# *Early Information Development:*
# *Fish Connectivity at the Boundary Hydroelectric Project*

***Boundary Hydroelectric Project (FERC No. 2144)***

***Prepared for:***

**Seattle City Light**
**Seattle, Washington**

***Prepared by:***

**R2 Resource Consultants, Inc.**
**Redmond, Washington**

**November 2006**

# TABLE OF CONTENTS

## FIGURES

# TABLES

# Early Information Development: Fish Connectivity at the Boundary Hydroelectric Project

**Boundary Hydroelectric Project (FERC No. 2144)**

## 1 INTRODUCTION

The Boundary Hydroelectric Project, (the "Boundary Project"), is owned and operated by Seattle City Light (SCL) under a license administered by the Federal Energy Regulatory Commission. The present license for the Boundary Project (FERC No. 2144) expires in September 2011, and in accordance with FERC regulations, SCL must file its application for a new license no later than September 2009. For the relicensing of the Boundary Project, SCL is using the FERC Integrated Licensing Process (ILP) to provide the framework for its consultation with stakeholders during the period leading up to the filing of its license application. As part of the ILP, SCL is responsible for developing a Proposed Study Plan that describes each study to be conducted in support of relicensing, a study schedule, and considerations of level of effort and cost. SCL identified the subject of fish habitat connectivity and potential fish entrainment as areas where early (i.e., prior to formal study phase) information development (EID) would be beneficial.

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. While anadromous fish no longer have access to the Pend Oreille River, potential fish connectivity between habitats upstream and downstream of Boundary Dam, and potential injury or mortality of fish that may be entrained in Project facilities have been identified as relicensing study issues.

The objective of this EID effort is to compile existing information to support future stakeholder discussions of potential fish connectivity and entrainment effects during FERC relicensing of the Boundary Project. No site-specific field studies of entrainment or upstream and downstream fish connectivity are anticipated prior to development of proposed study plans in 2006. As part of this EID effort, descriptions of existing Boundary Project facilities and operations and background information relevant to fish connectivity and entrainment have been compiled for the Boundary Project. Because the movement and potential connectivity of fish throughout the Pend Oreille River system is pertinent to the issue of fish passage at the Boundary Project; a summary of existing and planned fish connectivity programs has also been compiled for other hydropower projects on the Pend Oreille River.

Discussions during Fish and Aquatic Workgroup meetings (see Appendix A) have focused interest by relicensing participants on native salmonids, non-native sportfish, and their forage species. Fish that might be migrating downstream and pass through Project facilities may be directly injured or killed or indirectly impacted if they are made temporarily more vulnerable to predation due to disorientation and stress. Discussion in this EID Report focuses on connectivity and entrainment issues surrounding three native fish species potentially found at the Project: bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki lewisi*), and mountain whitefish (*Prosopium williamsoni*). Some discussion is also included for introduced fish such as rainbow trout (*O. mykiss*), smallmouth bass (*Micropterus dolomieu*), or yellow perch (*Perca flavescens*) that may have importance as a sportfish in the Project Reservoir.

## 1.1. Project Description

The Boundary Project is located on the Pend Oreille River in northeastern Washington, one of eleven hydroelectric and storage projects within the Pend Oreille River basin. The dam is located 1 mile south of the Canadian border at River Mile (RM) 17.0 (Figure 1-1). The upstream end of the Project reservoir (Boundary Reservoir) extends to the base of the Box Canyon Dam, at RM 34.5. The Project is a load-following operation shaped to deliver power during peak-load hours with a total plant capability of 1,070 MW from its six turbines. This operating regime allows SCL to meet continued service area load growth and provide regional system reliability. An aerial photo of Project Facilities located at Boundary Dam relevant to the discussion of habitat connectivity is provided in Figure 1-2.

Average annual inflows to Boundary Reservoir measured at USGS Gage 12396500 below Box Canyon Dam ranged from 13,400 cfs (2001) to 40,400 cfs (1997) between 1987 and 2004 (R2 Resource Consultants, Inc. 2006). The median flow duration (50% exceedance based on hourly flow records) over the period was 22,747 cfs recorded immediately downstream of the Project (R2 Resource Consultants, Inc. 2006). The month of June has the highest outflows from the Project with a median flow duration of 47,357 cfs and the month of August has the lowest with a median flow duration of 13,152 cfs. The largest tributary to Boundary Reservoir is Sullivan Creek (RM 27.9). Monthly mean flows reported in FERC (1998) for Sullivan Creek ranged from 63 cfs (February) to 519 cfs (May). Sullivan Creek is the only tributary to Boundary Reservoir that has a long-term flow record.

The normal maximum reservoir surface water is elevation 1,990 feet (NGVD 1929).[1] The reservoir has little active storage (about 43,000 acre-feet) within the maximum drawdown authorized by the current license of 40 feet (active storage from elevation 1,990 to elevation 1,950 feet). During the summer recreation season (approximately Memorial Day weekend through Labor Day weekend), SCL voluntarily restricts the surface water elevations to typically less than a 10-ft drawdown to facilitate reservoir access and related-recreational activities during daytime hours. For the remainder of the year, the surface water may fluctuate between elevation 1,990 and elevation 1,970 feet. Storage between elevation 1,970 and elevation 1,950 feet is reserved for extreme system load requirements. Flood storage is not provided, and other than the operating goals noted above there are no seasonal or minimum flow requirements.

Daily water surface elevation fluctuations occur in the Boundary Reservoir because of the load-following operational strategy used at the Project. The change in bathymetric characteristics of the reservoir at Metaline Falls may result in significant attenuation of fluctuations in the Upper

---

[1] All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

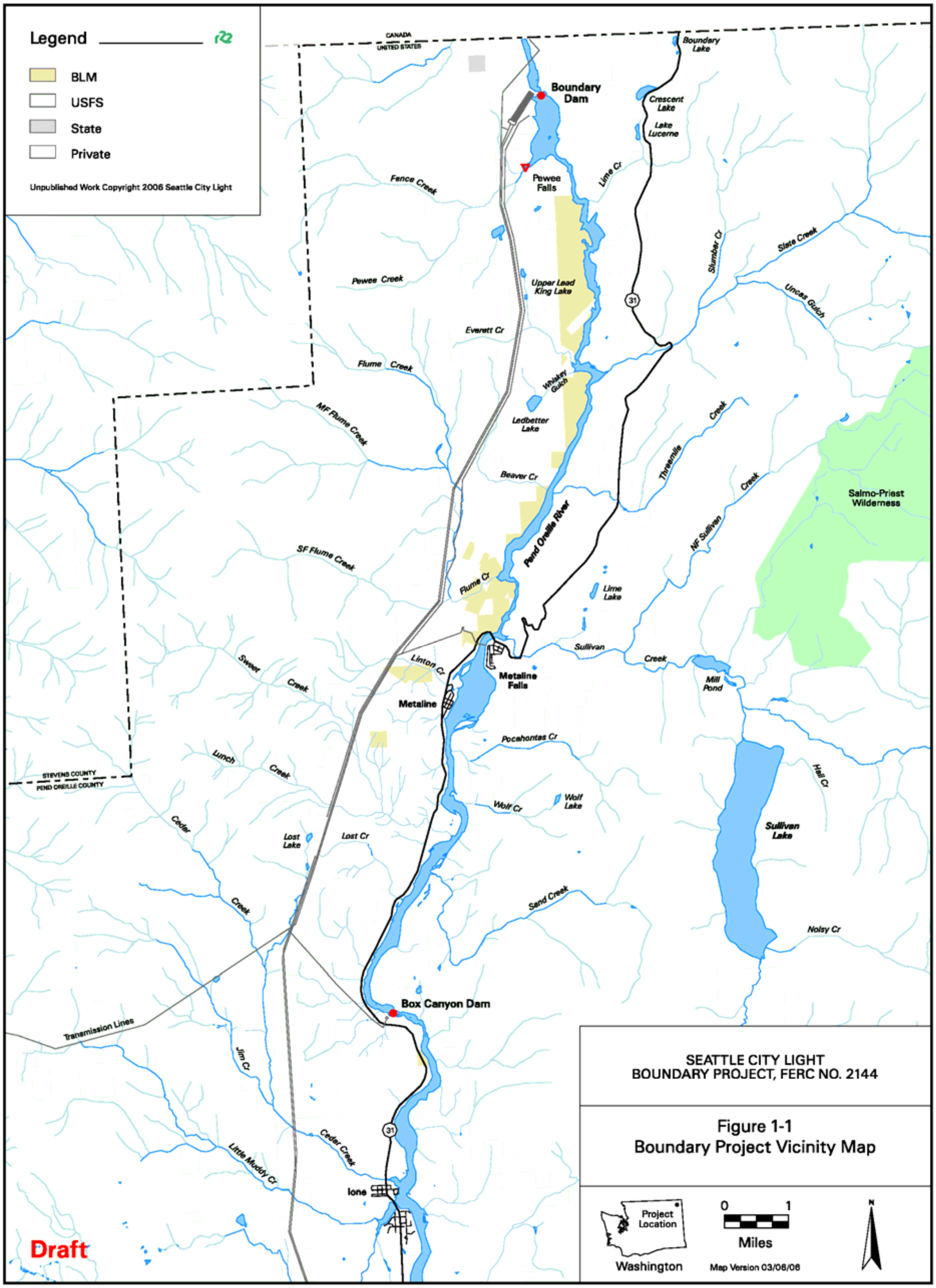


**Figure 1-1.** Boundary Project vicinity map.

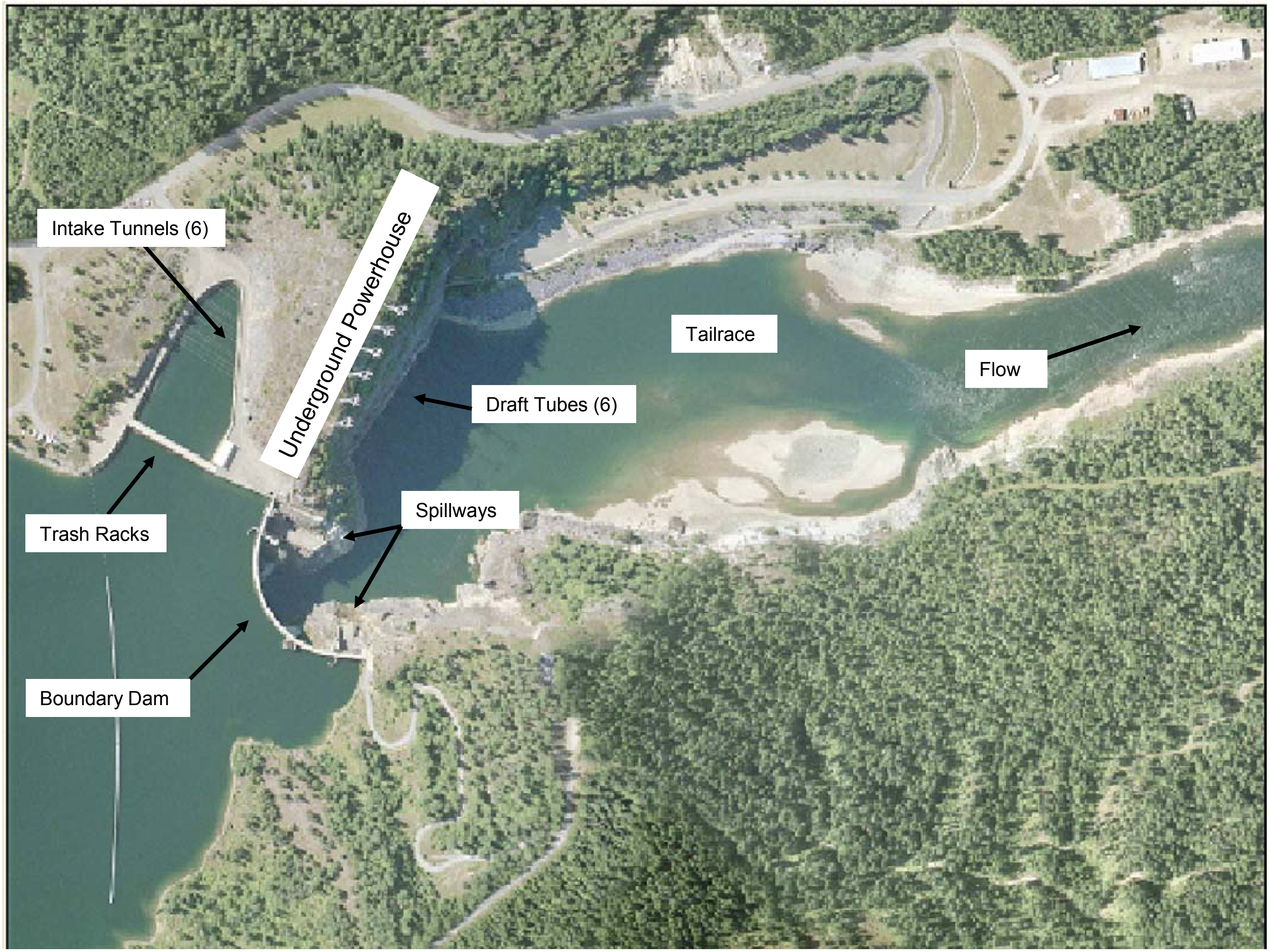


**Figure 1-2.** Aerial overview of Boundary Dam and associated facilities.

Reservoir Reach (Box Canyon Dam to Metaline Falls) at some pool levels. In addition to the apparent dampening of the magnitude of water surface elevation fluctuations, the constriction at the site of Metaline Falls slows the passage of water and may also slow the response time of the Upper Reservoir Reach to rapid changes in the Canyon (Metaline Falls to Z Canyon) and Forebay (Z Canyon to Boundary Dam) Reaches of the reservoir. Thus, both the magnitude and rate of change in surface water elevation of the Upper Reservoir Reach appear to be somewhat reduced as compared to the lower reservoir (Canyon and Forebay reaches). When the Project is operating at surface water elevations lower than the Metaline Falls (approximate surface water range of El. 1980 to 1975) as primarily reflected by the Boundary forebay data, there are almost no daily water surface elevation fluctuations in the Upper Reservoir Reach at the two USGS gages (primary and auxiliary) below Box Canyon Dam as a result of Boundary load-following operations.

Seven Mile Dam (RM 6.0) backs water up to the tailwater of Boundary Dam. Similar to the Boundary Project, the Seven Mile Project is operated as a load-following facility. In addition, from June 1 to August 31, Seven Mile Reservoir has been limited to a daily maximum fluctuation of 13.1 feet (4 m) with a rate of change of no more than 2.0 feet per hour (fph) (0.6 meters per hour) (R.L.&L. and Taylor & Associates 2001). During the remainder of the year the maximum fluctuation has been 19.7 feet (6.0 m) at a rate of no more than 3.9 fph (1.2 meters per hour) (R.L.&L. and Taylor & Associates 2001). The minimum pool level for Seven Mile Reservoir is 1,690 feet and normal full pool is 1,730 feet. Consequently, the effects of Boundary Project operations on aquatic habitats in the Seven Mile Reservoir are influenced by Seven Mile operations. At low Seven Mile pool levels, riverine habitat is present in the Boundary tailwater, but at high pool levels the riverine habitat is replaced with reservoir habitat.

The Seven Mile Project completed upgrades in April 2003 to provide increased generation capacity (Calder et al. 2004). There are also plans by the Columbia Power Corporation to add capacity at the Waneta Project, which is located downstream of the Seven Mile Project at RM 0.5. These plans are currently under environmental review in British Columbia. If implemented, the upgrades at the Waneta Project could potentially result in changes to the operational strategy at both Waneta and Seven Mile projects. Changes in Seven Mile Project operations will affect how Seven Mile pool levels and outflows from Boundary Reservoir interact and affect hydraulic conditions in the tailrace of Boundary Dam.

# 2 POTENTIAL HABITAT CONNECTIVITY

Habitat fragmentation has been cited as an important concern to the maintenance and recovery of bull trout and westslope cutthroat trout populations (69 FR 59996; USFWS 1999; Rieman and McIntyre 1993; Rieman et al. 1997; McIntyre and Rieman 1995). The broad-scale reviews by Rieman et al. (1997) and McIntyre and Rieman (1995) suggested the available survey information is sufficient to indicate that in most regions bull trout and westslope cutthroat trout distribution is discontinuous or patchy.

The draft recovery plan for bull trout has embraced metapopulation theory for guidance in the development of regional plans (USFWS 2002). The plan describes a metapopulation (or core population) as a set of local populations that have some level of gene exchange between them. Local populations can be extirpated, but can also be reestablished by straying of individuals from other local populations. The risk of losing the core population is decreased because the likelihood of losing all local populations simultaneously is low. Long term survival of a core population is dependent upon having an adequate distribution of local populations with relatively robust abundance and habitat quality. Rieman and McIntyre (1993) and McIntyre and Rieman (1995) have suggested the patchy distribution of bull trout and westslope cutthroat trout are consistent with the metapopulation concept.

A variety of biological and anthropogenic factors have been suggested as contributing to the patchy distribution of bull trout and westslope cutthroat trout. The most important of these are the species' habitat requirements, habitat degradation, and passage barriers such as natural falls, dams, and stream crossings (primarily culverts) by roads and railroads (Rieman and McIntyre 1993; McIntyre and Rieman 1995).

Rieman et al. (1997) suggested the patchy distribution of bull trout is in part due to their relatively narrow habitat requirements compared to other native salmonids, particularly water temperature. Bull trout populations are seldom found in areas with water temperatures that exceed 59°F (15°C) on a regular basis and optimal spawning temperatures are between 35.6°F and 39.2°F (2°C and 4°C) (Rieman and McIntyre 1993). Consequently, bull trout populations are often restricted to higher elevations or spring-fed streams where water temperatures are suitable. In addition, Rieman and McIntyre (1993) noted that bull trout require high levels of stream complexity in the form of instream woody debris, boulders, or large rubble.

Similar to bull trout, westslope cutthroat trout often exhibit a patchy distribution, but perhaps for a different reason. Westslope cutthroat trout often predominate in upper tributary reaches while introduced brown, brook, or rainbow trout occupy lower reaches. Fausch (1989) hypothesized this pattern may occur because cutthroat are more tolerant of higher stream gradients than the introduced trout and may be competitively excluded from the lower reaches.

Habitat degradation influences fish distribution by increasing the distance between areas of high quality habitat. Habitat quality can vary substantially across the landscape and can be dynamic over time. Both natural (e.g., fires) and anthropogenic (e.g., land management practices) disturbances can result in poor habitat that in many instances, given sufficient time without additional disturbances, can recover. Nevertheless, anthropogenic disturbances have been suggested as the principle factor that has resulted in fewer, more widely separated areas of high quality trout habitat (69 FR 59996; USFWS 1999). Rieman and McIntyre (1993) suggested areas with high quality habitat that harbor local populations act as the source of individuals that colonize underutilized habitat. Consequently, homing and straying is an important behavioral characteristic that interacts with a patchy distribution.

Similar to most other salmonids, bull trout and westslope cutthroat trout are known for their ability to return to natal streams for spawning, an aspect of their life history that contributes to genetic isolation and adaptation to local environmental conditions. In contrast, straying is the mechanism by which colonization of underutilized habitat occurs and provides some level of genetic mixing between nearby local populations. A low level of genetic mixing reduces the risk of inbreeding or genetic drift that could have long term adverse effects (Rieman and McIntyre 1993). Quinn (2005) reported that straying by salmonids is usually less than five percent and most straying occurs to nearby tributaries (or hatcheries), but his conclusions were based entirely on studies conducted on Pacific salmon and steelhead trout. Importantly, straying rates and the distance strayed for westslope cutthroat trout and bull trout are unknown at both the species level and for local populations (Rieman and McIntyre 1993; McIntyre and Rieman 1995). This uncertainty implies that defining critical distance thresholds between patches that would allow for gene flow would be difficult. In other words, there is no clear guidance for determining whether two local populations are separated by too great a distance for genetic mixing or colonization to occur. Nevertheless, it seems reasonable that the greater the distance between two local populations, the less likely that genetic mixing would occur from strays.

Passage barriers are clearly 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 that local population 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.

Rieman and McIntyre (1993) recommended a conservation strategy drawn from the metapopulation concept that focused on identifying and managing core areas and their local populations. Their recommended criteria for core areas are:

- Core areas must be selected to provide all critical habitat elements;
- Core areas should be selected from the best available habitat or from the habitat with the best opportunity to be restored to high quality;
- A core area must provide for replication of strong subpopulations within its boundaries;

- Core areas should be large enough to incorporate genetic and phenotypic diversity, but small enough to ensure that the component populations effectively connect; and
- Core areas must be distributed throughout the historic range of the species.

Largely following these recommendations, the USFWS defined the following in the draft bull trout recovery plan (USFWS 2002):

**Core area:** The combination of core habitat (i.e., habitat that could supply all elements for the long-term security of bull trout) and a core population (a group of one or more local bull trout populations that exist within core habitat) constitutes the basic unit on which to gauge recovery within a recovery unit. Core areas require both habitat and bull trout to function, and the number (replication) and characteristics of local populations inhabiting a core area provide a relative indication of the core area's likelihood to persist. A core area represents the closest approximation of a biologically functioning unit for bull trout.

**Core habitat:** Habitat that encompasses spawning and rearing habitat (resident populations), with the addition of foraging, migrating, and overwintering habitat if the population includes migratory fish. Core habitat is defined as habitat that contains, or if restored would contain, all of the essential physical elements to provide for the security of and allow for the full expression of life history forms of one or more local populations of bull trout. Core habitat may include currently unoccupied habitat if that habitat contains essential elements for bull trout to persist or is deemed critical to recovery.

**Core population:** A group of one or more bull trout local populations that exist within core habitat.

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

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 5 interconnected local populations are at increased risk of extirpation while core areas with 5 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. Within the Pend Oreille River Core Area, nine tributaries were identified as local populations with numeric recovery goals for adult migratory fish with an overall core area recovery goal of 1,575 to 2,625 fish. These are:

Boundary Reservoir tributaries

- Slate Creek (25 to 75 fish)
- Sullivan Creek (600 to 850 fish)

Box Canyon tributaries

- Cedar Creek (150 to 250 fish)
- Ruby Creek (100 to 200 fish)
- LeClerc Creek (400 to 500 fish)
- Mill Creek (50 to 150 fish)
- Tacoma Creek (150 to 350 fish)
- Calispell Creek (50 to 100 fish)
- Indian Creek (50 to 100 fish)

Slate Creek and Sullivan Creek drain into Boundary Reservoir while the remainder drain into Box Canyon Reservoir. Detailed population or habitat information utilized as the basis for including or excluding specific tributaries as local populations is not available or identified in USFWS (2002). 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.

Of those tributaries with recovery goals, individual bull trout have been observed in Sullivan Creek, LeClerc Creek, Mill Creek, Cedar Creek, and Indian Creek. LeClerc Creek is presumed to have a small spawning population because both juvenile and adult fish have been observed (Scholz et al. 2005). In all others only adult fish have been observed. For Sullivan Creek, the one fish observed was gutted, indicating it had been captured by an angler, but it is unknown if the fish was captured in Sullivan Creek or discarded there by the angler. Bull trout have been captured in Boundary Reservoir near the mouth of Slate Creek, but have not been observed within the creek. Three bull trout have been captured within or near the mouth of Sweet Creek, a tributary to Boundary Reservoir. No recovery goal has been identified for Sweet Creek in the draft recovery plan.

## 2.1. Adfluvial Fish Habitat within Boundary Reservoir

The fish community in Boundary Reservoir is dominated by suckers and minnows, primarily largescale sucker and northern pikeminnow. Sportfish include mountain whitefish, yellow perch, smallmouth bass, and a variety of trout and char (cutthroat, rainbow, brown, lake). Of these, yellow perch and smallmouth bass are abundant in some areas of the reservoir and mountain whitefish are common. The trout and char species are occasionally observed, but represent a very small proportion of the fish community (<2 percent by abundance). Bull trout have been rarely observed in Boundary Reservoir.

For tributaries with recovery goals that drain to Boundary Reservoir, passage barriers are present on both Slate and Sullivan Creeks. Slate Creek includes about 3,474 linear feet of adfluvial habitat downstream of a waterfall 19.7 feet in height (McLellan 2001). 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 definitively ruled out. In addition, the dam at Mill Pond, located 4.2 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 to Sullivan Lake on Outlet Creek is also a complete barrier to upstream fish passage.

Table 2-1 identifies the length of adfluvial habitat and the known sport fish present in tributaries that drain to Boundary Reservoir. Relicensing participants have expressed concerns that sediment accumulations at tributary mouths could result in blockages to fish migration (May 23, 2006, Workgroup Meeting; see Appendix A). Habitat surveys by the USFS, WDFW, or Kalispel Indian Tribe have occurred on Slate, Sullivan, Sand, Flume, Sweet, Lunch, Pewee, and Lime creeks. Three tributaries, Linton Creek, Pocahontas Creek, and Unnamed Creek No. 13, are not blocked by any known migration barriers but have not been surveyed for fish or habitat. Linton Creek flows through the town of Metaline. Flows in lower Pocahontas Creek downstream of the railroad crossing are generally subsurface (approximately 1,300 feet of stream) during the summer (T. Shuhda, USFS Fisheries Biologist, pers. comm. April 2005).

During August 1981, a snorkel/SCUBA survey of Sullivan Creek from the Sullivan Creek Powerhouse to Mill Pond documented the presence of rainbow trout and brown trout and estimated a total population size of 1,920 to 2,000 adult trout for the surveyed reach (TERA Corporation 1982), but the population estimate could have been influenced by trout stocking in Mill Pond and Sullivan Lake. The USDA Forest Service (1996), during its 1996 evaluation of the Sullivan Creek Watershed, concluded the abundance of fish in Sullivan Creek was low because of poor quality habitat. In particular, the USDA Forest Service (1996) noted that spawning gravels were lacking in many reaches, but different mechanisms were suggested for the lower and upper creek. Within lower Sullivan Creek, the USDA Forest Service (1996) suggested that suitable spawning gravels were retained behind Mill Pond Dam and consequently starved the lower creek of suitable gravel. In contrast, the USFS noted that low levels of large woody debris in upper Sullivan Creek reduced the ability of the stream to retain suitable spawning gravels (USDA Forest Service 1996). One confounding factor in the ability of lower Sullivan Creek to retain gravel is that a substantial proportion is relatively steep and confined (Rosgen Type A1) with an average gradient of 4 percent between Highway 31 and the mouth of North Fork Sullivan Creek (USDA Forest Service 1996; McLellan 2001). Streams with gradients greater than 3 percent are typically sediment transport reaches that rely on instream roughness elements (large woody debris, boulders, etc.) to retain sediment (Montgomery and Buffington 1993). Lower Sullivan Creek has levels of large woody debris (32.2 to 128.7 pieces per mile) that are generally lower than upper Sullivan Creek (80.5 to 643.7 pieces per mile) (McLellan 2001). Notably, downstream of Highway 31 (RM 0.0 to 0.5) Sullivan Creek had no large pools and only 32.2 pieces of large woody debris per mile, the lowest level of the entire stream (McLellan 2001); pools and large woody debris are both key components of quality trout habitat (Bjornn and Reiser 1991).

**Table 2-1.** Adfluvial habitat and known sport fish present in tributaries that drain into Boundary Reservoir.

| Stream Name | Pend Oreille River Mile | Length of Adfluvial Habitat (Feet) | Known Sport Fish Present[1] |
|---|---|---|---|
| Unnamed No. 1 | 18.1 | 82[2] | |
| Pewee Creek | 19.0 | 0[3] | CTT, EBT |
| Unnamed No. 2 | 19.1 | 129[2] | |
| Lime Creek | 20.5 | 6,746[3] | EBT |
| Everett Creek | 22.8 | 60[2] | |
| Whiskey Gulch | 22.9 | 547[2] | |
| Slate Creek | 23.1 | 3,474[3] | EBT, CTT, RBT |
| Beaver Creek | 25.2 | 0[3] | |
| Threemile Creek | 25.2 | 0[3] | EBT, RBT |
| Unnamed No. 3 | 26.4 | 58[2] | |
| Flume Creek | 26.8 | 1,626[3] | EBT |
| Sullivan Creek | 27.9 | 21,729[3] | EBT, CTT, RBT, MWF, BNT, BLT, KOK, BBT |
| Unnamed No. 4 | 28.1 | 77[2] | |
| Linton Creek | 28.5 | 19,159[2] | |
| Unnamed No. 5 | 28.9 | 130[2] | |
| Unnamed No. 6 | 29.1 | 955[2] | |
| Pocahontas Creek | 29.5 | 16,480[2, 4] | |
| Unnamed No. 7 | 29.7 | 53[2] | |
| Unnamed No. 8 | 31.3 | 66[2] | |
| Wolf Creek | 31.4 | 236[2] | |
| Sweet Creek\Lunch Creek | 32.0 | 3,202[3] | EBT, CTT, RBT, MWF, BNT, BLT |
| Unnamed No. 9 | 32.3 | 67[2] | |
| Sand Creek | 32.6 | 1,498[3] | EBT, CTT, RBT |
| Lost Creek | 33.1 | 165[2] | CTT |
| Unnamed No. 10 | 33.6 | 99[2] | |
| Unnamed No. 11 | 33.8 | 78[2] | |
| Unnamed No. 12 | 34.1 | 102[2] | |
| Unnamed No. 13 | 34.5 | 4,184[5] | |

Notes:

1. Blanks indicate nonfish-bearing stream or not surveyed. EBT=eastern brook trout; CTT= cutthroat trout; RBT= rainbow trout; MWF= mountain whitefish; BNT= brown trout; BLT= bull trout; KOK= kokanee; BBT= burbot. Sources: USFS (2005d); McLellan (2001); FERC (1998).
2. The length of adfluvial habitat is the distance from the mouth of the stream to the lowermost stream segment in the Salmonscape Geographic Information System (WDFW 2002) with a gradient greater than 20% and does not consider the quality of the adfluvial habitat for sustaining fish.
3. The length of adfluvial habitat is the distance from the mouth of the stream to the lowermost migration barrier identified by McLellan (2001) and does not consider the quality of the adfluvial habitat for sustaining fish.
4. Flows in the lower portions of Pocahontas Creek typically become subsurface during the summer.
5. The length of adfluvial habitat was based on the Salmonscape Geographic Information System (WDFW 2002); however, during a September 20, 2006 site visit, one of the authors of this report observed a natural fish migration barrier (>15-ft high) near the reservoir margin of Unnamed tributary No. 13.

Water temperatures downstream of Sullivan Lake and Mill Pond may also contribute to limiting the ability of bull trout to utilize Sullivan Creek. Rieman and McIntyre (1993) suggested that the distribution of bull trout populations is limited to waters with temperatures less than 59°F (15°C) and Goetz (1989) noted that bull trout are seldom observed in tributaries with summer temperatures over 64.4°F (18°C). Mid- to late summer water temperatures in lower Sullivan Creek were recorded during 1996 and 1997 by R2 Resource Consultants, Inc. (1998a) and during 2000 by McLellan (2001). During all three years average daily temperatures exceeded 59°F for a portion (10 days in 1996, 12 days in 1997, 29 days in 2000) of the period monitored. Maximum recorded water temperatures were 63.1°F (17.3°C) during 1996, 66.9°F (19.4°C) during 1997, and 66.0°F (18.9°C) during 2000. While these temperatures are suitable for the brook trout and rainbow trout (Bjornn and Reiser 1991) that are generally observed downstream of Mill Pond, they are considered above the range normally utilized by bull trout.

Slate Creek is moderately steep with an average gradient of 7 percent (range 5–9 percent) (McLellan 2001). Eastern brook, cutthroat, and rainbow trout are known to utilize Slate Creek. McLellan (2001) reported that only cutthroat trout and rainbow trout were observed downstream of the lowermost natural fish migration barrier. 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 (Terrapin Environmental 2000). No fish were captured in the trap and snorkelers did not observe fish congregating upstream or downstream of the trap.

Temperature recorders (i.e., thermographs) were deployed in lower Slate Creek during mid-August to late October 1996, late July to early November 1997, and late June to late November, 2000 (R2 Resource Consultants, Inc. 1998a; McLellan 2001). Average daily temperatures remained below the 59°F criterion during all three periods monitored. Maximum daily temperatures also remained below the criterion during the three periods except two days during 1997 when maximum temperatures reached 59.7°F (15.4°C). During both 1996 and 1997 Slate Creek exhibited the lowest average daily temperatures of the tributaries monitored (Sullivan Creek, Slate Creek, Flume Creek, Sand Creek, and Sweet Creek) (R2 Resource Consultants, Inc. 1998a).

Sweet Creek drains into the Upper Reservoir Reach. Lunch Creek is a major tributary to Sweet Creek. A 16-foot vertical falls limits the amount of adfluvial habitat in Sweet Creek to the lower 3,202 feet of stream (McLellan 2001). Three additional waterfalls, each up to 26.9 feet in height, are located over the next 2,200 feet of stream (McLellan 2001). Compared to most other tributaries (except Sullivan Creek) that drain into Boundary Reservoir, Sweet Creek appears to have a relatively diverse salmonid community that includes eastern brook trout, cutthroat trout, rainbow trout, brown trout, and mountain whitefish (McLellan 2001; R2 Resource Consultants, Inc. 1998a) with a variety of sizes represented. Three bull trout have been observed in lower Sweet Creek or near its mouth. During the early 1980s, one adult bull trout approximately 20 inches in length was captured with a gill net at the mouth of Sweet Creek and another dead bull trout about 35 inches in length was observed along the bank of the creek (S. Lembcke 2001, pers. comm.). A single 11.8-inch (300 mm) bull trout was observed in the pool below the lowermost waterfall during the summer of 2000 (McLellan 2001).

Sweet Creek has an average bankfull width of 34.1 feet and mean depth of 0.45 feet (McLellan 2001). The discharge measured during September 2000 when habitat surveys were conducted was 5.3 cfs (McLellan 2001). Stream gradient downstream of the migration barrier averages 2 to 4 percent. The stream is dominated by boulder and cobble substrate and includes a fair level of pools (27.4 to 80.5 pools per mile) and large woody debris (289.7 to 321.9 pieces per mile). Temperature recorders (i.e., thermographs) were deployed in lower Sweet Creek during mid-August to late October 1996, late July to early November 1997, and late June to late November, 2000 (R2 Resource Consultants, Inc. 1998a; McLellan 2001). Average daily temperatures remained below the 59°F criterion during all three periods monitored. Maximum daily temperatures also remained below the criterion during the three periods except six days during 1997 when maximum temperatures reached 61.0°F (16.1°C). Stream temperatures appear suitable in Sweet Creek for most salmonids, but may occasionally exceed maximum suitable temperatures for bull trout fry and juveniles.

## 2.2. Status of Fish Passage and Adfluvial Fish Habitat at other Pend Oreille River Projects

In addition to the Boundary Project there are four other hydroelectric projects along the Pend Oreille River. The status of fish passage and adfluvial fish habitat at these projects is presented below. In addition, two projects on the Clark Fork River, Cabinet Gorge and Noxon Rapids, have similar potential native fish habitat connectivity issues and were recently relicensed. These latter projects are also described because of their approach to resolving these issues.

### 2.2.1. Waneta

The Waneta Project located at RM 0.5 is the lowermost dam on the Pend Oreille River and has an active storage of 4,200 acre-feet. The existing project was completed in 1954 and operated by Teck Cominco. As indicated previously, there are plans in progress for an additional powerhouse and turbines to be developed by the Waneta Expansion Power Corporation (WEPC). Currently, there are no upstream or downstream passage facilities at the Waneta Project. However, in their Environmental Assessment Certificate Application, WEPC (2006) stated they would install passage facilities on a cost-sharing basis if anadromous fish were reintroduced above Chief Joseph and Grand Coulee Dams.

### 2.2.2. Seven Mile

The Seven Mile Project is located on the Pend Oreille River at RM 6.0 and has an active storage of 21,000 acre-feet. The project was completed in 1981 with neither upstream nor downstream passage facilities. In 2003, a major upgrade added a fourth turbine to the project. The major tributary to Seven Mile Reservoir is the Salmo River (Figure 2-1), which is over 37 miles in length and has a drainage size of approximately 475 square miles (Baxter 2001a). A portion of the South Fork Salmo River extends into the United States and is part of the Colville National Forest. In addition to the Salmo River there are seven smaller tributaries that drain into Seven Mile Reservoir.

The fish community in Seven Mile Reservoir is dominated by minnows and suckers (R.L.&L. and Taylor & Associates 2001). Mountain whitefish are commonly observed and cutthroat trout are occasionally observed. Most of the smaller tributary streams support cutthroat trout. Bull trout are present in Seven Mile Reservoir, but rarely observed. During surveys conducted by R.L.&L. and Taylor & Associates (2001) during 1999 and 2000, two bull trout were captured in the reservoir downstream of the Salmo River and none were captured upstream. R.L.&L. (1999) reported 4 bull trout were captured in Seven Mile Reservoir during their 1994/1995 surveys.

Snorkel surveys, spawning surveys, and radio telemetry studies in the Salmo River have confirmed five areas with bull trout spawning, and the Salmo River spawning population of bull trout has been estimated at approximately 200 individuals (Baxter 1999). Based upon the available information and studies performed, Baxter (1999) concluded the Salmo River bull trout population largely exhibit a fluvial life history pattern. That is, bull trout spawn in the Salmo River and its tributaries, remain in the river, and rarely migrate into Seven Mile Reservoir. Baxter (1999) based this conclusion primarily on the size of bull trout observed during snorkel and spawning surveys and the behavior of radio-tracked bull trout, none of which were observed to move into Seven Mile Reservoir. Nevertheless, BC Hydro is continuing to conduct bull trout studies in Seven Mile Reservoir and the Salmo River to confirm Baxter's (1999) conclusion.

In addition to the Salmo River, bull trout have been observed in four of the smaller tributaries: Nine Mile Creek (5 fish) and Harcourt Creek (1 fish), Lomond Creek (1 fish), and Tillicum Creek (R.L.&L. and Taylor & Associates 2001; R.L.&L. 1999; S. Lembcke 2001, pers. comm.). R.L.&L. and Taylor & Associates (2001) assessed the habitat conditions in the lower 100 to 300 m of 8 tributaries draining to Seven Mile Reservoir. Five of these tributaries, including Harcourt Creek, had impassable barriers (4 with natural barriers, 1 with a culvert barrier) within 100 m of their confluence with the reservoir. Tributaries without impassable barriers in their lower reaches included Nine Mile Creek (3.5 miles long), Russian Creek (1.0 mile long) and Lomond Creek (4.7 miles long). Although no bull trout were captured in Tillicum Creek during the surveys by R.L.&L. and Taylor & Associates (2001) and R.L.&L. (1999), S. Lembcke (2001, pers. comm.) cited information indicating that bull trout had been observed in the creek during the early 1980s by the USFS. An impassable culvert barrier in lower Tillicum Creek was identified by R.L.&L. and Taylor & Associates (2001).

The bull trout captured by R.L.&L. and Taylor & Associates (2001) in Nine Mile and Harcourt Creeks were relatively small. Those in Nine Mile Creek were 54 to 181 mm fork length (FL) and the fish in Harcourt Creek was 149 mm (FL). The size of these fish provides circumstantial evidence for bull trout reproduction occurring in these streams, particularly Nine Mile Creek.

In March 2003, BC Hydro and the BC Environmental Assessment Office agreed to revise the Mitigation and Compensation Plan developed for the Unit 4 upgrade at the Seven Mile Project. The plan and its revision were negotiated between BC Hydro, federal and provincial agencies, and the Canadian Columbia River Inter-Tribal Fisheries Commission. As compensation for fish entrainment impacts resulting from the Unit 4 upgrade the agencies and BC Hydro agreed to off-site enhancement in the South Salmo River in the form of a stream fertilization program. BC Hydro does not currently have plans to develop upstream or downstream passage facilities at Seven Mile Dam, but are continuing to implement bull trout studies to determine if bull trout from the Salmo River utilize Seven Mile Reservoir and are possibly at risk of entrainment at Seven Mile Dam.

### 2.2.3. Box Canyon

Box Canyon Dam is located upstream of Boundary Dam on the Pend Oreille River at RM 34.5. It is owned and operated by the Pend Oreille County Public Utility District No. 1 (POCPUD). It was completed in 1956 without upstream or downstream fish passage facilities. The fish community in Box Canyon Reservoir is dominated by introduced cool- and warm-water fish such as yellow perch, pumpkinseed, largemouth bass, and tench. Mountain whitefish are common in the reservoir. Based upon surveys conducted between 1988 and 1990, trout and char species represent less than 1 percent of the fish community. Between 1988 and 2002 there were seven documented observations of bull trout within Box Canyon Reservoir (Geist et al. 2004). During July 2003, Geist et al. (2004) captured 10 adult bull trout (two were subsequently recaptured) downstream of Albeni Falls Dam. Of these, one was captured near Indian Creek and the remaining were captured near to or inside a culvert draining a spring-fed wetlands. Geist et al. (2004) suggested the 10 captured bull trout likely originated from above Albeni Falls Dam. Fish surveys were also conducted during 2004 (Scholz et al. 2005). During these surveys 2 bull trout were captured and one additional bull trout observed, but escaped capture.

Box Canyon Reservoir has a number of tributaries draining into it. Most of the larger tributaries support brook, cutthroat, rainbow, or brown trout. Small numbers of bull trout have been observed in LeClerc Creek, Mill Creek, Cedar Creek, and Indian Creek. Scholz et al. (2005) concluded that LeClerc Creek has a small self-reproducing population of bull trout based upon observations of both adult and juvenile fish within the system. The Kalispel National Resource Department observed a 20-inch female bull trout on a redd during 2000 (USDA Forest Service 2006).

The Box Canyon Project is in the final stages of the relicensing process.[2] The U.S. Fish and Wildlife Service (USFWS) prescribed the development of upstream and downstream fish protection facilities at Box Canyon Dam targeting passage for juvenile, sub-adult, and adult bull trout, westslope cutthroat trout and mountain whitefish 4 inches (102 mm) in length or greater (FERC 2004). The upstream passage facilities are to be developed in a three stage process that includes the planning and construction of initially a temporary facility, then an interim facility, and a permanent facility if deemed appropriate. The temporary and interim facilities are to be designed for trap-and-haul of captured fish. Each stage of the upstream passage facility development includes the preparation of a design plan and specifications, an operation and maintenance plan, a monitoring and reporting plan, a post-installation effectiveness evaluation plan, and implementation of the plans. During March 2006, the POCPUD submitted these plans for the temporary facility to FERC (EES 2006a, 2006b, 2006c, 2006d). The USFWS approved the plans during June 2006 (USFWS 2006). The POCPUD expects to complete construction of the temporary upstream fishway (TUF) and deploy it by July 2007. The TUF is a fish attraction facility and trap that will be tested at a variety of locations in the Box Canyon Dam tailrace. These locations will be selected based upon hydroacoustic, depth, and water velocity profile information to be gathered periodically along standard transects. In addition to counting and other measurements and observations of captured bull trout, cutthroat trout, and mountain

[2] The FERC has approved the new license, but is currently considering appeals.

whitefish, native salmonids released in Box Canyon Reservoir near Ione will be monitored using radio and/or acoustic tags to determine general movement patterns and level of fallback downstream of the release site.

The USFWS has developed a biological criterion for triggering an evaluation for the need to develop and install a permanent volitional upstream facility. The criterion is a three-year rolling average of 97 bull trout or 97 westslope cutthroat trout captured annually by the interim facility. When the criterion is met or exceeded, representatives from the USFWS, U.S. Forest Service, Kalispel Indian Tribe, and Washington Department of Fisheries will consider a number of factors to determine if a permanent volitional upstream passage facility is needed. These include the effectiveness of the interim trap-and-haul facility, status of recovery tasks in the Bull Trout Recovery Plan, and the abundance and increasing trend in the number of migratory bull trout or westslope cutthroat trout at the interim trap-and-haul facility. If the evaluation concludes that a permanent facility is needed, the various plans described above are required within 12 months and construction is required with 24 months after they are approved. If the evaluation concludes that a permanent facility is not warranted at that time, representatives of the agencies will meet annually to re-evaluate the need. The interim facility will operate throughout the license term until superseded by an upstream volitional fishway.

The 97-fish criterion developed by the USFWS is based upon the mean number of the recovered abundance of migratory bull trout for tributaries downstream of Box Canyon Dam, Slate Creek and Sullivan Creek, and an estimate of the migration frequency for bull trout. As described previously, the bull trout recovery team developed recovery criteria for Northeast Washington Unit (Columbia River and tributaries from Chief Joseph Dam to the U.S.-Canadian Border; Pend Oreille River and tributaries from the U.S.-Canadian Border to Albeni Falls) that included the identification of local tributary populations and abundance numbers that would be needed in each population for recovery. Slate Creek and Sullivan Creek were two of nine tributaries in the Northeast Washington Unit designated as tributaries that would need to have local populations for recovery. Designated recovery abundances were 25 to 75 adults in Slate Creek and 600 to 850 adults in Sullivan Creek. Based upon information on the migratory frequency of bull trout in the Clark Fork River and St. Joe River, the USFWS calculated that approximately 12.5 percent of bull trout would migrate in any given year. The 97-fish criterion is 12.5 percent of 775 (50 from Slate, 725 from Sullivan) bull trout. One implicit assumption of the 97-fish criterion is that adfluvial bull trout migrating from Slate and Sullivan Creeks would move upstream to rear in Box Canyon Reservoir or Lake Pend Oreille.

The downstream passage facilities are to be developed in a two stage process that includes an interim facility and a permanent facility. The schedule for developing the interim facility is dependent upon completion of planned turbine upgrades and installation of a spill bypass system, or within 10 years of issuance of the license, whichever comes first. Beginning in 2006, the POCPUD is planning to begin a study program investigating fish abundance and behavior, turbine and spillway fish survival, and forebay hydraulics (via modeling). The study program's objectives are to provide needed information for the design of the interim downstream fishway at Box Canyon Dam. Preliminary design plans for the interim downstream fishway are scheduled for 2008 (EES 2006e).

### 2.2.4. Albeni Falls

Albeni Falls Dam was completed in 1952 and is operated by the U.S. Army Corps of Engineers (USACE). It is located on the Pend Oreille River at RM 86.9. The dam impounded 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. Currently Albeni Falls Dam has no passage facilities and has isolated upstream fish populations from downstream fish populations (Scholz et al. 2005). 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. The draft Bull Trout Recovery Plan (USFWS 2002) indicates that passage of bull trout at Albeni Falls is critical for the recovery of bull trout in the Northeast Washington Unit.

Historically, Lake Pend Oreille had a large bull trout sport fishery with an average harvest of 2,924 bull trout between 1951 and 1958 (Scholz et al. 2005). Since that time bull trout harvest has declined to a low of 621 fish in 1985, and capture of bull trout became illegal in 1996 (Scholz et al. 2005); however, bull trout are still captured incidentally, but must be released, while fishing for other species. Bull trout in Lake Pend Oreille exhibited an adfluvial life history pattern. Bull trout spawned in the Priest River, the Clark Fork River, and the smaller tributaries to these rivers and Lake Pend Oreille. Lake Pend Oreille and the Pend Oreille River were the historical foraging grounds for juvenile and adult bull trout and the Pend Oreille River also functioned as a migratory corridor (Scholz et al. 2005). Lake Pend Oreille is currently utilized as foraging and overwintering habitat. The upper Pend Oreille River above Albeni Falls Dam is currently utilized as a migratory corridor and overwintering habitat, but its utilization as foraging habitat is limited. This utilization is evident from the studies completed by DuPont and Horner (2003), Geist et al. (2004), and Scholtz et al. (2005). Few bull trout currently utilize 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 from 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 6 of the 7 radio-tagged bull trout tracked in 2003 below Albeni Falls Dam moved upstream towards the dam (Geist et al. 2004).

The Middle Fork East River, which drains into the Priest River, has been identified as an important local population in the Lake Pend Oreille Core Area, which is in the Clark Fork Recovery Unit (Lower Clark Fork Recovery Subunit) (USFWS 2002). Studies by DuPont and Horner (2003) and Geist et al. (2004) have concluded that the Middle Fork East River local bull trout population exhibits an adfluvial life history pattern that includes overwintering in Lake Pend Oreille. These authors have expressed concern that Middle Fork East River juvenile bull trout may be vulnerable to entrainment at Albeni Falls Dam.

Following the release of the USFWS (2000) Biological Opinion on the Federal Columbia River Power System, the USACE began to evaluate the feasibility of providing passage for bull trout at Albeni Falls Dam. The most recent study (Scholz et al. 2005) recommended that passage of migratory fish at Albeni Falls be facilitated and that a pilot-scale fish passage evaluation be implemented. Several options were suggested for locations of experimental traps as part of a trap-and-haul program. As of March 2006, the USACE has not made any decisions concerning the feasibility of passage at Albeni Falls Dam and continues to work with the USFWS and other stakeholders towards addressing critical information gaps through the implementation of feasibility studies (E. Lewis, USACE, pers. comm., March 8, 2006).

### 2.2.5. Cabinet Gorge and Noxon Rapids

The Cabinet Gorge and Noxon Rapids projects operated by Avista Corporation are located at RM 149.9 and 169.7 (measured from the Pend Oreille River confluence with the Columbia River), respectively, on the lower Clark Fork River upstream of Lake Pend Oreille. These projects are located within the Clark Fork River Basin Recovery Unit, which also includes the Pend Oreille River upstream of Albeni Falls Dam, the Priest River, Lake Pend Oreille, and the Flathead River. In March 1999, the Clark Fork Settlement Agreement began implementation two years prior to the start date of the new license FERC granted to the Avista Corporation. As part of the license and settlement agreement, Avista was required to implement the Native Salmonid Restoration Plan (NSRP) developed cooperatively between Avista, federal, state, and local agencies, affected tribes, and other stakeholders (Kleinschmidt and Pratt 1998). The NSRP did not set policy or specify how passage, initially focused on bull trout and westslope cutthroat trout, might be accomplished at Cabinet Gorge Dam or Noxon Rapids Dam. Instead, the NSRP identified a set of principles and a stepwise approach for the different entities to work cooperatively towards identifying and addressing issues concerning the restoration of native salmonids in the project area. The NSRP established a Fisheries Working Group and provided for a dispute resolution process when disagreements occurred.

The first step in the process was scoping, population modeling, policy review, and setting specific goals and objectives. This step had the goal of developing a strategy for evaluating data and policies so that subsequent aspects of the process could be prioritized with clear objectives. The second step was the identification of issues that would influence the availability of native fish stocks suitable for passage. The goal of this step was to "accurately define and assess the biological characteristics of native salmonid stocks, stock location, and the condition of habitats within the study area relative to the feasibility of restoration." At a broad level these issues were identified as genetics, pathogens, introduced or exotic fish species distribution and control programs, native fish abundance, and tributary and mainstem habitat evaluation, protection, and enhancement. The third step was to implement the colonization of streams in the project area using stocks identified in the second step. The fourth and final step was to establish and maintain habitat connectivity for migratory trout by initially implementing experimental facilities, which would then be followed by permanent facilities. During each step of the plan adaptive management was tied to monitoring, explicit hypothesis testing and utilization of the best scientific evidence available. Notably, the plan was designed to be flexible to allow for strategic and tactical changes in course as new information became available.

By the end of 2004, significant progress had been made for implementing the Native Salmonid Restoration Plan (Avista 2001, 2002, 2003, 2004, 2005a). Studies included:

- Population modeling using the Bayesian Viability Assessment Model
- Pathogen presence and risk of spread by bull trout passed over dams
- Bull trout genetics

- Radio-tracking of bull trout transferred from below to above dams
- Capture and radio-tracking of downstream migrating bull trout, westslope cutthroat trout, and brown trout in the Clark Fork River tributaries
- Bull trout spawner and redd surveys
- Design, deployment, and evaluation of an experimental upstream migration trap below Noxon Rapids Dam
- Modification of the Cabinet Gorge Fish Hatchery Ladder to capture native salmonids
- Exotic fish suppression and recreational fishery enhancement studies
- Abundance of native fish in tributaries
- Native fish life history research studies
- Study and evaluation of juvenile transport program from tributaries to below dams

The results of the studies to date have led to a focus on developing trap-and-haul facilities below both Noxon Rapids and Cabinet Gorge Dams and trapping of downstream migrating adults and juveniles within tributaries (Avista 2005b). This approach is being pursued because of uncertainty in the effectiveness of more traditional passage measures (fish ladders and screens) to successfully pass bull trout and westslope cutthroat trout and because of the high cost of the traditional measures at these facilities.

### 2.3. Summary of Potential Habitat Connectivity

The available information suggests there are two, and perhaps four, populations of bull trout in tributaries to the Pend Oreille River. The Salmo River at RM 12.7 and the Priest River at RM 95.2 are known to sustain reproducing bull trout populations and LeClerc Creek is suspected of having a small self-reproducing population of bull trout, but of unknown status (Scholz et al. 2005). Five juvenile bull trout have been observed in Nine Mile Creek, which drains into Seven Mile Reservoir, but additional monitoring is needed to determine if a self-reproducing population is present. LeClerc Creek is located in the Pend Oreille Core Area, while the Salmo River and Nine Mile Creek are located downstream and the Priest River is located upstream of the core area. Prior to 2003, individual bull trout were periodically observed within the Pend Oreille River or tributaries downstream of Albeni Falls, but the source of these individuals is unknown. However, during 2003 and 2004 at least 13 bull trout were captured or observed at several locations in the upper reaches of Box Canyon Reservoir, with most of these grouped in a localized area near a culvert releasing cool spring water. 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).

Adfluvial fish habitat within tributaries to Boundary Reservoir is limited due to natural passage barriers, small stream size, and poor habitat quality. Analysis of available information suggests that none of the tributaries to Boundary Reservoir currently sustain reproducing resident or adfluvial bull trout populations. Westslope cutthroat trout are known to be present in six tributaries draining to the Boundary Reservoir: Pewee Creek, Slate Creek, Sullivan Creek, Sweet/Lunch Creek, Sand Creek, and Lost Creek. Adfluvial fish habitat for these streams totals 30,068 linear feet (5.7 miles). Mountain whitefish are documented as present in Sullivan Creek and Sweet/Lunch Creek (24,931 feet or 4.7 miles of adfluvial habitat). It is unknown to what extent the westslope cutthroat trout and mountain whitefish that spawn in these tributaries exhibit an adfluvial life history form.

Currently none of the hydroelectric projects on the Pend Oreille River have fish passage facilities. If fish passage facilities are developed at Chief Joseph and Grand Coulee dams, and anadromous fish production is restored above Grand Coulee Dam, the Waneta Expansion Power Corporation agreed to install passage facilities at Waneta Dam on a cost-sharing basis (WEPC 2006). As part of a renewed license, the USFWS has required temporary and interim passage facilities be constructed at Box Canyon Dam with the need for permanent facilities dependent upon the level of future captures of cutthroat or bull trout at the upstream interim facility. The ESA Section 7 consultation for the federal Columbia River Power System included as a reasonable and prudent measure the need to provide passage at Albeni Falls Dam, but the feasibility and funding source is uncertain.

Unlike the Pend Oreille River projects, the Clark Fork projects have substantial self-reproducing bull trout populations in their project vicinities that exhibit adfluvial life history characteristics. Nevertheless, the Clark Fork projects are utilizing a phased adaptive approach to determining the need, feasibility, design, and implementation of passage facilities. The requirements for implementing passage at Box Canyon Dam also include monitoring and adaptive management measures prior to implementing permanent facilities. The apparent scarcity of bull trout and cutthroat trout within Boundary Reservoir and downstream of Boundary Dam warrants a thoughtful and cautious approach to evaluating fish connectivity at Boundary Dam. Uncertainties associated with potential movements and other life history characteristics of native salmonids will be addressed through relicensing studies to be developed in the Boundary PSP.

# 3 TARGET FISH SPECIES

The target fish species considered in this EID are bull trout, westslope cutthroat trout, and mountain whitefish. This section discusses the biological characteristics of these native salmonid species that are pertinent to addressing fish connectivity at the Boundary Project.

## 3.1. Seasonal Fish Distribution and Abundance

### 3.1.1. Bull Trout

Bull trout are salmonids classified as members of the char genus (*Salvelinus*). Brook trout (*S. fontinalis*) and lake trout (*S. namaycush*) also belong to the char genus, but only bull trout are native to the area. The USFWS have listed bull trout as threatened under Endangered Species Act. Under separate rulings, five Distinct Population Segments (DPSs) of bull trout (Klamath River, Columbia River, Jarbidge River, Coastal-Puget Sound, and St. Mary-Belly River) were listed as threatened under the ESA by the USFWS, with all five bull trout DPSs in the coterminous United States consolidated under a single rule on November 1, 1999 (64 FR 58910). These population segments are geographically isolated from one another with no genetic interchange between them due to natural and man-made barriers. Bull trout populations in the Pend Oreille River are part of the Columbia River DSP.

Within the Columbia River distinct population segment bull trout exhibit resident, fluvial and adfluvial life history strategies (69 FR 59996, 64 FR 58910). Bull trout spawn in cold, clear streams with complex channel characteristics. Juvenile rearing in streams occurs for 1 to 4 years. The migratory forms then begin to move downstream to take up residence for several years (usually two or more) as the fish grows to adulthood in lakes (adfluvial) or remain in their natal (resident) or larger mainstem rivers (fluvial). The migratory patterns of adfluvial behavior can be complicated, vary both among and between populations, and may include long migrations in excess of 100 miles (Rieman and McIntyre 1993; Goetz 1989). Some fish may reside in the lake or reservoir and only migrate to their tributary stream to spawn. Other fish may also periodically utilize their natal stream or other streams to forage or overwinter.

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 mm. The juvenile outmigration for tributaries to Lake Pend Oreille peaked during May, but information from the other areas (i.e., Flathead River, Metolius River, Mill Creek) had some juveniles also outmigrating later in the early to late summer.

Maturity occurs at age 5 to 6 years with spawning migrations to the natal stream (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 migrations 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 be fluvial.

Bull trout fry are usually found in shallow, slow backwater side channels and eddies in close proximity to instream cover (Pratt 1984). These characteristics are similar to that reported for other species of salmonids (Fraley and Shepard 1989). Juveniles are primarily bottom dwellers and are found among interstitial spaces in the substrate (Fraley and Shepard 1989; Pratt 1992). Sub-adults are often found in deeper stream pools or in lakes in deep water with temperatures less than 59°F (15°C) (Pratt 1992).

In the proposed rule for designating critical habitat (69 FR 35768), bull trout are described as opportunistic feeders that migrate between patches depending upon the available foraging opportunities. Consequently, habitat utilization during rearing can be variable and dependent upon available food sources. In a riverine or lacustrine setting, bull trout may forage on a variety a terrestrial and aquatic insects, zooplankton, and small fish. Larger bull trout are predominately fish-eaters.

As described previously, bull trout have rarely been observed in Boundary Reservoir or its tributaries. Summer water temperatures in the Pend Oreille River reservoirs are considered to be too warm for bull trout (Stovall 2000), except in thermal refugia near the outlets of coldwater tributaries (69 FR 59996).

### 3.1.2. Westslope Cutthroat Trout

Westslope cutthroat trout (*O. clarki lewisi*) is one of three cutthroat subspecies found in Washington State, the other two being coastal cutthroat trout (*O. clarki clarki*) and Lahontan cutthroat trout (*O. clarki henshawi*) (Wydoski and Whitney 2003). Westslope cutthroat trout are native to the Boundary Project area. Westslope cutthroat trout begin spawning at age 4 or 5 and individuals generally spawn every other year. Westslope cutthroat trout spawn from March through July when water temperatures warm to approximately 50°F (USFWS 1999). Fry emergence is usually complete by the end of August. Following emergence, fry disperse downstream. Fry habitat consists of shallow, slow moving areas between 5 cm and 50 cm in depth and velocities of 0.11 to 0.36 mps (Shepard et al. 1984). Similar to bull trout, westslope cutthroat trout can exhibit resident, adfluvial, or fluvial life history patterns. Resident westslope cutthroat trout generally mature at a smaller size than fluvial or adfluvial fish (Wydoski and Whitney 2003). The USFWS (1999) suggested that westslope cutthroat trout that spawned in tributaries to the Pend Oreille River were historically either fluvial or resident fish and under current conditions the fluvial form may have converted to the adfluvial form.

Juvenile cutthroat trout that exhibit the fluvial or adfluvial life history pattern usually spend 1 to 4 years rearing in natal streams before outmigration (McIntyre and Rieman 1995). During the summer, juvenile cutthroat trout rear in low velocity riffles, pool tailouts, and runs. Fall can be a period of movement between summer rearing habitat and overwintering habitat. Winter habitat for juveniles consists of pools and side channels in association with woody debris and large substrate with suitably-sized interstices. Bjornn (1971) found that the availability of overwintering habitat was a major factor influencing outmigration of subyearling trout. Low levels of overwintering habitat resulted in higher levels of outmigration. USFWS (1999) suggested that westslope cutthroat trout are usually found in the cooler upper extents of tributaries, but suggested this utilization was more likely driven by competition from other trout such as rainbow trout and brook trout that are less tolerant of cooler, higher gradient streams rather than a preference for that habitat type.

Historically, westslope cutthroat trout had a broad distribution across the western United States including many tributaries in the upper Columbia River such as the Kootenai River, Clark Fork River, the Spokane River above Spokane Falls, and the Missouri River (68 FR 46989). Within Washington State, westslope cutthroat trout were historically found in the Chelan River, Methow River, and upper Pend Oreille River basins (Wydoski and Whitney 2003) but it is unclear whether their distribution extended only upstream from Albeni Falls or further downriver (USFWS 1999). Based upon early accounts of cutthroat trout being harvested in the river, the USFWS (1999) concluded that westslope cutthroat trout were likely present throughout the Pend Oreille River.

Westslope cutthroat trout are found in nearly all of the larger tributaries that drain into Boundary Reservoir, the major exception being Flume Creek (Colville National Forest 2005). Within the Sullivan Creek watershed, westslope cutthroat trout are only found in the upper reaches upstream of Mill Pond. Along with rainbow trout and brook trout, cutthroat trout of both westslope and yellowstone genetic origin have been extensively stocked into tributaries to Boundary Reservoir (McLellan 2001). Consequently, the genetic purity of cutthroat trout populations in the Project area and tributaries is uncertain. Cutthroat trout are present in Boundary Reservoir in very small numbers; surveys conducted during spring, summer, and fall of 2000 using electrofishing and vertical and horizontal gillnets only captured a few cutthroat trout in the Upper Reservoir (McLellan 2001) (upstream of Sullivan Creek) and creel surveys conducted during the summer of 1997 yielded similar results (R2 Resource Consultants, Inc. 1998a). No cutthroat trout were captured in the Forebay Reach of Boundary Reservoir during any of the documented electrofishing, gillnet, or creel surveys.

The three cutthroat trout captured during surveys by McLellan were 3 years old and had a mean length of 354 mm (Table 3-1). Based upon scale analysis back-calculated mean length at age for the cutthroat trout captured in Boundary Reservoir during 2000 was 97 mm at Age 1, 167 mm at Age 2, and 254 mm at Age 3 (Table 3-2). Back-calculated mean length at age information is also available for cutthroat trout captured in Box Canyon Reservoir during 1988 to 1990 (Table 3-2), which were based upon a much larger sample size (confidence intervals on grand means not available).

There is little information available to discern movement patterns of cutthroat trout in Boundary Reservoir. Studies of cutthroat trout in other areas often demonstrate seasonal movements of tagged fish (e.g., Baldwin et al. 2002) as they respond to environmental conditions, such as thermal stratification, and the need to spawn. Relatively little information is available on cutthroat trout behavior from lakes or reservoirs that remain vertically isothermal throughout the year. In 1988, Barber et al. (1989) captured and floy-tagged 11 cutthroat trout in Box Canyon Reservoir of which only one was recaptured. The net movement of this fish was approximately 49.7 miles (80 km) away from its release site. Between April 7 and early September 1999, the location of a radio-tagged cutthroat trout was monitored on an approximately 2 week basis (Duke Engineering 1999). The fish moved from RM 70 (Calispel Slough) to RM 77 over a two-week period, then dropped back down-river to RM 66.5 (Tacoma Slough) by mid-June where it remained and was presumed dead.

It is possible that some cutthroat trout inhabiting Boundary Reservoir utilize thermal refugia near tributary mouths or enter cooler tributary streams to escape suboptimal temperature conditions in the reservoir during the summer and early fall, but no specific information for cutthroat trout is available to confirm this behavior pattern.

Some information on summer movements may be pertinent from brown trout tracking in Box Canyon Reservoir. Garrett and Bennett (1995) found that radio-tagged brown trout moved into Skookum or Cee Cee Ah Creeks during late June 1992 when temperatures in the reservoir reached 66.2°F-68°F (19°C-20°C). The fish remained in the creeks throughout the remainder of the summer while the reservoir was warm, but the creeks were less than 60.8°F (16°C). In contrast, this behavior was not observed during 1993 when temperatures in the reservoir were cooler. Duke Engineering (1999) also observed increased movement of brown trout during July and August, which they attributed to elevated water temperatures. Duke Engineering (2001) also reported that brown trout exhibited little movement during the winter, generally remaining within 300 feet of their capture location.

### 3.1.3. Mountain Whitefish

Except where noted, the following biological information is drawn from Wydoski and Whitney (2003) and Scott and Crossman (1973). Similar to bull and cutthroat trout, mountain whitefish (*Prosopium williamsoni*) are in the family salmonidae, but are not considered a trout. Mountain whitefish are widely distributed throughout western North America and found throughout the Columbia River Basin. While mountain whitefish have a similar overall shape as trout, they have relatively large scales and a sub-terminal mouth more suitable for foraging on benthic macroinvertebrates than surface or midwater drifting insects. Based upon surveys conducted during spring, summer, and fall of 2000 using electrofishing and vertical and horizontal gillnets, mountain whitefish are abundant in the Upper Reservoir Reach, and occasionally observed in the Canyon Reach, but surveys in the Forebay Reach during 2000 did not collect any mountain whitefish (McLellan 2001). Similarly, a creel survey conducted during the summer of 1997 found no mountain whitefish were captured by anglers in the Forebay Reach (R2 Resource Consultants, Inc. 1998a). Tributary surveys conducted during 2000 observed mountain whitefish in only Sullivan Creek and Sweet Creek (McLellan 2001).

Mountain whitefish usually spawn adhesive eggs on gravelly riffles in streams, but occasionally have also been observed to spawn on gravelly shoals within lakes or reservoirs. No documented observations of lake-spawning by mountain whitefish in Boundary Reservoir or Box Canyon Reservoir are available, but young-of-the-year have been captured in upper Boundary Reservoir (McLellan 2001) and in Box Canyon Reservoir (Ashe and Scholtz 1992). Unlike many other salmonids, no nest or redd are built by mountain whitefish. Spawning occurs during early to mid-November. The relatively large eggs hatch in about one month at 48°F. Following hatching, fry drift downstream until suitable shallow and slow-moving habitats are found. Within lakes or reservoirs, mountain whitefish fry will rear in shallow nearshore areas for several weeks before moving offshore (Northcote and Ennis 1994). Mountain whitefish generally rear in larger streams and lake or reservoirs at depths up to 30 feet. In streams and rivers mountain whitefish are opportunistic bottom-feeders predominantly eating a variety of benthic macroinvertebrates, but may also feed upon crayfish, freshwater shrimp, fish eggs, and occasionally small fish. In lakes and reservoirs, mountain whitefish may also include zooplankton such as cladocerans, copepods, and rotifers in their diet (Northcote and Ennis 1994).

In some areas adult mountain whitefish exhibit complex spawning and feeding migrations 6.2 to 18.6 miles in length (Northcote and Ennis 1994). However, in Box Canyon Reservoir 88.5 percent of 78 recaptured mountain whitefish exhibited no movement from their tagging location (Floy tags) and only 5.1 percent exhibited movements of more than 6.2 miles during studies conducted from 1988 to 1990 (Ashe and Sholtz 1992).

A radio-tracking study, although limited in sample size, generally confirmed the results of the Floy tag study. Between October 1998 and November 2000, a biweekly search was conducted for the location of five mountain whitefish (and other fish species) outfitted with radio-tags within Box Canyon Reservoir (Pend Oreille County PUD No. 1 2000). One mountain whitefish was never relocated, one traveled about 5 miles upriver and then remained at that location for the next 8 months, two moved no more than 6 miles from their tagging location, and the fifth remained near its tagging location for about 2.5 months, moved about 44.5 river miles over a two-week period and then stayed at that location until the end of the study or the transmitter ran out of power or failed. None of the radio-tagged mountain whitefish were detected by the seven fixed antennae located below Box Canyon Dam, suggesting that none passed through turbines or spillways. Taken together, the Floy tag and biotelemetry information suggest that most mountain whitefish have limited movement while rearing in Box Canyon Reservoir, but the information could not be used to draw conclusions about spawning run timing or locations.

Over 85 percent of the 35 mountain whitefish collected during surveys in Boundary Reservoir during 2000 were 3 years-old or older and the mean size of 3-year old fish was 12.1 inches (309 mm) (Table 3-1) (McLellan 2001). The mean length of one year-old whitefish was 4.8 inches (123 mm).

An alternative assessment of mountain whitefish length at age is available based upon scale analysis and back-calculation of mean length. Mean length at age for mountain whitefish collected in Boundary Reservoir were generally smaller than those collected over a three year period in Box Canyon Reservoir (McLellan 2001, Ashe and Sholtz 1992) (Table 3-2). However, the mean size for Age 1 fish back-calculated from the Boundary collection should be viewed with skepticism because the size at age analysis appears to have been affected by Lee's Phenomenon, which is apparent when back-calculated lengths at age are smaller for older fish than they are for younger fish (Devries and Frie 1996). Mean back-calculated lengths at Age 1 for mountain whitefish in McLellan (2001) were 96 mm for the youngest fish and 64 - 78 mm for older fish in the collection. Furthermore, mountain whitefish in the collection with no annulus (i.e., young-of-the-year fish) had a mean size of 103.9 mm[3], which is substantially larger than the back-calculated mean size for Age 1 fish (75 mm).

---

[3] Young-of-the-year mean size was calculated from the raw data sets obtained along with McLellan and O'Connor (2001) at www.streamnet.org.

**Table 3-1.** Age, mean length, and sample size of cutthroat trout and mountain whitefish captured in Boundary Reservoir during 2000 (McLellan 2001).

| | Cutthroat Trout | | Mountain Whitefish | |
|---|---|---|---|---|
| **Age** | **Length (mm)** | **Sample Size** | **Length (mm)** | **Sample Size** |
| 1 | | | 123 (±3) | 2 |
| 2 | | | 263 (±40) | 3 |
| 3 | 354 (±37) | 3 | 309 (±31) | 12 |
| 4 | | | 297 (±45) | 4 |
| 5 | | | 357 (±23) | 7 |
| 6 | | | 358 (±18) | 5 |
| 7 | | | 386 (±36) | 2 |
| Total | 354 (±37) | 3 | 314 (±64) | 35 |

**Table 3-2.** Back-calculated mean length in mm (sample size) at age for fish capture in Boundary Reservoir during 2000 and Box Canyon Reservoir during 1988 to 1990 (Ashe and Scholz 1992; Ashe et al. 1991; Barber et al. 1990; and Barber et al. 1989).

| | Cutthroat Trout | | Mountain Whitefish | |
|---|---|---|---|---|
| **Age** | **Boundary** | **Box Canyon** | **Boundary** | **Box Canyon** |
| 1 | 97 (3) | 85 (69) | 75 (35) | 149 (1,559) |
| 2 | 167 (3) | 145 (37) | 177 (33) | 206 (1,380) |
| 3 | 254 (3) | 222 (35) | 248 (30) | 250 (1,159) |
| 4 | | 285 (19) | 278 (18) | 285 (480) |
| 5 | | 321 (2) | 317 (14) | 341 (91) |
| 6 | | - | 324 (7) | 381 (40) |
| 7 | | - | 343 (2) | 413 (23) |
| 8 | | - | - | 435 (5) |

### 3.1.4. Other Species

Boundary Reservoir has populations of several introduced sportfish. Two of these, smallmouth bass (*Micropterus dolomieui*) and yellow perch (*Perca flavescens*), are common or abundantly present. Some aspects of their biology of these species may be pertinent to discussions concerning entrainment and habitat connectivity.

Smallmouth bass are typically found in clear streams and lakes and utilize coarse substrates such as boulders and rocky reefs, and are seldom found over sand (Wydoski and Whitney 2003). Prior to construction of the dams on the lower Snake River, smallmouth bass were observed to feed actively near current shears during the daytime, but settled motionless to the substrate surface or between rocks during the night (Munther 1970). Smallmouth bass are a sedentary species that generally have a small home range during most of the year, but may move short distances up to about 1.0 km often returning later to the home site (Todd and Rabeni 1989, Wydoski and Whitney 2003). Smallmouth bass spawn during May to June when water temperatures are 55°F to 60°F, building nests that are guarded until fry leave (Wydoski and Whitney 2003). Peak (2004) tested the swimming performance of smallmouth bass and found that critical swimming speed (Ucrit), a measure of sustained swimming performance, was related to fish length. Bass 240 to 450 mm FL had critical swimming speeds of 2.1 to 3.2 fps. However, Peak (2004) also observed that 80 percent or more of the smallmouth bass (270 to 470 mm) could ascend a 50 m raceway tested at water velocities ranging from 1.3 to 3.9 fps and concluded that critical swimming speeds underestimated the swimming ability of smallmouth bass.

Yellow perch are schooling fish usually found in clear lakes with a moderate amount of vegetation (Wydoski and Whitney 2003). Adult fish are generally found near the bottom, but occasionally swim off the bottom in 15 to 25 feet deep water. Similar to smallmouth bass, yellow perch are active during the day and rest on the bottom at night. Spawning occurs during April or May in shallow water on aquatic or submerged terrestrial vegetation and on sand, gravel, or rubble substrate (Scott and Crossman 1973; Wydoski and Whitney 2003). Yellow perch are active year-round (Scott and Crossman 1973). Fish and Savitz (1983) monitored the locations of four radio-tagged yellow perch for up to 102 days and determined home range areas of 1.3 to 5.4 acres. Tagged fish primarily were found in light macrophytes (42.8% of sightings) and over sand (29.7%), but were also observed in heavy macrophytes (14.2%), open water (1.3%), and transition zones between these habitat types (12.0%).

## 3.2. Biological Factors

The life history and distribution information described above for bull trout, westslope cutthroat trout, and mountain whitefish are useful for describing the biological factors to be considered when evaluating potential habitat connectivity across a migratory barrier. The effect of water temperature on swimming performance should also be considered (Scholz et al. 2005) when evaluating potential connectivity.

### 3.2.1. Fish Size

Bull trout and cutthroat trout are only known to spawn in riverine habitat, while mountain whitefish predominantly spawn in riverine habitat. Outside the Project area mountain whitefish have been observed to spawn on gravel bars in lakes, but this life history pattern has not been documented in Boundary Reservoir. Following hatching and emergence by bull and cutthroat trout in a riverine environment, young fish for these species typically rear in the stream for one or more years (primarily 2 years) prior to outmigration to mainstem rivers or lakes (McIntyre and Rieman 1995; Shepard et al. 1984; Hickman and Raleigh 1982). Consequently, it is unlikely that bull or cutthroat trout fry or fingerling (i.e., young-of-the-year) would be present in Boundary Reservoir. General life history information suggests there is the potential for all life history stages of mountain whitefish to utilize Boundary Reservoir; however, there are no documented observations of mountain whitefish spawning within Boundary Reservoir. Based upon a limited collection from Boundary Reservoir and a larger collection from Box Canyon Reservoir, Age 1 cutthroat trout are nearly 100 mm in size and Age 2 cutthroat trout and Age 1 or older mountain whitefish exceed 100 mm. As indicated above, the mean size of young-of-the-year mountain whitefish collected by McLellan (2001) was 103.9 mm. Mean size of Age 1 bull trout reported by Shepard et al. (1984) was 66 to 76 mm in length. By Age 2, all bull trout populations reported in the review had a mean size greater than 100 mm.

In their review of entrainment at hydroelectric projects Stone and Webster (1992) found that most entrained fish were less than 100 mm and generally over 90 percent were less than 200 mm even though trashrack bar spacing was usually large enough to pass much larger juvenile or adult fish. They concluded that larger fish could either avoid passing through trashracks or had a low propensity towards downstream movement. Notably, during the Box Canyon relicensing process, the USFWS prescribed the development of upstream and downstream fish protection facilities using a target fish size of 4 inches (102 mm) in length or greater (FERC 2004).

### 3.2.2. Fish Distribution

Westslope cutthroat trout and bull trout are respectively either occasionally or rarely observed in Boundary Reservoir. Neither have been documented as present in the Forebay Reach immediately upstream of Boundary Dam. Although numerous small fish less than 100 mm were captured by McLellan (2001), which indicates their methods were generally successful at capturing small fish within the depth range they could sample, no trout less than 100 mm of any species were captured. No documented reproduction of bull trout has occurred in tributaries to Boundary Reservoir and only three documented instances of bull trout observed in tributaries to Boundary Reservoir have occurred (one gutted carcass in Sullivan Creek, two in Sweet Creek). Bull trout have been documented as present in Boundary Reservoir near the mouth of Slate Creek and Sweet Creek. Westslope cutthroat trout are present in Sweet Creek, Sullivan Creek, Slate Creek, and Pewee Creek. Pewee Creek, Slate, and Sweet Creeks each have impassable barriers that isolate their upstream cutthroat populations. Sullivan has a difficult series of cascades in its lower reaches that may be passable under some flow conditions (CES 1996) and dams at Mill Pond and Sullivan Lake have no upstream passage facilities.

Mountain whitefish have only been observed in Sullivan Creek downstream of Mill Pond (Colville National Forest 2005; McLellan 2001) and Sweet Creek (1 fish; McLellan 2001). McLellan (2001) captured 10 young-of-the-year mountain whitefish in the upper part of Boundary Reservoir during July and September 2000 with a mean size of 103.9 mm. In general, mountain whitefish are considered common in the Upper Reservoir and Canyon Reach based upon surveys conducted by McLellan (2001). However, no mountain whitefish were captured by McLellan (2001) in the Forebay Reach.

There is little direct information from Boundary Reservoir about the seasonal movements of bull trout, cutthroat trout, or mountain whitefish. Furthermore, the available information is limited from other nearby areas or only available for surrogate species. General life history information suggests that, if present, juvenile fish of these species would likely enter Boundary Reservoir during spring (Wydoski and Whitney 2003). Smaller fish tend to remain in littoral areas that provide cover and move into deeper waters as they grow larger. During the summer, radio tracking of brown trout suggests that if water temperatures become unsuitable, trout may seek out and congregate near coolwater refugia near tributary outlets or groundwater seeps, or may enter tributaries (Garrett and Bennet 1995; Duke Engineering 2001; R2 Resource Consultants, Inc. 1998a). Bull trout may also begin spawning migrations during the summer (Baxter 2002), but spawning migrations occur in the fall for mountain whitefish and spring for cutthroat trout. Scholz et al. (2005) noted that in many areas (e.g., Lake Pend Oreille tributaries and the Priest River and its tributaries) bull trout spawning migrations begin as early as May or June to take advantage of higher flows when entering small spawning tributaries that may have intermittent flow at their mouths later in the year. Post-spawning migrations of bull trout to over-wintering sites were completed by the end of November in the Salmo River, but these fish did not utilize Seven Mile Reservoir (Baxter 2001b). Garrett and Bennet (1995) observed that half the brown trout they tracked returned to Box Canyon Reservoir to overwinter following spawning in October, while the other half overwintered in their spawning tributary. The results of a radio tracking-study suggest that brown trout may exhibit very little movement during the winter (Duke Engineering 2001).

### 3.2.3. Swimming Capacity

The swimming capacity of a fish depends on many factors, including fish species, size maturation, duration of activity, and environmental conditions. The swimming speed and the length of time that activity can be sustained will affect whether a fish is entrained into project facilities or whether facilities designed to attract and pass fish will be effective. Bell (1991) noted three levels of fish swimming capacity:

- Cruising – A speed that can be maintained for long periods of time (hours)
- Sustained – A speed that can be maintained for minutes; and
- Darting (or Burst) – A single effort, not sustainable.

Webb (1995) and Taylor and McPhail (1985) have also cited the importance of a “fast-start” behavior, essentially a startle response used to evade predators and other immediate threats. Fast-starts occur in less than a second and result from a rapid high amplitude stroke of the tail fin. Fast-starts accelerate the fish very rapidly but cannot be sustained. A fast-start can initiate movements at burst speeds, but quickly decelerate to sustained or cruising speeds.

Clay (1995) suggested that cruising and burst speeds, in particular, need to be considered when evaluating fish connectivity. Depending upon the type and specific design of facility, fish may easily hold position against the water current or make headway against the water current. Bell (1991) provided information on the swimming speeds for a variety of fish species including adult cutthroat and mountain whitefish. In general maximum sustained speeds for young-of-year salmonids approximately 100 mm in length appears to be around 2.0 feet per second (fps) (Table 3-3). Adult salmonids and suckers can sustain higher speeds up to 4.0 to 5.5 fps. Minimum burst speeds for adult salmonids and suckers appear to be in the range of 4.5 to 5.0 fps, while maximum burst speeds generally exceed 9.0 fps or higher. Bell (1991), Clay (1995), and Scholtz et al. (2005) each suggest that the effects of temperature on swimming capacity should be considered during fish passage design.

Several researchers have used the concept of a critical swimming speed ($U_{crit}$), which is the fastest sustained speed a fish can maintain for an hour, to assess the effects of water temperature on swimming capacity (Beamish 1978). $U_{crit}$ is generally measured by exercising fish to exhaustion in a modified respirometer by a stepwise (hourly) increase in water velocity. Using sockeye salmon 5.5 to 61.4 cm in length, Brett and Glass (1973) demonstrated that $U_{crit}$ is related to both fish length and water temperature. At a given temperature larger fish have a higher $U_{crit}$ than smaller fish. Similarly, for a given fish size $U_{crit}$ increases with temperature to a maximum and then declines. For sockeye salmon, $U_{crit}$ was maximized at 15°C and swimming capacity could be reduced by 25 percent or more at temperatures lower than about 5°C or greater than about 23°C.

**Table 3-3.** Approximate cruising, sustained, and burst swimming speeds for salmonids and suckers from Bell (1991).

| Species | Life Stage or Size | Swimming Speed (feet per second) | | |
|---|---|---|---|---|
| | | Cruising | Sustained | Burst |
| Cutthroat Trout | Adult | 2.0 | 5.5 | 14.0 |
| Whitefish | Adult | 1.0 | 4.5 | 9.0 |
| Mountain Whitefish | 305 mm | 2.0 | 4.0 | |
| Coho Salmon | 89 mm | | 1.7 | |
| Coho Salmon | 121 mm | | 2.1 | |
| Sockeye Salmon | 127 mm | 1.75 | 2.2 | |
| Brook Trout | 76 – 127 mm | 2.0 | | |
| Brown Trout | Adult | 2.0 | 7.0 | 12.5 |
| Suckers (non species specific) | Adult | 2.5 | 5.0 | 10.0 |

Optimal maximum cruising speed for sockeye and coho underyearlings is about 1.1 feet per second based upon Exhibit E in Bell (1991) but the optimal temperature for sockeye is about 57.2°F (14°C) while it is about 68°F (20°C) for coho salmon. To remain within 90 percent of maximum sustained cruising speed, or about 1.0 feet per second, temperatures should be within the range of 50°F to 62.6°F (10.0°C to 17.0°C) for sockeye underyearlings and about 59°F to 74.3°F (15.0°C to 23.5°C) for coho.

Mean monthly water temperatures for the Pend Oreille River near Boundary Dam between 2000 and 2003 ranged from 34.5°F (1.4°C) in January to 72.1°F (22.3°C) in August (Figure 3-1).

Assuming the information from Bell (1991) for sockeye and coho is representative of target salmonid species in the Boundary system, mean monthly water temperatures are within 90 percent of the optimal for maximum cruising speeds during spring and fall periods. In contrast, warm water temperatures would tend to reduce swimming capacity below optimal during the summer and cold water temperatures would tend to reduce swimming capacity below optimal during the winter.

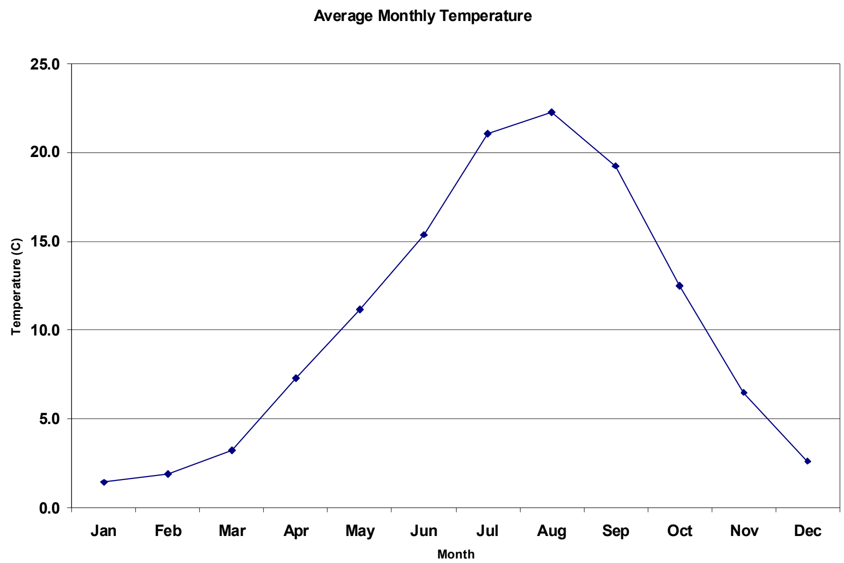


**Figure 3-1.** Average monthly water temperature in Boundary Reservoir near Metaline Falls (USGS Gage 12398550) from 2000 to 2003.

Currently, the WDFW has a maximum approach velocity for downstream fish screening devices of 0.4 feet per second, which is designed to protect all salmonid fry (fish less than 2.4 inches in length [60 mm] and larger fish [Nordlund and Bates 2000]). Clay (1995) concurs with this recommendation for the protection of fry, if they are present. For salmonids with a length of 3.1 inches (8 cm) or longer, Clay (1995) recommends that approach velocities of 1.0 feet per second are adequate.

# 4 ENTRAINMENT: PHYSICAL RISK FACTORS

There are four potential pathways through which fish can pass downstream through Boundary Dam. These are the turbines, spillways, sluiceways, and the skimmer gate. The likelihood that fish would pass through one of these pathways is a function of which pathways are open and passing flow, what percentage of the overall river flow each pathway is passing at the time, the relative depth of the pathway entrance in the water column, and the time of year relative to the fish species and its movement patterns both laterally in the river and vertically in the water column. The risk of injury or mortality associated with passage through each of these pathways is a function of the hydraulic conditions that would be experienced by the fish during the passage and upon reintroduction to the river in the tailrace below the dam. The following sections (4.1 through 4.5) describe the range of hydraulic conditions that potentially affect fish passing downstream through Boundary Project facilities, the existing information available concerning these conditions, and how this information applies specifically to the facilities at Boundary Dam. No attempt is made here to estimate numbers of fish or percentages of the populations that might be entrained at Boundary Dam.

## 4.1. Conditions Potentially Damaging to Fish

Fish have been shown to experience injury or mortality when exposed to particular extreme hydraulic or physical conditions upon passage through hydroelectric facilities. These conditions include:

- **Strike** – Physically contacting solid structures at high velocity. This could include striking turbine blades or other mechanical components while passing through turbine flow, striking solid objects protruding into spillway or sluiceway passages, or contacting rock upon reentry into the river downstream of the dam.
- **Shear** – Exposure to a transition zone between two bodies of water that are moving at different velocities. If a fish is in a body of water that is moving at a constant velocity then the fish will also move at that velocity and there will be no negative impacts on the fish regardless of the magnitude of the velocity. However, if a fish moves into a transition zone where velocities are significantly varying over small lateral distances then the fish can experience significantly different velocities on either side of its body at the same time. This can tear off scales or rip open portions of the operculum, or even bruise tissue on the fish.
- **Grinding** – Getting caught between moving and stationary mechanical components of a turbine. This can result in injury due to pinching or bruising, or can result in complete severing of the body.
- **Turbulence** – This is generally associated with downstream portion of passage where energy is dissipated through rapid mixing of flows, typical in and downstream of draft tubes, plunge pools, and stilling basins. Exposure to turbulent conditions can result in disorientation of the fish leaving them exposed to a greater risk of predation from larger fish or avian predators.

- **Cavitation** – In localized areas of extreme high velocities the effective water pressure can fall to well below atmospheric pressure and drive gas out of solution, forming small air bubbles in the flow. As these bubbles move back into more normal pressure zones they rapidly collapse which results in localized shock waves that can at times be strong enough to cause pitting in the steel blades of turbines. If a fish is immediately adjacent to a cavitating air bubble the associated shock wave can be extremely injurious.
- **Pressure Changes** – Rapid pressure changes typical in passage through turbines can result in bursting of the swim bladder or blood embolisms. Some species of fish are more susceptible to these effects than others due to their physiology, with salmonids being more resistant to problems associated with pressure changes than are perch or bass, for example. The potential for injuries associated with gas embolisms can be compounded by high levels of dissolved gasses in the water (see discussion under the following bullet).
- **Dissolved Gas Levels** – The presence of supersaturated total dissolved gas (TDG) levels, either upstream or downstream of the dam, can be a biological concern for any species living in the river, not just those that pass through the project. Therefore, for the most part, issues associated with TDG levels are beyond the scope of this fish connectivity report. However, high levels of TDG in the forebay may compound the effects of rapid pressure change associated with turbine passage by causing nitrogen bubbles to develop in the bloodstream, similar to a diver getting the bends by rising too fast.

These seven conditions are addressed relative to each of the potential passage routes in the following sections, along with ranges of estimated mortality given the Boundary Project characteristics. These mortality estimates are based on a range of mortality field studies performed at projects throughout North America, and laboratory studies of fish injury and mortality associated with hydraulic conditions likely to occur during passage. Although these estimates are based on the best available information, the unique characteristics of any hydroelectric project make estimates based on studies performed at other projects somewhat speculative. Therefore, the estimates are provided in terms of probable ranges of mortality.

## 4.2. Turbines

When inflow to the Boundary Project is less than the total turbine capacity the project is operated as a load-following project. Large generating flows are passed for a portion of each day and often low or no flow is released at night during off-peak hours. As is typical for large peaking projects, the Boundary powerhouse is equipped with a large total turbine flow capacity relative to the normal flows in the Pend Oreille River. Therefore, spill is much less frequent at Boundary than it is at typical non-peaking, run-of-river hydro projects. This results in turbine passage being the only existing pathway for fish to move downstream through the project for a majority of the time.

Mortality studies have been performed at a large number of hydroelectric turbines throughout North America. Study methods have varied over the years, and to some extent have likely influenced the results. Earlier studies generally involved tailrace netting in which a fyke net was set up downstream of the draft tube discharge and all the fish exiting the turbine were captured and inspected. More recently, turbine mortality studies have generally made use of the HI-Z balloon tag. This is a tag with a small deflated balloon that is attached to the fish before it is injected into the turbine flow. The balloon contains a mixture of ingredients that allow for a time-delayed inflation to occur after the fish has passed through the turbine. The fish is then buoyed to the surface in the tailrace by the inflating balloon and is retrieved by boat for inspection. This removes the potential problem of fish being injured or killed by the fyke net, and then having that injury attributed to passage through the turbine.

In conjunction with the U.S. Department of Energy's Advanced Hydro Turbine System Program (AHTSP), hundreds of turbine mortality study results were compiled and used to develop predictive equations of turbine mortality based on specific turbine characteristics (Franke et al. 1997). Kaplan and Francis turbines were considered separately in the review, since these are different turbine designs and understandably result in very different impacts on fish passing through them. The predictive equation for mortality through Francis turbines was used to estimate the likely mortality rate through the turbines at the Boundary Project.

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. The predictive equation also adjusts for head and efficiency. The equation is used to estimate the probability that a fish passing through the turbine will experience significant negative impacts. Strike, shear, grinding and cavitation (if it occurs) all are most pronounced very near to or in contact with the turbine blades, and pressure changes and turbulence are accounted for by the adjustments made for head and efficiency. A correlation factor is then developed that correlates actual field mortality measurements to the calculated probability estimate. Obviously, this factor will be different for different species of fish, as some species of fish fare better passing through turbines than others. The large majority of field studies at hydro projects in North America have been focused on salmonid species. Therefore, there is a greater confidence in estimates of mortality for salmonids than for other species, since there is a larger data set to work from. In developing the estimates of mortality for the Boundary turbines, the review is limited to salmonid species, particularly bull trout, westslope cutthroat trout, and mountain whitefish, since these are native species of interest on the Pend Oreille River.

The Boundary turbines are larger than any Francis turbines at which field mortality studies have been performed; however, turbines with similar and higher heads (albeit with smaller flow rates and diameters) have been studied which would indicate extrapolation of this equation is a reasonable approach. To gain confidence that extrapolating the equation to match the characteristics of the Boundary turbines is reasonable, two analyses were performed. First, mortality results from actual field studies involving Francis turbines with relatively large flow rates (but lower head than at Boundary) and studies where the head was similar to or higher than at Boundary (but the flow was less and the turbines smaller) were used to back-calculate correlation factors comparing the actual measured mortality to the probability estimated by the AHTSP predictive equation. The results of field studies from nine different projects were used in this analysis. Mortality rates measured at these sites indicated lower mortality at large low-head turbines and higher mortality at small high-head turbines. This relationship was reflected in the predictive equation based on the turbine features, and the factors correlating the actual measured mortality to the results of the predictive equation turned out to be surprisingly similar. Secondly, to ensure that extrapolating the equation outside the range of turbine sizes from which it was developed results in reasonable estimates, increasing values for turbine flow and size in small increments up to the size of the Boundary turbines were entered and the resulting estimates were reviewed. This analysis showed that as the turbine size and flow increased, the resulting mortality estimate tended to decrease, but not excessively so. This trend agrees with the field mortality study results from fish passed through various Francis turbines of different sizes. To be conservative in creating the range of estimated mortality for the Boundary turbines the low end of the estimate is based on a correlation factor of 80% of the average correlation factor from the nine field studies, and the high end uses a correlation factor of 200% of the average and is higher than the factor associated with any of the nine field studies.

The Boundary Project includes six turbines. Turbine Units 51 through 54 were installed with the original construction of the project. Units 55 and 56 were added later and are slightly larger than the original four turbines. The characteristics of the Boundary turbines were provided by Seattle City Light and are summarized in the Table 4-1.

**Table 4-1.** Boundary Project turbine characteristics.

| Turbine Characteristics | Unit 51 | Unit 52 | Unit 53 | Unit 54 | Unit 55 | Unit 56 |
|---|---|---|---|---|---|---|
| **Number of Buckets** | 14 | 14 | 14 | 14 | 11 | 11 |
| **Net Head (feet)** | 250 | 250 | 250 | 250 | 250 | 250 |
| **Flow at Max. Output (cfs)** | 9,518 | 9,518 | 9,518 | 9,518 | 10,471 | 10,471 |
| **Efficiency at Max. Output** | 87.5% | 87.5% | 87.5% | 87.5% | 94% | 94% |
| **Flow at Best Efficiency Point (cfs)** | 7,616 | 7,616 | 7,616 | 7,616 | 10,206 | 10,206 |
| **Efficiency at Best Efficiency Point** | 92.8% | 92.8% | 92.8% | 92.8% | 95.4% | 95.4% |
| **Speed (rpm)** | 120 | 120 | 120 | 120 | 128.6 | 128.6 |
| **Inlet Diameter (inches)** | 213.486 | 213.486 | 213.486 | 213.486 | 226.38 | 226.38 |
| **Outlet Diameter (inches)** | 208.386 | 208.386 | 208.386 | 208.386 | 218.82 | 218.82 |
| **Inlet Height (inches)** | 58.8 | 58.8 | 58.8 | 58.8 | 64.05 | 64.05 |
| **Centerline Elevation of Unit (ft)** | 1710 | 1710 | 1710 | 1710 | 1710 | 1710 |

The analysis considered three sizes of salmonids: 100 mm to represent juveniles; 250 mm to represent moderate size adult cutthroat, sub-adult bull trout, and whitefish; and 600 mm to represent large bull trout. One consideration with respect to fish size is that the trashrack consists of 1/2-inch thick bars at 6 inches on center, resulting in clear spaces of 5-1/2 inches. For the purposes of this analysis it was assumed that this spacing would not preclude any of the target sizes of fish from being entrained in the turbine flow, although the moderate and larger size fish may avoid passing through the racks as a result of their behavior. Studies at hydro projects have shown that the majority of turbine entrained fish tend to be smaller, juvenile fish, even if larger fish are present and theoretically able to pass through the trashrack spacing (Stone & Webster 1992).

Based on the turbine characteristics and the fish sizes being considered, the following ranges of estimated mortality associated with passage through the turbines were calculated using the predictive methodology from the AHTSP study (Franke et al. 1997). These results also tend to fall into general agreement with prior summary documentation of turbine entrainment study results (Stone & Webster 1992).

- Units 51 through 54
  - 100 mm salmonids: 6% to 15%
  - 250 mm salmonids: 13% to 33%
  - 600 mm salmonids: 26% to 65%
- Units 55 and 56
  - 100 mm salmonids: 5% to 12%
  - 250 mm salmonids: 11% to 28%
  - 600 mm salmonids: 23% to 59%

As can be seen from the estimated mortality rates above, it is estimated that the new turbines in Units 55 and 56 should have slightly greater survival for salmonid species passing through them than the older Units 51 through 54. This is due to reduced number of buckets within the turbines. A run of the equation was done with the dimensions of the new larger turbines with the number of buckets set to 14 to match the older turbines and the result was similar estimates for the smaller fish and slightly *higher* mortality for the larger fish even though the turbine is larger, due to the slightly higher rotational speed. This shows that factors such as the number of buckets and the speed are much more significant in the predictive equation than the size of the turbine or the flow rate. This is further justification that the extrapolation of this method to a larger turbine does not over estimate survival simply due to the size of the turbine.

These estimated mortalities were found to remain relatively constant from turbine flow rates slightly below the best efficiency point all the way up to the maximum unit flow capacity. This is because increasing flow generally increases fish survival by creating smoother hydraulics and moving the fish through the system more rapidly, whereas decreasing turbine efficiency tends to decrease survival by creating greater turbulence and shear zones. The two factors of increasing flow and decreasing efficiency tend to balance each other out through the high end range of turbine operation (from best efficiency point to maximum flow). However, operations below the best efficiency point, when flow and efficiency are both reduced, are estimated to increase mortality rates to levels greater than those shown above.

The fish mortality estimates developed using the AHTSP predictive equation are slightly lower than mortality estimates suggested by a general relationship between fish mortality and head developed by Stone & Webster (1992) (Figure 4-1). Stone & Webster (1992) plotted the results of 22 fish mortality field studies performed on Francis turbines for a range of turbine heads. Using their equation, a turbine with 250 feet of head would have a fish mortality of approximately 29 percent. The estimated mortality of fish passing through Units 51 through 54 ranges from a low of about 6 percent for 100 mm sized fish to a high of about 65 percent for 600 mm fish. The 22 field studies referenced by Stone & Webster were presumably conducted using smolt-sized fish, but the size of fish in each study was not integrated into the Stone & Webster equation.

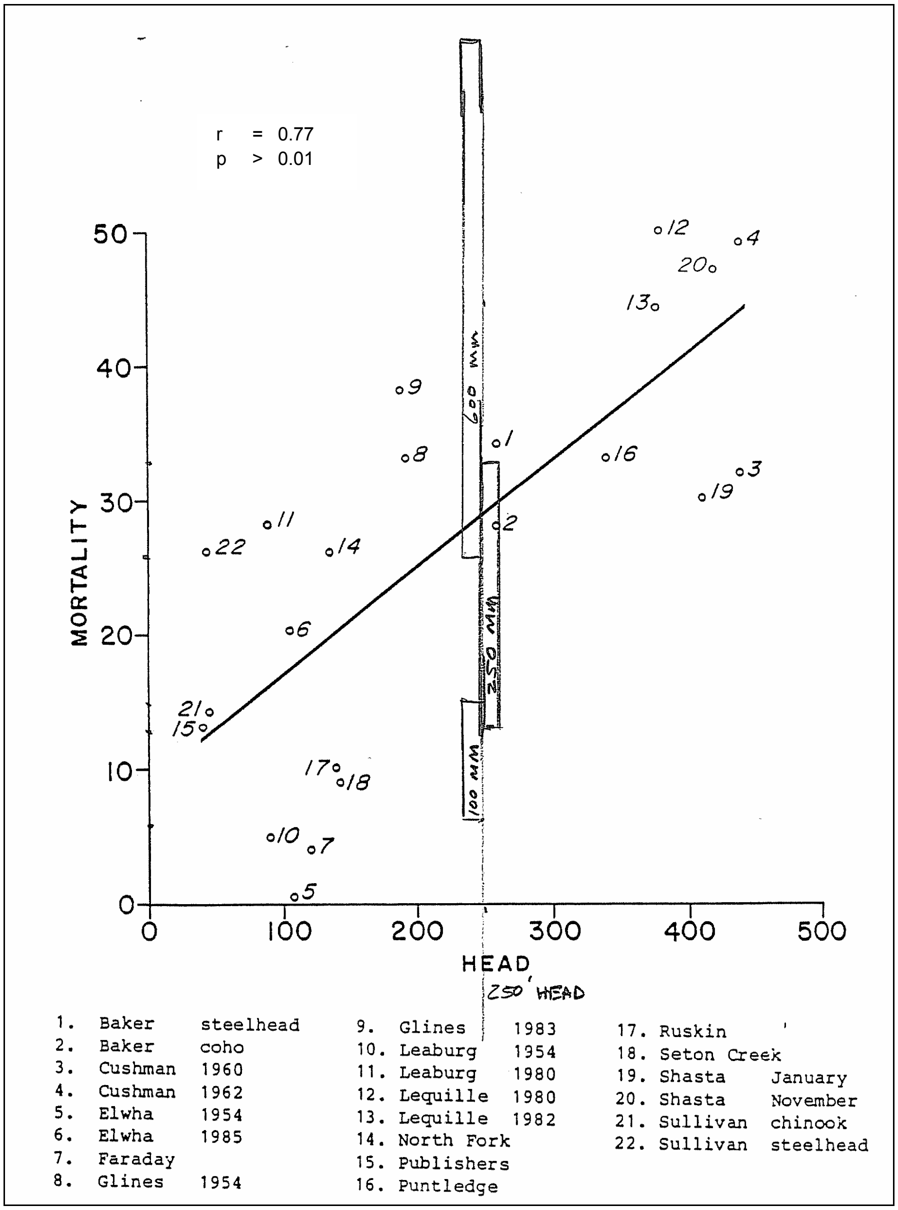


**Figure 4-1.** Comparison of mortality estimates for Units 51-54 to Stone & Webster (1992)

Concerning the seven potentially damaging conditions listed in Section 4.1, the following considerations are presented regarding turbine flow conditions and the estimates of fish mortality.

- Strike and shear are the major factors that are addressed by the predictive equation method because 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 occurs in very close proximity to the surfaces of the turbine where water is moving at high velocity over the surface of the steel. Strike and shear should represent the major factors resulting in injury in flow through a Francis turbine.

- Grinding is less of a source of injury in Francis turbines than in Kaplan turbines (common on the mainstem Columbia River) because the buckets, or vanes, of a Francis turbine are integral with the outer shroud and the entire structure rotates together. Therefore, the pinch points that are present in a Kaplan turbine, where the outer edges of the turbine blades are rotating at high velocity relative to the stationary discharge ring immediately adjacent to them, do not exist in a Francis turbine.
- Turbulence within the turbine should be minimized when it is running near to or above its best efficiency point. The influence of turbulence on fish mortality is addressed by the predictive method by the use of the turbine efficiency in the equation, since lowering the efficiency in the equation will increase the mortality estimate. Turbulence in the tailrace is a separate issue and can disorient fish making them more susceptible to predation until they recover. The influence of tailrace turbulence on predation is beyond the scope of the estimates in this study.
- Operating turbines within their cavitation zone is generally avoided because it is associated with inefficient turbine operation and can lead to turbine damage. It has been assumed in this analysis that SCL does not operate the Boundary turbines in their cavitation zone and that cavitation is not generally an issue for fish passage.
- Water pressure change occurs rapidly during passage through a turbine. Some fish are more susceptible to injury and mortality associated with rapid pressure change due to their inability to rapidly discharge air from their swim bladders. If fish cannot rapidly discharge air, their swim bladders will tend to expand in response to the reducing pressure. This is especially true for fish like perch and bass. However, salmonids are actually better suited to handle rapid pressure changes due to an air duct between the swim bladder and the digestive tract allowing for rapid release of air from the swim bladder. Field studies measuring mortality of salmonids passing through turbines at heads similar to or even greater than Boundary have shown survival rates complementary to the estimates made in this analysis.
- High dissolved gas levels above normal saturation can exacerbate the problems associated with rapid pressure change by causing the release of nitrogen bubbles in the bloodstream. This would be caused if the incoming flow to Boundary from upstream were supersaturated with dissolved gas as it passed through the turbines, and could cause the mortality rates to be higher than estimated using the AHTSP predictive equation. Increases in dissolved gas levels in the tailrace that may be caused by spill at Boundary Dam would not directly impact fish passing through the turbines, although potential recovery from turbine passage may be affected. The effects of total dissolved gas levels on fish downstream of the project is a separate issue from what is being addressed in this study.

As previously discussed in Section 1.3, turbine passage represents the only method of passage through the existing project facilities for the majority of the time. Operating conditions for spillway and sluiceway releases are discussed in the following sections along with the estimated mortality rates for passage through these facilities.

## 4.3. Spillways

Boundary Dam includes two spillways, with one on either side of the main arch dam section. Both spill gates are bottom opening Tainter gates 50 feet wide by 44 feet high. The spillways are ogee-shaped chutes with a crest elevation of 1946.0 feet. The top of the gate when closed is at elevation 1990.0 (normal maximum operating pool). The spillway chutes do not extend all the way to the tailwater, rather they end part of the way down and discharge flow into open air. The flow then plunges into a pool in the tailrace. Spillway 1, on the left bank looking downstream, extends 197 feet horizontally downstream from the crest. The end of the spillway chute has a flip bucket with a radius of 35 feet that causes the discharge to be released at an upward angle of about 21 degrees at an elevation of 1904.6 feet. Spillway 2, on the right bank, is a shorter chute, extending 93.9 feet horizontally downstream of the crest, and does not include a flip bucket. Flow is discharged from this spillway at a downward angle of about 5.7 degrees. Figures 4-2 and 4-3 show Spillways 1 and 2, respectively. Operating procedures for the spillways are presented in Section 1.3, and are not repeated here.

**Figure 4-2.** Spillway 1 and skimmer gate chute on left bank

**Figure 4-3.** Spillway 2 on right bank

Of the seven potentially damaging conditions listed in Section 4.1, the two that are major considerations associated with spill flow are shear and strike. Damaging shear occurs when the plunging spill flow enters the tailrace, and there is a substantial difference in velocities where the two flows come together. Although there is also potential for shear zones along the periphery of the flow within the concrete spillway chute, laboratory tests of the effects of localized shear have shown that there is little to no injury at differential velocities of up to approximately 60 fps (PNNL 2000). The length and height of the spillway chutes at Boundary Dam should result in maximum velocities of less than 60 fps, prior to discharge off the end of the chutes. Therefore, it would not be expected that there would be injurious shear conditions within the initial flow through the spillway chutes.

Strike can occur if the spill flow comes in contact at high velocity with projections within the spillway chute, or with rock along the bank or the bottom of the plunge pool. Although the flip bucket at the end of the Spillway 1 chute represents a projection into the flow path it is well rounded and the flow should generally follow the shape of the chute floor without producing damaging strike potential. No projections are readily apparent within the chute of Spillway 2.

Grinding, cavitation and rapid pressure changes are not generally problems associated with spill flow. Turbulence in the tailrace for the fish that survive the plunge could be a concern as the fish are likely to be initially disoriented upon entry into the tailrace; however, the level of predation in the Boundary tailrace is unknown. Increases in dissolved gas levels associated with spill flow would not be a direct immediate impact on the fish passing through the spill flow, but may have an impact on them downstream. Discussions concerning total dissolved gas levels and spill at Boundary are beyond the scope of this study. Potential modifications to the spillways or plunge pool to mitigate for dissolved gas increases should consider potential damage to fish passing through the facilities.

Based on the discussions above, the greatest impact on fish passing through spill would be expected to occur upon entrance of the plunging flow into the tailrace. Based on the height of the spillways above the tailrace (155 to 170 feet from the point of discharge off the spillway chute to the tailwater, depending upon tailwater level), the velocity of the plunging flow at Boundary is estimated to exceed 100 feet per second upon impact into the tailrace plunge pool. Figures 4-4 and 4-5 show the spill flow conditions at Boundary Dam.

**Figure 4-4.** Spill flow looking from above

**Figure 4-5.** Spill flow looking from downstream

Prior to the availability of the HI-Z balloon tag (see Section 4.2) it was difficult to perform a mortality study at a spillway since it was difficult to net the tailrace of a spillway and capture all the fish. Some early studies were performed but they tended to be based on random samples of fish captured at a location downstream, comparing the capture rates of fish released through the spill to fish released in the tailrace. This method required the release of large numbers of fish and produced results with large variability. Recent tests have produced results with a higher level of confidence; however, the large majority of these tests have been performed at spillways with lower head than at Boundary Dam. The typical spillways along the mid- and lower Columbia River, where the majority of these field tests have occurred, have heads between 45 and 85 feet, and have resulted in very low mortality rates. These spillways extend all the way to the tailrace and generally discharge flow horizontally across the tailrace at velocities of 50 feet per second or less. The few spillway mortality studies performed at higher head dams have tended to show higher mortality rates, with mortality increasing with increasing head (R2 Resource Consultants, Inc. 1998b). North Fork Dam on the Clackamas River in Oregon State has a head of 140 feet and a spillway chute that ends with the discharge as a free trajectory into a plunge pool, similar to the Boundary spillways. A recent balloon tag study at North Fork involving passing juvenile steelhead over the spillway resulted in 48-hour mortality rates that varied from 4% to 14%, with higher mortality resulting from a lower spill flow rate (Normandeau Associates 2002). Studies at Upper Baker Dam in Washington State in 1951 and 1952 resulted in estimated mortality rates of 50% to 82%, depending upon species and spill conditions (Hamilton 1955). Similar to Boundary, the total head at Upper Baker Dam is approximately 240 feet and the spillway chute ends with the discharge as a free trajectory into a plunge pool.

In addition to mortality field studies at spillways, laboratory studies of the effects of shear on fish have been performed (R2 Resource Consultants, Inc. 1998b; PNNL 2000). Fish experience shear forces when they are exposed to the periphery of a high-velocity jet discharging into low-velocity or still water. Laboratory studies have consistently shown that fish exposed to shear conditions resulting from jet velocities less than about 60 feet per second experience little or no mortality. However, mortality rises rapidly as jet velocities increase above this value. The size of the fish tested also had a significant effect, with fish greater than 200 mm showing a greater resistance to the shear forces.

The major factor to consider when applying the laboratory shear study results to real world spillways is the size and shape of the discharge jet and the flow across the concrete. If the flow is confined and deeper, a smaller percentage of the fish are likely to be exposed to the periphery of the jet. Fish entrained in the middle of the flow will not experience extreme shear forces, rather they will gradually decelerate with the bulk of the flow as it enters the tailrace. On the other hand, with shallow wide sheeting type flow a greater percentage of fish would likely be exposed to extreme shear along the periphery of the jet both as it enters the tailrace and as it passes along the concrete surface of the spillway. This explains the typical field results showing greater mortality for small magnitude spills and reduced mortality with larger spill flows. Another factor is the dissipation of the jet as it passes through the air in its trajectory to the plunge pool. The more the flow breaks up and becomes aerated mist and less of a coherent jet, the greater the percentage of the fish that will leave the jet and freefall into the tailrace. Smaller fish are relatively resistant to the effects of a freefall into water, and were commonly stocked in alpine lakes by being dropped from planes or helicopters. However, larger fish (above 300 mm) experience higher rates of mortality when freefalling from the height of the Boundary spillway discharges (R2 Resource Consultants, Inc. 1998b). Therefore, larger fish are likely to fair better if they stay in the jet, whereas smaller fish would fair better if they fully leave the jet and freefall into the tailrace.

Based on the review of previous studies at other projects and laboratory studies concerning the effects of shear forces on fish, the following assumptions are made concerning the impact on fish of passing through the spill flow at Boundary Dam.

1. *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*: Assume near 100% mortality for fish of all sizes.
2. *Relatively low spill flow rates, but high enough that the majority of the flow reaches the plunge pool*: The assumption here is that 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. In this case the small fish (approximately 100 mm) are estimated to experience an overall 60-70% mortality rate. Small fish that remain in the jet experience near 100% mortality due to exposure to shear, while small fish that leave the jet and freefall to the tailrace experience low mortality. The larger salmonids (approximately 600 mm) might experience similar or slightly smaller mortality rates of 40-50% but for the opposite

reasons, with the fish that leave the jet experiencing very high mortality and those that remain in the jet fairing better due to a greater resistance to shear forces.

3. *Larger spill flows where the large majority of the flow remains in a coherent jet to the tailrace*: Assuming the fish do not impact the bottom of the plunge pool the major source of mortality would 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%, similar to the results of field studies at Upper Baker Dam, whereas for larger fish the mortality could be as low as 20-40%.

It needs to be qualified that these are just estimates based on field studies at other sites, laboratory tests of the effect of shear, looking at the spillway with no spill flow during a site visit, drawings of the spillway shape, and photographs of the spill flow. No actual field studies estimating mortality have been performed at Boundary Dam. Results of spillway mortality field studies have varied and do not always fit in to what one might expect to find. There tend to be individual features of the spillways, stilling basins, and plunge pools at each project that do not fit neatly into a predictive model. Therefore, actual mortality rates for fish passing through the Boundary spillway can not be known without actually performing field tests at the spillway. However, some general assumptions would appear valid when comparing these estimates to those made for the turbines (Section 4.2). For the smaller fish being considered in this review it would make sense that they would fair better passing through the turbines than they would through the spill flow, whereas for the larger fish the survival would be better passing through the spill flow than through the turbines, assuming it was a large enough spill flow that the majority of the fish remained in the main water jet. A final consideration is the flip bucket on the end of Spillway 1. This tends to lift and spread out the flow from Spillway 1 more than is the case for Spillway 2 (see Figures 4-4 and 4-5). This tends to break up the flow and drive more of the flow, and presumably a greater percentage of the fish, out of the main jet and into a freefall condition, which should be slightly better for smaller fish and slightly worse for larger fish than is the case for Spillway 2.

## 4.4. Sluiceways

Boundary Dam includes seven sluiceways located at about mid-height 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 (see Section 1.3). The sluiceways are submerged on the upstream side of the dam and are rectangular in shape, with a reducing area in the downstream direction through the dam. At the discharge end, on the downstream face of the dam, the sluiceways are 21 feet high by 17 feet wide. The flow capacity of each of the seven sluiceways is approximately 35,000 cfs with the forebay at 1990 (normal maximum pool). The invert of the sluiceway outlet is at Elevation 1791.5 feet. The sluiceways are controlled by gates on the downstream discharge end. Figure 4-6 shows the seven sluice gates in the closed position with no flow.

**Figure 4-6.** Downstream face of the dam showing the sluice gates

Given the flow capacity and the dimensions of the sluiceway outlet the velocity of the flow exiting the sluiceway would be approximately 100 feet per second, and the impact velocity of the jet upon entry into the plunge pool should be about 115 feet per second, 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 of 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 of the periphery as the jet 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 would tend to imply that the mortality of entrained fish in the sluiceway flow should be somewhat lower than is estimated for the spill flow assuming the same magnitude of flow.

As was stated for the spillways in Section 4.3, no studies have been performed to investigate the actual mortality rates for fish passing through the sluiceways at Boundary Dam. Although the conditions would seem to imply that mortality should be somewhat lower than for the spillways, this is again somewhat speculative, based on presumed hydraulic conditions. One consideration worth noting is that the sluiceways all point slightly toward each other due to the curvature of the arch dam. Given the velocity exiting the sluiceways and the vertical drop to the tailwater it is estimated that the trajectory should extend about 160 feet downstream before reaching the tailwater. If two adjacent sluiceways are operating simultaneously it is estimated that the jets should impact each other about 125 feet downstream of the exits, before plunging into the tailrace (although this was not witnessed during this analysis and no photographs were provided showing this condition). This will create a significant impact condition breaking up both jets just when they are near their maximum velocity. This could create extreme shear conditions throughout both jets and may significantly increase fish mortality. It is estimated that if alternate sluiceways are used, with one closed between them, the jets should plunge into the tailrace before they would come in contact with each other. This would seem to be a better condition for entrained fish if multiple sluiceways need to be used.

As part of separate water quality investigations, SCL may consider use of the sluiceways as a means to reduce potential levels of gas supersaturation downstream of the spillways. The effects of sluiceway operations on fish mortality should be considered when evaluating alternative sluiceway operations. One note of caution here is that if the test were to be conducted with forced spill during lower river flow conditions, with correspondingly low tailwater levels, it may not be indicative of mortality conditions with a deeper plunge pool.

## 4.5. Skimmer Gate

The skimmer gate is located adjacent to Spillway 1 on the left bank looking downstream (see Figure 4-2). The gate is 26 feet wide by 8 feet tall with an invert at Elevation 1982.0. The gate is a flap gate that hinges down in the downstream direction to open. Flow passing over the gate when it is lowered passes onto a concrete chute extending downstream at a 10% slope to a discharge location at Elevation 1964.45. The flow then passes in a free trajectory to the tailwater. The skimmer gate was designed to provide for sluicing ice and debris from the forebay, however SCL personnel have reported that the gate is not currently used.

The flow capacity of the skimmer gate fully lowered is estimated to be approximately 1,800 cfs with the forebay at Elevation 1990, with reduced capacity at lower lake levels. If this gate were to be used, the wide shallow jet that would be discharged at an elevation more than 200 feet above the tailwater would likely be almost entirely broken up and aerated by the time it reached the tailwater and the majority of the fish would eventually freefall to the river below. This should result in relatively low mortality rates for the smallest fish, but relatively high mortality rates for the larger fish.

## 4.6. Entrainment Summary

If fish pass downstream through Boundary Dam facilities, they are exposed to potential injury and mortality, with the level of mortality depending on the pathway, flow rate, and size of fish. If fish pass through the spillways, the majority will be killed, while a large percentage of fish are expected to survive passage through the turbines (Table 4-2). Identifying and designing studies to further evaluate the risk of entrainment to fish and aquatic resources will be addressed during development of the PSP.

**Table 4-2.** Estimated mortality ranges for existing downstream passage routes.

| Passage Route | Range of Estimated Mortality by Fish Length | | | Comments |
|---|---|---|---|---|
| | 100 mm | 250 mm | 600 mm | |
| Turbines 51-54 | 6% - 15% | 13% - 33% | 26% - 65% | • Original Units |
| Turbines 55-56 | 5% - 12% | 11% - 28% | 23% - 59% | • New Units (larger turbines with fewer buckets & higher flow) |
| Spillways | 50% - 80% | 35% - 65% | 20% - 50% | • Depends on spill flow rate<br>• Spillway 1 better for smaller fish<br>• Spillway 2 better for larger fish |
| Sluiceways | 40% - 70% | 25% - 55% | 10% - 40% | • Speculative based on assumed reduction from spill estimates<br>• Assumes adjacent sluiceways are not operated simultaneously<br>• Does not consider influence of TDG impacts |
| Skimmer Gate | 0% - 20% | 10% - 30% | 50% - 80% | • Assumes fully aerated spray with freefalling fish upon tailrace entry |

# 5 SUMMARY

Stakeholders have expressed interest in the areas of fish entrainment and connectivity as part of relicensing of the Boundary Project. Boundary Dam was built without fish passage facilities because Grand Coulee and Chief Joseph dams, both federal power facilities, previously blocked anadromous fish migration. Chief Joseph Dam is located at river mile 545.5 on the Columbia River. The Columbia River is joined by the Pend Oreille River at river mile 744, and Boundary Dam is located at river mile 17 on the Pend Oreille River. Declines in native resident fish populations, such as bull trout, have placed increased focus on resident fish migration. Primary concerns at the Boundary Project center on three native fish species found at the project: bull trout, westslope cutthroat trout and mountain whitefish. The USFWS Draft Recovery Plan for bull trout currently calls for upstream and downstream passage at Albeni Falls (U.S. Army Corps of Engineers), Box Canyon Dam (Pend Oreille PUD) and Boundary Dam (Seattle City Light).

For the relicensing of the Boundary Project, SCL is using the Integrated Licensing Process to provide the framework for its consultation with stakeholders during the period leading up to the filing of its license application. As part of the Integrated Licensing Process, SCL is responsible for developing a Proposed Study Plan that describes each study to be conducted in support of relicensing, a study schedule, and considerations for level of effort and cost. Seattle City Light is developing the Proposed Study Plan using an analytical approach in collaboration with stakeholders that includes the following general sequence of efforts:

- Develop a thorough understanding of the existing resources potentially affected by the Project.
- Evaluate the potential for effects on existing resources through impact assessment focused studies and analyses.
- Ascertain those impacts that have a nexus to current and future project facilities and operations.
- Evaluate potential protection, mitigation and enhancement (PME) measures for addressing project related impacts.
- Develop a comprehensive set of PME measures for consideration in the FERC and related regulatory processes, and settlement efforts, as deemed appropriate.

In August 2005, Seattle City Light offered to prepare a report on existing information related to fish connectivity and entrainment issues at the Project. This early information effort summarized data on biological resources, potential habitat connectivity and the risk of injury and mortality through entrainment. The main objective of this effort was to support future stakeholder discussions of potential fish connectivity and entrainment during relicensing. A formal study program of fish connectivity and entrainment identified during the 2006 Proposed Study Plan effort will begin assessing these issues as they relate to current and future needs. The assessment of the potential need for fish passage and protection measures at the Project will rely heavily on new information developed in the formal study phase beginning in 2007 (Table 5-1). Over the next several years, studies will identify fish movement, tributary access, habitat analysis, productivity, and entrainment and ascertain those effects that have a nexus to current and future project facilities and operations. This includes identifying any project-induced impacts to fish and aquatic resources, and will be coordinated with studies addressing the total dissolved gas issue. The potential for effects on existing resources will be identified in the 2007 and 2008 formal study phase, and selected studies will be continued in 2009 if warranted. In 2009, with information from the formal study program about habitat fragmentation and entrainment, and their effect on current and future populations, Seattle City Light anticipates working collaboratively with stakeholders to develop a Connectivity Management Plan for the Project.

As currently envisioned, the Connectivity Management Plan will be developed using best available science, adaptive management, cost, benefit, and considerations for off site mitigation. The Plan will identify a comprehensive set of PME measures for consideration in the FERC and related regulatory processes, and settlement efforts, as deemed appropriate. Potential connectivity measures may take the form of structural, operational, habitat, production, or other options. These measures will be evaluated with the agencies and tribes and help in the development of Section 18 and Section 4(e) terms and conditions, including implementation schedules.

**Table 5-1.** Potential Boundary Project fish connectivity program.

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012… |
|---|---|---|---|---|---|---|---|
| **Integrated Licensing Process** | Preliminary Study Plan | Conduct Studies | Conduct Studies | License Application | EIS Review | License Issued | |
| **Fish and Aquatic Studies** | ▫ Study Plan Development<br>▫ Early Information Efforts | Potential Studies<br>▫ Turbine entrainment<br>▫ Spillway entrainment<br>▫ Forebay fish timing, abundance and movements<br>▫ Genetics<br>▫ Tailrace fish timing, abundance and movements<br>▫ Habitat distribution<br>▫ Water quality | Continue Studies | Continue Selected Studies<br><br>Connectivity Management Plan<br>▫ Structural options<br>▫ Habitat options<br>▫ Production options<br>▫ Other options | Continue Selected Studies | Continue Selected Studies | |
| **Post-Licensing Process** | | | | Settlement | Settlement | Develop Implementation Plans | Begin Plan Implementation |

# 6 REFERENCES CITED

*Document numbers designate references within Seattle City Light's Boundary relicensing library available online at www.seattle.gov/light/news/issues/bndryRelic/br_document.*

Ashe, B.L. and A.T. Scholz. 1992. Assessment of the Fishery Improvement Opportunities on the Pend Oreille River: Recommendations for Fisheries Enhancement - Final Report. U.S. Department of Energy, Bonneville Power Administration. Division of Fish and Wildlife. Project Number 88-66. Agreement DE-179-88BP39339. 295 p. 295 pp. Doc = 98005.

Ashe, B.L., K.L. Lillengreen, J.J.Vella, L.O.Clark, S.Graves, M.Barber, G.J. Nenema Jr., and A. Scholz. 1991. Assessment of the Fishery Improvement Opportunities on the Pend Oreille River - Annual Report Fiscal Year 1990. U.S. Department of Energy, Bonneville Power Administration. Division of Fish and Wildlife. Project Number 88-66. Agreement DE-A179-88BP39339. 350 p. 350 pp. Doc = 98006.

Avista Corp. 2001. The Clark Fork Project 1999 and 2000 Annual Report. Implementation of PM&E Measures. Avista Corp. PO Box 3727, Spokane, WA 99220-3727 392 pp. Doc = 953.

Avista Corp. 2002. The Clark Fork Project 2001 Annual Report. Implementation of PM&E Measures. Avista Corp. PO Box 3727, Spokane, WA 99220-3727 226 pp. Doc = 954.

Avista Corp. 2003. The Clark Fork Project 2002 Annual Report. Implementation of PM&E Measures. Avista Corp. PO Box 3727, Spokane, WA 99220-3727 183 pp. Doc = 955.

Avista Corp. 2004. The Clark Fork Project 2003 Annual Report. Implementation of PM&E Measures. Avista Corp. PO Box 3727, Spokane, WA 99220-3727 207 pp. Doc = 956.

Avista Corp. 2005a. The Clark Fork Project 2004 Annual Report. Implementation of PM&E Measures. Avista Corp. PO Box 3727, Spokane, WA 99220-3727 206 pp. Doc = 952.

Avista Corp. 2005b. 2005 Implementation Plans. Water Resources. Avista Corp. PO Box 3727, Spokane, WA 99220-3727 50 pp. Doc = 957.

Baldwin, C.M., D.A. Beauchamp, and C.P. Gubala. 2002. Seasonal and diel distribution and movement of cutthroat trout from ultrasonic telemetry. Trans. Am. Fish. Soc. 131:143-158. 16 pp. Doc = 951.

Barber, M.R. and R.A. Wilms, A.T.Scholz, L.O. Clark, B.L. Renberg, K.O'Laughlin, K.L. Woodward, and R.D. Heaton. 1989. Assessment of Fishery Improvement Opportunities on the Pend Oreille River - Annual Report 1988. U.S. Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 88-66. Agreement DE-179-88BP39339. 374 p. 374 pp. Doc = 98002.

Barber, M.R., B.L. Renberg, J.J.Vella, A.T. Scholz, K.L. Woodward, and S. Graves. 1990. Assessment of the Fishery Improvement Opportunities on the Pend Oreille River - Annual Report 1989. U.S. Department of Energy, Bonneville Power Administration. Division of Fish and Wildlife. Project Number 88-66. Agreement DE-179-88BP39339. 206 p. 206 pp. Doc = 98004.

Baxter, J. 1999. Bull trout studies in the Salmo River watershed: 1998 and 1999. Baxter Environmental, for BC Hydro. 16 pp. Doc = 869.

Baxter, J. 2001a. Bull trout studies in the Salmo River watershed: 2000. Baxter Environmental, for BC Hydro. 16 pp. Doc = 870.

Baxter, J. 2001b. Aspects of the biology of Bull trout (*Salvelinus confluentus*) in the Salmo River watershed as identified through radio telemetry (2000/2001 data) and a watershed management plan for the species. Baxter Environmental, for Columbia-Kootenay Fisheries Renewal Partnership and Columbia Basin Trust, and BC Hydro. Doc = 875

Baxter, J. and G. Nellestijn. 2000. Aspects of the biology of Bull trout (Salvelinus confluentus) in the Salmo River watershed as identified through radio telemetry. Baxter Environmental and Salmo Watershed Streamkeepers Society, for Columbia-Kootenay Fisheries Renewal Partnership and Columbia Basin Trust. 47 pp. Doc = 874.

Beamish, F.W.H. 1978. Swimming Capacity. Pages 101 to 187 *in* W.S. Hoar and D.J. Randall, editors. Fish Physiology, Vol. VII. Academic Press Inc., New York. 87 pp. Doc = 941.

Bell, M.C. 1991. Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers, Office of the Chief of Engineers. 223 pp. Doc = 939.

Bjornn, T.C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, stream flow, cover, and population density. Trans. Am Fish. Soc. 100: 423-438. pp. Doc = 942.

Bjornn, T.C. and D.W. Reiser. 1991. Habitat Requirements of Salmonids in Streams. Pages 83-138 *in* W.R. Meehan, editorInfluences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. Am. Fish. Soc. Spec. Pub. 19. 56 pp. Doc = 882.

Brett, J.R. and N.R. Glass. 1973. Metabolic rates and critical swimming speeds of sockeye salmon (Oncorhynchus nerka) in relation to size and temperature. J. Fish. Res. Board Can. 30: 379-387. 9 pp. Doc = 940.

Calder, P.D., D.M. Tammen, and C.M. Gleeson. 2004. Installing a fourth generating unit at Seven Mile Dam. Hydro Review, 23 (7) November 2004. 4 pp. Doc = 525.

Cascades Environmental Services (CES). 1996. Draft Final Report of Evidence for the Determination of Presence or Absence of Bull Trout in the Sullivan Creek Drainage. Report to Sullivan Creek Instream Flow Committee. 263 pp. Doc = 332.

Clay, C.H. 1995. Design of Fishways and Other Fish Facilities. CRC Press, Baca Raton, FL, 33431. 248 pp. Doc = 938.

Colville National Forest. 2005. Fish distribution map. Colville National Forest. 1 pp. Doc = 544.

Devries, D.R. and R.V. Frie. 1996. Determination of Age and Growth. Chapter 16 *in* Murphy, B.R. and D.W. Willis, editors. Fisheries Techniques. Second Edition. American Fisheries Society, Bethesda, MD. 30 pp. Doc = 930.

Duke Engineering. 1999. 1998-1999 Summary of radio telemetry tracking study Box Canyon Hydroelectric Project FERC No. 2042. *In* Pend Oreille County PUD No.1. Application for new license Box Canyon Hydroelectric Project FERC No. 2042. Vol. IV. Public Utility District No.1 of Pend Oreille County. 30 pp. Doc = 403. 2000.

Duke Engineering & Services. 2001. Response to FERC's Additional Information Request (AIR) Dated February 27, 2001, Box Canyon Hydroelectric Project. Duke Engineering & Services. Doc = 402.

DuPont, J. and N. Horner. 2003. Middle Fork East River bull trout assessment. Program: Fisheries Management F-71-R-28. Project: I-Surveys and Inventories, Subproject I-A Panhandle Region. Boise, ID.

EES Consulting. 2006a. Temporary upstream fishway design plans and specifications for Box Canyon Hydroelectric Project FERC No. 2042. FERC submittal prepared for the Public Utility District No. 1 of Pend Oreille County, Newport, Washington. 60 pp.

EES Consulting. 2006b. Temporary upstream fishway operation and maintenance plan for Box Canyon Hydroelectric Project FERC No. 2042. FERC submittal prepared for the Public Utility District No. 1 of Pend Oreille County, Newport, Washington. 21 pp.

EES Consulting. 2006c. Temporary upstream fishway monitoring and reporting plan for Box Canyon Hydroelectric Project FERC No. 2042. FERC submittal prepared for the Public Utility District No. 1 of Pend Oreille County, Newport, Washington. 15 pp.

EES Consulting. 2006d. Temporary upstream fishway post-installation effectiveness plan for Box Canyon Hydroelectric Project FERC No. 2042. FERC submittal prepared for the Public Utility District No. 1 of Pend Oreille County, Newport, Washington. 21 pp.

EES Consulting. 2006e. Downstream fishways behavior, survival and design investigation plan. Box Canyon Hydroelectric Project FERC No. 2042. FERC submittal prepared for the Public Utility District No. 1 of Pend Oreille County, Newport, Washington. 34 pp.

Fausch, K.D. 1989. Do gradient and temperature affect distributions of, and interactions between, brook charr (*Salvelinus fontinalis*) and other resident salminds in streams? Pages 303-322 *in* H. Kawanabe, F. Yamazaki, and D L. G. Noakes, editors. Biology of Charrs and Masu Salmon. Physiol. Ecol. Japan, Special Volume 1. Doc = 959.

Federal Energy Regulatory Commission (FERC). 1998. Final Environmental Impact Statement. Sullivan Creek Hydroelectric Project (FERC Project No. 2225), Washington. Federal Energy Regulatory Commission, Office of Hydropower Licensing. 350 pp. Doc = 335.

Federal Energy Regulatory Commission (FERC). 2004. Final environmental impact statement, Box Canyon Hydroelectric Project, Washington and Idaho. Federal Energy Regulatory Commission. 659 pp. Doc = 350.

Fish, P. A. and J. Savitz. 1983. Variations in home ranges of largemouth bass, yellow perch, bluegills, and pumpkinseeds in an Illinois lake. Trans. Am. Fish. Soc. 112: 147-153.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River systems, Montana. Northwest Science 63: 133-143. 11 pp. Doc = 907.

Franke, G.F., D.R. Webb, R.K. Fisher, Jr., D. Mathur, P.N. Hopping, P.A. March, M.R. Headrick, I.T. Laczo, Y. Ventikos, and F. Sotiropoulos. 1997. Development of environmentally advanced hydropower turbine system design concepts. Idaho National Engineering and Environmental Laboratory. August.

Garrett, J.W. and D.H. Bennett. 1995. Seasonal movements of adult brown trout relative to temperature in a coolwater reservoir. N. Am J. Fish. Management 15:480-487. Doc = 926.

Geist, D.R., R.S. Brown, A.T. Scholz, and B. Nine. 2004. Movement and survival of radio-tagged bull trout near Albeni Falls Dam. Battelle Pacific Northwest Division, Richland, Washington and Eastern Washington University, Department of Biology, Cheney, Washington. Annual report submitted to United States Army Corps of Engineers, Seattle. Washington. Contract DACW6802 D-0001. Task Order EC01. Project No. 44477 (Battelle Report No. PNWD-3356): 122 pp.

Goetz, F. 1989. Biology of the bull trout Salvelinus confluentus: A literature Review. Willamette National Forest, Eugene, OR. 53 pp. Doc = 98088.

Hamilton, J.A.R. 1955. An investigation of the effect of Baker Dam on downstream migrant salmon. University of Washington. May 13.

Hickman, T. and R.F. Raleigh. 1982. Habitat Suitability Index Models: Cutthroat Trout. U.S. Fish and Wildlife Service, Fort Collins, CO, 80526. 46 pp. Doc = 929.

Kleinschmidt Associates and K.L Pratt. 1998. Clark Fork River Native Salmonid Restoration Plan. Washington Water Power Company (Currently Avista Corporation). Spokane, WA. 83 pp. Doc = 943.

Lembcke, S. 2001. RL&L Report. Personal communication to A. Solonski of Seattle City Light. 3 pp. Doc = 921.

Lewis, E. 2006. U.S. Army Corps of Engineers. Personal Communication with A. Olson (R2 Resource Consultants, Inc.). March 8, 2006.

McIntyre, J.D. and B.E. Rieman. 1995. Westslope Cutthroat Trout. Chapter 1 *in* M.K. Young, editor. Conservation Assessment for Inland Cutthroat Trout. USDA Forest Service. General Technical Report RM-GTR-256. Fort Collins, CO, 80526. 15 pp. Doc = 927.

McLellan, J.G. 2001. 2000 WDFW annual report for the Project, Resident Fish Stock Status above Chief Joseph and Grand Coulee Dams. Part I. Baseline Assessment of Boundary Reservoir, Pend Oreille River and its Tributaries. Pages 18-173 *in* N. Lockwood, J. McKellan, and B. Crossley, 2001. Resident fish stock status above Chief Joseph and Grand Coulee Dams. 2000 Annual Report. Report to Bonneville Power Administration, Contract No. 00004619, Project No. 199700400 (BPA Report DOE/BP – 00004619-1). Doc = 373.

Montgomery, D.R., and J.M. Buffington. 1993. Channel Classification, Prediction of Channel Response, and Assessment of Channel Condition. Report TFW-SH10-93-002 to the SHAMW Committee of the Washington State Timber/Fish/Wildlife Agreement. Washington Department of Natural Resources, Olympia WA. 110 pp. Doc = 877.

Munther, G.L. 1970. Movement and distribution of smallmouth bass in the Middle Snake River. Trans. Am. Fish. Soc. 99: 44-53.

Nelson, M.L., T.E. McMahon, and R.F. Thurow. 2002. Decline of the migratory form in bull charr, *Salvelinus confluentus*, and implications for conservation. Environmental Biology of Fishes 64: 321-332. 12 pp. Doc = 950.

Nordlund, B. and K. Bates. 2000. Fish Protection Screen Guidelines for Washington State. Draft. Washington Department of Fish and Wildlife. Olympia, WA. 56 pp. Doc = 946.

Normandeau Associates. 2002. Estimation of juvenile salmonid spillway passage survival at North Fork Dam. Prepared for Portland General Electric.

Northcote, T.G. and G.L. Ennis. 1994. Mountain whitefish biology and habitat use in relation to compensation and improvement possibilities. Reviews in Fisheries Science 2(4): 347-371. 25 pp. Doc = 931.

Pacific Northwest National Laboratory (PNNL). 2000. Laboratory studies on the effects of shear on fish. Prepared for the U.S. Department of Energy. September.

Peak, S. 2004. An evaluation of the use of critical swimming speed for determination of culvert water velocity criteria for smallmouth bass. Trans. Am. Fish. Soc. 133: 1472-1479.

Pratt, K.L. 1984. Habitat use and species interactions of juvenile cutthroat (*Salmo clarki lewisi*) and Bull trout (*Salvelinus confluentus*) in the upper Flathead River basin. Master's thesis, University of Idaho, Moscow. pp. Doc = 890.

Pratt, K.L. 1992. A review of bull trout life history. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society. 6 pp. Doc = 885.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. University of Washington Press, Seattle. 378 pp. Doc = 948.

R2 Resource Consultants, Inc. 1998a. Boundary Hydroelectric Project, bull trout field investigations, draft data report. R2 Resource Consultants, Inc. 32 pp. Doc = 372.

R2 Resource Consultants, Inc. 1998b. Annotated bibliography of literature regarding mechanical injury with emphasis on effects from spillways and stilling basins. Prepared for U.S. Army Corps of Engineers Portland District. May.

R2 Resource Consultants, Inc. 2006. Compilation of Project Hydrologic Data. Phase 2: Preparation of Hydrologic Database.and Hydrologic Statistics For Preliminary Application Document (PAD). Boundary Hydroelectric Project (FERC No. 2144). Prepared for Seattle City Light. 173 pp. Doc = 958.

R.L.&L. Environmental Services Ltd. 1999. Review of Information on the Fish Resources of the Lower Pend Oreille River. Seattle City Light. Doc = 375.

R.L.&L. Environmental Services Ltd. and Taylor & Associates. 2001. Fish population assessment of the lower Pend Oreille River, draft report. Seattle City Light. 52 pp. Doc = 374.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. Gen. Tech. Rept. INT-302. U.S. Dept. of Agriculture, Forest Service, Intermountain Research Station. Ogden, Utah. 38 p. 0 pp. Doc = 98046.

Rieman, B.E., D.C. Lee, and R.F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River Basins. Trans. Am. Fish. Soc. 17: 1111-1125. 15 pp. Doc = 947.

Rieman, B.E. and F.W. Allendorf. 2001. Effective population size and genetic conservation for bull trout. N. Am. J. Fish Management 21: 756-764. 10 pp. Doc = 949.

Scholz, A., H.J. McLellan, D.R. Geist, and R.S. Brown. 2005. Investigations of migratory bull trout (Salvelinus confluentus) in relation to fish passage at Albeni Falls Dam. Final Report prepared for U.S. Dept. of the Army, Corps of Engineers, Seattle District. Contract No. DACW68-02-D-001. 204 pp. Doc = 418.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184. Fisheries Research Board of Canada, Ottawa. 966 pp. Doc = 98099.

Shepard, B.B., K.L. Pratt, and P.J. Graham. 1984. Life Histories of Westslope Cutthroat and Bull Trout in the Upper Fathead River Basin, Montana. Report to Environmental Protection Agency, Region VIII, Water Division, Denver, CO. 118 pp. Doc = 928.

Shuhda, T. 2005. USFS Fisheries Biologist, Colville National Forest. Personal Communication with A. Olson (R2 Resource Consultants, Inc.). April 12, 2005

Stone & Webster Environmental Services. 1992. Fish entrainment and turbine mortality review and guidelines. Prepared for the Electric Power Research Institute. September.

Stovall, S.H. 2000. Draft Pend Oreille subbasin summary. Kalispel Tribe of Indians. 192 pp. Doc = 363.

Taylor, E.B., and J.D. McPhail. 1985. Burst swimming and size-related predation of newly emerged coho salmon *Oncorhynchus kisutch*. Trans. Am. Fisheries Soc, 114: 546-551.

TERA Corporation. 1982. In Situ Survey of Sullivan Creek Fish Abundances Report to The Washington Water Power Company. Doc = 919.

Terrapin Environmental. 2000. Boundary Hydroelectric Project bull trout investigations, progress report. Report to City of Seattle, Environment and Safety Division. Seattle, WA 98104. 14 pp. Doc = 380.

Todd, B.L. and C.F. Rabeni. 1989. Movement and Habitat Use by Stream-dwelling Smallmouth Bass. Trans. Am. Fish. Soc. 118: 229-242.

USDA Forest Service. 1996. Sullivan Creek Watershed assessment. USDA Forest Service Colville National Forest. 101 pp. Doc = 538.

USDA Forest Service. 2006. Comments to Seattle City Light pre-application document for Boundary Hydroelectric Project, FERC No. 2144-035. Collville National Forest. Colville, WA.

USFWS (U.S. Fish and Wildlife Service). 1999. Status Review for Westslope Cutthroat Trout in the United States. Regions 1 and 6 of the U.S. Fish and Wildlife Service, Portland, Oregon, and Denver, CO. 191 pp. Doc = 893.

USFWS (U.S. Fish and Wildlife Service). 2000. Biological Opinion. Effects to Listed Species From Operations of the Federal Columbia River Power System. BI-OP prepared by United States Fish and Wildlife Service (Regions 1 and 6). BI-OP consultation document sent to Action Agencies: Army Corps of Engineers, Bonneville Power Administration, Bureau of Re 106 pp. Doc = 894.

USFWS (U.S. Fish and Wildlife Service). 2002. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Region 1 U.S. Fish and Wildlife Service Portland, Oregon. 73 pp. Doc = 554.

USFWS (U.S. Fish and Wildlife Service). 2006. Box Canyon Hydroelectric Project, FERC No. 2042 USFWS Approval of Section 18 Fishway Plans. Letter dated June 12, 2006, to M. R. Salas, Secretary Federal Energy Regulatory Commission. 9 pp.

Webb, P.W. 1995. Locomotion. Pages 71-85+ *in* Groot, L. Margolis and W.C. Clarke, editors. Physiological ecology of Pacific salmon. C. Vancouver: UBC Press.

WEPC (Waneta Expansion Power Corporation). 2006. Application for an Environmental Assessment Certificate for the Waneta Hydroelectric Expansion Project. Submitted to the British Columbia Environmental Assessment Office. Victoria, British Columbia.

Wydoski, R.S. and R.R. Whitney. 2003. Inland Fishes of Washington. University of Washington Press. Seattle and London. 220 pp. Doc = 98081.

# APPENDIX A

## Consultation Record Between Relicensing Participants

# APPENDIX A

## Consultation Record Between Relicensing Participants

A draft version of the early information development (EID) report: Fish Connectivity at the Boundary Hydroelectric Project was provided to relicensing participants during early-April, 2006, and discussed at the April 20 fish and aquatics workgroup meeting. The draft report and SCL presentation at the meeting included estimated ranges of fish mortality for existing downstream passage routes based on a review of available information in the literature (see Table 4-2, this document). SCL proposed to adopt these mortality estimates in lieu of conducting site-specific studies of entrainment mortality. The USFS, in an e-mail dated May 8, 2006, and the USFWS in an e-mail dated July 21, 2006, agreed to the use of the mortality estimates in lieu of site-specific studies for purposes of Boundary Project relicensing. During the August 14, 2006, workgroup meeting, relicensing participants confirmed that the estimated turbine and spillway mortality rates described in Table 4-2 could be used during relicensing in place of empirically derived results.

On May 18, 2006, the USFWS provided written comments on the draft EID report. These comments were reviewed by SCL and their consultants and many of the revisions incorporated in the final EID report were in response to the USFWS comments.

The following communications, comment letters, and meeting summaries are included in this appendix to document the consultation activities described above:

- April 20, 2006, fish and aquatic workgroup meeting summary;
- May 23, 2006, fish and aquatic workgroup meeting summary (includes May 8, 2006, USFS email concerning entrainment mortality estimates and May 18, 2006, EID comments by the USFWS)
- July 21, 2006, USFWS email concerning entrainment mortality estimates;
- August 14, 2006, draft fish and aquatic workgroup meeting summary (excerpts relating to turbine and spillway entrainment); and
- September 8, 2006, USFS and SCL conference call summary (excerpts relating to turbine and spillway entrainment).

**Boundary Hydroelectric Project (FERC No. 2144)**
**Fish & Aquatics Workgroup Meeting**
**April 20, 2006**
**Quality Inn Oakwood**
**7919 Division Street**
**Spokane, Washington**

**FINAL MEETING SUMMARY**

**In Attendance**

Peter Christensen, R2 Resource Consultants (R2)
Jason Connor, Kalispel Tribes (Kalispel)
Scott Deeds, US Fish and Wildlife Service (USFWS)
Randall Filbert, Long View Associates, (LVA)
Barbara Greene, Seattle City Light (SCL)
Phil Hilgert, R2
Scott Jungblom, Pend Oreille PUD
Joe Maroney, Kalispel
Llewellyn Matthews, Columbia Power Corporation (Columbia Power)
Steve Padula, LVA
Kim Pate, SCL
Christine Pratt, SCL
Doug Robison, Washington Department of Fish and Wildlife (WDFW)
Tom Shuhda, USDA Forest Service (USFS)
Al Solonsky, SCL
Curt Vail, WDFW

**Agenda**

- Introductions/review goals for meeting
- Status of 2006 early action efforts
- Draft Fish Connectivity EID Report
- Draft Fish and Aquatics Study Outlines
    - Turbine Entrainment
    - Spillway Entrainment
    - Tailrace Fish Distribution
    - Tailrace Biotelemetry
    - Reservoir Biotelemetry
    - Triploid Trout Biotelemetry
- Administrative items/closing remarks

**Introductions/review goals for meeting**

Barbara Greene (SCL) reviewed the agenda and goals for the meeting. Barbara pointed out that hardcopies of meeting materials (for topics identified in the agenda) were available and noted that in addition to these, SCL had brought copies of three other documents: 1) a Proposed Study Plan (PSP) Outline, which identified the section headings to be included in the PSP, 2) a stakeholder Study Request Template, which identified the items stakeholders would need to address in the event that they submit study requests beyond those identified and refined during the 2006 workgroup meetings, and 3) a list of study crossover topics, i.e., those that have relevance to more than one resource workgroup. Barbara explained that because of the limited time available to review study proposals, SCL intended to minimize the extent to which study plan presentations are revisited. To this end, said Barbara, SCL had identified the crossover topics and would identify the workgroup meetings at which they will be addressed, thereby allowing stakeholders from one workgroup to attend meetings of another workgroup as needed.

**Status of 2006 early action efforts**

Al Solonsky (SCL) reviewed the elements of the 2006 study plan developed by SCL: 1) evaluations of gill net effectiveness in Boundary Reservoir and the Boundary Dam tailrace, 2) assessment of the advantages and disadvantages of radio and acoustic tags for tracking fish, and 3) identification of logistical challenges associated with launching and operating boats in the tailrace. Al stated that SCL would soon be selecting a consultant to conduct this work and would notify stakeholders as soon as a study schedule was compiled, so stakeholders interested in participating in fieldwork could plan accordingly.

Al noted that a fishing derby was planned for May 2006 and that during this event SCL would be briefly interviewing anglers at boat launches to gather information about the species caught and locations in the reservoir where fish were taken. Al stated that for this exercise Boundary Reservoir would be longitudinally stratified into five sections.

**Draft Fish Connectivity Early Information Development (EID) Report**

***<u>Information for evaluating the need for fish passage</u>***

Phil Hilgert (R2) reviewed the draft *Fish Connectivity at the Boundary Hydroelectric Project* EID report. Phil referred to Table 2-1, which provides the length of adfluvial fish habitat (ft) for each tributary from Boundary Reservoir's high-water mark to the tributary's first upstream passage barrier. Phil commented that a numerical trigger for evaluating the need for a permanent fish passage facility at Box Canyon Dam was based on the recovery goals for Sullivan and Slate creeks, which are tributaries to Boundary Reservoir. Phil asked stakeholders if tributary habitat data from Seven Mile Reservoir tributaries would be needed to make determinations about the need for permanent fish passage facilities at Boundary Dam. He also asked that stakeholders provide SCL with any relevant existing information for Seven Mile tributaries of which they were aware.

- *Comment* – Llewellyn Matthews (Columbia Power) asked whether Canada's position regarding downstream fish passage at Boundary Dam—i.e., concern about downstream passage of nonnative fish species—was being considered. Llewellyn added that the interest in upstream passage appears to be driven by U.S. agencies and tribes and asked whether SCL had contacted Canadian agencies regarding their interest in upstream passage.
  *Response* – Phil Hilgert (R2) replied that the determination to pass fish was a regulatory issue to be decided by the stakeholders, including USFWS and the USFS, who have conditioning authority. Phil said that SCL's objective was not to make a determination on the desirability of passage but to ensure that appropriate information was available to allow regulators to make informed decisions.

- *Comment* – Scott Deeds (USFWS) stated that the management goals of the USFWS would not be based on habitat availability or productivity estimates derived from tributaries downstream of Boundary Dam. Rather, said Scott, the objective is to allow fish passed downstream at Boundary Dam—currently those surviving entrainment—an opportunity to migrate back upstream to their natal waters. Doug Robison (WDFW) added that WDFW was also primarily concerned with the return of fish that originate in Washington waters.
  *Response* – Phil Hilgert (R2) replied that SCL had thought that the return of fish previously passed downstream at the Project was only part of the issue and that the management agencies would be concerned about connectivity at a larger scale, which was the basis for seeking direction from the agencies on how to assess habitat availability downstream of Boundary Dam.

- *Comment* – Scott Jungblom (Pend Oreille PUD) stated that if the decision to implement fish passage was to be based on entrained fish, then the estimates of entrainment appeared to be the information needed by the agencies.
  *Response* – Al Solonsky (SCL) stated that entrainment studies were planned for both the turbines and spillway and that these plans would be discussed shortly.

- *Comment* – Joe Maroney (Kalispel) stated that what is most important to the Kalispel Tribe is the establishment of upstream passage at Boundary Dam.

- *Comment* – Tom Shuhda (USFS) stated that the USFS is concerned with all native fish attempting to pass Boundary Dam, regardless of their origin. Tom stated that the goal of the USFS is to ensure that ongoing adverse effects on aquatic connectivity associated with the Boundary Project are mitigated under the new FERC license. Tom added that the studies outlined by SCL would be necessary to ascertain what mitigation is needed.

- *Comment* – Doug Robison (WDFW) stated that the EID did not really address connectivity but fish passage at Boundary Dam. Doug stated that connectivity is a more comprehensive issue, related to the ability of fish and other aquatic organisms to access the full range of their natural habitat. For example, said Doug, connectivity in the Project area includes access to the reservoir's tributaries.
  *Response* – Phil Hilgert (R2) agreed that connectivity in the larger sense does involve, among other things, tributary access. However, said Phil, from a practical standpoint it is essential to deal with issues in manageable pieces and that to do this SCL had decided to address connectivity, i.e., fish passage, at the dam first. Phil explained that tributary access would be addressed at a subsequent meeting aimed at identifying studies needed to assess conditions in tributary deltas, particularly in response to variability in reservoir surface elevation.

- *Comment* – Doug Robison (WDFW) asked for more detail regarding the process to be used to arrive at decisions about fish passage at the dam.
  *Response* – Al Solonsky (SCL) stated that the purpose of the PSP is to identify studies that would be the basis of decisions made about fish passage. Phil Hilgert (R2) indicated that Table 5-1 in the EID provides an overview of the proposed Boundary Project Fish Connectivity Program.

***Estimates of turbine and spillway mortality***

Phil Hilgert (R2) stated that fish mortality associated with entrainment is a critical relicensing issue and stated that Peter Christensen (R2) had conducted an analysis of potential entrainment mortality at Boundary Dam. Peter Christensen (R2) stated that there are four potential avenues of downstream passage at the Boundary Project: turbines, spillways, sluiceways, and the skimmer gate. Kim Pate (SCL) stated that use of the skimmer gate was discontinued in the 1980s. Peter outlined the seven conditions associated with these passage avenues that are potentially damaging to fish: strike, shear, grinding, turbulence, cavitation, pressure changes, and dissolved gas levels. Peter then explained the analyses he had conducted and the estimates of potential mortality associated with the aforementioned Project features, emphasizing that the estimates were conservative in all instances. Peter also explained the background of the predictive equations of turbine mortality developed by the US Department of Energy's (DOE) Advanced Hydro Turbine System Program (AHTSP) (Franke et al. 1997) (for detail regarding these analyses see the *Fish Connectivity at the Boundary Hydroelectric Project* EID, *Entrainment: Physical Risk Factors*).

- *Comment* – Doug Robison (WDFW) asked whether the seven conditions potentially damaging to fish were directly proportional to head.
  *Response* – Peter Christensen (R2) replied that some of the conditions are more detrimental to fish as head increases, for example shear and pressure changes.

- *Comment* – Referring to Table 4-1 in the EID (i.e., Turbine Characteristics), Doug Robison (WDFW) asked Peter to explain the significance of the "number of buckets" associated with units 51 through 56.
  *Response* – Peter Christensen (R2) replied that the number of buckets is equivalent to the number of blades, the turbine feature that results in fish strike. Peter said that the greater the number of blades for a turbine of a given size, the higher the probability of strike.

- *Comment* – Llewellyn Matthews (Columbia Power) asked whether entrainment mortality estimates calculated by Peter Christensen (R2) accounted for direct mortality only or if they included delayed mortality as well.
  *Response* – Peter Christensen (R2) replied that estimates were based on direct mortality.

- *Comment* – Doug Robison (WDFW) asked if the flip bucket at the downstream end of Spillway #1 has adverse effects on fish as they pass over it.
  *Response* – Peter Christensen (R2) stated that the flip bucket has a 35-ft radius, so that fish should suffer no impacts resulting from contacting it. However, said Peter, flow passing over the flip bucket is released at an upward angle, which is relevant in terms of effects on fish. Peter explained that fish leaving Spillway #1 are launched upward with the water and then fall to the tailrace. Peter stated that this situation likely results in minimal impacts to small fish, unless they strike rocks in the tailrace, but likely results in higher mortality of large fish. In contrast, said Peter, Spillway #2 has no flip bucket, so water passing over the spillway flows downward. In this case, said Peter, shear is the primary cause of adverse effects on fish. Peter explained that fish moving in the center of the spill jet from Spillway #2 should enter the tailrace safely, whereas those at the periphery of the jet will experience strong shear forces. Peter stated that large fish are

more resistant to shear than are small fish so that small fish entrained in Spillway #2 likely suffer higher mortality than large fish.

- *Comment* – Referring to Table 4-2 in the EID (Estimated Mortality for Existing Downstream Passage Routes), Doug Robison (WDFW) asked how far open the spillway gates were considered to be when deriving the spillway mortality estimates.
  *Response* – Peter Christensen (R2) replied that he did not consider any specific opening except that it would be high enough to ensure that at least about a foot of depth is maintained across the concrete chute spillway. This would represent a flow of at least about 3,000 cfs, or a gate opening of greater than 2 feet. Peter added that the wider the spill gate opening, the lower the likelihood of fish mortality.

- *Comment* – Curt Vail (WDFW) asked how SCL operates the spillway gates.
  *Response* – Kim Pate (SCL) stated that when powerhouse flows reach capacity (i.e., 55,000 cfs) during higher flow or flood conditions, the spillway gates are opened first until half their discharge capacity (total of approximately 54,000 cfs) is reached, then the sluiceway is opened, with the sluice gates closest to the center of the dam opened first to reduce the possibility of eroding the abutments on the downstream side of the dam. Half the spillway gate capacity is reserved to maintain a steady forebay elevation while sluice gates are being opened. The sluice gates are either fully open or fully closed, and cannot be throttled.

- *Comment* – Llewellyn Matthews (Columbia Power) asked for clarification as to when the sluiceways at Boundary Dam are operated.
  *Response* – Kim Pate (SCL) stated that the sluiceways are only operated when flow through the powerhouse and over the spillways is maximized. Kim added that SCL avoids using the sluiceways because the sluice gates cannot be throttled, so that there is no ability to regulate the volume of flow passing through them.

- *Comment* – Joe Maroney (Kalispel) said that based on the information in Table 4-2 of the EID, entrainment mortality for all sizes of salmonids through all avenues of passage appeared to average about 35 to 40 percent.
  *Response* – Barbara Greene (SCL) asked stakeholders if the entrainment mortality estimates in Table 4-2 could be accepted by stakeholders for use in the relicensing process, thereby eliminating the need to conduct entrainment mortality studies. Al Solonsky (SCL) added that SCL was prepared to accept the estimated entrainment mortality rates developed by Peter Christensen (R2).
  *Response* – Joe Maroney (Kalispel) replied that he needed to think about it before agreeing to use the mortality estimates.
  *Response* – Tom Shuhda (USFS) stated that he would need to review the relevant section of the Franke et al. (1997) report to ensure that the predictive equations—and the studies whose results correlate with the equations' output—are relevant to the Boundary Project. Tom stated that if stakeholders are unconvinced of the applicability of the equations, it would be necessary to conduct turbine mortality studies with proxy salmonids. Tom added that in addition to turbine mortality it would also be necessary to address injury and that the same was true for fish entrained in the spillway or sluiceways.
  *Response* – Peter Christensen (R2) agreed to convert the Franke et al. (1997) report to a .pdf file and distribute it, through SCL, to the stakeholders.

- *Comment* – Steve Padula (LVA) asked stakeholders to provide SCL with comments on the Fish Connectivity EID and a decision as to whether the entrainment mortality estimates developed by Peter Christensen (R2) would be acceptable for use in the relicensing by May 16, 2006.
  *Response* – Stakeholders agreed to provide SCL with comments on the Fish Connectivity EID and a decision as to whether the entrainment mortality estimates developed by Peter Christensen (R2) would be acceptable for use in the relicensing by May 16, 2006.
  *Response* – Phil Hilgert (R2) suggested that if it would help make a decision, the USFWS could ask Jim Stow (USFWS fish passage engineer) for assistance in reviewing the Fish Connectivity EID and the Franke et al. (1997) report and provide his evaluation to the stakeholders.

**Draft Fish and Aquatic Study Outlines**

Al Solonsky (SCL) stated that in formulating the study plan outlines to be reviewed during the day's meeting, SCL had attempted to address or incorporate feedback received from stakeholders during the February 2006 Workshop, Fish & Aquatics breakout sessions. For example, said Al, SCL had not initially planned to conduct a spillway entrainment study, but in response to stakeholder requests had decided to conduct a spillway entrainment study, a study plan for which would be reviewed later in the meeting. Al noted that stakeholders provided comments during February on a range of studies, including some studies that were not being addressed at the April 20 Fish & Aquatics Workgroup meeting. Al said that comments on other studies would be addressed at subsequent workgroup meetings when the relevant study areas are addressed.

***<u>Turbine Entrainment</u>***

Al Solonsky (SCL) reviewed the *Turbine Entrainment* study plan objectives and described the tasks proposed by SCL to address the issue. Al explained that placing nets in the tailwater to validate and translate hydroacoustics data would not sample the entire water column and may be infeasible during turbulent tailrace conditions. Al said that SCL also considered placing nets downstream of the trash racks, but there would not be a capture velocity in this area. Al explained that SCL had decided instead to propose installing stacked, fyke-net assemblies in the turbine intake gatewell slots for this purpose (see the *Turbine Entrainment* study outline for descriptions of assumptions, proposed tasks, level of effort, and schedule).

- *Comment* – Doug Robison (WDFW) asked if a threshold velocity was needed for the fyke nets to function properly.
  *Response* – Al Solonsky (SCL) stated that the nets take shape as the result of velocity and that these velocities would be present under the sampling conditions, when the units are operating. Al added that SCL and the technical consultants eventually selected to conduct the studies will ensure that all sampling equipment works properly.
- *Comment* – Doug Robison (WDFW) asked whether the fyke nets would be damaged by debris carried with the flow into the intakes.
  *Response* – Al Solonsky (SCL) replied that the trash racks at the upstream end of the forebay would, as they currently do, catch large debris but that smaller debris would enter the nets. Phil Hilgert (SCL) stated that the nets would be constructed to withstand some debris entrainment, adding that this method of sampling has been conducted at other sites and shown to be effective.

- *Comment* – Tom Shuhda (USFS) stated that the study approach called for placing nets in one or two intakes based on which intakes were shown via hydroacoustics to have the greatest number of detections in front of them. Tom asked what would be done if hydroacoustics indicates that fish distribution is uniform across the face of the intakes.
*Response* – Phil Hilgert (R2) noted that the purpose of the hydroacoustics was to translate the fyke net results to the other intakes. He added that three factors would be considered when deciding in which units to place the fyke nets: 1) which intakes have the greatest number of hydroacoustic detections, 2) which units are used preferentially for generation, and 3) which intakes will best accommodate placement of the nets.

- *Comment* – Tom Shuhda (USFS) asked what would be done with the fish captured in the nets.
*Response* – Al Solonsky (SCL) replied that all fish captured in the nets would likely be dead and that SCL would document the species and size of each fish and whether it has a tag. Al said that genetics samples would be collected from bull trout and cutthroat trout captured in the nets.

- *Comment* – Tom Shuhda (USFS) asked if SCL would shut down its units if a radio-tagged bull trout is detected in the forebay while the fyke nets are in place, to avoid potential mortality of the bull trout.
*Response* – Al Solonsky (SCL) replied that at this time SCL was not proposing to shut the units down, and the test would continue.

- *Comment* – Doug Robison (WDFW) asked whether SCL would be willing to shutdown units during high flows to place fyke nets.
*Response* – Al Solonsky (SCL) replied that units would be shut down as needed if a fyke net sampling event is scheduled during a period of high flows.

- *Comment* – Llewellyn Matthews (Columbia Power) asked how hydroacoustics sampling would be set up so that results would best indicate the number of fish that are being entrained, as opposed to those simply in the vicinity of the intakes.
*Response* – Al Solonsky (SCL) stated that specifics related to the configuration of the hydroacoustics detection array would be worked out with the technical consultant that is selected to conduct the study. However, said Al, the goal will be to get the best estimate of the number of detections at risk of turbine entrainment.

- *Comment* – Tom Shuhda (USFS) asked why SCL had abandoned DIDSON (Dual Frequency Identification Sonar) as a potential method for assessing turbine entrainment.
*Response* – Phil Hilgert (R2) stated that given the limitations of DIDSON, it would be less effective than the combined use of hydroacoustics and intake fyke netting for assessing the extent of turbine entrainment.

- *Comment* – Scott Jungblom (Pend Oreille PUD) asked if it would be advantageous to place the transducers on the fyke net frames.
*Response* – Al Solonsky (SCL) replied that the confined environment of the intakes would likely interfere with the ability to perceive signals around the periphery of the detection beam.

- *Comment* – Joe Maroney (Kalispel) stated that it would be useful to conduct sampling under operating conditions similar to those expected under the new FERC license, for example operations designed for TDG abatement.
  *Response* – Barbara Greene (SCL) stated that such sampling could occur if there is some certainty regarding the nature of future operations at the time the turbine entrainment study is conducted. Barbara emphasized, however, that operational changes undertaken to reduce TDG concentrations would be designed to not exacerbate adverse impacts on fish.

- *Comment* – Phil Hilgert (R2) and Al Solonsky (SCL) asked stakeholders if Seattle City Light's overall approach to the turbine entrainment study was satisfactory.
  *Response* – Stakeholders agreed that the proposed approach to studying turbine entrainment at Boundary Dam appeared to be appropriate.

***Spillway Entrainment***

Al Solonsky (SCL) read the *Spillway Entrainment* study plan objectives and described the tasks proposed by SCL to address the issue. Al explained that the approach would involve a combination of hydroacoustics monitoring, extrapolations based on fyke net sampling undertaken as part of turbine entrainment studies, and sampling (likely gill-netting) conducted in the reservoir upstream of the spillway when spill is not occurring (see the *Spillway Entrainment* study outline for descriptions of assumptions and proposed tasks, level of effort, and schedule).

- *Comment* – Tom Shuhda (USFS) asked if DIDSON was still being considered as a tool for the assessment of spillway entrainment.
  *Response* – Al Solonsky (SCL) replied that DIDSON appeared to have limited utility for attempting to quantify spillway entrainment and that he and Phil believed the proposed approach to be more effective.

- *Comment* – Tom Shuhda (USFS) asked if tailrace sampling might be used to assess species composition of fish entrained in spill.
  *Response* – Al Solonsky (SCL) stated that the use of tailrace netting had not yet been ruled out as a possible sampling approach for assessing spillway entrainment. Phil Hilgert (R2) noted, however, fish that die during spillway passage might become lodged in the tailrace substrate, which would limit the value of trying to capture fish in the tailrace using a surface-oriented screw or scoop trap to assess spillway entrainment.

- *Comment* – Al Solonsky (SCL) asked stakeholders if SCL's overall approach to the spillway entrainment study was satisfactory.
  *Response* – Stakeholders agreed that the proposed approach to studying spillway entrainment at Boundary Dam appeared to be appropriate.

***Tailrace Fish Distribution***

Al Solonsky (SCL) read the objectives associated with the *Fish Distribution in the Boundary Tailrace* study plan and described the tasks proposed by SCL to address the issue. Al noted that sampling would consist of electrofishing, gill netting, snorkeling, and fyke netting and that sampling would be conducted during the day and at night. Al explained that sampling would not be conducted at high flows, perhaps greater than 40,000 cfs, although the actual threshold above which sampling would not occur would be determined in collaboration with the technical consultant hired to conduct the study. Al stated that all fish captured would be scanned for PIT-tags, that a fin-punch would be taken from native salmonids for genetics analysis, and that the study would be coordinated with biotelemetry work, i.e., native salmonids captured during the study would be used for tracking studies. Phil Hilgert (R2) added that seining had been ruled out as a method because it would be ineffective on the large substrates characteristic of the tailrace. Phil said angling had also been ruled out because of the difficulty in developing accurate catch-per-effort numbers for this method (see the *Fish Distribution in the Boundary Tailrace* study outline for descriptions of assumptions and proposed tasks, level of effort, and schedule).

- *Comment* – Tom Shuhda (USFS) asked whether SCUBA diving, in addition to snorkeling, had been considered as a sampling method.
  *Response* – Phil Hilgert (R2) replied that SCUBA had been evaluated but was considered to have low data return for the cost in the tailrace, especially because using SCUBA among Project structures would require support barges and additional surface personnel.

- *Comment* – Llewellyn Matthews (Columbia Power) asked if the study would shed light on whether bull trout in the tailrace were attempting to move upstream.
  *Response* – Phil Hilgert (R2) replied that the fish distribution study would address bull trout presence, but the sampling gear would not differentiate upstream migration from other behaviors.

- *Comment* – Scott Deeds (USFWS) stated that genetics samples could shed light on Llewellyn Matthew's question by helping to reveal the origin of fish captured in the tailrace.

- *Comment* – Joe Maroney (Kalispel) provided an overview of bull trout and cutthroat trout genetics studies being conducted in the lower Pend Oreille basin, including work done by the Kalispel Tribe, USFWS, and WDFW.

- *Comment* – Tom Shuhda (USFS) asked how genetics information would be used in the relicensing.
  *Response* – Phil Hilgert (R2) stated that it would be analyzed as part of fish distribution studies to help identify fish origins.

- *Comment* – Al Solonsky (SCL) asked whether stakeholders considered the tailrace fish distribution study plan to be acceptable.
  *Response* – Stakeholders agreed that the proposed approach to studying tailrace fish distribution at Boundary Dam appeared to be appropriate.

***Tailrace Biotelemetry***

Al Solonsky (SCL) read the objectives associated with the *Boundary Tailrace Native Salmonid Biotelemetry* study plan and described the tasks proposed by SCL to address the issue. Al stated that tracking of tagged fish would be coordinated with bull trout telemetry studies planned by BC Hydro for 2007. Al explained that fixed receivers would be located in Boundary tailrace, at the US-Canada border, and in Lomand, Russian, and Redbird creeks upstream of their confluences with Seven Mile Reservoir. Al noted that mobile tracking of fish would be conducted in Seven Mile Reservoir (see the *Boundary Tailrace Native Salmonid Biotelemetry* study outline for descriptions of assumptions and proposed tasks, level of effort, and schedule).

- *Comment* – Tom Shuhda (USFS) asked if fish in the tailrace would be tracked during high flows.
  *Response* – Al Solonsky (SCL) replied that fixed receivers would be in place in the tailrace at all times and that these are expected to detect fish under the range of flows. Al added that mobile tracking would also be conducted in the tailrace and Seven Mile Reservoir, although it had yet to be determined at what flow mobile tracking would no longer be feasible or safe. Al said that work conducted by Seattle City Light in 2006 will be used to help make determinations about when and how biotelemetry will be conducted.

- *Comment* – Llewellyn Matthews (Columbia Power) asked where tagged fish would be captured.
  *Response* – Al Solonsky (SCL) replied that all fish to be tagged as part of the tailrace biotelemetry study would be captured between Boundary Dam and the US-Canada border.

- *Comment* – Llewellyn Matthews (Columbia Power) asked what would be done if insufficient numbers of native salmonids were captured in this area.
  *Response* – Al Solonsky (SCL) replied that efforts applied to capture fish would be substantial but that if target sample sizes are unattainable, SCL would conduct studies with as many fish as possible.

- *Comment* – Scott Deeds (USFWS) and Joe Maroney (Kalispel) stated that native redband (rainbow) trout should be included in the tailrace biotelemetry study.
  *Response* – Al Solonsky (SCL) stated that Seattle City Light would include native redband (rainbow) trout in the tailrace biotelemetry study.

- *Comment* – Tom Shuhda (USFS) asked whether additional salmonids would be tagged in 2008 if the target number of 20 individuals of each species was not attained in 2007. Tom also asked if additional fish would be tagged to replace any whose tag dies during the study.
  *Response* – Al Solonsky (SCL) replied that tagging would continue in 2008, if necessary, and that fish with dead tags would be replaced, if additional fish could be captured.

- *Comment* – Al Solonsky (SCL) asked whether stakeholders considered the tailrace biotelemetry study plan to be acceptable.
  *Response* – Stakeholders agreed that the proposed approach to conducting biotelemetry downstream of Boundary Dam appeared to be appropriate.

***Reservoir Biotelemetry***

Al Solonsky (SCL) read the objectives associated with the *Boundary Reservoir Native Salmonid Biotelemetry* study plan and described the tasks proposed by SCL to address the issue. Al stated that the study design was similar to that of the tailrace biotelemetry study. Al pointed out that tracking of stocked triploid rainbow trout was covered in a separate study plan (see the *Boundary Reservoir Native Salmonid Biotelemetry* study outline for descriptions of assumptions and proposed tasks, level of effort, and schedule).

- *Comment* – Doug Robison (WDFW) asked whether mobile tracking would be undertaken to determine whether native salmonids are searching for and occupying cold-water refugia, such as tributary deltas and areas of groundwater inflow.
  *Response* – Phil Hilgert (R2) replied that mobile tracking will shed light on which habitats are used by native salmonids. However, said Phil, habitat modeling would be the primary method used to assess habitat suitability in tributary deltas and that the proposed approach to modeling would be the focus of the May 2006 Fish & Aquatics Workgroup meeting. Phil added that if captured fish are large enough, some fish could be fitted with depth and temperature tags to evaluate whether they are using areas of groundwater inflow.

- *Comment* – Joe Maroney (Kalispel) stated that smallmouth bass, which are a valuable gamefish in Boundary Reservoir, should be included in the reservoir biotelemetry study. Joe added that because smallmouth spawn in shallow, near-shore areas, their habitat is likely to be affected by fluctuating reservoir surface elevation.
  *Response* – Al Solonsky (SCL) said that SCL intended to address smallmouth with habitat modeling as part of the varial zone study. Phil Hilgert (R2) added that biotelemetry is typically applied when the objective is to gain much information regarding a small population of organisms, such as bull trout in Boundary Reservoir. Phil suggested that in the case of an abundant organism, such as smallmouth bass, other techniques, in this case sampling with electrofishing, gill nets, and fyke nets may provide sufficient data to validate habitat suitability curves. Al Solonsky (SCL) stated that SCL would consider whether to include smallmouth bass in the reservoir telemetry study.

- *Comment* – Joe Maroney (Kalispel) asked if reservoir-specific habitat suitability indices would be developed for smallmouth bass for use in the modeling study.
  *Response* – Phil Hilgert (R2) replied that the proposed approach would be to validate habitat suitability indices with observations made in Boundary Reservoir.

- *Comment* – Tom Shuhda (USFS) asked if a reservoir fish distribution study, like that proposed for the tailrace, was planned.
  *Response* – Al Solonsky (SCL) replied that a reservoir fish distribution study was planned and that the study plan was still in preparation and would be discussed at the June 2006 workgroup meeting.

- *Comment* – Tom Shuhda (USFS) stated that if radio-tagged fish pass stationary receivers at tributary mouths, it would be useful to employ mobile tracking to evaluate their habitat use in the tributaries upstream of the fixed receiver. Tom stated that such an effort would not be undertaken to assess direct impacts of Project operations on tributary habitat, because the habitat in question is outside the Project's influence. However, said Tom, the data provided by mobile tracking in tributaries would be useful in identifying potential sites that could be enhanced as mitigation for the ongoing impact of inundation of 17 miles of river resulting from the existence of Boundary Reservoir. Tom stated that the USFS is particularly interested in fish habitat use in Sullivan, Slate, Sweet, and Flume creeks.
  *Response* – Al Solonsky (SCL) replied that SCL would consider Tom's request.

- *Comment* – Al Solonsky (SCL) asked whether stakeholders considered the reservoir biotelemetry study plan, with the exception of tagging smallmouth bass and tracking fish in tributaries, to be acceptable.
  *Response* – Stakeholders agreed that the proposed approach to conducting biotelemetry in the reservoir, except for the two unresolved issues noted by Al, appeared to be appropriate.

***Triploid Trout Biotelemetry***

Al Solonsky (SCL) read the objectives associated with the *Triploid Trout Biotelemetry* study plan and described the tasks proposed by SCL to address the issue. Al stated that the goal would be to tag fish captured above and below Metaline Falls and newly stocked fish as well as some that had been in the reservoir for at least a year. Al stated that major goals of the study were to assess the degree to which triploid rainbow trout moved after stocking and whether they appear to be competing with native salmonids for space (see the *Triploid Trout Biotelemetry* study outline for descriptions of assumptions and proposed tasks, level of effort, and schedule).

- *Comment* – Doug Robison (WDFW) asked if SCL intended to post signs to alert anglers that they should return tagged fish to the reservoir.
  *Response* – Al Solonsky (SCL) replied that posters would be displayed at boat launches to alert anglers about tagged fish.

- *Comment* – Doug Robison (WDFW) asked if anglers could be queried as to where and when radio-tagged fish are captured, information that could be useful is assessing angler effort and harvest.
  *Response* – Al Solonsky (SCL) replied that SCL was proposing to conduct a creel survey to address the issues raised by Doug and that the study plan for this survey would be reviewed at the June Fish & Aquatics Workgroup meeting.

- *Comment* – Al Solonsky (SCL) asked whether stakeholders considered the triploid rainbow trout biotelemetry study plan to be acceptable.
  *Response* – Stakeholders agreed that the proposed approach to conducting triploid trout biotelemetry in the reservoir appeared to be appropriate.

**Closing**

Steve Padula (LVA) reiterated that SCL hoped to have written comments from stakeholders on the Fish Connectivity EID and the proposed study outlines by May 16. Steve noted that although stakeholders would have additional opportunities to comment on study plans during the PSP process, SCL would benefit from getting as much feedback as possible in the early stages of study plan development. Steve stated that comments made during the day's meeting would be captured in the meeting summary and that there would be no need for stakeholders to resubmit comments made during the meeting. Steve added that the draft meeting summary would be provided to stakeholders so that they could verify that their comments were properly characterized. Al Solonsky (SCL) asked that all comments on the Fish & Aquatics study plans be sent to him.

- *Comment* – Tom Shuhda (USFS) stated that it would be important for the draft meeting summary to be available to stakeholders before May 16 so that stakeholders could be sure which of their comments had already been included in the relicensing record.

*Response* – SCL agreed to distribute the draft Fish & Aquatics Workgroup meeting summary to stakeholders before May 16, 2006.

- *Comment* – Doug Robison (WDFW) asked if SCL intended to compile all stakeholder comments, including those from the meeting summary, into a single document for subsequent tracking.
  *Response* – SCL replied that the plan was to compile all comments, including those in meetings summaries, into a single document, i.e., the consultation record.

- *Comment* – Tom Shuhda (USFS) asked how soon stakeholders would be informed if any of their requested studies or study elements were being denied by SCL so that stakeholders will know whether they need to prepare a formal study request.
  *Response* – Steve Padula (LVA) replied that SCL would be making decisions about whether or not to accommodate stakeholder study requests throughout the summer. However, said Steve, stakeholders would have a formal 90-day review period for the PSP, after which there would be an opportunity for formal study requests to be submitted in writing. Barbara Greene (SCL) stated that SCL would provide responses to stakeholders' requests as soon as possible.

Phil Hilgert (R2) provided a preview of the topics to be addressed at the May 2006 Fish & Aquatics Workgroup meeting: hydraulic routing and physical habitat modeling, fish stranding, development of habitat suitability indices, and sediment transport and tributary delta habitat studies.

- *Comment* – Joe Maroney (Kalispel) asked for a summary of the scope of 2006 field studies.
  *Response* – Al Solonsky (SCL) replied that 2006 field studies would include 1) assessment of the advantages and disadvantages associated with the use of radio tags and sonic tags in the tailrace and reservoir, 2) effectiveness of gill netting in the reservoir and at the mouths of Sullivan, Slate, Sweet, and Flume creeks, and 3) an evaluation of potential logistical issues associated with launching and operating boats in the tailrace under various flows. Al added that SCL had received proposals to conduct the 2006 studies from three consultants on its roster and would likely be making its selection soon.

- *Comment* – Joe Maroney (Kalispel) asked whether stakeholders would be given the opportunity to provide input on which consultant is selected to conduct the studies. Doug Robison (WDFW) stated that because of their relevant experience, stakeholders could provide valuable input regarding consultants, which would help SCL select the company or individual best suited to conduct the work.
  *Response* – Barbara Greene (SCL) replied that she was not sure whether consultants who had already bid on the gillnetting and entrainment work were informed that their proposals could be shared with entities outside SCL. Therefore, said Barbara, there may be a limitation on providing the proposals to stakeholders. Barbara said she would check the City of Seattle contracting rules to verify any constraints on sharing proposals with stakeholders.

**Action Items:**

- Draft Fish Connectivity EID/entrainment mortality estimates
  - Peter Christensen (R2) agreed to convert the Franke et al. (1997) report to a .pdf file and distribute it, through SCL, to stakeholders.
  - Stakeholders agreed to provide SCL with written comments on the Fish Connectivity EID and a decision as to whether the entrainment mortality estimates developed by Peter Christensen (R2) would be acceptable for use in the relicensing by May 16, 2006.
- Draft Fish and Aquatic Study Outlines
  - Stakeholders agreed to provide SCL with written comments on the study plan outlines presented by SCL during the April 20 meeting by May 16, 2006.
  - SCL agreed to include native redband (rainbow) trout in the tailrace biotelemetry study.
  - SCL agreed to consider whether to include smallmouth bass in the reservoir telemetry study.
  - SCL agreed to consider whether mobile tracking of salmonids would be conducted in tributaries to Boundary Reservoir.
- Draft Meeting Summary for April 20 Fish & Aquatics Workgroup meeting
  - SCL agreed to provide a draft meeting summary of the April 20, 2006 Fish & Aquatics Workgroup meeting to stakeholders before May 16, 2006.
  - SCL agreed to compile all comments on study plans, including those contained in meeting summaries, into a single document, i.e., the consultation record.

**Decisions:**

- Turbine entrainment
  - Stakeholders agreed that Seattle City Light's proposed approach to studying turbine entrainment at Boundary Dam appeared to be appropriate.
- Spillway entrainment:
  - Stakeholders agreed that the proposed approach to studying spillway entrainment at Boundary Dam appeared to be appropriate.
- Fish Distribution in Boundary Tailrace
  - Stakeholders agreed that the proposed approach to studying tailrace fish distribution at Boundary Dam appeared to be appropriate.
  - At the request of stakeholders, Seattle City Light agreed to include native redband (rainbow) trout in the tailrace biotelemetry study.
- Tailrace Biotelemetry
  - Stakeholders agreed that the proposed approach to conducting biotelemetry downstream of Boundary Dam appeared to be appropriate.
- Reservoir Biotelemetry
  - Stakeholders agreed that the reservoir biotelemetry study plan, except for the yet-to-be-resolved issues of tagging smallmouth bass and tracking tagged fish in reservoir tributaries, was acceptable.
- Triploid Trout Biotelemetry
  - Stakeholders agreed that the proposed approach to conducting triploid trout biotelemetry in the reservoir appeared to be appropriate.

**Boundary Hydroelectric Project (FERC No. 2144)**
**Fish & Aquatics Workgroup Meeting**
**May 23, 2006**
**Quality Inn Oakwood**
**7919 Division Street**
**Spokane, Washington**

## FINAL MEETING SUMMARY

## In Attendance

Laurie Blau, Ponderay Newsprint
Scott Deeds, US Fish and Wildlife Service (USFWS)
Rick Donaldson, USFWS
Bill Duncan, Teck Cominco
Randall Filbert, Long View Associates, (LVA)
Barbara Greene, Seattle City Light (SCL)
Phil Hilgert, R2
Scott Jungblom, Pend Oreille PUD
Steve Padula, LVA
Kim Pate, SCL
Christine Pratt, SCL
Doug Robison, Washington Department of Fish and Wildlife (WDFW)
Jaime Short, Washington Department of Ecology (WDOE)
Tom Shuhda, USDA Forest Service (USFS)
Al Solonsky, SCL
Mark Tiley, CCRIFC
Curt Vail, WDFW

## Agenda

- Introductions/review goals for meeting
- Review outstanding action items
  - Status of 2006 early action efforts
  - Response to comments during April 20 Fish & Aquatics Workgroup meeting
  - Schedule of topics for 2006 workgroup meetings
  - Stakeholder response to draft meeting summary from April 20 meeting
- Integrated Resource Analysis
- Overview of Aquatic Habitat Analysis
- Draft Fish and Aquatic study outlines
  - Habitat Suitability Indices (HSI)
  - Hydraulic Routing
  - Aquatic Habitat Modeling
  - Tributary Delta Sediment Transport and Habitat Modeling
- Administrative items/closing remarks

## Introductions/review goals for meeting

Barbara Greene (SCL) welcomed stakeholders and reviewed the meeting agenda. Barbara referred to a forecast of 2006 meeting agenda topics provided on SCL's website. Barbara stated that the forecast would enable stakeholders to plan their schedules to attend Fish and Aquatics Workgroup meetings with topics relevant to their interests and attend other resource workgroups' meetings when relevant resource "crossover" topics are being addressed, for example TDG issues covered at Water Quality Workgroup meetings. Barbara noted that all workgroup meetings held in 2006 would take place in Spokane, except for the June meetings, which would be held at the Cutter Theater in Metaline Falls.

**Review outstanding action items**

***Status of 2006 early action efforts***

Al Solonsky (SCL) provided an update on 2006 early action efforts, stating that contractors had been selected to conduct studies. Al stated that Terrapin had been selected to conduct the evaluation of gill net effectiveness in Boundary Reservoir and tailrace and the identification and assessment of logistical challenges associated with launching and operating boats in the tailrace. Al stated that LGL was selected to conduct the assessment of the advantages and disadvantages of radio and acoustic tags for tracking fish. Al explained that the 2006 assessment of tagging options would be a literature-based effort and would not include actual tagging and tracking of fish. Al stated that LGL has much experience conducting radio telemetry and acoustic tagging studies on the mid-Columbia River, including studies of bull trout.

Barbara Greene (SCL) stated that no entrainment studies would be conducted in 2006. Barbara reminded stakeholders that SCL had originally considered getting spillway and turbine entrainment studies underway in fall of 2006. However, said Barbara, the City of Seattle's contracting rules mandate that a contract as large as that associated with entrainment studies be awarded via a competitive process and that completing such a process would not be possible in time to conduct work in the fall of 2006. Barbara stated, however, that PSP technical consultants would be hired by early 2007 and entrainment work would begin shortly after that.

- *Comment* – Tom Shuhda (USFS) asked if LGL would prepare a report to summarize its evaluation.
  *Response* – Al Solonsky (SCL) replied that both Terrapin and LGL would produce reports. Al stated that the reports would be important not only for informing stakeholders and SCL of results but also to provide information that will help technical consultants plan and execute PSP studies in 2007 and 2008.

- *Comment* – Scott Deeds (USFWS) reminded SCL that ESA take permits would be needed for bull trout before gill netting could be conducted, and Doug Robison (WDFW) added that that collection permits would be needed from WDFW. Scott Deeds stated that the USFWS staff member responsible for issuing recovery permits had resigned and that in the interim period prior to hiring a replacement a part-time staff person would be issuing permits at the USFWS regional office. Scott said that this would result in permits taking longer to issue and that to expedite its permitting process SCL should copy him (Scott Deeds) on all permit related correspondence. Scott added that he would be out of the office for about two weeks, and as a result the process of approving a permit for SCL would likely not begin until the week of June 12.

- *Comment* – Doug Robison (WDFW) asked which tributary deltas would be sampled with gill nets.
  *Response* – Al Solonsky (SCL) replied that gill nets will be deployed at the inflows of Sullivan, Slate, Flume, and Sweet creeks, as well as one location that will be identified by the contractor.

***Response to comments from April 20 Fish & Aquatics workgroup meeting***

<u>Radio-tagging of smallmouth bass</u>

Al Solonsky (SCL) noted that at the April 20, 2006 workgroup meeting, stakeholders had requested that smallmouth bass, because of their value as a gamefish in Boundary Reservoir, be tagged and tracked as part of the reservoir biotelemetry study. Al stated that SCL would tag smallmouth bass, some of which could be tagged when they are caught by anglers during the annual Boundary Reservoir bass tournament (see below).

- *Comment* – Tom Shuhda (USFS) stated that smallmouth bass anglers should be educated about the fish studies being conducted as part of relicensing, both to acquire information about where tagged fish are caught and to promote quick release of tagged fish so that they are not lost to the studies.

<u>Mobile tracking of tagged fish in tributaries to Boundary Reservoir</u>

Al Solonsky (SCL) stated that at the April 20 meeting, stakeholders had requested that mobile tracking be conducted to evaluate salmonid habitat use in the tributaries to Boundary Reservoir. Al stated that SCL was currently considering the request and would provide a response at the June 27 Fish and Aquatics Workgroup meeting in Metaline Falls.

<u>Stakeholder comments on study plan outlines reviewed at the April 20, 2006 meeting</u>

Al Solonsky (SCL) noted that the USFWS had submitted written comments to SCL regarding study plan outlines presented at the April 20 Fish and Aquatics Workgroup meeting. Al noted that many of the suggested edits were minor and would be accepted by SCL. Al then distributed a copy of the comments submitted by the USFWS and provided initial responses to those comments (a version of the USFWS comments, with highlighted responses from SCL, is attached; the attached version with responses is not the version handed out at the meeting).

- *Comment* – Referring to Task 2 (T2) of the spillway entrainment study outline, Rick Donaldson (USFWS) stated that limiting studies to the period of April through July could result in a lack of data for other periods of the year when spill could occur. Rick noted, for example, that spill could occur in winter as the result of rain-on-snow events.
- *Response* – Al Solonsky (SCL) replied that SCL believed significant spill would likely occur during the April through July period, as evidenced by 10-percent flow exceedance data. Al indicated that the spillway entrainment monitoring period would be adjusted if significant spill occurs outside the April through July period.

- *Comment* – Referring to the Boundary Reservoir fish distribution study, Scott Deeds (USFWS) emphasized that the use of CART tags, rather than acoustic tags, would allow for fish movements in the lower portions of reservoir tributaries to be monitored with the

fixed receivers at the tributary mouths, i.e., even without the use of mobile tracking in the tributaries.
*Response* – Al Solonsky (SCL) acknowledged Scott's comment and stated that decisions about the selection of tags would be made when the results of the 2006 field studies are available and a 2007 contractor has been selected.

- *Comment* – Referring to T3 of the Boundary Reservoir fish distribution study, Scott Deeds (USFWS) stated that Floy tags could be lost and that PIT-tags would likely generate more useful information because of their higher retention rate.
  *Response* – Phil Hilgert (R2) noted that unlike PIT-tags, which require a detector, Floy tags can be detected and read by anyone, including anglers. Phil stated that in other research situations, return rates on Floy tags provided by anglers have averaged about 12 percent. Phil also said Floy tags will alert anglers that a particular fish is part of a study, which may promote rapid release of that fish.

- *Comment* – Curt Vail (WDFW) stated that he was aware of Floy-tag return rates as high as 40 percent when a reward was provided for returns.
  *Response* – Al Solonsky (SCL) stated that SCL would consider the implementation of a reward program to increase Floy tag return rates.

- *Comment* – Scott Jungblom (Pend Oreille PUD) stated that an advantage of PIT tags is that they could be detected by the PIT-tag detector that will be in place at the base of Box Canyon Dam.
  *Response* – Al Solonsky stated that fish in good condition, i.e., showing low signs of stress, captured when water temperatures are low, would receive PIT-tags, in addition to radio tags (or acoustic/CART) and Floy tags.

Stakeholder comments on the Fish Connectivity EID and turbine/spillway mortality estimates

Al Solonsky (SCL) noted that the USFWS had also submitted written comments to SCL regarding the Fish Connectivity EID, which was presented at the April 20 Fish and Aquatics Workgroup meeting.

Al reminded stakeholders that at the April 20, 2006 meeting SCL had asked stakeholders if turbine and spillway entrainment mortality estimates (Table 4-2 of the EID) developed by SCL could be used in the relicensing process, in lieu of conducting studies to estimate entrainment mortality. Al noted that Tom Shuhda (USFS) had replied to this request, indicating that the USFS was prepared to allow SCL to use the turbine mortality estimates (see attached email). However, said Al, the USFS was still reviewing documents to make a determination as to whether the spillway mortality estimates could be used. Al asked remaining stakeholders if use of the entrainment mortality estimates would be acceptable. Steve Padula (LVA) stated that SCL would need to know before October—but preferably as soon as possible—if stakeholders are unwilling to accept turbine and spillway mortality estimates, so there would be adequate time to develop study plans to include in the PSP.

- *Comment* – Rick Donaldson (USFWS) stated that the USFWS needed more time to review the EID and its supporting documents before making a decision about whether the estimates could be used in lieu of the results of Project-specific mortality studies. Rick added that the USFWS would have to consider whether it is willing to base Section

10 incidental take permits on mortality estimates.  Rick agreed that the USFWS would attempt to make a decision by the June 2006 Workgroup meeting.

- *Comment* – Scott Deeds (USFWS) asked whether a revised EID would be submitted before stakeholders were expected to submit comments, adding that in some places the EID would benefit from greater detail.
  *Response* – Steve Padula (LVA) replied that SCL did not plan to issue any additional drafts of the Fish Connectivity EID, stating that the purpose of the document was to organize and present existing information and that more detailed information would be developed as the relicensing process moves forward.

- *Comment* – Tom Shuhda (USFS) asked if any relicensing documents would include a formal statement indicating stakeholder signoff on the estimated turbine and spillway mortality rates—if they are indeed accepted.
  *Response* – Steve Padula (LVA) replied that a definitive statement regarding the acceptance of the estimated mortality rates (if they are accepted) would be included in the PSP and that stakeholders could sign off on the estimated rates by accepting the contents of the PSP.

***Stakeholder response to the April 20 draft meeting summary***

Steve Padula (LVA) asked if stakeholders had comments on the draft summary of the April 20, 2006 Fish and Aquatics Workgroup meeting.  Stakeholders provided no comments.  Steve asked that comments be submitted to SCL and LVA no later than May 30, after which SCL would finalize the summary.

**Integrated Resource Analysis**

Kim Pate (SCL) reviewed a flow chart entitled *Integrated Resource Analysis*, which depicts relationships between the resource workgroups and the Technical Scenario Team as well as application of the scenarios tool and other resource analyses (The *Integrated Resource Analysis* flowchart is posted on SCL's website as part of the May 23 meeting materials).  Kim noted that the flowchart only identifies the tools to be used to assess potential future Project operating scenarios and that the decision as to which alternative is adopted will be made by SCL in coordination with stakeholders.

Kim explained that the scenarios tool is an Excel® spreadsheet based model that that can be used to assess existing and potential future operating scenarios.  Kim stated that the tool had been developed by Chuck Howard, an independent consultant with much experience modeling hydropower operations.  Kim stated that unlike many proprietary operations models, the spreadsheet-based tool is "transparent," so that its function could be understood by experts other than the developers of the model.  Kim stated that through analysis of operational optimization, the scenarios tool allows for an objective assessment of the impacts associated with various alternative scenarios, adding that multi-resource assessments would occur through independent analyses of post-process scenario model output.  Kim stated that stakeholder input will be sought as the scenarios tool is further refined and that a manual describing the tool's function and capabilities would be submitted to stakeholders in fall 2006.

- *Comment* – Tom Shuhda (USFS) asked if operational changes aimed at addressing particular issues, for example juvenile fish stranding, would be analyzed independently

or simultaneously with other operational constraints that together make up a potential future alternative.
*Response* – Kim Pate (SCL) stated that in the example provided by Tom the first step would be to evaluate the operational feasibility of the proposed fish stranding constraint. Then, if feasible, other operational constraints associated with the overall alternative would be added incrementally to determine where possible conflicts arise. In other words, said Kim, multiple variables would be analyzed simultaneously.

- *Comment* – Tom Shuhda (USFS) asked how (i.e., in what format) results of scenarios tool analyses would be presented.
  *Response* – Kim Pate (SCL) replied that the format would be dictated to a large extent by stakeholders' information requests and the nature of the variable being evaluated. Kim stated that collaborative decisions will have to be made regarding the format that best conveys the desired information. Kim added that—as shown in the flowchart—some output from the scenarios tool would feed directly into other models—e.g., habitat models—and that such models often generate results in a specific format.

- *Comment* – Tom Shuhda (USFS) stated that it would be helpful to see results of a fictitious alternative, so that stakeholders could gain a better appreciation of what information the scenarios tool will provide.
  *Response* – Kim Pate (SCL) replied that SCL would present examples of scenarios tool output at a subsequent meeting.

- *Comment* – Doug Robison (WDFW) asked if the scenarios tool could be used to improve the efficiency of existing operations.
  *Response* – Kim Pate (SCL) replied that the tool did provide insight into how historical operations could be streamlined. Kim stated that many factors would be included to determine how future operations could be made most efficient.

- *Comment* – Bill Duncan (Teck Cominco) stated that it would be critical to establish baseline conditions against which all proposed alternatives would be analyzed.
  *Response* – Kim Pate (SCL) replied that at this time, SCL is considering operations during the period 1987 through 2004 to be the baseline for scenarios tool analyses.

**Overview of Aquatic Habitat Analysis**

Al Solonsky (SCL) reviewed a flow chart titled *Conceptual Workflow for Aquatic Habitat Modeling*, which depicts how aquatic habitat analyses will be conducted for proposed operating scenarios. Al provided an overview of the components of the flowchart: scenarios tool, transect selection, flow routing, HSI models, habitat modeling, and integrated resource analyses (the *Conceptual Workflow for Aquatic Habitat Modeling* flowchart is posted on SCL's website as part of the May 23 meeting materials). Al emphasized that all modeling would be based on sound biological information and that results for a given operational alternative would be generated for a range of water year types (i.e., dry, average, and wet years). Al stated that the modeling would address the area from Box Canyon Dam to Redbird Creek, a tributary to Seven Mile Reservoir located just upstream of the Salmo River confluence.

Phil Hilgert (R2) stated that the purpose of the May 23 meeting was to introduce the overall proposed modeling approach to stakeholders and that there was no expectation by SCL that stakeholders would approve all of the details of the approach at this time. Instead, said Al

Solonsky, the topic of modeling would be revisited at the August 14 meeting, after stakeholders have had time to reflect on the approach, and at that time SCL would seek more definitive input from stakeholders.

- *Comment* – Tom Shuhda (USFS) noted that modeling would be based to some extent on empirical biological data collected in the Project area, for example information needed to validate HSI curves. Tom asked how modeling would be conducted in a timely manner, given that results of many site-specific investigations would not be available until late 2008.
  *Response* – Phil Hilgert (R2) described the sequence of events that would culminate in habitat modeling and agreed that involved modeling of alternative scenarios is anticipated to begin in late 2008. Phil reiterated that the scenarios tool was already in progress as there is significant lead time needed to develop the model. Phil stated that selection of habitat transects is scheduled for late summer 2007, after bathymetry and fish distribution studies are completed. Phil stated that data collection for the validation of HSI curves would also take place in 2007. Phil stated that transect data would be collected in fall of 2007 and throughout 2008 and that habitat modeling would occur in fall 2008. By this time, said Phil, the scenarios tool will have been completed and be ready for use. Phil stated that after habitat modeling results are available, field reconnaissance would be conducted to validate the model output, for example macrophyte distribution and abundance at select sites would be compared to the model's predictions. At that time, said Phil, assessment of discrepancies between model output and observed patterns would be conducted. Phil cautioned that field verification may not be a straightforward process; for example, actual macrophyte distribution could deviate from that predicted by the model because of inaccuracies in HSI information or because of other factors, such as a recent desiccation or freezing event that reduced macrophyte abundance in otherwise suitable habitat.

- *Comment* – Doug Robison (WDFW) asked when the validation process described by Phil would occur.
  *Response* – Phil Hilgert (R2) replied that it would take place in 2008.

- *Comment* – Doug Robison (WDFW) stated that it seemed that validation would require more time and therefore needed to extend into 2009.
  *Response* – Phil Hilgert (R2) replied that field observations made in fall 2008 should suffice, when combined with other elements of validation. Phil noted that biological data would be collected in 2007 for the validation of HSI curves derived from the scientific literature. Phil stated that adjusting HSI curves based on site-specific information was in itself a validation procedure.

- *Comment* – Doug Robison (WDFW) stated that regardless of whether validation of the habitat modeling is acceptable, a larger question remains regarding the validation of the overall model, which includes the scenarios tool and a number of other components.
  *Response* – Phil Hilgert (R2) replied that validation would only be feasible at the level of the component models and that a single validation of the overall results derived from the linked models would not be possible. Phil stressed that the modeling results would use habitat as an index of production and only provide a frame of reference by which alternative operating scenarios could be compared. The results would not predict numbers of fish under alternate scenarios—for example the model will not predict fish abundance in particular habitats under various operational scenarios. Ultimately, said Phil, the results will be used by SCL and stakeholders to select what appears to be the

preferred, balanced future operating approach and that the models would provide a defensible basis for making this selection.

- *Comment* – Doug Robison (WDFW) stated that it appeared that running each scenario would be costly and time consuming and asked whether these factors would limit stakeholders' ability to evaluate a range of alternatives.
  *Response* – Phil Hilgert (R2) replied that the modeling approach would be streamlined enough to allow for the evaluation of wide range of alternatives. Barbara Greene (SCL) added, however, that it would be prudent to avoid analysis of too many alternatives to prevent the workgroup from being inundated with information, which could make decision-making difficult.

- *Comment* – Bill Duncan (Teck Cominco) asked whether the sequence of analysis events described by Phil Hilgert (R2) meshed with FERC's expectations.
  *Response* – Steve Padula (LVA) replied that it would and said that that SCL is required to file its Preliminary Licensing Proposal (PLP) in April 2009 and its License Application in September 2009. After this, said Steve, FERC will conduct its NEPA analysis of future operating alternatives.

- *Comment* – Curt Vail (WDFW) stated that it would be useful to establish economic "sideboards" to define the limits of potential future operating scenarios.
  *Response* – Barbara Greene (SCL) agreed with this and said that SCL was currently in the process of developing such sideboards. Barbara added that the scenarios tool will be instrumental in completing this task.

**Draft Fish and Aquatic study outlines**

***Habitat Suitability Indices (HSI)***

Al Solonsky (SCL) reviewed the *Habitat Suitability Information* study plan objectives and described the tasks proposed by SCL to complete the study element (see the *Habitat Suitability Information, a subset of the Aquatic Habitat Modeling Study* outline for descriptions of assumptions, proposed tasks, level of effort, and schedule). Al reiterated that HSI curves would be derived from the literature and, where possible, would be validated for the Boundary Project area based on site-specific field data. Al stated that SCL would be amenable to consulting regional experts on fish, macrophytes, and benthic macroinvertebrates, if such consultation would give stakeholders greater confidence in model results. Al stated that the approach to developing suitability information for macroinvertebrates was still underway and that more detail regarding macroinvertebrates would be presented at the June 27 meeting. Phil Hilgert (R2) added that given the limited timeframe imposed by the ILP process, much work would have to take place in 2007 and 2008. With this in mind, said, Phil, stakeholders should consider the appropriate level of detail when modeling macroinvertebrate habitat.

Phil Hilgert reviewed Table 1 (Potential data sources for habitat suitability information) from the *Habitat Suitability Information* study plan. Phil pointed out that the table contained the proposed fish species for which HSI information would be developed and the primary and secondary sources of site-specific validation data for each of the species.

- *Comment* – Curt Vail (WDFW) and Tom Shuhda (USFS) stated that understanding the effects of potential future operating scenarios on macroinvertebrates, particularly from the standpoint of food availability for fish, would be important.
  *Response* – Phil Hilgert (R2) stated that unlike fish, a simpler modeling approach could be undertaken for macroinvertebrates, for example, considering all dewatering to be detrimental, so that macroinvertebrate habitat modeling would involve binary suitability criteria. Phil added that modeling of macroinvertebrate habitat could also be simplified by evaluating suitability at the level of biomass, species diversity, or functional feeding groups.

- *Comment* – Mark Tiley (CCRIFC) noted that a species of the genus *Hydra* appeared to be displacing native macroinvertebrates in some regulated rivers in the region. Mark stated that environments characterized by substantial short-term flow fluctuation appeared to favor this organism. Mark stated that it would be beneficial if studies could evaluate whether proposed Project operations will influence the proliferation of the *Hydra* species, and as a result assess the influence of this organism on native macroinvertebrates.

- *Comment* – Scott Jungblom (Pend Oreille PUD) stated that it should not be too difficult to model the effects of proposed alternatives on macroinvertebrates at the family level. Scott said that samples collected at a few sites, over the range of available substrate sizes, should suffice for validation. Scott added that it would be important to develop estimates of recolonization and survival rates on dewatered substrates.

- *Comment* – Curt Vail (WDFW) stated that the zone of pool level fluctuation might already be devoid of most macroinvertebrate taxa.

- *Comment* – Tom Shuhda (USFS) asked how the proposed modeling approach would address the issue of Project effects on phytoplankton and zooplankton communities, including assessment of impacts on overall reservoir productivity.
  *Response* – Phil Hilgert (R2) stated that reservoir productivity was being addressed as part of a separate study, the details of which would be reviewed with stakeholders at the June 27 Fish and Aquatics Workgroup meeting.

- *Comment* – Referring to Table 1 of the *Habitat Suitability Information* study plan outline (i.e., Potential data sources for habitat suitability information) Curt Vail (WDFW) stated that yellow perch could be removed from the list of species whose habitat would be evaluated, stating that yellow perch are adaptable and prolific and not a species of concern in Boundary Reservoir.
  *Response* – SCL agreed to remove yellow perch from the table and from subsequent model-based analysis.

- *Comment* – Also, referring to Table 1 of the *Habitat Suitability Information* study plan outline, Tom Shuhda (USFS) stated for the record that the USFS is concerned with native fish species, native game species in particular, and their forage species.

### *Hydraulic Routing Model, a subset of the Aquatic Habitat Model*

Al Solonsky (SCL) reviewed the *Hydraulic Routing Model* study plan objectives and described the tasks proposed by SCL to address this task (see the *Hydraulic Routing Model, a subset of* *the Aquatic Habitat Model* study plan outline for descriptions of assumptions, proposed tasks, level of effort, and schedule). Al stated that the development of the routing model was contingent on having reservoir bathymetry data, which were currently being collected and would likely be available by late summer 2006. Al stated that pressure transducers would soon be installed to measure reservoir surface elevation in key locations and that this information would be used to validate the routing model's output.

Phil Hilgert (R2) reiterated that the hydraulic routing model would address the area from Box Canyon Dam to Redbird Creek, a tributary to Seven Mile Reservoir located just upstream of the Salmo River confluence. Phil stated that SCL was coordinating with BC Hydro to assemble information needed to characterize Seven Mile Reservoir operations for use in developing the model. Phil stated that the proposed hydraulic routing approach would use 160 or more transects within the study area identified above.

- *Comment* – Rick Donaldson (USFWS) asked why modeling would only extend downstream to Redbird Creek.
  *Response* – Phil Hilgert (R2) stated that Redbird Creek is located at the approximate location of Seven Mile Reservoir's minimum surface elevation, i.e., the location of the minimum backwater effect of Seven Mile Dam, below which operations of the Boundary Project would have little effect.

***Aquatic Habitat Model***

Al Solonsky (SCL) reviewed the *Aquatic Habitat Model* study plan objectives and described the tasks proposed by SCL to address the study objectives (see the *Aquatic Habitat Model* study plan outline for descriptions of assumptions, proposed tasks, level of effort, and schedule). Al reiterated that two kinds of transects would be established: transects selected to represent particular habitat types and those selected to model unique habitat features. Al showed transect cross sections depicting hypothetical results of habitat modeling aimed at assessing Project effects on varial zone habitat. Al explained that the schematics provided a characterization of the variation in effects over different timeframes (see "Illustrative Snapshot of Hourly Varial Zone" materials distributed as part of the May 23 meeting materials). Al showed that the effects on the varial zone associated with a given alternative would vary spatially in the reservoir (e.g., above and below Metaline Falls) and depending upon the length of the period analyzed.

Phil Hilgert (R2) stated that in addition to transect-based habitat modeling, two other methods are commonly used for habitat assessment, two-dimensional (2D) modeling and techniques based on aerial photography and GIS. Phil explained that 2D modeling, which is based on a grid rather than transects, is more appropriate when detailed hydraulic information is required for a small area, particularly when much resolution regarding current patterns and velocity vectors is required. However, said Phil, the approach is very time-intensive, and most studies using 2-D modeling, trade off in-depth analysis of a few areas for the typical hydraulic analysis that involves more study sites. Phil stated that habitat assessment based on aerial photos and GIS analysis provides accurate system-wide characterizations of existing conditions but does not allow efficient modeling of a range of potential operational alternatives. Based on this, said Phil, the transect approach appears to be appropriate for use at Boundary Reservoir.

- *Comment* – Mark Tiley (CCRIFC) asked if data collection crews would require permission to operate in Canada.

*Response* – Al Solonsky (SCL) replied that to work on the river in Canada, consultants would need to launch their boats in Canada.

- *Comment* – Doug Robison (WDFW) questioned whether collecting data during a single spring and summer would be sufficient, stating that winter is, and is likely to be, the period when daily drawdown of the reservoir would be greatest.
  *Response* – Phil Hilgert (R2) replied that spring and summer would suffice for developing the habitat model, because the full range of surface elevations is experienced during this period. Phil stated that low reservoir levels often occur in spring during the pre-runoff period. Phil added that the early spring/late summer period would also provide a range of macrophyte densities, which influence channel roughness and, therefore, velocities.

- *Comment* – Rick Donaldson (USFWS) asked if maps would be produced based on the bathymetry data currently being collected.
  *Response* – Al Solonsky (SCL) showed a preliminary version of a map being produced from draft 2006 bathymetric data collected by Battelle. Al said that after data are checked and final maps are produced, SCL would make them available to stakeholders by posting them on the SCL website.

- *Comment* – Rick Donaldson (USFWS) asked if maps would be produced depicting velocity vectors in the reservoir under various flows.
  *Response* – Al Solonsky (SCL) replied that a map of the velocity distribution across transects could be produced from information used to develop the aquatic habitat model.

- *Comment* – Tom Shuhda (USFS) asked how far up the bank transects would extend.
  *Response* – Phil Hilgert (R2) stated that all transects would extend above the high-water mark on both sides of the reservoir.

- *Comment* – Doug Robison (WDFW) asked how flow variability would affect velocity and depth data collection at transects, stating that it would not be possible to collect data at all transects during a single flow.
  *Response* – Phil Hilgert (R2) replied that transect data would be collected independently at each transect and then be linked during model development.

- *Comment* – Doug Robison (WDFW) asked why varial zone modeling would be conducted at different time scales.
  *Response* – Al Solonsky (SCL) replied that the time periods used to assess impacts in the varial zone, which will be developed in collaboration with stakeholders, would vary to reflect colonization rates and dewatering-related mortality for a variety of aquatic species.

- *Comment* – Referring to the cross-section schematics shown by Al Solonsky, Tom Shuhda (USFS) asked whether there would be much difference in varial zone impacts over time, given the relatively consistent mode of operation at the Boundary Project.
  *Response* – Phil Hilgert (R2) replied that during certain times of year—for example during the shift from fall to winter operations—there would be differences in short- and longer-term effects on the varial zone. Phil added that the ability to analyze the varial zone over different timeframes might also be more important for potential future operating scenarios than for existing operations.

- *Comment* – Bill Duncan (Teck Cominco) stated that there would not only be spatial variation in varial zone impacts resulting from differences in reservoir geometry (i.e., above and below Metaline Falls) but also in response to differences in substrate—e.g., benthic macroinvertebrates associated with fine substrates would likely tolerate dewatering longer than those associated with coarse substrates.

- *Comment* –Tom Shuhda (USFS) asked how tributary deltas would be addressed in the context of the varial zone analysis.
  *Response* – Al Solonsky (SCL) replied that evaluation of tributary deltas would be conducted as a separate study, which would be reviewed later in the meeting.

- *Comment* – Doug Robison (WDFW) expressed concern that transects would not capture the full range of topographical variability present in the reservoir.
  *Response* – Al Solonsky (SCL) replied that representative transects would be selected to ensure that habitat modeling adequately characterized reservoir conditions. Al added that transects would be carefully selected in collaboration with stakeholders. Phil Hilgert (R2) added that IFIM studies are routinely carried out in this way, i.e., transects are selected to represent conditions by habitat type and by reach.

- *Comment* – Doug Robison (WDFW) asked if the weighting of transects would vary for different analyses.
  *Response* – Phil Hilgert (R2) replied that weighting could, but does not necessarily, vary between specific analyses; for example, an assessment of Project impacts on smallmouth bass spawning habitat, would only consider transects where spawning had been observed.

- *Comment* – Tom Shuhda (USFS) asked Phil if he had conducted a modeling evaluation in other locations that was comparable to what was being proposed for the Boundary Project.
  *Response* – Phil Hilgert (R2) presented and discussed comparable modeling results for the mainstem Skagit River, developed as part of the relicensing of the Baker Lake Project.

- *Comment* – Mark Tiley (CCRIFC) asked whether modeling macroinvertebrate habitat would involve assessment of the minimum period that substrate must be wetted before it is usable to macroinvertebrates.
  *Response* – Phil Hilgert (R2) replied that macroinvertebrate recolonization rates would be integrated into the modeling.

- *Comment* – Mark Tiley (CCRIFC) asked whether the macroinvertebrate recolonization rates referred to by Phil Hilgert would be determined empirically in Boundary Reservoir.
  *Response* – Phil Hilgert (R2) replied that it had not yet been determined whether the recolonization rates would be based solely on the scientific literature or whether rates derived from the literature would be augmented with site-specific measurements.

- *Comment* – Tom Shuhda (USFS) asked whether the modeling would be able to account for increased predation rates on juvenile native fish species resulting from concentration of juvenile fish during decreases in reservoir surface elevation.

*Response* – Al Solonsky (SCL) stated that at this time the modeling was not designed to address changes in predation. Al said that biotelemetry would be the tool used to assess fish movements in response to reservoir surface elevation changes but noted that fish evaluated with biotelemetry would have to be of a minimum size before they could be tagged.

- *Comment* – Doug Robison (WDFW) stated that he was still unclear as to how the issue of fish stranding would be addressed.
  *Response* – Phil Hilgert (R2) replied that stranding would be addressed through modeling of the varial zone and through ramp rates (i.e., the rate of change in reservoir surface elevation) in various habitat types and at different locations within the study area.

- *Comment* – Doug Robison (WDFW) asked what fieldwork would be conducted to validate modeling conducted to assess stranding.
  *Response* – Phil Hilgert (R2) replied that electrofishing would be conducted at some areas/transects prior to a reduction in pool level to identify the resource at risk. Phil stated that following the reduction in pool level, surveys would be conducted in those areas to locate and count any stranded fish. If appropriate, electrofishing could be conducted after a return to high pool levels to assess changes in abundance or habitat use. Phil noted that fish periodicity would be taken into account when determining when such fieldwork should be conducted.

***Tributary Delta Sediment Transport and Habitat Modeling***

Al Solonsky (SCL) reviewed the *Tributary Delta Sediment Transport and Habitat Modeling* study plan objectives and described the tasks proposed by SCL to address the objectives (see the *Tributary Delta Sediment Transport and Habitat Modeling* study outline for descriptions of assumptions, proposed tasks, level of effort, and schedule). Al referred to Figure 1 of the study plan outline and explained how modeling of various tributary deltas would be conducted depending upon whether delta conditions are expected to change over time and whether delta conditions are expected to vary in response to potential future operating alternatives (see Figure 1, *Conceptual Workplan for Tributary Delta Habitats in the Boundary Reservoir Drawdown Zone* for detail).

Phil Hilgert (R2) explained that transects would be established in the delta regions of selected tributaries and extend from above the high reservoir pool level along the tributary channel down to the lowest reservoir pool level. Phil said that modeling would be conducted in a manner similar to that described for the mainstem. Phil noted that transects would be established above the high water mark to assess whether the reservoir backs up sediment into the tributary itself. Phil stated that a geotechnical specialist would be consulted to estimate future changes to the delta regions based on bathymetry data. Phil stated that Stuart Beck, a hydrologist from R2 Resource Consultants, would be attending the August 14 Workgroup meeting in Spokane to explain in more detail the approach to modeling tributary deltas.

- *Comment* – Curt Vail (WDFW) asked how delta modeling would account for changes in land use and the concomitant potential for increases or decreases in sediment loading.
  *Response* – Phil Hilgert (R2) replied that assumptions would be made regarding sediment yield under current land uses, after which SCL would coordinate with landowners to project potential future changes to land use and when they might occur.

- *Comment* – Rick Donaldson (USFWS) asked whether the tributary delta study would address the potential for sediment accumulation at tributary mouths to block fish passage into the tributaries.
  *Response* – Phil Hilgert (R2) replied that assessing potential changes in tributary access would be a component of the analysis.

- *Comment* – Rick Donaldson (USFWS) asked whether mainstem sediment transport would be addressed as part of the Fish and Aquatics study program.
  *Response* – Al Solonsky (SCL) replied that it would be covered at the June 27 Workgroup meeting.

**Miscellaneous items**

***Questions regarding FERC process***

- *Comment* – Doug Robison (WDFW) stated that the FERC letter filed by SCL along with the Pre Application Document (PAD)—and distributed to stakeholders—differed from that posted on FERC's website.
  *Response* – Steve Padula explained that one letter was SCL's Notice of Intent (NOI) to file for a new FERC license for the Boundary Project and the other letter—the one posted on FERC's website—was a draft FERC notice that SCL is required to prepare and submit along with its NOI. Steve explained that FERC will eventually use the draft letter to provide notice of its receipt of the NOI/PAD and issuance of the Scoping Document 1 (SD1).

- *Comment* – Rick Donaldson (USFWS) asked SCL to clarify the process through which stakeholders would be able to comment on relicensing documents during 2006.
  *Response* – Steve Padula (LVA) stated that FERC would send out its notice of the receipt of the NOPI/PAD and issuance of the SD1 on July 3, 2006. Steve explained that this would initiate a 60-day comment period for stakeholders, which would end on September 1, 2006. Steve explained that FERC is required to hold a SD1 meeting no later than half way through this comment period, i.e., the meeting held at the Project on July 18 and 19, 2006. Steve explained that SCL would submit its Proposed Study Plan (PSP) in mid-October, 2006, and that this submittal would initiate a 90-day comment period.

***Boundary Reservoir annual smallmouth bass tournament***

Al Solonsky (SCL) stated that he had participated (weighing fish to determine the tournament winners) in the Annual Boundary Reservoir smallmouth bass derby. Al said that there had been 135 participants and that most anglers concentrated on areas upstream of Metaline Falls. Al stated that anglers did not provide specific information on the locations of their catches, but he was able to collect some information during the derby by driving along the river to see which areas were being fished by anglers. Al noted that other species caught during the tournament included peamouth, northern pikeminnow, whitefish, triploid rainbow trout, and four walleye. Al stated that SCL would prepare and distribute a summary of the outcome of smallmouth bass derby.

- *Comment* – Tom Shuhda (USFS) questioned whether anglers were asked if they had captured bull trout.

*Response* – Al Solonsky (SCL) replied that anglers had been asked if they had caught bull trout.

***Boundary Project, 2006 power transmission limitation***

Barbara Greene (SCL) and Kim Pate (SCL) explained that the Bonneville Power Administration (BPA) would be limiting power transmission from the Boundary Project to 300 MW from 5:00 a.m. to 7:00 p.m. during the period of June 12 through 30, 2006. Barbara explained that the constraint was imposed by BPA to provide for the transmission of energy derived from other sources. Kim Pate (SCL) stated that SCL planned to use the periods when generation is restricted to conduct TDG abatement evaluations of the sluice gates, in this way avoiding the potential for spill when generation is restricted. Barbara Greene stated that BPA plans to impose transmission limits again in 2007 but that SCL would not be informed until fall 2006 when the 2007 limitations would take place.

- *Comment* – Mark Tiley (CCRIFC) expressed concern regarding increased spill in June, noting that this is the period when sturgeon swim-up larvae would be present near the confluence of the Pend Oreille and Columbia rivers. Mark stated that swim-up fry are vulnerable to elevated TDG, which would occur during spill events.

- *Comment* – Tom Shuhda (USFS) questioned whether state and federal fish agencies could petition BPA to change the timing of the transmission limits.
  *Response* – Barbara Greene (SCL) replied that she believed that BPA's decision had been made but that she did not know what influence federal and state fish agencies might have.

- *Comment* – Doug Robison (USFS) questioned the need for spill during transmission limitations, suggesting that SCL could pass flow through the turbines without generating electricity.
  *Response* – Kim Pate (SCL) replied that whether or not to allow the turbines to spin, without generating electricity, is an option that would require internal deliberation at SCL. Kim and Barbara Greene (SCL) stated that SCL would do all it reasonably can to minimize TDG during the June 2006 transmission limitation.

**Closing**

Barbara Greene (SCL) thanked stakeholders for their participation in the meeting and encouraged them to contact Seattle City Light resource leads, or her, if the had questions related to the relicensing process. The meeting adjourned at 4:00 p.m.

**Action Items**

***Boundary Reservoir annual smallmouth bass tournament***

- SCL agreed to prepare a summary of the outcome of the annual Boundary Reservoir smallmouth bass tournament held in May 2006 and post it on SCL's website.

***Reservoir Biotelemetry***

- SCL stated that it would respond at the June 2006 meeting to stakeholder requests to conduct mobile tracking in tributaries to Boundary Reservoir.

***Use of turbine and spillway entrainment mortality estimates***

- Rick Donaldson (USFWS) agreed that the USFWS would attempt to make a decision by the June 2006 Workgroup meeting as to whether SCL could use turbine and spillway entrainment mortality estimates in lieu of conducting site-specific mortality studies at the Boundary Project.

***Reservoir Biotelemetry***

- SCL agreed to consider the implementation of a reward program to increase Floy tag return rates.

***Integrated Resource Analysis***

- SCL stated that a manual describing the function and capabilities of the scenarios tool would be submitted to stakeholders in fall 2006.
- SCL agreed to present examples of output from the scenarios tool at a meeting in 2006.

***Draft Fish and Aquatic study outlines; Aquatic Habitat Model***

- SCL stated that after 2006 bathymetry data are validated and final maps are produced based on these data, SCL would make the maps available to stakeholders by posting them on its website.

**<u>Decisions</u>**

***Reservoir Biotelemetry***

- In response to a stakeholder requests during the April 20, 2006 workgroup meeting, SCL agreed to tag smallmouth bass as part of the 2007/2008 reservoir biotelemetry study.

***Spillway entrainment***

- SCL agreed to conduct spillway entrainment monitoring outside the April-July period, if significant spill occurs outside this period.

***Reservoir biotelemetry***

- SCL agreed that salmonids in good condition, i.e., showing low signs of stress, captured when water temperatures are low, would receive PIT-tags, in addition to radio tags (or acoustic/CART) and Floy tags.

***Draft Fish and Aquatic study outlines, Habitat Suitability Indices (HSI)***

- *Comment* – At the requests of stakeholders, SCL agreed to remove yellow perch from Table 1 of the *Habitat Suitability Information* study plan outline (i.e., Potential data sources for habitat suitability information); SCL agreed that no habitat modeling would be undertaken to address Project effects on yellow perch.

USFWS COMMENTS ON SEATTLE CITY LIGHT'S
DRAFT SPILLWAY ENTRAINMENT STUDY (undated, 041406.doc)

Assumptions; A2: *"Hydroacoustic target signatures can be adequately translated to size and numbers of fish"* Should add the following: ***"however, determination of fish by species, cannot accurately be determined using this methodology."***

Initial SCL response: While the proposed additional text is accurate, expanding the sentence will change the purpose of the assumption. We added A2 as a caveat or warning to alert everyone that the study design assumes that hydroacoustics will work at the Boundary spillways. There is a risk that hydroacoustic may not be an effective technology.

Instead, perhaps modify Task 4 (new text underlined):
T4) Since hydroacoustics cannot accurately determine fish by species, spillway hydroacoustic target signatures will be translated into numbers, size and species of fish using:

Task Activities, T2: *"Continuously monitor Boundary spillway gates #1 and #2 using hydroacoustics for the period April through July during 2007 and 2008."* The duration of monitoring will need to be adjusted depending on when spill occurs. Thus monitoring may occur earlier or later than April or July each year.

Initial SCL response: We agree that monitoring should cover the likely periods of spill, and agree to adjust the duration of monitoring should significant spill occur outside of the April through July period. However, based on an analysis of hourly flow records we believe spill is likely to occur during the April through July period. The powerhouse generating capacity is about 55,000 cfs (varies depending on head and efficiency and 10 percent exceedance flows are less than 40,000 cfs August through March (see following table);

Table ___. Monthly 10 percent exceedance flows in the Pend Oreille River below the Boundary Project, hourly flow record 1987 to 2004 (Source: R2 Resource Consultants, 2006. Compilation of Project Hydrologic Database and Hydrologic Statistics, January 3, 2006.)

| **Month** | **10% Exceedance (cfs)** |
|---|---|
| January | 32,725 |
| February | 33,488 |
| March | 37,792 |
| April | 51,403 |
| May | 72,069 |
| June | 88,668 |
| July | 47,521 |
| August | 26,906 |
| September | 28,778 |
| October | 37,899 |
| November | 37,240 |
| December | 34,705 |

Task Activities, T3: *"The hydroacoutics array will provide estimates of the number and strength of targets passing through a defined field of view which will be extrapolated to the entire spillways and correlated to spill timing, duration, and magnitude."* The methods used to conduct the study, whether using hydroacoustic devices alone, or in conjunction with fyke netting, or some additional method (such as an underwater video system), will need to be adequate to collect sufficient empirical data to ensure an accurate accounting of the target fish species in the spillway. ***OR SOME WORDING SIMILAR TO THIS!!
Initial SCL response: We suggest the following text instead….

The methods used to conduct the study, whether using hydroacoustic devices alone, or in conjunction with fyke netting, or some additional method (such as an underwater video system), will need to identify the level of accuracy associated with any estimate of spillway entrainment.

Task Activities, T4, fourth bullet: *"if spillway target signatures cannot be translated to fish size and numbers using these available data. . ."* Need to modify this phrase as shown as follows in bold font: *"if spillway target signatures cannot be translated to fish size,* ***~~and~~*** *numbers,* ***and species****, using these available data. . . ."*
Initial SCL response: Agreed.

Task Activities, T4, fourth bullet: *"other opportunities to translate hydroacoustic targets to numbers and size of fish will be considered including, but not limited to and underwater video system installed to record the passage of fish during periods of spillway use, or a screw trap or scoop trap. . . ."* We agree that some other devices may be required to provide a more accurate portrayal of fish numbers, size, and species in the spillway.
Initial SCL response: Comment noted.

USFWS COMMENTS ON SEATTLE CITY LIGHT'S
DRAFT TURBINE ENTRAINMENT STUDY (dated April 20, 2006)

General Comment: Does SCL intend to conduct any studies that would pass fish (surrogate or target fish species) through the turbines to determine the extent of mechanical injury and mortality in the existing turbines under existing operational scenarios? SCL may need to compare the results of injury and/or mortality conducted under existing operations with alternative operational scenarios to determine possible means to reduce mechanical injury or mortality to target fish species passing through the generating turbines. At some point this could include modification of the existing turbines or their operation to reduce mechanical injury or mortality to target fish species.
Initial SCL response: At this point, SCL does not intend to conduct site-specific studies of turbine and spillway mortality. The AHTSP model will allow us to identify changes in estimated turbine mortality under alternate operational scenarios. SCL recognizes that fish mortality occurs and will work with stakeholders through the relicensing process to identify appropriate protection, mitigation and enhancement measures.

Assumptions, A2: *"Fyke net sampling with the Boundary intake tunnels or draft tubes can be used to validate and translate hydroacoustic targets into the number and size of fish."* Suggest modifying this sentence to read as follows: *"Fyke net sampling with the Boundary intake tunnels or draft tubes can be used to validate and translate hydroacoustic targets into the number,* ***~~and~~*** *size,* ***and species*** *of fish."*
Initial SCL response: Agreed.

Assumptions, A5: *"All fish captured within the fyke nets will suffer injury or mortality; however, federal and state collecting permits can be obtained to allow sampling."* Need to modify this sentence as shown as follows in bold font: *"All fish captured within the fyke nets will suffer injury or mortality;* ***therefore, ~~however~~*** *federal and state collecting permits* ***will need to ~~can~~*** *be obtained to allow sampling."*

Initial SCL response: While we agree that collecting permits will need to be obtained, the text of the original assumption is a caveat or warning that the design of the study would require major changes if SCL and their contractors can not get a collecting permit. For instance, if the fyke nets result in bull trout mortalities that exceed the allowable "take" identified in the permit - we may have to modify the sampling procedures in subsequent years.

USFWS COMMENTS ON SEATTLE CITY LIGHT'S
DRAFT BOUNDARY RESERVOIR ~~FISH DISTRIBUTION STUDY~~ NATIVE SALMONID BIOTELEMETRY
(undated, 041406.doc)

Assumptions; ~~A2~~ A3: "*Acoustic transmitters will be used because forebay water depths are too deep to effectively use radio tags*." The use of Lotek CART tags should be further considered for at least some of the large adult bull trout (maybe 5 fish). This would also provide a real test to see which tag type may be most effective in the Boundary reach.
Initial SCL response: CART tags require fairly large fish - and the results of the 2006 gill-netting surveys will give us an early indication of the likelihood of capturing large fish of the target species.

Assumptions; A5: "*A range of transmitter sizes and longevities (5 to 10 sec pulse interval) will be used depending upon fish size*:" Because bull trout and westslope cutthroat trout are limited here and may be difficult to capture, we feel at least initially, that longer lasting tags (ie. up to 400 days) should be used over the depth/temperature tags (up to 100 days). We understand that depth/temperature data can be valuable, but we believe that location data that may give insight into cold water refugia locations, tributary use, possible spawning streams, migration timing etc. is most valuable and longer lasting tags are necessary.
Initial SCL response: Details on tag size and tag longevity will be worked out early in 2007 when the results of the 2006 gill-netting and biotelemetry efforts are available.

Task Activities, T3: "*Tag up to 30 bull trout, 30 mountain whitefish, and 30 westslope cutthroat trout with acoustic transmitters attached intraperitoneally using surgical techniques. A numbered Floy tag will also be implanted into each fish*." These fish should also be PIT tagged as Floy tags can be more easily lost.
Initial SCL response: The intent of the Floy-tag was to allow recreational anglers to identify a fish that has an acoustic transmitter - and hopefully encourage release of the fish. Fish that have been implanted with an acoustic tag could be Floy and also PIT-tagged.

Task Activities, T5: "*Use mobile tracking to locate the positions of tagged fish once per month (as weather conditions allow during winter months) between Boundary Dam and Box Canyon Dam. Utilize GPS to the extent adequate signals are available or pinpoint locations on aerial photographs. Collect habitat information at the location of tagged fish including water depth, velocity, temperature, substrate type, macrophyte density and cover*." We believe that at least seasonally (maybe April-June and August-October) when bull trout are known to make migration movements, tracking should be done more frequently (every 10 days at a minimum). This may better help identify cold water refugia, potential spawning tributaries, foraging areas etc.
Initial SCL response: Thank you for your comments, we will address the issue of sampling frequency after we have the results of the 2006 field efforts and understand the scope of the other biological sampling efforts.

The original proposal called for 10 surveys (10 months at 1 survey/month). The USFWS is requesting 22 surveys (4 months at 1 survey/month plus 6 months at 3 surveys/month).

Task Activities, T9: "*Utilize manual tracking techniques throughout a tracking day (sunrise to sunset) to obtain frequent (every 2 hours or less) positions to discern daily movements. Ideally, the tracking team would obtain information over an entire day on all of the tagged fish in a single tributary delta area, such as Slate Creek (or two adjacent coldwater tributary deltas). Target the level of effort to 3 days for 3 fish (or more) of each species during each study year*." Because bull trout are known to be sedentary during day light hours, with foraging, migration etc. primarily occurring during the night, tracking from sunrise to sunset (a tracking day) may limit and bias your data. Also, during summer months when water temperatures rise to levels that force bull trout into cold water sites - water temperatures cool somewhat at night and bull trout are best able to make movements at this time. Geist et al. 2004 tracked numerous bull trout below Albeni Falls Dam in 2003 with this type of behavior, moving from coldwater refugia up to the dam.

Initial SCL response:  Tracking should occur on a 24-hour basis.  The intent of the daytime tracking was to assess whether pool level fluctuations associated with Project operations are affecting bull trout if they are holding in coolwater refugia.

USFWS COMMENTS ON SEATTLE CITY LIGHT'S
EARLY INFORMATION DEVELOPMENT:
FISH CONNECTIVITY AT THE BOUNDARY HYDROELECTRIC PROJECT (dated April 2006)

General Comment: Based on FWS guidance, peer review, and our draft recovery plans, we no longer use the original subpopulation terminology that was used at the time of listing for bull trout, but use the core area, core population, and local population structure for describing a bull trout unit. You identify this on page 2-3, however use the subpopulation language prior to this in the document. We recommend using the core area and local population structure versus the subpopulation.
Initial SCL response: The USFWS comments refer to details of the bull trout life history description; the text can be modified when the draft EID is revised.

General Comment: There are numerous documents (DuPont and Horner 2002, 2003; and Geist et al 2004) that report on bull trout telemetry studies conducted in the Pend Oreille River (both above and below Albeni Falls Dam) and in the lower Priest/East River systems. Information from these documents would greatly enhance this document when describing life history, migration timing, recent observations etc. for bull trout. This information may be more applicable than using information from other systems (Salmo) that likely have a different life history strategy.

Page 2-10, 1st paragraph: "*There have been seven documented observations of bull trout within Box Canyon Reservoir since 1988*." This is incorrect! Geist et al 2004 and Scholz et al 2005 identify at least nine bull trout captured and implanted with transmitters in 2003 and 2004 below Albeni Falls Dam, Geist et al 2004, also capture numerous other bull trout but did not implant with transmitters. So there was at least 12-13 alone captured in 2003/2004.

Page 2-11, 4th paragraph: "*Since that time bull trout harvest has declined to a low of 621 fish in 1985, and capture of bull trout became illegal in 1996 (Scholz et al. 2005)*." I believe this statement to be inaccurate – it became illegal to "harvest" bull trout in 1996 as they can still be captured legally if it is incidental to fishing for other species.

Page 2-11, 4th paragraph: "*Lake Pend Oreille and the Pend Oreille River were the historical foraging grounds for juvenile and adult bull trout, but currently utilization is restricted primarily to Lake Pend Oreille (Scholz et al. 2005)*." Again I don't think this statement is accurate. These areas were also utilized as migratory corridors and for overwintering. Furthermore, utilization is not restricted to Lake Pend Oreille. Last year alone, 52 bull trout redds were documented in the East River watershed, this would equate to roughly 150 adult bull trout migrating through the Pend Oreille River in the spring and a smaller number (post spawning mortality) in the fall. This does not take into account the unknown hundreds or more juveniles that outmigrate during the year to Lake Pend Oreille, and subadults that may use seasonally for forage etc. Geist et al 2004 also document that two of the six bull trout that they tracked, spent the entire winter in the Pend Oreille River.

Page 2-13, last paragraph: "*Individual bull trout have been periodically observed within the Pend Oreille River or tributaries downstream of Albeni Falls, but the source of these individuals is unknown. Historically, the Priest River and perhaps other tributaries to Lake Pend Oreille were considered the most likely source of bull trout in the mainstem Pend Oreille River downstream of Albeni Falls because bull trout numbers declined rapidly after construction of Albeni Falls Dam in 1952 (Scholz et al. 2005)*." Again, more than just "individual bull trout" were observed by Geist et al 2004 (in 2003) and based on genetic samples taken (as discussed with Joe Maroney), some of these fish closely align with East River fish while the rest are awaiting assignment based on further analyses. Furthermore, while the Priest River and Lake Pend Oreille may have been sources of some bull trout in the Pend Oreille River below Albeni Falls Dam, we feel that the most likely source of bull trout were the tributaries (below Albeni Falls Dam) of the Pend Oreille River themselves and that these fish had the same life history strategy as those in the East River and the construction of Albeni Falls Dam and Box Canyon Dam eliminated this migratory form.

Page 3-1, 2nd paragraph: "*The USFWS have listed bull trout as threatened under Endangered Species Act. Five Distinct Population Segments (DPS) of bull trout (Klamath River, Columbia River, Jarbidge*

*River, Coastal-Puget Sound, and St. Mary-Belly River) were listed as threatened under the ESA by the USFWS on October 28, 1999.*" While kind of accurate, here is what we use:

"On June 10, 1998, the Service published a final rule listing the Columbia River and Klamath River Distinct Population Segments (DPSs) of bull trout as threatened (63 FR 31647) under authority of the Endangered Species Act (Act) of 1973, as amended. With the listing of the Jarbidge River population (64 FR 17110) and the Coastal-Puget Sound and St. Mary-Belly River populations (64 FR 58910) on November 1, 1999, all bull trout in the coterminous United States received protection under the Act."

Therefore, the final listing rule for the bull trout population in the coterminous United States consolidates the five DPSs into one listed taxon (64 FR 58930). However, although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed.

Page 3-1, 3rd paragraph: "*Within the Columbia River distinct population segment bull trout exhibit resident*, fluvial, *and adfluvial life history strategies*". Fluvial bull trout are known to occur throughout the Columbia basin as well and should be added to this sentence.

Page 3-2, 3rd paragraph: *"As described previously, bull trout have been rarely observed in Boundary Reservoir or its tributaries and the few fish observed have been adult-sized fish."* In 2000, WDFW (McLellan) observed a 12" bull trout in Sweet Creek and in 1997 SCL (R2) caught an 8" fish in the reservoir. In general, these fish are not of adult size and we would consider them juvenile or subadult fish.

Page 3-9, 1st paragraph: "*Scholz et al. (2005) suggested that bull trout spawning migrations could begin as early as May or June to take advantage of higher flows when entering small spawning tributaries that may have intermittent flow at their mouths later in the year.*" This migration timing is well documented within Pend Oreille Lake, the Priest/East River, and throughout the bull trout range, so it is more than just "suggest and could".

Page 3-9, 1st paragraph: "*Garrett and Bennet (1995) observed that half the fish they tracked returned to Box Canyon Reservoir to overwinter following spawning in October, while the other half overwintered in their spawning tributary*." I believe that these were brown trout in the Garrett and Bennett study – the way the paragraph reads would lead the reader to thin these were bull trout – please verify.

USFS RESPONSE TO FISH CONNECTIVITY EID AND TURBINE AND SPILLWAY MORTALITY ESTIMATES

>>> Thomas H Shuhda <tshuhda@fs.fed.us> 05/08 10:40 AM >>>

I am satisfied with the recognition by SCL of the range of mortality of fish associated with the operation of their turbines in the EID for Fish Connectivity. I am also satisfied with the document, after review, used as a reference. I agree that SCL does not need to conduct a study to determine if there is mortality occurring due to turbine operations at Boundary Dam. If you wish a more formal response than this, please let me know.

Can you let me know where I can review R2's Annotated bibliography of literature regarding mechanical injury with emphasis on effects from spillways and stilling basins? I would like to review this reference.

Thanks

Tom Shuhda
Forest Fish Biologist
Colville National Forest
509 684-7211

From: Rick Donaldson 07/21/2006 03:00 PM

To: Al Solonsky, Barbara Greene
cc: Scott Deed, Dan Trochta, Rich Torquemada

Subject: FWS response on possible Turbine Mortality Study

Hi Al - -

Based on our review of the April 2006 version of Seattle City Light's draft EID document, and the outlines of the following proposed studies discussed in the fish work group meetings, including: Turbine Entrainment (4-20-06); Spillway Entrainment (undated); Fish Distribution, Timing, Abundance and Species Interactions in the Boundary Reservoir (6-27-06); and Fish Distribution in the Boundary Tailrace (undated) - - - and consideration of information that you and Phil Hilgert presented to both Rich Torquemada and I on June 23, 2006, we agree with your position that there is no need to proceed with a turbine injury/mortality study at this time. We are optimistic that the data obtained from the proposed studies, if successful, should provide us with information we are all seeking regarding potential (or need for) mitigation measures for aquatic species associated with Boundary Dam. We look forward to working with you designing and/or finalizing the proposed aquatic studies during the coming weeks.

Thanks for the special briefing last month!

Rick


Rick Donaldson
Manager, Habitat Conservation Branch
Upper Columbia Fish & Wildlife Office
U.S. Fish & Wildlife Service - Spokane
Phone: 509-893-8009
FAX : 509-891-6748
email: : rick_donaldson@fws.gov

# *Meeting Record Excerpts*
# *Related to Turbine and Spillway Entrainment Studies*

**Boundary Hydroelectric Project (FERC No. 2144)**
**Fish & Aquatics Workgroup Meeting**
**August 14, 2006**
**Quality Inn Oakwood**
**7919 North Division Street**
**Spokane, Washington**

**FINAL MEETING SUMMARY**

**In attendance**

Stuart Beck, R2 Resource Consultants (R2)
Gary Birch, BC Hydro
Jason Conner, Kalispel Tribe (Kalispel)
Bill Duncan, Teck Cominco
Randall Filbert, Long View Associates, (LVA)
Alec Fiskin, City of Seattle, Mayor's Office
Barbara Greene, Seattle City Light (SCL)
Phil Hilgert, R2 Resource Consultants (R2)
Michele Lynn, SCL
Joe Maroney, Kalispel
Steve Padula, LVA
Kim Pate, SCL
Christine Pratt, SCL
Doug Robison, Washington Department of Fish and Wildlife (WDFW)
Tom Shuhda, USDA Forest Service (USFS)
Al Solonsky, SCL

**Introduction/review agenda/meeting goals**

Barbara Greene (SCL) reviewed the following proposed meeting agenda:

- Review outstanding action items
    - Status of 2006 early action efforts
    - Stakeholder response to turbine and spillway fish mortality proposal
- Stakeholder response to June 27, 2006 workgroup meeting summary
- Review *Stakeholder Involvement Plan*
- Draft Fish and Aquatics study outlines
    - Mainstem sediment transport
    - Tributary habitats
    - Aquatic habitat modeling
    - Aquatic productivity
        - Periphyton productivity modeling
- Administrative items and closing remarks

# *Meeting Record Excerpts Related to Turbine and Spillway Entrainment Studies*

***Stakeholder response to turbine and spillway fish mortality estimates***

Al Solonsky (SCL) stated that the USFWS and the USFS had submitted correspondence accepting SCL's estimates of turbine mortality (see Fish Connectivity EID) for use in the relicensing process, in lieu of conducting site-specific studies designed to measure turbine mortality. Al stated that the USFWS had also accepted spillway mortality estimates in place of empirically derived results.

- *Comment* – Al Solonsky (SCL) asked Tom Shuhda (USFS) whether the USFS also accepted the estimates of spillway mortality developed by SCL for use in the relicensing, in lieu of site-specific, empirically derived results.
- *Response* – Tom Shuhda (USFS) replied that the USFS was willing to accept the use of the spillway mortality estimates.

- *Comment* – Al Solonsky (SCL) asked whether other stakeholders were also willing to accept the use of estimated turbine and spillway fish mortality rates.
- *Response* – Stakeholders agreed that SCL's estimates of turbine and spillway fish mortality rates could be used during the relicensing in place of empirically derived results.

**<u>Decisions</u>**

***Turbine and spillway mortality estimates***

- The USFWS, USFS, and other stakeholders agreed that SCL could use turbine and spillway estimates, developed as part of the fish connectivity EID, during the relicensing in lieu of site-specific, empirically derived mortality results.

# *Meeting Record Excerpts*
# *Related to Turbine and Spillway Entrainment Studies*

**Seattle City Light** *FINAL*
**Boundary Project Relicensing**
**September 8, 2006 USFS Conference Call**
**9:00 AM – 10:45 AM**

**Participants**
Glen Koehn (U.S. Forest Service) only first 15 minutes of conference call
Tom Shuhda (U.S. Forest Service)
Barbara Greene (Seattle City Light)
Al Solonsky (Seattle City Light)
Steve Padula (Long View Associates)
Phil Hilgert (R2 Resource Consultants)

**Introduction**
The purpose of the conference call was to discuss five of the U.S. Forest Service (USFS) Study Requests recently filed with FERC that pertain to fisheries topics. Al Solonsky (SCL) had arranged the conference call with Tom Shuhda (USFS) earlier in the week to discuss the five fisheries related USFS Study Requests and identify if there were any substantive differences with the study outlines that SCL developed in collaboration with stakeholders at Fisheries and Aquatics (F&A) workgroup meetings in April, May, June and August of 2006.

**The Conference Call was initiated by SCL at 9:00 AM**
Al Solonsky (SCL) began the conference call by asking Tom Shuhda (USFS) and Glenn Koehn (USFS) if they agreed with SCL writing up a summary of the conference call and sending it to the USFS for review. Al Solonsky (SCL) said that after there was agreement on the wording of the conference call summary, SCL would file the summary with FERC as part of the consultation record that will be incorporated into the PSP. Al Solonsky (SCL) said that the summary would help FERC compare SCL's PSP to be filed in October with the recently filed USFS Study Requests. Al Solonsky (SCL) mentioned that SCL also planned to include a description of what occurred in the conference call in the consultation section of each relevant study in the PSP. Barbara Greene (SCL) reinforced the objective of helping FERC understand where differences and similarities were between USFS study requests and SCL study proposals. Glenn Koehn (USFS) and Tom Shuhda (USFS) both agreed to review a draft summary of the conference call.

Al Solonsky (SCL) said that he thought there were few substantive differences between the USFS Study Requests that were filed with FERC and the study outlines that SCL had developed with stakeholders at F&A workgroup meetings. Tom Shuhda (USFS) agreed. Al Solonsky (SCL) further explained that in reviewing the USFS Study Requests, it was difficult to verify where the studies were actually identical and areas where the USFS was recommending a different approach or methodology. Al Solonsky (SCL) said that he wanted to step through each USFS Study Request where SCL had a question and see if there were truly differences and if so, see if agreement could be reached.

Glenn Koehn (USFS) said that the USFS felt the need to file study requests to ensure their perspectives on the studies were a part of the FERC record, and because the study outlines that

# *Meeting Record Excerpts*
# *Related to Turbine and Spillway Entrainment Studies*

SCL developed with stakeholders at workgroup meetings were not yet in the official FERC record. Glenn Koehn (USFS) further stated that the USFS would provide its formal comments on the studies included in the PSP once it was filed with FERC. Barbara Greene (SCL) said that it had been difficult to identify which SCL study outlines, or parts of SCL study outlines the USFS agreed with because the USFS did not reference any SCL workgroup efforts. Barbara Greene (SCL) added that the USFWS recently filed study requests with FERC and simply listed the SCL study outlines that had been developed in workgroups and identified that the USFWS agreed with them. Steve Padula (LVA) added that the USFS did not reference in their cover letter to FERC any consultation with SCL that had occurred over the past six months, so it was difficult to know how the USFS officially viewed F&A workgroup products.

Glenn Koehn (USFS) and Tom Shuhda (USFS) both stated that the USFS was in general agreement with all of the proposed SCL studies. USFS agreed that once the PSP is on the record, they would meet to discuss any remaining differences. Tom Shuhda (USFS) said that there were very few places where the USFS wanted any changes to study designs or study components.

Al Solonsky (SCL) proposed to begin the discussion with the genetics/fish transportation question, since that was one item that was briefly discussed when the conference call was arranged.

---

**2. Entrainment (USFS Study Title: Fish Entrainment Study Request)**

Al Solonsky (SCL) asked Tom if the USFS was in agreement with SCL's entrainment study outline presented earlier this summer and posted on the SCL relicensing website. Tom Shuhda (USFS) said that the USFS was in agreement with the study outline and discussions that had occurred during SCL's summer F&A workgroup meetings. Al Solonsky (SCL) asked if Tom Shuhda (USFS) concurred that SCL did not need to perform a spillway or turbine mortality or injury study. Tom Shuhda (USFS) said that the USFS is willing to accept SCL's mortality and injury estimates and that nothing in the USFS fish entrainment study request was in conflict with the agreement that had been reached in workgroup meetings.

---