Boundary Hydroelectric Project (FERC No. 2144)

Biological Assessment

Draft

Seattle City Light

April 2009

TABLE OF CONTENTS

List of Tables

List of Figures

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Draft
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1 INTRODUCTION

The purpose of this Draft Biological Assessment (BA) is to evaluate whether the operation of Seattle City Light's (SCL) Boundary Hydroelectric Project (FERC No. 2144) (Project), as proposed in SCL's application to the Federal Energy Regulatory Commission (FERC) for a new Project license, may affect any of the Threatened or Endangered species listed below. This BA has been prepared in accordance with legal requirements set forth under Section 7 of the Endangered Species Act (ESA) (16 U.S.C. 1536 [c]) and follows the standards established in FERC's NEPA guidance.

The Threatened and Endangered species considered in this document are listed in Table 1.0-1.

Table 1.0-1. Threatened and Endangered species in the Boundary Project Action Area addressed in this BA.

Species common name	Scientific name	Status
Bull trout	*Salvelinus confluentus*	Threatened
Canada lynx	*Lynx Canadensis*	Threatened
Grizzly bear	*Ursus arctos*	Threatened
Woodland caribou	*Rangifer tarandus caribou*	Endangered

1.1. Background

The Project, located on the Pend Oreille River in Pend Oreille County, Washington (Figure 1.1-1), was constructed in the mid 1960s and operates under an existing FERC license. The present license for the Project expires on September 30, 2011, and in accordance with FERC regulations, SCL must file its application for a new license no later than September 30, 2009. For the relicensing of the Project, SCL is using the FERC Integrated Licensing Process (ILP) to provide the framework for its consultation with agencies, tribes, and other relicensing participants during the period leading up to the filing of the License Application.

The filing of this BA fulfills one of SCL's obligations under the ILP. The BA presents SCL's assessment of the proposed Project's potential impacts on Threatened and Endangered species in the Project's Action Area, as well as the effects of relevant Conservation Measures. The filing of SCL's Preliminary Licensing Proposal (PLP), to which this BA is an attachment, presents SCL's proposed Project operations and draft non-operational Protection, Mitigation, and Enhancement (PME) measures identified through February 2009.

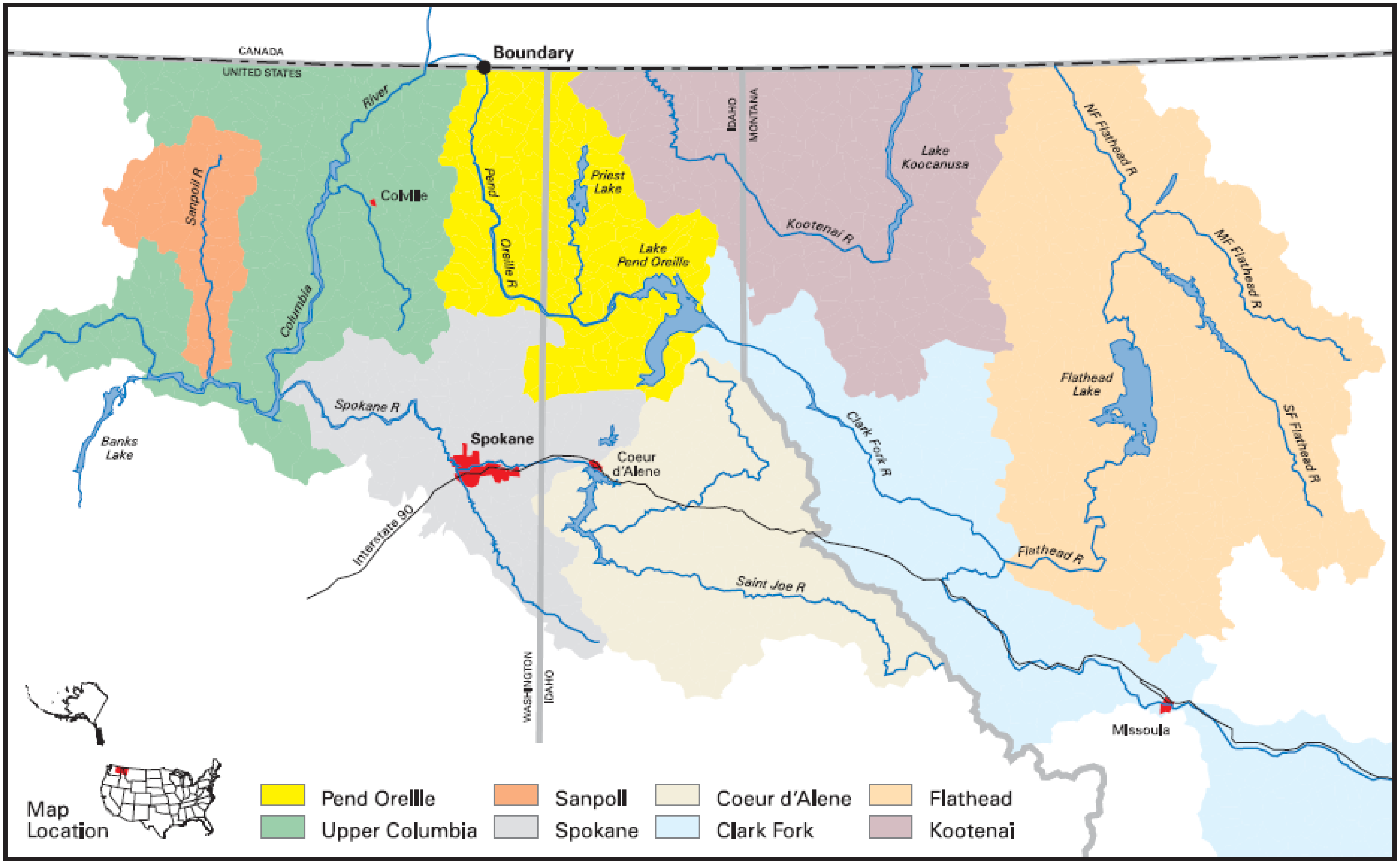


Figure 1.1-1. Pend Oreille River basin within the larger Columbia River basin.

Under the new FERC license term, SCL proposes to operate the Project as it is currently licensed, but with the formalization of two currently voluntary operational measures: forebay water surface elevation restrictions for summer recreation enhancement and turbine unit sequencing to reduce TDG production during non-spill conditions. SCL's proposed operations and nonoperational PM&Es are described in greater detail in Section 3.3 of the PLP and in Section 3 of this BA.

1.2. Project Purpose

FERC, under the authority of the Federal Power Act (FPA), may issue new licenses for a period of 30 to 50 years for the construction, operation, and maintenance of jurisdictional hydropower projects. FERC is considering the issuance of a new license to SCL for the existing Boundary Project. The purpose of the proposed action is to allow the Project to continue to provide reliable, low-cost electrical energy for the benefit of residential, industrial, and government customers, and to serve the energy needs of the region. For more information on the Project's role in supplying reliable energy to its ratepayers and the region see Section 2.2 of SCL's PLP (SCL 2009a).

In making a determination as to whether to issue a license for a hydroelectric project, FERC must conclude that the Project will be best adapted to a comprehensive plan for improving and/or developing a waterway. Beyond the power generation and developmental purposes (e.g., flood control, irrigation, water supply) for which licenses are issued, FERC must afford equal consideration to energy conservation; protection, mitigation, and enhancement of fish and wildlife, including Threatened, Endangered, and Sensitive species, and their habitat; protection and enhancement of recreational opportunities; and the overall preservation of environmental quality. In deciding whether and under what terms and conditions a new license should be issued to SCL for the Project, FERC is required to balance the relevant economic, environmental, and engineering factors pertinent to its decision.

It is anticipated that FERC's Environmental Assessment (EA) will evaluate the environmental and economic effects of the following alternatives: (1) No Action, i.e., continuing to operate the Project as it is currently licensed, with no environmental measures beyond those that already exist; (2) operating the Project consistent with operations and measures proposed by SCL; (3) operating the Project as proposed by SCL with modifications recommended by FERC staff; and 4) the "Staff Alternative with Mandatory Conditions," i.e., conditions provided by the relevant resource agencies.

2 EXISTING CONDITIONS

2.1. Site Description

The Project is located on the Pend Oreille River in northeastern Washington, one of a total of eleven hydroelectric and storage projects within the Clark Fork-Pend Oreille River basin. The dam is located 1 mile south of the U.S.-Canada border, 16 miles west of the Idaho border, 107 miles north of Spokane, and 10 miles north of Metaline Falls, in Pend Oreille County (Figure 2.1-1). The dam is located at Project River Mile (PRM) 17.0 on the Pend Oreille River, in the

NW 1/4 of Section 10, Township 40N, Range 43E, Willamette Meridian. The upstream end of the Project reservoir (Boundary Reservoir) is located immediately downstream of the Box Canyon Dam, at RM 34.5, in the NE ¼ of Section 19 of Township 38N, Range 43E. The Project, surrounding geographic features, and land ownership are shown on the general location map in Figure 2.1-2. The Project area lies within the Washington Department of Ecology's (Ecology) Watershed Inventory Resource Area (WIRA) 62 and USGS Hydrologic Unit (HUC) 17010216.

With a total drainage area of 26,260 square miles (25,090 square miles in the United States and 1,170 square miles in Canada), the Pend Oreille River is one of the two main tributaries to the Columbia River, contributing approximately 10 percent of the Columbia River's flow on an annual basis (Muckleston 2003). The Pend Oreille River is approximately 120 miles long from its head at the outlet of Lake Pend Oreille to its confluence with the Columbia River. On average, the Pend Oreille River gains about 1,300 cfs between Albeni Falls Dam and Boundary Dam, about 18 percent of that inflow coming from Sullivan Creek, the major tributary to Boundary Reservoir. However, most of the Pend Oreille River's tributaries in Washington are small streams.

Average annual flows in the Pend Oreille River for the 92-year period of record (1912-2004) were analyzed to determine historical trends in basin hydrology (SCL 2008a). The long-term average flow during this period was 26,370 cfs. Annual runoff is produced primarily by melting snow upstream of the Project, with peak flows typically occurring from April through June. A detailed report containing hydrologic statistics that describe the period--calendar years 1987 through 2005--used to characterize existing operations can be found in SCL (2008a). The report also provides a comparison of this dataset to the historic period of record (1912 to 2004).

Lands adjacent to Boundary Reservoir are owned by a mixture of public and private entities. North of Metaline Falls, the reservoir shoreline is owned by a mixture of private and federal entities, with a large portion of the eastern shoreline falling within the Colville National Forest, which is managed by the USDA Forest Service (USFS). The Bureau of Land Management (BLM), Spokane District, manages a large area along the western shoreline. The portion of the reservoir shoreline south of Metaline Falls is predominantly in private ownership, with some USFS-managed land along the eastern shoreline. Because of the steeply sloping topography and large amount of public land in the Project vicinity, much of the land is undeveloped, with more than two-thirds of the area currently consisting of forested open space.

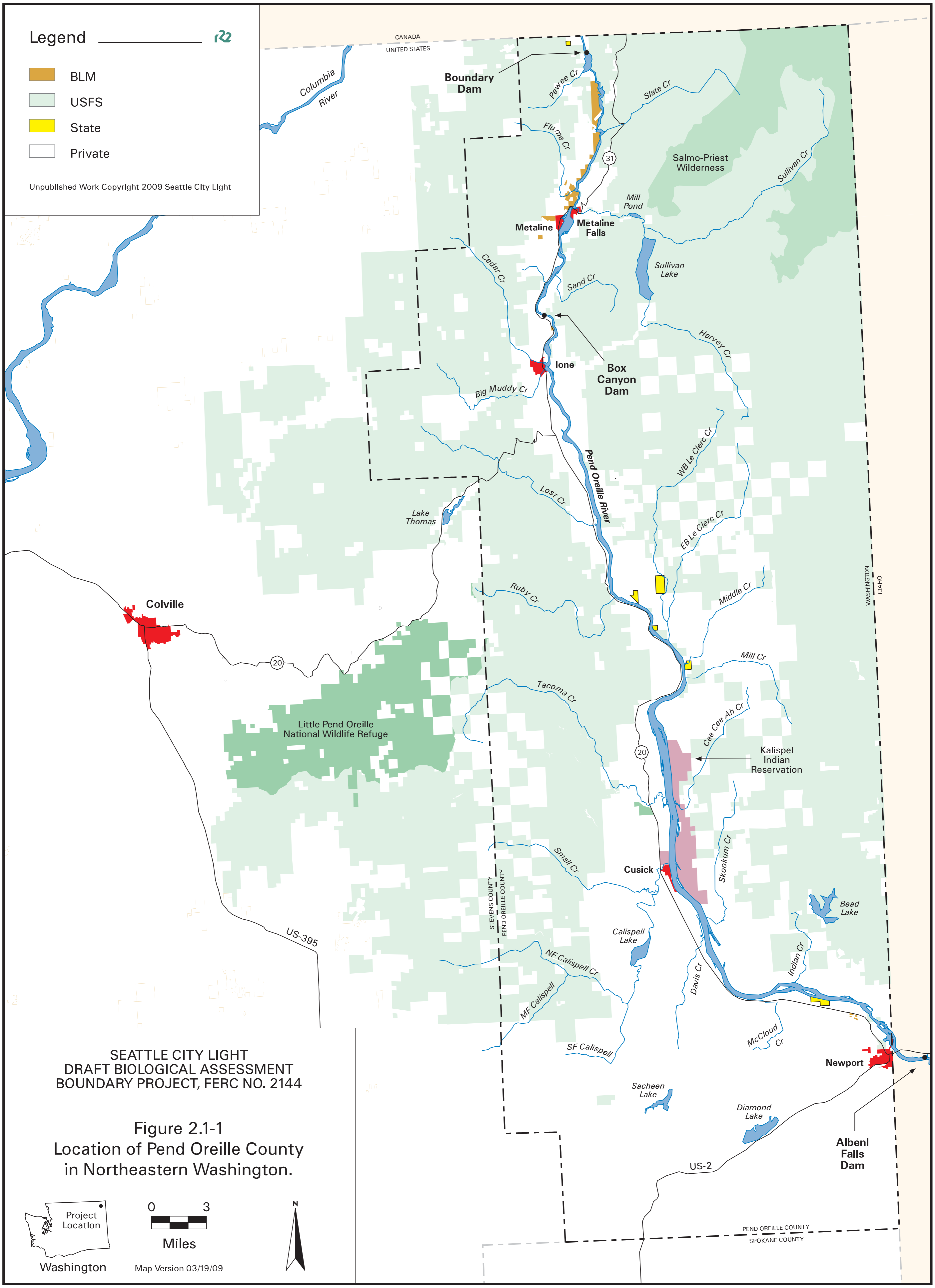


Figure 2.1-1
Location of Pend Oreille County in Northeastern Washington.

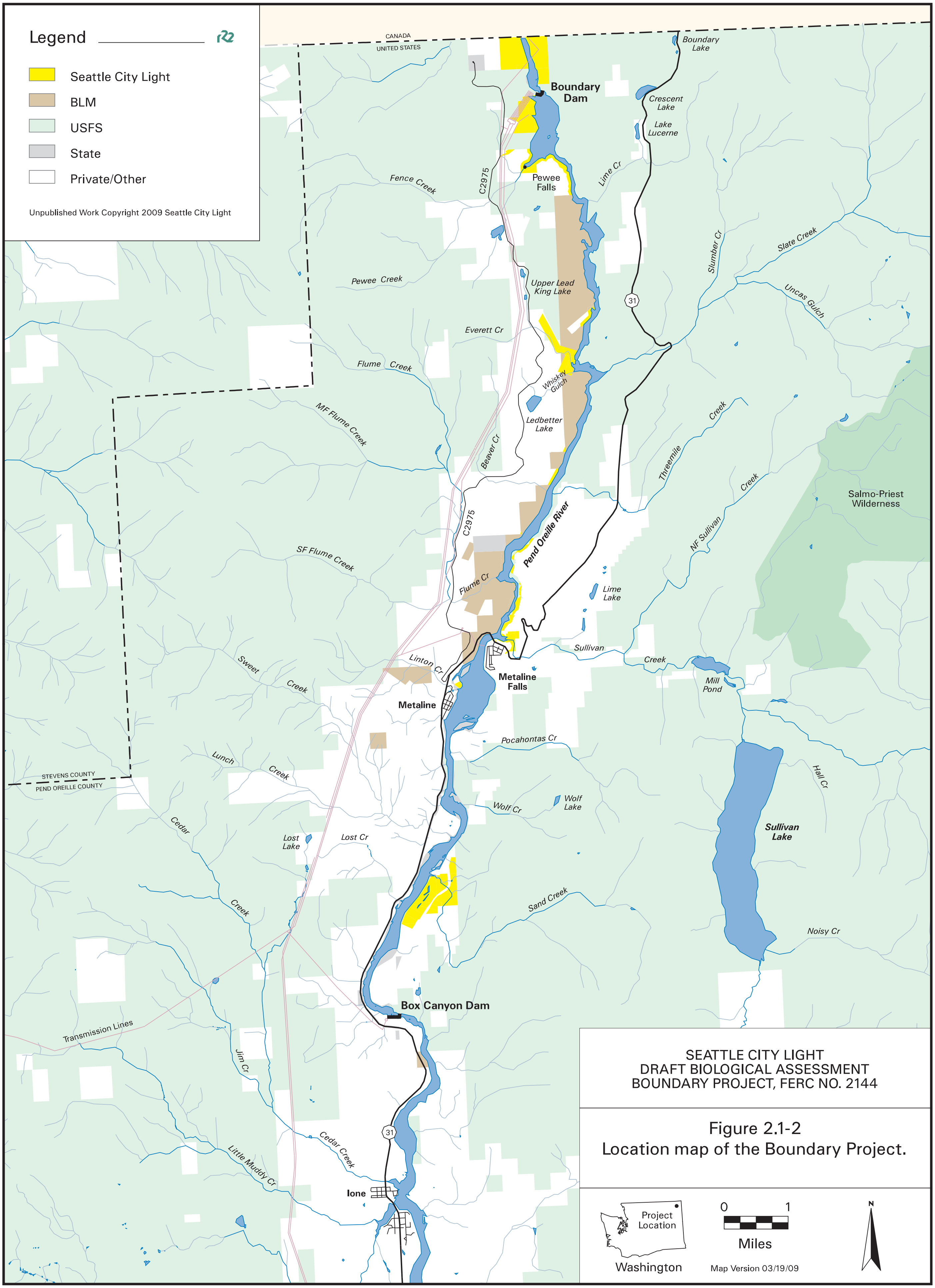


Figure 2.1-2
Location map of the Boundary Project.

Boundary Dam, which is situated in a narrow canyon and founded on inter-bedded limestone and dolomite of the Metaline Limestone formation, is a variable-radius concrete arch dam with a total height of 360 feet above the lowest part of the foundation and a structural height of 340 feet. The dam varies in thickness from 8 feet at its crest to 32 feet at its base, has a crest length of 508 feet, and has a total length, including the spillways, of 740 feet. The dam impounds the Pend Oreille River to a normal high water surface elevation of 1,994 feet North American Vertical Datum (NAVD 88), as measured in the forebay. The average elevation of the river surface below the dam is at approximately 1,733 feet NAVD 88; the reservoir provides approximately 261 feet of gross head for power purposes. Greater detail regarding the Boundary Project, its facilities, and operation can be found in SCL's PLP (SCL 2009a).

At its normal maximum pool elevation (1,994 feet NAVD 88), the 17.5-mile-long Boundary Reservoir has a surface area of approximately 1,790 acres, a shoreline length of roughly 46 miles, and a maximum depth in the forebay of approximately 270 feet. The reservoir's gross storage capacity is approximately 87,913 acre-feet (elevation 1,744 NAVD 88 to elevation 1,994 NAVD 88), and its usable storage capacity is approximately 40,843 acre-feet (elevation 1,954 feet NAVD 88 to elevation 1,994 feet NAVD 88). Because of the large amount of water flowing through the system and the limited amount of storage capacity in the reservoir, the residence time of the reservoir is very short. Maximum residence time is less than four days, but more typically the residence time is less than two days (Pickett 2004).

Metaline Falls is a geological feature that geographically divides the reservoir into two distinct reaches: an upstream reach that extends from Box Canyon Dam to Metaline Falls and a downstream reach that extends from Metaline Falls to Boundary Dam. The Pend Oreille River passes through a bedrock-controlled constriction located at Metaline Falls (elevation 1,974.6 feet NAVD 88). Gradient and depth of the upstream reach are much less than those of the downstream reach. Depths in the upstream reach typically range from 10 to 25 feet.

The reservoir has been delineated into four reaches based on habitat characteristics: the Forebay Reach (PRM 17.0 – 19.4), the Canyon Reach (PRM 19.4 – 26.8), the Upper Reservoir Reach (PRM 26.8 – 34.5), and the Tailrace/Seven Mile Reservoir Reach (PRM 13.1 – 17.0). The Forebay Reach is wide and deep, with steep-walled banks and maximum water depths to approximately 270 feet. The Canyon Reach is predominantly narrow with steep, rock walls. The Upper Reservoir Reach is relatively wide, with depths from 10 to 25 feet. The Tailrace Reach is characterized by deep pools (> 75 ft) in the spillway and turbine afterbays but is generally less than 30 ft deep. At low Seven Mile Reservoir water surface elevations, riverine habitat is present in the Tailrace Reach downstream to the confluence with Red Bird Creek. At high Seven Mile Reservoir water surface elevations, the riverine habitat above the Red Bird Creek confluence becomes reservoir habitat. Greater detail regarding the physical habitat and aquatic resources in the Project area can be found in SCL's Pre-Application Document (PAD) (SCL 2006) and Updated Study Report (USR) (SCL 2009b).

Summer water temperatures in Boundary Reservoir at times exceed 20 ˚C (68 ˚F), which is too warm to provide optimum summer habitat for native trout species (i.e., generally less than 16 ˚C [61˚F], Bjornn and Reiser 1991). Phosphorous and nitrogen concentrations are low throughout the year, and phytoplankton chlorophyll *a* concentrations (at times < 2.8 µg/l) indicate that the system is oligotrophic. The zooplankton community is limited by food availability in the reservoir, which is controlled to a large degree by phytoplankton entrained in the inflow from Box Canyon Reservoir.

At least 28 species of fish occur in the Project area (SCL 2009a). Although anadromous fish are not found in Boundary Reservoir, some fish species (e.g., bull trout) potentially found in the reservoir can have adfluvial life histories. Densities of all fish species are low in deep water within the reservoir, most of which occurs in the Forebay and Canyon reaches. The Forebay Reach fish community is dominated by largescale sucker, northern pikeminnow, peamouth, yellow perch, and smallmouth bass. Hatchery-reared rainbow trout are commonly observed, cutthroat trout are rarely found, and no bull trout have been captured or observed. The Canyon Reach is dominated by northern pikeminnow, largescale sucker, redside shiner, and peamouth. Smallmouth bass and yellow perch are abundant, and hatchery-reared rainbow trout are commonly observed. Bull trout have been captured near the mouth of Slate Creek in this reach (see Section 2.3 of this BA). Based on the Shannon-Weiner diversity index (Ricklefs 1979), fish species diversity is higher in the Upper Reservoir Reach (SWI 2.08) than downstream of Metaline Falls (SWI ranges from 1.55 to 1.87), likely as the result of increased habitat diversity. The fish community in the Upper Reservoir Reach is also dominated by minnows and suckers, although mountain whitefish are found in greater abundance than below Metaline Falls.

The fish community in the Tailrace Reach is dominated by northern pikeminnow, largescale sucker, redside shiner, and peamouth. Smallmouth bass is the most abundant sport fish species. Mountain whitefish and both wild and hatchery-reared rainbow trout are commonly observed. In the past, bull trout rarely have been captured. Three bull trout were captured in the Boundary Dam tailrace during 2007 - 2008 as part of fisheries studies conducted by SCL, and a fourth bull trout, radio-tagged as part of BC Hydro's Salmo River bull trout telemetry study, was detected by a receiver in the Boundary Dam tailrace in 2008 (SCL 2009b). Two of the bull trout captured in the tailrace were large enough to radio-tag (SCL 2009b). Genetics analysis confirmed that two of the captured bull trout had originated in tributaries to Lake Pend Oreille and one had originated in the Salmo River (P. DeHaan, USFWS, personal communication, November 14, 2007 and January 12, 2009).

The dominant vegetation cover in the study area is mixed coniferous forests of Douglas-fir, western red cedar, and western hemlock (Franklin and Dyrness 1988), growing on moderately steep slopes of rocky, well-drained soils. Most of the area surrounding the Project is forested, with both dry and moist mixed coniferous forests present, although the moist type is dominant. Harvested stands, including clear cuts and selective cuts harvested since the mid 1970s, comprise 24 percent of the land within the study area and contain a species composition similar to forested lands. Other vegetation and cover types include shrub- and grass-dominated areas, sparsely vegetated rock outcrops, and some wetlands. For greater detail regarding the vegetation communities, see SCL's PLP (2009a) and USR (2009b).

Of the total of 308 terrestrial vertebrate wildlife species that potentially occur in the area surrounding the Project, 152 species were confirmed during relicensing studies (SCL 2006, SCL 2009b). Species present represent all major groups of terrestrial vertebrates (i.e., mammals, birds, reptiles, and amphibians). Threatened and Endangered wildlife species that could occur within the study area include Canada lynx, grizzly bear, and woodland caribou.

2.2. Action Areas

2.2.1. Aquatic Action Area

For aquatic species, the Action Area extends from the Canada Border, which is located 1.0 mile downstream of Boundary Dam in Seven Mile Reservoir, British Columbia, upstream to the FERC Project boundary located just downstream of Box Canyon Dam.

2.2.2. Terrestrial Action Area

For terrestrial threatened and endangered species, the Action Area includes the entire area within the FERC Project boundary (Project area). Information on terrestrial threatened and endangered species (TES) was obtained primarily from the RTE Wildlife Species Study (RTE Wildlife Study) Final Report (SCL 2009b) and incidental observations during other field studies. The study area described in the final report extends beyond the range of the Project's influence. This study area, referred to in this document as the Project vicinity, is described below:

- *Downstream of Metaline Falls* – The reservoir, fluctuation zone allowed under the current license (as defined in the RTE Wildlife Study) and land within the FERC Project boundary (Project area), which includes most Project facilities, the area 200 horizontal feet (i.e., perpendicular to the shoreline) beyond the high water level along both reservoir shorelines, and the transmission line right-of-way from the powerhouse to the BPA interconnection.
- *Upstream of Metaline Falls* – The reservoir, fluctuation zone (approximately 1,986 – 2,020 feet NAVD 88, as measured at the USGS gage below Box Canyon Dam), and the land within approximately 200 horizontal feet above the high water level (approximately 2,020 feet NAVD 88) along both reservoir shorelines extending to the FERC Project boundary for the Box Canyon Project.
- The BWP (155 acres) and adjoining SCL-owned property (88 acres).
- 100 horizontal feet along both sides of the river from Boundary Dam to the U.S.-Canadian border (approximately 0.9 mile).
- 50 feet along both sides of Project-related roads, which include the road between the Boundary Dam and the Vista House, the road to the dam off County Road 2975, and the road from the Vista House to SR 31.

2.3. Aquatic Species

Currently there are no bull trout (*Salvelinus confluentus*) spawning populations in the Action Area (Pend Oreille RM 17.0 to RM 34.5), but individual bull trout are occasionally observed. Bull trout in the Action Area are within the Pend Oreille Core Area of the Northeast Washington Unit (NWU) of the Columbia River Distinct Population Segment (DPS) (Table 2.3-1). The available information suggests there are two, and perhaps four, populations of bull trout in tributaries to the Pend Oreille River, but only one of them (LeClerc Creek, a tributary to Box Canyon Reservoir) is within the Pend Oreille Core Area. The Salmo River located in British Columbia at RM 12.7 and the Priest River at RM 95.2 are both known to sustain reproducing bull trout populations. LeClerc Creek is suspected of having a small self-reproducing population of bull trout, but its status is unknown (Scholz et al. 2005). Five juvenile bull trout have been observed in Nine Mile Creek, which drains into Seven Mile Reservoir in British Columbia, but additional monitoring is needed to determine if a self-reproducing population is present there. Although LeClerc Creek is located in the Pend Oreille Core Area, the Salmo River and Nine Mile Creek are located downstream and the Priest River is located upstream of the core area.

Table 2.3-1. Threatened fish species that occur in the vicinity of the Boundary Hydroelectric Project.

Species	Scientific Name	Designated ESU/DPS	Federal Status	Listing History
Bull Trout	*Salvelinus confluentus*	Columbia River DPS	Threatened	Listed as Threatened on November 1, 1999.

Tributaries that drain into Boundary Reservoir with particular pertinence to bull trout include Sullivan Creek (RM 27.9), Slate Creek (RM 23.1), and Sweet Creek (RM 32). There are also 12 other named tributaries and 13 unnamed tributaries that drain into the Boundary Reservoir. Adfluvial fish habitat is severely limited in tributaries draining into Boundary Reservoir because of stream size and the presence of natural passage barriers at or near the mouths of the tributaries (Table 2.3-2). Sullivan Creek is the largest tributary, with a drainage area of 142.5 square miles. Two potential natural fish barriers occur at RM 0.60 and RM 0.65 on lower Sullivan Creek. Surveys of these two potential barriers by CES (1996) resulted in the conclusion that while the barriers would be extremely difficult to ascend, passage at some flow levels could not be ruled out. A recent study by a regionally recognized expert in salmonid fish passage concluded that the series of cascades and chutes in Sullivan Creek under low flow (99 cfs) conditions would be passable by bull trout 18 inches (457 mm) or larger, but at high flows (1,528 cfs) the falls is a complete barrier (Powers 2008). Turbulence makes passage difficult at flows higher than 300 to 500 cfs. In addition, the dam at Mill Pond, located 3.25 miles from the mouth of Sullivan Creek, does not include any fish passage facilities and is a complete barrier to upstream fish passage. The dam at the outlet of Sullivan Lake on Outlet Creek is also a complete barrier to upstream fish passage. Slate Creek has a drainage area of about 32.3 square miles and includes about 3,474 linear feet of adfluvial habitat downstream of a waterfall 19.7 feet in height (McLellan 2001). The Sweet Creek\Lunch Creek drainage has an area of about 11.1 square miles and a series of three waterfalls that limit potential adfluvial habitat to about 2,659 feet. The remaining tributaries average 2.6 square miles in size with a range up to 19.3 square miles.

In the final rule designating critical habitat for bull trout (70 FR 56212), the USFWS identified short sections of lower Slate Creek and Sullivan Creek as critical habitat. All impoundments behind dams that have a primary purpose of providing flood control, energy production, or water supply for human consumption were excluded from designation as critical habitat because disruption of these functions could adversely affect human health and safety or would be inconsistent with the President's energy policy at the time of designation (70 FR 56212).

Consequently, Boundary Reservoir is not considered critical habitat for bull trout. Except for very small reaches near the mouths, Slate and Sullivan creeks are located on National Forest System lands.

Few bull trout have been observed in the Action Area since the early 1980s (Table 2.3-3). Within Sullivan Creek, the one documented bull trout observed was gutted (McLellan 2001), indicating it had been captured by an angler, but it is unknown if the fish was captured in Sullivan Creek or caught somewhere else and discarded there by the angler. Another unidentified char was also observed in Sullivan Creek by snorkelers, but they were unable to confirm its identity (Fish Distribution, Timing, and Abundance Study Final Report, SCL 2009b). Three bull trout have been captured within or near the mouth of Sweet Creek (Lembcke 2001; McLellan 2001). Fyke nets were deployed just upstream of the mouths of both Sullivan Creek and Sweet Creek during 2007 and 2008, but failed to capture any bull trout (SCL 2009b). Three bull trout were captured in the Boundary Dam tailrace during 2007 - 2008 as part of fisheries studies conducted by SCL, and a fourth bull trout, radio-tagged as part of BC Hydro's Salmo River bull trout telemetry study, was detected by a receiver in the Boundary Dam tailrace in 2008 (SCL 2009b). Two of the bull trout captured in the tailrace were large enough to radio-tag (SCL 2009b). Genetics analysis confirmed that two of the captured bull trout had originated in tributaries to Lake Pend Oreille and one had originated in the Salmo River (P. DeHaan, USFWS, personal communication, November 14, 2007 and January 12, 2009).

No bull trout have been observed within Slate Creek despite numerous surveys (McLellan 2001; CES 1996; R2 Resource Consultants 1998a; Terrapin Environmental 2000). However, bull trout have been observed on several occasions in Boundary Reservoir near the mouth of Slate Creek, and R2 Resource Consultants (1998a) suggested that Slate Creek outflow provides a cold-water refuge for bull trout in the reservoir. The USFS reported that several bull trout were captured near the outlet of Slate Creek in 1994 and 1995 using hook and line (USFS 1998; FERC 2004; T. Shuhda, USFS Fisheries Biologist, personal communication, April 2005). In addition, a single bull trout was captured twice in 1997 near the outlet of Slate Creek using a trap (R2 Resource Consultants 1998a) and one bull trout was captured in 1999 (FERC 2004). During 1999 a weir designed to capture both upstream- and downstream-moving fish was deployed 150 feet upstream of the creek’s mouth between August 19 and November 11, but no bull trout were captured (Terrapin Environmental 2000). Fyke nets deployed during 2007 and 2008 also failed to capture any bull trout (Fish Distribution, Timing, and Abundance Study Final Report, SCL 2009b).

Table 2.3-2. Descriptive statistics for tributaries to Boundary Reservoir.

Stream name	Project river mile	Basin area (mi^2)	Adfluvial habitat length (ft)	2000		2007		2008		Sport fish present[1]
				Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)	Date	
Unnamed No. 1	17.2	0.61	82			0.1	9/6	0.1	9/22	
Peewee Creek	17.9	10.37	0	0.4	09/25	2[2]	9/6	2[2]	9/22	CTT, EBT
Unnamed No. 2	17.9	0.02	129			0.004	9/6	Dry	9/22	
Lime Creek	19.45	2.93	6,746	2.8	09/26	2.7	9/6	0.5	9/22	EBT
Everett Creek	21.9	2.18	60			0.3	9/6	2	9/22	
Whiskey Gulch	21.9	0.70	547			Dry	9/6	Dry	9/22	
Slate Creek	22.2	32.33	3,474	10.9	07/31	6.8	9/6	8.3	9/22	CTT, EBT, RBT
Beaver Creek	24.3	1.77	0			0.9	9/7	3	9/22	
Threemile Creek	24.3	4.91	0			0.5	9/7	2	9/22	EBT, RBT
Unnamed No. 3	25.4	0.15	58			0.04	9/7	Dry	9/22	
Flume Creek	25.8	19.33	1,056[3]	8.8	09/06	5.0	9/7	6.6	9/5	EBT
Sullivan Creek	26.9	142.46	21,729	77.7	08/16	40.5	9/10	59.5	9/5	BBT, BRT, CTT, EBT, KOK, MWF, RBT
Unnamed No. 4	27.1	0.08	77			--[4]	--[4]	--	--	
Linton Creek	28.1	2.11	19,159			1.9	9/8	1.8	9/6	
Unnamed No. 5	28.9	0.62	130			0.1	9/8	--	--	
Unnamed No. 6	29.2	0.01	955			Dry	9/11	--	--	
Pocahontas Creek	29.4	3.92	16,480			Dry	9/9	Dry	9/22	
Unnamed No. 7	29.6	0.30	53			Dry	9/11	--	--	
Unnamed No. 8	30.1	0.07	66			Dry	9/11	--	--	
Wolf Creek	30.3	1.57	236			Dry	9/11	--	--	
Sweet Creek / Lunch Creek	30.9	11.12	2,6593	5.3	09/11	2.5	9/11	2.8	9/5	BRT, CTT, EBT, MWF, RBT
Unnamed No. 9	31.1	0.04	67			Dry	9/11	Dry	9/22	
Sand Creek	31.7	8.22	1,3203	0.4	09/07	Dry	9/11	Dry	9/22	CTT, EBT, RBT
Lost Creek	32.2	1.20	165			0.03	9/12	1.4	9/23	CTT
Unnamed No. 10	33.5	0.93	99			0.001	9/12	0.3	9/23	
Unnamed No. 11	33.6	0.23	78			0.002	9/12	Dry	9/23	
Unnamed No. 12	34.0	0.93	<100			0.06	9/12	0.5	9/23	
Unnamed No. 13	34.3	1.72	<100			0.4	9/12	1.5	9/23	

Notes:

1. Blanks = non-fish-bearing or unsurveyed streams: EBT, eastern brook trout; CTT, cutthroat trout; RBT, rainbow trout; MWF, mountain whitefish; BLT, bull trout; KOK, kokanee; BBT, burbot; sources: USFS (2005); McLellan (2001); FERC (1998).
2 Flow rate at the base of Pewee Falls was visually estimated.
3. Adfluvial habitat based on distance from stream mouth to lowermost migration barrier reported in McLellan (2001) and/or Andonaegui (2003).
4. No tributary channel could be found in September 2007.

cfs – cubic feet per second

-- no data collected

Table 2.3-3. Observations of bull trout in Boundary reservoir, Boundary Dam tailrace, and tributaries to Boundary reservoir, 1980 to 2008.

Location	No. of Fish	Size (mm)	Month and Year	Genetic Testing[1]	Comment	Source
Mouth of Sweet Cr	1	508	Fall 1980, 81 or 82	U		Andonaegui (2003)
Sweet Cr	1	864	Fall 1980, 81 or 82	U	Dead	Andonaegui (2003)
Sullivan Cr below falls	1		1993	U	Char species ID not verified	Andonaegui (2003)
Boundary Reservoir at mouth of Slate Cr	2		1994	U		Andonaegui (2003)
Boundary Reservoir at mouth of Slate Cr	3	432-483	1995	U		Andonaegui (2003)
Sweet Cr below Falls	1	300	Sept 2000	N		McLellan (2001)
Sullivan Cr	1	757	Sept 1993	N	Gutted carcass	CES (1996)
Boundary Reservoir at mouth of Slate Cr	1	218	Aug and Nov 1997	N	This fish caught twice	R2 (1998a)
Boundary Reservoir at mouth of Slate Cr	2	457, 508	Aug 1999	N		Terrapin (2000)
Boundary Tailrace	1	285	June 2007	Y	Population Source: Salmo R.	SCL (2009)
Sullivan Cr	1		Sept 2007	N	Char species ID not confirmed	SCL (2009)
Boundary Reservoir	1		April 2008	Y	bull/brook hybrid	SCL (2009)
Boundary Reservoir	1	305	Aug 2008	N	Char species ID not confirmed	SCL (2009)
Boundary Tailrace	2	248, 530	Nov/Dec 2008	Y	Population Source: Tributaries to Lake Pend Oreille	SCL (2009)
Boundary Tailrace	1[2]		Dec 2008	NA	Population Source: Salmo River	SCL (2009)

Notes:
1. U: Unknown, but unlikely that genetic testing occurred; N: No genetic testing occurred; Y: genetic testing occurred.
2. Radio-tagged individual detected by a receiver in the Boundary Dam tailrace.

Currently, adfluvial bull trout may use the Pend Oreille River on a seasonal basis, but water temperatures are too warm during the summer for continuous use. Water temperatures in Boundary Reservoir are cold in the winter and warm in the summer (Figure 2.3-1). The range of water temperature recorded at 15 minute intervals between May 2007 and September 2008 was 3.3 to 25.2 ˚C and averaged 13.9 ˚C. Although it does not occur every year, the Forebay Reach was observed to ice-over for a period during the winters of 2007 and 2008. Water temperatures in the Action Area exceed 20 ˚C every year and at times exceed 24 ˚C. Temperatures in excess of 20 ˚C commonly occur during the months of July through September (Water Quality Constituent and Productivity Monitoring Final Report, SCL 2009b). Vertical profiles of water temperature taken monthly at seven locations in Boundary Reservoir suggested it is vertically mixed. Water temperature modeling (CE-QUAL-W2) conducted as part of application for Clean Water Act, Section 401 certification and the Interstate (Idaho and Washington) Temperature Total Maximum Daily Load (TMDL) process demonstrated that water temperatures in Boundary Reservoir under existing conditions are similar to what they would be under natural conditions (see Section 5.3.2 of the PLP for greater detail regarding the results of temperature modeling).

Observations of bull trout near Albeni Falls Dam (Geist et al. 2004, Dupont and Horner 2003), cutthroat trout, mountain whitefish, and triploid rainbow trout in Boundary Reservoir (SCL 2009b), and brown trout in Box Canyon Reservoir (Garrett and Bennett 1995) suggest that salmonids use thermal refugia when mainstem river temperatures begin to exceed 18 ˚C. Bull trout were captured and observed via snorkeling below Albeni Falls near a culvert that provided a thermal refuge (Geist et al. 2004). Geist et al. (2004) reported at the time of capture that river temperatures ranged from 18.0 to 23.1 ˚C, while the plume created by inflow from the culvert ranged from 11.8 to 15.0 ˚C, depending on the day and depth.

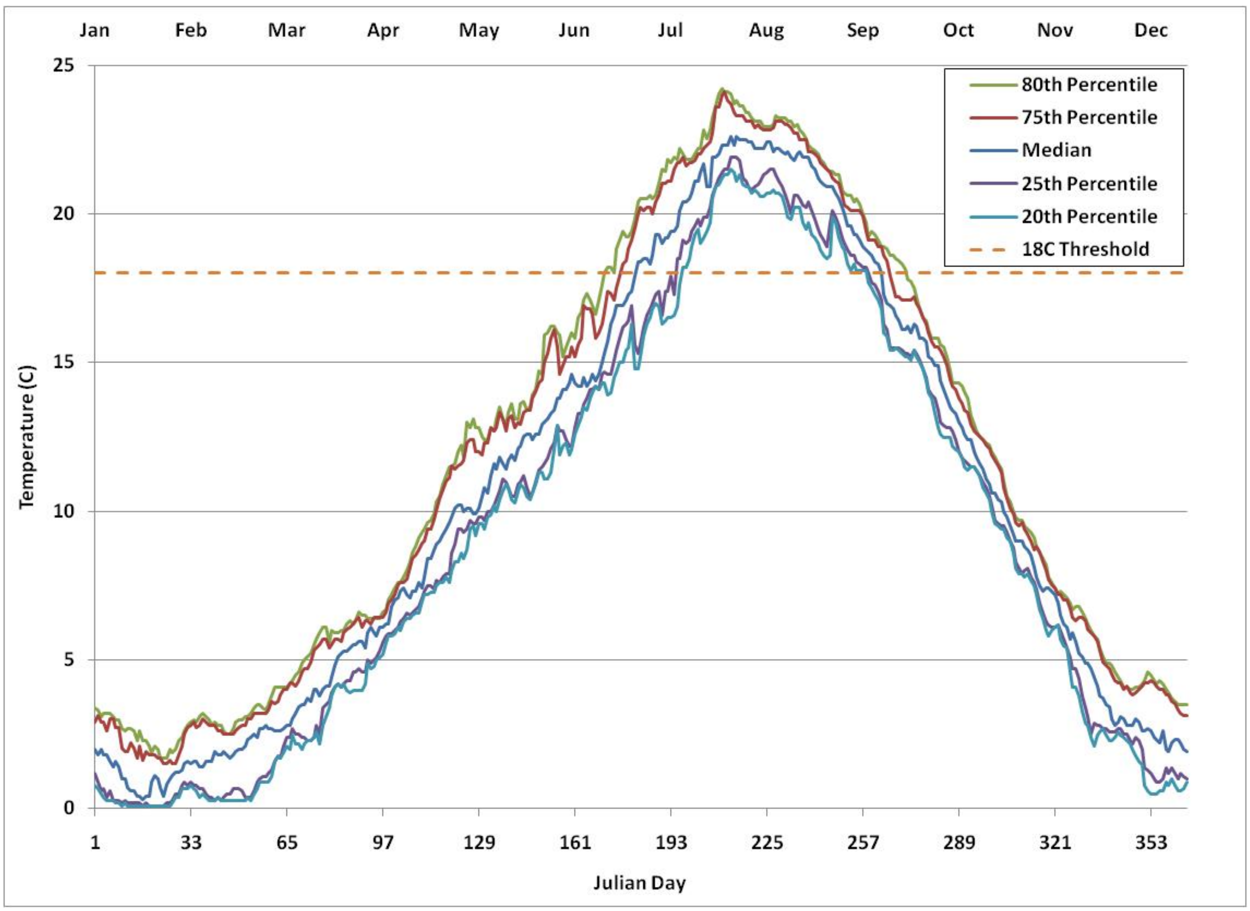


Figure 2.3-1. Median, 75th, and 80th percentile of average daily temperature at USGS gage 12398600 located at the international boundary for water years 1974 through 2007.

Seasonal use of the Pend Oreille River by bull trout is evident from the studies completed by DuPont and Horner (2003), Geist et al. (2004), and Scholz et al. (2005), but use patterns throughout the year are uncertain, particularly in Boundary Reservoir where few bull trout have been observed and none has been tracked using biotelemetry. Few bull trout currently use the mainstem Pend Oreille River downstream of Albeni Falls for rearing, and it is possible that the bull trout observed in the mainstem river may originate in the Priest River, Lake Pend Oreille, or their tributaries (Scholz et al. 2005). Scholz et al. (2005) reported that two radio-tagged bull trout captured downstream of Albeni Falls Dam and released above the dam moved rapidly into Lake Pend Oreille. In addition six of the seven radio-tagged bull trout tracked in 2003 below Albeni Falls Dam moved upstream towards the dam (Geist et al. 2004). Scholz et al. (2005) suggested it was reasonable to assume that bull trout were historically present in the Box Canyon reach and that local tributaries contributed at least some of them. The degree to which tributaries above or below Albeni Falls Dam historically contributed to bull trout use in the mainstem Pend Oreille River downstream of Albeni Falls is unknown. Regardless of their source, bull trout numbers declined rapidly after construction of Albeni Falls Dam in 1952 (USFWS 2000).

Bull trout mature at five to six years during spawning migrations to their natal streams (Scholz et al. 2005). Bull trout are iteroparous and repeat spawning annually or in alternate years. In the Salmo River, which has its confluence with the Pend Oreille River at RM 12.7 (approximately 4.3 miles downstream of Boundary Dam), bull trout spawning migrations initiate during late July and early August, spawning peaks during early September, and post-spawning migration to overwintering habitat is completed by the end of November (Baxter and Nellestijn 2000). Baxter and Nellestijn (2000) consider the Salmo River bull trout population to have a primarily fluvial life history pattern. However, a few bull trout from the Salmo River are known to enter Seven Mile Reservoir, including one that was captured, and another that was detected via telemetry, in the Boundary Tailrace during 2008. Consequently, some remnants of an adfluvial life history pattern may still be present in the population. Spawning sites are characterized by low-gradient, uniform flow, and a gravel substrate between 0.6 and 5 centimeters in diameter (Wydoski and Whitney 2003; Fraley and Shepard 1989). Groundwater influence and proximity to cover are also reported as important factors in spawning site selection (Fraley and Shepard 1989). Studies conducted throughout the species' range indicate that spawning occurs in water from 0.75 to 2.0 feet deep (Wydoski and Whitney 2003; Fraley and Shepard 1989) and often occurs in reaches fed by streams, or near other sources of cold groundwater (Pratt 1992).

Bull trout require a long period of time from egg deposition until emergence. Rieman and McIntyre (1993) indicate that optimum incubation temperatures are between 2 and 4 ºC. The alevins remain in the streambed, absorbing the yolk sac, for an additional 65 to 90 days after hatching (Pratt 1992). Emergence from the streambed occurs in late winter/early spring (Pratt 1992). High levels of fine sediment in spawning substrates reduce embryo survival, but the extent to which they affect bull trout populations is not entirely known (Rieman and McIntyre 1993). Long over-winter incubation periods for native char embryos and alevins make them particularly vulnerable to increases in fine sediments (USFWS 1998).

Scholz et al. (2005) summarized the available information on juvenile bull trout migratory behavior. They concluded that most migratory bull trout outmigrate at age 2 to 3 and at a size of 170 to 300 millimeters (6.7 - 11.8 inches). The juvenile outmigration from tributaries to Lake

Pend Oreille peaked during May, but information from the other areas (i.e., Flathead River, Metolius River, Mill Creek) showed that some juveniles also outmigrate in early to late summer.

Bull trout are typically thought to occur in steeper gradient, more upstream stream reaches than other salmonid species. Adult bull trout can navigate waterfalls and cascades that impede upstream migration of other species. Rather than exhibiting unusual leaping abilities, bull trout have been observed to seek out channel margins and bypass falls during high flow events or to burrow through logjams to ascend to upstream reaches. Bull trout can also exhibit a patchy distribution, where they are not found in all tributaries or reaches within a watershed (Watson and Hillman 1997; Baxter 1995). Bull trout may occur in greater densities in upstream, typically higher gradient reaches, avoiding higher water temperatures in downstream reaches, and possibly an inability to compete effectively against other salmonid species (Stolz and Schnell 1991).

The Washington Department of Fish and Wildlife (WDFW) lists the following as limiting factors for bull trout: stream temperatures that exceed the normal spawning and incubation temperature range, lack of spawning and rearing habitat, and a high percentage of fine sediment in spawning gravels (WDFW 1998). Because of their close association with the bottom, native char are sensitive to changes in the streambed (Fraley and Shepard 1989; USFWS 1998). Bull trout readily interbreed with non-native brook trout *(Salvelinus fontinalis).* Brook trout may also exclude bull trout from native habitats (USFWS 1998). Finally, bull trout are easily caught and highly susceptible to fishing pressure; therefore, any increase in the accessibility of a population to fishing pressure may negatively impact a population (Fraley and Shepard 1989; USFWS 1998).

The Northeast Washington Unit (NWU) Recovery Team for bull trout has designated the Pend Oreille River and its tributaries from Albeni Falls Dam to the United States – Canadian Border as a core area. To develop recovery criteria, the NWU Recovery Team used professional judgment, knowledge of the NWU, and guidance from Rieman and McIntyre (1993) and Rieman and Allendorf (2001). The guidance (Rieman and McIntyre 1993) included the suggestion that core areas with less than five interconnected local populations are at increased risk of extirpation, while core areas with five to 10 local populations are at intermediate risk, and those with more than 10 local populations are at diminished risk. Furthermore, Rieman and Allendorf (2001) suggested that local effective population sizes of more than 50 adults and core area effective populations greater than 1,000 adults minimize adverse genetic effects to the population.

Although there is at most one tributary (LeClerc Creek) within the Pend Oreille River Core Area that may have some bull trout reproduction, nine tributaries were identified by the NWU Recovery Team as having the potential to sustain local bull trout populations and were assigned numeric recovery goals for adult migratory fish with an overall core area recovery goal of 1,575 to 2,625 fish. Two of these tributaries drain into Boundary Reservoir: Slate and Sullivan creeks, which have goals of 25 to 75 fish and 600 to 850 fish, respectively. The remaining seven: Cedar Creek; Ruby Creek, LeClerc Creek, Mill Creek, Tacoma Creek, Calispell Creek, and Indian Creek drain into Box Canyon Reservoir. Of the Box Canyon tributaries, LeClerc Creek has the largest goal of 400 to 500 adult fish. Detailed population or habitat information used as the basis for including or excluding specific tributaries as local populations is not available or identified in

USFWS (2002), nor is the mechanism for establishing bull trout populations where none currently exists.

The NWU Recovery Team stated that recovery in the NWU was contingent upon reconnecting the Pend Oreille River with the Lower Clark Fork River Subunit that lies upstream of the Pend Oreille Core Area and Albeni Falls Dam (RM 86.9), which was completed in 1952 and is operated by the U.S. Army Corps of Engineers (USACE). The dam impounds the upper 18 miles of the Pend Oreille River and portions of Lake Pend Oreille, the Priest River, and the Clark Fork River (to Cabinet Gorge Dam). The Priest River is located about 5.0 miles upstream of Albeni Falls Dam. The USFWS Biological Opinion (USFWS 2000) concluded that completion of Albeni Falls Dam was responsible for the "abrupt decline" of bull trout within the Pend Oreille River.

2.3.1. Reservoir and Delta Habitat Conditions

2.3.1.1. Spawning and Incubation

Bull trout are not known to spawn in Boundary Reservoir, the Project tailrace, or tributary deltas that could be affected by Project operations. Scholz et al. (2005) describes bull trout spawning habitat as small tributaries with sufficient cover and upwelling. Consequently, bull trout would not be anticipated to spawn in Boundary Reservoir. During the relicensing process, state, federal, and tribal participants agreed that spawning and fry life history stages did not occur in Boundary Reservoir or tailrace and would not require modeling (SCL 2008b).

2.3.1.2. Sub-Adult Rearing

Juvenile bull trout typically rear in natal streams for two to three years and outmigrate at a size of about 170 to 300 millimeters (6.7 - 11.8 inches) in length (Scholz et al. 2005). Bull trout become sexually mature at five to seven years of age before returning to upstream areas to spawn. To assess juvenile bull trout habitat use as part of the relicensing process, juveniles were considered to be 55 to 150 millimeters (2.2 - 5.9 inches) in length, and adults were larger. Juvenile bull trout of this size would generally remain in tributaries rather than migrating to the mainstem Pend Oreille River. Nevertheless, juvenile bull trout habitat in Boundary Reservoir was assessed during relicensing.

As part of the relicensing process, habitat suitability index (HSI) information for bull trout and its congener, Dolly Varden trout (*Salvelinus malma*), was reviewed. Dolly Varden trout was included as a surrogate species for bull trout because HSI information for bull trout is very rare. HSI data are scaled between 0 and 1, where 1 represents optimal habitat conditions and 0 represents wholly unsuitable conditions. HSI data are usually depicted graphically as a continuous line chart for depth and velocity or a categorical histogram for substrate.

Depth suitability during the middle of the year (early spring through mid-fall; April through October) is generally highest at depths of 0.75 to 4 feet, but suitability declines in deeper waters, with bull trout generally found at depths up to 20 feet. During winter conditions (November through March), optimal suitability may occur in somewhat deeper water, from about 2.0 to 10 feet, but similar to the summer rearing season, bull trout generally remain at depths above 20 feet.

Optimal water velocities for bull trout are up to about 1.0 foot per second during the winter and 1.5 feet per second (fps) during the middle of the year. Suitability declines rapidly during the winter, with bull trout generally remaining in velocities less than 2.0 fps. In contrast, waters up to 4.0 fps are somewhat suitable during the mid-year rearing period because swimming capacity is greater at the higher water temperatures.

Juvenile bull trout have a high propensity for using cover, particularly at night (McPhail and Baxter 1996). Large woody debris (LWD) and coarse substrate such as large cobbles and boulders have the highest suitability (1.0) during mid-year and over-wintering periods. Aquatic vegetation has relatively high suitability during mid-year (0.75), but relatively low during winter. Submerged terrestrial vegetation may occasionally be used during periods with overbank flows. During winter, areas with no cover have a suitability of 0.0, meaning that some form cover is required for an area to be used by a juvenile bull trout at this time of year.

Aquatic Habitat Modeling was used to provide an index of the amount of physical habitat that might be available to bull trout based on the suitability of available water depths, water velocities, and substrate types. For comparability between reaches, the index calculated was Weighted Useable Area (WUA) per foot of river reach. The model suggested that during average flow years the Forebay and Canyon Reaches have a relatively low density (less than 35 square feet of monthly minimum WUA per foot of river) of potentially suitable habitat for bull trout juveniles, particularly during the fall and spring months when water surface elevations fluctuate more frequently and with a higher range than during the summer (Figure 2.3-2). Monthly minimum WUA density was slightly higher for the Tailrace (36 to 54 square feet per foot of river) and substantially higher for the Upper Reservoir (61 to 168 square feet per foot of river). Given its longer length, the Upper Reservoir Reach provides the most available potential habitat for juvenile bull trout. Given the overall lack of observations of bull trout less than 150 millimeters (5.9 inches) in length in any of the Project reaches, it is apparent that some factor other than physical habitat is limiting bull trout use of the Project area.

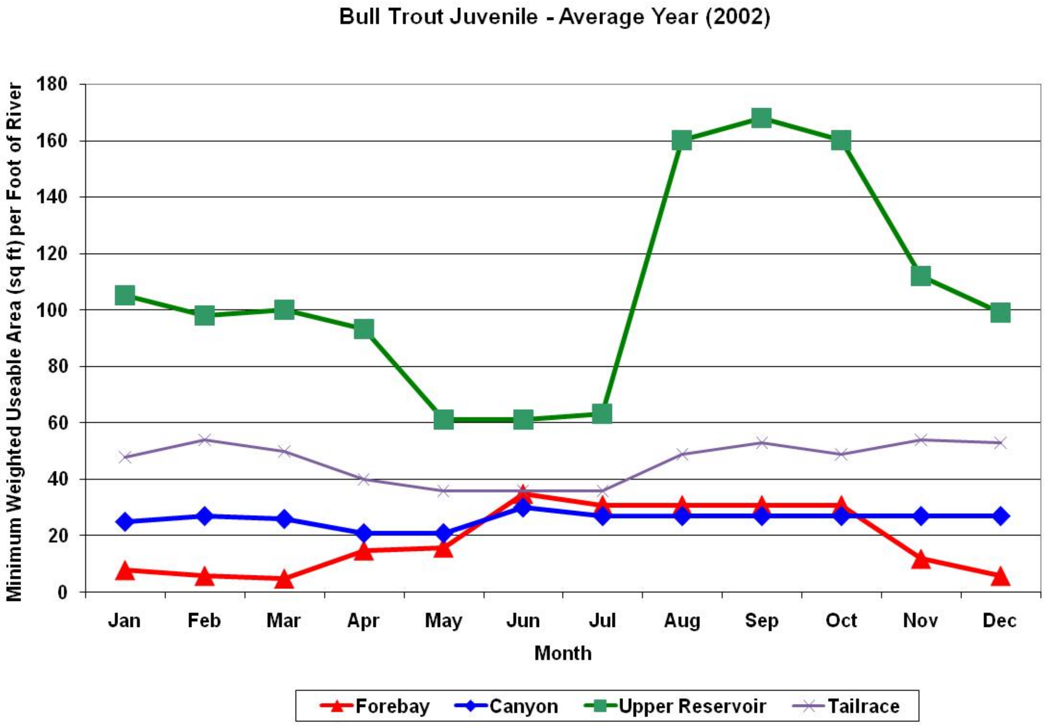


Figure 2.3-2. Monthly WUA minima for juvenile bull trout during and average flow year.

2.3.1.3. Adult Habitat

Adult bull trout (assumed > 150 millimeters [6 inches]) habitat suitability is broader than that of juveniles. Based on available HSI information, optimal suitability occurs at depth ranges from 2 to 30 feet during the mid-year rearing period and at depths of 5 to 30 feet for overwintering. Suitability is less in deeper waters (i.e., 0.2 at 50 feet) year-round, but all depths in Boundary Reservoir are somewhat suitable for adult bull trout. Tracking of bull trout in Lake Pend Oreille by Bassista et al. (2005) suggests that deep water may have a higher suitability than the available HSI information indicates. The five bull trout outfitted with acoustic tags used benthic areas during the spring at a mean depth of 75 feet. During summer, bull trout mostly used benthic areas (66 percent of observations), but were also found in nearshore (25 percent of observations) and pelagic areas. During the fall and winter, observations were only made on two bull trout that were at depths of 26 to 203 feet.

Optimal velocities are 0.20 to 2.25 fps during the mid-year rearing period. Bull trout adults are generally not found at velocities greater than 5.25 fps. During the over-wintering period suitable velocities are less than during the mid-year rearing period; optimal velocities are 0.00 to 1.00 fps, and bull trout are generally not found at velocities greater than 4.0 fps during the winter.

The suitability of different cover types for adult bull trout is the same as for juveniles.

The Aquatic Habitat Model indicated that about three times the density of WUA was available for adult bull trout than for juvenile bull trout, primarily as a result of the higher suitability of deeper and faster water. For an average flow year, the density of WUA was similar for the Upper Reservoir, Canyon, and Tailrace reaches between November and March at about 100 to 160 square feet per foot of river (Figure 2.3-3). In contrast, the Forebay Reach was substantially higher at about 300 square feet per foot of river throughout the year. Between April and October the Upper Reservoir WUA density was more similar to the Forebay Reach. Similar to juvenile bull trout, the relatively few observations of bull trout greater than 150 millimeters (5.9 inches) in length in any of the Project reaches suggests that some factor other than physical habitat is limiting bull trout use of the Project area.

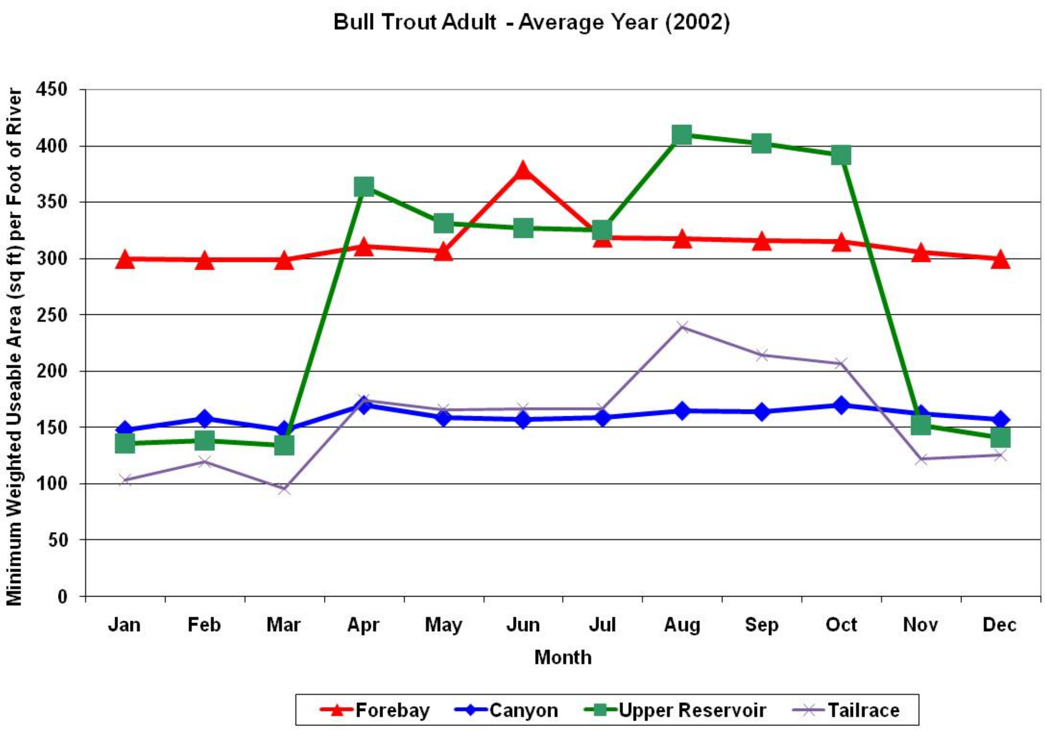


Figure 2.3-3. Monthly WUA minima for adult bull trout during an average flow year.

2.3.1.4. Delta Habitat

Tributary deltas are transition areas between the tributaries and reservoir that, depending upon their physical characteristics, provide a variety of ecological functions. Fish may congregate at the tributary confluence to feed on aquatic organisms transported downstream in the tributary flow, may use the deltas as temperature refugia, or may stage in delta habitats prior to spawning runs; fry and juvenile fish may rear in complex habitats associated with the deltas; and the influx of tributary water may provide protection from dewatering associated with reservoir water surface elevation fluctuations. Portions of tributary deltas are present in the varial zone of Boundary Reservoir, and therefore are affected by fluctuations in water surface elevation. The fluctuations in elevation associated with Project operations change portions of the deltas from stream habitat to lacustrine habitat as the reservoir pool rises and then back to stream habitat as the reservoir water surface elevation falls.

As described previously, there are 28 tributaries that drain into Boundary Reservoir, including 13 unnamed drainages. Most of the tributaries are very small, and some do not contain measurable surface flow during late summer months (Table 2.3-2). Following a screening process that included both desktop GIS and field assessments, habitat modeling analysis was limited to only those tributary deltas with substantial potential salmonid fish habitat (Sediment Transport and Boundary Reservoir Tributary Delta Habitats Study, SCL 2009b). Habitat modeling occurred on seven tributary deltas including Slate Creek, Flume Creek, Sullivan Creek, Linton Creek, Pocahontas Creek, Sweet Creek, and Sand Creek. The physical habitat modeling of major tributary deltas translated hourly fluctuations in Boundary Reservoir water surface elevations estimated from the hydraulic routing model into estimates of a habitat quality rating (HQR) for native salmonids, including bull trout. The HQR model was applied to three historical river flow conditions to evaluate representative tributary delta habitat for wet, dry, and average years.

The HQR (measured in square feet) was calculated as the product of two components: the area of lacustrine and riverine habitat (Figure 2.3-4) weighted by their respective riverine or lacustrine Habitat Suitability Index (HSI) scores. HSI values were calculated for individual representative tributary delta areas for three life stages (i.e., adult, juvenile, and fry) of "generic" native salmonids using the species-habitat relationships developed for cutthroat trout by Hickman and Raleigh (1982). The riverine HSI modeled three or four of the following parameters depending upon life stage: thalweg depth, percent cover, percent cobble/boulder substrate, percent pool, pool quality (size and depth), and percent fines. The lacustrine HSI model relied on three water quality parameters—water temperature, dissolved oxygen, and pH. To aid in interpretation of the model results, the HQR values for lacustrine habitat and for riverine habitat for various salmonid life stages were plotted on hourly and cumulative bases over the course of the wet, dry, and average years. Details of the HQR modeling are provided in (Sediment Transport and Tributary Delta Study Final Report, SCL 2009b).

The use of a cutthroat model to represent native salmonid habitat results in an imperfect representation of bull trout habitat in delta areas because bull trout suitability is more restricted for a number of habitat factors, such as water temperature, and broader for other factors, such as depth and velocity. Nevertheless, the HQR model is useful as an index for describing the relative importance of the different tributaries to native salmonids and for understanding how Project operations may affect habitat conditions.

Results of the Hickman and Raleigh (1982) riverine model indicate that the Slate Creek delta had the highest HSI scores for each of the different life stages of trout (Table 2.3-4). Flume Creek and Sullivan Creek (during periods of regulated flow) deltas had the next highest HSI values for the three different life stages of trout. The Pocahontas Creek and Sand Creek deltas were rated as unsuitable because of their dry channel beds (and associated zero depth of thalweg) at the time of the late summer surveys. For low-flow periods, the suitability is still low on both these creeks for adult salmonids at an HSI of 0.1.

The Hickman and Raleigh (1982) lacustrine model for salmonid habitat in the shallow water areas of the deltas during periods of inundation suggests a range of habitat quality throughout the year (Table 2.3-5). The model output was driven primarily by the variability in average monthly water temperature (range 1.2 ºC to 22.6 ºC). Monitoring data suggested that dissolved oxygen

(DO) and pH were relatively stable over the year, with values generally greater than 8.0 mg/L and between 8.0 and 9.0, respectively. Consequently, DO and pH values (8.54 m/L and 8.79, respectively) and suitabilities (0.15 and 0.65, respectively) were not varied over the year as part of HSI calculations. During the month with the greatest average water temperature (August), the water temperature value (22.6 °C) exceeds the maximum suitable value (22.0 °C) and the resulting HSI was zero (unsuitable habitat). Conversely, in May and October when the average monthly water temperature is between 11.5 and 15 °C, pH becomes the limiting factor and the HSI values approach 0.90. Rieman and McIntyre (1993) report that bull trout populations are limited to areas with temperatures less than 15 ºC. Consequently, the Hickman and Raleigh (1982) model likely overestimates the suitability of lacustrine habitat for bull trout during the summer months. As temperature fluctuated between the unsuitable values in August and the near optimal values in May, June and October, the HSI values change accordingly. Because of the influence of the potential presence of thermal plumes at the tributary mouths, the suitability for a reduced portion of the lacustrine area may be greater than 0.00 during times when water temperatures are unsuitable for salmonids.

Table 2.3-4. List of tributaries, their calculated Habitat Suitability Indices, and their relative ranking for generic "salmonid" adult, juvenile, and fry life stages in the tributary delta areas of Boundary Reservoir derived from the Hickman and Raleigh (1982) riverine model.

Tributary Name	Adult "Salmonid"		Juvenile "Salmonid"		"Salmonid" Fry	
	HSI	Rank	HSI	Rank	HSI	Rank
Slate Cr.	0.924	1	0.923	1	0.877	1
Flume Cr.	0.820	3	0.900	2	0.739	2
Sullivan Cr. (low flow)	0.703	4	0.340	6	0.340	6
Sullivan Cr. (regulated flow)	0.840	2	0.823	3	0.673	3
Linton Cr.	0.300	5	0.300	7	0.000	8
Pocahontas Cr. (dry)	0.000	9	0.000	9	0.000	8
Pocahontas Cr. (low flow)	0.100	6	0.300	7	0.589	5
Sweet Cr.	0.100	6	0.577	5	0.600	4
Sand Cr. (dry)	0.000	9	0.000	9	0.000	8
Sand Cr. (low flow)	0.100	6	0.703	4	0.160	7

Note:
HSI – Habitat Suitability Index, 0 indicates unsuitable habitat whereas 1 indicates optimal habitat

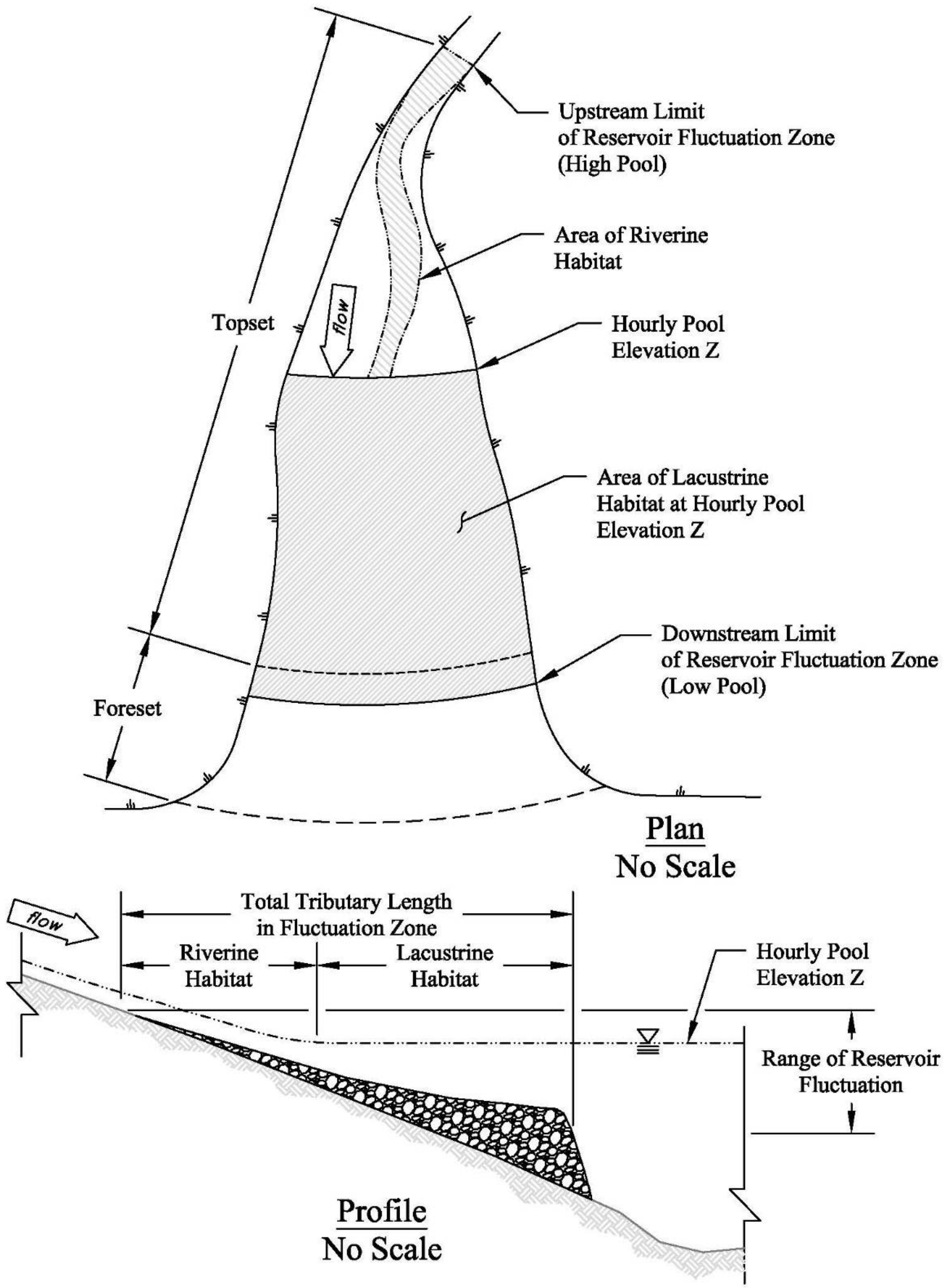


Figure 2.3-4. Conceptual model for determination of riverine and inundated habitat, example high pool and low pool conditions.

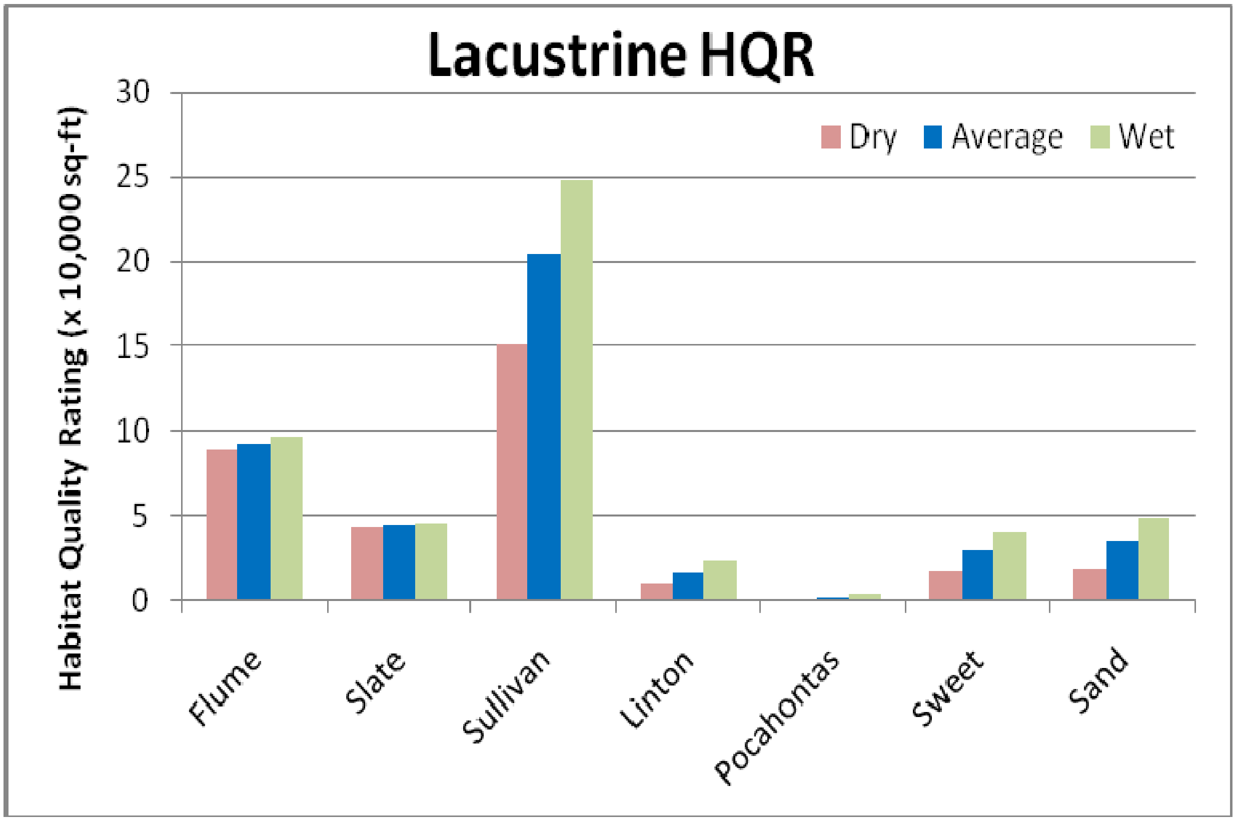
Table 2.3-5. Boundary Reservoir average monthly temperature values, their associated suitability, and final reservoir Habitat Suitability Index using Hickman and Raleigh's (1982) lacustrine model.

Month	Temperature (ºC)		HSI
	Value	Suitability	
January	1.2	0.15	0.15
February	1.9	0.24	0.24
March	3.9	0.48	0.67
April	7.5	0.83	0.81
May	11.7	1.00	0.86
June	15.3	0.99	0.86
July	21.3	0.16	0.16
August	22.6	0.00	0.00
September	18.9	0.66	0.75
October	13.0	1.00	0.86
November	6.7	0.77	0.79
December	2.4	0.30	0.30

Deltas for two of the tributaries, Slate Creek and Flume Creek, are expected to expand over a 50-year period because these tributaries are located in inlets and protected from sediment mobilizing mainstem current velocities. Consequently, HQR values are expected to increase over the next 50 years for Slate and Flume creeks. In contrast, the other five modeled tributary deltas are currently in equilibrium, with sediment delivered from the tributaries mobilized and redistributed farther downstream in the mainstem of the river during high flows.

A number of patterns are apparent from the results of the HQR modeling. Each of the modeled tributary deltas had minimum lacustrine HQRs of 0 because water temperatures during August were considered unsuitable. With the exception of Slate, Sullivan, and Sweet creeks, minimum fry, juvenile and adult riverine HQR values were also 0 under all year types, but different factors were limiting at different tributaries. Average lacustrine HQR values increased from dry, to average, to wet year conditions (Figure 2.3-5). Although not displayed, maximum lacustrine HQR values demonstrated a similar pattern to average HQR values.

The lacustrine HQR results followed the same general pattern for all tributaries, which is a function of water temperature. In the months of April and October when temperature is within the optimal range, the HQR values peak. Between these two maximums, HQR values rise and fall as water temperatures warm (prior to April), become unsuitably hot (April to October), and then cool (after October). In the wet (1997) and average (2002) years, the lacustrine HQR values reach a maximum at each delta during high mainstem flows because reservoir water surface elevations exceed the upper extent of the delta. Under these high flow conditions, the delta is fully inundated, including areas at higher elevations than the delta, so the lacustrine area is held constant at the maximum. Under these same conditions, the riverine HQR values go to zero because no free-flowing stream habitat exists on the delta.



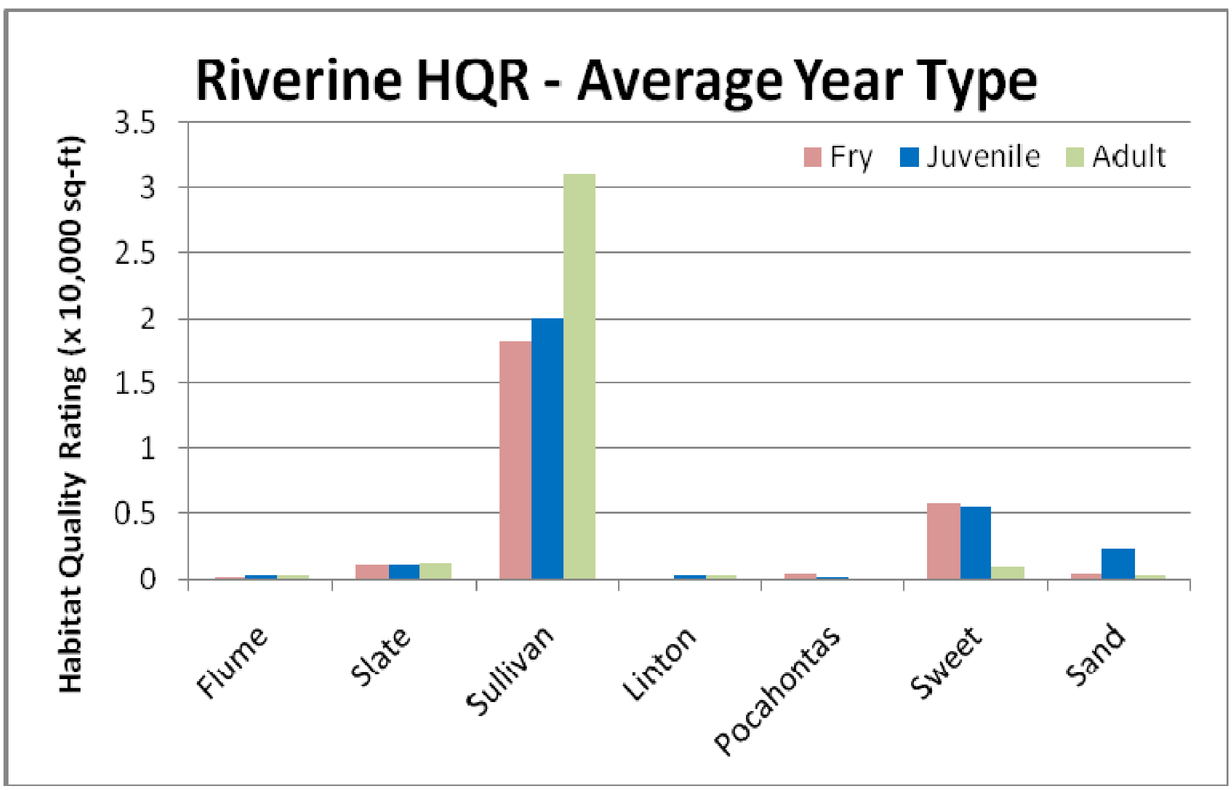


Figure 2.3-5. Average lacustrine and riverine HQR values. HQR values for Slate and Flume creeks are for Years 1-17 of the 50-year evaluation period.

The Sullivan Creek delta, with average HQRs of 20.4 x 10^5 square feet and 2.0 x 10^5 square feet for lacustrine and riverine juvenile habitat, respectively, supplies substantially more lacustrine and riverine habitat than any of the other tributaries. Average lacustrine HQR values are about an order of magnitude or higher than riverine HQR values. From highest to lowest based on lacustrine HQR values, key tributaries can be ranked as follows: Sullivan, Flume, Slate, Sand, Sweet, Linton, and Pocahontas creeks. Rankings based on riverine HQR values for the average flow year were as follows: Sullivan, Sweet, Slate, and Sand creeks. Flume, Linton, and Pocahontas creeks had nearly negligible suitability, with HQR values all less than 600 square feet of HQR.

Load following operations and the associated diurnal fluctuations in water surface elevations can change the physical characteristics of thermal plumes at tributary deltas. Modeling of the areal extents of thermal plumes for Flume, Sullivan, Linton, and Sweet Creeks during representative wet, dry, and average flow years suggested:

- For Flume Creek the modeled plume areas ranged from a low of about 10,000 square feet in to a high of about 20,000 square feet with little difference between the three representative years.
- The Sullivan Creek thermal plume area varied from 0 to 180,000 square feet. Mean plume areas ranged from about 70,000 square feet in the dry year to 100,000 square feet in the wet and average years. During the dry year mainstem water surface elevation dropped below the foreset slope elevation for seven hours during September, resulting in the disappearance of the plume area.
- The area of the Linton Creek thermal plume typically varies from over 1,000 square feet up to 10,000 square feet. During the dry year, the modeled plume area dropped below 1,000 square feet during approximately the same period as the Sullivan Creek plume minima.
- The modeled thermal plume area at Sweet Creek typically varied from over 2,000 to about 10,000 square feet. Similar to Sullivan Creek, plume areas of zero were modeled for a total of 25 hours during the dry year as the mainstem water surface elevation fell below the delta foreset slope.
- Complete disappearance of plume areas requires a combination of low Project inflow and unusually low forebay water surface elevations, which are uncommon events.
- The results of the modeling indicated that there are not large differences between the estimated areas of thermal plumes between wet, dry, and average years. In general, the thermal plume areas are very similar for the wet and average years and tend to be slightly smaller overall during the dry years.

In summary, water temperatures are a major contributor to the riverine HQR values, which are likely overestimates of suitability for bull trout during the summer because of the more restrictive temperature requirements of bull trout compared to the cutthroat trout criteria used in the HQR model. Riverine HQR values for bull trout would likely be zero, or near zero, during the months of July, August, and September. As previously mentioned, temperature modeling has demonstrated that the Project does not increase water temperatures relative to natural conditions, on a flow-weighted basis. Consequently, the low suitability of the reservoir for bull trout during the summer would occur even in the absence of the Project.

2.3.2. Habitat Connectivity

As described in more detail in Section 2.1 of this document, Boundary Dam is situated in a narrow canyon at River Mile (RM) 17.0 on the Pend Oreille River. The dam is 340 feet high and was built without fish passage facilities. Anadromous fish access to the upper Columbia River basin, including access to the Pend Oreille River, was blocked in 1942 by construction of Grand Coulee Dam 164 miles downstream. At the time of the construction of Boundary Dam, the importance of habitat connectivity for non-anadromous salmonids was not recognized; consequently fish passage was not considered during its design. Bull trout that might migrate downstream and pass through Project turbines or spillways may be directly injured or killed, or indirectly impacted if they are made temporarily more vulnerable to predation due to disorientation and stress following passage. All upstream movement of bull trout is blocked at Boundary Dam.

Passage barriers are an isolating mechanism for local populations. Types of barriers are waterfalls, landslides, water withdrawals, road crossings, and dams. A local population that lives above a barrier can only contribute individuals (and their genes) in a downstream direction. If a local population upstream of a passage barrier is extirpated, then there is virtually no opportunity for the local population to become re-established unless other local populations are present farther upstream or there is human intervention. The likelihood of re-establishing local populations is greatly enhanced if upstream populations include migratory life history forms, which are more likely to disperse. Nelson et al. (2002) reported that the migratory form of bull trout is in decline in the Bitteroot drainage and other locations, even though resident forms remain. Baxter (1999) has come to a similar conclusion for bull trout in the Salmo River drainage. Nelson et al. (2002) suggested that the loss of the migratory form in some areas increases the risk that local populations could go extinct.

Passage barriers may isolate local populations, but they can also prevent the spread of non-native species such as brook trout, which are considered a threat to native salmonids (Andonaegui 2003). Most of the tributaries to Boundary Reservoir have been stocked with non-native salmonid species such as brook trout, brown trout, and rainbow trout. However, Lost Creek and at least two subwatersheds, the NF Sullivan Creek and Lunch Creek, have apparently been unaffected by non-native species. High gradients and three culverts that are potential passage barriers have been identified in the lower reaches of Lost Creek. Fish distribution maps from the USFS (2005) identify cutthroat trout as the only species present in lower reaches of Lost Creek. The cutthroat trout population in NF Sullivan Creek has been isolated by the presence of a low head dam that supplies domestic water to the city of Metaline Falls. Surveys in Lunch Creek, a tributary to Sweet Creek, have also collected only cutthroat trout (R2 Resource Consultants 1998a, McLellan 2001). McLellan (2001) suggested high gradients in the lower reaches of Lunch Creek may have slowed or prevented the expansion of brook trout from Sweet Creek.

2.3.2.1. Upstream Fish Passage

As indicated above, the Boundary Project does not have upstream fish passage facilities. Consequently any bull trout that survive entrainment through the Albeni Falls, Box Canyon, and Boundary projects are currently prevented from migrating back upstream to their natal streams for spawning. Also, any bull trout from the Salmo River would be prevented from moving upstream past Boundary Dam. These fish are consequently prevented from potentially contributing genetic material to upstream populations and using upstream habitat for foraging. During relicensing studies, three bull trout were captured in the Boundary Dam tailrace, one of which was identified from genetic analysis of tissue samples to be from the Salmo River population, whereas the other two were assigned to populations from tributaries to Lake Pend Oreille. In addition, radio tracking of a bull trout tagged in the Salmo River indicated that one individual moved into the Boundary Tailrace Reach for several days during the late fall of 2008, then moved back downstream.

2.3.2.2. Downstream Fish Passage Facilities

There are no downstream passage facilities at Boundary Dam; consequently any bull trout that is entrained is at risk of injury or death. This section discusses two components important for understanding the effects of Boundary Dam on bull trout moving downstream in the Pend Oreille River. The first component is the level of risk of mortality as a result of passage through the Project's turbines or as a result of spill once a fish is entrained. The second component is an understanding of the risk of entrainment occurring.

2.3.2.2.1. Passage Survival

A desktop analysis of passage survival was conducted during the relicensing process (R2 Resource Consultants 2006). Results of the desktop analysis were presented to relicensing participants, who agreed that studies to determine Project-specific survival rates would not be necessary as part of relicensing because the desktop analysis likely depicted a reasonable representation of what an empirical study would show. The desktop analysis assessed the likely range of mortality to salmonids, depending upon the entrainment route (turbine, spillway, or sluiceway) and fish size (Table 2.3-6).

Table 2.3-6. Estimated mortality through Boundary Dam for different pathways and fish size.

Pathway	Percent Mortality by Fish Length		
	100 mm	**250 mm**	**600 mm**
Turbines 51- 54	6 – 15	13 – 33	26 – 65
Turbines 55 and 56	5 – 12	11 – 28	23 – 59
Spillways	50 - 80	35 - 65	20 - 50
Sluiceways	40 - 70	25 - 55	10 - 40

Turbine mortality rates were estimated using a predictive equation for Francis turbines developed by the U.S. Department of Energy's Advanced Hydro Turbine System Program (AHTSP), which was based on hundreds of turbine mortality studies and consideration of specific turbine characteristics (Franke et al. 1997). Strike and shear are the major factors that are addressed by the predictive equation method. The equation calculates the probability that a fish of a given size is likely to be near or come in contact with components of the turbine and the shear zone, which occurs in very close proximity to the surfaces of the turbine where water is moving at high velocity over the surface of the steel. The predictive equation uses turbine size, rotational speed, head, number of buckets (or vanes), flow, mechanical efficiency, and the length of the fish entrained to estimate the probability that a fish of a given size will come near to or in contact with a structural element as it passes through the turbine.

A number of field and laboratory studies were reviewed to understand the effects of spillway passage on fish and potential associated mortality levels (Hamilton 1955, R2 Resource Consultants, Inc. 1998b, PNNL 2000, Normandeau Associates 2002). Based on this review, the following conclusions were made concerning the mortality of fish passing through the spill flow at Boundary Dam.

- *Extremely low spill flow rates where the flow passes down or plunges onto the rock and does not reach the open water of the tailrace*: Near 100% mortality for fish of all sizes is likely.
- *Relatively low spill flow rates, but high enough that the majority of the flow reaches the plunge pool*: If roughly half the flow dissipates into mist before reaching the tailrace, and half the fish leave the flow and freefall in air to the tailrace, then small fish (approximately 100 mm) would likely experience a 60-70 percent mortality rate. Small fish that remain in the jet would likely experience near 100 percent mortality due to exposure to shear, while small fish that leave the jet and freefall to the tailrace would likely experience low mortality. The larger salmonids (approximately 600 mm) are expected to experience similar or slightly lower mortality rates of 40-50 percent, but for the opposite reasons: fish that leave the jet would be expected to experience very high mortality while those that remain in the jet would likely experience lower mortality due to a greater resistance to shear forces.
- *Larger spill flows where the large majority of the flow remains in a coherent jet to the tailrace*: If fish do not impact the bottom of the plunge pool, which seems reasonable because the plunge pool exceeds 75 feet in depth, the major source of mortality would likely be due to the shear effects on fish near the periphery of the jet. The greater the magnitude of the spill the more likely the fish will be in the body of the flow and not exposed to the peripheral shear effects, so there is a range of mortality probability with decreasing estimated mortality associated with increasing spill flow rates. For smaller fish this range is estimated to be about 50-80 percent, which would be similar to the results of field studies at Upper Baker Dam, which has similar spillway characteristics (Hamilton 1955), whereas for larger fish the mortality could be as low as 20-40 percent.

Boundary Dam includes seven sluiceways located at about mid-height (crest elevation 1,795 ft NAVD 88) of the dam that discharge into the plunge pool below the dam. The sluiceways are generally used to supplement the spill flow during extreme high-flow events. Given the flow capacity and the dimensions of the sluiceway outlet, the velocity of the flow exiting the sluiceway would be approximately 100 fps, and the impact velocity of the jet upon entry into the plunge pool should be about 115 fps, with a trajectory approximately 30 degrees downward from horizontal. The flow exiting the sluiceways should be fairly well confined as a jet, and given that the tailwater is less than 50 feet below the invert of the sluiceway when the river flow is above approximately 125,000 cfs (typical conditions when sluice gates are in use under current operations), the jet should remain fairly well confined all the way to the tailwater. This will result in a greater percentage of the entrained fish remaining in the body of the flow and not exposed to the shear conditions on the periphery of the jet as it enters the tailwater. Additionally, the closer to horizontal trajectory upon entry into the tailwater should reduce the likelihood of striking the bottom of the plunge pool. These two conditions imply that the mortality of entrained fish in the sluiceway flow should be somewhat lower than that estimated for the spill flow at the same magnitude of flow.

Some level of mortality or injury to bull trout that are entrained at Boundary Dam is unavoidable, and the analysis above suggests midpoint mortality rates would range from 35 to 43 percent for turbine or spillway passage. Collection of two healthy bull trout in the Boundary Tailrace Reach that derived from tributaries to Lake Pend Oreille confirms that some bull trout survive entrainment. The relatively low number of observations of bull trout in Boundary Reservoir since the early 1980s, despite intensive sampling in 2000, 2007, and 2008, suggests that the overall incidence of bull trout entrainment mortality at Boundary Dam is likely to be low.

2.3.2.2.2. Entrainment

During 2007 and 2008 SCL conducted hydroacoustic and fyke net sampling at Boundary Dam to estimate the number, size, species, and timing of fish that may be entrained within the Project turbine intakes and spillways. The limited frequency, duration of use, and flow conditions associated with the use of the sluiceways, and the discontinued use of the skimmer gate, reduces the need to quantify the number of fish potentially entrained through these pathways.

Hydroacoustic data collection was initiated at Boundary Dam on May 2, 2007 using split-beam target tracking techniques. Transducers were mounted above each turbine intake and aimed down to monitor the water column immediately upstream of each turbine intake opening. In addition, to monitor targets passing through the spillways during spill events, transducers were deployed at each spill bay. All entrained target detections were weighted for unsampled time and space, and the resulting estimates represent total hourly target passage at each turbine intake or spillway.

Fyke nets were initially deployed in the Unit 54 draft tube gatewell downstream of the turbine unit in October 2007. Substantial testing and net modifications were needed; consequently, routine fyke net sampling was not initiated until February 16, 2008. Fyke netting has generally occurred each weekend for a 24-hr period since April 1, 2008. The fyke net array consists of two frames of eight net panels each, and is designed to screen the entire draft tube downstream of turbine Unit 54.

The fyke netting procedures involved shutting down Unit 54, deploying the two net frames in the draft tube, restarting the turbine, sampling for a fixed period, and then stopping the unit again and retrieving the net frames. All routine fyke net tests to date have been conducted at a 90 MW unit loading. Sampling could not occur at flows higher than 90 MW without excessive net damage, and lower flows are not representative of typical operating loads (maximum Unit 54 output is 150 MW). Hydroacoustic data indicate that flows associated with 90 MW loadings entrained targets at rates generally consistent with higher loadings. Operations data from 2007 indicated that loadings less than 80 MW only occurred during about 7 percent of the operating hours at Unit 54, so using 90 MW was selected as the standard loading for fyke net tests. The typical duration of individual fyke net tests within each 24-hour sampling period was approximately three hours, although individual tests varied from about one to four hours in duration. The duration was selected to ensure the integrity of the captured fish. In general, three to four individual fyke net tests could be completed within each weekly 24-hr sampling period. While fishing the fyke nets, the hydroacoustic system was switched to sample continuously at Unit 54 to maximize temporal sampling coverage.

The fyke net deployment was designed to provide complete net sampling coverage across the Unit 54 draft tube. However, the very high flow rates and variable hydraulic conditions encountered by the nets can result in incomplete sampling due to net damage, potential gaps between the nets and frame, and other factors. To establish measures of fish capture efficiency, neutrally-buoyant targets (NBT), i.e., radishes, carrots, and potatoes, were introduced in the Unit 54 penstock at the head gates during most fyke net tests. It was assumed that NBT targets distributed within the draft tube in a similar manner as fish, and had the same net retention characteristics as fish with lengths greater than 4 inches (equivalent to the minimum size fish included in the hydroacoustic target estimates). The capture efficiency tests indicated that a mean of 61.0 percent of released NBTs were collected in the fyke nets. Live fish tests using triploid rainbow trout were also undertaken to verify that NBT's were suitable fish surrogates. The spatial distribution among the individual fyke nets and capture percentages were found to be statistically equivalent. Other important assumptions were that the calibration of hydroacoustic sampling numbers with fyke net sampling numbers at Unit 54 could be used for other turbine units, could be used to draw conclusions regarding the species mix and size of fish vulnerable to entrainment by the spillways, and could be used to estimate the magnitude of entrainment Project-wide. The FERC-approved study plan recognized that if discrepancies were identified between hydroacoustics and fyke net sampling results, fyke net results would be expected to provide a better estimate of fish entrainment, by species, size, and number, than that provided by hydroacoustics sampling.

Hydroacoustic and fyke net data collected concurrently between February and October 2008 indicate that fish entrainment is occurring at the Boundary Dam powerhouse. Preliminary analysis of the fyke net data suggests that 78,020 fish were entrained through the turbines during the April through October period, when consistent sampling protocols were used (protocols were refined during February and March 2008). In contrast, preliminary analysis of the hydroacoustic data suggests that 727,219 targets were entrained during the same period. There is nearly an order of magnitude difference between estimates from the two sampling techniques. Statistical analyses of estimates from fyke net captures and hydroacoustic targets at Unit 54 during the April through October period failed to provide reasonable correlations. Additional review and analysis of the data conducted by Hydroacoustic Technology Inc. (HTI, the firm that conducted the hydroacoustic data collection), Dr. John Skalski (School of Aquatic & Fishery Sciences, University of Washington), and SCL resulted in the development of a method to estimate entrainment using the actual numbers from the Unit 54 fyke netting effort and the hydroacoustic data collected at all other turbines and spillways. This method extrapolates fish entrainment rates observed at Unit 54 across all operating Boundary Dam turbines and spillways on a monthly basis based on the proportion of hydroacoustic passage at each location to derive monthly estimates of total Project fish entrainment. Entrainment estimates based upon the newly developed method will be incorporated into the Fish Entrainment and Habitat Connectivity Final Report that will be available in June 2009.

Suckers, pumpkinseed, and yellow perch dominated the fyke net sampling in the draft tube of turbine Unit 54 between February and October, 2008 (Figure 2.3-6). No native salmonids were captured. The fyke net catch was generally consistent with the composition of catch from electrofishing and gillnetting in the Forebay Reach. Notable exceptions were the higher proportions of burbot, pumpkinseed, and kokanee in the fyke net catch, which may indicate the suitability of habitat or their behavior patterns near to or downstream of the trashrack make them more vulnerable to entrainment than their representation in the catch from elsewhere in the Forebay Reach would suggest.

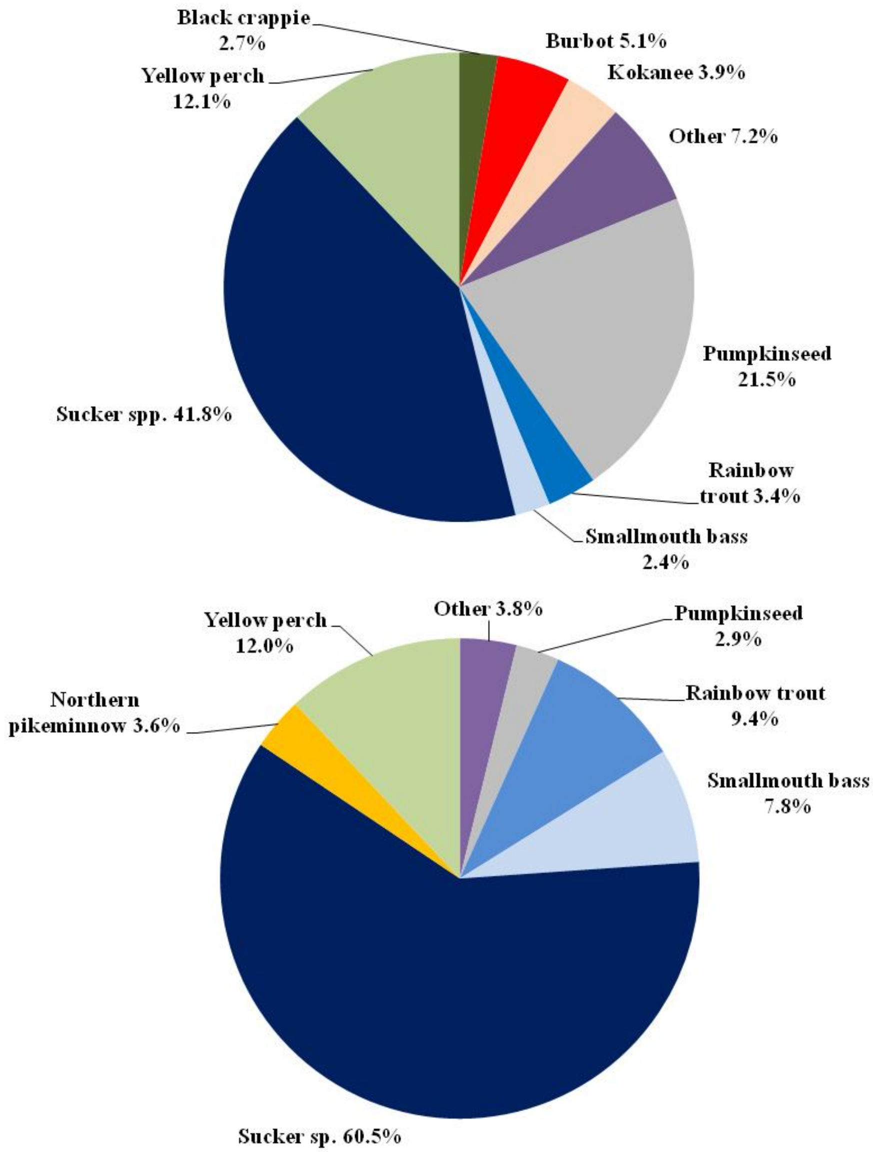


Figure 2.3-6. Species composition resulting from 414 fish captured from fyke net sampling in the turbine draft tube of Unit 54, February through October, 2008 (top) and 4,018 fish captured at standard sampling sites in the Forebay from March 2007 through September, 2008 (bottom).

The length-frequency of fish captured by fyke net in the Unit 54 draft tube demonstrated two distinct size modes, one centered at about 100 millimeters (3.9 inches) and the other at about 340 millimeters (13.4 inches) (Figure 2.3-7). Examination of the length-frequency histograms for individual fish species indicated that the smaller group of fish sizes consisted primarily of pumpkinseed (50-140 millimeters [2-5.5 inches]) and yellow perch (80-190 millimeters [3.1-7.5 inches]), but also included some salmonids (90-200 millimeters [3.5-7.9 inches]), while the larger group of fish sizes consisted primarily of suckers (270-400 millimeters [10.6-15.7 inches]) and a few salmonids (220-390 millimeters [8.7-15.4 inches]). Fish larger than 400 millimeters (15.7 inches) were suckers and burbot.

The length-frequency of fish captured by fyke net at Boundary Dam is consistent with the findings of FERC (1995) and Stone and Webster (1992), i.e., that small fish less than 4 inches to moderate size fish up to 6 inches generally account for 75 percent or more of entrained fish at low-head dams dominated by a non-salmonid fish community. Boundary Dam is different from the dams in the review studies in that it is a high-head project. However, many of the physical factors, primarily water velocities (0.7 to 7.2 feet per second in FERC 1995), are similar.

FERC (1995) and Coutant and Whitney (2000) indicated the life history traits and behavior of the fish species found in the impoundment, including the non-salmonids, are important factors affecting a species potential for being entrained. For example, schooling fish tend to be entrained on an episodic basis and non-salmonid fish that tend to use littoral habitat may have higher entrainment at turbine units that are closer to the shore. Juvenile or larval fish that have a planktonic life history are likely to have higher entrainment levels than those that are benthic or use backwaters. Species that have seasonal movements for spawning or other specific habitat traits may have higher levels of entrainment during these movement periods. Another factor that could affect entrainment levels are a species' depth preference and the depth of turbine intakes. These authors also noted that entrainment levels may increase during periods with very cold water when fish may succumb to extreme lethargy and torpor.

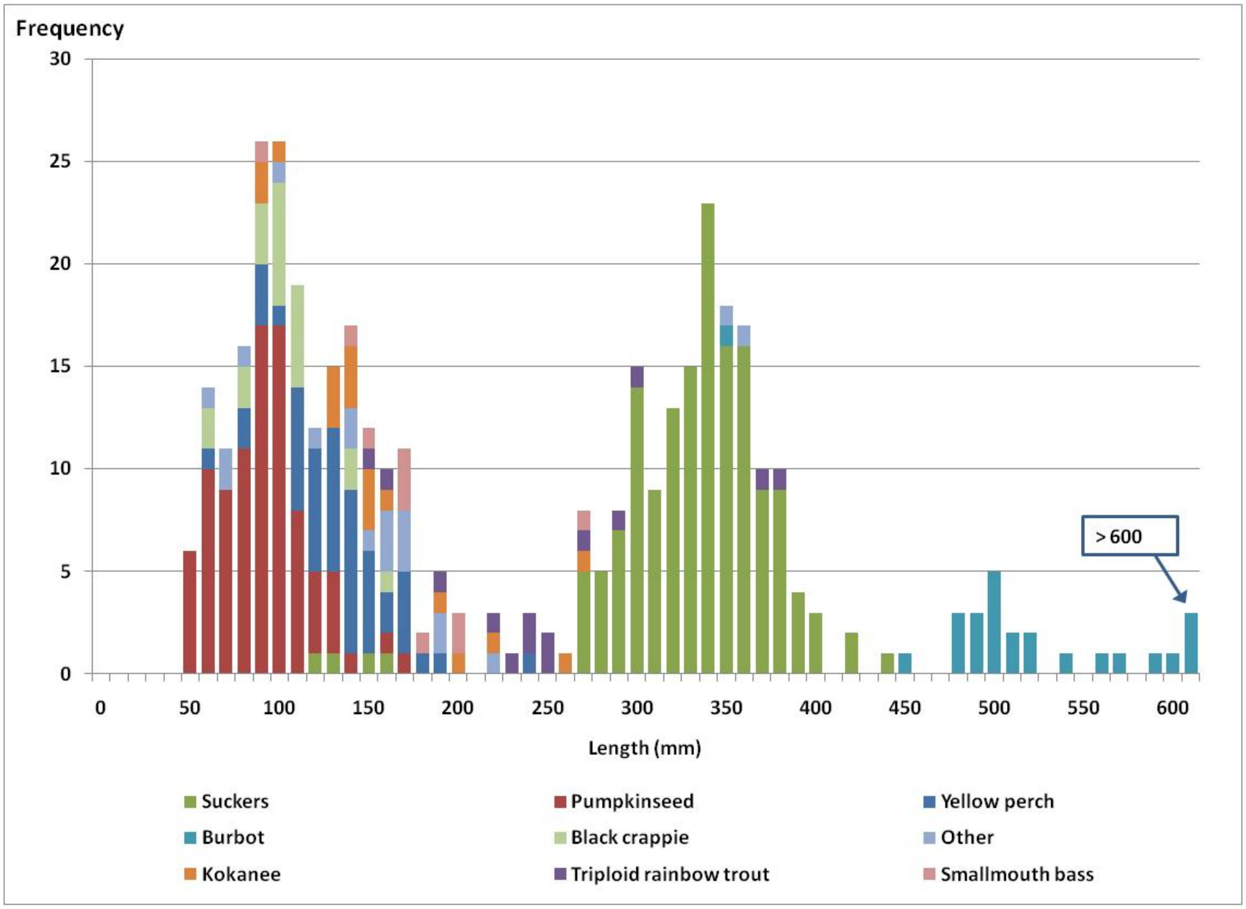


Figure 2.3-7. Length frequency of fish, by species, captured by fyke net in the Unit 54 draft tube.

The available information suggests that any bull trout in the vicinity of the dam would be vulnerable to entrainment at Boundary Dam, but their low overall abundance in Boundary Reservoir and forebay suggests entrainment of bull trout is extremely rare. Genetic testing of two bull trout captured in the Boundary Tailrace Reach during fall 2008 indicated they had originated in tributaries to Lake Pend Oreille. Relicensing fish surveys showed an increased incidence of triploid rainbow trout and radio-tagged cutthroat trout in the Tailrace Reach following release in Boundary Reservoir during 2008 compared to 2007. In addition, the catch of walleye, which are relatively common in Box Canyon, was substantially higher in Boundary Reservoir during 2008 than 2007. Taken together, this information suggests that during high flow years, such as the spring of 2008, the risk of entrainment may increase relative to normal or low flow years and may have been a factor that contributed to the entrainment of two bull trout from Lake Pend Oreille that were observed in the Boundary Dam Tailrace during late 2008.

2.3.3. Water Quality

2.3.3.1. Total Dissolved Gas

Supersaturation of gases in water has the potential to adversely affect fish by forming bubbles in tissues as the dissolved gases come out of solution (Weitkamp et al. 2003). Ecology standards require that waters remain below 110 percent total dissolved gas (TDG) supersaturation (Ecology 2006). At higher flows, the Project forebay TDG level is closely linked to upstream project TDG levels from Box Canyon and Albeni Falls dams. Spill from these upstream projects causes relatively high forebay TDG at flows near and slightly above the Project powerhouse capacity (55,000 cfs) (Evaluation of Total Dissolved Gas and Potential Abatement Measures [TDG Evaluation] Final Report, SCL 2009b). The Project tailrace TDG begins to increase slightly over the forebay level for flows above approximately 70,000 cfs. At flows greater than approximately 80,000 cfs, the incoming TDG levels decrease, due to removal of the spillway gates at Box Canyon Dam and corresponding elimination of overflow plunging into the tailwater at upstream projects at higher river flows (TDG Evaluation, SCL 2009b). Analysis of historic data indicates that, with the Project powerhouse operational changes initiated in 2003 (unit sequencing), TDG exceeds the regulatory limit in the Project tailrace for flows between approximately 70,000 cfs and 108,300 cfs (which corresponds to spill flows of approximately 15,000 cfs to 53,300 cfs). These flow conditions correspond to an occurrence of approximately 7.4 days per year based on the 1987 through 2005 period of record (TDG Evaluation, SCL 2009b). For flows equal to or greater than 108,300 cfs, i.e., the 7Q10 river flow, the TDG standard of 110 percent is not enforced.

The available information suggests that any bull trout residing in the Boundary Reservoir or tailrace during periods of high flow could be at risk of gas bubble trauma from TDG supersaturation. TDG levels in Boundary Reservoir result from operations at Albeni Falls and Box Canyon dams and are unaffected by Project operations. As noted above, under some conditions, high TDG conditions entering the Boundary Dam forebay, which result from upstream projects, may be exacerbated as water passes through or over Boundary Dam. Consequently, Project operations contribute to TDG conditions in the Boundary Dam Tailrace at times (see Section 5.3.2 of the PLP for discussion of TDG exceedances in the Boundary Dam tailrace.). Fish sampling during 2007 and 2008 resulted in no observations of fish with gas bubble trauma in the Boundary tailrace. Because of the species' benthic orientation and preference for deeper water, their risk to bull trout of contracting gas bubble disease is likely lower than that of other salmonid species that prefer shallower water or are more surface oriented.

2.3.3.2. Temperature

High water temperatures can affect salmonids by altering the timing of adult and juvenile migrations and may contribute to stress-related mortality or reduced growth. While migrating bull trout may exhibit a short-term tolerance for high water temperatures (KCDNR 2000), juvenile bull trout are particularly sensitive to changes in water temperature and are typically found in the coldest stream reaches within a basin. Researchers studied tributaries to Lake Pend Oreille, Idaho and found the highest densities of juvenile bull trout at sites with summer maximum temperatures between 11° C and 14° C (Saffel and Scarnecchia 1995). Based on a review of bull trout temperature studies, including those cited by the Environmental Protection Agency (EPA) in support of EPA standards, Hillman and Essig (1998) concluded that optimal water temperatures for juvenile bull trout growth and rearing range from 12 °C to 14 °C. Spawning activity begins when water temperatures drop below 9 °C in the fall and water temperatures consistently below 6 °C are needed for egg development.

Water temperatures in Boundary Reservoir are cold in the winter and warm in the summer. The range of water temperature recorded at 15-minute intervals between May 2007 and September 2008 was 37.9 to 77.4 ºF (3.3 to 25.2 ºC) and averaged 57.0 ºF (13.9 ºC). Although it does not occur every year, the Forebay Reach was observed to ice-over for a period during the winters of 2007 and 2008. Temperatures in excess of 68 ºF (20 ºC) commonly occur during the months of July and August. Vertical profiles of water temperature taken monthly at seven locations in Boundary Reservoir suggested it is vertically mixed. Water temperature modeling (CE-QUAL-W2) conducted as part of application for Clean Water Act Section 401 certification and the Interstate (Idaho and Washington) Temperature Total Maximum Daily Load (TMDL) process demonstrated that water temperatures under existing conditions are similar to what they would be under natural conditions (see Section 5.3.2 of the PLP for greater detail regarding the results of temperature modeling).

Water temperatures in Boundary Reservoir often exceed the suitable range for bull trout, as they would in the absence of the Project. During periods of high water temperatures in excess of 18 ºC, bull trout that do not locate cool water refugia near mouths of tributaries or by entering tributary streams are likely to be adversely affected by the warm water temperatures in the reservoir. Fish passage through the tributary deltas is a function of reservoir pool level, channel morphology, and tributary inflow. During the summer months, it is unlikely that fish could enter any of the tributaries except Sullivan, Slate, Linton, and Sweet creeks because of the lack of flow or presence of natural barriers near the tributary confluences.

Coolwater refugia at tributary deltas are generally very small and, as described previously, their size is affected by fluctuations in water surface elevations. Other coolwater refugia may exist in Boundary Reservoir at groundwater seeps, but the location, size, and number of seeps are unknown. Competition for space at thermal refugia may be a factor adversely affecting any bull trout. Thermal refugia are used by triploid rainbow trout, westslope cutthroat trout, and mountain whitefish, as observed during relicensing studies in 2007 and 2008. In particular, numerous triploid trout, on the order 100 to 150 fish, were observed congregating at the Sweet Creek delta during August of 2007. Many anglers are aware of this behavioral pattern and target their effort towards cool water refugia during warm water periods. Consequently, any bull trout also using these refugia may be at a higher risk of accidental capture by anglers.

2.3.3.3. Dissolved Oxygen

DO is strongly influenced by, and inversely related to, water temperature. Consequently, high water temperatures can adversely affect the ability of water to retain DO. DO levels can also be affected by plant and animal respiration and the amount of mixing in the water column. DO monitoring indicated that Boundary Reservoir is generally above the state standard of 8.0 mg/L, but several exceedances were recorded for July and August of 2008 within deeper portions of the

Canyon (Station V5) and Forebay Reach (Station V5), and at a shallow water site near the City of Metaline (Station V2). In addition, observations indicated that DO decreased about 1.0 mg/L from the surface to the deepest measurement between July through October, 2008, and these decreases were more prevalent at the Forebay Reach station (V6). The water quality and productivity study concluded that the small DO deficit produced by a low respiration rate indicated incomplete mixing in the water column despite the uniform temperature profiles and that the presence of Boundary Dam was affecting the amount of mixing in the northern portion of the Reservoir. If bull trout were to use the northern portion of Boundary Reservoir during late summer periods they could be adversely affected by DO levels less than 8 mg/L that were measured in waters greater than 20 feet during July and greater than 40 feet during August, 2007.

Macrophyte beds, primarily of Eurasian watermilfoil, *Potamogeton* species, and coontail have the potential for a localized diurnal effect on DO levels as a result of photosynthesis and respiration, but site-specific studies in Boundary Reservoir during 2007 suggested the local effects in the beds did not adversely affect overall DO levels in the reservoir. Macrophytes consume carbon dioxide and produce oxygen during daylight hours while photosynthesis occurs, but during hours of darkness consume oxygen during respiration. Together these result in maximum DO levels during the day and minimum levels (DO depression) at night. Monitoring of DO levels upstream, downstream, and within a macrophyte bed (Site M6) demonstrated low variability at the upstream and downstream locations, but high variability within the macrophyte bed. During periods of high photosynthesis, monitoring indicated that DO levels at night would frequently drop below 8 mg/L, with the lowest DO level recorded at 2.7 mg/L during August at the station across from the City of Metaline (Evaluation of the Relationship of pH and DO to Macrophytes in Boundary Reservoir Study, SCL 2009b). Vertical profiles taken in the middle of the shallow old channel (about 29 feet deep at typical summertime water surface elevations) across from the City of Metaline during August demonstrated DO levels at or less than 8 mg/L throughout the water column.

The EPA (1986) reports that DO levels less than 8 mg/L for salmonids, other than embryos, result in some level of impairment, with slight impairment occurring below 6 mg/L, and the limit to avoid acute mortality at 3 mg/L. Except in macrophyte beds, measurements in Boundary Reservoir were greater than 7.0 mg/L and most were above 7.6 mg/L, and exceedances of Ecology's DO standard were uncommon, both spatially and temporally, in 2007 and 2008 (Relationship of pH and DO to Macrophytes Study Final Report, SCL 2009b). Despite some indications of low DO levels near to and within macrophyte beds, DO generally remains above state standards and suitable for bull trout. For example, during the same period (August 16) that low DO levels were measured at Station V2, measurements at Station V3, downstream of Metaline Falls, demonstrated DO levels of 8.8 to 9.1 mg/L throughout August (Water Quality Constituent and Productivity Monitoring Final Report, SCL 2009b).

2.3.3.4. Turbidity

Water quality sampling between May 2007 and March 2008 indicated turbidity levels were well below the Washington State Standard of more than 5 nephelometric turbidity units (NTUs) over background when background is 50 NTUs or less (Ecology 2006). The turbidity values (range 0.3 to 4.5 NTUs) measured were less than 5 NTUs during the sample period in Boundary Reservoir; therefore, there were no exceedances of the numeric standard for turbidity. Pelagic and littoral turbidity measurements were similar throughout the reservoir, but with a decreasing trend from May to November. The higher turbidity measurements seen in May and June compared to the rest of the year were due to higher inflows during spring. The seasonal pattern was probably due to several factors, such as higher inorganic particulate matter from runoff in spring, higher phytoplankton abundance (chlorophyll *a*) at the time, and greater water residence and, hence, settling time during the summer. The higher value in March occurred prior to spring runoff and was probably due to high chlorophyll *a*. Based upon the available information, turbidity in Boundary Reservoir is not expected to have an adverse effect on bull trout.

2.3.4. Ecosystem Functions

2.3.4.1. Gravel Transport

The nature and quality of salmonid habitat in rivers is determined, in part, by the transport and instream storage of sediments recruited from upland areas (Spence et al. 1996). In free-flowing river channels, coarse, gravel-sized sediment is primarily transported downstream during moderate to high flows and is stored within the channel bed and banks during intervening low-flow periods. Suitably-sized gravel is particularly important for bull trout spawning habitat. As indicated previously, bull trout are not known to, and not anticipated to, spawn in the mainstem Pend Oreille River or in the lower reaches of tributaries or their deltas. Instead, spawning habitat would be located in upstream reaches of tributary streams that would not be affected by the Boundary Project. Consequently, mainstem gravel transport and distribution is not important to maintaining bull trout spawning habitat. However, sediment transport and deposition are important for shaping the morphology of the river and consequently the quality and quantity of rearing or overwintering habitat for bull trout.

The Pend Oreille River between Boundary Dam and Box Canyon Dam has two distinct segments in terms of sediment transport. The section from the Boundary Dam upstream to Metaline Falls, consisting of the Forebay and Canyon Reaches, is a depositional environment created as a result of the inundation from Boundary Dam. Upstream of Metaline Falls, in the Upper Reservoir Reach, the Pend Oreille River is at times influenced by a backwater effect from Boundary Dam, but it often experiences riverine conditions, particularly when forebay water surface elevations are low or inflows are high.

The Pend Oreille River character has also been greatly influenced by past glaciation. As the continental ice that covered the study area melted northward, widespread deposition of glacial sediments occurred in the Pend Oreille River valley. The melting ice also modified the flow direction of the river (from a historic southern path to the present northward direction), and with this change, rapid down-cutting commenced through the glacial deposits. In areas with resistant bedrock, control points such as Metaline Falls formed, resulting in deeply carved canyons downstream and broad, low gradient valleys upstream. The high energy portion of the Pend Oreille River, the Canyon Reach below Metaline Falls, has been inundated by Boundary Dam. The Upper Reservoir Reach was a low energy environment even prior to hydraulic influence from Boundary Dam, and, therefore, its capacity to transport coarse sediment is, and was historically, limited, and the larger gravels and cobbles forming its bed are only mobilized at high flows and are not transported in large quantities relative to the volume of water conveyed by the mainstem.

Considering the size of the Pend Oreille River watershed above the study area, the supply of sediment delivered to the study area is small. This disparity results from much of the contributing watershed passing through lakes and reservoirs that effectively trap sediment before entering the study area. The total drainage area contributing runoff to the study area is approximately 25,650 square miles; however, the portion of this area considered to contribute sediment is approximately 1,075 square miles.

These factors combine to create a river that is not exceedingly dynamic in terms of its sediment transport response. The results of the mainstem sediment transport model support this statement in that the only appreciable change in the system predicted by the model was continued deposition below Metaline Falls, primarily in the Forebay Reach. The bed elevation changes and volume of deposition in the Upper Reservoir Reach over the potential 50-year term of a future license are estimated to be relatively minor.

Additional aspects of sediment transport and river response of the Pend Oreille River are:

- The low sediment supply to the study area coupled with the low energy river system upstream of Metaline Falls creates a coarse pavement layer along the channel bed. The pavement layer limits the supply of sediment from the river bed and protects the underlying materials from channel degradation, even though the supply of sediment to the reach is small.
- The operation of Box Canyon Dam, located at the upstream extent of Boundary Reservoir, limits the supply of bed material to the Upper Reservoir Reach to flow rates that exceed 80,000 cfs. The hydraulic influence of the Boundary Dam affects the transport of sediment through the Boundary Reservoir; however, the effect of Project operations on sediment transport is negligible. The Project ceases to operate in a load following mode when flows into the reservoir exceed the turbine capacity (55,000 cfs). In general, most sediment is transported at flows approaching or greater than the "channel forming" flow (the estimated 2-year recurrence interval peak flow magnitude is 85,800 - 107,000 cfs [SCL 1997]). The operation of the Box Canyon Dam can create a temporary deficit of coarse sediments if the peak flows do not reach 80,000 cfs for an extended period of years because the leaves at the dam will not be lifted to release the temporarily stored bed load.
- The Tailrace Reach is even less dynamic than the reaches upstream of Boundary Dam because it is more heavily armored with large material and nearly all the inflowing sediment supply is trapped in Boundary reservoir, except for silts and clays and a small amount of sand.

Based upon sediment transport modeling (HEC-6T) conducted during relicensing (Sediment Transport and Boundary Reservoir Tributary Delta Habitats Study, SCL 2009b) the following was concluded:

- The morphology of the mainstem Pend Oreille River from Box Canyon Dam to the Canada Border was predicted to not substantially change over the 50-year term of a new license, except as a result of sediment accumulation in the Boundary Dam forebay. The predicted increase in channel bed elevation in the forebay is up to 20 feet, which is approximately 10 percent of the 200-foot average depth of this reach.

- The gradations of the mainstem channel substrates are not predicted to vary considerably from existing gradations over the 50-year term of a new license, except for localized areas of deposition. The Upper Reservoir Reach substrate is predicted to remain dominated by coarse gravels and cobbles, the Canyon Reach is predicted to continue to be dominated by boulders and bedrock (with sand and finer materials occurring in depositional areas), the deposition of silts and clays is predicted to continue in the Forebay Reach, and boulders are predicted to continue dominating channel substrate in the Tailrace Reach.
- Annual high flows that have the greatest capacity to mobilize and transport sediment typically exceed turbine capacity at the Project except during dry years. When flows exceed turbine capacity, the Project ceases to be operated in a load following mode and the hydraulic influence of Project operations becomes negligible.
- The simulated channel morphology over the period of a new license is so similar to the existing morphology that no significant responses on the morphology (and associated delta habitats) of tributary deltas were predicted. For example, there was no significant sediment accumulation modeled in the mainstem at the confluence of a tributary delta that could cause sediment delivered from the tributary to pile up and change the morphology of the delta.
- Downstream of Metaline Falls, the backwater from Boundary Dam has inundated the canyon and forebay and greatly reduced the ability for sediment to be transported, creating a depositional environment. However, sediment deposition was estimated to be approximately 4,500 acre-feet over the 39-year period from 1967 to 2006. This relatively small amount is a result of two factors:
  - The supply of sediment to the Boundary Reservoir is small; and
  - Because of the relatively small storage volume of the reservoir compared with inflow, the Project passes over 99 percent of clay, and approximately 75 percent of silt, although nearly all bedload is trapped.

The available information and modeling suggests that the morphology of the riverbed and the sediment size distribution in the Action Area are unlikely to substantially change from the current condition. The tailrace reach will continue to be limited in the availability of gravel as a result of deposition behind Boundary Dam. However, general life history information suggests that bull trout are unlikely to use the tailrace for spawning (Pratt 1992). Consequently, the adverse effects of reduced gravel levels in the Boundary Dam tailrace are expected to be minimal for bull trout.

2.3.4.2. Woody Debris Transport

Large woody debris (LWD) can be an important component of aquatic habitat in both riverine and reservoir habitats (Bjornn and Reiser 1991, Northcote and Atagi 1997). LWD provides habitat complexity, cover, and substrate for fish and macroinvertebrates and has been identified as an important component of bull trout habitat (Baxter 1997). As LWD decomposes, it may also provide nutrients to the water column and sediments (Harmon et al. 1986). LWD in reservoirs can be divided into three categories, each with a distinct biological function, based upon wood location: 1) submerged LWD, 2) floating LWD, and 3) shoreline LWD.

No generally recognized criteria for LWD size and distribution in Pacific Northwest reservoirs are available. For rivers and streams east of the Cascade Mountains, the USFWS and NOAA Fisheries consider streams with more than 20 pieces of LWD greater than 12 inches in diameter and 35 feet in length to be “properly functioning” (NMFS 1996). However, the physical processes affected by LWD in reservoirs and large rivers similar in form to the Pend Oreille River are likely to be different than the relatively small streams reported in the literature. Nevertheless it is reasonable to assume that larger wood has a greater likelihood of being stable and a higher potential to create water velocity breaks, fish cover, complex habitat structure, and surface area for the production of periphyton and macroinvertebrates that prefer woody substrate over rock substrate.

The Project affects the abundance, distribution, and quality of LWD as a component of aquatic habitat within the reservoir and downstream of Boundary Dam. Fluctuations in Boundary Reservoir water surface elevations may affect wood recruitment indirectly by affecting the establishment of new riparian stands adjacent to the varial zone (Inventory of Riparian Trees and Shrubs [Riparian Study], SCL 2009b). Wood recruitment mechanisms adjacent to lakes or reservoirs are primarily windthrow, senescence, or mass wasting events. Recruitment may also occur by transport from tributaries or passage over Box Canyon Dam during periods of spill, but the sizes of most of the tributaries draining to Boundary Reservoir are too small to result in transport of large wood pieces that could provide substantial habitat structure.

The increase in wood collected at the trashrack during the 2008 high flow year compared to 2007 suggests that peak flows are an important factor for the redistribution of LWD within the Pend Oreille River (Table 2.3-7). If LWD is delivered to Boundary Reservoir from tributaries or Box Canyon Reservoir, a portion could eventually become stranded on the floodplain or gravel bars and, when inundated during periods of high water surface elevations, serve as littoral habitat for aquatic invertebrates and fish. As reservoir levels recede, some of the non-anchored pieces could float off of these areas and into the main portion of the reservoir.

Reservoir fluctuations can affect the portion of time that a given piece of wood provides habitat. LWD that is stranded on mid-channel bars or along the shoreline during peak runoff periods may be at elevations above the water's surface during other parts of the year. Other pieces of wood may be located within the pool fluctuation (varial) zone affected by Project operations and may intermittently provide aquatic habitat.

Removal of LWD at the Boundary trashrack results in the potential depletion of shoreline wood farther downstream at Seven Mile Reservoir or Waneta Reservoir. Consequently, LWD removal at Boundary Dam primarily affects bull trout habitat outside of the Action Area, and outside the Pend Oreille River Core Area; only about one mile of the Pend Oreille River is located between Boundary Dam and the U.S.-Canada border. Similarly, removal of wood at Albeni Falls Dam and Box Canyon Dam depletes the amount of wood that enters Boundary Reservoir and could potentially contribute to bull trout habitat.

Table 2.3-7. Summary of Large Woody Debris Collected at the Boundary Dam during 2007 and 2008.

	Diameter at Large End	5 to 17 ft	17 to 50 ft	Greater than 50 ft	Total	Number with Root Wads
March 22 and July 29, 2007	4 to 12 in	130	36	2	168	17
	12 to 24 in	10	19	6	35	15
	24 to 32 in	1	1	2	4	2
	> 32 in	0	0	1	1	1
	Total	141	56	11	208	35
June 2 – 17, 2008	4 to 12 in	1084	194	23	1301	109
	12 to 24 in	82	41	23	146	12
	24 to 32 in	3	6	5	14	5
	> 32 in	3	1	0	4	2
	Total	1172	242	51	1465	128

Source: SCL 2009b; unpublished data.

As described previously, mapping conducted during 2007 demonstrated that LWD was distributed in concentrated areas throughout the reservoir, and some of these areas have remained stable since 2005. Throughout the reservoir 1,531 pieces of LWD were counted, which had a total volume of 63,350 ft^3. The LWD counted was primarily along the shoreline because submerged wood was difficult to observe. However, some of the LWD would be submerged for part of the year, depending on the flow from Box Canyon and operation of the Project. The volume and number of pieces of shoreline LWD per mile of reservoir was highest in the Canyon Reach (118 pieces/mi), lowest in the Upper Reach (53 pieces/mi), and intermediate in the Forebay Reach (80 pieces/mi). Stumps accounted for 141 pieces (about 8 percent) of the LWD counted along the shoreline, which resulted from timber harvest when the reservoir was created. The number of stumps counted in the inventory is considered an underestimate, because additional stumps were likely submerged and not visible during the survey. Floating wood generally ends up at the trash rack and is removed from the reservoir (LWD Management Study, SCL 2008c).

LWD mapping indicates that wood in the largest diameter category (i.e., greater than 32 inches) is extremely rare (about 0.4 percent if the numerical total and 1.3 percent of the volume), and wood in the largest length category is numerically low (399 pieces, 26 percent of total) but provides the most wood volume (40,717 ft^3, 64 percent of total). Records of LWD removal at Boundary Dam indicated that the proportions in the largest length and diameter categories were transported during 2007 and 2008 are also very low, so their removal reduces even further the amount of a rare resource that could potentially benefit aquatic habitat in the Pend Oreille River. Notably, 164 pieces of LWD greater than 12 inches in diameter were removed at Boundary Dam during 2008, which is about 29 percent of the LWD standing crop of those size categories that were counted along the shoreline during 2007. Consequently, LWD removal at Boundary Dam, particularly during high flow years, appears to potentially have a substantial effect on the number and volume of large woody debris over the one-mile reach between Boundary Dam and the U.S.-Canada Border in the Pend Oreille River.

Mass wasting events along the reservoir shoreline can result in the recruitment of new LWD to the system. However, areas with chronic erosion problems will not grow new trees. An erosion study conducted as part of relicensing inventoried 132 erosion sites along 15.5 miles of reservoir shoreline using GIS and aerial photos (Erosion Study Final Report, SCL 2009b). Trees and LWD were observed at only a few locations. Consequently, little high value LWD was available for recruitment. Of inventoried erosion sites, 60 were visited with relicensing participants to evaluate site-specific effects and the potential need for erosion control measures. Of these, only one of the sites that warranted consideration for erosion control measures, near Sullivan Creek (site 26E112), was identified as having a substantive effect on riparian habitat. Overall, Project-related mass wasting along the reservoir shoreline is considered to have a minor effect on LWD that could contribute to aquatic habitat.

Overall, the Project has a small effect on LWD resources through the removal of LWD at Boundary Dam and by limiting the potential development of new riparian stands of trees. The degree to which bull trout would use LWD resources in the reservoir and tailrace is uncertain. Bull trout are strongly associated with LWD and large substrate while occupying streams (Pratt 1992), but little information is available concerning microhabitat features used in lakes and reservoirs. Tracking by Bassista et al. (2005) of five bull trout outfitted with acoustic tags in Lake Pend Oreille indicated that bull trout used benthic areas during the spring at locations an average of 500 feet offshore at a mean depth of 75 feet. During summer bull trout mostly used benthic areas (66 percent of observations), but were also found in nearshore (25 percent of observations) and pelagic areas. During the fall and winter, observations were only made on two bull trout that were at depths of 26 to 203 feet; most observations were in nearshore benthic areas and the remainder were in the pelagic zone. Based on the observations by Bassista et al. (2005), bull trout are not likely to substantially use LWD along reservoir shorelines, but could perhaps use sunken LWD or submerged stumps. Consequently, the small effect on LWD resources by the Project is likely to translate into little to no adverse effects on bull trout.

2.3.4.3. Floodplain Connectivity

Rivers construct and maintain channels such that small and moderate-sized discharges (less than or equal to flows with a 2-year recurrence interval) are contained within the channel, while larger discharges that occur less frequently exceed the channel capacity and overflow onto the floodplain. During floods, water is stored in sloughs and side channels, or seeps into floodplain soils and recharges groundwater storage. This stored groundwater slowly drains back to the channel, providing a source of cool inflow during the summer (Naiman et al. 1992). Low-gradient, unconfined channels migrate back and forth across their floodplains in sinuous patterns in response to differential patterns of bank erosion and sediment deposition. Channel migration may occur as a result of slow, steady erosion of the outside of a meander bend, or it may occur as a sudden shift into an old channel during flood events. As a result of these processes, natural low gradient, alluvial channels typically develop a network of low-flow channels containing numerous gravel bars, side channels, abandoned oxbow lakes, sloughs and wetlands. Such off-channel and mainstem margin habitats are an important component of juvenile salmonid rearing habitat and refuge from high flows.

The formation, availability, and quality of off-channel habitat are currently limited in the Action Area due to natural topographic features, flood control operations associated with upstream projects, and land-use changes. Nearly all of Boundary Reservoir and the Boundary Dam tailrace north of Metaline Falls is confined within steep-walled canyon topography. Consequently, the availability of floodplain habitat in that part of the reservoir is naturally low. In contrast, the Pend Oreille River between Box Canyon Dam and Metaline Falls is somewhat broader and there are areas where flood flows result in small backwater sloughs and pools that could trap and/or strand fish. Bank hardening has contributed to confinement of the river in some places upstream of Metaline Falls. Significant amounts of riprap are present in the Box Canyon tailrace and some riprap is present near the mouth of Sullivan Creek and along the west bank as a result of bank stabilization to protect roads and homes. Flood storage operations upstream of the Project (e.g., Hungry Horse Dam) have reduced some of the large channel-altering flows that historically threatened people and property but were also responsible for creating new side channels.

Based on sediment transport modeling of Boundary Reservoir, the limited off-channel habitat available is likely to persist without substantial change over the next 50 years (SCL 2009b). Whether bull trout, if present in the Action Area, would use the available off-channel habitat during portions of the year is unknown. Bull trout tracked by Bassista et al. (2005) in Lake Pend Oreille were always observed at depths greater than 13 feet. If bull trout were to behave similarly in Boundary Reservoir, they would probably not use off-channel habitat, which is shallower than 13 feet deep. Consequently, bull trout use of off-channel habitat in the Action Area is unlikely to be affected by the Project.

2.3.4.4. Non-native Species

Numerous non-native fish species are present in the Action Area and tributaries draining to Boundary Reservoir that could have an adverse affect on bull trout. These include smallmouth and largemouth bass, walleye, northern pike, brook trout, triploid rainbow trout, brown trout, and lake trout. Many of these species are piscivorous and could forage on young bull trout, if present.

Smallmouth bass represent about 9 percent of the fish community (Fish Distribution, Timing, and Abundance Study Final Report, SCL 2009b). Radio-telemetry studies indicate that smallmouth bass use the flooded delta area at the mouth of Sullivan Creek during spring high-flow periods when young salmonids would be expected to move downstream and enter the reservoir (Fish Distribution, Timing and Abundance Study Final Report, SCL 2009b).

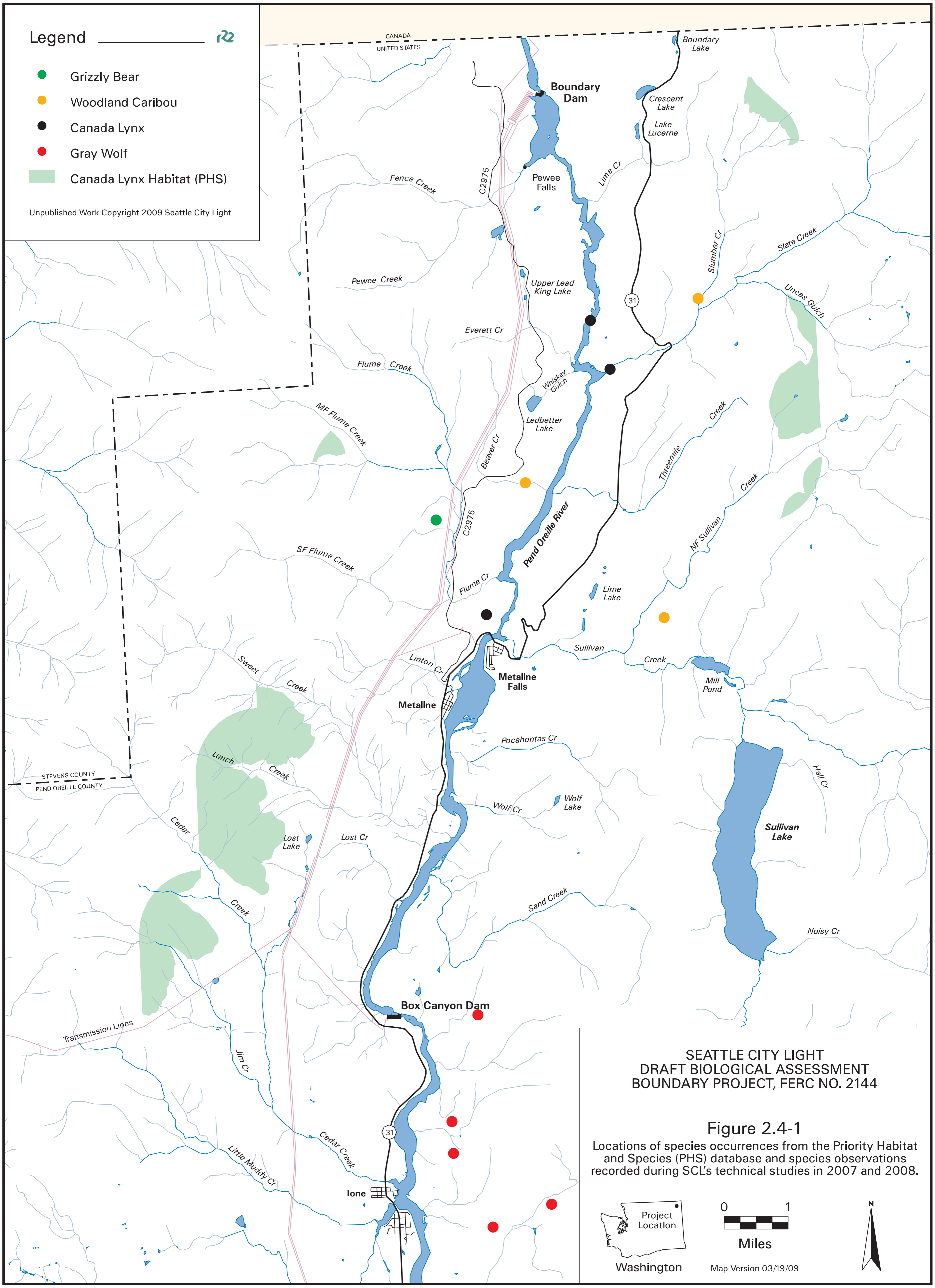
Northern pike, which are highly piscivorous and may prey on salmonids, have recently become established in Boundary Reservoir, likely as a result of entrainment from Box Canyon Reservoir. McLellan (2001) conducted extensive sampling in Boundary Reservoir during 1999 but did not capture any northern pike. However, sampling conducted as part of relicensing in 2007 and 2008 resulted in the capture of 35 northern pike up to 910 millimeters (35.8 inches) in length. In addition, numerous young-of-the-year northern pike were captured and observed during 2008 in vegetated areas considered to be suitable for northern pike spawning. The observations over the last few years suggest that the population of northern pike in Boundary Reservoir is increasing; however, it is unclear how large a population may be sustained within the reservoir.

The self-reproducing populations of non-native trout are relatively small in the reservoir, but could contribute to crowding in thermal refugia during periods of high mainstem water temperatures. In contrast, triploid rainbow trout are stocked into Boundary Reservoir by SCL to provided sport fishing opportunities. During the years 2001 to 2008 SCL stocked an average of 7,099 triploid rainbow trout into Boundary Reservoir, with about half of them being stocked in the spring and the other half during the fall. Relicensing studies during 2007 and 2008 indicated that few of the stocked triploid rainbow trout survive the winter in Boundary Reservoir. The primary threat from the stocked triploid rainbow trout to bull trout is crowding in thermal refugia. They also increase the risk of accidental capture by anglers targeting triploid rainbow trout.

Productivity in Boundary Reservoir is relatively low (Productivity Assessment, SCL 2009b). Theoretically, the presence of non-native trout in Boundary Reservoir could result in competitive interactions with bull trout for food. However, it is unclear if trout populations are sufficiently large, or food resources sufficiently scarce, for competition for food to be a limiting factor for bull trout.

2.4. Terrestrial Species

Three wildlife species listed as Threatened or Endangered under the ESA may occur in the Project vicinity: Canada lynx, grizzly bear, and woodland caribou. Locations of species occurrences from the Priority Habitat and Species (PHS) database and species observations recorded during SCL's technical studies in 2007 and 2008 are shown in Figure 2.4-1. Table 2.4-1 lists these species and provides a summary of their potential occurrence. No federally listed or proposed Threatened or Endangered plant species are known to occur in the Project vicinity. On February 27, 2009, the USFWS reclassified the gray wolf Rocky Mountain Distinct Population Segment (DPS) from Threatened to Delisted (73FR10514), and thus this species is not evaluated in this BA.



SEATTLE CITY LIGHT
DRAFT BIOLOGICAL ASSESSMENT
BOUNDARY PROJECT, FERC NO. 2144

Figure 2.4-1
Locations of species occurrences from the Priority Habitat and Species (PHS) database and species observations recorded during SCL's technical studies in 2007 and 2008.

Table 2.4-1. Federally Listed Threatened and Endangered Terrestrial Species that may occur in the Project vicinity.

Scientific/ Common Name	USFWS Status[1]	USFS Status	BLM Status	WDFW Status[2]	Occurrence
Lynx canadensis Canada lynx	FT	None	None	ST	One individual documented swimming across Canyon Reach in 2008.
Rangifer tarandus caribou Woodland caribou	FE	None	None	SE	Documented in Project vicinity. Introduced to Sullivan Creek Drainage in 1996. Periodic sightings over past 25 yrs.
Ursus arctos Grizzly bear	FT	None	None	SE	Documented in Project vicinity. Periodic sightings over past 10 years.

Notes:
1 FT = federal Threatened species, FE = federal Endangered species,
2 SE = State Endangered, ST = State Threatened.

2.4.1. Canada Lynx

The Canada lynx (*Lynx canadensis*) is a federal and state-listed Threatened species. In northeastern Washington, lynx use remote, high-elevation (> 4,000 feet) forests dominated by mature spruce (*Picea* sp.), subalpine fir (*Abies lasiocarpa*), and thickets of dense lodgepole pine (*Pinus contorta*) that support prey (primarily snowshoe hare [*Lepus americanus*]) populations (Brittell et al. 1989, Stinson 2001). Only a small amount of the land in the general area (within 5 miles) of the Project vicinity is above elevation 4,000 feet. Lynx habitat quality is believed to be lower in the southern periphery of its range than in the northern taiga, because landscapes are more heterogeneous in terms of topography, climate, and vegetation (Buskirk et al. 2000). Population recruitment and home range sizes of lynx in the United States are similar to those reported during the decline or low phase of snowshoe hare cycles at more northern latitudes (Koehler 1990, Apps 2000). Lynx at the southern periphery of their range may prey on a wider variety of organisms, because of differences in small mammal communities and lower average hare densities compared with northern taiga.

There have been several reported lynx sightings within five miles of the Project according to USFS records (USFS unpublished data, CNF Sullivan Lake Ranger District, Borysewicz 2008). During the 2007-2008 field season, a fisheries study crew observed a lynx swimming across the Canyon Reach of the reservoir south of Monument Bar in a narrow section of the reservoir (about 300 feet wide) (Big Game Study Final Report, SCL 2009b), confirming lynx use in the Project vicinity. This individual was thought to be a dispersing individual, traversing the Project vicinity and heading toward higher elevations and more suitable habitat.

The Project area is not located within a designated Lynx Management Zone (LMZ) established in the Washington State Recovery Plan for Lynx (Stinson 2001). LMZs include regions of the state that should be managed for lynx because they are occupied, or were recently occupied (within the past 30 years), by lynx. These LMZs are to be regularly surveyed to monitor the status of populations (Stinson 2001), although no status reports or updates have been issued since the 2001 recovery plan

(WDFW 2008). The two LMZs closest to the Project are the Salmo Priest LMZ to the east and the Little Pend Oreille LMZ to the west. The LMZs have been divided into Lynx Analysis Units (LAUs), which were established to assess habitat conditions and are useful as survey units for documenting lynx occurrence. The Project is nearest to the Russian and Cedar (to the west) and Slate and Totem (to the east) LAUs. The LAUs are at least 1 mile from the Project area.

Recovery goals in the Washington State Recovery Plan for Lynx (Stinson 2001) include the following:

- Lynx are consistently present during 10 consecutive years in >75 percent of the LAUs in LMZs.
- Lynx surveys indicate that recruitment from local reproduction regularly occurs.
- Agreements or forest management plans are in place for federal, state, and major private landholdings.

When these goals are met and verified, lynx will be considered for down-listing from state threatened to state sensitive (Stinson 2001).

The USFS signed an agreement with the USFWS on February 7, 2000, to manage habitat specifically for lynx to minimize the impact of the listing on forest management operations and comply with the ESA (USFWS and USFS 2000). While the species is unlikely to regularly inhabit the Project vicinity, individual animals may travel through the area. The USFWS has initiated the five-year review for grizzly bear and Canada lynx (72 FR 19549 19551); however, publication of this document is pending.

2.4.2. Woodland Caribou

The woodland caribou (*Rangifer tarandus caribou*) is a federal and state-listed Endangered species. A small number of woodland caribou occur in the southern Selkirk Mountains, with most of the animals occurring in British Columbia, north of the Project area. Caribou have been transplanted into northeastern Washington and northern Idaho, including some in the upper Sullivan Creek drainage on the Sullivan Lake Ranger District, beginning in the late 1990s (Audet and Allen 1996). During early winter, caribou move to low-elevation, old-growth cedar (*Thuja plicata*)/hemlock (*Tsuga heterophylla*) forests. They then move up to subalpine fir and whitebark pine (*Pinus albicaulis*) stands once snow becomes sufficiently compacted and crusted for caribou to be able to walk on top of it (USFWS 1994). During spring, caribou move downslope to forage in shrubfields, meadows, and open forest stands.

The majority of the caribou population resides in the Salmo-Priest Wilderness Area, more than five miles east of the Project. Areas above elevation 4,000 feet are included in the Selkirk Mountain Woodland Caribou Recovery Area (USFWS 1994).

Specific goals of the Selkirk Mountain Woodland Caribou Recovery Plan include the following:

- Maintain the two existing caribou herds in the Selkirk ecosystem.
- Establish a herd in the western portion of the Selkirk Mountains in Washington.
- Maintain an increasing population as reflected by March aerial surveys (i.e., r>l).

- Secure and enhance at least 179,000 ha (442,317 acres) of suitable and potential caribou habitat in the Selkirk Mountains to support a self-sustaining population.

To date, no updated information has been reported on the progress of management activities toward these goals.

Over the last 25 years, woodland caribou have occasionally been observed in the general vicinity of the town of Metaline Falls and near the West Side Access Road, and have been documented crossing the river north of Metaline (CNF Sullivan Lake Ranger District Wildlife Species Occurrence database, 1996; Borysewicz 2008). Despite these rare observations, the Project vicinity itself lacks the older forests and elevations typically used by this species.

2.4.3. Grizzly Bear

The grizzly bear (*Ursus arctos*) is listed as a threatened species under the ESA and as a Washington state-listed endangered species. The USFWS has determined that the grizzly bear population in the Selkirk area of Idaho and Washington warrants reclassification to Endangered status, but such action has been precluded by work on other higher priority species (FR 64(94):26725-26733, May 17, 1999). The Grizzly Bear Recovery Plan lists human activity, road building, forestry, and mining as adversely affecting the grizzly bear (USFWS 1993). Since 1975, habitat protection measures implemented by federal agencies under the ESA have focused on providing secure habitat for bears that lessens opportunities for human-caused mortality resulting from hunting (i.e., mistaken for black bear [*Ursus americanus*]), poaching, human-bear conflicts, and livestock-bear conflicts.

The boundary of the Selkirk Mountain Grizzly Bear Recovery Area (SR 31) is approximately 0.75 miles east of the Project area boundary. Thus, the Project area is not within a designated grizzly bear recovery area, although individual grizzly bears that occur outside the recovery area are protected. Populations are estimated to be 40 - 50 animals within the 2,200 square-mile Selkirk Mountain recovery zone (USFWS 2004).

Recovery goals for the Selkirk Mountain grizzly bear population are largely focused on retaining breeding females and reducing the human-caused mortality to zero. These goals are:

- Six females with cubs over a running 6-year average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone, including Canada.
- Seven of the 10 bear management units on the U.S. side occupied by females with young from a running 6-year sum of observations.
- Known human-caused mortality not to exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs; furthermore, no more than 30 percent of this 4 percent mortality limit shall be females.
- The mortality limits cannot be exceeded during any 2 consecutive years.

The USFWS has initiated the five-year review for grizzly bear and Canada lynx (72 FR 19549 19551); however, publication of this document is pending.

The CNF Forest Plan (USFS 1988) includes grizzly bear management in accordance with the Interagency Grizzly Bear Guidelines (IGBC 1986) and the CNF Guidelines for Management in Occupied Grizzly Bear Habitat. Secure bear habitat is primarily a function of the total and accessible (un-gated) motorized road density. Other guidelines are aimed at reducing bear habituation to recreation sites and other areas of human activity, and reducing direct and indirect bear mortality.

In the early 1990s, Wielgus et al. (1994) estimated densities of 3.65 bears per 100 square miles in the U.S. portion of the Selkirk grizzly bear recovery zone, whereas the Canadian portion had a density of 6.3 bears per 100 square miles. According to USFS records, grizzly bear sightings have been recorded within the last 10 years on both sides of the reservoir. In 2004, USFS biologists observed a grizzly bear feeding on a deer carcass in the lower Sullivan Creek drainage. Radiotelemetry from 2003 indicated that a grizzly bear may have used Slate Creek as a travel corridor before crossing the reservoir (USFS unpublished data, CNF Sullivan Lake Ranger District, Borysewicz 2008). A local resident reported that grizzly bears are often seen in the spring foraging in the meadows on both sides of Boundary Reservoir south of Metaline Falls in the secondary study area (Luhr 2008). Grizzly bears require spring forage habitats that provide large amounts of succulent, palatable herbaceous plants when they emerge from den sites. In most cases, these habitats are restricted to wetlands and riparian areas. During the summer and fall, berry-producing shrubfields are important. Both spring and summer/fall forage habitats are limited in the portions of the CNF near the Project (USFS 1998). Den sites are associated with high elevations farther to the east near the Salmo-Priest Wilderness Area (USFS 1998).

3 DESCRIPTION OF ACTIONS

3.1. Proposed Project Operation

Under the new FERC license term, SCL proposes to operate the Project as it is currently licensed, but with the formalization of two currently voluntary operational measures: forebay water surface elevation restrictions for summer recreation enhancement and turbine unit sequencing to reduce TDG production during non-spill conditions. The proposed summer forebay water surface elevation restriction is as follows: from Memorial Day weekend (starting Friday evening) through Labor Day weekend (ending Monday evening), forebay water surface elevations will be maintained at or above 1,984 NAVD 88 from 6:00 am through 8:00 pm to facilitate recreational access and use. From 8:00 pm through 6:00 am, forebay water surface elevations will be maintained at or above elevation 1,982 feet NAVD 88. Conditions or events under which these forebay restrictions will not be followed include 1) any event that triggers the Project Emergency Action Plan, 2) power emergencies, as defined by WECC Minimum Operating Reliability Criteria (WECC 2005), 3) equipment failures or emergencies at the Project dam or powerhouse, and, although unlikely during summer, 4) reservoir drawdowns needed for safe passage of anticipated flood flows to minimize damage to human life and property.

To reduce TDG under normal, non-spill operations, SCL will operate Units 55 and 56 above 125 MW and sequence their startup and shutdown so that they are the last units to be brought on line and the first units to be shut down (see Section 5.3.2.3.2, Total Dissolved Gas, of the PLP for greater detail on the effect of unit sequencing).

3.2. Conservation Measures Affecting Aquatic Species

Proposed non-operational PM&Es relevant to bull trout are as follows:

- Mainstem LWD and tributary deltas
- Offsite tributary mitigation
- Upstream fish passage
- Excavation of mainstem trapping pools
- Northern pike monitoring and radio-telemetry study
- Bull trout genetic conservation program
- TDG abatement measures

These measures are described in more detail below and Section 5.3.3.3 of the PLP.

3.2.1. Mainstem Large Woody Debris and Tributary Deltas

Relicensing studies indicate that native and non-native salmonids use tributary deltas during summer to take advantage of coldwater refugia. Although no bull trout were observed in coldwater refugia during relicensing studies conducted in 2007 and 2008, observations from a previous study in Boundary Reservoir (R2 Resource Consultants 1998a) and Box Canyon Reservoir (Geist et al. 2004) suggest that bull trout, when present, use these habitat features. Bull trout would also use tributary deltas when foraging during other periods of the year. Habitat studies indicated scarce amounts of LWD or other forms of cover in these tributary delta habitats. SCL proposes to enhance tributary delta habitat through placement of LWD at three tributaries to Boundary Reservoir. Sullivan, Sweet, and Flume creeks have been tentatively identified, but selection of target tributaries and design of LWD placement will be developed during implementation planning and collaboration with relicensing participants prior to and following issuance of the new license. Sullivan, Sweet, and Flume creeks' deltas are proposed for the initial focus because of their size and the presence of established delta habitat.

Specific details regarding the size and placement of LWD would occur as part of implementation planning, but SCL proposes to construct four engineered structures within five years of license issuance. The design-life for structures is anticipated to be five to 10 years; consequently, it is anticipated that maintenance or replacement structures will be needed every five to 10 years during the new license term. All LWD structures would be appropriately anchored through the use of pilings, boulder ballast, and cabling, or other methods to prevent transport of the large wood. Wood could be derived from collections at the Project forebay trashrack, from the USFS, or from commercial sources. Priority would be given to logs with attached rootwads, but final selection would depend on the site-specific project plan and availability.

3.2.2. Offsite Tributary Mitigation

Bull trout have infrequently been observed to use tributaries to Boundary Reservoir since the early 1980s (Table 2.3-3), and the characteristics of historic populations are unknown. Nevertheless, the bull trout recovery plan for the NWU Recovery Team includes the establishment of local populations in Slate Creek and Sullivan Creek (USFWS 2002). Therefore, the quantity and quality of tributary habitat in Slate and Sullivan creeks that is suitable for bull trout is important to the recovery efforts in the NWU. Habitat in other tributaries could also be important for supplying fry and juvenile fish that bull trout could forage on in Boundary Reservoir or in tributary deltas.

To partially offset potential unavoidable effects due to Project operation, SCL is proposing to implement enhancement and rehabilitation measures in tributaries draining into Boundary Reservoir. A limiting factors assessment and field surveys within eight tributaries identified12 projects with a medium or high ranking for protecting, enhancing, or rehabilitating tributary habitat for native salmonids (Table 3.2-1) (Tributary Productivity Assessment Final Report, SCL 2009b).

SCL is proposing to implement each of these 12 projects within five years following issuance of the new license. Other potential projects could be identified and substituted during discussions with relicensing participants. The types of projects could include culvert replacement or repair, riparian plantings, streambank stabilization, LWD placement, and others. In addition, SCL is proposing to implement a pilot project for reducing the abundance of non-native salmonids, mainly brook trout, in Sweet Creek. In the limiting factor assessment, non-native fish reduction was ranked low because of mixed success experienced in other streams where reduction has been attempted and because of the potential for strong opposition from anglers. Nevertheless, nonnative trout, especially brook trout, have been cited as an important limiting factor to the recovery of bull trout (Andonaegui 2003). Each of the projects would include some level of post-implementation monitoring. Specific projects and monitoring plans would be selected in a collaborative fashion between SCL and stakeholders as part implementation planning.

Table 3.2-1. Proposed protection, enhancement, and rehabilitation projects within tributaries draining to Boundary Reservoir.

Tributary [River Mile (RM)]	Quantity of Habitat Affected	Rank
Habitat Protection (protection of acres of land)		
Sullivan Creek (RM 0.0 – 0.66): Buffer Protected Area	40 acres (0.66 miles of stream)	Medium
Sweet Creek (RM 0.0 – 0.50): Buffer Protected Area	20 acres (0.50 miles of stream	Medium
Culvert Modification (stream habitat made accessible)		
Slumber Creek (RM 0.2)	0.30 mile	Medium
Styx Creek (RM 0.1)	1.90 miles	Medium
Non-Native Fish Eradication		
Sweet Creek	Entire drainage	Low
Riparian Planting (stream miles or acres)		
Sullivan Creek (RM 0.3 – 0.6)	0.19 mile	High
Linton Creek (RM 0.0 -0.21)	0.21 mile	High
Combined Habitat, Stream Channel, and Bank Enhancements (stream miles)		
Sullivan Creek (RM 0.3 – 0.6)	0.30 mile	Medium
Sullivan Creek (RM 2.30 – 2.70)	0.40 mile	High
Sullivan Creek (RM 2.50 – 3.00)	0.47 mile	High
Sullivan Creek (Bank Enhancement) (RM 2.30 – 3.25)	0.09 mile	High
Sullivan Creek (Bank Enhancement) (RM 2.30 – 3.25)	0.06 mile	High
Sweet Creek (RM 0.4 – 0.5)	0.10 mile	Medium

3.2.3. Upstream Fish Passage

Boundary Dam prevents upstream movement of fish, including bull trout. However, relicensing studies indicate that the abundance of bull trout in the Boundary Tailrace Reach is very low. From March 2007 to November 2008, three bull trout were captured during monthly electrofishing and gillnet sampling in the Boundary Dam tailrace, and a fourth bull trout from the Salmo River was detected via radio telemetry in 2008.

Because of the low abundance of bull trout in the tailrace and the high level of uncertainty regarding the feasibility of implementing a permanent upstream passage solution, SCL is proposing a phased approach to addressing the need for upstream passage. Similar approaches have been used for the recently relicensed Clark Fork River (FERC No. 2058) and Box Canyon projects (FERC No. 2042). As part of this approach, SCL proposes that a Fish and Aquatics Workgroup (FAWG) be created, with members from SCL, WDFW, USFS, USFWS, and other interested parties.

The first phase of the upstream passage program would include design and construction of a temporary trap-and-haul facility and development of protocols for deploying the trap and handling captured fish. SCL envisions that the design and construction of the temporary facility could occur within the first five to nine years following issuance of the new license, depending on other activities in the watershed. The objectives of this phase would be to research recent developments and implementation of trap-and-haul facilities under similar hydraulic, river channel, and operational constraints; conduct any necessary field measurements and surveying; develop design criteria; develop conceptual and final facility designs; and construct the temporary trap facility. During this period SCL would implement traditional trapping methods (e.g., fyke net) at various places in the tailrace to help determine appropriate locations for deploying the temporary trap-and-haul facility. All planning components would be conducted in consultation with the FAWG.

Development of protocols for deploying the trap and handling captured fish is an important objective of the first phase of the upstream fish passage measure. Feasibility for providing upstream passage during some times of the year may be affected by flow and temperature, i.e., when critical thresholds are exceeded. Flow or water velocities could exceed levels that are safe for operating in the Boundary Dam tailrace, could damage equipment, or result in capture efficiency that is too low. High water temperatures could result in stress to fish, thereby possibly precluding fish handling at some times of year.

Estimates of spill magnitude and timing are available for 1987 through 2006. Approximately 71 percent of the time spill occurred, flows were greater than 58,100 cfs, and about 23 percent of time flows were between 47,201 and 58,100 cfs. Spill primarily occurs in May and June. During December through March, spill has only occurred in one or two years during the 20-year period of record, and spill is insignificant during August through November (maximum of 1.3 percent of available monthly hours; 1 or 2 years out of 20). Substantive occurrences of spill (greater than 5 percent of available hours) are more frequent during April (4 of 20 years), May (12 of 20 years), June (12 of 20 years), and July (6 of 20 years). The median percentage of hours when spill occurred during May and June was 11 percent and 25 percent, respectively. During the first phase of upstream fish passage, SCL proposes to determine, in conjunction with the FAWG, the spill conditions that would prevent operation of a trap-and-haul facility.

Water temperatures in the Pend Oreille River at times exceed the tolerance level for bull trout. High water temperatures would likely reduce the likelihood of capturing bull trout, because they tend to congregate in thermal refugia to avoid areas of warmer water. Collection facilities and handling of captured fish could exacerbate the metabolic stress that would already be present at high temperatures. Furthermore, in the case of an upstream trap-and-haul facility, suitable release locations could be limited at some times of year. Short to moderate duration (days to weeks) holding facilities might be required, and complicated acclimation procedures could be needed to maximize the likelihood of fish survival following release. Under some circumstances the risks of operating the facility might exceed the benefits of providing the passage.

Water temperatures measured by the USGS at gage 12398600 at the U.S.-Canada border from October 1973 through September 2007 indicate that mean daily temperatures greater than 18 ˚C frequently (>75th percentile) occur as early as the last week in June and as late as the third week in September (Figure 2.3-1). In contrast, median (50th percentile) mean daily temperatures reach 18 ˚C in the first week of July and extend through the second week in September. Notably, these are the periods that bull trout spawning migrations occur in the Salmo River (Baxter and Nellestijn 2000). The plots of mean daily temperature percentiles in conjunction with temperature thresholds for bull trout suggest that trap-and-haul operations could pose a risk to fish health during July, August, and the first half of September, and during some years stressful thermal conditions could be present up to several weeks before or after this period. During the first phase of the upstream passage program, SCL proposes to determine, in conjunction with the FAWG, the protocols for handling, transport, and release of captured fish.

The second phase of the approach would be to deploy, test, and refine the temporary trap facility. SCL envisions the testing phase would occur between five and 10 years following installation of the trap. During this phase, capture of fish in the temporary trap would be used to evaluate the design and location of the facility, refine the periods of its operation and efficiency, and evaluate the numbers of bull trout entering the temporary trap as well as the time of year when they are present in the tailrace. Monitoring plans would be developed in consultation with the FAWG.

As part of monitoring during the test phase, SCL proposes to take tissue samples from all bull trout captured at the temporary facility and send them to a genetics lab for rapid (48 to 72 hour) population identification. During this period the captured fish would be held in either a shore-based holding tank, or a holding tank built into the temporary trapping facility. Holding duration, handling, transport, and release of any captured bull trout would follow protocols to be established during the first phase in consultation with the FAWG. These protocols would also address any marks or tags that might be applied to captured fish, including radio and/or acoustic tags.

The third phase of the approach includes evaluating a range of potential future options that are dependent on the results of Phase 2. These options could include continuation with the configuration as operated under Phase 2, construction of a permanent trap-and-haul facility, construction of a semi-permanent facility that is deployed during strategic periods corresponding to typical upstream movements of the target species, construction and testing of an alternative design temporary trap facility, determination that passage is not needed due a lack of target fish captures that meet criteria for transport above Boundary Dam, pursuit of alternative mitigation in lieu of an upstream passage facility, or other options developed in consultation with the FAWG. During Phase 3, the FAWG could conclude that upstream passage is desirable but infeasible under the site-specific conditions, leading to the conclusion that alternative mitigation is required. Alternative mitigation would be developed in consultation with the FAWG and could include additional enhancement and restoration projects in tributaries to Boundary Reservoir, development of a native salmonid supplementation program, or other options.

3.2.4. Excavation of Mainstem Trapping Pools

Relicensing studies during 2007 and 2008 suggest that fry and young-of-year fish may become trapped in pools during periods of declining reservoir water surface elevations and under some conditions may suffer injury or mortality during these events. While nearly all of the trapped fish observed during 2007 and 2008 were non-salmonids, such as suckers or minnows, these trapping mechanisms could also potentially adversely affect bull trout if they were present in the trapping areas when water surface elevations decline.

During 2008, Stranding and Trapping Region 10 within the Upper Reservoir Reach was identified as an area with a high occurrence of trapping. The pools and depressions at the site are the result of aggregate mining that occurred prior to completion of the Project. The excavated depressions have persisted since construction of the Project since the area is geomorphically stable. SCL proposes to dredge outlet channels of four pools (totaling about 74,000 square feet) within Region 10 of the reservoir to connect the pools to the mainstem river. The objective of this measure would be to provide fish within the pools an opportunity to avoid being trapped or subjected to dewatering during periods of declining reservoir water surface elevations. SCL proposes to plan and implement dredging within five years of license issuance. Implementation planning would occur in consultation with the FAWG. SCL is proposing the excavation of connecting channels in Region 10 because these habitats are man-made and stable. Excavation of channels connecting pools or depressions to the mainstem flow in other regions will be considered in lieu of other PM&Es should the FAWG determine that greater protection of aquatic resources can be achieved through such measures.

Although excavating connecting channels at Region 10 will reduce the incidence of stranding and trapping, the increased stability of habitats may allow colonization by an assemblage of warm and cool water predators. Biological monitoring of the region will occur at five-year intervals following implementation. Monitoring will be conducted following spring runoff to evaluate the distribution and abundance of fish species inhabiting Region 10. Measurements of physical habitats within the region will be collected to assess the morphology of the dredged channels and evaluate whether they continue to function as designed. If monitoring suggests the channels are not functioning as planned, remediation measures will be developed and implemented.

3.2.5. Northern Pike Monitoring and Radio-Telemetry Study

Northern pike (*Esox lucius*) is a relatively new predatory species inhabiting Boundary Reservoir that could adversely affect the abundance and distribution of bull trout. This study would monitor trends in the northern pike population over the near term and use radio-telemetry to understand the distribution and habitat use of pike in the reservoir. Northern pike are known to use macrophytes for cover and foraging habitat and can be significant predators on salmonids. A better understanding of their distribution, abundance, and habitat use in Boundary Reservoir may help identify areas where macrophyte control could potentially reduce habitat for northern pike, understand the effect of pike predation on bull trout recovery efforts, and assess the probability of success of PM&Es such as upstream fish passage.

The northern pike monitoring program will be implemented within five years of license issuance and include boat electrofishing at three or four selected sites in the Upper Reservoir Reach during two periods during a given year. Surveys will be conducted during each of the first two years following program initiation, and then up to three years of additional surveys would be completed within 20 years following license issuance for a total of five years of surveys. The timing of the latter three years of surveys would be determined in consultation with the FAWG. All captured northern pike will be weighed and measured, and their stomach contents will sampled via gastric lavage. A numbered Floy tag will be attached to larger northern pike (size to be determined), and angler rewards for returned tags will be made available in conjunction with the trout stocking program (see Section 5.3.3.3.1). During the first two years of surveys up to 30 northern pike will be radio-tagged as fish of an appropriate size and condition become available. Tagged fish will be tracked via a combination of fixed receivers placed in the Upper Reservoir and at Boundary Dam and mobile tracking conducted monthly in the Upper Reservoir during the spring, summer, and fall. Details of the program will be developed in consultation with the FAWG.

3.2.6. Bull Trout Genetic Conservation Program

A bull trout genetic conservation program is being discussed with relicensing participants. The objective of the program would be to produce fry or juvenile bull trout to be released in Boundary Reservoir tributaries to supplement existing populations, or more likely, introduce bull trout to stream reaches where they are currently absent. Conceptually, this could take the form of brood stock collection, egg incubation, and early fry rearing (facility based) or could take the form of brood stock collection, partial egg incubation, and use of egg boxes in tributaries (field based). Protocols for the collection of brood stock, artificial spawning, release of fry or juveniles, and egg-box construction and location would be developed collaboratively through the FAWG. Release sites could include locations where non-native salmonids have been removed as part of the non-native trout reduction program described above (Section 3.2.2 of this BA). It is anticipated that if bull trout eggs or adults are acquired, it would be from elsewhere in the region (e.g., Salmo River, Priest River, or tributaries to Lake Pend Oreille) because few, if any, eggs or adults are currently present in tributaries to Boundary Reservoir.

3.2.7. Total Dissolved Gas

TDG levels have the potential to adversely affect any bull trout that use the Tailrace Reach during periods of spill. Following issuance of the new license for the Project, SCL will implement measures identified in its Draft TDG Attainment Plan (Attachment 3 to the PLP [SCL 2009a]) that are designed to attain TDG compliance at the Project. SCL will initially evaluate the following three gate alternatives for TDG abatement:

- Throttle Sluice Gates, which involves operation of sluice gates in partially open positions.
- Roughen Sluice Flow, which entails modification of the sluice gate outlets to break up and spread flow.
- Spillway Flow Splitter/Aerator, which entails modifying the spillways to aerate, break up, and spread flow.

The three gate alternatives all involve spilling flow through existing outlets (the seven sluice gates and two spillway gates) into the tailwater plunge pool and rely on reduction in TDG production by spreading the flow and limiting plunging effects of the confined water jets. The historic performance of these outlets at small gate openings indicates the potential for successfully reducing tailwater TDG levels. Reduction of TDG levels would decrease the risk of gas bubble trauma in bull trout in the Boundary Dam tailrace.

3.3. Conservation Measures Affecting Terrestrial Species

Proposed environmental measures that will benefit terrestrial, federally listed species will be addressed in the TRMP (Attachment 2 to the PLP [SCL 2009a]) for the Project. Aspects of the TRMP that apply include a monitoring and adaptive management approach for Threatened and Endangered species that will be developed in coordination with a Terrestrial Resource Workgroup (TRWG). If Project-related effects to Threatened and Endangered wildlife are identified during monitoring, a joint solution will be developed between SCL and the TRWG. Other aspects of the TRWG that will benefit federally listed species include standards and BMPs for SCL maintenance activities, management prescriptions for all SCL-owned lands within the Project boundary, and incorporation of the BWP and an adjacent 88 acres of land into the Project boundary as well as management of these lands for terrestrial resource protection and enhancement.

4 EFFECTS OF ACTION

4.1. Aquatic Species

4.1.1. Direct Effects

The direct potential adverse effects of the Project on any bull trout include:

- Fluctuations in reservoir and tributary delta habitat as a result of varying water surface elevation due to load following operations
- Mortality and injury during entrainment at Boundary Dam
- Potential for fish trapping or stranding
- Loss of connectivity with habitat upstream of Boundary Dam
- Risk of gas bubble trauma resulting from elevated TDG concentrations in the Boundary Dam tailrace

Each of these effects has been described in detail above. The first two effects are unavoidable and are expected to occur under the new proposed license at a level similar to what has occurred under existing conditions, which has been very low because bull trout are quite rare in the Project area. However, formalizing the summer forebay water surface elevation restriction (see Section 3.1 of this BA), as proposed by SCL, will reduce potential adverse effects to bull trout relative to what may have occurred under the existing voluntary restriction. PM&Es are proposed, as described in previous sections, to reduce any adverse effects associated with trapping and stranding, the current lack of upstream fish passage, and risk of gas bubble trauma resulting from elevated TDG levels.

As described in Section 3.2.4, the current level of risk of mortality to bull trout from trapping or stranding in the Action Area is considered low because of the low number of bull trout that have been observed in the past and their large size, which is consistent with life history of bull trout in the region (i.e., juveniles rear in tributary streams for at least several years until they reach 170 - 300 millimeters [6.7 - 11.8 inches] in length). Nevertheless, under the SCL proposal, the potential for trapping and stranding by bull trout should decrease as a result of dredging outlet channels from pools located in Trapping Area 10 of the Upper Reservoir Reach. However, the proposed mitigation will not reduce the potential for trapping or stranding of any bull trout elsewhere in the Action Area. Consequently, some small level of risk to bull trout from trapping and stranding will be ongoing under the proposed license.

As described in Section 3.2.3, a phased approach for implementing upstream passage is proposed under the new license. There is uncertainty regarding the effectiveness of the proposed trap-and-haul facility. Furthermore, it is unlikely that the facility will be able to operate year-round because of physical constraints associated with the Boundary Dam tailrace and the temperature and flow regime of the Pend Oreille River, which are independent of the operation of the Project. Even under an optimistic scenario, it is unlikely that bull trout can obtain complete connectivity with upstream habitat under the proposed mitigation. Consequently, under the new license upstream connectivity is anticipated to improve but may not be fully restored for bull trout.
As described in Section 3.2.7, SCL is proposing to evaluate a number of alternatives for attaining TDG compliance at the Project. Attainment of TDG compliance is expected to completely mitigate for potential Project effects on bull trout, i.e., in the Boundary Dam tailrace. However, TDG levels in the Action Area (in the reservoir upstream of the dam) are the result of upstream operations at Albeni Falls and Box Canyon Dams. Consequently, it is not possible for the Boundary Project to independently restore TDG levels in the Action Area, i.e., upstream of its area of influence.

4.1.2. Indirect, Interdependent, and Interrelated Effects

An analysis of the effects of the proposed action on listed species must determine whether the species in question, in this case bull trout, can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action, the environmental baseline, and any interrelated, interdependent and indirect effects. The baseline includes existing operations of the Boundary Project. Interrelated actions are activities that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those which have no independent utility apart from the action being considered. Indirect effects are themselves caused by the action but are removed in space and/or time. The interrelated, interdependent, and indirect effects include:

- Bull trout recovery activities
- Hatchery and harvest practices
- Changes to flood control operations
- Implementation of the license at the Box Canyon Project
- Disposition of the Sullivan Creek Project
- Implementation of the Waneta Project Upgrade and resulting operational changes at the Seven Mile Project in British Columbia

4.1.2.1. Bull Trout Recovery Activities

Ongoing or planed bull trout recovery activities in the region that could result in more bull trout using Boundary Reservoir will be described in future drafts of this BA.

4.1.2.2. Hatchery and Harvest Practices

WDFW manages fisheries in the Action Area and regulates private and public hatchery releases. WDFW modifies and publishes recreational fishing regulations on an annual basis. Currently, recreational anglers may not target bull trout, but may incidentally catch and release bull trout. Changes in the regulations such as seasons, closed areas, and harvestable sizes and numbers of other trout species could also change the likelihood of the incidental catch of bull trout by reducing or increasing the level of effort expended by anglers.

4.1.2.3. Flood Control Operations

Significant storage reservoirs within the basin include Hungry Horse Reservoir and Flathead Lake in Montana, and Lake Pend Oreille and Priest Lake in Idaho. Other projects along the mainstem upstream from the Boundary Project include the Box Canyon Project, the Albeni Falls Project, the Cabinet Gorge Development and Noxon Rapids Development of the Clark Fork Project in Idaho and Montana, and the Thompson Falls Project in Montana. Downstream of Boundary Dam, the Pend Oreille River flows past Seven Mile and Waneta dams, both in Canada, before entering the Columbia River. Because of the basin size and corresponding annual flow, typically no single project has an overriding influence on flows in the river. Potential influence on flows by individual projects is greater during low-flow periods and for those reservoirs having significant storage capacity (Enserch 1994). In addition to the dams listed above, the Sullivan Creek Hydroelectric Project dam is located on Sullivan Creek, the main tributary to Boundary Reservoir.

The upstream projects have a significant effect on inflows to the Project reservoir. In the absence of upstream impoundments, flows would typically exceed regulated flows from May through July, during the periods when water is stored in upstream projects (SCL 2008a). Regulated flows are typically greater than unimpaired flows from August through April, as stored water is released from upstream projects. Future changes to flood control and other operations at these upstream projects could affect the timing and magnitude of inflows to the Boundary Project and, as a result, interact with Boundary Project operations to influence water surface elevations in the reservoir.

4.1.2.4. Box Canyon Project

The Pend Oreille PUD recently received a new license for its Box Canyon Project. Included in the license articles are a number of measures designed to benefit bull trout, such as turbine upgrades, upstream fish passage, and restoration and enhancement of tributary streams. These improvements, if successful, could increase the number of bull trout in Boundary Reservoir or Boundary Dam tailrace.

4.1.2.5. Sullivan Creek Project

The Pend Oreille PUD is currently in negotiations with federal, state, and tribal agencies regarding the disposition of the Sullivan Creek Project, which the PUD has decided not to relicense. SCL has an interest in the negotiations and is considering potential opportunities for off-site mitigation for the Boundary Project that could include some aspects of the Sullivan

Creek Project. The interrelated effects of the Sullivan Creek Project negotiations and the Boundary Project relicensing will be more fully described in future drafts of this BA.

4.1.2.6. Waneta Upgrade and Seven Mile Project Operations.

BC Hydro's Seven Mile Dam is located 11 river miles (RMs) downstream of Boundary Dam, and Seven Mile reservoir at times backs water up to the base of Boundary Dam. The average maximum water surface elevation of Seven Mile Reservoir is approximately 1,734 feet NAVD 88 (BC Hydro 2003). Because of downstream water quality and flow requirements and capacity limitations at the Waneta Project (i.e., the next project downstream of Seven Mile) the Seven Mile Project has operated to reregulate flows from the Boundary Project. Upgrades to the capacity at the Waneta Project are anticipated to allow the Seven Mile Project to modify its operations to engage in a greater degree of load following. The specific effects of any operational modifications at the Seven Mile Project on pool levels in the Boundary Dam tailrace are uncertain. In general, however, changes could affect the amount of suitable rearing habitat available to bull trout in the Boundary Dam tailrace and could affect the design and operation of the upstream trap-and-haul facility proposed as mitigation for the Boundary Project.

4.2. Terrestrial Species

The three terrestrial threatened or endangered species that may occur in the Project area, Canada Lynx, grizzly bear, and woodland caribou, are wide-ranging species, with territories far beyond the size of the Project vicinity. Limited use of the Project area by these species has been observed. The primary terrestrial effects associated with the Project–water fluctuation effects on shoreline habitat, erosion and loss of habitat, and human disturbance–occur on a localized and discrete scale compared to the expansive home ranges of these species. Potential effects that apply to all of the ESA species are discussed below, followed by a species-specific discussion.

Streams, rivers, and lakes, represent potential obstacles to unrestricted wildlife movement across the landscape. In undisturbed landscapes, these features are part of the "natural matrix" (Meffe and Carroll 1997) and represent barriers to the movement of some species but not others. Big game species readily cross large rivers by swimming, or on foot under favorable conditions, such as seasonal low flows or periods of ice cover during the winter. Wolves often use topographic features, such as rivers and long lakes, as territory boundaries, crossing only during dispersal (Mech and Boitani 2003).

Boundary Reservoir does not represent a barrier to the movement of the large Threatened or Endangered mammals found in the Project vicinity; however, the slope and composition of the shoreline, as well as water currents in the reservoir, influence where these species can cross. This may affect the movement patterns of these large mammals.

Of the 6.2 miles of roads in the Project area (0.4 sq mi), 2.5 miles (40 percent) are Project-related, and of the 118 miles of road in the secondary study area (26.5 square miles), 9.5 miles (8 percent) are Project-related (Big Game Study Final Report and Land and Roads Study Revised Final Report, SCL 2009b). While Project-related roads may have a cumulative effect on these wide-ranging species, they do not make up the majority of roads in the vicinity.

4.2.1. Canada Lynx

Canada lynx use of the Project vicinity is presumed to be primarily as a travel corridor between lynx populations on either side of the Pend Oreille River, in the designated LMZs (RTE Wildlife Species Study Final Report, SCL 2009b). Lynx are not directly dependent on resources associated with the river or Project, and are not affected by water fluctuations, vegetation changes in the water fluctuation zone, or erosion. The observation of an individual lynx swimming across the Canyon Reach (RTE Wildlife Species Study, SCL 2009b) confirms that lynx occasionally use the Project area.

Construction of roads may reduce lynx habitat by removing forest cover. On the other hand, in some instances, along less-traveled roads where vegetation provides good snowshoe hare habitat, lynx may use the roadbed for travel and foraging (Koehler and Brittell 1990). Roads and trails may facilitate snowmobile and other human uses in the winter, and snow compaction on roads or trails may allow competing carnivores, such as coyotes (*Canis latrans*) and mountain lions (*Felix concolor*), access to lynx habitat (Buskirk et al. 2000). In the absence of roads and trails, snow depths and snow conditions normally limit the mobility of these other predators during mid winter.

Preliminary information suggests that lynx do not avoid roads (Ruggiero et al. 2000a), except at high traffic volumes (Apps 2000). It is possible that summer use of roads and trails through denning habitat may have negative effects, if lynx are forced to move kittens because of associated human disturbance (Ruggiero et al. 2000b). At this time, there is no compelling evidence to suggest that management of road density is necessary to conserve lynx. However, new road construction continues to occur in many watersheds within lynx habitat, many of which are already highly roaded, and the effects on lynx are largely unknown (Interagency Lynx Biology Team 2000). The primary prey of lynx, snowshoe hare, is commonly available in the Project vicinity (PAD, SCL 2006), as are other small animals that lynx are known to prey upon (Squires et al. 2007). Given the lack of suitable habitat and the lack of Project effects on lynx' prey base (Stinson 2001), and the minor effect that Project roads contribute to the overall landscape, there are no Project-related effects on lynx.

The determination for Canada lynx is that the Project is "Not Likely to Adversely Affect" this species.

4.2.2. Woodland Caribou

There are few records of woodland caribou in the Project vicinity, but this species may use the general area east of the Project for winter forage grounds. Woodland caribou are occasionally known to cross the reservoir south of Metaline Falls, where topography may allow easier river access to crossing points. Because of the steeper terrain around the lower reservoir (below Metaline Falls), big game trails are concentrated in areas that follow topographic features such as drainages. Along the upper reservoir (above Metaline Falls) the terrain is gentler and allows for a more diffuse pattern of big game travel. No impediments to big game travel or to reservoir access were identified during field studies and subsequent analysis (Big Game Study Final Report, SCL 2009b). Woodland caribou are likely to use big game trails that other ungulates use, especially in areas of steep topography. In Jasper National Park, woodland caribou generally avoided areas within 1 km (0.6 miles) of campgrounds and up to 750 meters (2,460 feet) from trails; however, displacement distances and intensity of avoidance depended on the level of human use on the nearest trails (Whittington and Mercer 2004). Caribou were noted to avoid areas with 250 meters (820 feet) of linear features such as gravel roads and seismic test corridors (Dyer 1999).

Habitat in the Project vicinity is generally unsuitable for woodland caribou because of its low elevation and lack of older forest habitat; therefore, Project operations would not be expected to affect caribou. Project-related roads are not a primary component of the road network in the vicinity and would not hinder the movement of any woodland caribou that may wander into the vicinity. Because Project-related roads represent a minor component of the landscape in the vicinity, the marginal quality of available caribou habitat, and the extremely low use of the vicinity by woodland caribou, there are no Project effects to this species.
The determination for woodland caribou is that the Project is "Not Likely to Adversely Affect" this species.

4.2.3. Grizzly Bear

The Grizzly Bear Recovery Plan lists human activity, road building, forestry, and mining as adversely affecting grizzly bears (USFWS 1993). Grizzly bears are not affected by Project operations, but road use has the potential to alter grizzly bear use of the vicinity.

Road density and associated human activity affect grizzly bear movements and can cause significant mortality to bears from road kills and human-bear conflicts (Mace and Jonkel 1980). In southeastern British Columbia, McLellan and Mace (1985) reported that adult bears, on average, used an area extending 100-250 meters (328-820 feet) from open roads significantly less than the area available; use within 100 meters (328 feet) of roads was 40 percent of expected in spring and 50 percent of expected in summer/fall. Kasworm and Manley (1988) reported a similar response of bears to roads in the Cabinet Mountains, Montana; use within 500 meters (547 yards) of open roads was reduced 78 percent from expected in spring and 87 percent in fall. However, bears have readily habituated to high levels of human disturbance, as long as it was predictable and non-lethal (McArthur 1979, Dood et al. 1986).

Aune and Kasworm (1989) found that bears living in the foothills of the Rocky Mountains appeared to accommodate a high level of human activity by adopting a more nocturnal activity pattern than bears that occupied more remote backcountry areas. Kasworm and Manley (1988) compared habitat use by bears in two areas in the Cabinet Mountains with different road densities and seasonal access. In the areas with 4 km (2.5 miles) of road open only from July 1 to October 15, the average distance of bear use to nearest road prior to July 1 was 0.6 km (0.4 miles). When roads opened, the mean distance of bear activity to roads increased to 1.1 km (0.7 miles). Most importantly, the amount of area avoided by bears after the roads were opened was similar to the maximum distance avoided by bears in the area with a higher open road density and no seasonal closure. Grizzly bears can become habituated to roads and will regularly cross even high-traffic highways, such as SR 31 through the Project vicinity (Gibeau et al. 2001).

Despite the continued influence of human-caused mortality in the Selkirk Mountain recovery zone, the grizzly bear population appears to be expanding its range, as evidenced by an increase in sightings in areas with few reports of grizzly bears. This range expansion may also be at least partially responsible for the increase in agency removal of bears and other interactions with humans around the periphery of the recovery zone. This grizzly population is still small, and gains in recovery could quickly be reversed (Wakkinen and Kasworm 2004).

Grizzly bears may occasionally use the Project vicinity, but Project operations do not have an effect on the habitat of this wide-ranging species. In addition, the Project area roads represent a minor contribution to the landscape conditions of the vicinity and would not hinder the movement of grizzly bears that may wander through the vicinity. Use of the BWP by snowmobiles and ORVs could discourage use of this area by bears if they were to wander into this area. In general, because of the low grizzly bear use of the Project area and minimal impacts on habitat from Project operations, there are negligible Project-related effects to this species.

The determination for grizzly bear is that the Project "May Affect but is Not Likely to Adversely Affect" this species.

5 CONCLUSIONS

5.1. Aquatic Species

Relative to the baseline condition, implementation of proposed Project operations and proposed PM&E measures under the new Project license is not likely to adversely affect bull trout using the Action Area. Formalization of summertime water surface elevation restrictions is expected to provide little benefit to bull trout, because the effects would occur primarily during a time of year when temperatures in the mainstem are naturally too high to allow for bull trout use of the reservoir. However, more stable water surface elevations could result in fewer disturbances to thermal plumes (which could be used by bull trout) located at tributary deltas during the summer months. Several mitigation measures are also anticipated to contribute to bull trout recovery in the Pend Oreille Core Area. In particular, these include improved habitat connectivity as the result of implementing upstream fish passage at Boundary Dam, large woody debris enhancement at tributary deltas, excavation of channels connecting trapping pools to the mainstem river, and off-site tributary habitat and stream channel improvements. Table 5.1-1 provides a summary diagnostics matrix of the anticipated effects of proposed conservation measures on bull trout.

Table 5.1-1. Summary diagnostics matrix of effects of the proposed conservation measures for the Boundary Project (FERC No. 2144) on bull trout (*Salvelinus confluentus*) pending Federal Energy Regulatory Commission relicensing.

Diagnostics	Distinct Population Segment (DPS) jeopardy	Effects of the action			
		Restore	Improve	Maintain	Degrade
Reservoir and tributary delta conditions					
Spawning and Incubation	No			X	
Sub-adult rearing	No		X		
Adult upstream migration	No		X		
Habitat connectivity					
Upstream passage facilities	No		X		
Downstream passage facilities	No			X	
Water quality					
Total dissolved gases	No		X		
Water temperature	No			X	
Turbidity	No			X	
Ecosystem functions					
Gravel transport	No			X	
Woody debris transport	No			X	
Floodplain connectivity	No			X	

5.2. Terrestrial Species

Under the proposed action, there may be negligible effects to Canada lynx, woodland caribou, and grizzly bear from Project-related human use that may alter the way these wide ranging species use terrestrial habitats in the Action Area. All of these species are occasional visitors to the Project vicinity but are not affected by water level fluctuations or the corresponding effects on shoreline vegetation. Use of Project-related roads and use of the BWP by snowmobiles and ORVs may alter habitat use patterns if these species were to wander through the vicinity, but this effect is not considered significant.

Table 5.2-1 summarizes the effect determination for the Threatened and Endangered terrestrial species that may occur in the Project vicinity.

Table 5.2-1. Summary of ESA effect determination for terrestrial wildlife that may occur in the Boundary Project vicinity.

Species	No Effect	Not Likely to Adversely Affect	Likely to Adversely Affect
Canada lynx		X	
Woodland caribou		X	
Grizzly bear		X	

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