adfluvial Habitat (ft)	Natural Barrier at Mouth	Gradient (%)	Discharge (m^3/s)[8]	Native Species[8]	Level of Opportunity
Slate Creek	Lime Creek	2.9	6,746[2]		6[2]	0.08	DG	Primary
Slate Creek	Slate Creek	32.3	3,474[2]		6.3[2]	0.31	BT (near mouth); CT	Primary
Slate Creek	Flume Creek	19.3	1,056[2]		7[2]	0.05 to 0.25	CT	Primary
Sullivan Creek	Sullivan Creek WAU	91	21,729[2]		3[2]	7.1	BT; CT; MWF	See Sullivan Creek Opportunity Below
Sullivan Creek	Sullivan below Mill Pond Dam	21	21,729[2]		1 to 10[2]	1.4 to 56.6	BT; CT; MWF	Primary
Sullivan Creek	N.Fk.Sullivan	10.1	0[3]		2.2[7]	0.04	CT	Primary
Box Canyon	Linton Creek	2.1	19,159[1]		0.3 to 56.4[1]	DG	DG	Primary
Box Canyon	Pocahontas Creek	3.9	16,480[1]		1.5 to 26.9[1]	DG	CT	Primary
Box Canyon	Sweet Creek\Lunch Creek	11.1	2,659[2]		5 to 12[2]	0.15	BT; CT; MWF	Primary
Box Canyon	Sand Creek	8.2	1,320[2]		7[2]	0.01 to 0.02	CT; MWF	Primary
Slate Creek	Pewee Creek	10.4	0[2]	Yes	7 to 9[2]	0.01	CT	Secondary
Slate Creek	Everett Creek	2.2	60[1]		>20 after 60 ft[1]	DG	DG	Secondary
Slate Creek	Whiskey Gulch	<1	547[1]		>20 after 547 ft[1]	DG	DG	Secondary
Sullivan Creek	Sullivan above Outlet Creek	70	0[4]		1.5 to 4[2]	1.2	CT; MWF	Secondary
Harvey Creek	Harvey Creek WAU (Outlet Creek)	51.5	0[4]		0.8 to 60.2[1]	0.3 to 34	CT; MWF	Secondary
Box Canyon	Unnamed No. 6	<1	955[1]		>20 after 955 ft[1]	DG	DG	Secondary
Box Canyon	Wolf Creek	1.6	236[1]		16.5[1]	DG	DG	Secondary
Box Canyon	Lost Creek	1.2	165[1]		8.6[1]	DG	CT	Secondary
Box Canyon	Unnamed No. 13	1.7	<100[5]		>20 after 100 ft[1]	DG	DG	Secondary
Slate Creek	Unnamed No. 1	<1	82[1]		>20 after 82 ft[1]	DG	DG	Exclude
Slate Creek	Unnamed No. 2	<1	129[1]		>20 after 129 ft[1]	DG	DG	Exclude
Slate Creek	Beaver Creek	1.8	0[2]	Yes	12.7[1]	DG	DG	Exclude

Table 5.2-1. Determination of primary, secondary, and excluded tributaries (continued).

WAU	Tributary Name	Watershed Area (mi^2)	Length of Adfluvial Habitat (ft)	Natural Barrier at Mouth	Gradient (%)	Discharge (m^3/s)[8]	Native Species[8]	Level of Opportunity
Slate Creek	Threemile Creek	4.9	0[2]	Yes	10.5[1]	DG	None	Exclude
Slate Creek	Unnamed No. 3	<1	58[1]		>20 after 58 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 4	<1	77[1]		>20 after 77 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 5	<1	130[1]		>20 after 130 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 7	<1	53[1]		>20 after 53 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 8	<1	66[1]		>20 after 66 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 9	<1	67[1]		>20 after 67 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 10	<1	99[1]		>20 after 99 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 11	<1	78[1]		>20 after 78 ft[1]	DG	DG	Exclude
Box Canyon	Unnamed No. 12	<1	<100[6]		>20 after 102 ft[1]	DG	DG	Exclude

Notes:

DG – Data Gap; CT – Cutthroat Trout; BT – Bull Trout; MWF – Mountain Whitefish; m^3/s – cubic meter per second; m^2 – square mile

1 The length of adfluvial habitat and the gradient were determined from the WDFW SalmonScape (2007) as the distance from the mouth of the stream up to a gradient greater than 20%.

2 The length of adfluvial habitat is based on the distance from the mouth of the stream to the lowermost migration barrier reported in McLellan (2001) and/or Andonaegui (2003). Gradients were based on information reported in McLellan (2001) and/or Andonaegui (2003).

3 North Fork Sullivan Creek would be secondary, based on the criteria. However, because there is a culvert at the mouth limiting adfluvial habitat length, there is potential to increase the length to 1,056 ft by removing a culvert at the mouth. Therefore it was determined to be a Primary Tributary evaluated for factors limiting productivity of native salmonids. In addition, North Fork Sullivan Creek is located in the Sullivan Creek drainage downstream of Mill Pond Dam.

4 Because there is a dam located at Mill Pond Dam (RM 3.25), no adfluvial habitat is available.

5 Based on a site visit in September 2007, the outlet of the culvert which the tributary flows was blocked by riprap, although seepage flow was observed. The length of adfluvial habitat was estimated as less than 100 linear feet of stream (B. Fullerton, Tetra Tech, pers. comm., 2007).

6 Based on a site visit in September 2007, a culvert perched higher than 15 feet was observed near the reservoir margin. The length of adfluvial habitat was estimated as less than 100 linear feet of stream (B. Fullerton, Tetra Tech, pers. comm., 2007).

7 Determined from Conner et al. (2005).

8 Determined from McLellan (2001) and Andonaegui (2003).

5.2.1. Slate Creek WAU

Based on available literature, natural waterfalls, cascades, chutes, culverts, and other potential barriers within tributaries of the Slate Creek WAU were determined to be present in Slate, Slumber, Styx, Pewee, Threemile, Beaver, Lime, Everett, Whiskey Gulch, Flume, and South Fork Flume creeks (see Appendix 7 and Figure 5.2-1.). Most of the barriers within the Slate Creek WAU primary tributaries occur naturally. Although the Slate Creek WAU barriers are mostly waterfalls, cascades, and chutes, in the Slate Creek and Flume Creek watersheds culverts are present, offering potential areas where upstream connectivity for resident populations of native cutthroat trout could be restored. A vertical waterfall near the mouth of Flume Creek is a fish passage barrier (McLellan 2001; R2 Resource Consultants 1998; Andonaegui 2003; WDFW SalmonScape 2007). Farther upstream from the vertical waterfall is a culvert that is a potential fish passage barrier. Although barriers are present in Flume Creek, local agency biologists, studies on resident fish stock status, and surveys conducted throughout the Flume Creek tributary suggest there are suitable habitat characteristics for resident trout upstream of the waterfall barrier or adfluvial trout downstream of the barrier (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003).

Reviews and surveys suggest there is suitable habitat for resident or adfluvial trout throughout the Slate Creek watershed (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). In 2005, 0.15 mile of Slate Creek, from the confluence with the Pend Oreille River upstream, was designated as "Critical Habitat" by the USFWS (Federal Register 2005). Overall, within the Slate Creek tributary, available spawning and rearing habitat for bull and cutthroat trout residing in Boundary Reservoir is limited to the stretch from RM 0.0 to an impassable cascade at RM 0.75 (T. Shuhda 2007). Cutthroat trout were documented as well distributed, and successful reproduction was occurring indicated by the presence of young of the year (USFS 1998). Cutthroat trout were collected between May and June 2007 during a fyke net survey at the mouth of Sand Creek (SCL 2008b). But Young et al. (2005) suggested that cutthroat trout in Slate creek had significant genetic influence from hatchery fish stocked during the middle of the 20th century.

Throughout the Slate Creek WAU the riparian vegetation is intact and continuous with few road crossings; provides adequate shade, detritus, and LWD for future recruitment; and is composed of species reflecting a natural community (USFS 1998; USFS 1999b; Andonaegui 2003). Entrix (2002) reported that riparian harvest and catastrophic wildfires have reduced the availability of LWD, but riparian areas currently contain sufficient large trees to provide for future recruitment. For the Slate Creek WAU, instream LWD exceeded 20 pieces per mile for all surveyed reaches (USFS 1999b; Andonaegui 2003).

The WAU primarily consists of V- and U-shaped narrow valley forms (Rosgen A and B channel types) (USFS 1998; Andonaegui 2003). Braiding due to collections of LWD provides some off-channel habitat in side channels and along stream margins (Andonaegui 2003). However, because many of the channels in the WAU are high-gradient streams, they do not contain large amounts of off-channel habitat (USFS 1998; Andonaegui 2003. The USFS (1998) study of the Slate and Salmo watersheds concluded that past management activities had not resulted in conditions where flows, both peak and low, produced adverse impacts on the watersheds.

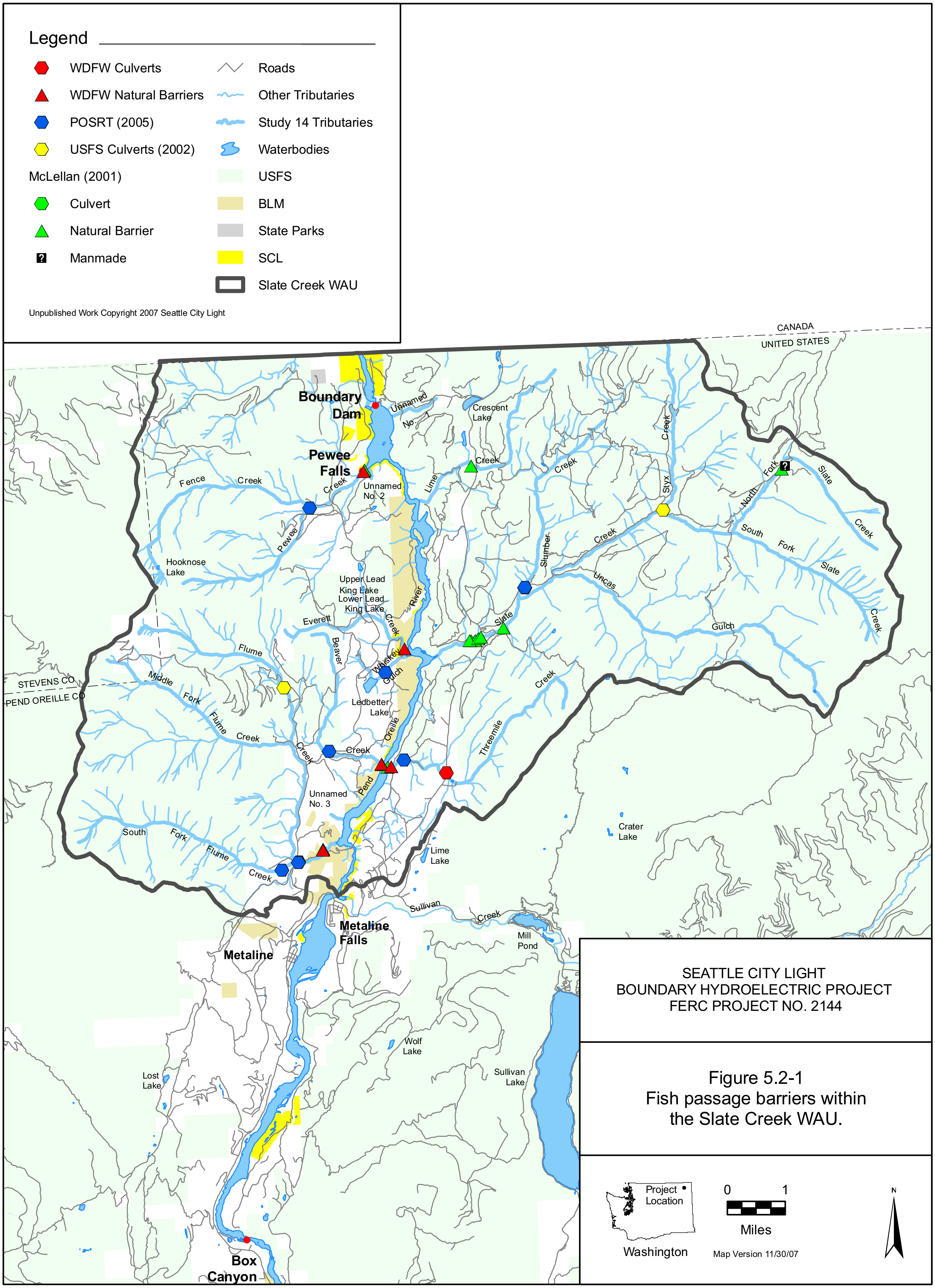

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Figure 5.2-1
Fish passage barriers within the Slate Creek WAU.

5.2.2. Sullivan Creek WAU

Based on available literature, natural waterfalls, cascades, chutes, culverts, and dams within the Sullivan Creek WAU were determined to be located in North Fork Sullivan Creek, in the mainstem of Sullivan Creek downstream of, at, and upstream of RM 3.25 (see Appendix 7 and Figure 5.2-2.). The Sullivan Creek hydroelectric project has been reported as limiting to bull and cutthroat trout in the WAU (T. Shuhda 2007). In 2005, the POSRT documented significant fish passage barriers as a bull trout habitat limiting factor. Within the North Fork Sullivan Creek drainage a culvert at the mouth is a barrier to fish passage. Natural barriers are present upstream from the culvert and an artificial barrier is also present, the North Fork Sullivan Creek Dam. Although barriers to fish passage are present, both the habitat and the cutthroat trout in the drainage make this tributary to Sullivan Creek distinct. Conner et al. (2005) describe North Fork Sullivan Creek as one of the most undisturbed streams in the lower Pend Oreille watershed.

Reviews and surveys suggest there is suitable habitat to support populations of native salmonids throughout the Sullivan Creek watershed (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). In 2005, 0.66 mile of Sullivan Creek, from the confluence with the Pend Oreille River upstream, was designated as "Critical Habitat" for bull trout. Throughout the Sullivan Creek watershed only two bull trout were detected prior to 2003, each below the uppermost natural cascades and chutes that occur near RM 0.65 on Sullivan Creek, upstream from the confluence with the Pend Oreille River (RM 0.0) (Andonaegui 2003). In September 2007, during a snorkel survey being conducted under Study 9 (SCL 2008b), a presumed bull trout was observed in Lower Sullivan Creek. From snorkel surveys conducted in 2000, Sullivan Creek had the lowest fish densities, compared to all other tributaries (McLellan 2001). However, of the tributaries surveyed (Slate, Sullivan, Sand, Flume, Sweet, Lunch, Pewee, and Lime creeks), Sullivan Creek had the greatest diversity observed (seven species) (McLellan 2001). McLellan (2001) suggests that the low fish densities in Sullivan Creek may have been a result of poor habitat, indicated by low densities of LWD and pool habitats, and/or high angling pressure. Overall, spawning and rearing habitat for bull and cutthroat trout from Boundary Reservoir is limited to the stream reach downstream of Mill Pond Dam (RM 3.25).

Historically, the riparian areas along main Sullivan Creek have been harvested and have roads located within some of the riparian areas (USFS 1999d). Entrix (2002) reported that aquatic habitat has been most influenced by historic timber harvest, especially clearcutting of riparian areas, road building, fires, and dispersed recreation. The USFS (1996) reported that by the mid-1980s, road density was between 1.7 and 2.0 miles per square mile. In addition, the USFS (1999d) stated that the majority of the road system is inside riparian areas, and portions of the riparian areas have been replaced by forest and county road systems limiting the total riparian areas from historic levels. Of approximately 234 miles of road within the WAU, nearly 46 miles are within 61 meters (200 feet) of streams, with Sullivan Creek Road open and adjacent to Sullivan Creek for most of its length (Entrix 2002). Overall, adequate shade, detritus, and LWD are provided by the riparian area for the Sullivan Creek WAU (Andonaegui 2003).

Above bankfull flow, streambanks have high vegetative cover and well-established riparian communities (Andonaegui 2003); USFS (1996) described the banks along Sullivan Creek as "generally in pretty stable condition." The primary erosional process throughout the drainage is landslides, and the channel is deeply entrenched and confined as it cuts through a rock canyon

(USFS 1996; Andonaegui 2003). Sections of Sullivan Creek downstream and continuing upstream from Mill Pond Dam are historically prone to landslide activity (USFS 1996; Andonaegui 2003). The POSRT (2005) documented embedded substrate/sedimentation as a bull trout habitat limiting factor.

Throughout the Sullivan Creek drainage, channels primarily comprise narrow V- or U-shaped valley forms (Rosgen A and B channel types) and do not and did not historically have many oxbows, backwater habitat, and ponds (USFS 1996; Andonaegui 2003). Although lacking off-channel habitat, the Sullivan Creek WAU does have some stream margins providing shallow water habitat and some side channel habitat resulting from accumulated complexes of woody debris forming bars and initiating channel braiding (USFS 1999d; Andonaegui 2003).

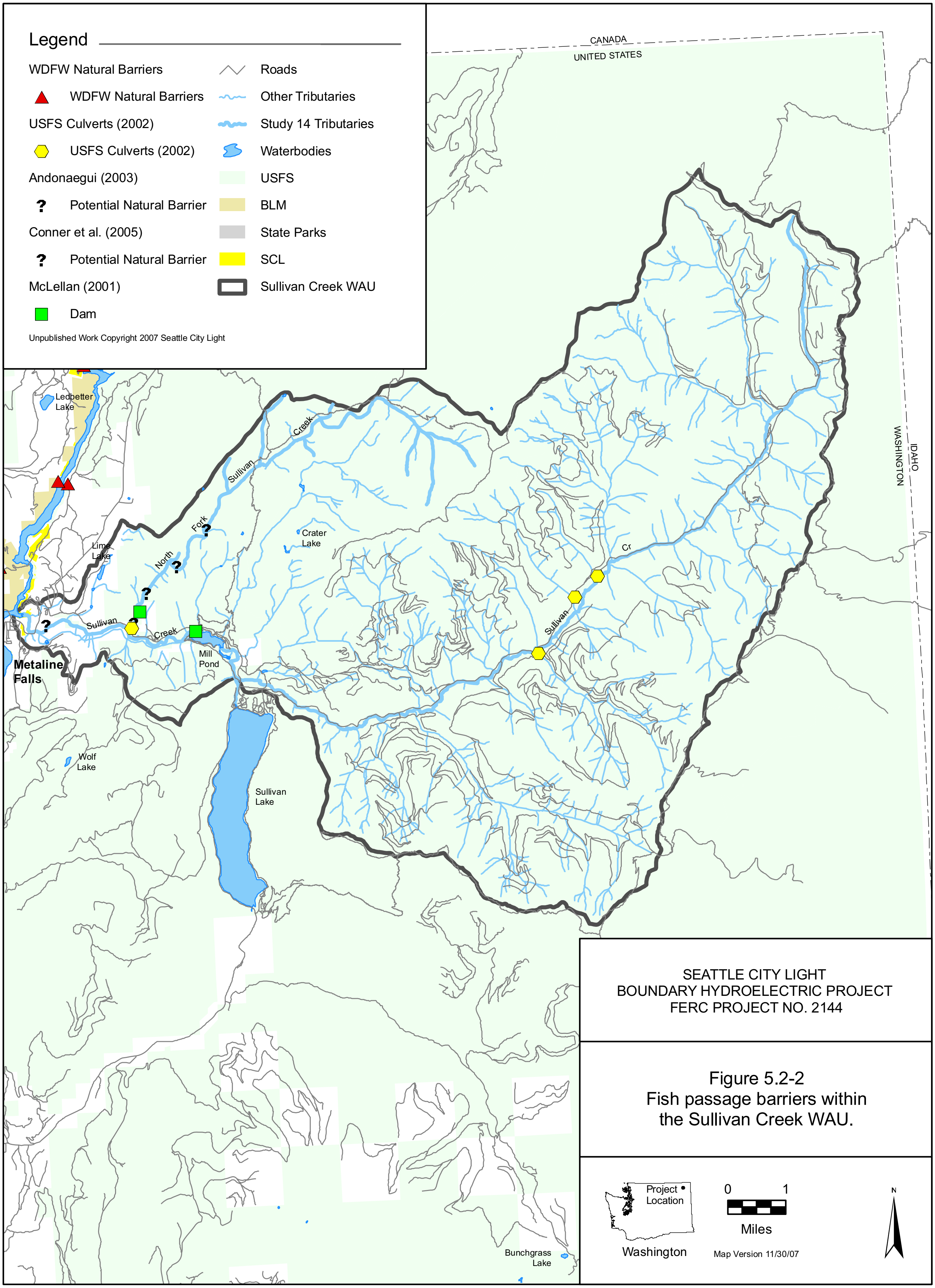

Figure 5.2-2
Fish passage barriers within the Sullivan Creek WAU.

5.2.3. Box Canyon WAU

Based on available literature, natural waterfalls, cascades, chutes, culverts, and other potential barrier within tributaries of the Box Canyon WAU were determined to be located in Linton, Pocahontas, Wolf, Sweet, Lunch, Sand, Lost, and 13 unnamed creeks (see Appendix 7 and Figure 5.2-3.). Nearly 1.5 miles of Linton Creek are blocked by culverts that are fish passage barriers. A culvert barrier in the lower stream section of Pocahontas Creek is a fish passage barrier (POSRT 2005). In Sweet Creek, a road crossing at State Highway 31 has been described as a velocity barrier to fish passage (Andonaegui 2003; WDFW SalmonScape 2007). However, as Andonaegui (2003) reports, and as documented in McLellan (2001), an adult bull trout was observed between the culvert and a waterfall barrier located upstream of the culvert. In addition, upstream of State Highway 31 juvenile whitefish had been observed, indicating some degree of passage (C. Vail 2002 as cited in Andonaegui 2003).

Reviews and surveys suggest there are suitable habitat characteristics for resident or adfluvial trout in the Box Canyon watershed (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). Bull trout, cutthroat trout, and mountain whitefish have all been documented as present in the lower sections of the drainage. R2 Resource Consultants (1998) indicated that potential spawning and rearing habitat for adfluvial salmonids is available below a waterfall barrier in Sweet Creek. In addition, Tom Shuhda (2007) noted that available spawning and rearing habitat for bull and cutthroat trout in Boundary Reservoir is limited to the area downstream of the falls barrier.

R2 Resource Consultants (1998) identified a limited amount of spawning and rearing habitat for salmonids below a fish passage barrier in the lower portion of Sand Creek. Andonaegui (2003) documented that limited "suitable" bull trout habitat was identified by TAG for Sand Creek. In addition, within the watershed existing habitat has been modified by human activities (Andonaegui 2003). However, instream habitat in Sand Creek was documented as fair to good and complex enough to provide refuge for all life stages of cutthroat trout present in the drainage (USFS 1999a; Andonaegui 2003). Tom Shuhda (2007) noted that available spawning and rearing habitat for bull and cutthroat trout in Boundary Reservoir is limited to the stretch from RM 0.0 to an impassable culvert near RM 0.25 in Sand Creek.

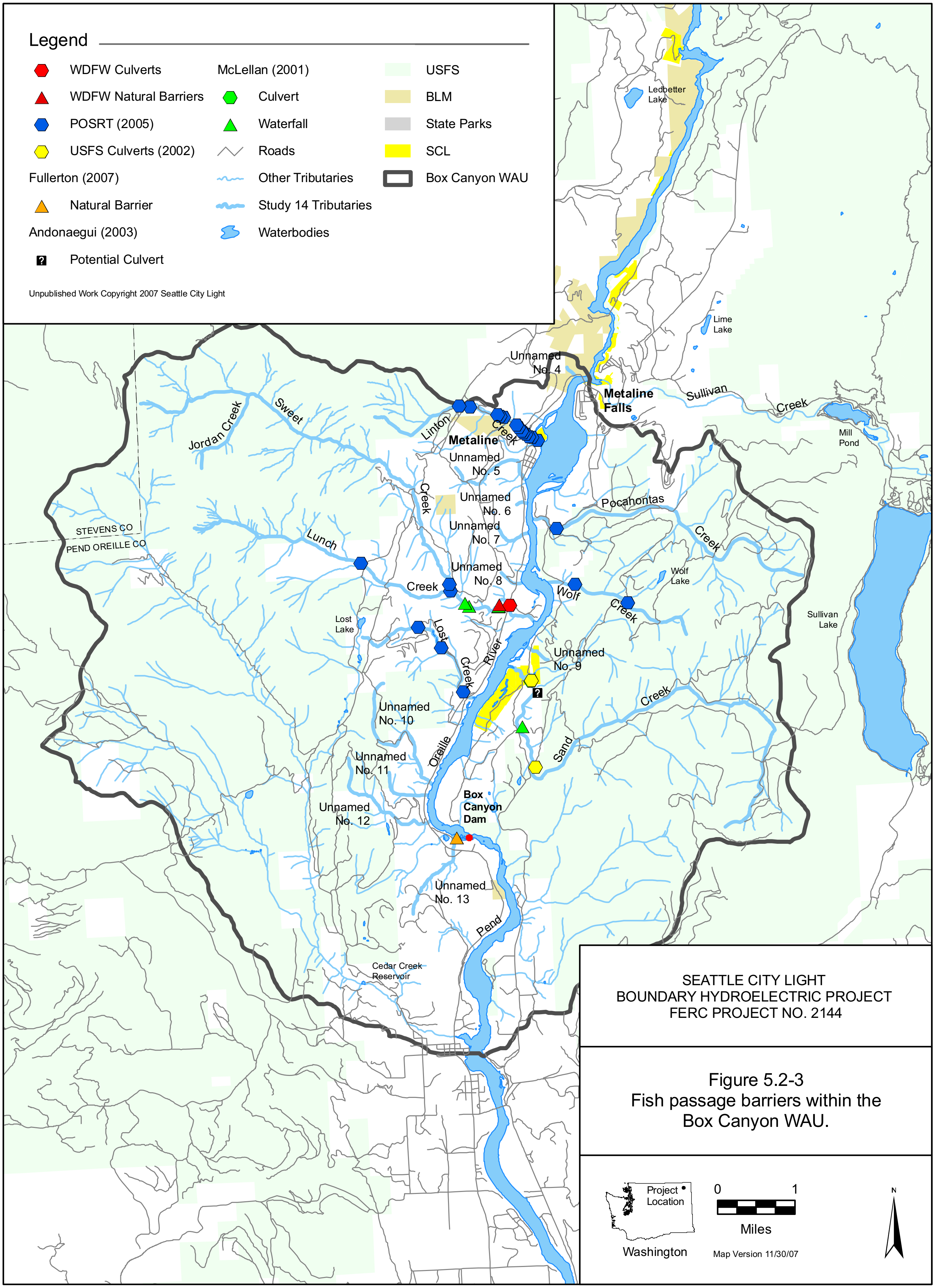

Figure 5.2-3
Fish passage barriers within the Box Canyon WAU.

5.3. Limiting Factors Matrix

The status of productivity factors potentially limiting native salmonid populations in Boundary Reservoir tributaries was put in the form of a matrix, categorizing the factors as poor quality habitat (not properly functioning), fair habitat (at risk), and good quality habitat (properly functioning). The matrix can be used to establish a priority ranking of Boundary Reservoir tributaries.

A list of tributaries that had the greatest opportunity to be modified through human intervention was shown in Table 5.2-1. The primary streams and limiting conditions by productivity factor are shown in Table 5.3-1. A matrix was also developed for secondary tributaries using the same methods as for Table 5.3-1 (see Appendix 4). To evaluate which conditions limit the ability of habitat to fully sustain populations of salmonids, the information was compared to habitat rating criteria from Andonaegui (2003) (see Appendix 3) and Smith (2005) (see Appendix 8). The categories in these habitat rating criteria comprise, in general, the following: access to spawning and rearing habitat, riparian condition, channel conditions, habitat elements, water quality, water quantity, and species competition.

The matrices facilitated in evaluating factors limiting aquatic productivity that can be modified through human intervention, and assist in determining data gaps for the primary and secondary tributaries.

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Table 5.3-1. Matrix of factors limiting productivity of native salmonids in primary tributaries.

Stream Name/Reach	Productivity Factors												
	Access to Spawning and Rearing	Riparian Condition	Channel Conditions/Dynamics			Habitat Elements					Water Quality	Water Quantity	Species Competition
	Artificial Structures		Streambank Condition	Floodplain Connectivity	Channel Stability	Channel Substrate	LWD	Pool Frequency and Quality	Pool Depth	Off-Channel Habitat	Temperature	Change in Flow Regime	Non-indigenous Fish
SLATE CREEK WAU													
Lime Creek (RM 19.0)													
RM 0.0 - 1.3	G1	√	√	G1	F1	P1	G1	F1	F1	F1	F1	G1	P1
Slate Creek (RM 22.2)													
RM 0.0 - 6.2	G1	F1	G1	G1	F1	F1	G1	G1	G1	G1	G1	G1	P1
Slumber Creek (RM 2.0)													
RM 0.0 - 0.5	P1	G1	G1	G1	G1	F1	G1	G1	G1	G1	G1	G1	P1
Uncas Gulch (RM 2.75)													
RM 0.0 - 2.0	G1	G1	G1	G1	G1	G2	G1	P1	G1	G1	G1	G1	P1
Styx River (RM 4.9)													
RM 0.0 - 2.0	P1	G1	G1	G1	G1	G2	G1	P1	G1	G1	G1	G1	P1
S. Fk. Slate Creek (RM 6.2)													
RM 0.0 - 1.0	G1	G1	G1	G1	G1	G2	G1	G1	G1	G1	G1	G1	P1
N. Fk. Slate Creek (RM 6.2)													
RM 0.0 - 2.5	DG	G1	G1	G1	G1	G2	G1	P1	F1	G1	G1	G1	P1
Flume Creek (RM 25.8)													
RM 0.0 - 4.75	P1	√	G1	DG	√	G1	G1	P1	F1	DG	F1	F1	P1
S. Fk. Flume Creek (RM 1.1)													
RM 0.0 - 0.3	P1	DG	DG	DG	√	G1	√	P1	F1	DG	F1	DG	P1
M. Fk. Flume Creek (RM 3.3)													
RM 0.0 - 0.75	G1	√	DG	DG	√	G1	√	P1	F1	DG	F1	√	P1
SULLIVAN CREEK WAU DOWNSTREAM OF MILL POND DAM (RM 3.25)													
Sullivan Creek (RM 26.9)													
RM 0.0 - 3.25	P1	G1	F1	G1	√	P1	P1	F1	F1	NA	P1	P1	P1
N. Fk. Sullivan Creek RM (2.35)													
RM 0.0 - headwaters	P1	G1	DG	G1	G1	P1	G1	F1	G1	G1	G1	G1	G1
BOX CANYON WAU													
Linton Creek (RM 28.1)													
RM 0.0 - 1.10	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Pocahontas Creek (RM 29.4)													
RM 0.0 - 0.6	P1	√	DG	G1	P1	P1	F1	P1	F1	F1	√	√	P1
Sweet Creek (RM 30.9)													
RM 0.0 - 0.6	P1	√	DG	DG	√	P1	G1	G1	F1	√	P1	√	P1
Lunch Creek (RM 1.5)													
RM 0.0 - 1.4	P1	√	DG	DG	DG	DG	G1	P1	F1	DG	√	√	P1
Sand Creek (RM 31.7)													
RM 0.0 -1.8	P1	G1	F1	G1	F1	P1	G1	P1	F1	NA	P1	DG	P1

Notes:
P – Average habitat condition considered to be poor (Not Properly Functioning)
F – Average habitat condition considered to be fair (At Risk)
G – Average habitat condition considered to be good (Properly Functioning)
NA – Not Applicable.
√ : 1) data is available but not in a format to allow for ready comparison with Andonaegui (2003) habitat rating criteria, and/or 2) data is not assessed in a geomorphic context.
DG – Data Gap; the stream or reach has not been surveyed or so little information is available that rating the condition was not valid.

1 – Quantitative studies, surveys, or published reports documenting habitat condition.
2 – Professional knowledge of the TAG members as reported in Andonaegui (2003)

= Based on available information, conditions are not limiting.
= Based on available information, conditions may be limiting.
= Based on available information, conditions are limiting.
= No information is available.

5.4. Identification of Data Gaps and Proposed Data Collection Areas for 2008

Data gaps were identified as described in Section 4.4. By using the primary and secondary tributary matrices, data gaps and partial data gaps were noted. A preliminary list of data gaps was then developed for primary tributaries (see Table 5.4-1). As discussed in Section 5.4.1, priority areas for potential habitat improvements, as noted by regional groups, were identified next for consideration to further refine the preliminary list of data gaps. Finally, as discussed in Section 5.4.2, a list of locations where data could be collected in 2008 based on the streams and reaches where critical data gaps were determined to exist was developed. This determination of critical data gaps and the development of a list of locations where data could be collected were based on considering areas where potential habitat improvements may be feasible, recommendations from regional groups, and the criteria described in Section 4.4.

A broad list of data gaps for the primary tributaries is provided in Table 5.4-1. The predominant data gaps for the secondary tributaries are identified in Appendix 4.

Table 5.4-1. Identified data gaps for the Slate Creek, Sullivan Creek, and Box Canyon WAUs.

Creek Name	Data Gap
Slate Creek WAU	
Styx Creek	• Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7). Specifically, the length of the culvert at RM 0.1.
North Fork Slate Creek	• Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7). Specifically, McLellan (2001) reports an artificial barrier in North Fork Slate Creek; however, information regarding the barrier is not available.
Flume Creek	• Dimensions of the barriers listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7). Specifically, the culvert lengths at RM 1.0 and 4.75. • Information on floodplain connectivity and available off-channel habitat is lacking.
South Fork Flume Creek	• Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7). Specifically, the culvert height and length at RM 0.3. • Information on riparian conditions, channel connectivity and dynamics, available off-channel habitat, and changes in the flow regime is needed to evaluate factors limiting productivity in South Fork Flume Creek. • Andonaegui (2003) reports that within Flume Creek "instream temperatures are not available for winter months when bull trout eggs are incubating (December – June 28)." Further evaluation and analysis of habitat attribute data (other than barriers, instream temperature, and brook trout competition) are necessary (Andonaegui 2003).
Middle Fork Flume Creek	• Surveys of channel connectivity and dynamics and available off-channel habitat need to be conducted to evaluate factors limiting productivity in Middle Fork Flume Creek.

Table 5.4-1. Identified data gaps for the Slate Creek, Sullivan Creek, and Box Canyon WAUs (continued).

Creek Name	Data Gap
Sullivan Creek WAU	
Sullivan Creek	• It is uncertain the extent to which human-induced activities like past timber harvest, road construction, channel straightening and bank armoring, and alteration to bedload and LWD transport by the dams are contributing to habitat degradation in Sullivan Creek. A channel migration zone study may be needed (Andonaegui 2003). • Placer gold mining should be evaluated to determine if restrictions or elimination of this activity could improve habitat conditions for bull trout (POPUD 1/29/03 final draft report review comments, March 2003 as cited in Andonaegui [2003]). • Regarding habitat for bull and cutthroat trout in Boundary Reservoir, there is a possibility that within the lower sections of Sullivan Creek the fluctuations in flows caused by release from Sullivan Lake Dam may result in redds becoming dewatered before emergence. Based on this information from Tom Shuhda (CNF, pers. comm., 2007), the extent to which redds become dewatered before emergence (October through December) is a data gap. • The effect of Sullivan Lake on warming inflow to Sullivan Creek during the summer has not been determined (T. Shuhda, CNF, pers. comm., 2007).
North Fork Sullivan Creek	• Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7). Specifically, the culvert height, length, and gradient at RM 0.0. • Streambank conditions in North Fork Sullivan Creek have not been evaluated.
Box Canyon WAU	
Linton Creek	• Dimensions of the barriers listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7) for Linton Creek. • Data are not available to evaluate channel conditions and dynamics, habitat elements, water quality, water quantity, and species competition throughout Linton Creek. The POSRT has identified 13 culverts between RM 0.18 and 1.1. Available habitat downstream, throughout, and upstream of these barriers is not known, and therefore is a data gap in identifying conditions limiting productivity in Linton Creek. • Linton Creek has yet to be surveyed to determine bull trout presence or absence and habitat suitability (Andonaegui 2003).
Pocahontas Creek	• Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7). Specifically, the culvert height, length, and gradient at RM 0.34. • Information on streambank conditions in Pocahontas Creek is not available.
Sweet Creek	• Dimensions of the barriers listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7) for Sweet Creek. • Data are not available to evaluate channel conditions and dynamics.
Lunch Creek	• Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7) for Lunch Creek. • Data are not available to evaluate channel conditions and dynamics, channel substrate, or available off-channel habitat.
Sand Creek	• Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7). Specifically, the culvert height, length, and gradient at RM 0.0.

5.4.1. Priorities in Boundary Reservoir Tributaries

Not all data gaps identified were critical to determining where additional data may need to be gathered in 2008. Although all data gaps were identified and reported in Table 5.4-1, it was necessary to screen this information for data gaps that are critical to fill in order to evaluate areas where factors limiting aquatic productivity can be modified through human intervention. One of the factors in determining where data should be collected was what regional groups consider to be priority habitat for potential improvement projects.

Table 5.4-2 provides the POSRT (2005) priorities and the Colville National Forest (CNF) (2007) priorities as they relate to Boundary Reservoir tributaries. The POSRT (2005) identifies the Slate Creek Subbasin and the Sullivan and Harvey Creek WAUs as high priorities within WRIA 62 (see Appendix 9). Tom Shuhda with the CNF (pers. comm., 2007) provided a priority list of tributaries draining into Boundary Reservoir with the highest potential for providing bull and cutthroat trout habitat. These organizations' priorities were utilized following the criteria described in Section 4.4.

Table 5.4-2. Priorities identified by POSRT (2005) and CNF (2007).

Creek Name	Priorities	
	POSRT	**CNF**
Slate Creek	The POSRT (2005) identifies the removal of non-native fish species (brook, brown, and rainbow trout) and the replacement or removal of culverts which have been identified as fish passage barriers throughout the Slate Creek subbasin as high priorities.	Slate Creek between RM 0.0 and 0.75 is the only habitat available to bull trout in this watershed and is therefore high priority habitat (T. Shuhda, CNF, pers. comm., 2007). For cutthroat trout upstream from barriers, the area upstream of RM 0.75 on Slate Creek is priority cutthroat habitat.
Sullivan Creek	The POSRT (2005) identified the following improvements to salmonid habitat within the Sullivan Creek drainage: the removal of Mill Pond Dam; restoring the upstream channel to proper form and function; restoring fish passage at Sullivan Lake Dam; removing non-native fish species (brook, brown, and rainbow trout), except kokanee, relocating, obliterating, and/or reconstructing road segments which are contributing sediment to the stream; installing engineered log jams above Mill Pond Dam; stabilizing slopes below Mill Pond Dam; and restoring habitat complexity.	Tom Shuhda (CNF, pers. comm., 2007) notes that between RM 0.0 and 3.25 in Sullivan Creek is the longest section of available habitat to fish in Boundary Reservoir, and is therefore high priority habitat. He further notes that if Mill Pond Dam and/or Sullivan Lake Dam are removed or if fish passage is provided at these locations, then all of Sullivan Creek and the Harvey Creek drainage would become high priority habitats. For cutthroat trout upstream from barriers, Sullivan Creek above Mill Pond Dam, Sullivan Lake, and throughout the Harvey Creek WAU are areas of high priority habitats.
Sweet Creek	—	Sweet Creek between RM 0.0 and 0.5 is available habitat that has been utilized by bull trout (T. Shuhda, CNF, pers. comm., 2007), and is therefore priority habitat.
Flume Creek and Pocahontas Creek	—	For bull trout, Flume Creek and Pocahontas Creek were also identified as high priority tributaries draining into Boundary Reservoir (T. Shuhda, CNF, pers. comm., 2007).

Notes:
CNF – Colville National Forest
POSRT – Pend Oreille Salmonid Recovery Team

5.4.2. Critical Data Gaps and Planned Tasks for 2008

Critical data gaps were identified by screening all the identified data gaps (Table 5.4-1), considering priority areas as identified above (Table 5.4-2), and applying the decision criteria described in Section 4.4. In addition to determining critical data gaps by utilizing all the identified data gaps, the critical data gaps were determined based on the need to evaluate locations where factors limiting aquatic productivity can be potentially be modified through human intervention. Information is provided in Table 5.4-3 that describes high priority tasks (next steps) intended to address critical data gaps. Slate, Slumber, Styx, Flume, Sullivan, Pocahontas, and Sweet creeks all surfaced as priority areas with identified data gaps and stream segments where aquatic productivity could potentially be modified through human intervention. Of these creeks, only the data gaps for Flume Creek were not deemed necessary to fill through data collection tasks planned for 2008. Flume Creek was not included in tasks for 2008 because of the limited amount of current and potential habitat available and the extensive actions that would be necessary to potentially modify productivity.

Table 5.4-3. Critical data gaps and planned tasks.

Creek Name	Critical Data Gap	Task
Slate Creek WAU		
Slate Creek	Between RM 0.0 and 0.75 is the only habitat available to bull trout in this watershed. There is a lack of information on the level of protection for this stream segment of Slate Creek.	Evaluate the feasibility of entering the stream segment between 0.0 and 0.75 into an area of protected habitat.
Slumber Creek	The amount of quality habitat that would be available by removing the culvert at RM 0.2 is not known.	Evaluate habitat in Slumber Creek upstream and downstream of the culvert at RM 0.2 to determine the extent of habitat which would be available by removing the fish barrier.
Styx Creek	Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7) are not known. Specifically, the length of the culvert at RM 0.1. The amount of quality habitat that would be available by removing the culvert is not known	Evaluate barrier dimensions and habitat in Styx Creek upstream and downstream of the culvert at RM 0.1 to determine the extent and quality of habitat which would be available by removing the fish barrier.
Sullivan Creek WAU		
Sullivan Creek	Between RM 0.0 and 0.66 is listed as critical habitat available to bull trout in this watershed. There is a lack of information on the level of protection for this stream segment of Sullivan Creek.	Evaluate the feasibility of entering the stream segment between RM 0.0 and 0.66 into an area of protected habitat.
	Sources of coarse and fine sediment to the stream below Mill Pond and the geomorphic conditions affecting sediment storage and transport are poorly understood. The locations where sediment control or enhancement may be possible are not known.	Evaluate the fluvial geomorphic conditions of Sullivan Creek downstream of Mill Pond and identify potential sediment control or enhancement measures between RM 0.0 and 3.25.
Box Canyon WAU		
Pocahontas Creek	Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7) are not known. The amount of quality habitat that would be available by removing the culvert is not known.	Evaluate barrier dimensions and habitat conditions upstream and downstream of the culvert at RM 0.34, determine streambank conditions through field surveys or other methods between RM 0.0 and 0.6.

Table 5.4-3. Critical data gaps and planned tasks (continued).

Creek Name	Critical Data Gap	Task
Sweet Creek	Between RM 0.0 and 0.5 is habitat available to bull trout in this watershed. In addition, bull trout have been observed using this area. There is a lack of information on the level of protection for this stream segment of Sweet Creek.	Evaluate the feasibility of entering the stream segment between 0.0 and 0.5 into an area of protected habitat.
	Dimensions of the barrier listed in the Barrier Inventory for Boundary Reservoir tributaries (see Appendix 7) are not known. The amount of quality habitat that would be available by removing the culvert is not known. In addition, there is a data gap for channel conditions and dynamics and habitat elements between RM 0.0 and 0.6.	Evaluate barrier dimensions and habitat conditions upstream and downstream of the culvert at RM 0.5; determine channel conditions and dynamics and habitat elements through field surveys or other methods between RM 0.0 and 0.6.

6 SUMMARY

6.1. Work Conducted

The following work has been conducted:

- Available information has been reviewed and compiled.
- A detailed list of productivity factors has been created.
- A draft limiting factors matrix has been created.
- Data gaps have been identified.
- A spreadsheet containing available information on water quantity, water quality, fish habitat, fish presence, channel morphology, riparian conditions, and migration barriers from Boundary Reservoir tributaries with the highest opportunity to be modified through human intervention has been created.
- Tasks for 2008 have been identified.

6.2. Tasks for 2008 in Boundary Reservoir Tributaries

In 2008, the tasks listed in Table 6.2-1 will be undertaken.

Table 6.2-1. Tasks to be completed in 2008.

Stream Name and Task Location	2008 Tasks	Modification Benefit
Slate Creek WAU		
Slate Creek (PRM 26.9)		
RM 0.0 - 0.75	Evaluate the feasibility of entering this segment of Slate Creek into an area of protected habitat. • This is an office task. • Utilize phone calls, emails, documentation, web sites, and GIS layers to determine property ownership, property tax value, existing USFS land designation (current forest plans), and applicable conservation easement/acquisition procedure.	Protection of critical habitat
Slumber Creek (RM 2.0)		
RM 0.2	Evaluate habitat in Slumber Creek upstream and downstream of the culvert to determine the extent of habitat that would be available under culvert modifications; evaluate potential culvert modifications. • This is a field task • Habitat assessment will entail surveying 150 to 500 m (492 to 1,640 ft) downstream and between 150 to 500 m (492 and 1,640 ft) upstream of the culvert by measuring the thalweg, slope, wetted width, LWD, substrate, and channel cover. • Culvert assessment will entail measuring the dimensions and slope of the barrier.	Potentially ≥ 1,584 ft of cutthroat habitat
Styx Creek (RM 4.9)		
RM 0.1	Evaluate habitat in Styx Creek upstream and downstream of the culvert to determine the extent of habitat that would be available under culvert modifications; evaluate potential culvert modifications. • This is a field task. • Habitat assessment will entail surveying 150 to 500 m (492 to 1,640 ft) downstream and 150 to 500 m (492 and 1,640 ft) upstream of the culvert by measuring the thalweg, slope, wetted width, LWD, substrate, and channel cover. • Culvert assessment will entail measuring the dimensions and slope of the barrier.	Potentially ≥ 10,032 ft of cutthroat habitat
Sullivan Creek WAU		
Sullivan Creek (PRM 26.9)		
RM 0.0 - 0.66	Evaluate the feasibility of entering this segment of Sullivan Creek into an area of protected habitat. • This is an office task. • Utilize phone calls, emails, documentation, web sites, and GIS layers to determine property ownership, property tax value, existing USFS land designation (current forest plans), and conservation easement/acquisition procedure.	Protection of critical habitat

Table 6.2-1. Tasks to be completed in 2008 (continued).

Stream Name and Task Location	2008 Tasks	Modification Benefit
Sullivan Creek (PRM 26.9)		
RM 0.0 - 3.25	Evaluate the fluvial geomorphic conditions of Sullivan Creek downstream of Mill Pond and identify potential opportunities for sediment control or enhancement measures between RM 0.0 and 3.25. • Activities include both office and field tasks. • Perform a geomorphic field reconnaissance of Sullivan Creek downstream of Mill Pond to characterize the overall geomorphic condition and the key processes contributing to the current condition. Of particular emphasis will be the sediment balance and influence of the trapping of upstream sediments in Mill Pond as well as opportunities for potential sediment control or enhancement measures. • Characterize the dominant bed material size, representative bank materials, and the presence or absence of suitable spawning substrate in this segment of Sullivan Creek. Vertical and lateral geologic controls are to be identified. In addition, 6 to 10 pebble counts will be performed to characterize typical substrate conditions. No pebble counts are required in the tributary delta as this information has been collected as part of Study 8. • In support of the geomorphic field reconnaissance, a profile of Sullivan Creek from RM 0.00 to 3.25 will be developed from the best available topographic mapping and review of current and historical aerial photographs. • Results and conclusions will be documented from the geomorphic field reconnaissance, including the identification of potential opportunities for sediment control or enhancement measures and increased habitat complexity.	Improve sediment recruitment, storage and transport processes; increase habitat complexity
Sullivan Creek (PRM 26.9)		
RM 2.8 - 3.25	Evaluate locations where road segments can be relocated, obliterated, and/or reconstructed. • Activities include both office and field tasks. • Stream segments where road segments encroach Sullivan Creek will be identified and documented through aerial photographs, available literature, phone calls, and field surveys. • Road segment measurements from field surveys will entail sideslope angle on both sides of the road segment, length of road segment encroaching on Sullivan Creek, and description of road type.	Improve sediment recruitment, storage and transport processes
Box Canyon WAU		
Pocahontas Creek (PRM 29.4)		
RM 0.34	Evaluate barrier dimensions and habitat upstream and downstream of the culvert to determine the extent of habitat which would be available under culvert modifications; evaluate potential culvert modifications. • This is a field task. • Habitat assessment will entail surveying 150 to 500 m (492 to 1,640 ft) downstream and 150 to 500 m (492 to 1,640 ft) upstream of the culvert by measuring the thalweg, slope, wetted width, LWD, substrate, and channel cover. • Culvert assessment will entail measuring the dimensions and slope of the barrier.	Provide upstream access to fish in Boundary Reservoir

Table 6.2-1. Tasks to be completed in 2008 (continued).

Stream Name and Task Location	2008 Tasks	Modification Benefit
Pocahontas Creek (PRM 29.4)		
RM 0.0 - 0.6	Evaluate habitat conditions and determine streambank conditions, focused on the stretch between RM 0.0 and approximately RM 0.6, to learn which, if any, modifications can be identified to improve habitat conditions. • This is a field task. • The entire length (RM 0.0 to 0.6) will be walked and observations on the creeks condition will be documented. • Habitat and streambank assessment will entail surveying 150 to 500 m (492 to 1,640 ft) of Pocahontas Creek collecting thalweg, slope, wetted width, LWD, substrate, channel cover, and stream bank measurements.	Unknown; information on habitat quality, accessibility, and stream bank conditions is unknown, therefore modification type and benefit are not known
Sweet Creek (PRM 30.9)		
RM 0.0 - 0.5	Evaluate the feasibility of entering this segment of Sweet Creek into an area of protected habitat. • This is an office task. • Utilize phone calls, emails, documentation, web sites, and GIS layers to determine property ownership, property tax value, existing USFS land designation (current forest plans), and conservation easement/acquisition procedure.	Protection of critical habitat
Sweet Creek (PRM 30.9)		
RM 0.0 - 0.6	Evaluate channel conditions and dynamics between RM 0.0 and 0.6 to learn which, if any, modifications can be identified to improve habitat conditions. • This is a field task. • The entire length (RM 0.0 to 0.6) will be walked and observations on the creeks condition will be documented. • Streambank condition, floodplain connectivity, and channel stability measurements will entail surveying two cross-sections, each in a riffle.	Unknown; information on stream bank condition, floodplain connectivity, and channel stability is unknown, therefore modification type and benefit are not known

Table 6.2-1. Tasks to be completed in 2008 (continued).

Stream Name and Task Location	2008 Tasks	Modification Benefit
Sweet Creek (PRM 30.9)		
RM 0.5	Evaluate barrier dimensions and habitat in Sweet Creek upstream and downstream of the culvert to determine the extent of habitat which would be available under culvert modifications; evaluate potential culvert modifications. • This is a field task. • Habitat assessment will entail surveying 150 to 500 m (492 to 1,640 ft) downstream and 150 to 500 m (492 to 1,640 ft) upstream of the culvert by measuring the thalweg, slope, wetted width, LWD, substrate, and channel cover. • Culvert assessment will entail measuring the dimensions and slope of the barrier.	Provide upstream access to fish in Boundary Reservoir

7 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

There were no variances from the RSP.

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Appendix 1. Northwest Power and Conservation Council Subbasin Planning (2005)

Table A.1-1. Ranking of reaches with the largest deviation from the reference habitat conditions for bull trout in the Pend Oreille Subbasin.

The table is based on Qualitative Habitat Assessment (QHA) results, the number of reaches and watersheds that currently contain bull trout has decreased by 57 percent from historic numbers. Historically there were 98 of 167 delineated reaches and watersheds within the Pend Oreille Subbasin that supported bull trout. Currently, that number has dropped by 56 reaches to only 42 reaches and watersheds supporting bull trout.

A reach rank equal to 1 has the greatest deviation from reference condition in comparison to other reaches. Reach scores range from 0 to 1, with 1 having the greatest deviation from reference. Values associated with each habitat attribute range from 1 to11; a value of 1 indicates a habitat attribute having the greatest deviation from reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes equally deviate the most from the reference

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Lower Sullivan Creek	4	0.5	2	2	5	9	5	5	10	10	1	5	4
Lower Harvey Creek	15	0.3	2	2	1	4	6	6	8	8	8	8	4
Lower Sand Creek	26	0.3	2	4	2	1	4	4	9	9	4	9	8
Pass Creek	35	0.2	1	1	4	1	5	5	8	8	5	8	8
Middle Sullivan Creek	39	0.2	1	4	1	1	4	4	8	8	4	8	8
Upper Sullivan Creek	57	0.2	2	4	1	2	4	4	7	7	7	7	7
Sweet/Lunch Creek	68	0.1	1	3	3	1	5	5	8	8	5	8	8
Middle Harvey Creek	68	0.1	1	2	2	2	2	2	7	7	7	7	7
Sullivan Lake	73	0.1	6	2	2	2	1	6	8	8	8	8	5
North and Middle Fork Harvey Creek	74	0.1	1	1	1	1	1	1	7	7	7	7	7
Slate Creek	87	0.1	2	2	2	1	2	2	7	7	7	7	7
Deemer/Leola Creek	93	0.1	1	1	1	1	1	1	7	7	7	7	7
Gypsy Creek	93	0.1	1	1	1	1	1	1	7	7	7	7	7

Table A.1-2. Ranking of streams whose habitat is most similar to the reference condition for bull trout in the Pend Oreille Subbasin in comparison to other reaches.

The table is based on Qualitative Habitat Assessment (QHA) results, the number of reaches and watersheds that currently contain bull trout has decreased by 57 percent from historic numbers. Historically there were 98 of 167 delineated reaches and watersheds within the Pend Oreille Subbasin that supported bull trout. Currently, that number has dropped by 56 reaches to only 42 reaches and watersheds supporting bull trout.
A reach rank equal to 1 reveals the reach with current conditions most similar to reference conditions in comparison to other reaches. Reach score ranges from 0 to -1, with -1 having the least deviation from reference. Values associated with each habitat attribute range from 1 to 11; a value of 1 indicates a habitat attribute being most similar to the reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes are equally the most similar to the reference

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Slate Creek	8	-0.84	5	5	5	10	5	5	1	1	1	1	11
Lower Sullivan Creek	29	-0.5	8	8	4	3	4	4	1	1	10	4	11
Sweet/Lunch Creek	41	-0.32	8	5	7	8	6	3	1	10	3	1	10

Table A.1-3. Ranking of reaches with the largest deviation from the reference habitat conditions for westslope cutthroat in the Pend Oreille Subbasin.

A reach rank equal to 1 has the greatest deviation from reference condition in comparison to other reaches. Reach scores range from 0 to 1, with 1 having the greatest deviation from reference. Values associated with each habitat attribute range from 1 to 11; a value of 1 indicates a habitat attribute having the greatest deviation from reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes equally deviate the most from the reference.

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Lower Sullivan Creek	5	0.5	2	2	5	9	5	5	10	10	1	5	4
Lower Harvey Creek	20	0.3	2	2	1	4	6	6	8	8	8	8	4
Lower Sand Creek	39	0.3	2	4	2	1	4	4	9	9	4	9	8
Pass Creek	48	0.2	1	1	4	1	5	5	8	8	5	8	8
Upper Sand Creek	48	0.2	3	4	2	1	4	4	8	8	4	8	8
Middle Sullivan Creek	56	0.2	1	4	1	1	4	4	8	8	4	8	8
Upper Sullivan Creek	77	0.2	2	4	1	2	4	4	7	7	7	7	7
Sweet/Lunch Creek	89	0.1	1	3	3	1	5	5	8	8	5	8	8
Middle Harvey Creek	89	0.1	1	2	2	2	2	2	7	7	7	7	7
Flume Creek	95	0.1	1	3	3	1	5	5	8	8	5	8	11
Sullivan Lake	95	0.1	6	2	2	2	1	6	8	8	8	8	5
North and Middle Fork Harvey Creek	97	0.1	1	1	1	1	1	1	7	7	7	7	7
Pocahontas Creek	99	0.1	2	2	2	1	5	5	8	8	5	8	11
Threemile Creek	103	0.1	1	1	1	1	6	6	6	6	1	6	6
Peewee/Russian Creek	103	0.1	1	1	1	1	5	5	7	7	7	7	7
Slate Creek	115	0.1	2	2	2	1	2	2	7	7	7	7	7
Deemer/Leola Creek	120	0.1	1	1	1	1	1	1	7	7	7	7	7
Gypsy Creek	120	0.1	1	1	1	1	1	1	7	7	7	7	7
Lime Creek	122	0.1	1	1	1	1	5	5	8	8	5	8	11
North Fork Sullivan Creek	123	0.0	2	2	2	2	2	2	2	2	2	2	1

Table A.1-4. Ranking of streams whose habitat is most similar to the reference condition for westslope cutthroat trout in the Pend Oreille Subbasin in comparison to other reaches.

A reach rank equal to 1 reveals the reach with current conditions most similar to reference conditions in comparison to other reaches. Reach score ranges from 0 to -1, with -1 having the least deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute being most similar to the reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes are equally the most similar to the reference.

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
North Fork Sullivan Creek	7	-0.86	1	1	1	1	1	1	1	10	1	1	11
Deemer/Leola Creek	8	-0.86	4	4	4	4	4	4	1	11	1	1	10
Gypsy Creek	8	-0.86	4	4	4	4	4	4	1	11	1	1	10
South Fork Lost Creek	10	-0.84	6	7	7	7	1	1	1	11	1	1	10
Slate Creek	21	-0.8	5	5	4	5	1	5	1	11	5	1	10
North and Middle Fork Harvey Creek	24	-0.79	4	4	4	4	4	4	1	11	1	1	10
Sullivan Lake	25	-0.78	4	6	6	6	9	4	1	10	1	1	10
Middle Harvey Creek	26	-0.78	6	6	6	10	3	3	1	10	3	1	9
Pocahontas Creek	26	-0.78	10	6	6	9	1	1	1	10	4	4	8
Peewee/Russian Creek	34	-0.75	6	6	6	6	4	4	1	10	1	1	11
Upper Sullivan Creek	36	-0.74	8	4	10	8	4	4	1	10	1	1	7
Sweet/Lunch Creek	51	-0.72	8	3	3	8	5	5	1	11	5	1	8
Middle Sullivan Creek	59	-0.7	8	3	8	8	3	3	1	8	3	1	7
Pass Creek	63	-0.69	8	8	7	8	3	3	1	8	3	1	6
Upper Sand Creek	63	-0.69	8	3	9	11	3	3	1	9	3	1	7
Lower Sand Creek	73	-0.66	7	3	7	11	3	3	1	7	3	1	7
Lower Harvey Creek	90	-0.61	8	8	10	6	4	4	1	6	1	1	11
Lower Sullivan Creek	109	-0.45	8	8	3	2	3	3	1	3	10	3	11

Table A.1-5. Reaches where mountain whitefish are no longer present and corresponding rank for the degree of habitat deviation from reference conditions.

It should be noted in 2003 (after information had been collected for the QHA), WDFW captured mountain whitefish in an adfluvial trap in lower Harvey Creek (WDFW, unpublished data 2003). Reach rank refers to the degree of habitat change from reference to present conditions, 1 = greatest habitat alteration.

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Lower Sullivan Creek	3	0.3	9	2	7	7	3	6	10	10	5	3	1
Lower Harvey Creek	6	0.2	7	3	4	1	5	6	8	8	8	8	1
Lower Sand Creek	11	0.2	7	4	2	1	2	5	9	9	7	9	5
Pass Creek	18	0.2	6	2	4	1	3	5	8	8	6	8	8
Sullivan Lake	36	0.1	7	3	5	2	1	6	8	8	8	8	4
Middle Harvey Creek	42	0.1	6	3	5	1	1	4	7	7	7	7	7
Sweet/Lunch Creek	44	0.1	5	2	3	1	3	6	8	8	7	8	8
North and Middle Fork Harvey Creek	45	0.1	5	2	4	1	6	6	6	6	6	6	3
Pocahontas Creek	48	0.1	6	2	3	1	3	5	8	8	6	8	11
Threemile Creek	52	0.1	5	2	3	1	6	6	6	6	3	6	6
Slate Creek	54	0.1	6	3	5	1	2	4	7	7	7	7	7
Lime Creek	61	0.0	6	2	3	1	3	5	8	8	6	8	11

Table A.1-6. Ranking of streams whose habitat is most similar to the reference condition for mountain whitefish in the Pend Oreille Subbasin in comparison to other reaches.

A reach rank equal to 1 reveals the reach with current conditions most similar to reference conditions in comparison to other reaches. Reach score ranges from 0 to -1, with -1 having the least deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute being most similar to the reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes are equally the most similar to the reference.

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Sullivan Lake	7	-0.6	11	6	10	3	4	5	1	7	7	1	7
Middle Sullivan Creek	12	-0.57	11	5	10	6	3	6	1	6	9	1	4
Sweet/Lunch Creek	17	-0.56	10	6	9	4	3	5	1	7	8	1	11
Lower Sullivan Creek	22	-0.38	10	8	7	2	3	6	1	3	9	3	11

Table A.1-7. Ranking of reaches with the largest deviation from the reference habitat conditions for kokanee in the Pend Oreille Subbasin.

A reach rank equal to 1 has the greatest deviation from reference condition in comparison to other reaches. Reach scores range from 0 to 1, with 1 having the greatest deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute having the greatest deviation from reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes equally deviate the most from the reference.

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Lower Harvey Creek	5	0.2	7	1	4	2	5	5	7	7	7	7	2
Sullivan Lake	15	0.1	7	2	5	2	1	5	7	7	7	7	4

Table A.1-8. Ranking of streams whose habitat is most similar to the reference condition for kokanee in the Pend Oreille Subbasin in comparison to other reaches.

A reach rank equal to 1 reveals the reach with current conditions most similar to reference conditions in comparison to other reaches. Reach score ranges from 0 to -1, with -1 having the least deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute being most similar to the reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes are equally the most similar to the reference.

Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Sullivan Lake	3	-0.65	11	5	9	5	7	4	1	1	10	1	8
Lower Harvey Creek	13	-0.54	11	7	10	6	4	4	1	1	8	1	9

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Appendix 2. Pend Oreille Salmon Recovery Team (2005) Limiting Factors Evaluation

Table A.2-1. Results from the POSRT (2005) WRIA 62 limiting factors evaluation.

Summary of Bull Trout Limiting Factors by Subbasin				**HABITAT LIMITING FACTORS and PRIORITY** **Numbered boxes indicate limiting factor presence and priority, with "1" being a higher priority limiting factor in that subbasin than "10". Unless otherwise indicated, all data is from the WRIA 62 Habitat Limiting Factors Report for Bull Trout (Andonaegui 2003). Pink shaded boxes denote limiting factors which are undocumented but are suspected by the Technical Advisory Group (TAG).**														
Subbasin	**POLE[a] Priority**	**USFWS Critical Habitat**	**LF Habitat Types**	**Degraded riparian habitat**	**Embedded substrate/sedimentation**	**Channel complexity lacking**	**Degraded pool habitat**	**Altered channel morphology**	**Stream channel instability**	**Elevated stream temperature**	**Other water quality problem**	**Significant fish passage barriers**	**Other fish passage barriers**	**Non-native species competition**	**Development pressure**	**High road density**	**Dewatering**	**Undetermined – Data Lacking**
Slate	High	No	Suitable										2[b]	1				
Sullivan	High	**Yes**	Recoverable Suitable		6		5	3		4		2		1				7

[a] Pend Oreille Lead Entity

[b] DNR internal data

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Appendix 3. Bull Trout Habitat Rating Criteria from Andonaegui (2003)

Table A.3-1. WRIA 62 Pend Oreille bull trout habitat rating criteria from Andonaegui (2003).

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Access to Spawning and Rearing Habitat						
Artificial Structures (i.e. culverts, dams, dikes)	Man-made physical barriers (address subsurface flows or dewatering where they impede fish passage under water quality attributes)	All	Man-made barriers present in reaches do not allow upstream and /or downstream fish passage at a range of flows.	Man-made barriers present in the reach do not allow upstream and/or downstream fish passage at base/low flows.	Man-made barriers present in the reach allow upstream and downstream fish passage at all flows.	USFWS Guidelines
Riparian Condition						
Riparian Condition	Riparian Habitat Conservation Areas (RHCAs): Riparian corridors, wetlands, intermittent headwater streams, and other areas where proper ecological functioning is crucial to maintenance of the stream's water, sediment, woody debris and nutrient delivery systems (definition taken from INFISH)	All – Eastside	Riparian areas are fragmented, poorly connected, or provide inadequate protection of habitats for sensitive aquatic species (<70% intact, refugia does not occur), and adequately buffer impacts on rangelands; percent similarity of riparian vegetation to the potential natural community/composition is <25%.	Moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian areas, or incomplete protection of habitats and refugia for sensitive aquatic species (≈ 70-80% intact) and adequately buffers impacts on rangelands: percent similarity of riparian vegetation to the potential natural community/composition is 25-50% or better.	The riparian areas provide adequate shade, LWD recruitment, and habitat protection and connectivity in subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact) and adequately buffers impacts on rangelands: percent similarity of riparian vegetation to the potential natural community/composition is >50%.	USFWS Guidelines
Channel Conditions/Dynamics						
Streambank Condition	% of stream reach in stable condition	All - Eastside	<50% of any stream reach has ≥90% stability	50–80% of any stream reach has ≥90% stability	>80% of any stream reach has ≥90% stability	USFWS Guidelines

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	All – Eastside	Severe reduction in hydrologic connectivity between off channel, wetland, floodplain and riparian areas; wetlands extent drastically reduced and riparian vegetation/success on altered significantly.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function and riparian vegetation/succession.	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	USFWS Guidelines
Channel Stability		All	W/D or Entrenchment ratio is inappropriate for geomorphologically correct Rosgen stream type	W/D or Entrenchment ratio is increasing/decreasing beyond range of acceptable for geomorphologically correct Rosgen stream type	W/D and Entrenchment ratio is appropriate for geomorphologically correct Rosgen stream type	TAG 2002 and Rosgen 1996
Habitat Elements						
Channel Substrate	Substrate condition as it relates to rearing habitat and spawning and incubation habitat, including but not limited to, the degree of substrate embeddedness, substrate mobility, and percent fines.	All – Eastside	>30% embeddedness (rearing) or >17% fines <0.85mm (spawning/incubation)	20 – 30% embeddedness (rearing) or 12 - 17% fines <0.85mm (spawning/incubation)	<20% embeddedness (rearing) or <12% fines <0.85mm (spawning/incubation)	USFWS Guidelines
Large Woody Debris	Pieces/mile that are >12" in diameter and >35 ft. in length with at least one end of piece within the OHWL (Ordinary High Water Line); also adequate sources of woody debris are available for both long and short-term recruitment	All – Eastside	Current levels are not at those desired values for "Good/Properly Functioning", and potential sources of woody debris for short and /or long term recruitment are lacking	Current values are being maintained at minimum levels desired for "Good/Functioning Appropriately", but potential sources for long-term woody debris recruitment are lacking to maintain these minimum values	Current values are being maintained at greater than >20 pieces/mile, >12" in diameter and >35" ft. in length.	USFWS Guidelines

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Habitat Elements						
Pool Frequency and Quality	% wetted channel surface area comprising pools	All	Pool frequency is considerably lower than values desired for “good/properly functioning”; also cover/temperature is inadequate, and there has been a major reduction of pool volume by fine sediment.	Pool frequency is similar to values in “good/ properly functioning” but pools have inadequate cover/temperature and /or there has been a moderate reduction of pool volume by fine sediment.	Pool frequency in a reach closely approximates: Wetted Width (ft) – # Pools/ mile 0–5 – 39 5-10 – 60 10-15 – 48 15-20 – 39 20-30 – 23 30-35 – 18 35-40 – 10 40-65 – 9 65-100 – 4 (can use formula: pools/ mile = 5,280/ wetted channel width ÷ # channel widths per pool	USFWS Guidelines
Pool Depth	Pools >1 meter	Streams >3m in wetted width	No pools	few pools	many pools present	USFWS Guidelines
Off-channel Habitat	Area within the channel migration zone which is also accessible during peak flow events.	Reaches with average gradient <2%	Reach has no ponds, oxbows, backwaters, or other off-channel areas	Reach has some ponds, oxbows, backwaters, and other off-channel areas with cover; but side-channel areas are generally high energy areas	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover; and side-channels are low energy areas	USFWS Guidelines

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Water Quality						
Temperature	degrees Celsius/ degrees Fahrenheit	All	7-day average maximum temperature in a reach during the following life history stages: • >15°C/ >59°F (rearing) • <4°C or >10°C/ <39°F or >50°F (spawning) • <1°C or >6°C/ <34°F or >43ºF (incubation) also temperatures in areas used by adults during migration regularly exceed 15ºC/59ºF (thermal barriers present)	7-day average maximum temperature in a reach during the following life history stages: • <4°C or 13-15ºC/ <39°F or 55º-59ºF (rearing) • <4°C or 10°C/ <39°F or 50°F (spawning) • <2°C or 6°C/ <36°F or 43ºF (incubation) also temperatures in areas used by adults during migration sometimes exceed 15ºC/59ºF	7-day average maximum temperature in a reach during the following life history stages: • 4°-12ºC/ 39°-54ºF (rearing) • 4° - 9ºC/ 39°-48°F (spawning) • 2°-5°C/ 36°-41ºF (incubation) also temperatures do not exceed 15ºC/59ºF in areas used by adults during migration (no thermal barriers)	USFWS Guidelines
Water Quantity						
Change in Flow Regime	Change in Peak/Base Flows	All	Pronounced changes in peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	Some evidence of altered peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	Watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	USFWS Guidelines
Species Competition						
Non-indigenous fish species	Presence/ Absence	All	Present in the drainage	Present in an adjacent drainage and have access to the drainage	Absent in the drainage and there is not opportunity for access to the drainage	TAG 2002

Appendix 4. Secondary Tributaries Limiting Factors Matrix

Table A.4-1. Secondary tributaries limiting factors matrix.

	Access to Spawning and Rearing		Channel Conditions/Dynamics			Habitat Elements					Water Quality	Water Quantity	Species Competition
Stream Name	**Artificial Structures**	**Riparian Condition**	**Streambank Condition**	**Floodplain Connectivity**	**Channel Stability**	**Channel Substrate**	**LWD**	**Pool Frequency and Quality**	**Pool Depth**	**Off-Channel Habitat**	**Temperature**	**Change in Flow Regime**	**Non-indigenous Fish**
SLATE CREEK WAU													
Pewee Creek (RM 17.9)													
RM 0.0 - 1.3	P1	P1	DG	DG	P1	P1	G1	P1	DG	DG	G1	√	P1
Fence Creek (RM 1.1)													
RM 0.0 - 0.31	G1	DG	DG	DG	DG	DG	DG	P1	F1	DG	G1	√	P1
Everett Creek (RM 21.9)													
RM 0.0 - 1.2	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Whiskey Gulch (RM 21.9)													
RM 0.0 - 0.6	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
SULLIVAN CREEK WAU UPSTREAM OF MILL POND DAM (RM 3.25)													
Sullivan Creek (RM 26.9)													
RM 3.25 - ?/headwaters	P1	F1	F1	G1	√	√	P1	P1	F1	NA	F1	F1	P1
Elk Creek (RM 3.7)													
RM 0.0 - 0.58	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Outlet Creek (RM 5.3)													
RM 0.0 - 0.5	G1	F2	F2	DG	DG	F2	DG	G1	G1	DG	DG	P1	P1
Pass Creek (RM 8.9)													
RM 0.0 - headwaters	G1	√	DG	DG	√	√	DG	G1	G1	DG	√	√	F1
Stony Creek (RM 11.6)													
RM 0.0 - 0.04	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Kinyon Creek (RM 12.65)													
RM 0.0 - 0.27	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Copper Creek (RM 13.35)													
RM 0.0 - 0.05	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Gypsy Creek (RM 13.8)													
RM 0.0 - 2.0	G1	√	DG	DG	√	√	DG	G1	G1	DG	√	√	P1
Leola Creek (RM 17.6)													
RM 0.0 - 3.0	G1	G1	G1	G1	F1	DG	G1	F1	G1	G1	√	√	F1
Deemer Creek (RM 0.32)													
RM 0.0 - 2.0	G1	√	G1	√	F1	DG	G1	P1	P1	G1	√	√	P1
HARVEY CREEK WAU													
Sullivan Lake (RM 0.5)													
RM 0.0 - 4.0/length of lake	P1	F1	G1	G1	NA	NA	DG	NA	NA	NA	√	P1	P1
Noisy Creek (RM 3.8/Lk. Sullivan inlet)													
RM 0.0 - ?	G1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Harvey Creek (RM 4.0/Lk. Sullivan inlet)													
RM 0.0 - headwaters	G1	F1	F1	√	G1	√	F1	P1	P1	NA	F1	√	P2
M. Fk. Harvey Creek (RM 10.0)													
RM 0.0 - 1.5	G1	√	F1	√	G1	√	G1	P1	F1	NA	√	√	F1
N. Fk. Harvey Creek (RM 0.5)													
RM 0.0 -2.3/headwaters	G1	√	F1	√	G1	√	G1	P1	P1	NA	√	√	F1

Table A.4-1. Secondary tributaries limiting factors matrix (continued).

	Access to Spawning and Rearing		Channel Conditions/Dynamics			Habitat Elements					Water Quality	Water Quantity	Species Competition
Stream Name	Artificial Structures	Riparian Condition	Streambank Condition	Floodplain Connectivity	Channel Stability	Channel Substrate	LWD	Pool Frequency and Quality	Pool Depth	Off-Channel Habitat	Temperature	Change in Flow Regime	Non-indigenous Fish
BOX CANYON WAU													
Unnamed No. 6 (RM 29.2)													
RM 0.0 - 0.18	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Wolf Creek (RM 30.3)													
RM 0.0 - 1.21	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Lost Creek (RM 32.2)													
RM 0.0 - 1.41	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Unnamed No. 13 (RM 34.3)													
RM 0.0 -0.02	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG

Notes:

P – Average habitat condition considered to be poor (Not Properly Functioning)
F – Average habitat condition considered to be fair (At Risk)
G – Average habitat condition considered to be good (Properly Functioning)
NA – Not Applicable.

1 – Quantitative studies, surveys, or published reports documenting habitat condition.
2 – Professional knowledge of the TAG members as reported in Andonaegui (2003)

(green) = Based on available information, conditions are not limiting.
(orange) = Based on available information, conditions may be limiting.
(red) = Based on available information, conditions are limiting.
(white) = No information is available.

√ : 1) data are available from reports, the NPCC (2005), and/or POSRT (2005), but not in a format to allow for ready comparison with Andonaegui (2003) habitat rating criteria, and/or 2) data are not assessed in a geomorphic context.

DG = Data Gap; the stream or reach has not been surveyed or so little information is available that rating the condition was not valid.

Appendix 5. List of Productivity Factors

Slate Creek WAU

Pewee Creek

- ***Barrier:*** A naturally occurring 50 meter (165 ft) vertical waterfall at the mouth of Pewee Creek is a barrier to fish passage, making the creek disconnected from Boundary Reservoir (McLellan 2001; Andonaegui 2003; WDFW SalmonScape 2007). Approximately upstream from RM 1.2 there is a fish passage barrier (POSRT 2005).
- ***Habitat Elements:***
  - *Channel Substrate:* In surveying sites within two reaches of Pewee Creek conducted in 2000, McLellan (2001) reported the dominant substrate boulder for the upper reach and rubble for the lower reach. However, for the entire Pewee Creek watershed McLellan (2001) reported rubble as the dominant substrate.
  - *LWD:* McLellan (2001) conducted habitat surveys within two reaches on Pewee Creek and based on data available from the report, there was a mean of 290 pieces of LWD per mile.
  - *Pool Frequency and Quality:* McLellan (2001) conducted habitat surveys within two reaches on Pewee Creek, and reported 21 large pools per mile for the upstream reach and zero large pools per mile for the downstream reach. The downstream reach started at approximately RM 0.31 and went upstream to approximately RM 0.62. The upstream reach went from approximately RM 0.62 to the confluence of Pewee Creek and Fence Creek (approximately RM 1.1 on Pewee Creek).
  - *Pool Depth:* McLellan (2001) reported no information for mean pool width, maximum depth, and residual depth for two reaches surveyed on Pewee Creek.
  - *Wetted Width:* McLellan (2001) reported the average wetted width was 2.8 m (9.2 ft) in 2000 from surveys of three stream reaches.

- ***Water Quality:***
  - *Temperature:* In a water temperature study conducted in Boundary Reservoir by R2 Resource Consultants (1998), cool water refugia were available for salmonids during August and September at the confluence of the creek and the reservoir. However, the cool water zone was relatively small in size, but well defined (R2 Resource Consultants 1998; Andonaegui 2003). Based on the data available from the McLellan (2001) report the 7-day average maximum temperature for Pewee Creek at its mouth was 11.8ºC (53.24ºF) between August 6 and August 12, 2000.

- ***Water Quantity and Characteristics:*** McLellan (2001) determined the discharge on September 25, 2000, to be 0.01 m^3/s (0.35 ft^3/s) at the mouth of Pewee Creek. The mean gradient from two reaches surveyed on Pewee Creek was 7 percent, and in Fence Creek, a tributary draining into Pewee Creek, the gradient was 9 percent (McLellan 2001). Entrix (2002) reported the maximum flow recorded as 0.0 m^3/s (0.4 ft^3/s).
- ***Fish Species:***
  - *Cutthroat Trout:* Cutthroat trout density in Pewee Creek was 1 fish/100 m^2 based on sites within two 500 m (1,640.4 ft) reaches surveyed in 2000 (McLellan 2001). However, cutthroat trout were not observed during snorkel surveys in the reach

between the confluence of Fence and Pewee creeks (approximately RM 1.1) and downstream to approximately RM 0.62 (McLellan 2001). Eastern brook trout were the only other fish species observed during the survey and were found in both surveyed reaches on Pewee Creek (McLellan 2001).
    - *Brook Trout:* Eastern brook trout density in Pewee Creek was 1 fish/100 m^2 based on sites within two 500 m (1,640.4 ft) reaches surveyed in 2000 (McLellan 2001). Cutthroat trout were the only other fish species observed during the survey (McLellan 2001).

Fence Creek

- ***Habitat Elements:***
    - *Channel Substrate:* In surveying sites within a 500 m (1,640.4 ft) reach of Fence Creek conducted in 2000, McLellan (2001) reported the dominant substrate as cobble.
    - *LWD:* McLellan (2001) conducted habitat surveys within a reach on Fence Creek and documented 402 pieces of LWD per mile.
    - *Pool Frequency and Quality:* McLellan (2001) conducted habitat surveys within a reach on Fence Creek and reported a mean of 31 large pools per mile.
    - *Pool Depth:* McLellan (2001) conducted habitat surveys within a reach on Fence Creek and determined the mean width, maximum depth, and residual depth for the reach was 2.6 m (8.5 ft), 43 centimeters (cm) (16.9 inches [in]), and 10 cm (3.9 in), respectively.
- ***Water Quantity and Characteristics:*** The gradient from one reach surveyed on Fence Creek was 9 percent (McLellan 2001).
- ***Fish Species***
    - *Cutthroat Trout:* Cutthroat trout density in Fence Creek was 1 fish/100 m^2 based on sites within a 500 m (1,640.4 ft) reach surveyed in 2000 (McLellan 2001). Eastern brook trout were the only other fish species observed during the survey (McLellan 2001).
    - *Brook Trout:* Eastern brook trout density in Fence Creek was 1 fish/100 m^2 based on sites within a 500 m (1,640.4 ft) reach surveyed in 2000 (McLellan 2001). Cutthroat trout were the only other fish species observed during the survey (McLellan 2001).

Lime Creek

- ***Barriers:*** Lime Creek goes subsurface for approximately 100 m (330 ft) at RM 1.3, downstream of the Lake Lucerne tributary and State Highway 31 (McLellan 2001; Andonaegui 2003).
- ***Channel Conditions and Dynamics:***
    - *Floodplain Connectivity:* The USFS (2005) SMART database documents braiding, off-channel areas, and beaver activity in the comments for Lime Creek.
    - *Channel Stability:* The USFS (2005) SMART database reports the entrenchment ration between 2.0 and 3.9.

- ***Habitat Elements:***
    - *Channel Substrate:* The USFS (1998) reported embeddedness was greater than 35 percent and attributed the condition of substrate in Lime Creek to the drainage

occurring in area of decomposed limestone (USFS 1998). In habitat surveys conducted in 2000, McLellan (2001) reported the dominant substrate as gravel.
  - LWD: McLellan (2001) conducted habitat surveys within four reaches on Lime Creek and documented a mean of 772 pieces of LWD per mile.
  - Pool Frequency and Quality: McLellan (2001) conducted habitat surveys within four reaches on Lime Creek and determined the dominant habitat type was riffle (60 percent). Although riffle was reported as the dominant habitat type, McLellan (2001) reported a mean of 47 large pools per mile.
  - Pool Depth: McLellan (2001) conducted habitat surveys within four reaches on Lime Creek and determined the mean width, maximum depth, and residual depth for two of the four reaches was 4.0 m (13.1 ft), 38 cm (15.0 in), and 24 cm (9.4 in), respectively.
  - Off-Channel Habitat: The USFS (2005) documents braiding, off-channel areas, and beaver activity in the comments for Lime Creek.
  - Wetted Width: McLellan (2001) reported the average wetted width was 3.1 m (10.2 ft) in 2000 from surveys of four stream reaches.

- ***Water Quality:***
  - Temperature: Instream summer time water temperatures naturally exceeded the tolerance level for bull trout fry and juveniles (T. Shuhda, USFS, email comm., 2003 as cited in Andonaegui 2003). The USFS (1998) documents temperatures in Lime Creek as high as 15ºC (59ºF) during the summer and attributed these summer temperatures to warm water input from Lake Lucerne. Using data reported by McLellan (2001) from monitoring water temperature 1,340 times with a thermograph between June 28 and October 27, 2000, the 7-day average maximum temperature was 11.6ºC (52.88ºF) between August 6 and August 12, 2000. The CNF Total Maximum Daily Load (TMDL) (Ecology 2005) reported Lime Creek as unlisted impaired under section 303(d) of the Clean Water Act for temperature in 1998.

- ***Water Quantity and Characteristics:*** McLellan (2001) determined the discharge on September 26, 2000, to be 0.08 m^3/s (2.83 ft^3/s), and noted the creek went subsurface approximately 100 m downstream of State Highway 31. The mean gradient from four reaches surveyed on Lime Creek was 6 percent (McLellan 2001). Entrix (2002) reported the maximum flow recorded as 0.2 m^3/s (5.3 ft^3/s). The CNF TMDL (Ecology 2005) reported average July – August flow to be 0.02 m^3/s (0.76 ft^3/s).

- ***Fish Species:***
  - Brook Trout: A sustaining population of eastern brook trout was documented in Lime Creek (USFS 1998). In snorkel surveys conducted in 2000 on four reaches in Lime Creek, McLellan (2001) reported eastern brook trout as the only fish species observed. No fish were observed upstream of approximately RM 1.3 (McLellan 2001). However, McLellan (2001) reported that the mean density of brook trout for the three reaches where brook trout were present was 5 fish/100 m^2.

Everett Creek

- ***Barrier:*** Approximately at RM 0.16 of Everett Creek there is a potential waterfall barrier (WDFW SalmonScape 2007). At approximately RM 1.2 there is a culvert listed in the WDFW GIS layers; however, it is noted that the crossing was abandoned (WDFW SalmonScape 2007).
- ***Water Quantity and Characteristics:*** The mean gradient was greater than 20 percent after 18.3 m (60 ft) upstream from the confluence with Boundary Reservoir (RM 0.0) (R2 Resource Consultants 1996; WDFW SalmonScape 2007).

Whiskey Gulch

- ***Barrier:*** Approximately at RM 0.60 on Whiskey Gulch there is a fish passage barrier (POSRT 2005).
- ***Water Quantity and Characteristics:*** The mean gradient was greater than 20 percent after 166.7 m (547 ft) upstream from the confluence with Boundary Reservoir (RM 0.0) (R2 Resource Consultants 1996; WDFW SalmonScape 2007).

Slate Creek

- ***Barrier:*** A survey of Slate Creek in 1997 by R2 Resource Consultants provided information that no fish passage barriers existed in the creek, although portions of the creek have several steep gradients which could limit passage by small salmonids under some streamflow conditions (R2 Resource Consultants 1998; Andonaegui 2003). The USFS (1999b) reported that there are no known artificial fish passage barriers in the Slate Creek WAU, but did identify a series of cascades at RM 0.75 that could limit passage under some streamflow conditions. However, McLellan (2001) reported that a series of natural falls, cascades, and chutes are a complete barrier to fish passage. Based on maps and written descriptions from McLellan (2001), the series of natural falls, cascades, and chutes starts approximately at RM 0.75 and continues upstream for 800 meters (m) (2,624.7 ft). Moving in an upstream direction, the first waterfall (near RM 0.75) was 6.0 m (19.7 ft) high, the second waterfall was 4.0 m (13.1 ft) high, the third waterfall was 5.0 m (16.4 ft) high, the fourth waterfall was 2.8 m (9.2 ft) high, and the chute was 30 m (98.4 ft) long, 2.0 m (6.7 ft) wide, and had a gradient of 38 percent with uninterrupted flow (McLellan 2001). The differences between the conditions reported by McLellan (2001) and those from R2 Resource Consultants (1998) and USFS (1999b) require further evaluation to determine under what flow conditions portions of Slate Creek limit upstream passage to fish species utilizing the drainage. McLellan (2001) identifies an additional waterfall (3.0 m [9.8 ft]) and chute (10 m [32.8 ft] long, 1 m [3.3 ft] wide, gradient of 24 percent) as a fish passage barrier in Slate Creek (near RM 1.5), approximately 400 m (1,312.3 ft) upstream from the State Highway 31 bridge.
- ***Riparian Conditions:*** Alder, alder/dogwood, and conifer/alder are the primary riparian vegetation communities documented for Slate Creek (USFS 1998; Andonaegui 2003). R2 Resource Consultants (1998) documented a shaded riparian corridor in Slate Creek, based on observed temperatures.
- ***Channel Conditions and Dynamics:***
    - *Streambank Condition:* Of the stream reaches surveyed on USFS land in 1991 and 1997, the majority of the reaches had greater than 90 percent stability (USFS 1999b; Andonaegui 2003).

- ***Habitat Elements:***
  - *Channel Substrate:* Based on reaches surveyed in 1991 and 1997 by the USFS, cobble and gravel were determined to be the dominant substrate with embeddedness less than 35 percent (USFS 1998; Andonaegui 2003). R2 Resource Consultants (1998) reported a mean of 6 percent for surface fines from surveys in Slate Creek. McLellan (2001) reported the dominant substrate type was cobble and boulder with a mean embeddedness of 6 percent based on sites surveyed in seven reaches on Slate Creek.
  - *LWD:* For the nine stream reaches surveyed by the USFS in Slate Creek, 210, 142, 201, 234, 154, 187, 161, 137, and 128 pieces of LWD per mile were documented (USFS 1998). In the nine stream reaches surveyed on Slate Creek, the USFS (1998) reports that LWD is the primary source of instream cover. McLellan (2001) conducted habitat surveys in sites within seven reaches on Slate Creek and based on data available from the report, there was a mean of 635 pieces of LWD per mile.
  - *Pool Frequency and Quality:* Nine stream reaches were surveyed in Slate Creek by the USFS and 24, 26, 22, 10, 17, 19, 23, and 20 pools per mile documented (USFS 1998). McLellan (2001) conducted habitat surveys at sites within seven reaches on Slate Creek and reported a mean of 38 large pools per mile. However, McLellan (2001) reported that riffles were the dominant habitat type for Slate Creek.
  - *Pool Depth:* Based on observations during snorkel surveys, there were negligible amounts of fine sediment in pool substrate (USFS 1999b; Andonaegui 2003). McLellan (2001) conducted habitat surveys at sites within seven reaches on Slate Creek and the mean width, maximum depth, and residual depth for the combined reaches was 3.8 m (12.4 ft), 53 cm (20.9 in), and 36.1 cm (14.2 in), respectively. On average in Slate Creek, pool depths have been documented to range between 0.8 and 1.1 m (2.5 and 3.5 ft) and provide suitable overwintering habitat (Andonaegui 2003).
  - *Wetted Width:* Based on data available from the McLellan (2001) survey of seven stream reaches on Slate Creek, the average wetted width was 6.3 m (20.7 ft).

- ***Water Quality:***
  - *Temperature Near RM 0.0:* In a water temperature study conducted in Boundary Reservoir by R2 Resource Consultants (1998), cool water refugia were available for salmonids during August and September at the confluence of the creek and the reservoir. However, the cool water zone was relatively small in size, but well defined (R2 Resource Consultants 1998; Andonaegui 2003). The USFS (1998) documents temperatures in Slate Creek and its tributaries reaching 10ºC (50ºF) during the summer. Based on limited data from the USFS (1999b) reported by Andonaegui (2003), during the summer months and into the spawning period for bull trout water temperatures were consistently between 7 and 9ºC (44 and 48ºF). Andonaegui (2003) describes that the information available from the USFS (1999b) was "insufficient to determine the 7-day average maximum temperature in Slate Creek and its tributaries." However, of the data that were available, spot temperatures taken during surveys were determined to be within the acceptable

bull trout ranges for spawning and rearing and assumed accessible for incubation (USFS 1999b; Andonaegui 2003). Andonaegui (2003) goes on to state that there are inconsistencies between the data provided to SCL by R2 Resource Consultants (1998) and the data reported by the USFS (1999b). R2 Resource Consultants (1998) recorded water temperatures at the mouth of Slate Creek (RM 0.0) using thermographs in 1996 and again from late July through early November 1997. At the mouth of Slate Creek the maximum water temperature recorded was 15.4ºC (59.7ºF) on August 5 and 6, 1997 (R2 Resource Consultants 1998). The 7-day average maximum temperature at the mouth of Slate Creek in the study by R2 Resource Consultants (1998) was 14.6ºC (58.3ºF) between August 1 and 7, 1997. McLellan (2001) measured the temperature of lower Slate Creek between June 28 and October 17, 2000, and determined the maximum temperature to be 13.34ºC (56.0ºF) on August 8 and 9, and the minimum temperature to be 2.80ºC (37.0ºF) on October 6. Using data reported by McLellan (2001), the 7-day average maximum temperature in lower Slate Creek was 13.1ºC (55.58ºF) between August 6 and August 12, 2000.

- <u>*Temperature Near RM 2.6:*</u> R2 Resource Consultants (1998) recorded water temperatures near the confluence of Uncas Gulch and Slate Creek (approximately RM 2.6 on Slate Creek) using thermographs in 1996 and again from late July through early November 1997. The 7-day average maximum temperature for the period of record on Slate Creek was 11.7ºC (53.06ºF) between August 1 and 7, 1997 (R2 Resource Consultants 1998).

- ***<u>Water Quantity and Characteristics:</u>*** At the mouth of Slate Creek (RM 0.0) the discharge was 0.31 m^3/s (10.95 ft^3/s) on July 31, 2000 (McLellan 2001). The mean gradient from seven reaches surveyed on Slate Creek was 6.3 percent (McLellan 2001). Entrix (2002) reported the maximum flow recorded as 0.3 m^3/s (11.0 ft^3/s).

- ***<u>Fish Species:</u>***
  - <u>*Bull Trout:*</u> In 1998 the USFS documented that near the mouth of Slate Creek (RM 0.0) bull trout had been captured in 1994, 1995, and 1997 (USFS 1998 and 1999b). Five bull trout were captured using hook-and-line near the confluence of Slate Creek and Boundary Reservoir from 1994 and 1995 by USFS and WDFW biologists (R2 Resource Consultants 1998; Andonaegui 2003). Between 1996 and 1997, R2 Resource Consultants captured one bull trout near the confluence of Slate Creek and Boundary Reservoir (RM 0.0) during a 2-year fish sampling survey of the reservoir and its tributaries (R2 Resource Consultants 1998; Andonaegui 2003). R2 Resource Consultants (1998) documented that the USFS observed possible bull trout hybrids in the middle and upper reaches of Slate Creek.
  - <u>*Cutthroat Trout:*</u> Westslope cutthroat trout were found in Slate Creek (USFS 1998). Cutthroat trout were observed at sites in nine reaches on Slate Creek and North Fork Slate Creek at a mean density of 4 fish/100 m^2 (McLellan 2001). Cutthroat trout were observed in all of the reaches during snorkel surveys conducted in 2000, except the uppermost reach in North Fork Slate Creek (McLellan 2001).

- *Rainbow Trout:* Rainbow trout were found in Slate Creek and, based on documentation of surveys provided by the USFS (1998), successful reproduction had been occurring (USFS 1998). Electrofishing conducted the next day after snorkel surveys in 1997 resulted in no rainbow trout captured in Slate Creek (R2 Resource Consultants 1998). Rainbow trout were only observed at one site out of nine reaches surveyed on Slate Creek and North Fork Slate Creek at a mean density of less than 1 fish/100 m^2 (McLellan 2001). In the study by McLellan (2001), rainbow trout were only observed in a single reach located upstream from the mouth of Slate Creek (RM 0.0).
- *Brook Trout:* Brook trout were stocked in Slate Creek in 1981 (USFS 1998). In addition, earlier stocking of brook trout in Slate Creek prior to 1981 most likely occurred (USFS 1998; Andonaegui 2003). Brook trout have been observed during surveys in Slate Creek (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). In snorkel surveys conducted in 2000 at sites within nine reaches on Slate Creek and North Fork Slate Creek, McLellan (2001) reported eastern brook trout at a mean density of 1 fish/100 m^2 for the combined reaches. Within the stretch of Slate Creek between RM 0.0 and 0.75, brook trout can be found in this habitat competing for food and habitat, and interbreeding with bull trout (T. Shuhda 2007).
- *Brown Trout:* During electrofishing surveys conducted the next day after snorkel surveys in 1997, no brown trout were observed in Slate Creek (R2 Resource Consultants 1998).

Slumber Creek

- ***Barrier:*** Within Slumber Creek, upstream (RM 0.2) from the confluence with Slate Creek (RM 0.0) is a culvert, 2.4 m (8 ft) high and 5.2 m (17 ft) long, that is a complete barrier to fish passage (USFS 2002; Andonaegui 2003; POSRT 2005). At RM 2.3 Slumber Creek has been documented to dewater in August (see Appendix 1).
- ***Riparian Conditions:*** A conifer/alder community is the dominant riparian vegetation documented for Slumber Creek (USFS 1998). Stream cover greater than 30 percent was reported in the USFS (2005) SMART database.
- ***Channel Conditions and Dynamics:***
  - *Channel Stability:* The USFS (2005) SMART database reports the entrenchment ration between 1.7 and 2.0.

- ***Habitat Elements:***
  - *Channel Substrate:* The present condition of substrate in Slumber Creek has been attributed to the drainage occurring in area of decomposed limestone (USFS 1998). Based on reaches surveyed in 1991 and 1997 by the USFS, cobble, gravel and sand were determined to be the dominant substrate with embeddedness greater than 35 percent (USFS 1998; Andonaegui 2003). Within two reaches surveyed by the USFS (1999b), percent fines were between 40 and 90 percent.
  - *LWD:* Two stream reaches were surveyed by the USFS in Slumber Creek, and 155 and 167 pieces of LWD per mile were documented (USFS 1998; USFS 2005). In the two stream reaches surveyed of Slumber Creek the USFS (1998) reports that LWD is the primary source of instream cover.

    - *Pool Frequency and Quality:* The USFS conducted two stream reach surveys in Slumber Creek and determined there were 33 and 56 pools per mile in each of the surveyed reaches (USFS 1998; USFS 2005).
    - *Pool Depth:* In Slumber Creek pool depths have been documented to range between 0.61 and 0.91 m (2 and 3 ft) and provide suitable overwintering habitat (Andonaegui 2003). Based on observations during snorkel surveys, there were negligible amounts of fine sediment in pool substrate (USFS 1999b; Andonaegui 2003).
    - *Wetted Width:* Based on data available in the USFS (2005) SMART database, the average wetted width was 2.3 m (7.4 ft) in 2000 during surveys of Slumber Creek.

- ***Fish Species:***
    - *Cutthroat Trout:* Westslope cutthroat trout were found in fish surveys of Slumber Creek (USFS 1998).
    - *Brook Trout:* Eastern brook trout were found in fish surveys of Slumber Creek (USFS 1998). Brook trout were stocked in Slumber Creek in 1981 (USFS 1998). However, earlier stocking of brook trout in Slumber Creek prior to 1981 most likely occurred (USFS 1998; Andonaegui 2003).

Uncas Gulch

- ***Riparian Conditions:*** A conifer/alder and conifer/forb riparian vegetation community is documented for Uncas Gulch (USFS 1998).
- ***Habitat Elements:***
    - *Channel Substrate:* The dominant substrates in the reaches surveyed in 1991 and 1997 by the USFS were cobble, gravel, and sand with embeddedness less than 35 percent (USFS 1998; Andonaegui 2003).
    - *LWD:* Three stream reaches were surveyed by the USFS in Uncas Gulch, and 218, 138, and 44 pieces of LWD per mile were documented in the reaches (USFS 1998). In the three stream reaches surveyed of Uncas Gulch the USFS (1998) reports that LWD is the primary source of instream cover.
    - *Pool Frequency and Quality:* Surveys conducted by the USFS resulted in documentation of 17, 22, and 10 pools per mile in three stream reaches surveyed (USFS 1998).
    - *Pool Depth:* Within Uncas Gulch pool depths range between 0.61 and 0.91 m (2 and 3 ft) and provide suitable overwintering habitat (Andonaegui 2003). Based on observations during snorkel surveys, there were negligible amounts of fine sediment in pool substrate (USFS 1999b; Andonaegui 2003).
    - *Wetted Width:* Based on data available in the USFS (2005) SMART database, the average wetted width was 4.1 m (13.3 ft) in 2000 during surveys of Uncas Gulch.

- ***Fish Species:***
    - *Cutthroat Trout:* Westslope cutthroat trout were found in fish surveys of Uncas Gulch (USFS 1998).
    - *Brook Trout:* Eastern brook trout were found in fish surveys of Uncas Gulch (USFS 1998).

Styx Creek

- ***Barrier:*** Within Styx Creek, upstream from the confluence of Styx Creek and South Fork Slate Creek (RM 0.10 on Styx Creek) the culvert, 3.96 m (13 ft) high, at USFS Road 3155 is a fish passage barrier (USFS 2002; Andonaegui 2003).
- ***Riparian Conditions:*** A conifer/alder and conifer/forb riparian vegetation community is documented for Styx Creek (USFS 1998).
- ***Habitat Elements:***
    - *Channel Substrate:* Determined from reaches surveyed in 1991 and 1997 by the USFS, the dominant substrates in Styx Creek were cobble, gravel, and sand with embeddedness less than 35 percent (USFS 1998a; Andonaegui 2003).
    - *LWD:* The USFS surveyed four stream reaches in Styx Creek and documented 141, 214, 102, and 128 pieces of LWD per mile in the surveyed reaches (USFS 1998). In the four stream reaches surveyed of Styx Creek the USFS (1998) reports that LWD is the primary source of instream cover.
    - *Pool Frequency and Quality:* Within the four stream reaches surveyed by the USFS, 4, 4, 11, and 4 pools per mile were documented for each of the surveyed reaches in Styx Creek (USFS 1998).
    - *Pool Depth:* Pool depths in Styx Creek range between 0.55 and 0.70 m (1.8 and 2.3 ft) and provide suitable overwintering habitat (Andonaegui 2003). Based on observations during snorkel surveys, there were negligible amounts of fine sediment in pool substrate (USFS 1999b; Andonaegui 2003).
    - *Wetted Width:* Based on data available in the USFS (2005) SMART database, the average wetted width was 1.8 m (5.8 ft) in 2000 during surveys of Slumber Creek.

- ***Fish Species:***
    - *Cutthroat Trout:* Westslope cutthroat trout were found in fish surveys of Styx Creek (USFS 1998).
    - *Brook Trout:* Eastern brook trout were found in fish surveys of Styx Creek (USFS 1998).

North Fork Slate Creek

- ***Barrier:*** Within the North Fork Slate Creek, located 300 m (984.3 ft) downstream from USFS Road 209 crossing (approximately RM 1.4), McLellan (2001) identifies a chute (27.5 m [90.2 ft] long, 1 m [3.3 ft] wide, with an 18 percent gradient) as a barrier. Upstream of this chute barrier McLellan (2001) provides an artificial barrier point (Figure 5.2-1.). However, McLellan (2001) provides no additional information, barrier dimensions, or reference for this barrier.

- ***Habitat Elements:***
    - *Channel Substrate:* McLellan (2001) reported the dominant substrate types were cobble and boulder with a mean embeddedness of 3 percent based on sites surveyed in two reaches on Slate Creek.
    - *LWD:* McLellan (2001) conducted habitat surveys in sites within two reaches on North Fork Slate Creek and based on data available from the report, there was a mean of 604 pieces of LWD per mile.

- *Pool Frequency and Quality:* McLellan (2001) conducted habitat surveys at sites within two reaches on North Fork Slate Creek and reported a mean of 23 large pools per mile.
- *Pool Depth:* McLellan (2001) conducted habitat surveys at sites within two reaches on North Fork Slate Creek and the mean width, maximum depth, and residual depth for the combined reaches were 2.9 m (9.5 ft), 47.5 cm (18.7 in), and 30 cm (11.8 in), respectively.
- *Wetted Width:* Based on data available from the McLellan (2001) survey of two stream reaches on North Fork Slate Creek, the average wetted width was 3.5 m (11.5 ft).

- ***Water Quality:***
  - *Temperature Near RM 0.9:* McLellan (2001) measured the temperature of North Fork Slate Creek between June 28 and October 17, 2000. Using data reported by McLellan (2001), the 7-day average maximum temperature during the period of record in upper Slate Creek was 9.0ºC (48.2ºF) between August 3 and August 9, 2000.

- ***Water Quantity and Characteristics:*** The mean gradient from two reaches surveyed on North Fork Slate Creek was 6.5 percent (McLellan 2001).

- ***Fish Species:***
  - *Cutthroat Trout:* Westslope cutthroat trout were found in Slate Creek (USFS 1998). Cutthroat trout were observed at sites in nine reaches on Slate Creek and North Fork Slate Creek at a mean density of 4 fish/100 m^2 (McLellan 2001). Cutthroat trout were observed in all of the reaches during snorkel surveys conducted in 2000, except the uppermost reach in North Fork Slate Creek (McLellan 2001).
  - *Brook Trout:* Brook trout were stocked in Slate Creek in 1981 (USFS 1998). In addition, earlier stocking of brook trout in Slate Creek prior to 1981 most likely occurred (USFS 1998; Andonaegui 2003). Brook trout have been observed during surveys in Slate Creek (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). In snorkel surveys conducted in 2000 at sites within nine reaches on Slate Creek and North Fork Slate Creek, McLellan (2001) reported eastern brook trout at a mean density of 1 fish/100 m^2 for the combined reaches. Within the stretch of Slate Creek between RM 0.0 and 0.75, brook trout can be found in this habitat competing for food and habitat, and interbreeding with bull trout (T. Shuhda 2007).

South Fork Slate Creek

- ***Fish Species:***
  - *Cutthroat Trout:* Westslope cutthroat trout were found in fish surveys of South Fork Slate Creek (USFS 1998).
  - *Brook Trout:* Eastern brook trout were found in fish surveys of South Fork Slate Creek (USFS 1998).

Threemile Creek

- ***Barrier:*** The naturally occurring falls (5.0 m [16.4 ft] high) at the mouth of Threemile Creek is a barrier to fish passage, making the creek disconnected from Boundary Reservoir (McLellan 2001; Andonaegui 2003; WDFW SalmonScape 2007). The USFS (1998) documents that Threemile Creek is intermittent and non-fish bearing where the creek flows through National Forest lands. Approximately at RM 0.15 there is a fish passage barrier (POSRT 2005).
- ***Riparian Conditions:*** A conifer/alder riparian vegetation community is documented for Threemile Creek (USFS 1998).
- ***Habitat Elements:***
  - *Channel Substrate:* Sand and gravels were dominant substrates with embeddedness greater than 35 percent for the reaches surveyed in 1991 and 1997 (USFS 1998). The USFS notes in the 1998 Slate Salmo Watershed Assessment that for the existing geology there was an excessive amount of sand present in Threemile Creek (USFS 1998).
  - *LWD:* In Threemile Creek the USFS surveyed two reaches and documented 149 and 518 pieces of LWD per mile for the surveyed reaches (USFS 1998). In the two stream reaches surveyed of Threemile Creek the USFS (1998) reports that LWD is the primary source of instream cover.
  - *Pool Frequency and Quality:* In two stream reaches surveyed by the USFS (1998), 20 and 15 pools per mile were documented for each of the surveyed reaches.

- ***Water Quality:***
  - *Temperature:* The USFS (1998) documents temperatures in Threemile Creek reaching 7.2ºC (45ºF) during the summer. McLellan (2001) measured water temperature near the mouth (RM 0.0) of Threemile Creek with a thermograph from June 28 to October 17, 2000. Based on the data available from the McLellan (2001) report, the 7-day average maximum temperature was 10.4ºC (50.72ºF) between August 6 and August 12, 2000.

- ***Water Quantity and Characteristics:*** The mean gradient was 10.5 percent in the drainage upstream from the natural barrier at the mouth (RM 0.0) (WDFW SalmonScape 2007).

- ***Fish Species:***
  - *Rainbow Trout:* Within the private lands of Threemile Creek a sustaining population of rainbow trout has been documented (USFS 1998). The USFS (1998) reported that Threemile Creek is intermittent and non-fish bearing where the creek flows through National Forest lands.
  - *Brook Trout:* Within the private lands of Threemile Creek a sustaining population of eastern brook trout has been documented (USFS 1998; USFS 2005). The USFS (1998) documents that Threemile Creek is intermittent and non-fish-bearing where the creek flows through National Forest lands.

Beaver Creek

- ***Barriers:*** A natural 25.3 m (83 ft) falls at the mouth of Beaver Creek is a fish passage barrier (McLellan 2001; Andonaegui 2003; WDFW SalmonScape 2007). Approximately at RM 1.1 there is a fish passage barrier (POSRT 2005).
- ***Water Quantity and Characteristics:*** The mean gradient was 12.7 percent in the drainage upstream from the natural barrier at the mouth (RM 0.0) (WDFW SalmonScape 2007).

Flume Creek

- ***Barriers:*** A vertical waterfall that is 13.0 m (43 ft) high is located at RM 0.2 and is a fish passage barrier (McLellan 2001; R2 Resource Consultants 1998; Andonaegui 2003; WDFW SalmonScape 2007). A culvert under the County Road, Boundary Road, at RM 1.0 is a potential fish passage barrier, and was approximately 2.5 m (8.2 ft) above the surface of the plunge pool (McLellan 2001; Andonaegui 2003; POSRT 2005). At RM 4.75 the culvert crossing at the USFS Road 350 is a potential fish passage barrier, as the culvert mouth was 1.5 m (4.9 ft) high and there was no plunge pool below it in 2000 (McLellan 2001; USFS 2002; Andonaegui 2003).
- ***Riparian Conditions:*** Habitat units surveyed by R2 Resource Consultants (1998) in Flume Creek were found to have a percent cover supplied by overhanging vegetation of 10 percent. In addition, the mean canopy cover was 22 percent (R2 Resource Consultants 1998). Percent of stream channel covered was reported as between 20 and 30 percent in the USFS (2005) SMART database.
- ***Channel Conditions and Dynamics:***
  - *Streambank Condition:* Habitat units surveyed by R2 Resource Consultants (1998) in Flume Creek were found to have an average undercut bank cover of 10.2 percent.

- ***Habitat Elements:***
  - *Channel Substrate:* R2 Resource Consultants (1998) reported a mean of 10 percent for surface fines from surveys in Flume Creek. McLellan (2001) conducted habitat surveys within four reaches on Flume Creek and determined the dominant substrate as cobble.
  - *LWD:* McLellan (2001) conducted habitat surveys within four reaches on Flume Creek and documented a mean of 357 pieces of LWD per mile. Within habitat units surveyed throughout Flume Creek, including the Middle and South Fork, R2 Resource Consultants (1998) found four to six pieces of LWD per habitat unit.
  - *Pool Frequency and Quality:* McLellan (2001) conducted habitat surveys within four reaches on Flume Creek and determined the dominant habitat type was riffle (86 percent). Although riffle was reported as the dominant habitat type, McLellan (2001) reported a mean of 19 large pools per mile. The dominant habitat type in Flume Creek is riffle as reported by Andonaegui (2003).
  - *Pool Depth:* Average maximum depths for habitat units surveyed throughout Flume Creek, including the Middle and South Forks, were reported to be around 0.5 m (1.5 ft) deep (R2 Resource Consultants 1998). McLellan (2001) conducted habitat surveys within four reaches on Flume Creek and determined the mean width, maximum depth, and residual depth for all four reaches were 2.6 m (8.5 ft), 37cm (14.6 in), and 18 cm (7.1 in), respectively.

- o *Wetted Width:* McLellan (2001) reported the average wetted width was 4.5 m (14.8 ft) in 2000 from surveys of four stream reaches.

- ***Water Quality:***
  - o *Temperature at RM 0.0:* In a water temperature study conducted in Boundary Reservoir by R2 Resource Consultants, cool-water refugia were available for salmonids during August and September at the confluence of the creek and the reservoir. However, the cool water zone was relatively small in size, but well defined (R2 Resource Consultants 1998; Andonaegui 2003). From August 15 through October 27, 1996, and again from July 25 through November 11, 1997, hourly recordings of water temperatures were collected at the mouth of Flume Creek (RM 0.0) (R2 Resource Consultants 1998). The 7-day average maximum temperature during the period of record was 14.2ºC (57.6ºF) between August 1 and 7, 1997 (R2 Resource Consultants 1998). Between June 28 and October 17, 2000, the water temperature in lower Flume Creek was measured with an electronic thermograph (McLellan 2001). The maximum temperature recorded near RM 0.0 on Flume Creek in 2000 was 14.71ºC (58.46ºF) on July 21 and 29, and the minimum was 3.19ºC (37.74ºF) on October 6 (McLellan 2001; Andonaegui 2003). Based on the data available from the McLellan (2001) report, the 7-day average maximum temperature was 14.3ºC (57.74ºF) between July 31 and August 6, 2000.
  - o *Temperature between RM 2.2 and 3.3:* From August 15 through October 27, 1996, and again from July 25 through November 11, 1997, hourly recordings of water temperatures were collected between the South and Middle forks of Flume Creek (approximately RM 2.2) (R2 Resource Consultants 1998). The 7-day average maximum temperature during the period of record was 12.6ºC (54.7ºF) between August 24 and 30, 1996 (R2 Resource Consultants 1998). Between June 28 and October 17, 2000, the water temperature in upper Flume Creek (near RM 3.3) was measured with an electronic thermograph (McLellan 2001). The maximum temperature recorded within upper Flume Creek in 2000 was 12.68ºC (54.82ºF) on August 9, and the minimum was 2.88ºC (37.18ºF) on October 6 (McLellan 2001; Andonaegui 2003). Based on the data available from the McLellan (2001) report, the 7-day average maximum temperature for upper Flume Creek was 12.4ºC (54.32ºF) between August 7 and August 13, 2000. The USFS deployed a thermograph at the USFS boundary (approximately RM 3.1) on Flume Creek from July 24 to September 30, 2002 (Andonaegui 2003). The 7-day average maximum temperature during the period of record at the USFS boundary on Flume Creek was 11.5ºC (52.7ºF) and the maximum temperature was 12.6ºC (54.7ºF) (Honeycutt 2003 as cited in Andonaegui 2003).

- ***Water Quantity and Characteristics:*** McLellan (2001) determined the discharge on September 6, 2000, to be 0.25 m^3/s (8.83 ft^3/s). The mean gradient from four reaches surveyed on Flume Creek was 7 percent (McLellan 2001). The CNF TMDL (Ecology 2005) reported average flow July between August to be 0.05 m^3/s (1.9 ft^3/s).

- ***Fish Species:***

- *Bull Trout:* Access to habitat is limited for migratory life history forms of bull trout (Andonaegui 2003). Bull trout have not been detected in Flume Creek from snorkeling and electrofishing surveys (R2 Resource Consultants 1998; USFS 1999a; McLellan 2001; Andonaegui 2003). However, habitat within Flume Creek has been identified as "Suitable" by the TAG (Andonaegui 2003).
- *Cutthroat Trout:* Two cutthroat trout were observed in upper Flume Creek (R2 Resource Consultants 1998). Electrofishing conducted the next day after snorkel surveys in 1997 resulted in no cutthroat trout captured in Flume Creek (R2 Resource Consultants 1998). The POSRT (2005) documents the presence of cutthroat trout in Flume Creek.
- *Rainbow Trout:* Electrofishing conducted the next day after snorkel surveys in 1997 resulted in no rainbow trout captured in Flume Creek (R2 Resource Consultants 1998).
- *Brook Trout:* From day creel surveys conducted on Flume Creek in 1950, 1959, and 1960, brook trout were the only fish captured (WDFW, unpublished data as cited in McLellan 2001). Brook trout have been documented as the dominant fish species in Flume Creek (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). In 1997, during snorkel surveys, Flume Creek was comprised almost exclusively of brook trout (R2 Resource Consultants 1998). During snorkel surveys in 2000, McLellan (2001) reported that brook trout were the only fish species observed (9 fish/100 m^2) throughout Flume Creek. The majority of brook trout (20 fish/100 m^2) were observed between the confluence of the Middle Fork Flume Creek with the mainstem Flume Creek (approximately RM 3.3) and 500 m upstream (1,640.4 ft). However, within the headwaters of Flume Creek (approximately upstream from RM 4.3) no fish were observed (McLellan 2001).
- *Brown Trout:* During electrofishing surveys conducted the next day after snorkel surveys in 1997, no brown trout were observed in Flume Creek (R2 Resource Consultants 1998).

South Fork Flume Creek

- ***Barriers:*** Approximately at RM 0.3 on South Fork Flume Creek there is a potential fish passage barrier (POSRT 2005).

- ***Habitat Elements:***
  - *Wetted Width:* Based on data available in a report by R2 Resource Consultants (1998), the average wetted width was 3.1 m (10.2 ft).

Middle Fork Flume Creek

- ***Habitat Elements:***
  - *Wetted Width:* Based on data available in a report by R2 Resource Consultants (1998), the average wetted width was 3.1 m (10.3 ft).

- ***Water Quantity and Characteristics:*** R2 Resource Consultants (1998) noted that Middle Fork Flume Creek is relatively undisturbed.

- ***Fish Species:***

- o *Bull Trout:* Habitat is documented as relatively undisturbed and containing possible bull x brook trout hybrids (R2 Resource Consultants 1998).
- o *Brook Trout:* In the Middle Fork Flume Creek several unusual brook trout phenotypes were observed with markings similar to those observed in brook trout *x* bull trout hybrids (R2 Resource Consultants 1998).

Sullivan Creek WAU

Sullivan Creek

- ***Barriers:***
  - o *Between RM 0.0 and 2.35:* Within the mainstem Sullivan Creek, between RM 0.6 and 0.65, natural cascades and chutes have been documented to potentially prevent fish passage under some stream flow conditions (CES 1996; Andonaegui 2003). However, there is disagreement on the degree to which the cascades and chutes prevent fish passage under all conditions and flows (Andonaegui 2003). CES (1996) evaluated the barriers under multiple flows on various days (September 22, 1994, at 1.4 cubic meters per second [m^3/s] (50 cubic feet per second [ft^3/s]); July 6, 1995, at 5.6 m^3/s [198 ft^3/s]; August 7, 1995, at 2.0 m^3/s [72 ft^3/s]; November 2, 1995, at 5.4 m^3/s [192 ft^3/s]; November 4, 1995, at 9.1 m^3/s [323 ft^3/s]) and determined that passage under certain flow conditions is possible between RM 0.6 and 0.65. However, CES (1996) did determine that barriers may be a primary factor in the absence of both fluvial and adfluvial populations of bull trout in Sullivan Creek upstream of RM 0.65. McLellan (2001) noted that CES (1996) had determined the cascades and chutes between RM 0.6 and 0.65 as potential barriers. However, McLellan (2001) identified neither of them as barriers in 2000.
  - o *At RM 3.25:* The Mill Pond Dam at RM 3.25 on the mainstem Sullivan Creek is a complete barrier to fish passage (R2 Resource Consultants 1998; USFS 1999d; McLellan 2001; Andonaegui 2003). The Mill Pond Dam height is 16.8 m (55 ft) (Andonaegui 2003).
- ***Riparian Conditions:*** Hemlock/wild ginger with thinleaf alder on point bars and other depositional areas described the climax riparian vegetation for the mainstem Sullivan Creek (USFS 1996). The USFS (1996) noted that the existing riparian vegetation contained spruce with some small cedar and hemlock, and a lack of shrubs and herbaceous cover caused a decrease in the duff layer. The lack of shrubs and herbaceous cover were attributed to disperse recreational sites (USFS 1996). The USFS (1996) reported that by the mid-1980s, road density was between 1.7 and 2 miles per square mile. Historically, the riparian areas along main Sullivan Creek have been harvested and have roads located within some of the riparian areas (USFS 1999d). In addition, the USFS (1999d) states that the majority of the road system is inside of riparian areas, and portions of the riparian areas have been replaced by forest and county road systems limiting the total riparian areas from historic levels. However, the USFS (1999d) also states that drainage-wide there are limited road crossings and riparian areas are continuous in nature. The USFS (1999d) concludes that the width of existing riparian buffers may not be adequate to filter all sediments leaving road surfaces, particularly in valley bottoms of the drainage. Habitat units surveyed by R2 Resource Consultants (1998) in Sullivan Creek were found to have a

percent cover supplied by overhanging vegetation of 4 percent. In addition, the mean canopy cover was 10 percent (R2 Resource Consultants 1998). Entrix (2002) reported that aquatic habitat has been most influenced by historic timber harvest, especially clearcutting of riparian areas, road building, fires, and dispersed recreation. Of approximately 234 miles of road within the WAU, nearly 46 miles are within 61 m (200 ft) of streams, with Sullivan Creek Road open and adjacent to Sullivan Creek for most of its length (Entrix 2002). Andonaegui (2003) determined that although "the riparian vegetation is not at a climax condition, over 50 percent of the existing vegetation is what would be expected of these conditions." Overall, adequate shade, detritus, and LWD are provided by the riparian area for the Sullivan Creek WAU (Andonaegui 2003). Above bankfull flow there is high vegetative cover (75 percent or greater) and well-established riparian communities (Andonaegui 2003).

- ***Channel Conditions and Dynamics:***
    - Streambank Condition: Above bankfull flow, streambanks have high vegetative cover and well-established riparian communities (Andonaegui 2003). The primary erosional process throughout the drainage is landslides (USFS 1996; Andonaegui 2003). Habitat units surveyed by R2 Resource Consultants (1998) in Sullivan Creek were found to have an average undercut bank cover of 3 percent. The channel is deeply entrenched and confined as it cuts through a rock canyon (USFS 1996; Andonaegui 2003). Along some sections of the south side of Sullivan Creek the bank slopes are unstable due to a closed-box flume that was used to transport water to a power house near the mouth of Sullivan Creek (Andonaegui 2003). The closed-box flume historically, and as recently as 1997, had caused landslides into Sullivan Creek (USFS 1999d; Andonaegui 2003). Sections of Sullivan Creek downstream from and continuing upstream from Mill Pond Dam are historically prone to landslide activity (USFS 1996; Andonaegui 2003). Based on a USFS report in 1996, the banks along Sullivan Creek were documented as "generally in pretty stable condition" (USFS 1996). However, from the confluence of North Fork Sullivan Creek with the mainstem Sullivan Creek (RM 2.35), upstream to Gypsy Creek (RM 13.8), sections of the channel have been straightened (USFS 1996; Andonaegui 2003).
    - Floodplain Connectivity: Throughout the Sullivan Creek drainage, channels primarily comprise narrow V- or U-shaped valley forms (Rosgen A and B channel types) and do not and did not historically have many oxbows, backwater, and ponds (USFS 1996; Andonaegui 2003). Channels comprising narrow V- or U-shaped valley forms have relatively small floodplains and riparian areas, and lack off-channel habitat and extensive wetlands areas. Although lacking off-channel habitat, the Sullivan Creek WAU does have some stream margins providing shallow water habitat and some side channel habitat resulting from accumulated complexes of woody debris forming bars and initiating channel braiding (USFS 1999d; Andonaegui 2003). The channel is deeply entrenched and confined as it cuts through a rock canyon between RM 0.0 and 2.35 (USFS 1996; Andonaegui 2003).
    - Channel Stability: The channel has deepened and stabilized, mid-channel bars have generally disappeared, and lateral migration has ceased from the mouth upstream beyond Mill Pond Dam (USFS 1996; Andonaegui 2003). In 1996 the

USFS determined that changes in the flow regime and the bed load transport had resulted from the construction of Mill Pond Dam and Sullivan Lake Dam (USFS 1996). However, the USFS (1996) noted that the effect within Sullivan Creek below Mill Pond Dam from the reduced peak spring (channel maintenance) flows and the reduced sediment load is difficult to determine. Instream restoration activities that have occurred in Sullivan Creek, downstream of Sullivan Lake Dam, have been blown out in the past due to flows exceeding 28.3 m^3/s (1,000 ft^3/s) in the spring during high run-off years (POPUD 2003 as cited in Andonaegui 2003). Within Sullivan Creek, channel stability ranges from good to excellent (Wasson 1992 as cited in USFS 1996; Andonaegui 2003). In contrast, the POSRT (2005) documented altered channel morphology as a bull trout habitat limiting factor. The USFS (2005) SMART database documents the entrenchment ration as between 1.1 and 2.0.

- ***Habitat Elements:***
  - Channel Substrate between RM 0.0 and 3.25: This section of Sullivan Creek is primarily a bedrock-dominated channel (USFS 1996; Andonaegui 2003). Within this section of Sullivan Creek, flooding and scouring can frequently occur, and spring high flows (exceeding 28.3 m^3/s [1,000 ft^3/s] at times) are likely occurrences when bull trout eggs and alevins are still in the gravel (CES 1996; Andonaegui 2003). In the 1950s and 1960s, Sullivan Creek from RM 0.5 to 2.1 was straightened through the placement of riprap and gabion structures (Andonaegui 2003). The channel-straightening activity may have increased the intensity of flooding and scouring downstream of RM 2.1. However, Andonaegui (2003) reports that substrate is not a limiting factor in Sullivan Creek downstream of Mill Pond Dam (RM 3.25). Bedload material is deficient downstream of Mill Pond Dam (RM 3.25), because all bedload and most suspended sediment are retained behind the dam (USFS 1996; Andonaegui 2003). The USFS (1996) determined that this section of Sullivan Creek is lacking in spawning gravels caused by sediment being retained behind Mill Pond Dam. Regarding the fate of Mill Pond, the USFS (1996) reported that eventually the pond will fill with sediment and become a large wetland. In surveying sites within three reaches of Sullivan Creek downstream of Mill Pond Dam, McLellan (2001) reported the dominant substrate as rubble for two of the reaches and boulder for the other reach. Within this section of Sullivan Creek the scarcity of spawning size material, due to the interception of Mill Pond Dam, is a limiting factor (T. Shuhda 2007). The USFS (2005) SMART database documents greater than 20 percent fines.
  - LWD between RM 0.0 and 3.25: Downstream of Mill Pond Dam (RM 3.25) woody debris that creates habitat complexity is generally lacking (CES 1996; Andonaegui 2003). Within the steep-walled canyon in lower Sullivan Creek, LWD has been described as being "flushed" during high winter flows (CES 1996; Andonaegui 2003). Five out of nine reaches surveyed in this section of Sullivan Creek had less than 20 pieces of LWD per mile (USFS 1996; Andonaegui 2003). Sullivan Creek historically had LWD jams, but channel straightening and removal of LWD jams between the 1950s and 1970s, from North Fork Sullivan Creek

(RM 2.35) upstream, may have simplified the channel (USFS 1996; Andonaegui 2003). McLellan (2001) conducted habitat surveys at sites within three reaches in lower Sullivan Creek, and based on data available from the 2001 report, there was a mean of 70 pieces of LWD per mile.

- <u>*Pool Frequency and Quality between RM 0.0 and 3.25:*</u> Within Sullivan Creek pools are lacking (USFS 1996; Andonaegui 2003). Bedrock and boulder structure throughout the canyon reach of Sullivan Creek have been documented to create some pools, contribute to hydraulic complexity, and provide overhead cover (CES 1996; Andonaegui 2003). Downstream of the canyon reach (between RM 0.0 and 0.6), riffles, boulder runs, and low-gradient cascades have been documented as the primary habitat unit (CES 1996; Andonaegui 2003). In habitat surveys conducted in 2000 throughout Sullivan Creek, McLellan (2001) reported the dominant habitat type as riffles (69 percent). In three reaches surveyed downstream of RM 3.25, McLellan (2001) reported a mean of 10.4 large pools per mile. The POSRT (2005) documented degraded pool habitat as a bull trout habitat limiting factor.
- <u>*Pool Depth between RM 0.0 and 3.25:*</u> McLellan (2001) conducted habitat surveys in three reaches downstream of RM 3.25. However, only results from two of the surveyed reaches were provided in McLellan (2001). Based on the information provided, the mean width, maximum depth, and residual depth for the two reaches were 15.3 m (50.2 ft), 161 cm (63.4 in), and 100 cm (39.4 in), respectively.
- <u>*Wetted Width between RM 0.0 and 3.25:*</u> The average wetted width was 17.9 m (58.7 ft) in 2000 from surveys conducted of three reaches in lower Sullivan Creek (McLellan 2001).

- <u>***Water Quality:***</u>
  - <u>*Temperature at RM 0.0:*</u> In a water temperature study conducted in Boundary Reservoir by R2 Resource Consultants, cool water refugia were available for salmonids during August and September at the confluence of the creek and the reservoir. However, the cool water zone was relatively small in size, but well defined (R2 Resource Consultants 1998, Andonaegui 2003). The Sullivan Lake impoundment modifies water temperatures in lower reaches of Sullivan Creek (R2 Resource Consultants 1998; Andonaegui 2003). From August 15 through October 27, 1996, and again from July 25 through November 11, 1997, hourly recordings of water temperatures were collected at the mouth of Sullivan Creek (R2 Resource Consultants 1998; Andonaegui 2003). The 7-day average maximum temperature during the period of record was 16.9ºC (62.4ºF) between August 24 and 30, 1996 (R2 Resource Consultants 1998; Andonaegui 2003). Throughout the 1997 monitoring period warm water temperatures, measured approximately at RM 1.7 by R2 Resource Consultants (1998), demonstrated the warming effect of Mill Pond Dam on waters discharged from Sullivan Lake and flowing towards the mouth of Sullivan Creek (Andonaegui 2003). During bull trout incubation, rearing, and spawning periods in lower Sullivan Creek the USFS (1999d) calculated the 7-day average maximum temperatures to be 9.6ºC (49.2ºF), 18.3ºC (64.9ºF), and 14.9ºC (58.9ºF), respectively. Between June 28

and October 19, 2000, the water temperature of lower Sullivan Creek (upstream of RM 2.35) was measured with an electronic thermograph (McLellan 2001; Andonaegui 2003). The maximum temperature recorded for lower Sullivan Creek in 2000 was 18.86ºC (66.0ºF) on August 9, and the minimum was 4.93ºC (40.87ºF) on September 23 (McLellan 2001; Andonaegui 2003). The 7-day average maximum temperature during the period of record was 18.2ºC (64.8ºF) between August 8 and August 14, 2000 (McLellan 2001). The USFS deployed a thermograph at the USFS boundary on lower Sullivan Creek from July 24 to October 28, 2002, and determined the 7-day average maximum temperature to be 17.1ºC (62.8ºF) (K. Honeycutt, USFS, email. comm., 2003 as cited in Andonaegui 2003).

- <u>*Temperature approximately at RM 0.6:*</u> Between May 19, 1993, and October 17, 1997, stream temperatures were recorded weekly, and the maximum temperature was 19.7ºC (67.4ºF) recorded in July and August 1994 (CES 1996; Andonaegui 2003). The minimum stream temperature between May 1993 and October 1997 was -4.8ºC (23.3ºF) recorded in February 1994 (CES 1996; Andonaegui 2003). During the stream temperature recording from May 1993 to October 1997, the 7-day average minimum temperature was -1.8ºC (28.8ºF) (January 4 through 10, 1995), and the 7-day average maximum temperature was 24.7ºC (76.4ºF) (July 22 through 29, 1994) (CES 1996; Andonaegui 2003).
- <u>*Temperature approximately at RM 1.7:*</u> The Sullivan Lake impoundment modifies water temperatures in lower reaches of Sullivan Creek (R2 Resource Consultants 1998; Andonaegui 2003). From August 15 through October 27, 1996, and again from July 25 through November 11, 1997, hourly recordings of water temperatures were collected midway between the Lime Lake Road turnoff (approximately RM 1.2) and the North Fork confluence with Sullivan Creek (RM 2.35) (R2 Resource Consultants 1998; Andonaegui 2003). The 7-day average maximum temperature during the period of record was 14.0ºC (57.2ºF) between August 1 and 7, 1997 (R2 Resource Consultants 1998; Andonaegui 2003). Throughout the 1997 monitoring period warm water temperatures, measured approximately at RM 1.7 by R2 Resource Consultants (1998), demonstrated the warming effect of Mill Pond Dam on waters discharged from Sullivan Lake and flowing towards the mouth of Sullivan Creek (Andonaegui 2003). A difference of nearly 6.5ºC (43.7ºF) in the maximum daily temperature was determined between the thermograph stations at the mouth of Sullivan Creek (RM 0.0) and the station at approximately RM 1.7 (R2 Resource Consultants 1998; Andonaegui 2003). The difference of nearly 6.5ºC (43.7ºF) between these two monitoring stations was greater than the differences observed in upper and lower temperature monitoring stations in Slate and Flume creeks (Slate Creek WAU), and Sweet and Sand creeks (Box Canyon WAU) during the same period of record (R2 Resource Consultants 1998; Andonaegui 2003).
- <u>*Temperature downstream of RM 3.25:*</u> During the summer months water temperatures can exceed 16ºC (60.8ºF), with release from Mill Pond Dam increasing water temperature by approximately 0.5 to 1ºC (32.9 to 33.8ºF) (T. Shuhda 2007). The CNF TMDL (Ecology 2005) reported average July – August flow to be 0.02 m^3/s (0.76 ft^3/s). Pickett (2004) reported that Sullivan Creek

required a TMDL. The POSRT (2005) documented elevated stream temperature as a bull trout habitat limiting factor.

- *Temperature at RM 3.25:* Stream temperatures were collected at Mill Pond Dam (RM 3.25) from March 1, 1993 to June 26, 1993, and again from August 13, 1993 to October 17, 1995, and the maximum temperature recorded was 18.9ºC (66.0 ºF) recorded in July 1994 (CES 1996; Andonaegui 2003). The minimum stream temperature during the period of record was -0.8ºC (30.6ºF) recorded in January 1995 (CES 1996; Andonaegui 2003). Throughout both stream temperature recording periods, the 7-day average minimum temperature was -0.5ºC (31.1ºF) (January 2 through 8, 1995), and the 7-day average maximum temperature was 18.3ºC (64.9ºF) (July 24 through 30, 1994) (CES 1996; Andonaegui 2003).

- ***Water Quantity and Characteristics:*** In the 1950s and 1960s, Sullivan Creek from RM 0.5 to 2.1 was straightened through the placement of riprap and gabion structures (Andonaegui 2003). The channel-straightening activity may have increased the intensity of flooding and scouring downstream of RM 2.1. On August 16, 2000, the discharge was 2.20 m^3/s (77.69 ft^3/s) near the mouth (RM 0.0) of Sullivan Creek (McLellan 2001). Using data from McLellan (2001), the mean channel gradient was calculated to be 2.3 percent based on results from surveys of three stream reaches, ranging between 1 and 4 percent, downstream of RM 3.25. The average stream gradient between North Fork Sullivan Creek (RM 2.35) and Highway 31 has been reported as 4 percent (USFS 1996; McLellan 2001; R2 Resource Consultants 2006), with stream reaches ranging between 4 and 10 percent (USFS 1996). The average annual flow has been reported as 7.1 m^3/s (251.1 ft^3/s) at the mouth of Sullivan Creek (RM 0.0) (Entrix 2002). Entrix (2002) determined that at a point near Metaline Falls (near RM 0.0), monthly average flows are higher in May and June, ranging between 19.4 and 21.7 m^3/s (685.9 and 764.9 ft^3/s), respectively, than throughout the rest of the year. In addition, Entrix (2002) determined that at a point near Metaline Falls (near RM 0.0), minimum flows occurred in both January and February, ranging between 2.3 and 2.1 m^3/s (81.4 and 73.5 ft^3/s), and August and September, ranging between 2.6 and 2.4 m^3/s (91.1 and 85.4 ft^3/s). Baseflows have been measured as low as 1.4 m^3/s (50 ft^3/s), and the maximum flow recorded exceeded 56.6m^3/s (2000 ft^3/s) below Mill Pond Dam as described in a 1996 USFS report of the Sullivan Creek Watershed (Wasson 1992 as cited in USFS 1996). The USFS (1996) noted that the maximum spring run-off flows, downstream of Sullivan Lake Dam, is perhaps half to three quarters the historic levels. Artificial raising and lowering of water levels in Sullivan Lake behind Sullivan Lake Dam have moderated flows from natural levels downstream of Sullivan Lake Dam to the mouth of Sullivan Creek (USFS 1999d; Andonaegui 2003). The Sullivan Lake impoundment alters the flow regime of the lower reaches of Sullivan Creek (R2 Resource Consultants 1998; Andonaegui 2003). Specifically, the manipulation of streamflow through the release of water from Sullivan Lake Dam in the fall (first week of October) changes from between 1.4 and 2.1 m^3/s (50 to 75 ft^3/s) to between 8.5 and 11.3 m^3/s (300 to 400 ft^3/s) in one day within Sullivan Creek between RM 0.0 and 3.25 (T. Shuhda 2007). These large fluctuations in stream flow, due to the release of water from Sullivan Lake Dam, may drive fry and juvenile fish into the open, making them more susceptible to predation.

Although the increase in streamflow during the fall provides access to additional spawning habitat within lower Sullivan Creek, as discharge decreases from approximately 11.3 m^3/s (400 ft^3/s) back to 1.4 m^3/s (50 ft^3/s) between October and December, redds may become dewatered before emergence (T. Shuhda 2007).

- ***Fish Species:***
  - *Bull Trout:* A biologist for CES in 1993 observed an adult bull trout in approximately 2.4 m (8 ft) of water downstream of a natural chute at RM 0.65 (CES 1996; Andonaegui 2003). However, positive identification of the bull trout through repeated diving at the location was not feasible due to high water velocities, water depth, and turbulence at the location (Blum 2002 as cited in Andonaegui 2003). In 1993 and 1994, no live bull trout were identified between RM 0.0 and RM 3.25 from electrofishing several locations (CES 1996). However, CES (1996) did find one dead female bull trout in proximity to the mouth of Sullivan Creek during the 1993 surveys. In lower Sullivan Creek, downstream of RM 3.25 to the confluence with the Pend Oreille River (RM 0.0), no bull trout were observed during surveys in 1994 and 1995 (CES 1996).
  - *Cutthroat Trout:* Cutthroat trout were observed and identified during surveys in 1993, 1994, and 1995 of Sullivan Creek between the mouth (RM 0.0) and Mill Pond Dam (RM 3.25) (CES 1996). From snorkel surveys in Sullivan Creek downstream of Mill Pond Dam, McLellan (2001) found cutthroat trout density to be less than 1 fish/100 m^2.
  - *Rainbow Trout:* In Sullivan Creek, rainbow trout were the most common fish species observed during snorkel surveys in 1997 (R2 Resource Consultants 1998). Electrofishing conducted the next day after snorkel surveys in 1997 resulted in an intermediate amount of cutthroat captured in Sullivan Creek (R2 Resource Consultants 1998). Rainbow trout were documented by the USFS (1996) as found only in the mainstem of Sullivan Creek up to the confluence of Rainy Creek (Rainy Creek is beyond the focus study area described for the Sullivan Creek WAU). However, documentation of native redband rainbow trout in the Pend Oreille River system between Albeni Falls and Boundary Dam is limited based on POPUD statements (POPUD 2003 as cited in Andonaegui 2003). From snorkel surveys of 55 sites within 20 stream reaches, McLellan (2001) found rainbow trout density to be less than 1 fish/100 m^2. Rainbow trout were observed in lower Sullivan Creek during surveys in 1993, 1994, and 1995 (CES 1996). From snorkel surveys in Sullivan Creek downstream of Mill Pond Dam, McLellan (2001) found rainbow trout density to be greater than 1fish/100 m^2. Within the stretch of Sullivan Creek downstream of Mill Pond Dam (RM 3.25), rainbow trout can be found in this habitat competing for food and habitat, and interbreeding with cutthroat trout (T. Shuhda 2007).
  - *Brook Trout:* Brook trout have been observed in Sullivan Creek (R2 Resource Consultants 1998; McLellan 2001; Andonaegui 2003). In the USFS (1996) watershed assessment of Sullivan Creek, eastern brook trout were found throughout Sullivan Creek, spawning and rearing in tributary habitats, with very little spawning occurring in the mainstem of Sullivan Creek. From snorkel surveys of 55 sites within 20 stream reaches, McLellan (2001) found brook trout

density to be less than 1 fish/100 m^2. Brook trout were observed between the mouth of Sullivan Creek (RM 0.0) and Mill Pond Dam (RM 3.25) during fish surveys conducted in 1993, 1994, and 1995 (CES 1996; Andonaegui 2003). Brook trout were not observed in Sullivan Creek downstream of Mill Pond Dam (RM 3.25) during snorkel surveys conducted between August 7 and August 16, 2000 (McLellan 2001). Within the stretch of Sullivan Creek downstream of Mill Pond Dam (RM 3.25), brook trout can be found in this habitat competing for food and habitat, and interbreeding with bull trout (T. Shuhda 2007). R2 Resource Consultants (2006) also reported the presence of brook trout in Sullivan Creek.

- <u>Brown Trout:</u> Brown trout were observed in lower Sullivan Creek during surveys conducted in 1993, 1994, and 1995 (CES 1996). Brown trout are known to occur downstream of Mill Pond Dam, though not in the tributaries (T. Shuhda 2002 as cited in Andonaegui 2003). An adfluvial population of brown trout utilizes the Pend Oreille River and spawns in Sullivan Creek downstream of Mill Pond Dam (USFS 1996). However, the lower chutes and cascades at RM 0.6 and 0.65 have been suggested as barriers to fish passage, limiting access to upstream migration (Andonaegui 2003). The USFS (1996) documented that streams in eastern Washington had not been stocked with non-native salmonid fish species since the mid-1980s. Electrofishing conducted the next day after snorkel surveys in 1997 resulted in relative low densities (0.02 fish/m^2) of brown trout at sites surveyed in Sullivan Creek (R2 Resource Consultants 1998). From snorkel surveys in Sullivan Creek downstream of Mill Pond Dam, McLellan (2001) found brown trout density to be less than 1 fish/100 m^2.
- <u>Mountain Whitefish:</u> Next to rainbow trout, mountain whitefish was the second most common fish species observed during snorkel surveys of Sullivan Creek in 1997 (R2 Resource Consultants 1998). From snorkel surveys of 55 sites within 20 stream reaches, McLellan (2001) found mountain whitefish density to be less than 1 fish/100 m^2. Mountain whitefish were observed in lower Sullivan Creek during surveys conducted in 1994 and 1995 (CES 1996). From snorkel surveys in Sullivan Creek downstream of Mill Pond Dam, McLellan (2001) found the average mountain whitefish density to be greater than 1 fish/100 m^2.

<u>North Fork Sullivan Creek</u>

- ***<u>Barriers:</u>***
  - <u>At RM 0.0:</u> The culvert crossing at Sullivan Lake Road (County Road 9345) within the North Fork Sullivan Creek drainage (RM 0.0 of North Fork Sullivan Creek), near the confluence of North Fork Sullivan Creek and Sullivan Creek (RM 0.0 on North Fork Sullivan Creek and RM 2.35 on the mainstem Sullivan Creek), is a fish passage barrier (USFS 2002; Andonaegui 2003). Conner et al. (2005) documented the culvert crossing on Sullivan Lake Road as potential slope and velocity fish passage barrier.
  - <u>At RM 0.20:</u> In the North Fork Sullivan Creek drainage, upstream of the culvert crossing at Sullivan Lake Road, is a natural falls (RM 0.20) that appears to prevent fish passage (T. Shuhda, USFS, and C. Vail, WDFW, as cited in Andonaegui 2003). Conner et al. (2005) documented the natural falls (RM 0.20)

as a series of three falls, between 2 to 4 m (6.6 to 13.1 ft) high, potentially blocking fish passage.

  - *At RM 0.25:* The North Fork Sullivan Creek Dam at RM 0.25, which is owned an operated by the Pend Oreille Public Utility District (POPUD) to supply drinking water to the town of Metaline Falls, is a complete fish passage barrier (USFS 1996; Andonaegui 2003; Conner et al. 2005).
  - *At RM 0.60:* Conner et al. (2005) document a significant gradient and habitat change 540 m (1,771.7 ft) upstream of the dam (approximately near RM 0.60); however, no information is provided on whether the gradient may limit fish passage.
  - *At RM 1.50:* Conner et al. (2005) report that a 2.3 m (7.5 ft) fall and bedrock cascade near RM 1.50 (1,980 m [6,496.1 ft] upstream from the North Fork Sullivan Creek Dam) is potential fish passage barrier.
  - *At RM 2.60:* Upstream of RM 2.60, Conner et al. (2005) report two potential fall barriers, one 2.1 m (6.9 ft) high and the other 1.5 m (4.9 ft) high.
- ***Riparian Conditions:*** The riparian vegetation in North Fork Sullivan Creek has been described as a hemlock/oak/fern association with alders growing on depositional areas and in the North Fork Sullivan Creek channel (USFS 1996). There are no roads and no major human impacts above North Fork Sullivan Creek Dam, and the creek flows through a mature cedar forest with overhead canopy nearly complete (RM 0.25) (Conner et al. 2005).
- ***Channel Conditions and Dynamics:***
  - *Streambank Condition:* Throughout North Fork Sullivan Creek, habitat ranged from high gradient entrenched canyons to wide valleys with sediment laden, braided channels influenced by past beaver activity (Conner et al. 2005).
  - *Floodplain Connectivity:* Throughout North Fork Sullivan Creek habitat ranged from high gradient entrenched canyons to wide valleys with sediment-laden, braided channels influenced by past beaver activity (Conner et al. 2005). There are no roads and no major human impacts above North Fork Sullivan Creek Dam (RM 0.25) (Conner et al. 2005).
  - *Channel Stability:* Throughout North Fork Sullivan Creek, habitat ranged from high gradient entrenched canyons to wide valleys with sediment-laden, braided channels influenced by past beaver activity (Conner et al. 2005). There are no roads and no major human impacts above North Fork Sullivan Creek Dam (RM 0.25) (Conner et al. 2005).

- ***Habitat Elements:***
  - *Channel Substrate:* Conner et al. (2005) surveyed seven reaches totaling 5.1 km (3.2 mi) in 2003, and determined gravel and cobble were the dominant substrate (42.2 percent and 27.9 percent, respectively) within North Fork Sullivan Creek. In all surveyed reaches in 2003, except the reach downstream of North Fork Sullivan Creek Dam which acts as a sediment trap, substrate embeddedness was relatively high (mean of 69 percent)(Conner et al. 2005).
  - *LWD:* Conner et al. (2005) reported that active LWD was abundant, averaging 578 pieces per mile, with many log jams comprising large cedars in the watershed.

- *Pool Frequency and Quality:* Instream habitat in North Fork Sullivan Creek was documented as very diverse with pocket pools and short riffles (USFS 1996). From surveys in 2003, Conner et al. (2005) reported that riffle was the dominant habitat type (58.0 percent of the seven transects surveyed), with pools and runs recorded at 19.0 percent and 23.0 percent, respectively. Conner et al. (2005) went on to report that eight-four primary pools were counted corresponding to 26.6 pools per mile.
- *Pool Depth:* From conducting surveys in seven reaches within North For Sullivan Creek, Conner et al. (2005) found the average length, maximum depth, and residual depths of pools were 3.8 m (12.5 ft), 63.8 cm (25.1 in), and 46.7 cm (18.4 in), respectively.
- *Off-Channel Habitat:* Throughout North Fork Sullivan Creek habitat ranged from high gradient entrenched canyons to wide valleys with sediment-laden, braided channels influenced by past beaver activity (Conner et al. 2005).
- *Wetted Width:* Conner et al. (2005) surveyed seven reaches totaling 5.1 km (3.2 mi) in 2003, and found the mean wetted width was 3.8 m (12.5 ft) and depth 23.7 cm (9.3 in) within North Fork Sullivan Creek.

- ***Water Quality:***
  - *Temperature:* The USFS deployed a thermograph upstream from the confluence of North Fork Sullivan Creek and the mainstem Sullivan Creek at the USFS boundary from July 18 to September 18, 2002, and determined the 7-day average maximum temperature during this period was 11.8ºC (53.2ºF) (K. Honeycutt, USFS, email. comm., 2003 as cited in Andonaegui 2003). McLellan (2001) measured water temperature near the mouth (RM 0.0) of North Fork Sullivan Creek with a thermograph from June 28 to October 19, 2000. Based on the data available from the McLellan (2001) report, the 7-day average maximum temperature was 11.9ºC (53.42ºF) between August 6 and August 12, 2000. Conner et al. (2005) recorded stream temperature hourly between June 19 and October 16, 2003, and determined the 7-day average maximum temperature during this period was 13.0ºC (55.4ºF). The maximum temperature during this period of record was 14.9ºC (58.8ºF) on August 19, and the minimum was 4.8ºC (40.6ºF) on October 15 (Conner et al. 2005).

- ***Water Quantity and Characteristics:*** The watershed is roadless and borders the Salmo-Priest Wilderness Area, with typical land use practices such as logging, road building, and grazing absent in the drainage (Conner et al. 2005). Conner et al. (2005) documented the mean channel gradient was 2.2 percent, ranging from 0.5 percent to 15.0 percent, from the seven reaches surveyed within North Fork Sullivan Creek in 2003. The North Fork Sullivan Creek has a low flow restriction of 0.06 m^3/s (2 ft^3/s) (Entrix 2002). At the confluence of North Fork Sullivan Creek and the mainstem Sullivan Creek (RM 0.0 on North Fork Sullivan Creek and RM 2.35 on Sullivan Creek), Conner et al. (2005) determined the discharge to be 0.04 m^3/s (1.34 ft^3/s) on September 4, 2003. Located at RM 0.25, North Fork Sullivan Lake Dam is operated as a run-of the-river dam (Andonaegui 2003). At the base of the dam there is an eight-inch pipe, and even during the lowest flows during the summer months water is typically spilling over the dam (Blum 2003 as cited in Andonaegui 2003). Conner et al. (2005) reported that above the North Fork Sullivan Creek Dam there were no major impacts from human development.

- ***Fish Species:***
  - *Bull Trout:* No bull trout have been found in any of the tributaries draining into Sullivan Creek, including North Fork Sullivan Creek (Andonaegui 2003). No bull trout were detected from surveying seven sites in North Fork Sullivan Creek, at least one of which was located upstream of the North Fork Sullivan Creek Dam (RM 0.25) (Blum 2003 as cited in Andonaegui 2003).
  - *Cutthroat Trout:* Conner et al. (2005) used electrofishing to sample two 100 m (328.1 ft) reaches in North Fork Sullivan Creek for fish species, and found only cutthroat trout, both above and below the dam (RM 0.25). From electrofishing downstream of the dam, Conner et al. (2005) reported cutthroat trout density was 13.9 fish/100 m^2. The westslope cutthroat trout population present in North Fork Sullivan Creek downstream of RM 0.25 was indicated as a distinct genetic stock, with no hybridization and no record of past stocking (Shaklee and Young 2000 and Gayeski et al. 2001 as cited in Conner et al. 2005). In addition, the stock in North Fork Sullivan Creek were found to be distinct, indicating they exist as reproductively isolated from other stocks occurring in Upper Sullivan Creek (isolated above Mill Pond Dam) (Shaklee and Young 2000 as cited in Conner et al. 2005). Only westslope cutthroat are known to occur upstream of the North Fork Sullivan Creek Dam (CES 1996; Vail 2003 as cited in Andonaegui 2003; USFS 2005). Conner et al. (2005) used electrofishing to sample two 100 m (328.1 ft) reaches in North Fork Sullivan Creek for fish species, and found only cutthroat trout, both above and below the dam (RM 0.25). From the electrofishing survey conducted upstream of the dam, Conner et al. (2005) reported cutthroat trout density was 5.2 fish/100 m^2. Conner et al. (2005) note that conducting electrofishing surveys in reaches farther upstream of the dam was not feasible due to the remote location and steep valley walls with large downed trees. However, while conducting habitat surveys in the reaches farther upstream of the dam, cutthroat trout were observed but were not collected during attempts using hook-and-line sampling (Conner et al. 2005).

Box Canyon WAU

Linton Creek

- ***Barriers:*** Approximately at RMs 0.18, 0.21, 0.25, 0.33, 0.34, 0.38, 0.42, 0.67, 0.71, 0.76, 0.78, 1.07, and 1.10 on Linton Creek there are fish passage barriers (POSRT 2005).
- ***Water Quantity and Characteristics:*** The gradient in Linton Creek ranges between 0.3 percent in reaches near Boundary Reservoir to 56.4 percent in the headwaters (WDFW SalmonScape 2007).

Pocahontas Creek

- ***Barriers:*** Approximately at RM 0.34 on Pocahontas Creek there is a fish passage barrier (POSRT 2005). During the summer, flows in lower Pocahontas Creek between RM 0.0 and approximately 0.25 are generally subsurface (R2 Resource Consultants 2006; T. Shuhda, USFS, pers. comm., 2005 as cited in R2 Resource Consultants 2006).

- ***Riparian Conditions:*** In the comments of the USFS (2005) SMART database for the Pocahontas records it is noted that there is a closed cedar canopy.
- ***Channel Conditions and Dynamics:***
  - *Streambank Condition:* In the comments of the USFS (2005) SMART database for the Pocahontas records, it is noted for a number of locations that there are unstable banks and landslides.
  - *Channel Stability:* The entrenchment ratio, based on the USFS (2005) SMART database, was 1.3. In the comments of the database for the Pocahontas records, it is noted that the channel is entrenched.

- ***Habitat Elements:***
  - *Channel Substrate:* The percent of fines, based on the USFS (2005) SMART database, was greater than 20 percent.
  - *LWD:* Based on data available in the USFS (2005) SMART database, there were 21.4 pieces of LWD per mile.
  - *Pool Frequency and Quality:* The amount of pools per mile, based on the USFS (2005) SMART database, was 36.4.
  - *Pool Depth:* The pool depth, based on the USFS (2005) SMART database, was 0.61 m (2 ft).
  - *Wetted Width:* The mean wetted width, based on the USFS (2005) SMART database, was 1.9 m (6.1 ft).

- ***Water Quantity and Characteristics:*** During the summer, flows in lower Pocahontas Creek between RM 0.0 and approximately 0.25 are generally subsurface (R2 Resource Consultants 2006; T. Shuhda, USFS, pers. comm., 2005 as cited in R2 Resource Consultants 2006). Stream gradient ranges between 1.5 percent in reaches close to Boundary Reservoir and 26.9 percent in headwater reaches (WDFW SalmonScape 2007).

- ***Fish Species:***
  - *Cutthroat Trout:* The POSRT (2005) documents cutthroat trout as present in Pocahontas Creek.
  - *Rainbow Trout:* The POSRT (2005) documents rainbow trout as present.

Wolf Creek

- ***Barriers:*** Approximately at RM 0.35 and 1.21 on Wolf Creek there are fish passage barriers (POSRT 2005).
- ***Water Quantity and Characteristics:*** The average gradient in Wolf Creek is 16.5 percent (WDFW SalmonScape 2007).

Sweet Creek

- ***Barriers:***

  - *At RM 0.5:* A road crossing at State Highway 31 (RM 0.5) is described as a velocity barrier to fish passage (Andonaegui 2003; WDFW SalmonScape 2007). However, as Andonaegui (2003) reports, and as documented in McLellan (2001), an adult bull trout was observed upstream of the culvert and downstream of the first waterfall barrier in 2000. In addition, upstream of State Highway 31 juvenile whitefish had been observed indicating some degree of passage (C. Vail 2002 as cited in Andonaegui 2003). Andonaegui (2003) documents that the barrier at RM 0.5 was listed in the WDFW Salmonid Screening, Habitat Enhancement, and Restoration Division (SSHEAR) database GIS barrier coverage as of November 2002. As of August 2007, the road crossing is still included in the GIS culverts layer available from WDFW SalmonScape (2007).
  - *RM 0.60:* From RM 0.6, and continuing upstream 870 m (2854.3 ft), there is a series of four natural waterfalls, 6.0 m (19.7 ft), 6.0 m (19.7 ft), 6.0 m (19.7 ft), and 8.2 m (26.9 ft) high, that are fish passage barriers (McLellan 2001; Andonaegui 2003). Based on the WDFW SalmonScape (2007) GIS barrier layer, only the first natural waterfall is reported (approximately RM 0.6). R2 Resource Consultants (1998) also documented a barrier falls at approximately RM 0.6 on Sweet Creek, but noted that below the falls is potential spawning and rearing habitat for adfluvial salmonids.
  - *RM 1.4:* Approximately upstream from RM 1.4 on Sweet Creek there is a potential fish passage barrier (POSRT 2005). Approximately upstream from RM 1.5 on Sweet Creek there is a fish passage barrier (POSRT 2005).
- ***Riparian Conditions:*** R2 Resource Consultants (1998) documented a well-shaded channel for Sweet Creek. In addition, from surveys of habitat units in Sweet Creek, R2 Resource Consultants (1998) determined the mean canopy cover was 30 percent.
- ***Habitat Elements:***
  - *Channel Substrate:* R2 Resource Consultants (1998) reported a mean of 12 percent for surface fines from surveys in Sweet Creek. The dominant substrate is boulder for Sweet Creek (McLellan 2001; Andonaegui 2003).
  - *LWD:* Based on 14 sites in five stream reaches surveyed within Sweet Creek, there was a mean of 290 pieces of LWD per mile (McLellan 2001). R2 Resource Consultants (2006) reported Sweet Creek contains a fair level of LWD (289.7 to 321.9 pieces per mile).
  - *Pool Frequency and Quality:* The dominant habitat type is riffle for Sweet Creek (McLellan 2001; Andonaegui 2003). McLellan (2001) reported 27 large pools per mile from surveying 14 sites in five stream reaches of Sweet Creek in 2000. R2 Resource Consultants (2006) reported Sweet Creek contains a fair amount of pools (27.4 to 80.5 pools per mile).
  - *Pool Depth:* McLellan (2001) conducted habitat surveys within five reaches of Sweet Creek and determined the mean width, maximum depth, and residual depth for the combined five reaches were 3.7 m (12.1 ft), 52 cm (20.5 in), and 33 cm (13.0 in), respectively.
  - *Wetted Width:* McLellan (2001) conducted surveys of five stream reaches in Sweet Creek and reported a mean wetted width of 4.3 m (14.1 ft).

- ***Water Quality:***

  - *Temperature:* From August 15 through October 27, 1996, and again from July 25 through November 11, 1997, hourly recordings of water temperatures were collected just downstream of the State Highway 31 crossing (R2 Resource Consultants 1998). The 7-day average maximum temperature during the period of record was 15.3ºC (59.5ºF) between August 1 and 7, 1997 (R2 Resource Consultants 1998). R2 Resource Consultants (1998) also placed a second water temperature recording station upstream of the State Highway 31 crossing, but there was little difference in temperature between the upper and lower sites. Between June 28 and October 17, 2000, the water temperature downstream of the State Highway 31 crossing in Sweet Creek was measured with an electronic thermograph (McLellan 2001). The maximum temperature recorded within Sweet Creek in 2000 was 15.63ºC (60.13ºF) on August 6, 7, and 9, and the minimum was 2.26ºC (36.07ºF) on October 6 (McLellan 2001). Based on the data available from the McLellan (2001) report, the 7-day average maximum temperature was 15.4ºC (59.7ºF) between August 7 and 13, 2000.

- ***Water Quantity and Characteristics:*** McLellan (2001) determined the discharge to be 0.15 m^3/s (5.30 ft^3/s) for Sweet Creek on September 11, 2000. From habitat surveys at five stream reaches, McLellan (2001) reported and mean gradient of 5 percent on Sweet Creek.

- ***Fish Species:***
  - *Bull Trout:* Access to habitat is limited for migratory life history forms of bull trout (Andonaegui 2003). However, three bull trout have been documented in the Sweet Creek drainage (Andonaegui 2003). At the mouth of Sweet Creek (RM 0.0), a 20-inch adult bull trout was captured by Bob Peck (WDFW biologist) using a gill net in the fall during the early 1980s (Andonaegui 2003). Again in the fall during the early 1980s, Bob Peck found a dead 34-inch bull trout along the streambank upstream from RM 0.0 (Andonaegui 2003). In 1988, R2 Resource Consultants conducted snorkel surveys on Sweet Creek and no bull trout were observed (USFS 1999c). In the fall of 1997, R2 Resource Consultants again surveyed Sweet Creek using snorkel surveys and did not observe bull trout (R2 Resource Consultants 1998). In the fall of 2000, a 12-inch adult bull trout was observed during a snorkel survey in a plunge pool downstream of the barrier waterfall at RM 0.6, approximately 400 m (1312.3ft) upstream of the State Highway 31 stream crossing (McLellan 2001). Based on the surveys reported in McLellan (2001), bull trout density was less than 1 fish/100 m^2.
  - *Cutthroat Trout:* Predominately cutthroat trout were observed in snorkel survey of Sweet Creek in 1997 (R2 Resource Consultants 1998). Electrofishing conducted the next day after snorkel surveys in 1997 resulted in an intermediate density of cutthroat trout captured in Sweet Creek (R2 Resource Consultants 1998). From snorkel surveys conducted in 2000 at 14 sites within five stream reaches, McLellan (2001) reported cutthroat trout density to be 4 fish/100 m^2. Cutthroat trout were collected during June of 2007 in a survey where fyke nets were deployed at the mouth of Sweet Creek intended to collect downstream migrating fish (SCL 2008b).

- *Rainbow Trout:* Next to cutthroat trout, rainbow trout were the second most common fish species observed during snorkel surveys of Sweet Creek in 1997 (R2 Resource Consultants 1998). Electrofishing conducted the next day after snorkel surveys in 1997 resulted in an intermediate density of rainbow trout captured in Sweet Creek (R2 Resource Consultants 1998). From snorkel surveys conducted in 2000 at 14 sites within five stream reaches, McLellan (2001) reported rainbow trout density to be 4 fish/100 m^2. Within the stretch of Sweet Creek between RM 0.0 and 0.5, rainbow trout can be found competing for food and habitat, and interbreeding with cutthroat trout (T. Shuhda 2007). A rainbow trout was collected during June 2007 in a survey in which fyke nets were deployed at the mouth of Sweet Creek to collect downstream migrating fish (SCL 2008b).
- *Brook Trout:* Within Sweet Creek, brook trout have been known to occur (R2 Resource Consultants 1998; McLellan 2001). Electrofishing conducted the next day after snorkeling surveys in 1997 resulted in relative low densities of brook trout at sites surveyed in Sweet Creek (R2 Resource Consultants 1998). From snorkel surveys conducted in 2000 at 14 sites within five stream reaches, McLellan (2001) reported brook trout density to be 1 fish/100 m^2. Within the stretch of Sweet Creek between RM 0.0 and 0.5, brook trout can be found in this habitat competing for food and habitat, and interbreeding with bull trout (T. Shuhda 2007).
- *Brown Trout:* Electrofishing conducted the next day after snorkel surveys in 1997 resulted in relative low densities (0.02 fish/m^2) of brown trout at sites surveyed in Sweet Creek (R2 Resource Consultants 1998). From snorkel surveys conducted in 2000 at 14 sites within five stream reaches, McLellan (2001) reported brown trout density to be less than 1 fish/100 m^2. Brown trout were collected during June 2007 in a survey in which fyke nets were deployed at the mouth of Sweet Creek to collect downstream migrating fish (SCL 2008b).
- *Mountain Whitefish:* From snorkel surveys conducted in 2000 at 14 sites within five stream reaches, McLellan (2001) reported a single mountain whitefish (less than 1 fish/100 m^2) was observed.

Lunch Creek

- ***Barriers:*** Approximately upstream from RM 1.4 on Lunch Creek there is a potential fish passage barrier (POSRT 2005).
- ***Habitat Elements:***
  - *Channel Substrate:* The dominant substrate is rubble for Lunch Creek (McLellan 2001).
  - *LWD:* Based on three stream reaches surveyed within Lunch Creek, there was a mean of 338 pieces of LWD per mile (McLellan 2001).
  - *Pool Frequency and Quality:* The dominant habitat type is riffle for Lunch Creek (McLellan 2001). McLellan (2001) reported 12 large pools per mile from surveying three stream reaches of Lunch Creek in 2000.
  - *Pool Depth:* McLellan (2001) conducted habitat surveys within three reaches of Lunch Creek and determined the mean width, maximum depth, and residual depth

for the combined three reaches were 2.9 m (9.5 ft), 46 cm (18.1 in), and 29 cm (11.4 in), respectively.
- o *Wetted Width:* The mean wetted width, based on surveys of three stream reaches conducted in 2000 on Lunch Creek, was 3.5 m (11.5 ft).

- ***Water Quality:***
  - o *Temperature:* McLellan (2001) reported mean values of water temperature from surveys conducted in three stream reaches on Lunch Creek. The mean water temperature for all three reaches was 8ºC (44.6ºF), but the 7-day average maximum temperature was not able to be calculated from the data available.

- ***Water Quantity and Characteristics:*** From habitat surveys at three stream reaches on Lunch Creek, McLellan (2001) reported a mean gradient of 12 percent.

- ***Fish Species:***
  - o *Cutthroat Trout:* From snorkel surveys conducted in 2000 at seven sites within three stream reaches, McLellan (2001) reported cutthroat trout density to be 2 fish/100 m^2 and cutthroat trout were the only fish species observed.

Sand Creek

- ***Barriers:*** From the confluence of Sand Creek with the Pend Oreille River (RM 0.0) upstream to RM 0.25, portions of the creek have been documented to dewater in September, with water going subsurface (USFS 1999a; Andonaegui 2003). The USFS (1999a) noted that in June 1992 the recorded flow at the mouth was very low for that time of year. In August of 1996, the water depth in all areas of the channel in the lower 0.25 mile of Sand Creek was less 0.3 m (1 ft) deep (R2 Resource Consultants 1998). At RM 0.25, near USFS Road 3669, the culvert (2.0 m [6.6 ft] vertical drop and 75.0 m [246.1 ft] long) under the railroad track is a fish passage barrier at all flows (USFS 1999a; McLellan 2001; Andonaegui 2003). Andonaegui (2003) documents a culvert at RM 0.5 as a fish passage barrier, but the culvert is not listed in barriers spreadsheet provided in the report (see Appendix 1). A natural waterfall barrier (5.0 m [16.4 ft] vertical) occurs at RM 1.25 offering limited access to habitat for migratory life history forms of bull trout (McLellan 2001; Andonaegui 2003). At RM 1.8 in Sand Creek there is a culvert, 4.2 m (13.94 ft) high and 15.7 m (51.6 ft) long, at the USFS Road 3310160 creek crossing preventing fish passage (USFS 2002; Andonaegui 2003).
- ***Riparian Conditions:*** Most of the largest components of the riparian stands along Sand Creek have been removed by wildfires and past harvest (USFS 1999a). However, the USFS (1999a) notes in the report that species expected of the natural riparian community comprised the current vegetation species composition. With the exception of several road crossings and portions of old road located within the RHCA (Riparian Habitat Conservation Area), the riparian areas are continuous in nature (USFS 1999a). In 1999 the USFS documented that upstream of RM 2.0 there was approximately 0.75 mile of road system located inside of the riparian areas (USFS 1999a). Of the 0.75 mile of road system in riparian areas, 0.5 mile is not maintained and closed to vehicular traffic, and 0.25 mile is maintained, but only when there is

damage to the road (USFS 1999a). The 0.25 mile of road system that is maintained is being overgrown, but is kept open through public utilization of the road (USFS 1999a). The USFS (1999a) reported the riparian areas existing along the main channel as functioning and hydrologically linked to Sand Creek. In surveys of habitat units in Sand Creek, R2 Resource Consultants (1998) determined the mean canopy cover was 37 percent.

- ***Channel Conditions and Dynamics:***
  - o Streambank Condition: Habitat units surveyed by R2 Resource Consultants (1998) in Sand Creek were found to have an average undercut bank cover of 9.6 percent. Ground cover for the streambanks was less than 25 percent along two reaches and between 51 and 75 percent at two other reaches surveyed on USFS land (USFS 1999a). In addition, the USFS (1999a) states that on two reaches surveyed within private lands, streambank cover was less than 25 percent. The USFS (1999a) documents that the quality of refugia for native salmonids is fair to good, but there was a problem with streambank stability and embeddedness throughout the system. Andonaegui (2003) describes the streambank condition as fair in Sand Creek (USFS 2002f and Honeycutt 2003 as cited in Andonaegui 2003).
  - o *Floodplain Connectivity:* The valley form is V-shaped with low to moderate sideslopes and narrow floodplains along Sand Creek (USFS 1999a). The USFS (1999a) reported the riparian areas existing along the main channel as functioning and hydrologically linked to Sand Creek.
  - o *Channel Stability:* The USFS (1999a) reported a problem primarily with streambank stability and embeddedness of the streambed substrate throughout the system. Channel stability has been reported as fair in Sand Creek (K. Honeycutt, USFS, email. comm., 2003 as cited in Andonaegui 2003).
- ***Habitat Elements:***
  - o *Channel Substrate:* R2 Resource Consultants (1998) reported a mean of 30 percent for surface fines from surveys in Sand Creek. Five out six reaches surveyed by the USFS (1999a) had embeddedness levels of greater than 35 percent. Sand was determined to be the dominant substrate material, with gravel as the subdominant material in one out four reaches surveyed (USFS 1999a). The other three reaches surveyed for sediment had gravel as the dominant substrate (USFS 1999a). The streambanks have sand as the dominant substrate, and natural erosion is expected (USFS 1999a). In the USFS (1999a) report on Sand Creek, the level of embeddedness and the natural rates of bank erosion are attributed to the lack of streambank cover. Boulder, sand, and cobble were found as the dominant substrates in five reaches surveyed in 2000 (McLellan 2001). However, McLellan (2001) determined sand was the dominant substrate for Sand Creek.
  - o *LWD:* Within all reaches surveyed and reported by the USFS (1999a), LWD exceeded 20 pieces per mile. Based on 12 sites in five reaches surveyed within Sand Creek, there was a mean of 579 pieces of LWD per mile (McLellan 2001).
  - o *Pool Frequency and Quality:* The USFS (1999a) reported that the number of pools per mile on all surveyed reach was lower than what would be expected (listed as 60 pools per mile by the Andonaegui [2003]) for a stream with an average wetted width of 3.7 m (12 ft). In addition, the USFS (1999a) reported

that sand was the dominant substrate in pools, which appeared to be moderately reducing pool volume. Based on review of the USFS SMART database (2005), for six reaches surveyed in 1992, pools per mile ranged from nearly 14 to over 24. Based on surveys conducted in 2000 of five reaches within Sand Creek, a mean of 29 large pools per mile was reported (McLellan 2001). However, McLellan (2001) documented that riffles were the dominant habitat type (69 percent) for the sites surveyed within the five reaches on Sand Creek.

- *Pool Depth:* McLellan (2001) conducted habitat surveys within five reaches on Sand Creek and determined the mean width, maximum depth, and residual depth for the combined five reaches were 2.5 m (8.2 ft), 34 cm (13.4 in), and 20 cm (7.9 in), respectively. Andonaegui (2003) reported pool depth as fair (K. Honeycutt, USFS, email. comm., 2003 as cited in Andonaegui 2003).
- *Off-Channel Habitat:* Of all existing habitat surveyed by the USFS (1999a), approximately 1 percent is off-channel habitat resulting from the channel braiding around debris jams. In addition, beaver dams and ponds are frequent in Sand Creek (USFS 1999a).
- *Wetted Width:* McLellan (2001) conducted surveys of five stream reaches on Sand Creek and reported a mean wetted width of 2.1 m (6.9 ft).

- ***Water Quality:***
  - *Temperature:* The USFS (1999a) reports that "sporadic" water temperature data are available for Sand Creek. In 1979, a Forest Hydrologist collected water temperature data, and crews collecting physical habitat as part of electroshocking (1992) and snorkeling (1997) inventories in Sand Creek also collected water temperature data (USFS 1999a). During a two week period in July of 1992, temperatures in Sand Creek ranged from 11ºC (52ºF) to 14ºC (58ºF) (USFS 1999a). In the upper portion of Sand Creek water temperature was recorded at 12.5ºC (55ºF) on August 15, 1997 (USFS 1999a). In the lower portion of Sand Creek the highest temperature recorded was 14ºC (58ºF) during the month of July. The lowest temperature recorded for Sand Creek was 5ºC (41ºF) in May of 1979 (USFS 1999a). The USFS (1999a) notes that the based on the limited available data it was not possible to determine a 7-day average maximum temperature. Also due to the lack of data available, the USFS (1999a) was not able to determine whether water temperatures were suitable for bull trout spawning and incubation. However, for bull trout rearing the USFS (1999a) notes there are more tolerable temperatures in the upper headwaters with more marginal water temperatures in lower Sand Creek. From August 15 through October 27, 1996, and again from July 25 through November 11, 1997, hourly recordings of water temperatures were collected near the mouth of Sand Creek (RM 0.0) (R2 Resource Consultants 1998). The lower reach of Sand Creek is braided with water flowing through a delta area containing porous streambed with subsurface flows (R2 Resource Consultants 1998; Andonaegui 2003). Due to this braiding in the lower reach, Sand Creek was dewatered soon after placement of the thermograph (R2 Resource Consultants 1998; Andonaegui 2003). By 1997 the thermograph was replaced at the mouth of Sand Creek and recorded water temperature throughout the entire monitoring period (R2 Resource Consultants 1998). The

7-day average maximum temperature during the period of record was 15.9ºC (60.6ºF) between August 1 and 7, 1997 (R2 Resource Consultants 1998). Between June 28 and October 19, 2000, the water temperature at the mouth of Sand Creek was measured with an electronic thermograph (McLellan 2001). The maximum temperature recorded within Sand Creek in 2000 was 16.26ºC (62ºF) on August 23, and the minimum was 2.53ºC (36.5ºF) on October 6 (McLellan 2001; Andonaegui 2003). Based on the data available in the McLellan (2001) report, the 7-day average maximum temperature was calculated and determined to be 14.5ºC (58.1ºF) between August 7 and 13, 2000, at the mouth of Sand Creek.

- ***Water Quantity and Characteristics:*** There are no undisturbed watersheds of similar nature to evaluate changes in the flow regime within the Sand Creek drainage (USFS 1999a). In the USFS (1999a) biological evaluation of the Wolf Creek Timber Sale, it was believed that within the watershed the high density of roads (2.9 miles per square mile), located primarily outside of the RHCA, and the low level of acreage in harvested openings (9.4 percent), may not have a noticeable effect on the natural flow regime. However, the USFS (1999a) documented that there was not enough information available for this determination. The USFS (1999a) reported that the flow at the mouth of Sand Creek on June 3, 1992, was 0.02 m^3/s (0.83 ft^3/s), and noted that this was very low for that time of year. In the lower reach of Sand Creek the channel is braided with water running through a delta area containing porous stream bed with subsurface flows (Andonaegui 2003). R2 Resource Consultants (1998) estimated the flow in the lower 0.25 miles of Sand Creek during August 1996 to be less than 0.03 m^3/s (1 ft^3/s), with no channel areas exceeding 0.3 m (1 ft) deep. No information is available on whether the dewatering in the lower reach of Sand Creek is a natural condition or related to human impacts in the drainage (Andonaegui 2003). On September 7, 2000, McLellan (2001) determined the discharge to be 0.01 m^3/s (0.35 ft^3/s) for Sand Creek at the mouth (RM 0.0). The mean gradient from five reaches surveyed on Sand Creek was 7 percent (McLellan 2001).

- ***Fish Species:***
  - *Bull Trout:* Access to habitat is limited for migratory life history forms of bull trout (Andonaegui 2003). Bull trout have not been detected in Sand Creek from snorkeling and electrofishing surveys (R2 Resource Consultants 1998; USFS 1999a; McLellan 2001; Andonaegui 2003). However, habitat within Sand Creek has been identified as "Suitable" by the TAG (Andonaegui 2003).
  - *Cutthroat Trout:* During electroshocking and snorkeling surveys along the fish-bearing segments of Sand Creek, the USFS (1999a) documented that westslope cutthroat trout fry, juveniles, and adults were observed. Cutthroat trout were observed during snorkel surveys of Sand Creek in 1997 (R2 Resource Consultants 1998). Electrofishing conducted the next day after snorkel surveys in 1997 resulted in an intermediate density of cutthroat trout captured in Sand Creek (R2 Resource Consultants 1998). From snorkel surveys conducted in 2000 of sites within five reaches on Sand Creek, McLellan (2001) reported a mean of 2 fish/100 m^2. Cutthroat trout were collected between May and June of 2007 in a

survey where fyke nets were deployed at the mouth of Sand Creek intended to collect downstream migrating fish (SCL 2008b).

- *Rainbow Trout:* During electroshocking and snorkeling surveys along the fish-bearing segments of Sand Creek, the USFS (1999a) documented that rainbow trout fry, juveniles, and adults were observed. Rainbow *x* cutthroat trout hybrids and rainbow trout were observed during a snorkel survey of Sand Creek in 1997 (R2 Resource Consultants 1998). Electrofishing conducted the next day after snorkel surveys in 1997 resulted in a high density of rainbow trout captured in Sand Creek (R2 Resource Consultants 1998). From snorkel surveys conducted in tributaries draining into Boundary Reservoir in 2000, Sand Creek had the highest fish densities of rainbow trout, compared to all other tributaries, of 11 fish/100 m^2 (McLellan 2001). Within the stretch of Sand Creek between RM 0.0 and 0.25, rainbow trout can be found in this habitat competing for food and habitat, and interbreeding with cutthroat trout (T. Shuhda 2007). Rainbow trout were collected between May and June 2007 in a survey in which fyke nets were deployed at the mouth of Sand Creek to collect downstream migrating fish (SCL 2008b).
- *Brook Trout:* The USFS (1999a) observed a few eastern brook trout in the stream below a culvert approximately at RM 0.3 and was not able to determine if reproduction was occurring. During a snorkel survey in 1997, R2 Resource Consultants (1998) identified brook trout throughout Sand Creek. However, electrofishing conducted the next day after snorkel surveys in 1997, resulted in relative low densities of brook trout at sites surveyed in Sand Creek (R2 Resource Consultants 1998). In surveys conducted in 2000, McLellan (2001) did not observe any brook trout in five reaches. However, within the stretch of Sand Creek between RM 0.0 and 0.25, brook trout have been found in this habitat competing for food and habitat, and interbreeding with bull trout (T. Shuhda 2007).
- *Brown Trout:* Electrofishing conducted the next day after snorkel surveys in 1997 resulted in relative low densities (0.02 fish/m^2) of brown trout at sites surveyed in Sand Creek (R2 Resource Consultants 1998). In surveys conducted in 2000, McLellan (2001) did not observe any brown trout in five reaches. Brown trout were collected between May and June of 2007 in a survey in which fyke nets were deployed at the mouth of Sand Creek to collect downstream migrating fish (SCL 2008b).
- *Mountain Whitefish:* In surveys conducted in 2000, McLellan (2001) did not observe any mountain whitefish in five reaches. However, the POSRT (2005) documents mountain whitefish present in Sand Creek.

Lost Creek

- ***Barriers:*** Approximately at RM 0.16, 0.92, and 1.41 on Lost Creek there are potential fish passage barriers (POSRT 2005).
- ***Water Quantity and Characteristics:*** The average gradient in Lost Creek is 8.6 percent (WDFW SalmonScape 2007).

- ***Fish Species:***

- *Cutthroat Trout:* R2 Resource Consultants (2006) reported the presence of cutthroat trout in Lost Creek.

Unnamed No. 13

- ***Barriers:*** During a March 2007 site visit as part of the Boundary Reservoir Project (FERC No. 2144) relicensing process, a natural fish migration barrier more than 4.6 m (15 ft) high was observed (B. Fullerton, Tetra Tech EC Inc., pers. comm., 2007).
- ***Water Quantity and Characteristics:*** The gradient is greater than 20 percent approximately 30.5 m (100 ft) upstream from the confluence with Boundary Reservoir (RM 0.0) (WDFW SalmonScape 2007).

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Appendix 6. Spreadsheet of Data from Primary Tributaries

Table A.6-1. Migration barrier and channel condition and dynamic information for primary tributaries draining into Boundary Reservoir.

Tributary Name	Creek Name	Access to Spawning and Rearing		Riparian Condition	Channel Conditions/Dynamics		
		Artificial Barrier	Natural Barrier		Streambank Condition	Floodplain Connectivity	Channel Stability
SLATE CREEK WAU							
Lime Creek (RM 19.0)	Lime Creek Mainstem						
	RM 0.0 - 1.3	None	Yes	DG	DG	Connected	Acceptable
Slate Creek (RM 22.2)	Slate Creek Mainstem						
	RM 0.0 - 6.2	None	Yes	Adequate	>90% stability	Connected	Appropriate
	Slumber Creek (RM 2.0)						
	RM 0.0 - 2.3	Yes	Yes	Adequate	↑	↑	Appropriate
	Uncas Gulch (RM 2.75)						
	RM 0.0 - 2.0	None	None	Adequate	↑	↑	Appropriate
	Styx Creek (RM 4.9)						
	RM 0.0 - 2.0	Yes	None	Adequate	↑	↑	Appropriate
	S. Fk. Slate Creek (RM 6.2)						
	RM 0.0 - 1.0	None	None	Adequate	↑	↑	Appropriate
	N. Fk. Slate Creek (RM 6.2)						
	RM 0.0 - 2.5	?	Yes	Adequate	↑	↑	Appropriate
Flume Creek (RM 25.8)	Flume Creek Mainstem						
	RM 0.0 - 4.75	Yes	Yes	DG	DG	DG	DG
	S. Fk. Flume Creek (RM 1.1)						
	RM 0.0 - 0.3	Yes	None	DG	DG	DG	DG
	M. Fk. Flume Creek (RM 3.3)						
	RM 0.0 - 0.75	None	None	DG	DG	DG	DG
SULLIVAN CREEK WAU DOWNSTREAM OF MILL POND DAM (RM 3.25)							
Sullivan Creek (RM 26.9)	Sullivan Creek Mainstem						
	RM 0.0 - 3.25	Yes	?	Adequate	50 to 80% stable	Stream margins	Appropriate
	N. Fk. Sullivan Creek (RM 2.35)						
	RM 0.0 - headwaters	Yes	?	Adequate	DG	Connected	Appropriate

Table A.6-1. Migration barrier and channel condition and dynamic information for primary tributaries draining into Boundary Reservoir (continued).

Tributary Name	Creek Name	Access to Spawning and Rearing		Riparian Condition	Channel Conditions/Dynamics		
		Artificial Barrier	Natural Barrier		Streambank Condition	Floodplain Connectivity	Channel Stability
BOX CANYON WAU							
Linton Creek (RM 28.1)	Linton Creek Mainstem						
	RM 0.0 - 1.10	Yes	None	DG	DG	DG	DG
Pocahontas Creek (RM 29.4)	Pocahontas Creek Mainstem						
	RM 0.0 - 0.6	Yes	Yes	DG	DG	Connected	Inappropriate
Sweet Creek (RM 30.9)	Sweet Creek Mainstem						
	RM 0.0 - 1.5	Yes	Yes	DG	DG	DG	DG
	Lunch Creek (RM 1.5)						
	RM 0.0 - 1.4	Yes	None	DG	DG	DG	DG
Sand Creek (RM 31.7)	Sand Creek						
	RM 0.0 - 1.8	Yes	Yes	Adequate	50 to 80% stability	Connected	Appropriate

Notes:
↑ – Limited data were available and not in a format that was similar to other reported data; and/or data are not assessed in a geomorphic context.
Data from tributaries under the same Tributary Name and/or WAU will be used in evaluating limiting factors.
? – Conflicting data and/or lack of data provided in order to determine value.
DG – Data Gap; the stream has not been surveyed; or so little information is available that reporting data would not provide insight into evaluating conditions limiting tributary productivity.
Adequate – provides shade, LWD recruitment, and habitat protection and connectivity.
Connected – Hydrologically linked to off-channel areas.
Acceptable – W/D or entrenchment ratio is beyone range for geomorphologically correct Rosgen stream type.
Appropriate – W/D and Entrenchment is appropriate for geomorphologically correct Rosgen stream type.
Inappropriate – W/D or Entrenchment ratio is inappropriate for geomorphologically correct Rosgen type.

Table A.6-2. Habitat information for primary tributaries draining into Boundary Reservoir.

Tributary Name	Creek Name	Habitat					
		Channel Substrate	LWD (pieces per mile)	Pool Frequency (pools per mile)	Pool Depth (m)	Off-Channel Habitat	Wetted Width (m)
SLATE CREEK WAU							
Lime Creek (RM 19.0)	Lime Creek Mainstem						
	RM 0.0 - 1.3	>35% embeddedness	772	47	0.38	Some	3.1
Slate Creek (RM 22.2)	Slate Creek Mainstem						
	RM 0.0 - 6.2	5 to <35% embeddedness & 5% fines	635	38	0.8 to 1.1	Some	6.3
	Slumber Creek (RM 2.0)						
	RM 0.0 - 2.3	>35% embeddedness & 30 to 40% fines	155 to 167	33 to 56	0.61 to 0.91	Some	7.4
	Uncas Gulch (RM 2.75)						
	RM 0.0 - 2.0	<35% embeddednes	44 to 218	10 to 22	0.61 to 0.91	Some	4.1
	Styx Creek (RM 4.9)						
	RM 0.0 - 2.0	<35% embeddedness	102 to 214	4 to 11	0.55 to 0.70	Some	1.8
	S. Fk. Slate Creek (RM 6.2)						

Table A.6-2. Habitat information for primary tributaries draining into Boundary Reservoir (continued).

Tributary Name	Creek Name	Habitat					
		Channel Substrate	LWD (pieces per mile)	Pool Frequency (pools per mile)	Pool Depth (m)	Off-Channel Habitat	Wetted Width (m)
	RM 0.0 - 1.0	5 to <35% embeddedness	↑	↑	↑	Some	↑
	N. Fk. Slate Creek (RM 6.2)						
	RM 0.0 - 2.5	5 to <35% embeddedness	604	23	0.5	Some	3.5
Flume Creek (RM 25.8)	Flume Creek Mainstem						
	RM 0.0 - 4.75	10% fines	357	19	0.37 to 0.5	DG	4.5
	S. Fk. Flume Creek (RM 1.1)						
	RM 0.0 - 0.3	↑	↑	↑	0.5	DG	3.1
	M. Fk. Flume Creek (RM 3.3)						
	RM 0.0 - 0.75	↑	↑	↑	0.5	DG	3.1
SULLIVAN CREEK WAU DOWNSTREAM OF MILL POND DAM (RM 3.25)							
Sullivan Creek (RM 26.9)	Sullivan Creek Mainstem						
	RM 0.0 - RM 3.25	>20% fines	<20 to 70	10.4	0.8 to 1.61	Stream Margins	17.9
	N. Fk. Sullivan Creek (RM 2.35)						
	RM 0.0 - headwaters	69% embeddedness	578	26.6	0.64	Some	3.8
BOX CANYON WAU							
Linton Creek (RM 28.1)	Linton Creek Mainstem						
	RM 0.0 - 1.10	DG	DG	DG	DG	DG	DG
Pocahontas Creek (RM 29.4)	Pocahontas Creek Mainstem						
	RM 0.0 - 0.6	>20% fines	21.4	36.4	0.61	Some	1.9

Table A.6-2. Habitat information for primary tributaries draining into Boundary Reservoir (continued).

Tributary Name	Creek Name	Habitat					
		Channel Substrate	LWD (pieces per mile)	Pool Frequency (pools per mile)	Pool Depth (m)	Off-Channel Habitat	Wetted Width (m)
Sweet Creek (RM 30.9)	Sweet Creek Mainstem						
	RM 0.0 - 1.5	12% surface fines	289.7 to 321.9	27 to 80.5	0.52	DG	4.3
	Lunch Creek (RM 1.5)						
	RM 0.0 - 1.4	DG	338	12	0.46	DG	3.5
Sand Creek (RM 31.7)	Sand Creek						
	RM 0.0 - 1.8	>35% embeddedness and 30% fines	579	14 to 29	0.34	Some	2.1

Notes:
↑ – Limited data were available and not in a format that was similar to other reported data; and/or data are not assessed in a geomorphic context.
Data from tributaries under the same Tributary Name and/or WAU will be used in evaluating limiting factors.
DG – Data Gap; the stream has not been surveyed; or so little information is available that reporting data would not provide insight into evaluating conditions limiting tributary productivity.

Table A.6-3. Water quality, water quantity, native species, and species competition and hybrids information for Primary Tributaries draining into Boundary Reservoir.

Tributary Name	Creek Name	Water Quality 7-day Average Maximum Temperature (°C)	Water Quantity Changes in Flow Regime	Native Species Present	Species Competition & Hybrids	
					Non-indigenous Fish	Hybrids
SLATE CREEK WAU						
Lime Creek (RM 19.0)	Lime Creek Mainstem					
	RM 0.0 - 1.3	11.6	↑	None	BK	None
Slate Creek (RM 22.2)	Slate Creek Mainstem					
	RM 0.0 - 6.2	13.1 to 14.6	Comparable	BT (near mouth); CT	BK; RB	BT x BK
	Slumber Creek (RM 2.0)					
	RM 0.0 - 2.3	↑	Comparable	CT	BK	None
	Uncas Gulch (RM 2.75)					
	RM 0.0 - 2.0	11.7	Comparable	CT	BK	None
	Styx Creek (RM 4.9)					
	RM 0.0 - 2.0	↑	Comparable	CT	BK	None
	S. Fk. Slate Creek (RM 6.2)					
	RM 0.0 - 1.0	↑	Comparable	CT	BK	None
	N. Fk. Slate Creek (RM 6.2)					
	RM 0.0 - 2.5	9	Comparable	CT	BK	None
Flume Creek (RM 25.8)	Flume Creek Mainstem					
	RM 0.0 - 4.75	12.4 to 14.3	DG	CT	BK	None
	S. Fk. Flume Creek (RM 1.1)					
	RM 0.0 - 0.3	↑	DG	↑	↑	None
	M. Fk. Flume Creek (RM 3.3)					
	RM 0.0 - 0.75	11.5 to 12.6	Comparable	↑	↑	BT x BK

Table A.6-3. Water quality, water quantity, native species, and species competition and hybrids information for Primary Tributaries draining into Boundary Reservoir (continued).

Tributary Name	Creek Name	Water Quality 7-day Average Maximum Temperature (°C)	Water Quantity Changes in Flow Regime	Native Species Present	Species Competition & Hybrids: Non-indigenous Fish	Species Competition & Hybrids: Hybrids
SULLIVAN CREEK WAU DOWNSTREAM OF MILL POND DAM (RM 3.25)						
Sullivan Creek (RM 26.9)	Sullivan Creek Mainstem					
	RM 0.0 - RM 3.25	9.6 to 24.7; majority >14.9	Pronounced	BT; CT; MWF	BK; GBT; RB	BT x BK; CT x RB
	N. Fk. Sullivan Creek (RM 2.35)					
	RM 0.0 - headwaters	11.9 - 13.0	Comparable	CT; distinct stock	None	None
BOX CANYON WAU						
Linton Creek (RM 28.1)	Linton Creek Mainstem					
	RM 0.0 - 1.10	DG	DG	DG	DG	DG
Pocahontas Creek (RM 29.4)	Pocahontas Creek Mainstem					
	RM 0.0 - 0.6	DG	DG	CT	RB	DG
Sweet Creek (RM 30.9)	Sweet Creek Mainstem					
	RM 0.0 - 1.5	15.4	DG	BT; CT; MWF	BK; GBT; RB	BT x BK; CT x RB
	Lunch Creek (RM 1.5)					
	RM 0.0 - 1.4	↑	DG	CT	↑	↑
Sand Creek (RM 31.7)	Sand Creek					
	RM 0.0 - 1.8	14.5 to 15.9	DG	CT; MWF	BK; GBT; RB	BT x BK; CT x RB

Notes:
↑ – Limited data were available and not in a format that was similar to other reported data; and/or data are not assessed in a geomorphic context.
Data from tributaries under the same Tributary Name and/or WAU will be used in evaluating limiting factors.
DG – Data Gap; the stream has not been surveyed; or so little information is available that reporting data would not provide insight into evaluating conditions limiting tributary productivity.
Comparable – watershed hydrography indicates an undisturbed watershed of similar size, geology and geography.
Pronounced – watershed hydrography indicates changes relative to an undisturbed watershed of similar size, geology and geography.
BT – Bull trout; CT – Cutthroat trout; MWF – Mountain whitefish; BK – Brook trout; GBT – Brown trout; RB – Rainbow trout

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Appendix 7. Barrier Inventory for Boundary Reservoir Tributaries

Table A.7-1. Results from evaluating all available literature sources and available GIS layers on fish migration barriers occurring in tributaries draining into Boundary Reservoir.

Tributary Name	Tributary/Creek Name	Barrier Location (RM)	Barrier Type	Height (m)	Length (m)	Gradient (%)	Comments	Source
SLATE CREEK WAU								
Pewee Creek (RM 17.9)	Pewee Creek Mainstem	0.0	Waterfall	50	N/A			McLellan (2001)
	Pewee Creek Mainstem	1.2	Culvert	DG	DG			POSRT (2005)
Lime Creek (RM 19.0)	Lime Creek Mainstem	1.3	Dewatering	N/A	100			McLellan (2001)
Everett Creek (RM 21.9)	Everett Creek Mainstem	0.16	Waterfall	DG	DG		Potential barrier	WDFW SalmonScape (2007)
	Everett Creek Mainstem	1.20	Culvert	DG	DG		Potentially abandoned	WDFW SalmonScape (2007)
Whiskey Gulch (RM 21.9)	Whiskey Gulch Mainstem	0.6	Culvert	DG	DG			POSRT (2005)
Slate Creek (RM 22.2)	Slate Creek Mainstem	0.75	Natural Series	2.8 to 6.0	800	38		McLellan (2001)
	Slate Creek Mainstem	1.5	Natural Series	3	10	24		McLellan (2001)
	Slumber Creek (RM 2.0)	0.2	Culvert	2.4	5.2	0.03		USFS Culvert Database (2002)
	Slumber Creek (RM 2.0)	2.3	Dewatering	N/A	N/A			Andonaegui (2003)
	Styx River (RM 4.9)	0.1	Culvert	3.96	DG	0.1		USFS Culvert Database (2002)
	N. Fk. Slate Creek (RM 6.2)	1.4	Natural Series	DG	27.5	18		McLellan (2001)
	N. Fk. Slate Creek (RM 6.2)	1.5	Manmade	DG	DG	DG	Questionable	McLellan (2001)
Threemile Creek (RM 24.3)	Threemile Mainstem	0	Waterfall	5	N/A			McLellan (2001)
	Threemile Mainstem	0.15	Culvert	DG	DG			POSRT (2005)
Beaver Creek (RM 24.3)	Beaver Creek Mainstem	0	Waterfall	25.3	N/A			McLellan (2001)
	Beaver Creek Mainstem	1.1	Culvert	DG	DG			POSRT (2005)
Flume Creek (RM 25.8)	Flume Creek Mainstem	0.20	Waterfall	13	N/A			McLellan (2001)
	Flume Creek Mainstem	1.0	Culvert	2.5	DG			McLellan (2001)
	Flume Creek Mainstem	4.75	Culvert	1.5	DG			McLellan (2001)
	S. Fk. Flume Creek (RM 1.1)	0.3	Culvert	DG	DG			POSRT (2005)
SULLIVAN CREEK WAU								
Sullivan Creek (RM 26.9)	Sullivan Creek Mainstem	0.6	Natural Series				Questionable	CES (1996)
	Sullivan Creek Mainstem	3.25	DAM	16.8	N/A	N/A	Mill Pond Dam	R2 Resource Consultants (1998)
	North Fork Sullivan Creek (RM 2.35)	0.0	Culvert	DG	DG	DG		USFS Culvert Database (2002)
	North Fork Sullivan Creek (RM 2.35)	0.2	Natural Series	2 to 4	DG	DG		USFS Culvert Database (2002)
	North Fork Sullivan Creek (RM 2.35)	0.6	Gradient	DG	DG	DG		Conner et al. (2005)
	North Fork Sullivan Creek (RM 2.35)	1.5	Natural Series	2.3	DG	DG		Conner et al. (2005)
	North Fork Sullivan Creek (RM 2.35)	2.6	Two Waterfalls	2.1 and 1.5	DG	DG		Conner et al. (2005)
	Elk Creek (RM 3.7)	0.58	DG	DG	DG	DG	No information provided	WDFW SalmonScape (2007)
	Stony Creek (RM 11.6)	0.04	Culvert	3.9	15.2	0.03	Questionable	USFS Culvert Database (2002)
	Kinyon Creek (RM 12.65)	0.27	Culvert	3.5	12.8	0.05		USFS Culvert Database (2002)
	Copper Creek (RM 13.35)	0.05	Culvert	DG	DG	DG		USFS Culvert Database (2002)

Table A.7-1. Results from evaluating all available literature sources and available GIS layers on fish migration barriers occurring in tributaries draining into Boundary Reservoir (continued).

Tributary Name	Tributary/Creek Name	Barrier Location (RM)	Barrier Type	Height (m)	Length (m)	Gradient (%)	Comments	Source
BOX CANYON WAU								
Linton Creek (RM 28.1)	Linton Creek Mainstem	0.18	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.21	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.25	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.33	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.24	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.38	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.42	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.67	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.71	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.76	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	0.78	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	1.07	Culvert	DG	DG	DG		POSRT (2005)
	Linton Creek Mainstem	1.1	Culvert	DG	DG	DG		POSRT (2005)
Pocahontas Creek (RM 29.4)	Pocahontas Creek Mainstem	0.0 to 0.25	Dewatering	N/A	402	N/A		R2 Resource Consultants (2006)
	Pocahontas Creek Mainstem	0.34	Culvert	DG	DG	DG		POSRT (2005)
Wolf Creek (RM 30.3)	Wolf Creek Mainstem	0.35	Culvert	DG	DG	DG		POSRT (2005)
	Wolf Creek Mainstem	1.21	Culvert	DG	DG	DG		POSRT (2005)
Sweet Creek (RM 30.9)	Sweet Creek Mainstem	0.5	Culvert	2.59	19.5	DG	Problem is velocity	WDFW SalmonScape (2007)
	Sweet Creek Mainstem	0.6	Natural Series	6 to 8.2	870	DG		McLellan (2001)
	Sweet Creek Mainstem	1.4	Culvert	DG	DG	DG		POSRT (2005)
	Sweet Creek Mainstem	1.5	Culvert	DG	DG	DG		POSRT (2005)
	Lunch Creek (RM 1.5)	1.4	Culvert	DG	DG	DG		POSRT (2005)
Sand Creek (RM 31.6)	Sand Creek Mainstem	0.0 to 0.25	Dewatering	N/A	402.3	N/A		Andonaegui (2003)
	Sand Creek Mainstem	0.25	Culvert	2	75	DG		McLellan (2001)
	Sand Creek Mainstem	0.5	Culvert	DG	DG	DG	No information provided	Andonaegui (2003)
	Sand Creek Mainstem	1.25	Waterfall	5	N/A	N/A		McLellan (2001)
	Sand Creek Mainstem	1.8	Culvert	4.2	15.7	0.03		USFS Culvert Database (2002)
Lost Creek (RM 31.6)	Lost Creek Mainstem	0.16	Culvert	DG	DG	DG		POSRT (2005)
	Lost Creek Mainstem	0.92	Culvert	DG	DG	DG		POSRT (2005)
	Lost Creek Mainstem	1.41	Culvert	DG	DG	DG		POSRT (2005)
Unnamed No. 13	Unnamed No. 13 Mainstem	**0.18**	**Natural**	**>4.6**	**DG**	**DG**		**B. Fullerton, TT EC Inc., pers. Comm., 2007)**

Appendix 8. Washington Conservation Commission Salmonid Habitat Rating Criteria (Smith 2005)

Table A.8-1. Salmonid habitat rating criteria from Smith (2005).

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA/ NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS
Large Woody Debris	pieces/m channel length	≤ 4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	BFW (m)	Diameter (m)	Length (m)		
		0-5	0.4	8		
		6-10	0.55	10		
		11-15	0.65	18		
		16-20	0.7	24		

Table A.8-1. Salmonid habitat rating criteria from Smith (2005) (continued).

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	channel widths per pool	>15 m	-	-	chann width / pools/ mile / cw/ pool 50' / 26 / 4.1 75' / 23 / 3.1 100' / 18 / 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/ WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	>100 or exceeds natural rate*	-	<100 or does not exceed natural rate*	Skagit
*Note: this rate is highly variable in natural conditions						
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS

Table A.8-1. Salmonid habitat rating criteria from Smith (2005) (continued).

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
or use results from Watershed Analysis where available						
Riparian Zones						
Riparian Condition	riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) Riparian composition	Type 1-3 and untyped salmonid streams >5' wide	<75' or <50% of site potential tree height (whichever is greater) OR Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.or non-native species (<30% conifer) unless these species were dominant historically.	75'-150' or 50-100% of site potential tree height (whichever is greater) AND Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	>150' or site potential tree height (whichever is greater) AND Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP

Table A.8-1. Salmonid habitat rating criteria from Smith (2005) (continued).

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C (degree)	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
	or use results from Watershed Analysis where available					
	% impervious surface	Lowlands basin	>10%	3-10%	≤3%	Skagit

Appendix 9. POSRT (2005) Priority Subbasins and Actions

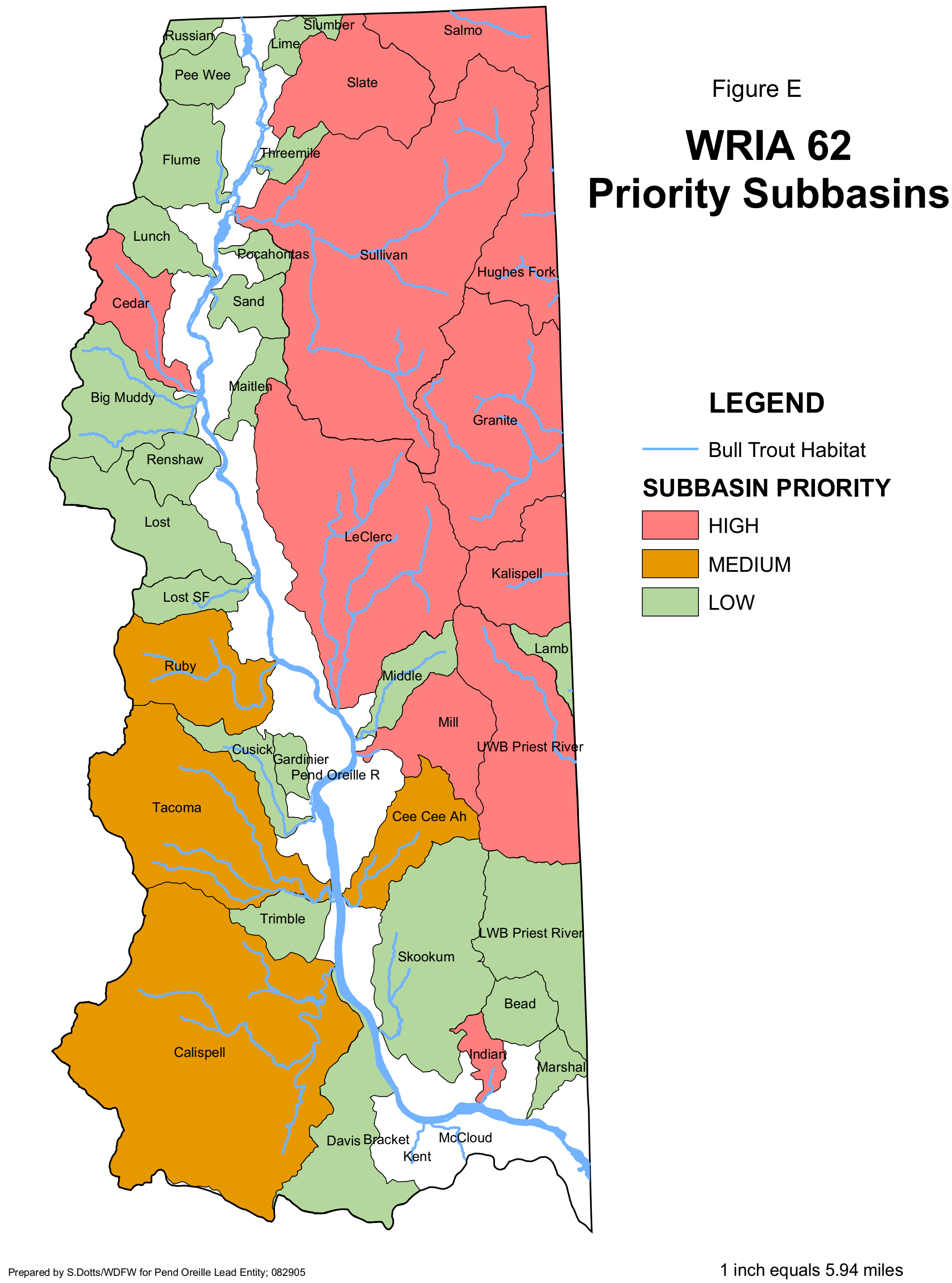

Figure A.9-1. Priorities and actions map for WRIA 62 Subbasins identified by the POSRT (2005). The figure illustrates all priorities identified in WRIA 62. Subsequent information in Appendix 9 will only focus on Boundary Reservoir tributaries.

Table A.9-1. Priorities and actions for subbasins identified as "High" priorities by the POSRT (2005) for Boundary Reservoir tributaries.

Reach[1]	Species	Habitat Type Addressed	Project Type[2]	Actions/Need	Action Priority	LF[4] Priority	Rationale	Community Support[5]	Project Status
SLATE SUBBASIN – High Priority Area #5 (Figure J)									
Slate Creek (subbasin-wide)	Bull trout (threatened) WCT	Spawning Rearing	R	Remove non-native fish species (brook, brown and rainbow trout)	1	1	Non-native brook trout hybridize with bull trout and complete for habitat and resources; non-native rainbow trout hybridize with native WCT trout and complete for habitat and resources with both WCT and bull trout. Brown trout compete for habitat and resources with both WCT and bull trout and are predators on these two species as well.	Low	Out of Scope
Slate Creek (subbasin-wide)	WCT	Migration	R	Replace or remove culverts which have been identified as fish passage barriers	2	2	These barriers prevent migration of WCT.	Moderate	See Appendix E
SULLIVAN SUBBASIN – High Priority Area #7 (Figure L)									
Sullivan Creek (RM 3.25)	Bull trout (threatened) WCT	Migration	R	Remove Mill Pond Dam and restore upstream channel to proper form and function	1	2,4	This barrier blocks access to 28 miles salmonid habitat.	Low	Unfunded
Outlet Creek (RM 0.5)	Bull trout (threatened) WCT	Migration	R	Restore fish passage at Sullivan Lake Dam	2	2	This barrier blocks access to 16 miles and 1,251 acres (Sullivan Lake) of salmonid habitat.	Moderate	Unfunded

Table A.9-1. Priorities and actions for subbasins identified as "High" priorities by the POSRT (2005) for Boundary Reservoir tributaries (continued).

Reach[1]	Species	Habitat Type Addressed	Project Type[2]	Actions/Need	Action Priority	LF[4] Priority	Rationale	Community Support[5]	Project Status
Sullivan Creek (subbasin-wide)	Bull trout (threatened) WCT	Spawning Rearing	R	Remove non-native fish species (brook, brown and rainbow trout), except kokanee	3	1	Non-native brook trout hybridize with bull trout and complete for habitat and resources; non-native rainbow trout hybridize with native WCT trout and complete for habitat and resources with both WCT and bull trout Brown trout compete for habitat and resources with both WCT and bull trout and are predators on these two species as well.. Kokanee are an important recreational fish in Sullivan Lake, which do not negatively impact bull trout populations and provide forage.	Moderate	Out of Scope
Sullivan Creek (RM 2.8-3.2) Pass Creek (RM 2.6-5.1)	Bull trout (threatened) WCT	Spawning Rearing	R	Relocate, obliterate, and/or reconstruct road segments which are contributing sediment to streams	4	6	Excessive soil input into streams can limit winter rearing and spawning habitat through the filling of pools and interstitial spaces within gravels and cobbles.	Low	Unfunded

Table A.9-1. Priorities and actions for subbasins identified as "High" priorities by the POSRT (2005) for Boundary Reservoir tributaries (continued).

Reach[1]	Species	Habitat Type Addressed	Project Type[2]	Actions/Need	Action Priority	LF[4] Priority	Rationale	Community Support[5]	Project Status
Sullivan Creek (RM 3.75-5.25)	Bull trout (threatened) WCT	Spawning Rearing	R	Install engineered log jams above Mill Pond Dam	5	3,5	This section of Sullivan Creek lacks habitat complexity, particularly in the amount of instream wood needed for cover.	Moderate	Unfunded
Sullivan Creek (RM 0-3.25)	Bull trout (threatened) WCT	Spawning Rearing	R	Stabilize slopes below Mill Pond Dam	6	3	Steep slopes with drainage problems are a periodic source of fine sediment that degrades downstream spawning and rearing habitat.	Moderate	Unfunded
Sullivan Lake (RM 0.5 of Outlet Creek)	Bull trout (threatened)	Spawning Rearing Migration	A	Determine the biological effects of current and alternative management of lake water levels on bull trout life histories above and below the dam	7	7	Existing unnatural flow regime in lower Sullivan Creek, lack of littoral area in Sullivan Lake and possibly aggradation of lower Harvey Creek are results of present hydroelectric project (i.e., Sullivan Lake Dam). This is a critical data gap.	Moderate	Unfunded
Sullivan Lake	Pygmy whitefish	Spawning Rearing	A	Assess habitat factors limiting pygmy whitefish in lake	8	7	Pygmy whitefish are a state "sensitive" species and long term viability needs to be assured to keep it from being listed under ESA. This is a critical data gap.	MIR	Unfunded

Table A.9-1. Priorities and actions for subbasins identified as "High" priorities by the POSRT (2005) for Boundary Reservoir tributaries (continued).

Reach[1]	Species	Habitat Type Addressed	Project Type[2]	Actions/Need	Action Priority	LF[4] Priority	Rationale	Community Support[5]	Project Status
Sullivan Creek (Subbasin-wide)	Bull trout (threatened) WCT	Spawning Rearing	R	Restore habitat complexity	9	3,5,6	Upper Sullivan Creek had extensive riparian harvest and wood pulled out of the steam in the 1960-70s. Lower Sullivan Creek lacks spawning material and instream wood due to interception by Mill Pond Dam. Habitat complexity must be improved to provide appropriate spawning and rearing habitat for bull trout and other salmonids.	Moderate	Partially Funded (PUD)

Notes:
1 River Miles are estimated.
2 A = Assessment Project; R = Restoration Project
3 A sequential prioritization of action/need within subbasin
4 LF = Limiting Factor
5 Values for Community Support

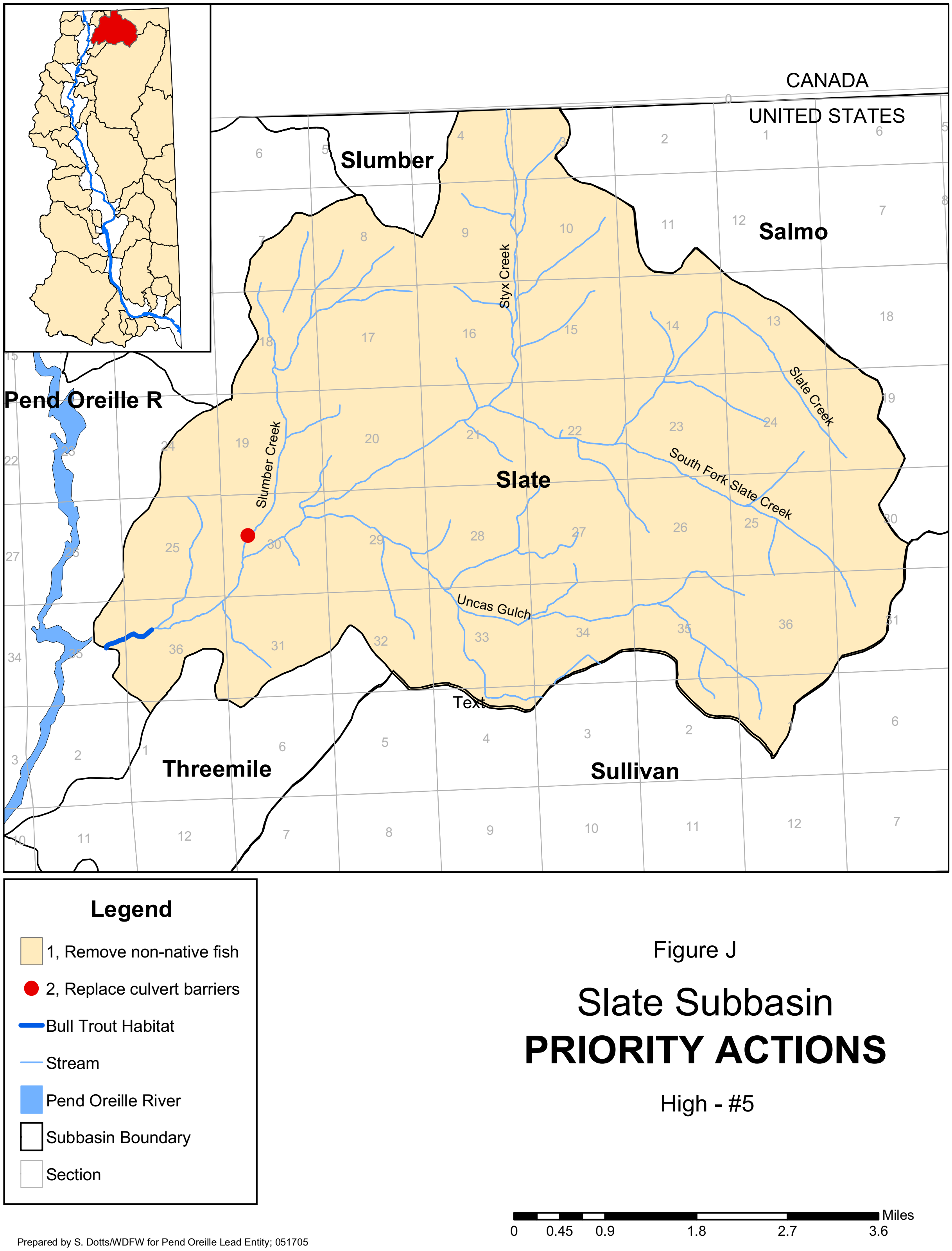

Figure A.9-2. Map of priority actions for the Slate Subbasin identified by the POSRT (2005). Priorities are documented in Table A.9-1.

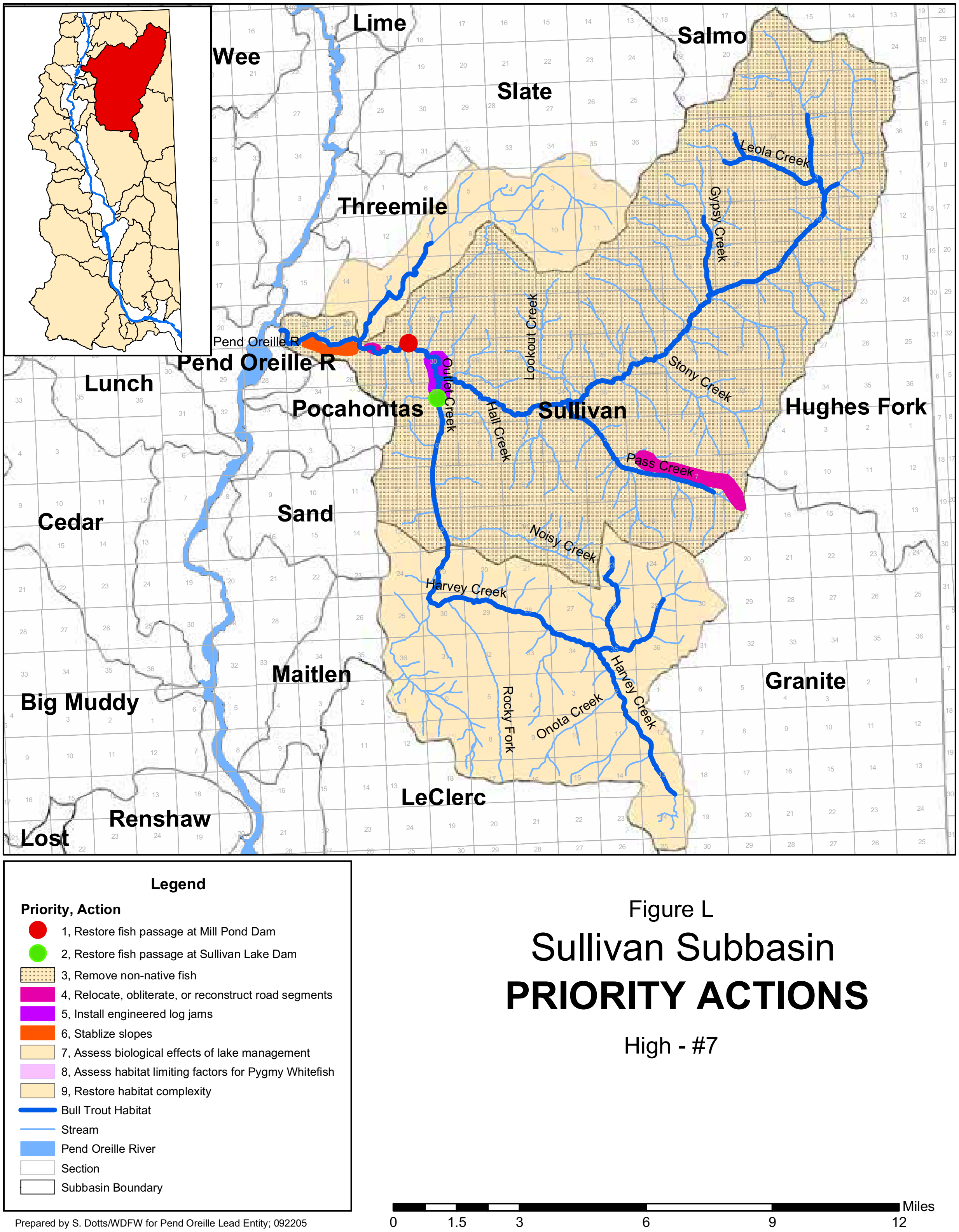

Figure A.9-3. Map of priority actions for the Slate Subbasin identified by the POSRT (2005). Priorities are documented in Table A.9-1.

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