Lake Merwin and Swift Creek Reservoir Tributary Streams Bull Trout Limiting Factors Analysis

Final Report

Prepared for

PACIFICORP ENERGY
A DIVISION OF PACIFICORP

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1.0 INTRODUCTION

As a component of the Lewis River Hydroelectric Project's Settlement Agreement (PacifiCorp 2004), PacifiCorp agreed to conduct a limiting factors analysis (LFA) for bull trout (*Salvelinus confluentus*) occurring in the tributaries to Lake Merwin and Swift Creek Reservoir and to finalize this evaluation in consultation with the Aquatics Coordination Committee (ACC). Specifically, Section 5.5 of the Settlement Agreement states:

> *By the second anniversary of the Effective Date, PacifiCorp shall provide a limiting factors analysis for bull trout occurring in Lake Merwin tributary streams and Swift Creek Reservoir tributary streams and finalize this evaluation in Consultation with the ACC. If the Licensees, in Consultation with the ACC and with the approval of USFWS, determines that one or more locations have the potential to provide long-term, sustainable habitat for critical life stages of bull trout, the ACC may implement enhancement measures through the use of the Aquatics Fund as described in Section 7.5 below [of the Settlement Agreement].*

According to the *Bull Trout LFA Scope of Work* issued by PacifiCorp in January 2006, the LFA should seek to answer (at a minimum) the following key questions:

1) Other than known bull trout streams associated with Merwin and Swift Creek reservoirs, do other streams exist at either project that can potentially provide long-term spawning, incubation, and rearing habitat?
2) Are the habitat conditions in each potential tributary suitable for any one of the critical life stages of bull trout?
3) Do bull trout reside in these other streams?
4) Of the potential streams that do exist, what are the limiting factors that can be attributable to the absence of bull trout?
5) Are there any physical changes that can be made to potential streams lacking bull trout to provide for colonization by existing bull trout stocks?

To address these questions, Meridian Environmental, Inc. (Meridian) prepared a draft study plan in consultation with PacifiCorp, the U.S. Fish and Wildlife Service (USFWS), and the Washington Department of Fish and Wildlife (WDFW). The Revised Study Plan (incorporating agency comments, dated September 19, 2006) and responses to agency comments on the first draft study plan (dated April 21, 2006) are provided in Appendix A and Appendix B, respectively.

1.1 EXISTING LEWIS RIVER BULL TROUT INFORMATION

This section briefly summarizes existing information describing bull trout populations in the Lewis River basin to provide a context for this study. Unless otherwise cited, this summary is derived primarily from USFWS (2006, pages 68 to 71).

Bull trout (*Salvelinus confluentus*) within the coterminous United States were listed as threatened pursuant to the Endangered Species Act (ESA) of 1973 as amended on November 1, 1999 (64 FR 58910). Local populations of bull trout in the Lewis River basin (collectively grouped together) are designated as one of the 97 core areas that form the Columbia River Interim Bull Trout Recovery Unit.

Currently, reproducing populations of bull trout within the Lewis River Core Area (Figure 1) are known to spawn in the Pine Creek and Rush Creek drainages, both of which flow into the upper North Fork Lewis River upstream of Swift Creek Reservoir, and in Cougar Creek which flows into Yale Lake. A genetic study performed by Neraas and Spruell (2004, pages 7 to 8) showed that the spawning population of bull trout in Pine Creek is genetically distinct from the population in Rush Creek, and that the population in Cougar Creek is genetically indistinguishable from the Pine and Rush Creek populations. These data suggest that the Cougar Creek population is composed largely of bull trout that have moved downstream from Swift Creek Reservoir into Yale Lake.

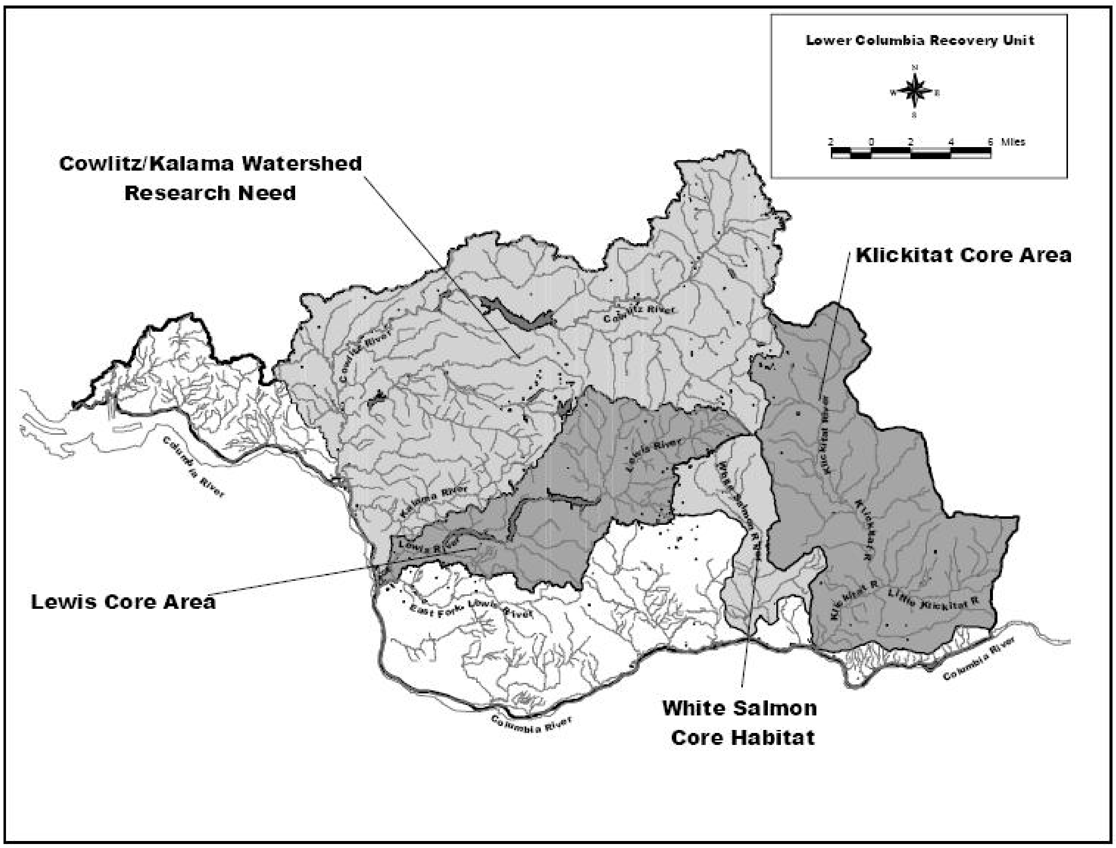


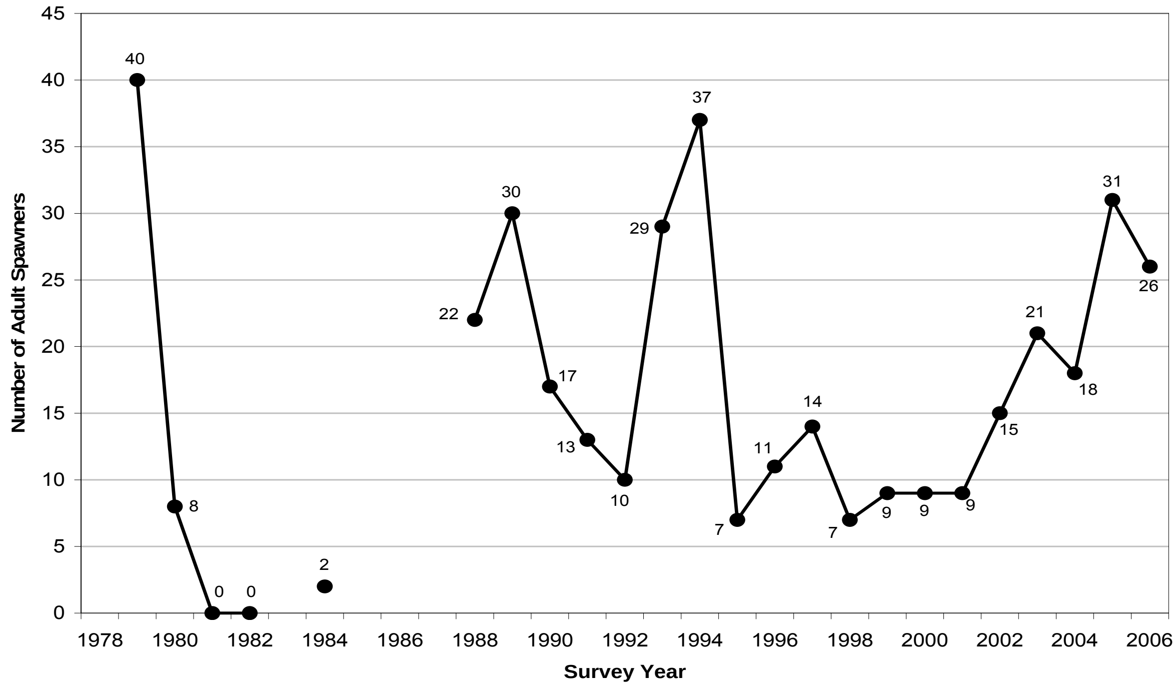
Figure 1. Lower Columbia River bull trout recovery unit.

Cougar Creek is the only known bull trout spawning and rearing tributary to Yale Lake. A habitat limiting factors study conducted during project relicensing further suggested that other tributaries to Yale Lake would not support successful bull trout egg incubation under several habitat management scenarios, primarily because high water temperatures during egg incubation would limit egg survival (Pratt 2003, page AQU 19-i). Although bull trout are routinely observed seasonally in the Yale Dam tailrace (the upstream end of Lake Merwin), they have not been observed spawning or rearing in Lake Merwin tributaries. It is thought that the bull trout residing in Lake Merwin originated from Yale Lake and moved downstream past Yale Dam through the turbines or over the spillway. Similar to the Cougar Creek genetic assessment, bull trout sampled from Lake Merwin were indistinguishable from Pine and Rush creek fish (Neraas and Spruell 2004, page 8).

Bull trout exhibit resident and migratory life-history patterns through much of their current range. Resident bull trout complete their entire life cycle in the tributary streams in which they spawn and rear. Migratory bull trout spawn in tributary streams where juveniles rear for several years before migrating to one of 3 habitats: (1) lakes or reservoirs (adfluvial); (2) rivers (fluvial); or (3) in certain coastal areas, to saltwater (anadromous). Bull trout in the Lewis River basin appear to exhibit an adfluvial life history pattern. Spawning occurs in headwater tributaries in the fall. Juveniles typically rear in these tributaries for 1 to 3 years and then migrate into the Project reservoirs in the spring. Some young-of-the-year bull trout have been documented migrating out of Rush Creek (J. Byrne, WDFW, ScCS PowerPoint presentation 2006, unpublished data). These fish then remain in the reservoirs until about age 4 or 5 when they become sexually mature and move back into the tributaries to spawn. After spawning, adults return to the reservoirs to over-winter.

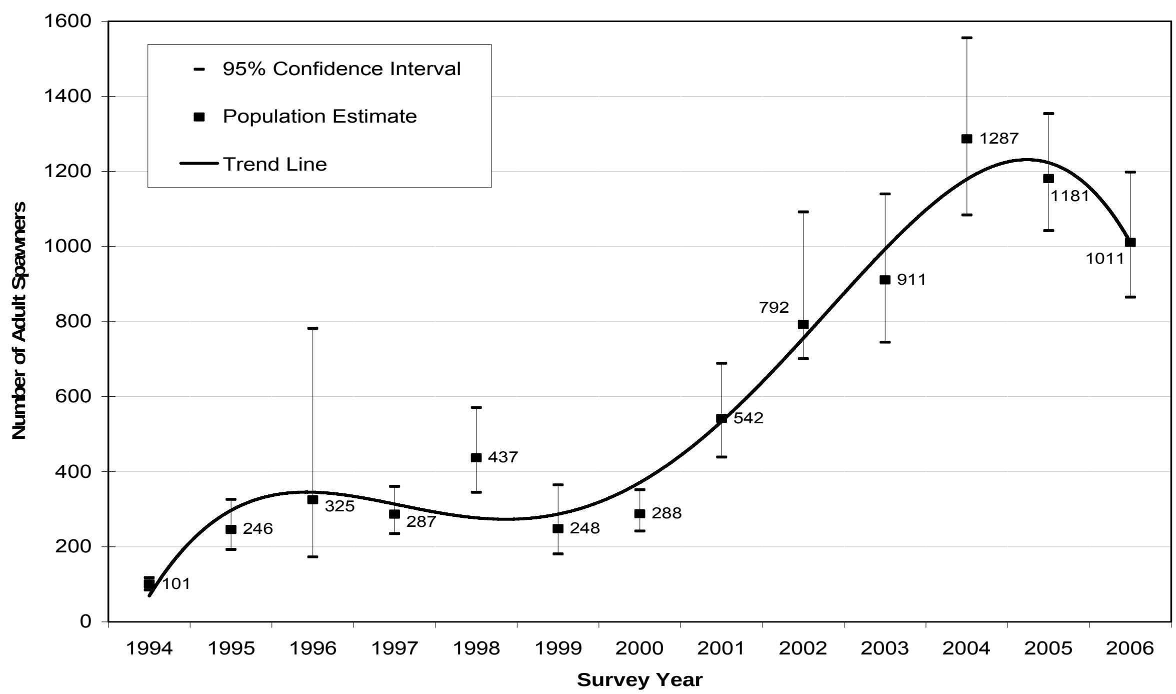
Spawning adfluvial bull trout in Yale Lake migrate into Cougar Creek from the middle of August through early September and spawn from late September through early October (USFWS 2002, page 12). Bull trout residing in Swift Creek Reservoir migrate into tributary streams from late May through early-August, and are believed to spawn from early August through the middle of September (USFWS 2002, page 11). Throughout their range, bull trout fry usually emerge from the gravel from mid-January to late February. Emigration of juveniles from the tributaries to Swift Creek Reservoir and Yale Lake is believed to occur primarily from mid-May through June (USFWS 2002, page 11).

Annual one-day peak counts of adult bull trout in Cougar Creek have ranged from 0 to 40 individuals based on spawning surveys conducted from 1979 to 2006 (Figure 2). An adult population estimate has not been made for Cougar Creek to date. The adult spawning population in Swift Creek Reservoir (Pine and Rush creek local populations combined) is currently estimated to be greater than about 850 fish, and adult abundance generally has been increasing over the past decade (Figure 3). As there are no upstream passage facilities between the three reservoirs and there is thought to be no spawning habitat in tributaries of Lake Merwin, PacifiCorp, in cooperation with the WDFW, annually net and transport bull trout from the Yale tailrace (Lake Merwin) to the mouth of Cougar Creek (the only Yale Lake spawning tributary). As of the end of 2006, 102 bull trout have been captured in the Yale tailrace since the program began in 1995; yearly captures ranged from 0 to 19 fish (Lesko and Doyle 2007, page 8).



Source: Lesko and Doyle 2007, page 11.

Figure 2. Annual peak counts of bull trout spawners observed in Cougar Creek from 1979 to 2006.



Source: Lesko and Doyle 2007, page 4.

Figure 3. Estimated bull trout spawning population in Swift Creek Reservoir from 1994 to 2006.

1.2 STUDY OBJECTIVE

Although local populations of bull trout in the Lewis River basin upstream of Swift Creek Reservoir have been generally increasing over the last 13 years, their long-term persistence depends almost entirely on habitat conditions in two relatively small spawning streams: Rush Creek and Pine Creek. The accessible reach of Rush Creek is fairly short (approximately 1.7 miles in length), making it particularly susceptible to stochastic events such as landslides or from deterministic events such as climate change and attendant potential effects on stream flow and water temperature. Pine Creek, Muddy River, and the upper mainstem Lewis River, while much longer than Rush Creek, are vulnerable to massive debris flows from Mt. St. Helens, or debris flows of unstable sediments (exposed during the 1980 eruption) during periodic flood events (USFWS 2006, page 71). According to the Bull Trout Draft Recovery Plan (USFWS 2002, page vii), establishing additional local populations in the Lewis River Core Area is essential for recovery in order to spread the risk of population decline or local population extirpation due to deterministic or stochastic events. Identification of other potential tributaries which could support local populations is considered a Priority 1 Action (i.e. highest priority level) under the Draft Recovery Plan.

The Draft Recovery Plan (USFWS 2002, page vii) specifically recommends a limiting factors study of lower Speelyai Creek and three stream reaches accessible from Yale Lake (Rain Creek, Ole Creek, and the Lewis River bypass reach). In response to this recommendation, PacifiCorp conducted an *Evaluation of Three Proposed Management Scenarios to Enhance Three Potential Bull Trout Nursery Habitats, Accessible to Lake Merwin and Yale Lake, Lewis River* (Pratt 2003). This evaluation found that none of the three management intervention proposals would result in bull trout production in the study streams, primarily because high water temperatures during egg incubation would limit egg survival (Pratt 2003 published in PacifiCorp and Cowlitz PUD 2004, page AQU 19-i). The Draft Recovery Plan further recommends a limiting factors analysis for “other potential sites within the Lewis Core Area which have, or could support suitable habitat conditions if restored” (USFWS 2002, page vii). According to the Draft Recovery Plan, key information gaps that need to be addressed in the Lower Columbia Recovery Unit include: (1) specific information on the suitability of potential spawning and rearing areas in each basin, (2) increased inventory in each basin to establish the current distribution, and (3) a complete limiting factors analysis to identify site specific actions needed to recover bull trout within each system (USFWS 2002, page v).

The objective of this study is to answer each of the key questions presented in the *Bull Trout LFA Scope of Work* issued by PacifiCorp in January, 2006 (see Section 1.0) and to address the key information gaps described in the Draft Recovery Plan for those tributaries entering Swift Creek Reservoir and Lake Merwin that have the potential to provide at least some accessible habitat. Specifically, this study addresses four fundamental questions:

1. Do the tributaries to Swift Creek Reservoir and Lake Merwin contain suitable bull trout spawning, incubation, and rearing habitat?
2. Do bull trout currently inhabit these tributaries?

3. If these tributaries do not contain suitable spawning, incubation, and rearing habitat, what are the limiting factors?
4. Could these limiting factors be adequately addressed through habitat restoration actions so that the habitat could support long-term bull trout spawning, incubation, and rearing?

Studying those tributaries not known to contain bull trout will help determine if new local populations are becoming established in Swift Creek Reservoir and Lake Merwin tributaries or if existing tributary habitats have the potential to allow bull trout colonization through habitat restoration. Lake Merwin bull trout are not considered a local population under the Draft Recovery Plan, and spawning areas are not known to exist in Lake Merwin tributaries (USFWS 2002, page 18). Because no study was conducted to support this conclusion, this investigation will address this information gap.

1.3 STUDY AREA

The study area for this investigation includes the accessible reaches of 16 tributaries to Lake Merwin and Swift Creek Reservoir that were identified in the *Assessment of Potential Anadromous Fish Habitat Upstream of Merwin Dam* (PacifiCorp and Cowlitz PUD 2004, page AQU 4-9 to AQU 4-11) as having habitat that could be accessible to anadromous salmonids, but that were not known to contain bull trout (Figure 4). These "candidate" tributaries include Marble, Rock, Canyon, Cape Horn, Indian, Jim, M4, Brooks, M14 and Buncombe Hollow creeks (tributaries to Lake Merwin); and Diamond, Swift, Range, Drift, S10, and S15 Creeks (tributaries of Swift Creek Reservoir). The alpha-numeric stream designations for streams not named on USGS 7.5 minute series topographic maps are the same designations used in the relicensing studies (PacifiCorp and Cowlitz PUD 2004, page AQU 4-9 to AQU 4-11). This study does not include the upper North Fork Lewis River and tributaries that are known to be used by bull trout, as these areas are currently being assessed by other long-term monitoring studies.

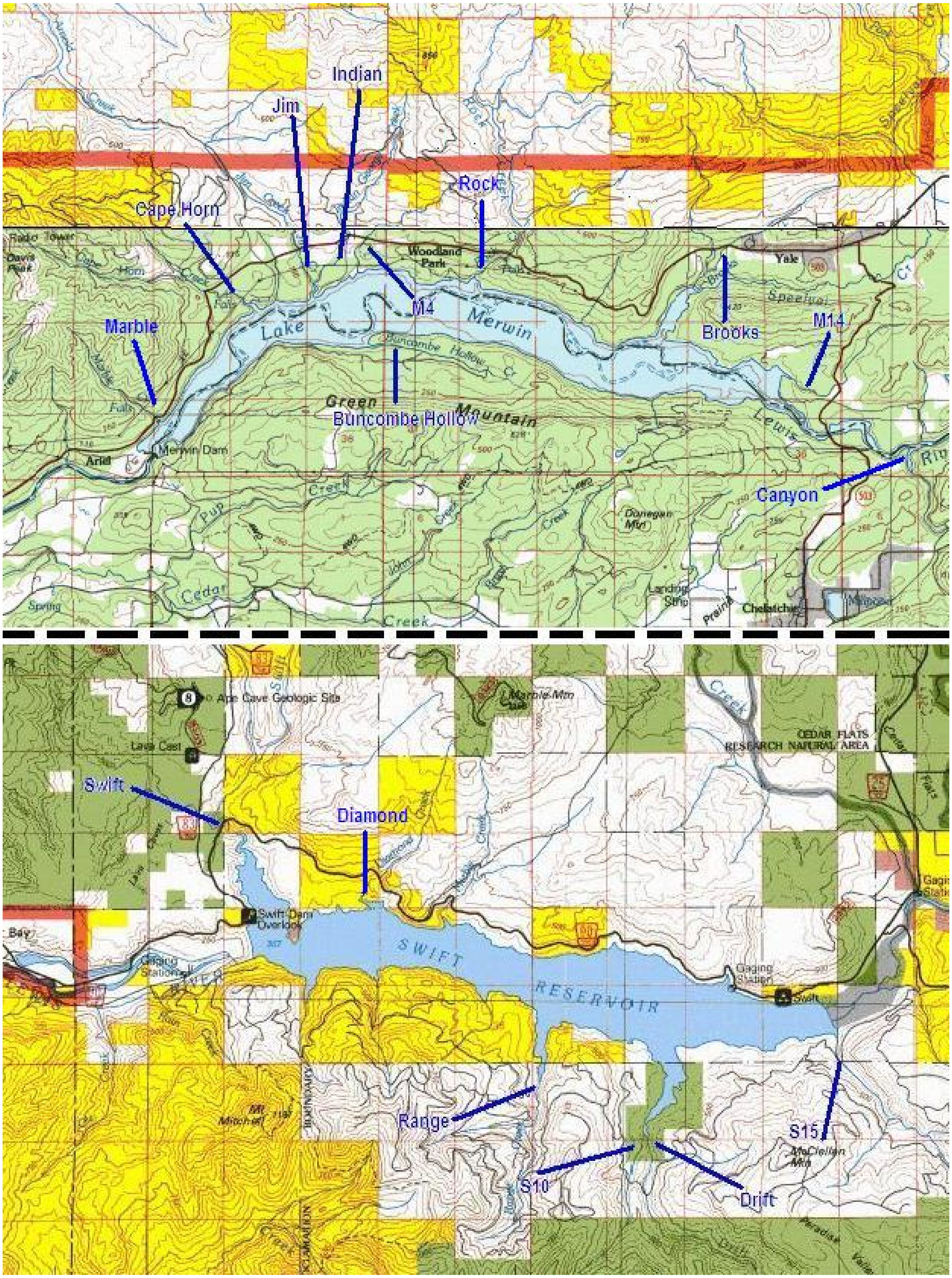


Figure 4. Lake Merwin and Swift Creek Reservoir tributary stream locations.

2.0 METHODS

The overall study approach was to review existing habitat information, collect additional field data to fill habitat information gaps, and to use this data to perform a qualitative habitat assessment to identify limiting factors in streams with the greatest potential to support bull trout spawning, incubation, and rearing. We also conducted a bull trout presence/absence survey in a short list of streams that at least met the "marginal" habitat suitability criteria for bull trout. In this section, we summarize the methods used to perform these tasks (see Appendix A, Revised Study Plan, for further details).

2.1 INITIAL TRIBUTARY HABITAT RANKING BASED ON EXISTING INFORMATION (OFFICE PHASE)

Existing streamflow, channel gradient (including natural barriers), and water temperature information for the 16 candidate tributaries was evaluated during an "office phase". This data was used to develop an initial short list of potential bull trout streams entering Lake Merwin and Swift Creek Reservoir, as these habitat factors appear to be some of the best predictors of potential bull trout use (Dunham et al. 2003, page 901 and 902). The goal of this first task was to minimize the amount of field work needed to identify streams that could potentially provide long-term spawning, incubation, and rearing habitat. Primary sources of information included the data sheets developed during the *Assessment of Potential Anadromous Fish Habitat Upstream of Merwin Dam* (AQU 4) (PacifiCorp and Cowlitz PUD 2004, pages AQU 4-9 to AQU 4-11), USFS habitat surveys, existing water temperature data, and USGS 7.5 minute quadrangles.

Using this existing information and bull trout habitat requirements described in the scientific literature, each of the 16 tributaries were then categorized as having "optimal", "marginal", "poor", or "unknown" potential to support bull trout spawning, incubation, and rearing according to the criteria presented in Table 1. Water temperature was believed to be the best predictor of potential bull trout use (Dunham et al. 2003, page 901 and 902). Streams that ranked as "poor" for at least one parameter listed in Table 1 were eliminated from further consideration. We assumed that if "optimal" and "marginal" criteria for flow, gradient, and water temperature were not met, there was little chance that restoration efforts would create suitable habitat for bull trout spawning and rearing. All streams which ranked as "optimal", "marginal", or "unknown" were carried forward to the field phase for additional data collection.

It should be noted that the "optimal" water temperature and flow criteria used in Table 1 are the same as those currently being used by the USFWS to model and map potential bull trout spawning and early rearing "habitat patches" in the Lewis River basin[1]. The more conservative "marginal" ranking included in Table 1 was designed to capture those streams that have sub-optimal habitat conditions, but that may be capable of supporting at least some bull trout spawning and rearing through habitat restoration. To be conservative (i.e. so as to not exclude areas that may have some bull trout habitat

[1] The USFWS was driven to use elevation and basin size as surrogates for water temperature and perennial streamflow due to the lack of available data for most streams.

potential), streams meeting both the "optimal" and "marginal" criteria were carried forward to the field data collection phase of this study. Streams categorized as "unknown" were also carried forward to the field phase.

Table 1. Initial bull trout habitat ranking categories.

Habitat Parameter	Optimal	Marginal	Poor	Unknown
Flow	Perennial	Perennial	Seasonal[1]	Observations of late summer flow do not exist
Gradient	≤12%[4]	<20%	≥20%[2]	Unknown barrier presence
Maximum water temperature by mid-November[3] (spawning)	≤10°	≤13°	>13°C	Continuous water temperature data through the fall do not exist
Maximum water temperature (summer rearing)	≤16°C	≤18°C	>18°C	Continuous water temperature data through the summer do not exist

1 Based on AQU-4 study results (PacifiCorp and Cowlitz PUD 2004, pages AQU 4-9 to AQU 4-11) and anecdotal information (Pers. comm. J. Byrne, WDFW, July 2006), accessible reaches for all study streams are likely perennially flowing.
2 Based on AQU-4 study results (PacifiCorp and Cowlitz PUD 2004, pages AQU 4-9 to AQU 4-11), accessible reaches for all study streams are <20% in gradient.
3 Spawning may occur in Lewis River tributaries through November (Pers. comm. J. Byrne, WDFW, July 2006).
4 Gradient of Rush Creek, known bull trout spawning tributary in the Lewis River basin.

2.2 FIELD SURVEY OF OPTIMAL, MARGINAL, AND UNKNOWN STREAMS

The habitat requirements of bull trout are often expressed as the four Cs: cold, clean, complex, and connected habitat. Cold temperatures, clean water (that is relatively free of sediment and contaminants), complex channel characteristics (such as abundant large wood and undercut banks), and large patches of habitat that are well connected by unobstructed migratory pathways, are all needed to promote the conservation of bull trout at multiple scales ranging from the coterminous to the local stream population level (USFWS 2006, page 22). Following these guidelines, we assessed water temperature, habitat complexity, and presence of migration barriers in those tributaries that met the "optimal", "marginal", or "unknown" criteria described in Table 1.[2]

2.2.1 Temperature Monitoring Using In-Situ Loggers

Water temperature data loggers (Onset Tidbit®) were deployed in all study streams that met the initial "optimal", "marginal", or "unknown" criteria. In relatively small tributaries (accessible habitat lengths that were less than one mile), one temperature logger was placed at the mouth of the tributary. In tributaries with accessible reaches longer than one mile, two temperature loggers were deployed: one at the mouth of the tributary and one in the middle to upper end of the accessible reach (see Appendix C for tributary maps and logger locations). Sixteen temperature loggers were deployed by mid-July of 2006, with the intent of collecting data through mid-November of 2006 in order to

[2] The Draft Recovery Plan chapter pertaining to the Lewis River Core Area also recognizes the need to identify habitat that could potentially be used to support additional local populations in the Lewis River basin by assessing water temperature, flow regime, and habitat characteristics.

measure water temperatures during the summer rearing period through the end of the potential spawning period. Each temperature logger was attached inside a piece of 2-inch-diameter PVC pipe approximately 6 inches in length in order to protect the logger. The logger was secured inside the PVC pipe using plastic zip-ties. The PVC pipe containing a logger was secured to a 4-foot-long rebar stake that was driven approximately 2.5 to 3 feet into the stream channel. Temperature loggers were set to record data once every half-hour (i.e. 48 measurements per day). Approximately once a month, each data logger was field downloaded and immediately re-launched. As temperature data was collected, downloaded, and summarized through the summer, streams that were found to have daily maximum temperatures over 18°C were ranked as "poor" and dropped from further phases of data collection. We did, however, continue to collect temperature data using the in-situ loggers for these streams throughout the study period.

2.2.2 Cold Water Refugia Survey

As requested by the USFWS, a cold water refugia survey was also conducted in all tributaries where temperature loggers were deployed. The purpose of this survey was to determine how the in-situ logger measurements represented water temperatures in the accessible reach of each tributary and to determine if patches of suitable cold water habitat (refugia) were present that were not detectable by the temperature loggers. These surveys involved walking the accessible reach of each tributary and taking hand-held thermometer readings approximately every 150 feet. Cold water refugia surveys were conducted in mid-August for streams that rated as "poor" based on the in-situ logger data to determine if cold water habitat existed upstream that may meet the "marginal" or "optimal" criteria for summer rearing. For streams where the in-situ loggers showed that the streams would meet "marginal" or "optimal" criteria for summer rearing temperature, the cold water refugia survey was postponed until mid-September to determine if reaches of colder water may be upstream of an in-situ logger. This task was requested by the USFWS in response to their review of the first draft study plan.

2.2.3 Bull Trout Presence/Absence Survey

Bull trout presence/absence surveys were conducted in all tributaries that met either the “optimal” (i.e. ≤16°C) or "marginal" (i.e. ≤18°C) criteria for summer rearing water temperature following guidance presented in Peterson et al. (2002). The presence/ absence survey was lead by a Meridian fisheries biologist with over five years of direct bull trout sampling experience to ensure accurate fish identification. The entire reach of each survey tributary was sampled for bull trout because most accessible reaches were less than one mile long. Snorkeling was used in those tributaries with sufficient depth to allow direct observation without fish handling. Electrofishing was used in tributaries that were too shallow to effectively snorkel. During snorkel surveys, all pools and other habitats with sufficient depth and lack of turbulence were sampled. Only daytime snorkeling was conducted due to the remote location and safety constraints (all snorkel survey tributaries were only accessible by boat or steep, hazardous trails). All surveys (electrofishing and snorkeling) started at the mouth of each tributary and proceeded upstream to the impassable barrier. Additionally, an electrofisher was used to sample tributary margin, off-channel, and side channel habitat in each reach that was snorkle-surveyed. Because the objective was to determine bull trout presence or absence, other fish species were not enumerated. They were, however, recorded with general notes taken on species and abundance by size-class.

2.2.4 Tributary Habitat Inventory

Detailed habitat surveys were also planned in all tributaries that met either the "optimal" or "marginal" bull trout spawning and rearing habitat criteria using the USFS Region 6 survey protocol (USFS 2006). These surveys were designed to quantify those habitat attributes that may be limiting to bull trout and that could be improved through habitat restoration. The habitat surveys were originally scheduled for late-September/early-October, coinciding with the peak bull trout spawning period in the Lewis River basin. A barrier survey in the reservoir drawdown zone was also planned to determine if barriers were exposed during reservoir drawdown that would preclude adult bull trout from migrating upstream to spawn. Due to the overall lack of stream flow in several streams and the lack of bull trout observations from the presence/absence surveys conducted in September (see Section 3.0), we delayed habitat surveys until November, which is suspected to be the latter part of the bull trout spawning period in the Lewis River basin (personal communication, J. Byrne, WDFW, July 2006). A significant flood event occurred the week of November 6, 2006, when the habitat surveys were scheduled to begin. As a result, these surveys were delayed until flow conditions improved.

Following the flood event, we attempted to survey the "optimal" or "marginal" tributaries at flows similar to those observed just prior to the flood in order to represent potential early-November spawning habitat. Unfortunately, flows remained too high to conduct habitat surveys until the week of December 4, 2006 when we habitat surveyed Brooks and S10 creeks, and conducted the drawdown zone barrier survey of Brooks, S10, Drift, and Swift creeks. However, we were not able to habitat survey Swift and Drift creeks at that time due to increasing flows. Swift and Drift creeks were not habitat surveyed until the first week in April 2007; conditions up until this date precluded habitat surveys due to either extremely high flows or lack of boat ramp access caused by low reservoir levels[3]. All habitat data was collected per the USFS Region 6 protocol and summarized using an MS Access 2000 database program developed by Moore et al. 2005, which was designed to be compatible with USFS Region 6 protocol habitat data. The Moore et al. (2005) program was used because the USFWS Region 6 data summary program is not accessible to non-federal personnel. Photographs of representative habitat units and riparian conditions were also taken for each reach.

2.3 QUALITATIVE HABITAT ANALYSIS

Qualitative Habitat Assessment (QHA) is a simple procedure for developing and documenting a working hypothesis regarding habitat conditions with respect to a target species, bull trout in this case. In general, QHA provides a structured, "qualitative" approach to analyzing the relationship between a given fish species and its habitat. It

[3] Drift and Swift creeks are only accessible by boat in winter, although Swift Creek is accessible by a steep trail during snow-free periods.

uses a systematic assessment of several aquatic habitat attributes (sediment, water temperature, etc.) that are thought to be key to biological production and sustainability. Habitat attribute findings are then considered in terms of their influence on a given species and life stage.

QHA is a systematic assessment of species habitat relationships that capitalizes on the strengths of professional judgment while minimizing subjectivity and inconsistency. The assessment is structured by: (1) following a logical and replicable sequence, (2) using the best available quantitative data as the basis for decisions, (3) generating a product that is similar in form to products resulting from other more quantifiable approaches, and (4) documenting the decision process.

Following completion of the field habitat surveys in April 2007, we invited all members of the Lewis River ACC to participate in a one day meeting to complete the QHA habitat rating exercise. This meeting was conducted on May 5, 2007 at the Cowlitz Indian Tribe office in Toledo, Washington and was attended by Frank Shrier (PacifiCorp), Eric Lesko (PacifiCorp), Jeremiah Doyle (CH2MHill), Jim Byrne (WDFW), Shannon Wills (Cowlitz Indian Tribe), Adam Haspiel (USDA Forest Service), Bernadette Graham Hudson (Lower Columbia Fish Recovery Board), Chip McConnaha (Jones and Stokes), Kevin Malone (Jones and Stokes), George Gilmour (Meridian Environmental), and Jason Shappart (Meridian Environmental).

For this study, QHA was used to develop a working hypothesis regarding how bull trout relate to habitat conditions in the Lewis River basin, and specifically, how bull trout may use habitat in the candidate tributaries that met “optimal” or “marginal” potential for bull trout spawning and rearing. Using QHA, a group of expert scientists and managers developed a consensus regarding conditions in these streams at a reach scale. They rated those conditions using a consensus hypothesis of bull trout habitat preferences based on their local expert knowledge and the habitat survey data collected under this study. A series of tables was produced that (1) described the physical habitat of each study tributary, (2) established an hypothesis concerning how species may interact with the available habitat by life stage, and (3) and a relative ranking of the reaches in regard to protection and restoration needs and a ranking of habitat limiting factors in each reach for bull trout, focusing on promoting long-term spawning, incubation, and rearing success.

3.0 RESULTS

3.1 INITIAL TRIBUTARY HABITAT RANKING

Based on a preliminary assessment of available flow, gradient, and barrier data from PacifiCorp and Cowlitz PUD (2004, pages AQU 4-9 to AQU 4-11) there were 7 independent tributaries to Lake Merwin and 5 independent tributaries to Swift Creek Reservoir that were potentially accessible to bull trout and contained perennial flowing water (Table 2). Marble, Rock, and Canyon creeks (Lake Merwin tributaries), and Diamond Creek (Swift Creek Reservoir tributary) were ranked "poor" based on the initial assessment of available data and were eliminated from further evaluation (Table 3). Rationale for eliminating these streams from further analysis is presented in Table 3.

Table 2. Independent tributaries to Lake Merwin and Swift Creek Reservoir potentially accessible to bull trout that were carried forward to the water temperature monitoring phase.

Reach Name	Length of Accessible Habitat (ft)	Average Bankfull Width (ft)	Average Gradient (%)
LAKE MERWIN			
Cape Horn Creek	1,744	23.3	6.5
Jim Creek	3,140	21.5	3.4
Indian George Creek	4,760	21.9	5.0
Buncombe Hollow Creek	4,168	10.9	3.9
M4	3,900	11.5	10.0
Brooks Creek	5,714	19.5	4.0
M14	6,507	35.7	2.5
SWIFT CREEK RESERVOIR			
Swift Creek	1,639	NS	8.4
Range Creek	3,486	45.1	8.9
S10	1,855	24.7	6.8
Drift Creek	8,506	48.1	11.2
S15	6,680	29.7	6.7

NS = not surveyed
M4, B1, M14, S10, and S15 represent code names given to tributaries that are unnamed on 7.5 minute USGS topographic maps.

Table 3. Streams assessed in PacifiCorp and Cowlitz PUD (2004) ranked as "poor" for bull trout spawning, incubation, and rearing in this study.

Reach Name	Length of Accessible Habitat (ft)	Average Bankfull Width (ft)	Average Gradient (%)
Marble Creek[1]	40	15.2	2.0
Rock Creek[2]	320	47.5	6.1
Canyon Creek[3]	0	not surveyed	not surveyed
Diamond Creek[4]	655	20.8	10.0

1 Marble Creek contains only 40 feet of accessible habitat downstream from a 40-foot-high falls. It is highly unlikely that only 40 feet of habitat, at a relatively low elevation (<300 feet above sea level), would support long-term spawning, incubation, and rearing habitat for bull trout.

2 The lowermost 200 feet of accessible habitat in Rock Creek has an average gradient of <1 percent. The remaining accessible 150 feet has an average gradient of approximately 20 percent. It is highly unlikely that only 200 feet of habitat, at a relatively low elevation (<300 feet above sea level), would support long-term spawning, incubation, and rearing habitat for bull trout.

3 Numerous waterfalls located at the mouth and throughout the lower 1,000 feet of Canyon Creek block fish access from Lake Merwin.

4 Diamond Creek is a high gradient tributary to Lake Merwin (16.5 percent for first 200 feet, and 8 percent for the remaining 455 accessible feet from the mouth). Habitat in the accessible portion is dominated by shallow, high gradient riffles with occasional pocket pools. Cobble and small boulder are the dominant substrate types. Gravel is extremely limited. Because of its relatively short length, high gradient, and low summer flow of 0.5 cfs observed during the AQU-4 Study, Diamond Creek appears to contain only a limited amount of salmonid habitat, and would not likely support long-term spawning, incubation, and rearing habitat for bull trout.

While there were some available water temperature data for the 12 streams that were carried forward in analysis (Table 2), there was not enough continuous monitoring data throughout a summer and fall period to classify each tributary using our summer rearing or fall spawning water temperature criteria (Table 1). As a result, these streams were rated "unknown" for temperature. Consequently, all 12 streams listed in Table 2 were carried forward to the water temperature monitoring phase described below.

3.2 WATER TEMPERATURE MONITORING

As described in Section 2.2.1, water temperature was monitored in all streams listed in Table 2 using in-situ temperature loggers to further classify each tributary as “optimal”, “marginal”, or “poor” based on the criteria listed in Table 1. While the majority of water temperature loggers were lost during the November 2006 flood event, temperature data were collected for all streams in Table 2 extending into late September 2006, making it possible to rate the streams using the summer rearing temperature criteria and also to examine spawning temperatures during the first half of the known Lewis River bull trout spawning period.

Temperature data collected through late-September 2006 are summarized in Table 4. As denoted by the gray shading, eight of the 12 streams had summer maximum water temperatures >18°C, and therefore, ranked “poor” for juvenile bull trout summer rearing. Brooks and Drift creeks (yellow shading) both ranked “marginal” for summer bull trout rearing (summer maximum water temperatures (>16°C and ≤18°C). Swift and S10 creeks (green shading) both ranked “optimal” for bull trout summer rearing (summer maximum water temperatures ≤16°C). Both of these streams had water temperatures that were continually less than 12°C throughout the summer.

As of late-September, Swift Creek was the only accessible tributary that met the “optimal” criteria for both summer rearing (≤16°C) and fall spawning (≤10°C) (Table 2). Water temperatures in S10 Creek met the “optimal” criteria for summer rearing (≤16°C) and the “marginal” criteria for spawning (≤13°C). Brooks and Drift creeks met the “marginal” criteria for summer rearing (≤18°C), and as of mid-September, met the “marginal” criteria for bull trout spawning. As these four streams (Brooks, Drift, S10, and Swift creeks) appeared to meet both the summer rearing and fall spawning temperature criteria (for either “marginal”, “optimal”, or a combination of both), they were carried forward to the tributary habitat survey phase (see Section 3.5).

Three of 16 temperature loggers were recovered after the November flood: the single logger located in Cape Horn Creek and both loggers from M14 Creek. Both streams dropped below 13°C by the beginning of October, and were generally between 8 to 10°C by mid-November when the temperature loggers were recovered. However, both of these streams ranked “poor” because summer rearing temperatures were greater than 18°C (Table 4).

Table 4. Summary of in-situ water temperature data.

(green, yellow, and gray shading corresponds to streams that meet criteria for optimal, marginal or poor temperature criteria, respectively)

	Tributary name / continuous data collection period	Brooks mouth 6/28/06-9/20/06	Brooks upper 6/28/06-9/20/06	Buncombe Hollow mouth 6/29/06-9/20/06	Cape Horn upper end 7/13/06-9/20/06	Indian George mouth 6/28/06-9/18/06	Jim mouth 6/28/06-9/18/06	M4 mouth 6/28/06-9/20/06	M14 mouth 6/28/06-9/20/06	M14 upper end 6/28/06-9/20/06	Drift mouth 7/14/06-9/21/06	Drift mid 7/14/06-9/21/06	Range mouth 7/14/06-9/22/06	S10 mouth[3] 7/14/06-9/19/06	S15 mid 7/14/06-9/21/06	Swift mouth 7/14/06-9/19/06
No. days continuously monitored[1]		84	84	83	69	82	82	82	84	84	69	69	70	67	69	67
Percent of Observations Exceeding Water Temperature Value	6.0°C															100.0
	7.0°C															81.0
	8.0°C													100.0		41.8
	9.0°C											100.0	100.0	99.9		15.0
	10.0°C	100.0	100.0		100.0						100.0	93.0	99.6	57.8	100.0	2.9
	11.0°C	99.6	96.5	100.0	97.9	100.0	100.0	100.0	100.0	100.0	93.6	83.1	91.9	4.4	98.0	0.5
	12.0°C	90.3	74.9	97.1	84.3	98.2	96.0	99.7	95.6	98.9	84.6	56.6	83.1	0.0	88.4	0.0
	13.0°C	48.6	38.0	89.1	55.6	90.0	83.0	94.8	81.4	95.0	58.8	27.2	57.9		74.8	
	14.0°C	20.8	18.8	73.4	24.0	68.1	47.7	75.4	58.5	88.5	27.1	11.3	31.3		49.6	
	15.0°C	4.7	5.6	49.5	9.7	30.6	20.2	48.9	28.7	76.2	10.7	4.3	12.7		28.3	
	16.0°C	0.6	0.8	25.1	3.7	11.9	7.7	24.5	12.6	55.6	4.3	1.0	5.8		13.2	
	17.0°C	0.0	0.2	10.6	0.8	4.7	3.3	8.9	4.1	41.4	1.6	0.0	1.9		5.6	
	18.0°C		0.0	4.2	0.1	1.1	0.9	4.1	0.8	26.7	0.0		0.1		2.4	
	19.0°C			1.2	0.0	0.03	0.0	1.1	0.0	14.2			0.0		0.8	
	20.0°C			0.2		0.0		0.2		6.1					0.0	
	21.0°C			0.0				0.0		3.0						
	22.0°C									1.0						
Water Temperature (°C)	Summer max	16.7	17.2	20.0	18.1	19.1	18.8	20.4	18.8	23.5	17.6	17.0	18.2	11.8	19.8	11.5
	Max after Aug 31	14.7	15.8	16.6	14.5	15.6	15.1	16.6	15.1	18.4	13.8	13.5	14.4	11.0	15.1	8.2
	Min after Aug 31	11.2	10.3	11.4	10.6	11.8	11.2	11.8	11.1	11.4	10.3	9.2	9.7	9.0	10.5	6.2
Number of Days	Max exceeded 18°C	0	0	7	1	2	2	7	2	49	0	0	1	0	6	0
	Max exceeded 16°C	2	5	42	7	21	8	40	21	71	8	5	10	0	27	0
	After Aug 31 max exceeded 13°C[2]	12/20	15/20	17/20	12/20	16/18	14/18	16/18	16/20	18/20	8/21	6/21	10/22	0/19	12/21	0/19
	After Aug 31 daily max was ≤10°C[2]	0/20	0/20	0/20	0/20	0/18	0/18	0/18	0/20	0/20	0/21	1/21	0/22	5/19	0/19	19/19

[1]Temperature continuously monitored using Onset Tidbit® loggers recording temperature every 0.5 hours.
[2]Number is a ratio of days counted matching criteria to total days continuously monitored after August 31.
[3]Only data from the mid-point logger exists. The logger deployed at the mouth of S15 Creek was stolen before being downloaded.

3.3 COLD WATER REFUGE SURVEY

Cold water refugia surveys were conducted between mid-August and mid-September of 2006 in 11 of the candidate streams. Cape Horn Creek (Figure 4) was the only tributary not surveyed due to private property access issues.

No cold water refugia were observed during the longitudinal surveys in streams that rated “poor” for summer rearing temperature (i.e. >18°C). For the most part, water temperatures recorded throughout the longitudinal survey in each tributary differed by less than ±1.0°C from the in-situ temperature logger at the mouth of the tributary (Table 5). In general, streams that rated “poor” for summer rearing based on the in-situ logger data became slightly colder (about 0.5°C) or slightly warmer upstream (Figure 5, top chart).

Relatively large differences in the longitudinal temperature profiles were found in M14 Creek. This creek becomes much cooler as water flows downstream, which is atypical of the general trend of stream warming in the downstream direction. The headwaters of M14 Creek flow through a pasture with no shade, where it appears to receive a large amount of solar radiation. As M14 Creek flows into a steep wooded ravine, several small wetland seeps enter the channel, substantially cooling the creek. Based on the cold water refugia survey and the in-situ logger data, M14 Creek cooled by about 4°C in an approximately 3,500-foot reach during the warmest part of the year. The daily maximum water temperature at the coolest site exceeded 18°C during the sampling period (Table 4); therefore, M14 rates “poor” for summer rearing water temperature.

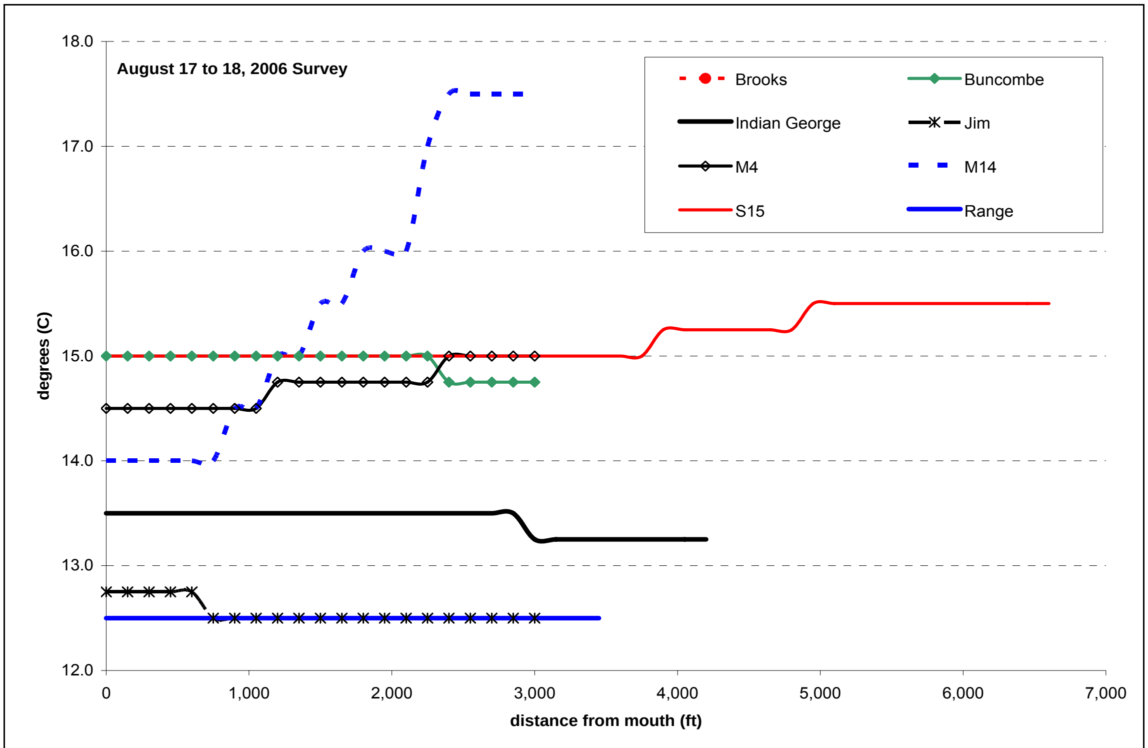
Another exception was in the Brooks Creek drainage, where a tributary to Brooks Creek (B1 Creek) was about 1°C cooler than the mainstem of Brooks Creek. This flow contribution cooled the water in lower Brooks Creek by about 1°C. Because Brooks Creek, already rated “marginal” for summer rearing and spawning, it was carried forward to the tributary habitat survey phase.

Because those streams that ranked “poor” for summer rearing water temperature (based on the in-situ logger data) were found not to have cold water refugia, they were dropped from further analysis. These streams included Buncombe Hollow, Cape Horn, Indian George, Jim, M4, M14, Range and S15 creeks. Warm water limits potential bull trout rearing within these streams and there is little chance that habitat restoration or protection would substantially alter this condition, making long-term bull trout spawning, incubation, or rearing unlikely.

Based on the in-situ logger data and the cold water refugia survey, Brooks, Swift, S10, and Drift creeks could potentially support bull trout spawning and rearing. Therefore, these streams were carried forward to the bull trout presence/absence and tributary habitat survey phases to determine if bull trout are present and to quantify additional physical habitat parameters that may limit their production within these streams.

Table 5. Cold water refugia survey attributes.

	Survey Attributes			In-Situ Logger Data During Survey			Hand-held Thermometer Data	
Reach Name	**Date**	**Duration (hrs:min)**	**Distance (ft)**	**Δ at Lower Site (°C)**	**Distance to Upstream Logger (ft)**	**Δ at Upper Site (°C)**	**Max Δ Measured During Survey (°C)**	**Δ Measured Between Start and End Point (°C)**
AUGUST 17-18, 2006 SURVEY								
Buncombe Hollow Creek	8/17/2006	1:40	3,000	+0.2	NA	NA	0.25	0.25
Indian George Creek	8/17/2006	2:20	4,200	+0.2	NA	NA	0.25	0.25
Jim Creek	8/17/2006	1:40	3,000	0.0	NA	NA	0.25	0.25
M4 Creek	8/17/2006	1:40	3,000	+1.1	NA	NA	0.5	0.5
M14 Creek	8/17/2006	1:47	3,000	+0.1	3,000	+0.5	3.5	3.5
Range Creek	8/18/2006	2:15	3,450	+0.2	NA	NA	0	0
S15 Creek	8/18/2006	1:44	6,600	NA	3,000	+0.8	0.5	0.5
SEPTEMBER 18-21, 2006 SURVEY								
Brooks Creek	9/18/2006	3:20	3,600	+0.3	4,000	+0.5	2.5	0
S10	9/19/2006	1:00	1,950	0.0	NA	NA	0	0
Swift	9/19/2006	2:21	1,950	+0.6	NA	NA	1.0	0.5
Drift	9/21/2006	3:15	8,400	0.0	4,000	+0.2	1.5	1.0



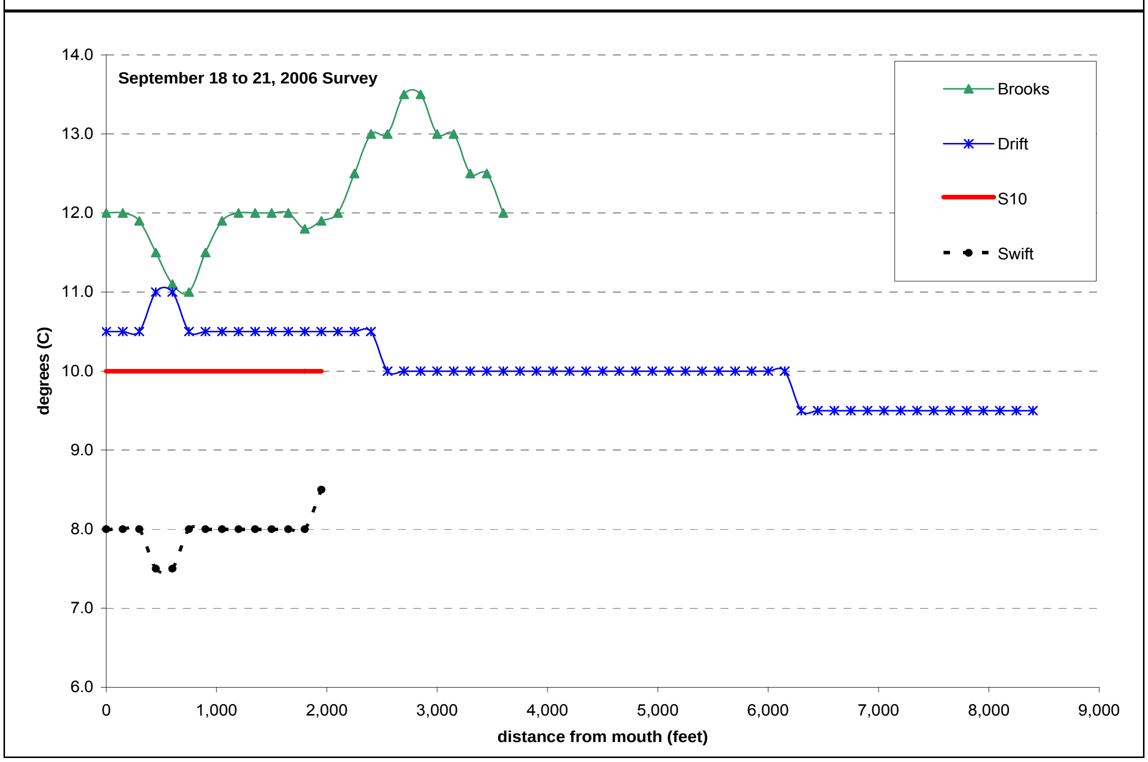


Figure 5. Cold water refugia survey longitudinal temperature profiles.

3.4 BULL TROUT PRESENCE/ABSENCE SURVEY

Bull trout presence/absence surveys were conducted in the four tributaries that had summer maximum water temperatures of ≤18°C (Brooks, Swift, S10 and Drift creeks) (Figure 3). We also conducted bull trout presence/absence surveys in three streams (Range, Jim, and Indian George creeks) that exceeded this temperature criteria for only one or two days during the monitoring period. These three streams were sampled to test the validity of our summer rearing water temperature ranking criteria (Table 1). Our hypothesis was that juvenile bull trout would not be present in streams with daily maximum water temperatures that exceed 18°C. Presence/absence surveys were performed between September 19 and September 28, 2006. In addition, we conducted an exploratory snorkel survey of Swift Creek on August 31, 2006 assisted by volunteers attending the 2006 *Salvelinus confluentus* Curiosity Society (ScCS) meeting.

Due to low flow conditions (estimated at less than 1.5 cfs), single pass electrofishing was used to determine bull trout presence/absence in the accessible reaches of Brooks, S10, Jim, Indian George, and Range creeks. Daytime snorkel surveys were used to determine presence/absence in Swift and Drift creeks because they had sufficient flow. Daytime surveys were conducted in both streams because of their remote location and difficult access terrain. We also used single pass electrofishing to sample the margins of Drift and Swift creeks, although we were only able to safely electrofish approximately 1,000 feet of margin habitat in Swift Creek (approximately 60 percent of the potentially accessible reach).

3.4.1 Results of Lake Merwin Tributary Surveys

Lake Merwin tributaries surveyed for bull trout presence/absence were Brooks, Indian George, and Jim creeks. No bull trout were observed or captured in these streams. During the presence/absence surveys, flows at the mouth of each tributary were estimated to be approximately 1.5 cfs in Jim Creek, 0.5 cfs in Indian George Creek, and less than 0.5 cfs in Brooks Creek.

Approximately 900 feet upstream from its mouth, Brooks Creek was intermittent and flows were so low that fish could not enter the creek from Lake Merwin (Photos 1 and 2). During the September 19, 2006 survey, Brooks Creek upstream of the B1 Creek confluence was dry with intermittent isolated pools extending about 2,000 feet before flowing water was again present. However, during the cold water refugia survey on September 18, 2006, Brooks Creek was observed to have continuous surface flow, although at a low level and B1 Creek was dry upstream of the confluence.

We observed approximately 5 adult kokanee spawners and 1 adult Chinook salmon (approximately 600 mm in length) holding in Lake Merwin at the mouth of Brooks Creek. We did not find kokanee spawners in Brooks Creek, providing further evidence that flow was too low for fish to enter the creek. We also observed 5 kokanee spawners in the lower 300 feet of Jim Creek. In all three streams we found numerous cutthroat trout ranging from young-of-the-year (50 mm in length) to presumed adults (up to about 200 mm in length). Density of cutthroat trout was similar in all three streams and was approximately several hundred cutthroat trout per 300 lineal feet of stream, comprised primarily of young-of-the-year. Sculpin were ubiquitous throughout the accessible reaches. We also observed one adipose fin-clipped hatchery rainbow trout (approximately 120 mm in length) approximately 1,000 feet upstream from the mouth of Indian George Creek.

Photo 1. Brooks Creek mouth (September 2006).

Photo 2. Brooks Creek downstream of B1 Creek confluence (September 2006).

3.4.2 Results of Swift Creek Reservoir Tributary Surveys

Swift Creek Reservoir tributaries surveyed for bull trout presence/absence included Swift, S10, Range, and Drift creeks. During the ScCS meeting on August 31, 2006, snorkel surveyors in Swift Creek observed four large bull trout ranging from approximately 400 to 600 mm in length. All four bull trout were in the lower 800 feet of the accessible reach (the accessible reach is approximately 1,600 feet long). Snorkel surveyors also observed large cutthroat/rainbow trout and large whitefish. While electrofishing margin habitat in Swift Creek on September 19, surveyors captured 15 to 20 juvenile cutthroat trout, one whitefish, and sculpin. Attempts were made to re-snorkel Swift Creek on two separate occasions in mid- to late-September, but due to turbidity, surveys were not possible. Swift Creek surveys and bull trout observations are discussed in more detail in Section 3.4.3.

During bull trout presence/absence surveys conducted in S10, Range, Drift, and Swift creeks between September 19 to 28, 2006, flow was estimated to be less than 0.5 cfs in S10 Creek (intermittent to approximately 0.5 cfs); less than 1.5 cfs in Range Creek; 4 to 5 cfs in Drift Creek, and greater than 15 cfs in Swift Creek. Although several isolated pools were present in S10 Creek, low flow appeared to preclude migration of fish into the creek during the survey period (Photo 3). Flow was so low during the survey of S10 Creek that most of the accessible reach had no surface flow (Photo 4).

During the presence/absence surveys, Meridian and PacifiCorp biologists observed several hundred juvenile coho in S10, Drift, and Range creeks; however, none were observed in Swift Creek. Coho density was highest in S10 Creek, with more than 100 juvenile coho estimated per 300 lineal feet of stream. Juvenile coho were present all the way up to the impassible barriers on each stream (i.e. present throughout the accessible reaches). Many small isolated pools within S10 Creek had numerous juvenile coho (more than 50 fish in individual pools). In Range and S10 creeks, surveyors observed hundreds of cutthroat trout, ranging from young-of-the-year (50 mm in length) to presumed adults (up to about 200 mm in length). Most cutthroat trout observed were young-of-the-year. Density of cutthroat trout within Range and S10 creeks was similar, and was approximately several hundred cutthroat trout per 300 lineal feet of stream. Sculpin were ubiquitous throughout the accessible reaches. Cutthroat trout density within Drift Creek was much less than observed in Range and S10 creeks.

Surveyors observed one large redd in Drift Creek, located approximately 3,000 feet upstream from its mouth. The redd was approximately 3 feet wide and 6 feet long, made of large gravel and small cobble, and located mid-channel in a pool tailout. The origin of the redd is not known, as no large adult salmonids were observed in the area. Fish of the size necessary to build a redd this large and that are known to have been present upstream of Swift Dam during the survey include adfluvial bull trout, coho, and a few Chinook salmon. Coho and Chinook were trucked upstream from the lower Lewis River and released into Swift Reservoir as part a habitat preparation plan required by the Settlement Agreement.

Photo 3. S10 Creek mouth (September 2006).

Photo 4. S10 Creek dry / intermittent flowing reach (September 2006).

3.4.3 Swift Creek Bull Trout Observations

The four large bull trout observed in Swift Creek during the ScCS snorkel survey on August 31, 2006 (ranging from 400 to 600 mm in fork length) were all in the lower 800 feet of the accessible reach. To our knowledge, this is the first observation of bull trout in Swift Creek proper, although they are thought to rear in the Swift Creek arm of Swift Reservoir (USFWS 2006, page 69). These fish are also within the size range of bull trout observed spawning in Rush and Pine creeks, suggesting that these fish were potentially reproductively mature. The late-August observations are within the known Lewis River basin bull trout spawning period.

On September 19, 2006, an electrofishing survey was conducted along the margins of Swift Creek in an attempt to locate juvenile bull trout. None were observed or captured during sampling. Although some margin habitat with large woody debris was sampled for fish, only a few juvenile cutthroat trout, sculpin, and one whitefish were captured. During sampling, surveyors specifically avoided electrofishing larger pools to prevent disturbing any potential bull trout spawners. Surveyors did observe an approximately 400 mm bull trout in a riffle/rapid adjacent to some margin habitat that was being sampled for juveniles.

Surveyors also attempted to snorkel survey Swift Creek on September 19 to count adult bull trout during the potential spawning period and to look for redds. Due to high turbidity levels that reduced underwater visibility, snorkeling was not possible. While Swift Creek was clear during August 31 snorkel survey, following a brief rain event, turbidity increased dramatically. Turbidity levels were checked at the mouth of Swift

Creek on September 22 and September 27 after several days without rain. Although turbidity levels appeared to be lower, they were still not favorable for snorkeling. On September 22, a biologist did capture 2 adult bull trout >400 mm in length at the mouth of Swift Creek using a barbless hook and line.

Presented below is a summary of the notes taken during the ScCS snorkel survey on August 31, 2006 when bull trout were first observed in Swift Creek. The general habitat description does not reflect current conditions because a debris torrent washed through Swift Creek in November 2006, extensively altering the stream channel conditions.

- Snorkelers: Jason Shappart (Meridian), George Gilmour (Meridian), Jeff Chan (USFWS), Karen Meyers (USFWS), Bao Le (Douglas County PUD)

- Snorkeled the reservoir arm within approximately 250 feet of the mouth of Swift Creek and the entire creek from the mouth to the 80-foot falls located about 1,600 feet upstream of the mouth.

- Water temperature at the mouth of Swift Creek: 7°C at 10:15 am; 8.5°C at 1:37 pm

- Habitat unit at the mouth = rapid with cobble/small boulder substrate
  Unit length = approx 125 feet
  Wetted width = approx. 25 to 30 feet; bank full width = approx. 50 feet
  Average unit depth = approx. 1.5 feet; max. depth = approximately 2 feet

- Habitat from the stream mouth to barrier falls is steep (4 to 8 percent gradient), with many rapids and cascades, extensive areas of habitat not conducive to snorkeling due to velocity and bubble curtains, a few large scour pools were present (approximately 6) and gravel was limited. Habitat was similar to Rush Creek where many bull trout are thought to be produced.

- B. Le, J. Chan, and G. Gilmour observed 2 bull trout (approximately 400 mm in length) in stream at mouth in riffle/rapid unit (Photo 5).

- J. Chan and J. Shappart observed 1 bull trout (400 mm in length) in first big pool approximately 300 feet upstream from mouth. Note that this pool was filled in and covered by at least 10 feet of bedload during the November 2006 flood.

- G. Gilmour and J. Shappart observed 1 bull trout (600 mm in length) approximately 800 feet upstream from mouth in scour pool unit (Photo 6).

- J. Chan observed possibly 1 more bull trout (400 mm) between 300 to 500 feet upstream of mouth, but might have been a fish previously counted.

- Falls over bedrock approximately 700 feet upstream from mouth; 4 to 5-foot-high falls with big plunge pool at base (over 6 feet deep) (Photo 7). No bull trout were observed above this small falls, although many large rainbow/cutthroat trout (300 to 350 mm) were present (Photo 8). No whitefish were observed upstream of the small falls. This small falls is potentially passable by large bull trout and rainbow/cutthroat trout. Note that the falls was eliminated by the November 2006 flood; the stream bed aggraded several feet, nearly filling in the scour pool that was below the falls.

- Fewer than 20 rainbow/cutthroat trout less than 150 mm long were observed in the creek, but schools of rainbow/cutthroat of this size were observed in the reservoir at the creek mouth.

- Several large rainbow/cutthroat trout (300 to 400 mm) were observed downstream of the small falls, with 10 or more large fish in some of the larger pools (more fish than above the small falls). Many large whitefish (up to 450 mm) were observed downstream of the small falls, with more than 15 whitefish in some of the larger pools.

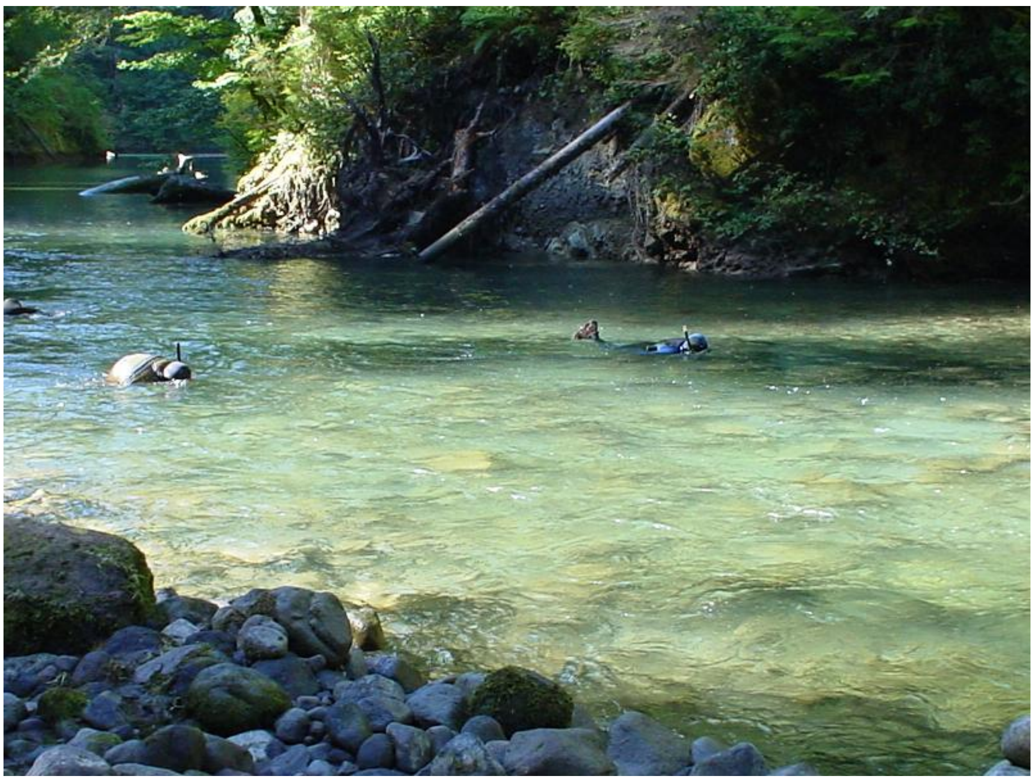


Photo 5. Swift Creek mouth where 2 bull trout were observed during snorkel survey (August 31, 2006).

Photo 6. Swift Creek where large 600 mm bull trout was observed during snorkel survey (August 31, 2006).

Photo 7. Swift Creek, 5 foot falls during snorkel survey (August 31, 2006).

Photo 8. Swift Creek typical habitat upstream of 5 foot falls during snorkel survey (August 31, 2006).

3.5 TRIBUTARY HABITAT INVENTORY

Brooks, S10, Drift, and Swift creeks were the only tributaries entering Swift Creek Reservoir and Lake Merwin that met the criteria needed to move into the habitat survey phase. The November 2006 flood substantially altered aquatic habitat conditions in three of these streams (S10, Drift, and Swift creeks). In the following paragraphs, we briefly describe some general observations of aquatic habitat conditions in these streams made in previous years and during the summer 2006 water temperature monitoring and fish presence/absence surveys. We then compare this information with the quantitative habitat data collected after the November 2006 flood event. Summary tables of the quantitative habitat survey data are also presented for each stream.

We also conducted the drawdown zone barrier survey of Brooks, S10, Drift, and Swift Creeks during the week of December 4, 2006. We visually inspected the drawdown channel of each stream for physical barriers that might prevent the upstream spawning migration of adult adfluvial bull trout. No migration barriers were found in the drawdown zone of these streams.

3.5.1 Brooks Creek

The 1999 habitat survey of the accessible length of Brooks Creek and its major tributary B1 Creek (reported in PacifiCorp and Cowlitz PUD, 2004, AQU-4 Appendix 1, sheet 08, Brooks Creek and sheet 09, B1) states:

> *Brooks Creek is a moderate gradient (4.0 percent average slope) 2nd order stream with an "A/B" Rosgen channel type. Fish habitat in the accessible portion of this stream is comprised of 9-to 20-foot-wide cobble and small boulder dominated riffles. Spawning gravel is common throughout the lower portion of the stream. Cover in the form of LWD and overhanging vegetation is abundant. The channel appears stable and the riparian area provides excellent stream shade. Overall, Brooks Creek contains very good salmonid habitat. B1 Creek (unnamed tributary to Brooks Creek) is a moderate to high gradient (average 7.0 percent slope) 2nd order tributary to Brooks Creek with an "A" Rosgen channel type. Habitat conditions in the accessible portion of B1 were similar to those found in Brooks Creek. Low summer flows would likely limit the production of anadromous salmonids (coho and steelhead) in this stream.*

The 1999 survey also reported an average bankfull width of 19.5 feet and an accessible length of 5,714 feet in Brooks Creek, and an average bankfull width of 23.4 feet and accessible length of 2,650 feet in B1 Creek (PacifiCorp and Cowlitz PUD 2004, pages AQU 4-9).

Based on qualitative observations made during the summer 2006 (pre-flood), the 1999 survey results continued to accurately reflect summer habitat conditions in both Brooks and B1 creeks, except for the density of large woody debris. Large woody debris was not "abundant" in the summer of 2006, as there were few key pool-forming pieces of large wood per mile. The November 2006 flood event did not appear to cause substantial habitat changes in Brooks and B1 creeks, although it was apparent that flow over-topped the active channel bank by approximately 1 to 2 feet. There did not appear to be substantial bedload scour or deposition; however, several trees did fall into Brooks Creek, providing additional large woody debris.

Under post-flood conditions, the channel gradient throughout the accessible reach of Brooks Creek (including B1 Creek) averages 4.4 percent (Table 6). Approximately 70 percent of the accessible reach is located in a moderate V-shaped valley with a narrow valley floor (constrained by hill slopes). The remaining 30 percent of the reach is located within a broad valley floor and is constrained by alternating terraces. The valley width index averages 2.2 (i.e. ratio of the width of the active stream channel to the width of the valley floor), but ranged from 1 to 7, indicating some floodplains exist within the valley floor (Table 6). Riparian vegetation is dominated by shrubs (primarily Himalayan blackberry and salmonberry), while the vegetation on the hill slopes is dominated by mixed coniferous and deciduous forest (primarily western red cedar and red alder). Several houses are located along the accessible reach within 300 feet of the stream channel. We also observed approximately 10 submersible irrigation pumps scattered along the upper portion of the accessible reach. Most of the accessible habitat is comprised of fast-water units, primarily rapids and riffles (Table 7 and Photos 9, 10, and 11). Pools observed were fairly shallow and were not complex (Photo 12).

Table 6. Brooks Creek channel, pool, LWD, and other habitat metrics (December 2006).

Channel Metrics	**Avg. Wetted**	**Avg. Active**	**Avg. Flood Prone**
Width (ft)	11.2	16.4	45.3
Depth (ft)	1.3	2.6	4.3
Pool Summary	**Total**	**No. /Mile**	
No. Pools	20	15.8	
No. Pools ≥3 ft deep	3	2.4	
No. of Complex Pools (≥3 LWD pieces present)	1	0.8	
Pool Frequency (channel widths/pool)		20.4	
Avg. Residual Pool Depth (ft)		1.7	
LWD Summary	**Total**	**No./ Mile**	
No. Pieces ≥ 10 ft x 0.5 ft	72	58	
Volume (ft^3)	6,778	5,396	
No. Key Pieces (≥ 40 ft x 2 ft)	2	1.6	
Misc. Habitat Metrics			
Avg. Unit Gradient		4.4	
Width:Depth Ratio		6.8	
Slow Water:Fast Water Unit Ratio		0.14	
Entrenchment (active channel width:flood prone width)		2.7	
Bank Condition (% actively eroding)		7%	
% Undercut Banks		3%	
Shade (% stream enclosed)		60%	

Note: includes B1 Creek

Photo 9. Brooks Creek typical fast water habitat unit (December 6, 2006).

Photo 10. B1 Creek typical fast water habitat unit near Brooks Creek confluence (December 7, 2006).

Photo 11. B1 Creek typical fast water unit near Hwy 503 (December 7, 2006).

Photo 12. B1 Creek typical low complexity pool unit (December 7, 2006).

Table 7. Brooks Creek habitat unit metrics (December 2006).

Habitat Type	No. Units	Total Length (ft)	Avg. Wetted Width (ft)	Avg. Depth (ft)	No. Large Boulders	Total Wetted Area (ft^2)	% Total Habitat	Substrate (% of Wetted Area)					
								Silt/ Organic	Sand	Gravel	Cobble	Boulder	Bed Rock
Side/Off Channel	1	102	5.9	dry	0	592	0.8%	9	27	9	55	0	0
Lateral Scour Pool	6	318	13.4	2.3	11	5,455	7.5%	17	16	29	30	8	0
Plunge Pool	8	112	13.8	3.2	11	1,614	2.2%	22	7	33	35	0	3
Straight Scour Pool	6	118	13.4	2.4	12	1,657	2.3%	20	11	25	41	2	0
Riffle	12	1,548	10.5	0.8	17	19,486	26.7%	9	6	34	50	0	0
Riffle with Pockets	2	449	8.5	0.5	2	4,046	5.5%	26	31	12	32	0	0
Rapid	23	2,749	10.8	0.8	143	30,548	41.9%	8	4	17	67	4	0
Cascade (Boulder)	8	1,043	8.9	0.8	213	8,274	11.4%	8	1	12	42	37	0
Falls over Log	3	7	13.8	0.3	2	86	0.1%	10	12	39	27	13	0
Culvert Crossing	3	249	4.9	0.9	0	1,194	1.6%	10	0	23	58	10	0
Total / Average:	**55**[a]	**6,694**[a]	**11.2**[b]	**1.3**[b]	**411**[a]	**72,953**[a]		**12**[b]	**7**[b]	**23**[b]	**49**[b]	**7**[b]	**0**[b]

Note: includes B1 Creek tributary
[a] total
[b] average

3.5.2 S10 Creek

The 1999 habitat survey of the accessible length of S10 Creek (reported in PacifiCorp and Cowlitz PUD, 2004, AQU-4 Appendix 1, sheet 26, S10) states:

> *S10 Creek (unnamed) is a high gradient (6.8 percent average slope) 2nd order stream with an "A" Rosgen channel type. Fish habitat in the accessible portion of S10 is dominated by relatively high gradient riffles with occasional pocket pools. Cobble and small boulders are the dominant substrate type. Numerous low flow migration obstacles were observed throughout the surveyed reach. These low flow obstacles would be passable at higher flows. However, summer low flows (0.5 cfs) appear to be a major limiting factor for salmonids. Overall, this stream contained very poor anadromous fish habitat.*

The 1999 survey also reported the average bankfull width as 24.7 feet and the accessible length as 1,855 feet (PacifiCorp and Cowlitz PUD 2004, pages AQU 4-10). The 1999 survey conditions were consistent with those observed during the summer of 2006, with exception of fish habitat quality. Contrary to the 1999 survey conclusion that S10 likely contained very poor habitat for anadromous fish, we observed hundreds of juvenile coho distributed throughout the accessible length, many of which were in small isolated pools. The observed natural production of coho indicates that this tributary can support spawning and rearing coho salmon.

The November 2006 flood substantially altered the habitat in S10 Creek. Prior to the flood, both stream banks and constraining slopes were stable and not actively eroding, and riparian vegetation (such as vine-maple, alder, and salmonberry) was thick along both sides. The flood resulted in vegetation and bank scour along over 50 percent of the entire accessible stream length. The hill slope was scoured on both sides of the creek, exposing vertical cuts of about 6 to 8 feet in height (Photos 14 and 16). This scour also caused numerous small sloughs/landslides, and more than 100 trees, 1.5 to 4 feet diameter-at-breast-height (dbh), fell into the creek within the 1,500-foot accessible length (Photo 14). It appears that major bedload deposition occurred; few pools remain within the accessible length compared to pre-flood conditions, although some large new scour pools were formed (primarily associated with new large woody debris) in areas previously observed to be riffles (Photo 15). A new upstream migration barrier was formed during the November 2006 flood (Photo 17), approximately 300 feet downstream of the previous barrier.

Under post-flood conditions, the S10 Creek channel is steep, with an average gradient of 8.1 percent (Table 8) and is contained within a moderate V-shaped valley with a narrow floor (Photo 13). The stream channel is constrained by hill slopes on both sides of the channel. The valley width index is 1.0 indicating there is little or no floodplain. The riparian vegetation is dominated by shrubs (such as salmonberry and devils club), while the slopes are dominated by mature coniferous trees (probably second or third-growth) averaging approximately 2 to 3 feet dbh. Most of the stream habitat is comprised of fast-water units, primarily boulder cascades and rapids (Table 9).

Photo 13. S10 Creek mouth riffle unit (December 8, 2006).

Photo 14. S10 Creek typical fast water habitat, vertical cut-bank, and large woody debris recruitment from November 2006 flood bank-scour (December 8, 2006).

Photo 15. S10 Creek pool scour after November 2006 flood (left) and before flood (right); red arrow and blue oval indicate reference objects.

Photo 16. S10 Creek typical fast water habitat unit and vertical cut-bank (December 8, 2006).

Photo 17. S10 Creek new barrier scoured during November 2006 flood (December 8, 2006).

Table 8. S10 Creek channel, pool, LWD, and other habitat metrics (December 2006).

Channel Metrics	Avg. Wetted	Avg. Active	Avg. Flood Prone
Width (ft)	13.1	24.3	27.9
Depth (ft)	1.5	2.6	5.2
Pool Summary	**Total**	**No. /Mile**	
No. Pools	4	14.2	
No. Pools ≥3 ft deep	3	10.6	
No. of Complex Pools (≥3 LWD pieces present)	1	3.5	
Pool Frequency (channel widths/pool)		15.4	
Avg. Residual Pool Depth (ft)		3.1	
LWD Summary	**Total**	**No./ Mile**	
No. Pieces ≥ 10 ft x 0.5 ft	137	562	
Volume (ft^3)	29,158	3,389	
No. Key Pieces (≥ 40 ft x 2 ft)	50	206	
Misc. Habitat Metrics			
Avg. Unit Gradient		8.1%	
Width:Depth Ratio		8.8	
Slow Water:Fast Water Unit Ratio		0.07	
Entrenchment (active channel width:flood prone width)		1.2	
Bank Condition (% actively eroding)		58%	
% Undercut Banks		1%	
Shade (% stream enclosed)		91%	

Table 9. S10 Creek habitat unit metrics (December 2006).

Habitat Type	No. Units	Total Length (ft)	Avg. Wetted Width (ft)	Avg. Depth (ft)	No. Large Boulders	Total Wetted Area (ft^2)	% Total Habitat	Substrate (% of Wetted Area)					
								Silt/ Organic	Sand	Gravel	Cobble	Boulder	Bed Rock
Side/Off Channel	none							NA					
Plunge Pool	3	43	16.1	4.5	4	678	3.3%	25	10	33	33	0	0
Straight Scour Pool	1	26	20.0	2.4	0	495	2.5%	29	7	36	29	0	0
Glide	1	30	5.9	1.6	0	172	0.9%	38	13	25	25	0	0
Riffle	3	226	11.2	1.0	16	2,453	12.0%	22	15	24	39	0	0
Rapid	2	302	12.1	0.9	32	3,809	18.6%	14	6	16	54	10	0
Cascade (Boulder)	9	856	13.8	0.8	118	12,772	62.5%	16	0	16	42	25	0
Falls over Bedrock	1	7	5.9	0.6	0	43	0.2%	0	0	0	0	0	100
Total / Average:	**20**[a]	**1,489**[a]	**13.1**[b]	**1.5**[b]	**170**[a]	**20,422**[a]		**19**[b]	**5**[b]	**21**[b]	**38**[b]	**12**[b]	**5**[b]

[a] total
[b] average

3.5.3 Swift Creek

Data from a USFS study conducted in 1995 were summarized in PacifiCorp and Cowlitz PUD (2004, AQU-4 Appendix 1, sheet 23, Swift Creek) and state:

> *Swift Creek is a high gradient (8.4 percent average slope) 4th order stream with an "A" Rosgen channel type. Fish habitat in the accessible portion of Swift Creek is comprised of a mixture of high gradient riffles (52 percent) and pools (42 percent). Cobble and small boulders are the dominant substrate types. Large, stable LWD and spawning gravel is extremely limited. An 80-foot-high waterfall at 1,639 feet blocks the upstream migration of fish into the upper watershed.*

The 1995 USFS survey also reported the average bankfull width as 29.8 feet and the accessible length as 1,639 feet (PacifiCorp and Cowlitz PUD 2004, pages AQU 4-10). The 1995 USFS survey results reflect the steep gradient, lack of gravel and large wood, but did not match our summer 2006 observations of habitat conditions with respect to the riffle/pool ratio. The 1995 data summary reported that 42 percent of the habitat was comprised of pools; however, we only observed about 6 pools in the accessible reach (prior to the November 2006 flood), comprising less than about 5 percent of available habitat by either length or surface area.

Prior to the November 2006 flood, substrate was a fairly equal mixture of cobble, bedrock, and large boulders. A few large pieces of wood and two log jams were present, but provided little habitat function. From the mouth upstream to about 700 feet where the small falls was located, the habitat consisted primarily of long riffles and rapids, 2 scour pools, and 1 large plunge pool at the base of the small 5-foot falls.

A large washout occurred on upper Swift Creek at the Forest Road 83 crossing during the November 2006 flood (http://www.fs.fed.us/gpnf/recreation/autumn-colors/fall-2006-flood-images-02.shtml). Based on the washout photos and our observations at the Swift Creek mouth in mid-November 2006, it is apparent that a large sediment/debris torrent washed through Swift Creek. The large scour pool where the temperature logger was located (approximately 300 feet upstream from the mouth) was buried by approximately 8 to 10 feet of bedload (Photo 18). Sediment filled in about 800 linear feet of reservoir within the Swift Creek Arm up to about the reservoir full pool level. Prior to the flood, the maximum water depth in this area was about 30 feet (Photo 19). The lower rapid section aggraded 6 to 8 feet due to bedload deposition (Photo 20).

We conducted a habitat survey of the accessible portion of Swift Creek on April 3, 2007, but we were only able survey approximately 961 feet of the approximately 1,600-foot-long accessible reach due to unsafe wading conditions. The accessible portion of Swift Creek is located in a steep V-shaped valley that is constrained by steep slopes and rock cliffs. The active channel fills most of the narrow valley bottom (Table 10). Very little riparian vegetation is present along the creek banks due to the narrow valley bottom, presence of cliffs along each bank, and the bank scour that occurred during the November 2006 flood. There are currently no pools present in the lower 961 feet of the accessible reach; this area is now comprised of rapid and cascade habitat units (Table 11). The three pools present during the August and September 2006 presence/ absence surveys were filled in by bedload, primarily cobble. The average gradient of the lower 961 feet is now approximately 4.2 percent. The valley width index is 1, which indicates the lack of a floodplain. The 5-foot falls observed during 2006 in the middle of the accessible reach was eliminated by streambed aggradation caused by the 2006 flood (Photo 21). However, as future high flow events occur, the deposited bedload will likely be scoured and the bedrock falls will emerge. The remaining 700 feet of Swift Creek that was not habitat surveyed was observed to be primarily boulder cascades during the August 2006 snorkel survey (Photo 8), which is suspected to be similar to current conditions.

Photo 18. Former site of 5-foot-deep scour pool on Swift Creek (April 3, 2006).

Photo 19. Swift Creek drawdown zone; blue oval indicates area that was 20 to 30 feet deep prior to November 2006 flood (March 2007).


Photo 20. Lower Swift Creek bedload deposition example after November 2006 flood (left) and before flood (right); red oval and blue line indicate reference points.


Photo 21. Swift Creek bedload deposition at 5 foot falls after November 2006 flood (left) and before flood (right); red and blue ovals indicate reference points.

Table 10. Swift Creek channel, pool, LWD, and other habitat metrics (April 2007).

Channel Metrics	Avg. Wetted	Avg. Active	Avg. Flood Prone
Width (ft)	30.2	44.9	65.6
Depth (ft)	2.6	5.6	11.2
Pool Summary	NA, no pools present		
LWD Summary	**Total**	**No./ Mile**	
No. Pieces ≥ 10 ft x 0.5 ft	37	203	
Volume (ft^3)	9,178	1,429	
No. Key Pieces (≥ 40 ft x 2 ft)	23	127	
Misc. Habitat Metrics			
Avg. Unit Gradient		4.2%	
Width:Depth Ratio		8.3	
Slow Water:Fast Water Unit Ratio		NA, no slow water units	
Entrenchment (active channel width:flood prone width)		2.2	
Bank Condition (% actively eroding)		45%	
% Undercut Banks		0%	
Shade (% stream enclosed)		75%	

Note: includes only the lower 961 feet of the approximately 1,600-foot-long accessible reach

Table 11. Swift Creek habitat unit metrics (April 2007).

Habitat Type	No. Units	Total Length (ft)	Avg. Wetted Width (ft)	Avg. Depth (ft)	No. Large Boulders	Total Wetted Area (ft^2)	% Total Habitat	Substrate (% of Wetted Area)					
								Silt/ Organic	Sand	Gravel	Cobble	Boulder	Bed Rock
Side/Off Channel	none							NA					
Pools	none							NA					
Riffle	none							NA					
Rapid	5	830	30.8	2.2	16	26,835	12%	0	13	8	72	1	6
Cascade (Bedrock)	1	131	27.9	4.9	6	3,626	88%	0	0	0	30	0	70
Total / Average:	**6**[a]	**961**[a]	**30.2**[b]	**2.6**[b]	**22**[a]	**30,462**[a]		**0**[b]	**11**[b]	**7**[b]	**65**[b]	**1**[b]	**17**[b]

Note: includes only the lower 961 feet of the approximately 1,600 foot long accessible reach
[a] total
[b] average

3.5.4 Drift Creek

Data from a USFS habitat survey conducted in 1995 were summarized in PacifiCorp and Cowlitz PUD (2004, AQU-4 Appendix 1, sheet 27, Drift Creek) and stated:

> *Drift Creek is a moderate to high gradient (average 11.2 percent slope) 3rd order stream with an "A/B" Rosgen channel type. Fish habitat in the accessible portion of Drift Creek contains an estimated 41.6 pools/mile, well above USFS Regional Standards. The streambed substrate is dominated by gravel and cobble. LWD is extremely limited. The riparian area adjacent to Drift Creek has been impacted by past timber harvest activities. Stream shading is poor; however, summer water temperatures are well within the State standard.*

The 1995 survey also reported the average bankfull width as 48.1 feet and the accessible length as 8,506 feet (PacifiCorp and Cowlitz PUD 2004, pages AQU 4-10). The 1995 results are not consistent with qualitative habitat observations made during the summer of 2006, or the quantitative habitat measurements made in April 2007 (post flood) including stream slope, pool abundance, and substrate. For example:

1. The current average slope of the lower 4,000 feet averages about 3 percent, and the upper 4,000 feet of the accessible reach averages about 4 percent. Quantitative measurements recorded in April 2007 indicate the average slope of the entire accessible reach to be approximately 2.8 (Table 12) percent, not 11 percent as reported by the 1995 study.
2. Very few pools were observed during the 2006 presence/absence surveys. Large woody debris was recruited into the accessible reach from the November 2006 flood and subsequent scour around the large wood created additional pools. The April 2007 post-flood habitat survey identified 6.4 pools per mile (Table 12), far less than the 41.6 pools per mile reported from the 1995 study.
3. The April 2007 survey identified the dominant substrate as cobble in the lower half of the accessible reach and large cobble/boulder in the upper half of the accessible reach. The 1999 survey reported a gravel-dominated substrate. On average gravel made up approximately 21 percent of habitat unit substrate throughout the accessible reach in April 2007 (Table 13).

The accessible portion of Drift Creek can logically be divided by valley form into two distinct reaches, which are roughly equal in length. The reach divide is located at the road culvert crossing. Downstream of the road crossing, timber harvest has recently occurred, the creek flows through a broader valley and the channel slope is gradual. Upstream of the road crossing, timber harvest has not occurred for decades, the stream is confined by steep hill slopes, and the channel slope is steeper.

The November 2006 flood altered the habitat in the lower reach of Drift Creek. Prior to the flood there were no pools in the lower 800 feet of the accessible reach, and very little large woody debris. However, several large trees were recruited into the lower portion of Drift Creek from an apparent land slide at the confluence of a tributary located approximately 900 feet upstream from Swift Creek Reservoir (Photos 24). The new large wood and subsequent scour created 3 pool units in this lower reach with residual pool depths greater than 3 feet. A very large log jam located approximately 2,000 feet upstream of the reservoir was also somewhat broken up and the wood redistributed downstream by the flood.

Under post-flood conditions, the channel gradient throughout the accessible reach of Drift Creek averages 2.8 percent (Table 12); the lower reach averages approximately 2.2 percent, while the upper reach averages approximately 3.4 percent. The lower reach is unconstrained in a broader valley, but the creek flows predominately through a single channel with multiple terraces on either side (Photo 22). Some side channel habitat is present (Photo 25). The upper reach is located in a steep V-shaped valley with a narrow floor constrained by hill slopes (Photo 23). The upper reach of Drift Creek is dominated by rapids and cascades with few pools or key habitat-forming large woody debris pieces (Photo 23). The valley width index of the lower reach averages 2, but ranged from 1 to 4, indicating some floodplains exist. The upper reach has a valley width index of 1, ranging from 1 to 2, indicating there is very little floodplain.

Riparian vegetation in the lower reach is dominated by sparse shrubs (primarily salmonberry and alder, with a few trees), while the vegetation on the hill slopes is dominated by newly planted coniferous trees (the lower reach probably was harvested within the last 15 years). The upper reach hill slopes are dominated by larger mature coniferous trees averaging approximately 2 to 3 feet dbh. While some pool development has occurred as a result of the November 2006 flood, stream habitat is dominated by fast water units, primarily riffles and rapids in the lower reach (Photo 22), and rapids and cascades in the upper reach (Photo 23). Drift Creek apparently can experience very high flow events, as indicated by large logs perched within the channel (Photo 26). This evidence, coupled with the overall lack of gravel and coarseness of the substrate within the accessible reach, suggests that gravel scour within the accessible reach is relatively high.

Table 12. Drift Creek channel, pool, LWD, and other habitat metrics (April 2007).

Channel Metrics	**Avg. Wetted**	**Avg. Active**	**Avg. Flood Prone**
Width (ft)	27.2	43.3	61.0
Depth (ft)	2.8	3.9	7.2
Pool Summary	**Total**	**No. /Mile**	
No. Pools	9	6.4	
No. Pools ≥3 ft deep	9	6.4	
No. of Complex Pools (≥3 LWD pieces present)	2	1.4	
Pool Frequency (channel widths/pool)		18.9	
Avg. Residual Pool Depth (ft)		3.1	
LWD Summary	**Total**	**No./ Mile**	
No. Pieces ≥ 10 ft x 0.5 ft	244	209	
Volume (ft^3)	36,536	31,409	
No. Key Pieces (≥ 40 ft x 2 ft)	65	56.3	
Misc. Habitat Metrics			
Avg. Unit Gradient		2.8%	
Width:Depth Ratio		11	
Slow Water:Fast Water Unit Ratio		0.10	
Entrenchment (active channel width:flood prone width)		1.4	
Bank Condition (% actively eroding)		10%	
% Undercut Banks		0%	
Shade (% stream enclosed)		53%	

Photo 22. Drift Creek typical habitat downstream of culvert (April 3, 2007).

Photo 23. Drift Creek typical fast water habitat upstream of culvert (April 3, 2007).

Photo 24. Drift Creek large woody debris recruited during November 2006 flood (April 3, 2007).

Photo 25. Drift Creek side channel habitat unit downstream of culvert (April 4, 2007).

Photo 26. Drift Creek evidence of periodic high flow level downstream of culvert (April 4, 2007).

Table 13. Drift Creek habitat unit metrics (April 2007).

Habitat Type	No. Units	Total Length (ft)	Avg. Wetted Width (ft)	Avg. Depth (ft)	No. Large Boulders	Total Wetted Area (ft^2)	% Total Habitat	Substrate (% of Wetted Area)					
								Silt/ Organic	Sand	Gravel	Cobble	Boulder	Bed Rock
Side/Off Channel	5	1,200	6.6	NA	10	7,726	4.1%	13	22	41	22	3	0
Lateral Scour Pool	1	26	29.8	4.5	0	742	0.4%	5	10	45	40	0	0
Plunge Pool	1	39	29.8	6.5	0	1,194	0.6%	20	20	35	20	5	0
Straight Scour Pool	7	384	27.6	4.6	27	10,900	5.7%	9	15	23	43	11	0
Glide	2	164	29.8	2.9	8	4,928	2.6%	8	10	38	38	8	0
Riffle	7	640	30.2	3.0	53	20,014	10.5%	7	11	16	55	11	0
Riffle with Pockets	3	505	34.8	3.0	39	18,669	9.8%	8	15	28	28	10	10
Rapid	8	1,260	27.2	1.9	106	34,314	18.0%	4	5	13	59	19	0
Cascade (Bedrock)	1	151	24.9	1.8	1	3,734	2.0%	0	0	5	5	0	90
Cascade (Boulder)	20	2,913	29.2	2.6	633	86,188	45.3%	7	7	15	40	28	2
Culvert Crossing	1	59	29.8	1.5	16	1,797	0.9%	5	10	25	40	20	0
Total / Average:	**56**[a]	**7,341**[a]	**27.2**[b]	**2.8**[b]	**893**[a]	**190,205**[a]		**8**[b]	**10**[b]	**21**[b]	**42**[b]	**17**[b]	**3**[b]

[a] total
[b] average

3.6 QHA ANALYSIS

The Lewis River QHA analysis was developed during a one day workshop that brought together local managers and scientists with a detailed knowledge of Lewis River tributaries and with experience in bull trout management.

Brooks, S10, Drift, and Swift creeks were carried forward into the QHA analysis phase. QHA participants were asked to divide the streams into reach segments representing tributary confluences or significant changes in topography or valley form, which was determined from the habitat surveys conducted under this study. Seven reaches were identified for assessment. Brooks Creek was divided into 3 reaches based on tributary flow including: 1) Lower Brooks Creek (Brooks Creek mouth upstream to the B1 Creek confluence; 2) B1 Creek (B1 Creek from its confluence with Brooks Creek upstream to the natural salmonid barrier); and 3) Upper Brooks Creek (Brooks Creek from the B1 Creek confluence upstream to the natural salmonid barrier). Drift Creek was divided into 2 reaches based on valley form including: 1) Lower Drift Creek (Drift Creek mouth upstream to the road crossing), and 2) Upper Drift Creek (upstream of the road crossing to the natural salmonid barrier). Swift and S15 creeks consisted of only one reach each, extending from the mouth of each creek upstream to the natural salmonid barrier (see Appendix A). See Appendix C for reaches delineated in Brooks and Drift creeks.

During the QHA workshop, participants relied on their knowledge and professional judgment to develop a species hypothesis (Table 14). The species hypothesis defines bull trout life stages and habitat attributes most important to each life stage with regard to successful bull trout spawning, incubation, and rearing in tributary streams within the Lewis River basin and specifically within the candidate stream reaches assessed using QHA (Table 14). Participants weighted life stages in terms of overall importance to successful juvenile bull trout production within tributary stream (Table 14). Participants concluded that habitat conditions were most critical for the egg incubation life stage and gave it a higher weight than other life stages. For each life stage, attributes from Table 14 were ranked for importance. A ranking of 2 indicates that an attribute was critically important to a bull trout life stage. A blank indicates that the attribute was not the most important to the success of the life stage (only the attributes thought to be most important for the successful completion of each life stage were ranked). A second component of the hypothesis was to describe the geographic distribution of the life stages within each reach. Because of the limited geographic area within each reach, the group assumed that all life stages were equally likely to occur in all reaches.

QHA participants developed definitions and rating scores for each habitat attribute (Table 15). These rating scores were used to rate current habitat conditions within each stream reach, relying heavily on the habitat data collected under this study (Table 16). Secondly, the participants used their professional judgment to rate the habitat within each stream reach as it most likely would have occurred under a natural historic state (i.e. without anthropogenic modifications). This is termed the "reference" condition (Table 16). In most cases, reaches received the highest functional rating of "4" for the reference condition; however, in some cases, geologic or other intrinsic conditions warranted a lesser rating.

Table 14. Bull trout habitat hypothesis; life stage importance ranking and habitat attribute weighting by life stage (determined by QHA group consensus).

	Incubation	Juvenile Summer Rearing	Juvenile Winter Rearing	Adult Migration and Spawning
Life Stage Rank[a]	4.0	3.0	3.0	3.0
Relative Importance Weighting of Each Attribute to Each Life Stage[b]				
Habitat Types		1.5	1.5	1.5
Channel Stability	1.3		1.0	
Cover and Structure		1.5	2.0	1.0
Fine Sediment	1.5			
High Flow	1.8		1.5	
Low Flow		2.0		2.0
Summer Temperature		2.0		
Fall Temperature	2.0			2.0
Riparian		1.0		
Fragmentation				1.5

Note: A "biological community" attribute (primarily the presence of non-native fish species such as brook trout) was considered along with the habitat attributes above, but was discarded for the QHA analysis because the presence/absence surveys conducted under this study found no non-native fish species within the candidate streams.

[a] Rank of importance of each life stage to successful bull trout production in tributary streams in the Lewis River basin, with a rank of "4" as the most important life stage.

[b] Weighting of habitat attributes by importance to the successful completion of each life stage, with a rank of "2" as the most important habitat attribute. Only the parameters considered most directly related to a specific life stage were weighted.

Table 15. Attributes, definitions and rating used to rate stream habitat conditions within potential bull trout spawning and rearing streams.

Attribute	Definition	Attribute Rating				
		0	1	2	3	4
Habitat Types	Diversity and availability of habitat types	Simplified channel with single dominant habitat type	Simplified channel with low diversity of habitat types	Channel with moderate diversity of habitats	Channel with structure and diversity of habitats including side channels	Channel with ample structure and diversity of habitats including side channels
Channel Stability	Stability and nature of channel form	Highly constrained, simplified channel	Highly unstable channel with deep scour	Generally stable channel form with moderate scour	Stable channel form with rare scour	Channel in dynamic equilibrium
Cover and Structure	Amount of vegetative, channel or rock structure producing cover and habitat complexity	Simple, hardened channel, no structure	Occasional wood and rocks but little overall structure	Some channel complexity and large wood	Moderate large wood and cover	Abundant large wood and cover (undercut banks, boulders, etc.)
Fine Sediment	Fine sediment in riffles	Not defined	Abundant fine sediment producing embedded and buried riffles	Moderate level of fine sediment resulting in some embedded riffles	Lower level of fine sediment with little embeddedness	Very low fine sediment and no embeddedness
High Flow	Peak and high flow level	Greatly increased flood frequency with deep scour	Moderately increased flood frequency with significant scour	Occasionally floods with significant scour	Occasional floods and deep scour	Normative flood frequency without deep scour
Low Flow	Summer low flow level	Extended periods of dry channel	Brief periods of dry channel	Occasional dry channel periods	Stream channel normally wetted but low in summer	Abundant flow during summer
Summer Temperature	Summer maximum water temperature	≥20°C	≥18 to <20°C	≥16 to <18°C	≥14 to <16°C	<14°C
Fall Temperature	Maximum water temperature by spawning time	>13°C by spawning	Not defined	≥9 to <13°C by spawning	Not defined	<8°C by spawning
Riparian	Riparian vegetation composition	No riparian vegetation	Sparse, poorly functioning riparian forest	Moderate riparian forest, alder, conifer mix	Maturing riparian forest	Normative, mature riparian forest
Fragmentation	Migration blockages	Highly fragmented by natural or features	Significant fragmentation by natural features	Moderate fragmentation by natural features	Little fragmentation by natural features	No fragmentation by natural features

Table 16. Attribute ranking of current and reference habitat conditions of potential bull trout spawning and rearing stream reaches.

	Current Habitat Rating (based QHA group consensus rating of habitat survey data summarized in this report)										Reference Habitat Rating (based on QHA group consensus of reach potential under historic conditions)									
Reach Name	**Habitat Types**	**Channel Stability**	**Cover and Structure**	**Fine Sediment**	**High Flow**	**Low Flow**	**Summer Temperature**	**Fall Temperature**	**Riparian**	**Fragmentation**	**Habitat Types**	**Channel Stability**	**Cover and Structure**	**Fine Sediment**	**High Flow**	**Low Flow**	**Summer Temperature**	**Fall Temperature**	**Riparian**	**Fragmentation**
Lower Brooks Creek (stream mouth to confluence with B1 Creek)	1.0	3.0	1.5	4.0	3.5	2.5	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0	2.0	4.0	4.0
B1 Creek (upstream of confluence with Brooks Creek to salmonid barrier)	1.0	3.0	1.0	4.0	3.5	1.0	2.0	2.0	1.5	3.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0	2.0	4.0	4.0
Upper Brooks Creek (upstream of B1 Creek confluence to salmonid barrier)	1.0	3.0	1.0	4.0	3.5	1.0	2.0	2.0	1.0	3.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0	2.0	4.0	4.0
Lower Drift Creek (stream mouth to road crossing)	1.5	2.0	2.0	2.0	2.0	3.0	2.0	3.0	1.0	3.5	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.5	4.0	4.0
Upper Drift Creek (upstream of road crossing to salmonid barrier)	1.5	1.5	2.0	4.0	3.0	3.0	2.0	3.0	3.0	4.0	4.0	3.0	3.0	4.0	4.0	4.0	3.0	3.5	4.0	4.0
Swift Creek (stream mouth to salmonid barrier)	0.5	1.0	1.0	3.0	1.0	4.0	4.0	4.0	4.0	3.0	1.0	2.0	1.5	3.0	2.0	4.0	4.0	4.0	4.0	3.0
S10 Creek (stream mouth to salmonid barrier)	1.5	1.0	4.0	1.5	3.0	2.5	4.0	3.0	4.0	3.0	4.0	3.0	4.0	4.0	4.0	3.0	4.0	4.0	4.0	3.0

The QHA methods uses the species hypothesis to weight current and reference habitat condition scores and ranks each stream reach against one another with respect to protection and restoration value (Table 17). The QHA score is computed as follows:

$$\text{QHA Reach Score}_{ij} = (\text{Reference}_{ij} - \text{Current}_{ij}) * \text{LSWeight}_{ijk}$$

Where the Score is for reach *i* for attribute *j*, Reference is the attribute score for the reach and attribute for the Reference Condition, and Current is the attribute score for the reach and attribute for the Current Condition. LSWeight is the weight developed in the species hypothesis (Table 14) to the attribute *j* for a life stage *k* using the reach *i*. This equation results in a number that provides a relative indication of the effect of the current condition relative to the reference condition weighted by how the expert participants viewed the bull trout-habitat relationship. The reach score is the simple sum of the individual attribute scores. These scores are then converted to a user-friendly whole number ranking system for the final summary output.

In the final summary output (Table 17), reaches are ranked against each other in regard to protection (the risk of further degradation of the reach) and restoration (the value of restoring the reach for the species). In turn, habitat attributes are ranked for importance within each reach. Habitat attribute rankings for protection describe what is considered good (i.e. functional habitat attributes) within a reach, while attribute rankings for restoration describe limiting habitat factors that could be addressed through restoration. A rank of "1" for habitat protection indicates the habitat is functioning at its greatest potential and rates high for habitat protection, while a rank of "1" for habitat restoration denotes the reach could most benefit from restoration. For example, S10 Creek rated highest for habitat protection when compared to all other reaches, and the "Cover and Structure" attribute was rated as the most functional habitat attribute. Regarding habitat restoration potential, Lower Drift Creek received the highest rank of "1" for restoration because this reach would benefit the most from restoration when compared to all other reaches, and the "Habitat Types" attribute was the most limiting feature of this reach.

Upper Drift Creek, Lower Brooks Creek, and S10 Creek received the highest protection rankings (protection of current condition) while Lower Drift Creek, Upper Brooks Creek and B1 Creek had the highest restoration ranks (i.e. these reaches would most benefit from restoration). Lack of complex habitat types and cover and structure were the most common limiting factors. Figure 6 provides a graphical depiction of the protection and restoration rankings for each reach.

Table 17. Habitat protection and restoration ranking by reach and by parameter within each reach for potential bull trout spawning and rearing stream reaches.

	Protection Ranking (reach rank 1 = highest functional rating and highest priority to protect existing conditions)											**Restoration Ranking** (reach rank 1 = reach most degraded and would benefit most from restoration)										
Reach Name	**Reach Rank**	Habitat Types	Channel Stability	Cover and Structure	Fine Sediment	High Flow	Low Flow	Summer Temperature	Fall Temperature	Riparian	Fragmentation	**Reach Rank**	Habitat Types	Channel Stability	Cover and Structure	Fine Sediment	High Flow	Low Flow	Summer Temperature	Fall Temperature	Riparian	Fragmentation
Lower Brooks Creek	3	8	4	6	5	1	2	9	3	10	7	4	1	3	2	8	7	4	4	8	4	8
B1 Creek	6	6	3	6	4	1	8	8	2	10	5	3	1	4	1	9	7	3	6	9	5	8
Upper Brooks Creek	7	6	3	6	4	1	8	8	2	10	5	2	1	5	1	9	7	3	6	9	4	8
Lower Drift Creek	5	5	6	3	8	4	2	8	1	10	7	1	1	4	2	5	3	5	9	8	7	10
Upper Drift Creek	2	6	8	4	5	3	2	9	1	10	7	5	1	3	2	9	5	4	7	6	8	9
Swift Creek	4	10	9	6	4	8	2	3	1	7	5	7	3	2	3	5	1	5	5	5	5	5
S10 Creek	1	6	10	1	9	3	4	5	2	8	7	6	1	2	7	3	5	6	7	4	7	7

Note: Reaches are ranked vertically (Reach Rank) in regard to protection and restoration priority between reaches. Within each reach, attributes are ranked horizontally in regard to their contribution to the overall reach rank.

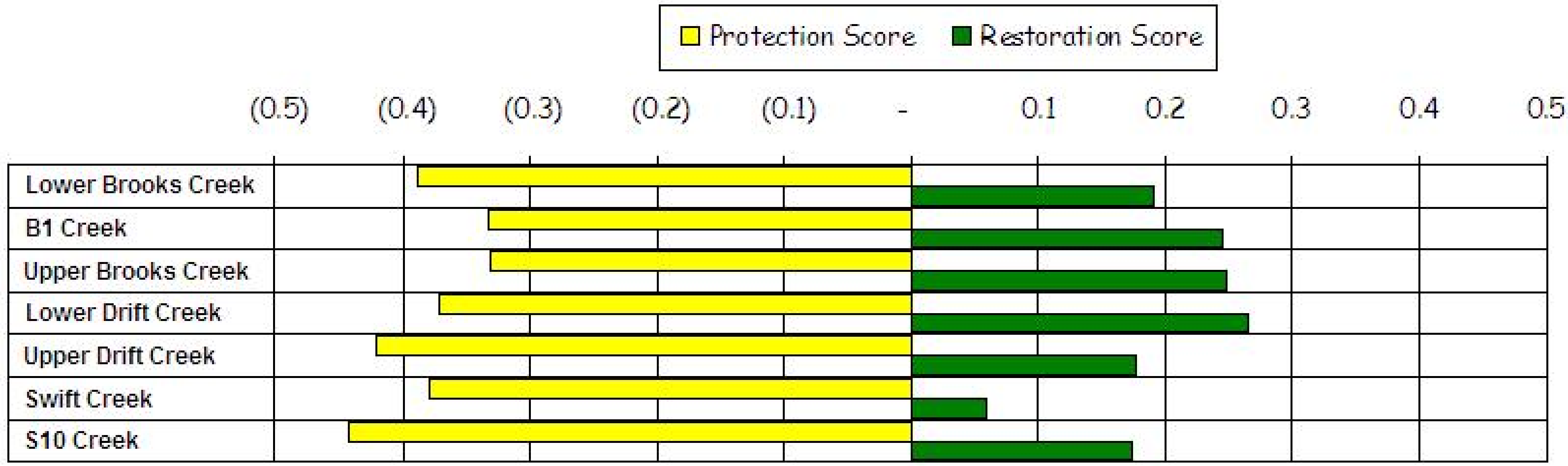


Figure 6. Tornado chart depicting protection and restoration ranking of scores presented in Table 17.

4.0 DISCUSSION

4.1 WATER TEMPERATURE MONITORING RESULTS AND BULL TROUT PRESENCE/ABSENCE

As described in Section 3.4.2, bull trout were only found in Swift Creek during the 2006 presence/absence surveys. Swift Creek is the only tributary in this analysis that met the "optimal" criteria for both summer maximum rearing temperatures (≤16°C) and fall spawning temperatures (≤10°C) (Table 1), and that had sufficient flow for fish to enter the stream from the reservoir during the late summer and early fall. Swift Creek had approximately 5 to 10 times the amount of base flow than the next largest study tributary that met at least the "marginal" criteria (Drift Creek). The fact that we found no bull trout in the three streams with temperatures barely exceeding 18°C (rated as "poor" for juvenile bull trout rearing) supports the hypothesis that tributaries with water temperatures exceeding 18°C would not contain bull trout.

Results of this study are also consistent with other studies conducted in the upper Lewis River basin in which bull trout were not found in streams with maximum temperatures >17.5°C, but were found in streams with temperatures <16°C. For example, Clearwater BioStudies snorkeled 4 streams in the upper Lewis River basin for bull trout presence/absence (Big Rock, Swampy, Big Spring, and Cussed Hollow creeks); however, water temperature was only continuously monitored using an electronic logger in Cussed Hollow Creek (Clearwater BioStudies 2002, page 3 and 14). Cussed Hollow Creek had a summer maximum temperature of 17.6°C and no bull trout were found (Clearwater BioStudies 2002, page 18 and 14). Bull trout were not found in any of the streams sampled during the Clearwater BioStudies surveys.

A temperature monitoring study conducted by Hiss et al. (2005) summarized water temperature data for Pine and Rush creeks, where bull trout spawning and rearing is known to occur. A temperature logger in Rush Creek (upstream of FR 90 bridge) had a maximum temperature of 9.8°C in 1994 within known spawning and rearing habitat (Hiss et al. 2005, page 24). Data from the summer of 2005 showed that water temperatures in Rush Creek were <13°C (J. Byrne, WDFW, ScCS PowerPoint presentation 2006, unpublished data). Hiss et al. (2005, page 23 to 28) also summarized daily maximum water temperatures for several locations (covering various years during summer) throughout the Pine Creek drainage that is known to provide bull trout spawning and rearing habitat. The daily maximum water temperature at all sites was <16°C.

Results from Dunham et al. (2003)[4] provides further insight into the relationship between stream temperature and bull trout occurrence. The focus of Dunham and Chandler (2001, page 2) was on small bull trout (<150 mm in length) and spawning and early rearing habitat throughout Washington. The distribution of small bull trout was thought to represent the distribution of spawning and early rearing habitat, factors most essential for population persistence. These habitats are also used year round by bull trout, so habitat

[4] Dunham et al. 2003 is an expansion of work originally reported in Dunham and Chandler 2001.

conditions must be suitable at all times. Dunham et al. (2003, page 895) modeled the distribution of small bull trout in relation to maximum summer water temperatures, occurrence of native and non-native salmonids, large wood, undercut banks, levels of fine sediment, and stream width (an index of stream size). This collection of variables reflects a broad spectrum of potential habitat-related influences on bull trout that have been referenced in the literature. Dunham and Chandler (2001, page 4) sampled 109 sites within 6 streams across a broad range of environmental variation throughout the state of Washington, sampling habitat characteristics and occurrence of bull trout in streams ranging from the Blue Mountains in southeast Washington to streams on the Olympic Peninsula in western Washington. Model selection analysis using logistic regression indicated that summer maximum temperature was the most likely factor to explain patterns of occurrence for juvenile bull trout (Dunham and Chandler 2001, page 15). Dunham et al. (2003, page 897 and 898) reported that of 109 samples sites scattered throughout Washington, the maximum daily temperature at which small bull trout were found was 17.5°C. The Dunham et al. (2003, page 900) model predictions of small bull trout presence/absence imply that although bull trout may be present at potentially lethal temperatures, the probability of occurrence is relatively low (e.g., 50 percent) at maximum daily temperatures above approximately 14 to 16°C. The probability of small bull trout occurrence does not become high (e.g., 75 percent) until the maximum daily temperature drops to approximately 11 to 12°C (Dunham et al. 2003, page 900).

The results of the presence/absence survey and temperature monitoring conducted in the tributaries to Lake Merwin and Swift Creek Reservoir under this study are consistent with the results presented in Dunham et al. (2003), as no bull trout were observed in streams with maximum water temperatures >17.5°C (i.e. Indian George, Jim, Range and Drift creeks). Similarly, Dunham et al. (2003, page 901) predicted less than a 50 percent chance that small bull trout would occur in streams with maximum water temperatures >16°C. Both Brooks Creek and the upper portion of Drift Creek had maximum temperatures above 16°C and no bull trout were found in these streams.

The only tributary found to contain bull trout in the study area (i.e. Swift Creek) had a maximum temperature of 11.5°C during summer of 2006. Based on a maximum summer temperature of 11.5°C, the Dunham et al. (2003, page 900) Washington-specific presence/absence model predicts about a 75 percent chance of small bull trout presence. However, we did not observe small bull trout (i.e. <150 mm) in Swift Creek, only large bull trout between 400 to 600 mm in length. These observations of reproductive-sized bull trout holding in Swift Creek during the known Lewis River spawning period strongly suggest that these fish may have been staging to spawn in Swift Creek. Bull trout greater than 400 mm in length are thought to be primarily piscivourous; the lack of abundant forage fish within Swift Creek during the time of the bull snorkel observations suggests these bull trout were not primarily foraging within Swift Creek. Yet the lack of juvenile bull trout suggests that either bull trout are not spawning in Swift Creek or that a few attempt to spawn. Other factors may limit spawning/incubation success and recruitment to the juvenile rearing stage.

In 2006, S10 Creek had a maximum summer water temperature of 11.8°C. The Dunham et al. (2003, page 901) Washington-specific presence/absence model predicts about a 75 percent probability that juvenile bull trout would be present in S10 Creek; however, we found none. This absence may be due to low flows during the normal start of the spawning period (i.e. August and September). Flow during this period was intermittent within the accessible reach of S10 Creek, precluding upstream migration from the reservoir (note that low flow also limited access into Brooks Creek during this time period).

Buncombe Hollow, Cape Horn, Indian George, Jim, M4, M14, Range and S15 creeks all rated "poor" for bull trout juvenile rearing because each had summer maximum water temperatures >18°C and contained no appreciable cold water refugia. Based on the results of Dunham et al. (2003), there is a low probability that juvenile bull trout would be found in streams with maximum water temperatures >18°C in Washington. Therefore, we conclude that all streams rated as "poor" for bull trout summer rearing water temperatures have a low probability of providing long-term bull trout spawning, incubation, and rearing habitat. We further conclude that there is no feasible habitat restoration or protection strategy to substantially lower a stream's water temperature regime to the level that Dunham et al. (2003) suggests would be much more likely to support juvenile bull trout (i.e. 14 to 16°C or colder). Therefore, we conclude that Buncombe Hollow, Cape Horn, Indian George, Jim, M4, M14, Range and S15 creeks have little or no potential to provide successful long-term bull trout spawning, incubation, and rearing habitat.

Based on the in-situ logger data and cold water refugia surveys, Brooks, Swift, S10, and Drift creeks could potentially support rearing juvenile bull trout. This conclusion is based on the presence of relatively cool summer maximum water temperatures, with S10 and Swift creeks having the greatest potential due to temperatures less than 12°C during summer. Therefore, these four streams were carried forward to the QHA phase to determine if there are other habitat factors that may limit spawning, incubation, and rearing potential within these streams. These limiting factors are discussed in the following section.

4.2 QHA ANALYSIS OF HABITAT LIMITING FACTORS

4.2.1 Brooks Creek Limiting Factors

According to the QHA analysis, the attribute that would most benefit from restoration in all reaches of Brooks Creek (Lower Brooks, Upper Brooks, and B1 Creek) is Habitat Types (ranked “1” for restoration) (Table 17). Over 85 percent of available habitat is comprised of fast water habitat units, such as riffles, rapids, and cascades. The Cover and Structure attribute was ranked second (i.e. "2") for restoration priority in Brooks Creek because there was very little wood (only 2 key pieces) and limited areas of undercut banks along the stream channel. These attributes can be corrected with active habitat enhancement measures, such as LWD and boulder placement, and restoration of the riparian zone to increase natural LWD recruitment over the long-term. However, the Brooks Creek accessible reach (including B1 Creek) suffers from a severe lack of flow during the summer (see Section 3.5.1).

During late summer, most of the accessible length of Brooks and B1 creeks were intermittent or dry, with some isolated pools. Flow was so low at the mouth of Brooks Creek in September 2006 that kokanee and one adult Chinook could not ascend the creek and were forced to hold in the reservoir near the creek's mouth. While cutthroat trout and coho are known to readily use seasonally flowing stream reaches for spawning and isolated pools for rearing, bull trout are not known to do so.

It is clear that additional flow would be needed in Brooks Creek in the late summer and fall to support adult bull trout migration and spawning. During project relicensing, Pratt (2003) discussed the feasibility of adding additional flow to Rain and Ole creeks (two small tributaries entering the Lewis River bypass reach) to facilitate upstream migration during the bull trout spawning period. Similar to Brooks Creek, potential bull trout spawning, incubation, and rearing within Rain and Ole creeks was thought to be limited by late summer and fall low flows. Pratt (2003) concluded that adding flow to Rain and Ole creeks from outside sources such as pumped river or reservoir water was not biologically feasible, as the added water would be too warm to initiate spawning. Pratt (2003) also noted that water temperatures above 8°C in these streams during the bull trout incubation period would severely limit egg survival. Like Rain and Ole creeks, there is no known flow augmentation source that could be used to provide Brooks Creek with enough cold water to support successful bull trout spawning and incubation. Water temperatures would need to be less than approximately 9°C during the spawning period (late August through October) and less than 6°C during the egg incubation period.

While Brooks Creek does contain sufficient flow for adult bull trout upstream migration after the fall rains begin (probably starting in October), high water temperatures during the incubation period likely would limit egg survival. As noted previously, the Brooks Creek thermographs were lost during the November 2006 flood; however, incubation period water temperature data are available for Cape Horn Creek. Fall water temperatures within Brooks and Cape Horn creeks were very similar in September, although Cape Horn Creek was slightly colder in the latter part of September (Figure 7). In October and November, water temperature in Cape Horn Creek was generally well above 8°C. We performed a regression analysis between the Cape Horn Creek and Brooks Creek Mouth thermographs to predict water temperatures that would likely have occurred in Brooks Creek from late-September to mid-November 2006 (Figure 8). The lower 95 percent confidence level for the predicted temperature values was generally greater than 8°C (Figure 8), and the average lower 95 percent confidence interval temperature after October 15, 2006 was 8.7°C.

As stated in the Pratt (2003) review of the scientific literature on bull trout egg incubation temperature requirements, bull trout egg survival was less than 15 percent when water temperatures during incubation reached 8°C (McPhail and Murray 1979). Assuming bull trout could enter Brooks Creek and spawn in September and October under some flow augmentation scenario that would allow successful upstream migration and spawning, natural flows after the fall rains begin would likely be too warm for successfully egg incubation. This assumption follows the logic in Pratt (2003) where incubation temperatures greater than approximately 6°C would greatly reduce bull trout egg survival. This is an important finding, because even if habitat enhancement projects were initiated in Brooks Creek to improve the Habitat Types and Cover and Complexity attributes (which QHA showed to be the most in need of physical restoration) egg incubation temperature would still limit incubation success, precluding long-term bull trout production in Brooks Creek. Based on the available data, we conclude that long-term bull trout spawning, incubation, and rearing success within Brooks Creek is primarily limited by warm water temperatures in the late fall and winter, which would likely result in low egg survival.

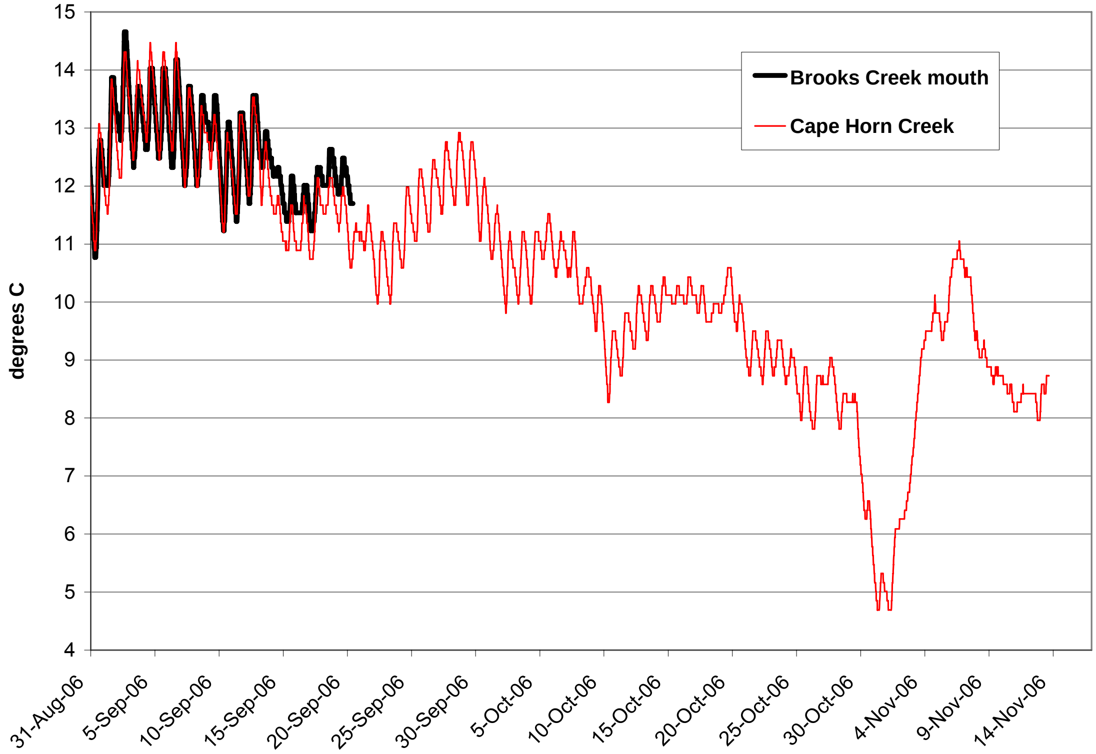


Figure 7. Brooks Creek and Cape Horn Creek 2006 thermograph data during the potential bull trout spawning period and onset of egg incubation period.

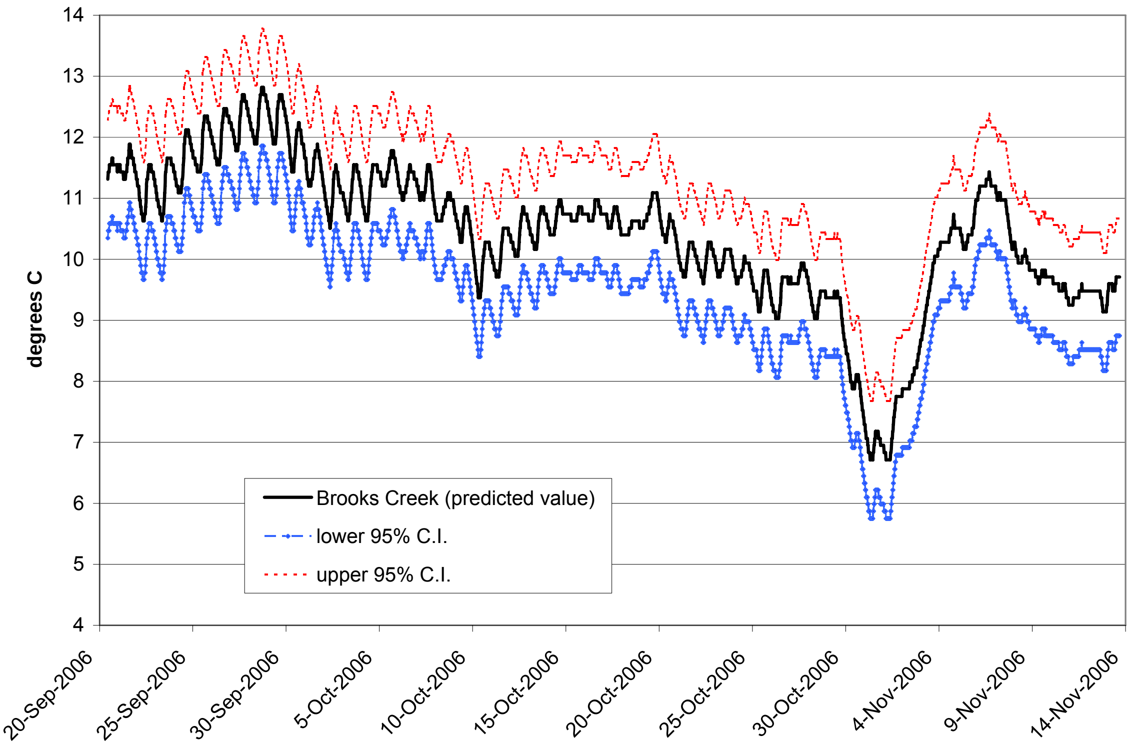


Figure 8. Brooks Creek (mouth) predicted temperatures based on linear regression of Cape Horn Creek and Brooks Creek summer 2007 data (linear regression R^2 = 0.88), including 95% confidence interval.

4.2.2 Drift Creek Limiting Factors

Lower Drift Creek ranked the highest of all reaches (i.e. "1") for restoration. The attributes that would most benefit from restoration in Lower Drift Creek are the Habitat Types and Cover and Structure attributes. Lower Drift Creek is approximately 4,000 feet long and is mostly comprised of long riffles and rapids, with essentially no undercuts banks. Although LWD is present, it is mostly located in a few large accumulations and not well distributed throughout the reach. These types of attributes can be corrected with active habitat enhancement measures, such as LWD and boulder placement projects, and restoration of the riparian zone to increase natural LWD recruitment over the long-term. However, the Drift Creek accessible reach appears to suffer from poor egg incubation temperatures.

While Drift Creek is a rain dominated system similar to Brooks Creek and Cape Horn Creek, the subbasin is larger and summer low flows are greater. Drift Creek has perennial surface flow and does not have the low flow migration barrier issues found in Brooks Creek. However, because it is a rain-dominated system, stream temperatures are similar to Cape Horn and Brooks Creek. We performed a regression analysis between the Cape Horn Creek and Drift Creek Mouth thermographs to predict water temperatures that would likely have occurred in Lower Drift Creek from late-September to mid-November 2006 (Figure 9). The lower 95 percent confidence level for the predicted temperature values was generally greater than 8°C (Figure 9), and the average lower 95 percent confidence interval temperature after October 15, 2006 was 7.7°C. While this is about 1°C colder than Brooks Creek, incubation temperatures in this range would still likely result in substantial bull trout egg mortality following the incubation temperature rational in (Pratt 2003). Similar to the analysis for Brooks Creek, even if habitat enhancement projects were initiated in Lower Drift Creek to improve the Habitat Types and Cover and Complexity attributes (which QHA showed to be most in need of physical restoration) egg incubation temperature would still limit incubation success, precluding long-term bull trout production in Lower Drift Creek.

Upper Drift Creek is about 4,000 feet long and water temperatures recorded at the downstream end after August 31, 2006 were 1.0° (standard deviation = 0.48) colder than temperatures recorded at the mouth of the Creek. Based on regression with Cape Horn Creek data, the lower 95 percent confidence level for the predicted temperature values was generally greater than 7°C (Figure 10), and the average lower 95 percent confidence interval temperature after October 15, 2006 was 6.6°C. While somewhat colder than Lower Drift Creek for incubation temperature, Pratt (2003) determined that temperatures would have to be consistently below 6°C during the egg incubation period to have a good chance for substantial egg survival. Given that the predicted temperature in Upper Drift Creek is generally above 7°C (Figure 10) during the onset of incubation, high egg mortality is likely.

We are unaware of a flow augmentation water source that could be used to cool Drift Creek water temperatures to 6°C or less during the bull trout egg incubation period. Based on the available data, we conclude that long-term bull trout spawning, incubation, and rearing success within Drift Creek is primarily limited by warm water temperatures in the late fall and winter, which would likely result in low egg survival.

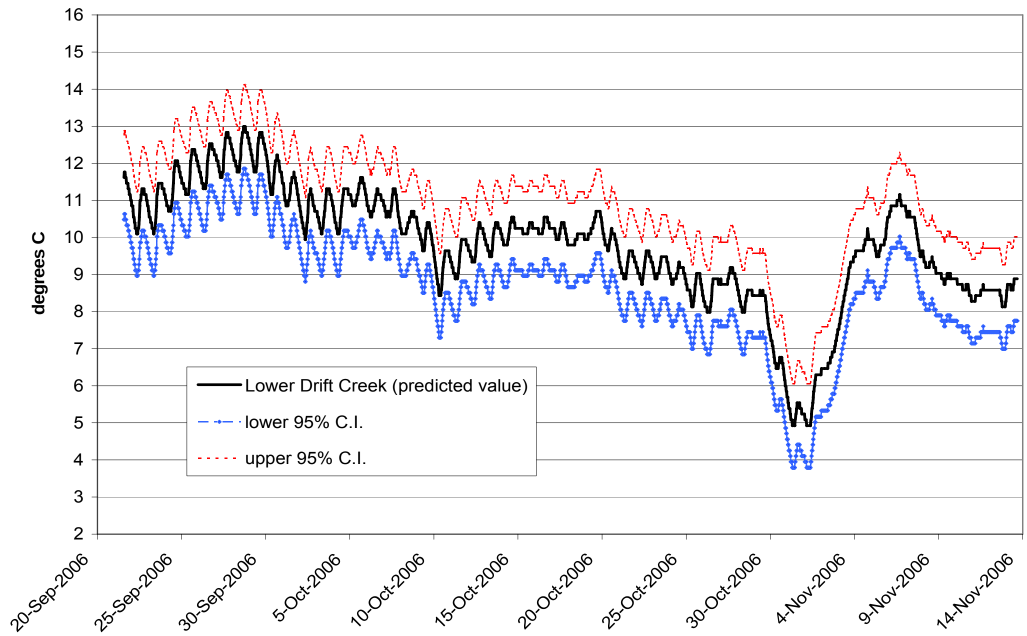


Figure 9. Lower Drift Creek predicted temperatures based on linear regression of Cape Horn Creek and Drift Creek summer 2007 data (linear regression $R^2 = 0.84$), including 95% confidence interval.

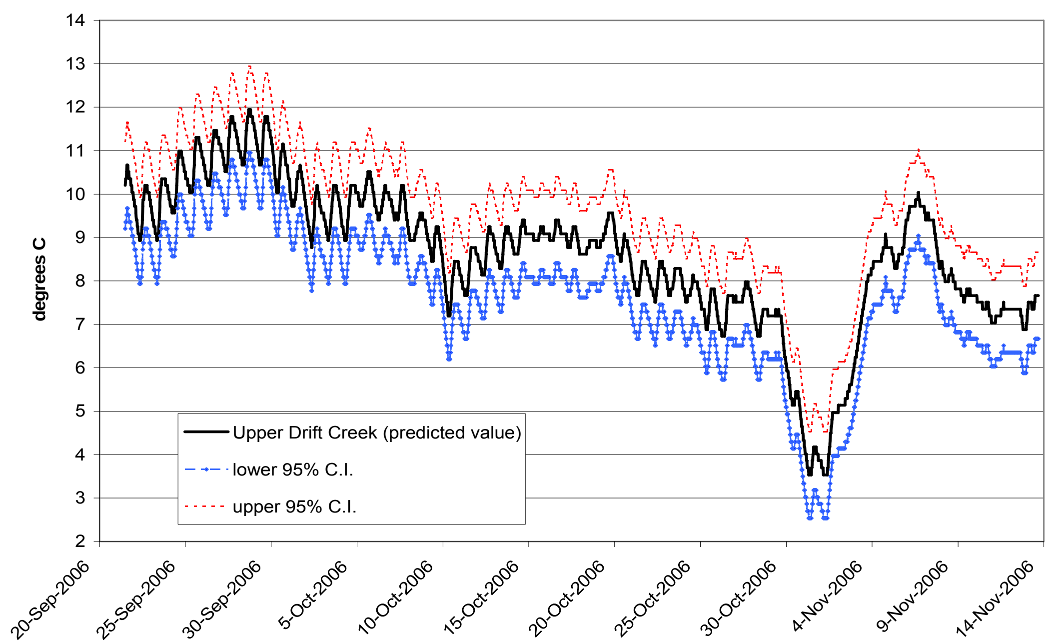


Figure 10. Upper Drift Creek predicted temperatures based on linear regression of Cape Horn Creek and Drift Creek summer 2007 data (linear regression $R^2 = 0.88$), including 95% confidence interval.

4.2.3 S10 Creek Limiting Factors

Out of the seven stream reaches assessed using QHA, S10 Creek ranked highest for habitat protection primarily because the accessible reach is highly complex with abundant cover and structure. The water temperatures in S10 Creek also remain cool throughout the summer and fall; however, similar to Brooks Creek, most of S10 Creek is seasonally flowing and is partially dry in the summer. As noted previously, bull trout do not appear to be particularly adapted to spawning and rearing in seasonally flowing streams, as this is not a life history reported in the literature. Therefore, it is likely that summer low flows limit potential bull trout production in S10 Creek. Low flows during September and October likely prevent adult bull trout from migrating upstream to spawn. We are unaware of flow augmentation sources that could be used to increase summer and fall flows in S10 Creek to the level that would promote successful adult bull trout upstream migration.

Due to the loss of all the thermographs deployed in the Swift Creek Reservoir tributaries during the November 2006 flood, we have no information on incubation temperatures in S10 Creek, except that by late-September, the thermograph data show temperatures were above 9°C at the mouth. The S10 Creek thermograph data does not correlate well with the Cape Horn Creek data, which precluded making an estimate of incubation temperatures.

4.2.4 Swift Creek Limiting Factors

The QHA analysis ranked Swift Creek as the reach that would benefit the least from habitat restoration, yet the habitat protection ranking (4th out of 7 streams) indicated that current habitat attributes are functioning near the historic conditions, but are naturally limited. This natural habitat function limitation is caused by four factors: 1) the accessible reach of Swift Creek is entirely contained within a steep canyon where the active channel comprises nearly all the valley floor; 2) relatively steep channel gradient; 3) relatively high stream flows compared to the other streams in this assessment (estimated to be 5 to 10 times greater then the next largest stream in this assessment); and 4) the stream drains from Mt. St. Helens and was impacted by the eruption. The combination of these factors result in high bedload movement and likely deep scour and substantial aggradation events (see Section 3.5.3).

Based on the 6 to 8-foot-high gravel/cobble terrace covered with approximately 5 year old alder saplings (shown in Photo 20 at the blue reference line), substantial bedload movement appears to occur regularly in lower Swift Creek. Even if the adult-size bull trout we observed in Swift Creek had spawned during the fall of 2006, the bedload movement observed from the flood would have wiped out all redds. Bedload deposition and scour events in Swift Creek are unavoidable and will continue into the future due to the inherent valley form constraints and unstable sediments at the headwaters of Swift Creek.

Of all streams examined in this study, water temperatures in Swift Creek appear to be the most conducive for successful bull trout spawning, incubation, and rearing; however, successful egg incubation is likely limited by frequent, naturally occurring, and massive bedload deposition and scour events. It is unknown how frequently large scour and bedload deposition events occur. It is possible that in drier years, peak flows may be lower and hence scour and bedload deposition may be reduced to a level that could allow for successful bull trout incubation and juvenile rearing.

We do not know if the large bull trout observed in 2006 during the onset of the spawning season actually spawned in Swift Creek. These fish may have been foraging in Swift Creek; however, the lack of forage fish observed during the August 31, 2006 snorkel survey and subsequent electrofishing survey suggests this is unlikely. If these bull trout were spawners, they may have originated from adults that spawned in either Rush or Pine creeks, or there might just be enough sporadic successful reproduction within Swift Creek to maintain a very small local population.

4.3 INTEGRATION WITH YALE LAKE LFA FINDINGS PRESENTED IN PRATT (2003)

In the *Evaluation of Three Proposed Management Scenarios to Enhance Three Potential Bull Trout Nursery Habitats Accessible to Lake Merwin and Yale Lake*, Pratt (2003) evaluated potential bull trout spawning, incubation, and rearing habitat in Rain, Ole, and Speelyai creeks and the Lewis River bypass reach. Pratt (2003) concluded that unless a cold water source (less than approximately 6°C) is present in the fall and winter during the bull trout egg incubation period, egg mortality is the primary limiting factor for successful bull trout production. This current bull trout limiting factors analysis evaluated egg incubation temperatures using the same criteria as Pratt (2003) and arrived at the same conclusion for Drift and Brooks creeks, which is that warm incubation temperatures would likely limit egg survival. Furthermore, Pratt (2003) determined that flow augmentation would not increase egg survival because warm incubation temperatures would continue to be limiting. Similar to Pratt (2003), we are unaware of a flow augmentation source that could be used to substantially cool Drift and Brooks creeks to appropriate incubation temperature levels.

5.0 RECOMMENDATIONS

Long-term bull trout spawning and rearing in Brooks and S10 creeks is limited by naturally low summer and early fall stream flows that likely preclude adult bull trout upstream migration and limit summer rearing potential. Bull trout egg incubation in Brooks and Drift Creeks is limited by warm water temperatures that would likely result in high egg mortality. Bull trout egg incubation and rearing potential in Swift Creek is limited by fairly regular large scour and bedload deposition events. Our conclusions are that there are no feasible restoration strategies to increase low flow conditions in Brooks and S10 creeks, and no feasible strategies to substantially lower incubation temperatures in Drift Creek. Therefore, we make no recommendations to improve these streams to promote long-term bull trout spawning, incubation, and rearing.

As noted in Section 4.2.4, habitat conditions in the accessible reach of Swift Creek are severely limited by frequent bedload movement and scour, high gradient, and valley form constraints. As a result, we conclude it would be infeasible to reduce scour or bedload movement or to increase habitat complexity and cover. However, we do recommend future monitoring in Swift Creek to determine if bull trout spawning occurs in Swift Creek, and to determine if some successful egg incubation and juvenile rearing occurs in drier years. To answer these questions we recommend that the Licensees:

1) Conduct annual snorkel surveys around August 31st to determine if large spawner-size bull trout are holding in Swift Creek and conduct subsequent redd surveys as water clarity conditions allow.

2) Conduct electrofishing surveys for bull trout fry during the summer low flow period following a substantially dryer than average winter (i.e. winters that experience less scour and bedload deposition).

Although outside the scope of this LFA, it is important to determine the origin of any bull trout found in Swift Creek. Therefore, we further recommend that genetic samples be obtained from any adult or juvenile bull trout found in Swift Creek during future surveys. These fish could be sampled using angling or electrofishing. The Swift Creek bull trout genetic information could then be compared with existing genetic information to determine if Swift Creek bull trout comprise a small genetically-distinct local population, or if they originate from either the Pine or Rush creek local populations.

6.0 REFERENCES

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Appendix A

Lake Merwin and Swift Creek Reservoir Tributary Streams Bull Trout Limiting Factors Analysis - Revised Study Plan

September 19, 2006

Lake Merwin and Swift Creek Reservoir Tributary Streams
Bull Trout Limiting Factors Analysis

Revised Study Plan

Prepared for

PACIFICORP

Prepared by

Meridian
Environmental, Inc.

September 19, 2006

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1.0 INTRODUCTION

As a component of the Lewis River Hydroelectric Project's Settlement Agreement (Settlement Agreement), PacifiCorp has agreed to conduct a limiting factors analysis (LFA) for bull trout (*Salvelinus confluentus*) occurring in the tributaries to Lake Merwin and Swift Creek Reservoir and to finalize this evaluation in consultation with the Aquatics Coordination Committee (ACC). Section 5.5 of the Settlement Agreement states:

> *By the second anniversary of the Effective Date, PacifiCorp shall provide a limiting factors analysis for bull trout occurring in Lake Merwin tributary streams and Swift Creek Reservoir tributary streams and finalize this evaluation in Consultation with the ACC. If the Licensees, in Consultation with the ACC and with the approval of USFWS, determines that one or more locations have the potential to provide long-term, sustainable habitat for critical life stages of bull trout, the ACC may implement enhancement measures through the use of the Aquatics Fund as described in Section 7.5 below [of the Settlement Agreement].*

According to the *Bull Trout LFA Scope of Work* issued by PacifiCorp in January, 2006, the LFA should seek to answer (at a minimum) the following key questions:

1) Other than known bull trout streams associated with Merwin and Swift Creek reservoirs, do other streams exist at either project that can potentially provide long-term spawning, incubation, and rearing habitat?
2) Are the habitat conditions in each potential stream suitable for any one of the critical life stages of bull trout?
3) Do bull trout reside in these other streams?
4) Of the potential streams that do exist, what are the limiting factors that can be attributable to the absence of bull trout?
5) Are there any physical changes that can be made to potential streams lacking bull trout to provide for colonization by existing bull trout stocks?

Therefore, this study plan is designed to answer each of these questions and to develop a list of habitat enhancement measures that could be implemented to address limiting factors in those streams that have the potential to provide long-term bull trout habitat.

The approach to completing the bull trout LFA is presented below, following a brief literature summary of important bull trout habitat requirements and Lewis River basin life history timing. The literature summary provides a background on the habitat factors (abiotic interactions) that may have the greatest influence on the distribution and abundance of bull trout in the Lewis River basin. More detailed information describing general bull trout life histories and habitat requirements is available in Appendix 1 (EDT Bull Trout Species-Habitat Rules) (note that due to specific Lewis River basin characteristics, bull trout life history and habitat usage within the Lewis River basin may be somewhat different from that described in Appendix 1 (Pers. comm. J. Byrne, WDFW, July 2006).

2.0 KEY BULL TROUT HABITAT REQUIREMENTS

It is well documented in the scientific literature that bull trout have more specific habitat requirements than most salmonids (USFWS 1998; Rieman and McIntyre 1993). Habitat components that particularly influence their distribution and abundance include water temperature, channel form and stability, cover, spawning and rearing substrate conditions, and migratory corridors (natural and man-made barriers) (Dunham et al. 2001; Watson and Hillman 1997; Fraley and Shepard 1989; Goetz 1989).

2.1 WATER TEMPERATURE

Bull trout is one the most thermally sensitive salmonid species in western North America and researchers recognize water temperature as the most consistent factor influencing their distribution and abundance (Dunham et al. 2001; Hass 2001; USFWS 1998; Rieman and McIntyre 1993; Buchanan and Gregory 1997). Optimal water temperatures for bull trout have been estimated at 2 to 10°C, while temperatures above 15°C are thought to provide a thermal limitation for most bull trout populations (Fraley and Shepard 1989; Rieman and McIntyre 1996).

According to the U.S. Environmental Protection Agency (EPA) (2003), optimal bull trout growth occurs at water temperatures ranging from 8 to 12°C, spawning initiation takes place at temperatures less than 9°C, and optimal bull trout egg incubation happens at temperatures ranging from 2 to 6°C (Table 1). Bull trout egg mortality is reported to increase dramatically as water temperatures begin to exceed 8ºC (McPhail and Murray 1979; Weaver and White 1995) (Table 1). A narrow range from 10 to 12°C represents the preferred water temperatures for spawning migrations (McPhail and Murray 1979; Buchanan and Gregory 1997).

Table 1. Summary of temperature considerations for bull trout life stages.

Life Stage	Temperature Consideration	Temperature & Unit
Spawning and Egg Incubation	Spawning initiation	<9ºC (constant)[1]
	Temperature at which peak spawning occurs	<7ºC (constant)[1]
	Optimal temperature for egg incubation	2-6ºC (constant)[1]
	Substantially reduced egg survival and size	6-8ºC (constant)[1]
Juvenile Rearing	Lethal temperature (1-week exposures)	22-23ºC (constant)[1]
	Optimal growth Limited food Unlimited food	 8-12ºC (constant) 12-16°C (constant)
	Highest probability to occur in the field	12-13ºC (daily maximum)[1, 2]
	Competition disadvantage	>12ºC[2]

1 McCullough, D.A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue paper 5: summary of technical literature examining the physiological effects of temperature on salmonids. EPA-910-D-01-005. U.S. Environmental Protection Agency, 114 pp.

2 Sauter, S.T., J. McMillian, and J. Dunham. 2001. Issue Paper 1: salmonid behavior and water temperature. Prepared as part of USEPA Region 10 temperature water quality criteria guidance development project.

Source: EPA 2003

Although numerous field studies conducted to date suggest that juvenile and adult bull trout are uncommon in streams and rivers where water temperatures exceed 16°C for extended periods (Haas 2001; Fraley and Shepard 1989; Goetz 1989; Donald and Alger 1993; and Rieman and McIntyre 1993), recent studies in the Puget Sound region (Snohomish River) and in eastern Washington have documented adult and juvenile bull trout residing in streams with maximum daily water temperatures approaching 18°C (Goetz et al. 2004, Dunham et al. 2003). Unfortunately, there is no information available describing how frequently water temperatures can exceed 16°C before streams loose their capacity to provide long-term, sustainable habitat for bull tout.

2.2 CHANNEL FORM AND STABILITY

In addition to cool water temperatures, juvenile and resident adult bull trout are usually associated with relatively stable, perennial stream channels containing complex forms of cover, including large woody debris, undercut banks, boulders and pools (Goetz et al. 2004; Fraley and Shepard 1989; Goetz 1989). Dambacher and Jones (1997) found that seven habitat variables were significant descriptors of the presence of juvenile bull trout: (1) high levels of shade; (2) high levels of undercut banks; (3) large woody debris volume; (4) high level of gravel in riffles; (5) large woody debris pieces; (6) low level of fine sediments in riffles; and (7) low levels of bank erosion. Watson and Hillman (1997) also found a direct relationship between bull trout density, maximum pool depth, and percentage of undercut banks. Although bull trout are often found associated with large woody debris, they are known to use other forms of cover, including cobble and boulders, when wood is limited (Mullan et al. 1992; Bonneau and Scarnecchia 1998; Watson and Hillman 1997).

2.3 SPAWNING AND REARING SUBSTRATE CONDITIONS

Bull trout spawn in a wide range of substrate sizes, including sand and fine gravel, loosely compacted gravel and cobble, and large cobble (Shepard et al.1984; Shellberg 2002). In general, an increased proportion of fines in the substrate is inversely related to bull trout egg survival and emergence (Watson and Hillman 2002). However, when spawning occurs in upwelling groundwater areas, the adverse effects of sediment on eggs and emerging fry are largely negated, resulting in high survival (Bjornn and Reiser 1991; Waters 1995; Lestelle et al. 2002). Following emergence from the gravel, juvenile bull trout are found in close association with the channel bottom, often using substrate for cover (Rieman and McIntyre 1993). Low levels of fine sediments in riffles (embeddedness) and low levels of bank erosion are considered significant descriptors of the presence of juvenile bull trout (Dambacher and Jones 1997; Goetz 1997).

2.4 MIGRATORY CORRIDORS AND STREAM GRADIENT

Bull trout typically spawn in relatively low gradient stream channels (less than 2 percent) (McPhail and Baxter 1996; Shellberg 2002), though spawning has been documented in reaches with channel gradients as high as 15 percent or greater (USFWS 2000). In Rush Creek (Lewis River basin), bull trout use reaches up to approximately 11.5 percent for spawning and rearing, although the accessible reach averages approximately 8 percent (PacifiCorp and Cowlitz PUD 2004). In general, stream channel gradients in excess of 20 percent are thought to limit the distribution of all resident and anadromous salmonids, including bull trout (DNR 2002).

3.0 LEWIS RIVER BULL TROUT LIFE HISTORY TIMING

In the Lewis River basin, bull trout residing in Swift Creek Reservoir migrate into tributary streams from late May through early-August, and are believed to spawn from early August through the middle of September(PacifiCorp and Cowlitz PUD 2004; Faler and Bair 1992; Graves 1982), possibly spawning until the end of November (Pers. comm. J. Byrne, WDFW, July 2006). The population of bull trout living in Yale Lake migrates into tributary streams from the middle of August through late-September. Throughout their range, bull trout fry usually emerge from the gravel from mid-January to late February. Emigration of juveniles from the tributaries to Swift Creek Reservoir and Yale Lake is believed to occur primarily from late April to Mid-June.

4.0 STUDY PLAN APPROACH

The Lewis River bull trout LFA will include an initial "office phase" (Task 1) intended to collect and evaluate published habitat and water temperature data for the tributaries to Lake Merwin and Swift Creek Reservoir, followed by a "field phase" (Task 2) designed to fill any data gaps, further evaluate aquatic habitat conditions, and determine bull trout presence/absence in a short list of candidate streams. Then in Task 3, we will use Mobrand / Jones & Stokes' Qualitative Habitat Assessment (QHA) analysis as a means to identify limiting factors in those streams that are found to have the greatest potential to support bull trout. A more detailed description of each of these study plan components is presented below.

4.1 TASK 1: DATA COLLECTION AND ANALYSIS (OFFICE PHASE)

During the Task 1 office phase, an initial short list of potential bull trout streams entering Lake Merwin and Swift Creek Reservoir will be developed using existing streamflow, migration barrier, and channel gradient, as these habitat factors appear to be some of the best predictors of potential bull trout use (Dunham et al. 2003; Goetz et al. 2004, Goetz 1989). The goal of this task is to minimize the amount of field work needed to identify streams that can potentially provide long-term spawning, incubation, and rearing habitat. Primary sources of information will include the data sheets developed during the *Assessment of Potential Anadromous Fish Habitat Upstream of Merwin Dam* (AQU 4) (PacifiCorp and Cowlitz PUD 2004), existing DNR stream typing information, USFS habitat surveys and water temperature data, WDFW Salmon and Steelhead Analysis Inventory and Analysis Program (SHIAPP) data, and other relevant sources.

Using this existing information and what is known about bull trout habitat requirements, each stream entering Lake Merwin and Swift Creek Reservoir will be categorized as having "optimal", "marginal", or "poor" bull trout potential (Table 2). A fourth category "unknown" will be applied to perennial streams that have no available habitat and water temperature data. All streams ranking from "optimal" to "marginal" and those ranking as "unknown" for a particular parameter will be carried forward to the field phase (Task 2). Only streams ranking "poor" for at least one parameter will be eliminated from further consideration and deemed not suitable for bull trout use under any habitat restoration scenario. We assume that if "optimal" and "marginal" criteria for flow, temperature, and gradient parameters are not met, there is little chance that restoration efforts will create suitable habitat for bull trout over the long term.

Table 2. Initial bull trout habitat ranking categories.

Habitat Parameter	Optimal	Marginal	Poor
Flow	Perennial	Perennial	Seasonal[1]
Gradient	≤12% (same as Rush Creek)	<20%	≥20%[2]
Water temperature (spawning) - by mid-November[3]	≤10°	≤13°	>13°C
Maximum water temperature (rearing)	≤16°C	≤18°C	>18°C

1 Based on AQU-4 study results and anecdotal information (Pers. comm. J. Byrne, WDFW, July 2006), accessible reaches for all streams listed in Table 3 are likely perennially flowing.

2 Based on AQU-4 study results, accessible reaches for all streams listed in Table 3 are <20% in gradient.

3 Spawning may occur in Lewis River tributaries through November (Pers. comm. J. Byrne, WDFW, July 2006).

It should be noted that the "optimal" water temperature and flow criteria used in Table 2 are the same as those currently being used by the U.S. Fish and Wildlife Service (USFWS) to model and map potential bull trout spawning and early rearing "habitat patches" in the Lewis River basin[1]. The more conservative "marginal" ranking included in Table 2 is designed to capture those streams that have sub-optimal habitat conditions but may be capable of supporting at least some limited bull trout spawning and rearing through enhancement. To be conservative, streams meeting both the "optimal" and "marginal" criteria will be carried forward and further assessed during the field phase (see Task 2). As stated previously, only streams ranking as "poor" for at least one parameter listed in Table 2 will be eliminated from further assessment during the field phase.

Based on a preliminary assessment of available flow, gradient, and barrier data (PacifiCorp and Cowlitz PUD 2004, AQU-4), there are at least 7 independent tributaries to Lake Merwin and 5 independent tributaries to Swift Creek Reservoir that are both accessible to bull trout and that have the potential to support long-term spawning, incubation, and rearing habitat (i.e. perennial stream channels) (Table 3). Water temperature will be monitored in all streams listed in Table 3 to further classify each

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[1] The USFWS was driven to use elevation and basin size as surrogates for water temperature and streamflow due to the lack of available data for most streams.

stream as "optimal", "marginal", or "poor" based on the water temperature criteria listed in Table 2 (see Task 2, Field Survey, for temperature monitoring methods).

Table 3. Independent tributaries to Lake Merwin and Swift Creek Reservoir, not known to contain bull trout, to be evaluated as part of the bull trout LFA.

Reach Name	Length of Accessible Habitat (ft)	Length of Accessible Habitat (miles)	Average Wetted Width (ft)	Average Bankfull Width (ft)	Average Gradient (%)
LAKE MERWIN					
Cape Horn Creek	1,744	0.3	13.1	23.3	6.5
Jim Creek	3,140	0.6	11.7	21.5	3.4
Indian George Creek	4,760	0.9	9.7	21.9	5.0
Buncombe Hollow Creek	4,168	0.8	6.7	10.9	3.9
M4	3,900	0.7	6.1	11.5	10.0
Brooks Creek	5,714	1.1	14.8	19.5	4.0
M14	6,507	1.2	12.0	35.7	2.5
SWIFT CREEK RESERVOIR					
Swift Creek	1,639	0.3	29.8	NS	8.4
Range Creek	3,486	0.7	19.0	45.1	8.9
S10	1,855	0.4	5.3	24.7	6.8
Drift Creek	8,506	1.6	26.7	48.1	11.2
S15	6,680	1.3	13.4	29.7	6.7

NS = not surveyed

M4, B1, M14, S10, and S15 represent code names given to tributaries that were not assigned names on USGS topographic maps (7.5 minute quadrangles).

Source: PacifiCorp and Cowlitz PUD 2004

There are four smaller tributaries entering these reservoirs (identified in the AQU- 4 Study) that ranked "poor", and are not included in Table 3. Table 4 lists streams assessed in the AQU-4 study that will be dropped from further limiting factors analysis and describes the rational for eliminating these streams.

Table 4. Streams assessed in Study AQU-4 that rank as "poor" and will be dropped from further analysis in the bull trout LFA study.

Reach Name	Length of Accessible Habitat (ft)	Average Wetted Width (ft)	Average Bankfull Width (ft)	Average Gradient (%)	Reservoir Tributary
Marble Creek[1]	40	8.2	15.2	2.0	Merwin
Rock Creek[2]	320	15.0	47.5	6.1	Merwin
Canyon Creek[3]	0	not surveyed	not surveyed	not surveyed	Merwin
Diamond Creek[4]	655	4.1	20.8	10.0	Swift

1 Marble Creek contains only 40 feet of accessible habitat downstream from a 40 foot high falls. It is highly unlikely that only 40 feet of accessible habitat, at a relatively low elevation (240 feet above sea level), would support long-term spawning and rearing habitat for bull trout.

[2] The lowermost 200 feet of accessible habitat in Rock Creek has an average gradient of <1% , the remaining 150 feet of accessible habitat has an average gradient of approximately 20%. It is highly unlikely that only 200 feet of accessible habitat, at a relatively low elevation (240 feet above sea level), would support long-term spawning and rearing habitat for bull trout.

[3] Numerous waterfalls located at the mouth and throughout the lower 1,000 feet of Canyon Creek block fish access into Canyon Creek from Lake Merwin.

[4] Diamond Creek is a high gradient tributary to Lake Merwin (16.5% for first 200 feet, and 8% for the remaining 455 accessible feet from the mouth). Fish habitat in the accessible portion of Diamond Creek is dominated by shallow, high gradient riffles with occasional pocket pools. Cobble and small boulder are the dominant substrate types. Gravel is extremely limited. Because of its relatively short length, high gradient, and low summer flow of 0.5 cfs (observed during the AQU-4 Study, Diamond Creek appears to contain only a limited amount of salmonid habitat, and would not likely support long-term spawning and rearing habitat for bull trout.

4.2 TASK 2: FIELD SURVEY OF OPTIMAL, MARGINAL, AND UNKNOWN STREAMS

Water temperature data loggers will be deployed in all streams listed in Table 3. In relatively small tributaries (accessible habitat lengths that are less than one mile), one temperature logger will be placed at the mouth of the stream. In tributaries with accessible reaches greater than one mile in length, two temperature loggers will be deployed: one at the mouth of the stream and one in the middle of the accessible reach. The temperature loggers will be deployed in the selected tributaries in July of 2006 and data will be collect through mid-November of 2006. Temperature loggers will be set to record data once every half-hour (i.e. 48 measurements per day). Each data logger will be downloaded on a monthly basis. In addition, in the late summer, a cold water refugia survey will be conducted in each stream that will involve walking the accessible reaches and taking hand-held thermometer readings (approximately every 100 to 200 feet) to determine if any cold water refugia are present and to generally determine how the thermograph data compares with the stream temperature profile during the warmest period in late summer.

If water temperature data indicates that a stream is too warm during the summer bull trout rearing period (i.e. exceed the 18°C daily maximum “marginal” criteria), the stream will be dropped from further analysis. The stream will also be dropped from further analysis if water temperatures remain high (over 13°C daily maximum) throughout the bull trout spawning period (mid-September to mid-November).

For all streams that remain in the “optimal” and “marginal” categories, field data will be gathered on a suite of other habitat factors (environmental attributes) that could potentially be addressed to promote long-term spawning, incubation, and rearing habitat. Besides temperature, habitat components that particularly influence bull trout distribution and abundance include cover, channel form and stability, spawning and rearing substrate conditions, and migratory corridors (Fraley and Shepard 1989; Goetz 1989; Watson and Hillman 1997). The environmental attributes evaluated in the field will be the same as those needed to populate a QHA. A qualitative assessment of potential limiting factors will also be completed for each candidate stream and the percentage of the stream in which the factor is limiting will be documented. Appendix 2 identifies the environmental attributes that will be assessed in the field for all streams initially ranked as “optimal” and “marginal”. In addition, prior to the field habitat surveys, we will have a brief meeting with agency participants to identify the final habitat attributes to survey in the field and to include in the QHA analysis of limiting factors.

Habitat surveys will be scheduled for late-September/early-October, coinciding with the peak bull trout spawning period in the Lewis River basin. An added benefit associated with the timing of these surveys is that they may lead to identification of bull trout redds in candidate streams not previously known to support bull trout. A barrier survey will also be conducted during the fall in the drawdown zone portion of stream channels to determine if any barriers are exposed that would preclude adult bull trout from migrating upstream to spawn in particular creeks that may be suitable for spawning and rearing.

In addition to completing the Task 2 habitat surveys, bull trout presence/absence surveys will be conducted in the candidate streams. The presence/absence surveys will be based on guidance presented in the Western Division of the American Fisheries Society's document "Protocol for Determining Bull Trout Presence" (Peterson et al. 2002), and will be designed to meet the desired 80 percent power of detection. The level of effort and the sampling method will be similar to that used in Siouxon Creek in September of 2003. Each individual tributary system will be considered an individual sample frame. For the presence/ absence surveys, night snorkeling will be used; however, if a stream is generally too shallow to snorkel or if night snorkeling presents safety concerns, then electrofishing will be used following the AFS (2002) protocol methods. During the presence/absence survey, as soon as one bull trout is encountered in a particular stream, the survey will cease as presence will have been established.

4.3 TASK 3: QHA ANALYSIS

Following completion of the field phase, the QHA technique, led by Mobrand / Jones & Stokes (see Appendix 2), will be used to conduct a limiting factors analysis on each stream examined with "optimal" or "marginal" potential. QHA provides a structured, "qualitative" approach to analyzing the relationship between a given fish species and its habitat. It does this through a systematic assessment of the condition of several aquatic habitat attributes (sediment, water temperature, etc.) that are thought to be key to biological production and sustainability. Habitat attribute findings are then considered in terms of their influence on a given species and life stage.

QHA relies on largely qualitative habitat survey data combined with the expert knowledge of natural resource professionals with experience in a given local area to describe physical conditions in the target stream and to create an hypothesis about how the habitat would be used by a given fish species. The hypothesis is the "lens" through which physical conditions in the stream are viewed. The hypothesis consists of weights that are assigned to life stages and habitat attributes, as well as a description of how reaches are used by different life stages. These result in a composite weight that is applied to a physical habitat score in each reach. This score is the difference between a rating of physical habitat in a reach under the current condition and a theoretical "reference" condition. Ratings for life stages and habitat attributes will be developed in consultation with the agency participants, as the rating process relies heavily on local expert knowledge.

QHA produces a series of tables that (1) describe the physical habitat, (2) establish an hypothesis concerning how species interact with the natural environment, and (3) identify where restoration and/or protection activities may be the most productive. Taken as a whole, these tables offer a means to focus the attention of biologists and planners and track the decision process.

The ultimate result is an indication of the relative restoration and protection value for each reach and habitat attribute. QHA also provides a means to compare restoration and protection ratings to other biological and demographic information of the user's choosing. QHA includes features for documenting the decision process and describing the level of confidence that users have in the various ratings.

A complete description of the QHA method is included as Appendix 2.

4.4 TASK 4: PREPARE DRAFT AND FINAL BULL TROUT LFA REPORT

The information collected in tasks 1 through 3 will be compiled in draft and final reports that will be distributed to the ACC for review and comment. The reports will include a brief introduction, a detailed methods description, the results of each task, and a discussion that includes the categorization of each stream, a ranked list of limiting factors in the "optimal" and "marginal" streams, the results of the bull trout presence/absence surveys, and a description of potential restoration and/or protection activities that may be the most productive. In addition, the final report will include a discussion of how this bull trout LFA is related to the bull trout habitat assessment conducted on Yale Lake tributary streams. Both the draft and final reports will be submitted to the ACC according to the schedule presented in Section 5.0 of this study plan.

5.0 PROPOSED SCHEDULE

The proposed schedule for the Lewis River bull trout LFA is presented in Table 4.

Table 5. Proposed bull trout LFA schedule.

Action	Date (YR 2006)
1. Draft study plan to the ACC	April 13
2. Final study plan to the ACC	May 15
3. Meeting with agency participants to finalize attributes of habitat survey	September 29 (tentative)
4. Data collection and analysis	May 20 – November 30
5. Meeting with agency participants to rate QHA parameters	October 15 (tentative)
4. Draft report to the ACC	December 15
5. Final report to the ACC	January 31 (2007)

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Appendix 1

Ecosystem Diagnosis and Treatment (EDT)
Bull Trout Species-Habitat Rules

Appendix 1 can be provided on request.

Appendix 2

Qualitative Habitat Assessment (QHA) User's Guide

Appendix 2 can be provided on request.

Appendix B

Comments and Responses on First Draft Study Plan (April 21, 2006)

USFWS Email Comments and Associated Responses Addressing the Draft Bull Trout LFA Study Plan

From: LouEllyn_Jones@fws.gov
Sent: Monday, May 22, 2006 8:44 AM
To: Shrier, Frank
Cc: Jeffrey_Chan@fws.gov; Joe_Hiss@fws.gov; byrnejbb@dfw.wa.gov
Subject: Comments on the Bull trout limiting factors analysis study proposal

Hi Frank.

Jeff Chan and I looked at the study proposal, although we didn't delve deeply into the details of the model. We believe Jim Byrne did a good job at bringing attention to some of the unique differences between the general model parameters and what might be present in the Lewis system. Is it possible to "tweak" the model to take some of these into account, and explore what alternate outputs might result?

One thing Jim didn't raise is the way in which they propose to evaluate/collect temperature data in some of the candidate tributaries (see section 4.2 Task 2). By placing just a single temperature logger at
the mouth of a stream, or a temperature logger at the mouth and mid-point of a stream, they may not be able to capture unique cold water features that could actually support bull trout. Given the unique hydrology seen in Cougar Creek, there may be similar features (but at a much smaller scale) in other streams. The whole stream may not need to be at an "optimal" temperature to successfully support a bull trout population. Bull trout are certainly known for homing in on unique cold water features within a stream for spawning, overwintering, and refugia. This might mean that potential use within a particular stream might be more patchy in nature as opposed to uniform. This is actually the case in many bull trout systems.

Since temperature is such a key driver for successful bull trout spawning and rearing, and we likely have a limited number of candidate streams within the Lewis, we think it is important to put in the extra effort up front to do a more comprehensive assessment of water temperature within these streams to make sure potential cold water features don't get missed.

Lou Ellyn Jones
U.S. Fish and Wildlife Service
510 Desmond Drive
Lacey, WA 98503
telephone: 360-753-5822
fax: 360-753-9008

From: jshappart@meridianenv.com
Sent: Tuesday, May 23, 2006 2:13 PM
To: Shrier, Frank
Subject: Re: Comments on the Bull trout limiting factors analysis study proposal

Hi Frank,

Thanks for forwarding Lou Ellyn's email.

Regarding Lou Ellyn's first comment, I am not exactly sure what model she is referring to. Is she referring to the USFWS patching model or the QHA method included in our draft Bull Trout LFA Study Plan? As discussed in our study plan, the QHA method "relies largely on qualitative habitat survey data combined with the expert knowledge of natural resource professionals with experience in a given local area to describe physical conditions in the target stream and to create a hypothesis about how the habitat would be used by a given fish species". As the QHA method will rely on local expert knowledge from local biologists such as you, Eric, Jim, Lou Ellyn, etc., the evaluation parameters will be "tweaked" to account for local conditions. If Lou Ellyn's comment deals directly with the USFWS patching model, I'm not sure it needs to be addressed in our study plan. Maybe she could shed some light on this subject.

The second comment regarding unique cold water features raises an important point. I have personally struggled with this issue many times in the past, especially when I worked for ODFW assessing bull trout water temperature and habitat relationships throughout Oregon. Water temperature as a bull trout habitat identifier is a difficult thing to address and it all revolves around the spatial scale and resolution that is needed to answer the question (meet the study objective). So what exactly is the question? In this case, I believe that the question revolves around what is needed to provide long-term spawning, incubation, and rearing habitat. How much habitat are we looking for? Are we looking for a 300 foot-long reach that can support spawning and rearing, a 1/4 mile-long reach, or a 1/2 mile-long reach?

As I see it, the primary objective of the Bull Trout LFA is to identify those tributaries to Lake Merwin and Swift Creek Reservoir that have the greatest potential to support long term bull trout spawning and rearing (i.e. increase abundance in the core area). Because of this, I think we should focus our efforts on those reaches that are relative long (greater than 1/4 mile or so) and that can support substantial spawning and rearing, and not spend a lot of time trying to find 100 or 200 foot-long reaches, here or there, that have cooler water temperatures.

Lou Ellyn also suggests that the "whole stream" need not have "optimal" temperatures to successfully support a bull trout population. To avoid only looking at the best (i.e. optimal) habitat, our LFA study plan includes a "marginal" habitat category that will allow us to consider streams that did not fall into what is generally considered "the best or optimal" habitat for bull trout. We consider our marginal habitat to be "on the fringe" of what is considered potential bull trout habitat.

All of the streams that will be assessed during our bull trout LFA (listed in Table 3 of the Study Plan) are relatively small (60% have less than 3/4 of a mile of accessible habitat from the reservoir). The longest tributary, Drift Creek, has 1.6 miles of accessible habitat. Given these short lengths, we believe that one temperature logger at the mouth of each stream that is less than one mile long will adequately describe temperatures in the accessible reaches. For the few longer streams with greater than 1 mile of accessible habitat we will place two thermographs to split the reach in half.

We believe that this strategy will adequately describe the water temperature regime in each target stream. However, if the group is still interested in identifying short reaches of cool water refugia, we could conduct a series longitudinal "spot checks" for cool water temperatures in the target streams during the summer low flow period (say a warm day in late August), and compare these longitudinal temperature data to what is recorded on the loggers at the mouth and upper end of each stream (if applicable). We could then review these data with the group during the QHA analysis. We also welcome any other alternative suggestions to address this issue. I hope this helps. Please don't hesitate to call or email me with any questions or comments.

Cheers,

Jason K. Shappart, Fisheries Scientist
Meridian Environmental, Inc.
1900 N. Northlake Way, Suite 211
Seattle, WA 98103
Phone: 206-522-8282
Fax: 206-522-8277

From: LouEllyn_Jones@fws.gov]
Sent: Friday, June 09, 2006 9:17 AM
To: Shrier, Frank
Cc: Jeffrey_Chan@fws.gov
Subject: Re: FW: Comments on the Bull trout limiting factors analysis study proposal

Frank: I'm not sure I ever responded to this. I was referring to the model that was attached to the study plan, which sounds like the QHA.

Lou Ellyn Jones
U.S. Fish and Wildlife Service
510 Desmond Drive
Lacey, WA 98503
telephone: 360-753-5822
fax: 360-753-9008

From: Lesko, Erik
Sent: Friday, June 02, 2006 8:55 AM
To: Shrier, Frank; 'George Gilmour'
Cc: McCune, Kimberly; Olson, Todd
Subject: RE: Scan from a Xerox Document Centre

In reading the comments [WDFW Comment Letter] I believe that electrofishing has proven itself effective in the Lewis without harming juveniles. I have never seen Jim electrofish the Lewis and believe this is opinion rather than field testing. We were successful at obtaining genetic samples from both Cougar and Pine with the shocker. We would need to get into these streams prior to spawning however. Also, I do not know if we were planning on collecting any genetic samples, but because we are going to be sampling P8 this year (as part of the bull trout plan) I anticipate collecting fin clips from that population. By the way, we only find brook trout in the bypass reach area, some of which are large (>12 inches). Lastly, their screw trap results in Rush Creek do not reflect what the population size was in Rush Creek, therefore it is incorrect for them to make statements like 80 percent migrated from Rush Creek as YOY.

Erik Lesko
(503) 813-6624

From: George Gilmour
Sent: Tuesday, June 13, 2006 4:15 PM
To: byrnejbb@dfw.wa.gov
Cc: frank.Shrier@Pacificorp.com; Jason Shappart
Subject: Lewis River Bull Trout LFA Comments

Jim,

Frank Shrier recently sent us a copy of your comments on the Lewis River Bull Trout LFA study plan. We appreciate your detailed review and understand that you have some concerns regarding our approach (specifically, the use of EDT rules). In short, we included the EDT rules in our study plan only to provide a general description of bull trout habitat requirements. We fully recognize that many of these "rules" do not apply to bull trout in the Lewis River core area, as Lewis River bull trout have relatively unique life histories and habitat preferences/tolerances. Please understand that our proposed QHA analysis will rely not only on the water temperature and habitat data collected in the field this summer, but on the expert knowledge of biologist like you, Lou Ellyn, Frank, Erik, and others with experience in the basin. We will then use this local bull trout knowledge and our field data in our QHA analysis to develop a thorough understanding of potential bull trout habitat, identify any limiting factors (including reservoir related limiting factors), and recommend possible enhancement measures. QHA is not EDT and the assumptions that we will use in our analysis will be developed and refined by all parties involved in the study.

Rather than respond to all of your comments in a detailed letter, Jason Shappart and I thought it might be more productive to have a discussion during an informal conference call. Does this work for you? Are you available this week or next week? If so, please let me know a good day and time.

Thank you,

George Gilmour
Fisheries Biologist
Meridian Environmental, Inc.
(206) 522-8282

From: Shrier, Frank
Sent: Monday, July 31, 2006 10:16 AM
To: ggilmour@meridianenv.com; jshappart@meridianenv.com; Erik.Lesko@PacifiCorp.com; kmalone@jsanet.com; shelley_spalding@fws.gov; LouEllyn_Jones@fws.gov ; Joe_Hiss@fws.gov ; BYRNEJBB@DFW.WA.GOV
Cc: Todd.Olson@PacifiCorp.com
Subject: Lewis River Implementation LFA conference call.doc

I've attached some notes that George recorded from the LFA conference call on July 21st. These are not official notes but they did serve to capture the main points of the call and gave me an opportunity to review what was said. I understand that Lou Ellyn also took some notes. I've added in responses to George's and, if anything, these responses will serve to keep the conversation going. I'm assuming there will be a follow-up call.

--

Lewis River Draft Bull Trout LFA Study Plan
Conference Call Notes
July 21, 2006 (10:00 am to 12:00 pm)

[Note: Frank Shrier comments on conference call notes are highlighted in yellow.]

Attendees:
George Gilmour (MEI)
Jason Shappart (MEI)
Erik Lesko (PacifiCorp)
Kevin Malone (Mobrand/Jones and Stokes)
Chip McConnaha (Mobrand/Jones and Stokes)
Shelley Spalding (USFWS)
LouEllyn Jones (USFWS)
Joe Hiss (USFWS)
Jim Byrne (WDFW)

General conference call discussion regarding the LFA Scope of Work:

1. The agency participants were not in full agreement with the existing scope of the LFA. In general, the agency participants felt that a comprehensive approach to assessing bull trout limiting factors in the Lewis River basin should be developed in collaboration with the USFWS and WDFW. We noted that it was not our position to discuss the overall scope of the LFA and that our task was to respond to the scope of work as it was presented in PacifiCorp's RFP and described in the Settlement Agreement. The agency participants understood this, but would like to meet with PacifiCorp to discuss the overall scope.

2. In addition to the tributaries to Lake Merwin and Swift Reservoir, the agency participants thought that the LFA should include streams that are known to contain bull trout (i.e. Rush and Pine creeks) to serve as reference reaches and also to evaluate limiting factors and to assess actions that could be implemented to enhance habitat in those streams that already contain bull trout.

3. All agency participants felt that in addition to tributary habitat, reservoir limiting factors should be addressed in this study. Chip McConnaha's response to this was that the QHA could be modified if needed to address reservoir habitat. We agreed to survey the reservoir drawdown zones for any potential barriers to upstream migration but felt that it was not our position recommend any modifications to the scope.

4. Jim Byrne also felt strongly that Yale Reservoir and tributaries should be included and that all the reservoir habitat and ecological interactions in the reservoirs should be included in the limiting factors analysis. LouEllyn Jones and Shelley Spalding felt that this LFA should at least discuss how this effort is consistent with the Yale LFA analysis and results (conducted by Karen Pratt) to provide a "big picture" view of bull trout

limiting factors in the Lewis River basin. We noted that we could add the information included in Karen's report to our LFA report.

The SA is clear that Yale is not included. That is because Karen Pratt already did that analysis.

This is the actual SA language:

5.5 Bull Trout Limiting Factors Analysis. By the second anniversary of the Effective Date, PacifiCorp shall provide a limiting factors analysis for bull trout occurring in Lake Merwin tributary streams and Swift Reservoir tributary streams and finalize this evaluation in Consultation with the ACC. If the Licensees, in Consultation with the ACC and with the approval of USFWS, determine that one or more locations have the potential to provide long-term, sustainable habitat for critical life stages of bull trout, the ACC may implement enhancement measures through the use of the Aquatics Fund as described in Section 7.5 below.

Since the parties in this meeting were not at the settlement negotiations, let me add this. The request to conduct a limiting factors analysis for bull trout came from WDFW following review of Karen Pratt's work and with the intent to complete the other two reservoir tributaries so that we had a complete picture of the spawning and rearing potential in the reservoir area. Rush and Pine creeks were not added to the mix since they were already undergoing observation and there was known presence. Because of this and because of the need to stay true to the SA intent, I cannot agree to work that is significantly outside the present scope. If the meeting participants would still like to meet and discuss this issue, I am happy to oblige.

5. Kevin Malone commented that it would be valuable to link this study with the salmon re-introduction effort in terms of monitoring effects of the reintroduction on bull trout.

6. The agency participants were concerned that electrofishing may have adverse effects on bull trout, especially in relatively warm water. Although we felt there was little risk to bull trout associated with electrofishing (based on past sampling experience), we agreed to use night snorkel surveys in some of the larger tributaries and large pools (if possible).

Agency recommended changes to the draft bull trout LFA study plan based on the July 21, 2006 conference call consensus:

1. Add language regarding how the Yale Lake LFA is related to this study (where applicable).

It's OK to add this to the discussion section of the final report

2. Add language on why all the streams from AQU 4 were not carried forward in to the list of streams to be initially assessed in this study (Table 4 of the Bull Trout LFA Study Plan).

An explanation is warranted

3. For temperature monitoring, add language that all streams (in Table 4) will be monitored this year, and that in the late summer, a cold water refugia verification survey will be conducted that will involve walking the accessible reaches of each stream and taking hand-held thermometer readings (every 100 to 200 feet or so) to determine if any cold water refugia are present and to generally see how the thermograph data matches up with the stream temperature profile during the late summer.

OK

4. The initial bull trout habitat ranking category (Table 2 of the study plan) for spawning should be for the time frame of mid-November, not the end of September.

Why so late? Is this intended to be a redd survey?

5. The criteria for maximum temperature is good and streams should be excluded from further analysis if the temperature is clearly greater than 18°C, but if there are only a few readings over 18°C, then a group decision will be made on whether to rank the stream as "poor" and excluded it from further analysis.

This could only be determined by group consensus after the field season – not a practical solution

6. Some verbiage should be added that all the accessible habitat is <20% gradient, this category is not really applicable, but may justify why some of the AQU 4 streams were not included in this LFA study.

OK

7. Shelly Spalding felt that the seasonal stream criteria may not be justified, but the consensus was that if one is looking at spawning and rearing streams that the greatest potential would be in perennial streams. No final resolution to this issue was clear, but most if not all of the streams (1st draft of the LFA Study Plan, Table 3) are probably perennial according to Jim Byrne so it would not really be an issue.

8. For the presence/absence surveys, night snorkeling will be used based on safety and appropriateness, i.e. if it is too shallow then electrofishing will be used.

OK with safety and practicality in mind

9. Before the habitat surveys occur, we will have a meeting to identify parameters to be surveyed in order to make sure that we collect data for parameters that participants anticipate will be used in the QHA.

OK

10. Have meetings during the QHA phase to develop habitat rules for the analysis.

OK

Additional information to supply to participants:

1. Provide AQU 4 study, or link to study, and data sheets, etc. to agency participants (Meridian will do this).

2. Revise the study plan and send it out for review to participants (Meridian will do this).

3. Prepare a written response to Jim Byrne's comment letter (Meridian will do this).

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
2108 Grand Blvd. • Vancouver WA 98661 • (360) 696-6211 • Fax (360) 906-6776/6777

May 25, 2006

Mr. Frank Shrier
PacifiCorp
825 NE Multnomah St.
Portland, OR 97232

SUBJECT: Comments on the Lake Merwin and Swift Creek Reservoir Tributary Streams Bull Trout Limiting Factors Analysis draft study plan.

Frank

Dear ~~Mr. Shrier~~;

Washington Department of Fish and Wildlife thanks PacifiCorp for the opportunity to review and comment on this Bull Trout Limiting Factors Analysis (LFA) draft study plan. After careful review we would recommend caution when comparing bull trout populations and habitat in the Lewis Basin with what is found to be excellent or classic bull trout habitat in other parts of the Intermountain West.

The assumptions made for bull trout and EDT outside the lower Columbia River Basin may not be appropriate for the Lewis River since Lewis River bull trout thrive in what would appear to be marginal or inhospitable conditions elsewhere. The heavy weighting of substrate, stability and side channels could be inappropriate as level two attributes for the Lewis River Basin; as there is very little spawning gravel and side channels on bull trout streams in this basin. The out-of-basin species habitat rules additionally may not be appropriate here. The limiting factors analysis does not address the time bull trout reside in the reservoir and any negative interactions associated with winter drawdown. The limiting factors analysis should be made on Lewis River specific criteria not a generalized stream EDT template.

This document describes the plan to draft a Bull Trout Limiting Factors Analysis for Swift and Merwin Reservoirs. It contains a large section on bull trout biology and habitat needs for most of this species range. However, the life history and habitats described are generalized and not specific to the Lewis River Basin. Rush and Pine Creeks have habitats very different from what is usually associated with bull trout in other river basins. A majority of the document discusses the methodology of EDT analysis for bull trout. The EDT analysis of bull trout is for generalized bull trout populations and may not apply to specific conditions found in Rush, Pine and Cougar Creeks, or in the Muddy system, which vary dramatically from bull trout habitat documented elsewhere. We are asking that recovery efforts be based on the specific habitat needs for bull trout found in the Lewis River, not from somewhere else out of the basin.

Section 2.0 (page two), discusses generalized bull trout habitat requirements; temperature, channel stability, substrate and gradient. Bull trout populations in the Lewis River system tend to survive in habitats generally not associated with bull trout in the intermountain west. Lewis River fish can be found in high gradient, unstable streams with limited gravel and high amounts of fine moving substrate (ash and pumice). Some streams have been subject to volcanic lahars and ash deposition which seldom apply to bull trout elsewhere and these conditions may not be built into the EDT analysis. WDFW requests the limiting factors analysis be more specific to Lewis River streams and not merely an attempt to place Lewis River bull trout into an existing EDT (stream only-reservoir exclusive) template.

Section 3.0 (page four), references generalized bull trout life history timing. WDFW believes much of the timing suggested is inaccurate for Lewis River populations and requests the study plan better reflect Lewis River life histories. In recent (2002-2005) field seasons, WDFW found later spawn timing in Rush and Pine Creeks, than that proposed in this draft. In 2002 and 2005, we found bull trout in Rush Creek and Rush Creek Hole through mid-October. In 2003, we saw bull trout in Cougar Creek from 9/11 through 11/13; in 2004 from 8/27 through 10/15 when flows were too high to safely snorkel; and in 2005 from 8/4 through 11/23. In 2004 and 2005, we found bull trout young-of-year (YOY) migrating into our downstream migrant trap starting in mid-March and throughout the summer. Numbers of YOY peaked in March and April. Emigration of juveniles to the reservoir also persists later than that suggested in the draft.

The Study Plan Approach 4.0 (page four), consists of three logical tasks and timeframes. Task 1 (4.1) consists of a data collection and analysis. Task 2 (4.2) (page six), is actual fieldwork with habitat data collection. Our experience is that Lewis River juvenile bull trout are not visible during daytime, but have a nocturnal lifestyle. We typically observe them during night snorkeling. Waters in the basin have generally low conductivity making electroshocking bull trout in the Lewis difficult. Juveniles reside in the gravel or litter along stream margins. They can be shocked but are not otherwise seen. Since conductivities are so low often fish are shocked at high voltage and pulse. Great care is necessary operating electroshockers at optimal voltage amperage and frequency levels to capture bull trout without harming them. WDFW recommends that night snorkeling surveys be used. Night snorkel surveys, where safety conditions permit, are the best way to document bull trout presence.

Joe Hiss, USFWS, has recently completed a review of stream temperatures in the Lewis River basin. This document may provide some guidance as to criteria for optimal, and marginal streams.

4.3 QHA Analysis, Task 3 (page seven), will determine which optimal or marginal streams to conduct the limiting factors analysis. Again, in the Lewis River, bull trout reside in habitats not normally associated with bull trout elsewhere (low altitude, high gradient, poor gravel, constant substrate shift etc.). These unique Lewis River attributes must be incorporated into the decision making process. Streams such as Rush and Pine Creeks, cannot be ruled out due to high gradient, or poor substrate as they serve as the bastions of bull trout in the basin.

In 4.4 Task 4: Prepare Draft and Final Bull Trout LFA Report, (page eight), the schedule indicates a draft report will be delivered to the Aquatic Coordination Committee (ACC) by Oct. 15. WDFW data indicates bull trout are still actively spawning during this time frame. This due date will not reflect the full duration of bull trout spawning. WDFW recommends adjusting the completion of the report to reflect the full duration of spawning.

Appendix One, Section 2.3.2 (page five), discusses intra-specific interactions and discusses specifically inter-cohort cyclical patterns of juvenile abundance. We have not observed such cyclical patterns from our decade of adult estimates. However, little research on juvenile life history has occurred in the Lewis River Basin. WDFW would like to see emphasis on juvenile life history, particularly in the Pine Creek drainage. The potential exists that Pine Creek may contain both adfluvial and resident bull trout populations. It would be desirable if distinctions in bull trout in this drainage could be detected (genetically) and determine if these 150-350 mm fish interact. Therefore, we recommend a genetic study be designed and funded to address these issues.

Section 2.3.3 (page six), on the hybridization section details the negative impacts of brook trout. However, most brook trout in the Lewis system do not share waters with bull trout. Most of the brook trout populations are located above Lower Falls and above impassible barriers on Pine Creek where adfluvial bull trout cannot reach. WDFW does not believe inter-specific habitat overlap and resultant genetic hybridization is a major issue for the Lewis River bull trout populations. If brook trout interactions are perceived as a potential problem, WDFW requests genetic studies be conducted on apparent hybrids and on brook trout captured in waters with bull trout.

Section 2.3.5 (page seven); harvest, harassment and poaching may have the greatest impact as a limiting factor. Skamania County has permitted residential housing to be developed on bull trout rearing and spawning streams. This development has the potential for negative human–bull trout interactions in key areas of the basin. This situation is in flux as the County struggles to provide residential development yet preserve fish and wildlife habitats and values. Enhanced enforcement efforts, increased funding, and a strong time commitment will be key to dealing with these issues.

Section 2.4.1 (page eight), on Channel Stability implies bull trout have a limited range of substrates they tolerate. Spawning habitats in Rush, Pine and Cougar Creeks appear marginal at best yet bull trout have been thriving in these streams. Cougar Creek shows volcanic influence and both Pine Creek and the Muddy River, have had volcanic lahars stream through them, leaving pumice and ash as substrate. We have never observed redds in Pine Creek and few redds have been observed in Cougar Creek.
Section 2.4.2 (page nine), sedimentation studies typically involve fine silt and do not deal with coarser pumice and volcanic ash seen in Pine, Cougar creeks and in the Muddy.
Section 2.4.3 discusses the importance of cover and structure. Pine Creek is virtually devoid of cover and the structure changes dramatically on a yearly basis. Spawning may occur in pine Creek tributaries and this deserves increased attention.

Table 2 (page 21). We have not observed evidence of intra or inter-specific competition in our adult estimates. In most if not all locations where bull trout are present in the Lewis we have not observed brook trout. Brook trout are generally located above impassible barriers to adfluvial bull trout.

In Appendix A: Bull Trout Life Stages it should be recognized that the majority (80%) of Rush Creek juveniles migrate from this creek to the mainstem Lewis as YOY. In Appendix Table B1. We observed bull trout juveniles leaving Rush Creek over a nine-week period and we probably missed the beginning of the out migration in February.

On page 21 of the Qualitative Habitat Assessment (QHA) User's Guide Version 1.1 it states, *"As presently constituted, QHA is designed for use with streams and stream habitat characteristics. It does not contain a module for dealing with adfluvial populations once these enter a lake or reservoir."* It appears this is not an appropriate methodology. All adult Lewis River bull trout spend half the year in reservoirs.

Bull trout juveniles in the upper Lewis predominantly spend only one to two years in the mainstem before entering the reservoir. Much of their lifetime is spent in the reservoirs – areas not covered by EDT analysis. The effect of winter reservoir drawdown could have definite negative effects on bull trout (stranding, predation issues, loss of riparian habitat, etc), yet under present EDT analysis this is not addressed. Since adult bull trout spend six months in the reservoir and subject to a drastic habitat change, this must be considered as a potential limiting factor. Yet fluctuations in water level are not addressed in the proposed LFA. The effects of reservoir draw down must be addressed in the LFA. Any assumptions about bull trout habitat requirements in the reservoirs will need the full agreement of the ACC.

Thank you for the opportunity to review and comment on the draft plan. We hope you find our comments helpful. If you have any questions or comments please contact Jim Byrne, Area Fish Biologist, at (360) 906-6751.

Sincerely,

Craig Burley
Region 5 Fish Program Manager

Meridian Environmental's Response to WDFW's comments on the Draft LFA Study Plan (letter dated May 25, 2006)

Comment 1: *The assumptions made for bull trout and EDT outside the lower Columbia River basin may not be appropriate for the Lewis River since Lewis River bull trout thrive in what would appear to be marginal or inhospitable conditions elsewhere* (and other comments dealing with EDT bull trout rules presented in Appendix 1).

Response 1: We are not proposing to use EDT in the Lewis River Bull Trout LFA. The EDT rules presented in Appendix 1 of the LFA Study Plan were included only to provide additional information on bull trout life history and habitat requirements. We propose to use QHA, which relies heavily on local expert knowledge to rate life history and habitat parameters. Ratings for life stages and habitat attributes will be developed in consultation with the agency participants that have extensive local knowledge in to ensure that life history and habitat use assumptions are appropriate for Lewis River basin bull trout. We are fully aware that bull trout in the Lewis River use habitat not considered as optimal for bull trout in other parts of the species distribution.

Comment 2: *The limiting factors analysis does not address the time bull trout reside in the reservoir and any negative interactions associated with winter drawdown.*

Response 2: As noted in the Lewis River Projects Settlement Agreement and in the LFA Study Plan, the purpose of the LFA is to assess tributaries to Lake Merwin or Swift Creek Reservoir. Specifically, the Settlement Agreement states:

> *By the second anniversary of the Effective Date, PacifiCorp shall provide limiting factors analysis for bull trout occurring in Lake Merwin tributary streams and Swift Creek Reservoir tributary streams and finalize this evaluation in Consultation with the ACC. If the Licensees, in Consultation with the ACC and with the approval of USFWS, determines that one or more locations have the potential to provide long-term, sustainable habitat for critical life stages of bull trout, the ACC may implement enhancement measures through the use of the Aquatics Fund as described in Section 7.5 below [of the Settlement Agreement].*

The primary questions being asked by the LFA are: Do other streams exist in either reservoir that can potentially provide long-term spawning, incubation, and rearing habitat for bull trout? Are bull trout present? What are the limiting factors in these streams? Are there any changes that could be made to these streams to allow bull trout spawning and rearing? The LFA does not focus on reservoir habitat. However, reservoir drawdown does have the potential to create drawdown-zone migration barriers in the late summer and fall that would not allow adult bull trout to migrate into tributaries that may be suitable for spawning and rearing. To address this concern, we have agreed to conduct a drawdown zone barrier survey during the fall of 2006 in those tributaries that meet either the optimal and marginal habitat criteria identified in the LFA Study Plan.

However, drawdown issues were discussed at length during relicensing, and it should be recognized that reservoir drawdown will occur into the future to provide flood control and power generation. Future project operations, including drawdown, were supported by WDFW in the Settlement Agreement.

Comment 3: References to bull trout life history timing in Section 3.0 of the LFA Study Plan do no reflect data collected by WDFW. *WDFW believes much of the timing suggested is inaccurate for Lewis River populations and requests the study plan better reflect Lewis River life histories.*

Response 3: In Section 3.0 of the Bull Trout LFA Study Plan, we used the information from the recent relicensing studies and the current annual bull trout monitoring reports produced by PacifiCorp (reviewed by WDFW). Where life history timing affects the QHA analysis, we will use all available data that agency participants can provide, as well as local expert knowledge to insure the QHA is most applicable to local Lewis River basin bull trout population characteristics.

Comment 4: *Our experience is that Lewis River juvenile bull trout are not visible during daytime, but have a nocturnal lifestyle. We typically observe them during night snorkeling. Waters in the basin have generally low conductivity making electroshocking bull trout in the Lewis difficult. Juveniles reside in the gravel or litter along the stream margins. They can be shocked but not otherwise seen. Since conductivities are so low often fish are shocked at high voltage and pulse. Great care is necessary operating electroshockers at optimal voltage amperage and frequency levels to capture bull trout without harming them. WDFW recommends that night snorkeling surveys be used. Night snorkel surveys, where safety conditions permit, are the best way to document bull trot presence*

Response 4: We appreciate your comment and have modified the LFA Study plan to incorporate night snorkeling; however, if a stream is generally too shallow to snorkel or if night snorkeling presents safety concerns, then electrofishing will be used following the AFS recommended protocol (Peterson et al. 2002). As soon as one bull trout is encountered in a particular stream, the survey will cease, as presence will have been established.

Please note that USFWS Bull Trout Research and Monitoring Group used single-pass electrofishing during the summer of 2006 throughout the upper Lewis River basin to determine juvenile bull trout presence/absence within known bull trout habitats in order to validate their bull trout suitable spawning and rearing habitat "patching" model.

Please also note that we have used electrofishing in the Lewis River basin in the past to collect bull trout genetic samples in both Pine and Rush creeks, with no mortalities or external injuries noted. In addition, these fish (primarily fry) were relatively easy to capture. We also used multi-pass electrofishing methods following the AFS recommended protocol to conduct surveys within the Siouxon Creek subbasin of the Lewis River. These methods were approved by both WDFW and USFWS.

Meridian biologists have over 15 years each of electrofishing experience, sampling numerous streams for bull trout throughout the Pacific Northwest. We are very aware of the care that must be exercised when electrofishing for bull trout so as not to cause injury or mortality, while maintaining acceptable capture efficiencies.

Comment 5: *Joe Hiss, USFWS, has recently completed a review of stream temperatures in the Lewis River basin. This document may provide some guidance as to criteria for optimal and marginal streams.*

Response 5: We appreciate your comment and have reviewed the referenced report. In addition, we have reviewed the criteria recently used by the USFWS for the bull trout habitat patching model covering the entire Lewis River basin. The habitat criteria used in the LFA Study Plan is consistent with these efforts.

Comment 6: *QHA Analysis, Task 3 (page 7), will determine which optimal or marginal streams to conduct the limiting factors analysis. Again, in the Lewis River, bull trout reside in habitats not normally associated with bull trout elsewhere (low altitude, high gradient, poor gravel, constant substrate shift, etc.). These unique Lewis River attributes must be incorporated into the decision making process.*

Response 6: We understand your concern and note that QHA will not be used to determine which optimal or marginal streams are analyzed. As the first sentence in Section 4.3 of the LFA Study Plan states "QHA...will be used to conduct a limiting factors analysis on each stream examined with “optimal” or “marginal” potential." In other words, all streams ranked "optimal" or "marginal" will be analyzed for limiting factors using QHA. The QHA will rely heavily on local expert opinion and site specific Lewis river data provided by WDFW, the USFWS, and PacifiCorp. The only streams that will not be analyzed using QHA are streams that meet the "poor" criteria. The "poor" criteria are streams with >20% average gradient for the length of accessible habitat, are seasonally flowing, have >18°C stream temperatures in the summer, and have temperatures >13°C by mid-November.

Comment 7: *In 4.4 Task 4: Prepare Draft and Final Bull Trout LFA Report, (page 8), the schedule indicates a draft report will be delivered to the Aquatic Coordination Committee (ACC) by Oct. 15. WDFW data indicates bull trout are still actively spawning during this time frame. This due date will not reflect the full duration of bull trout spawning. WDFW recommends adjusting the completion of the report to reflect the full duration of spawning.*

Response 7: The schedule has been revised to address your comment. Please note that we are not proposing to conduct detailed spawning surveys in the tributaries to Lake Merwin and Swift Creek Reservoir; however, we will note any spawning activity observed during the scheduled habitat surveys in the fall. The presence/absence surveys are primarily for juveniles, which would indicate bull trout do currently use a particular tributary for spawning.

Comment 8: *WDFW would like to see emphasis on juvenile life history, particularly in the Pine Creek drainage. The potential exists that Pine Creek may contain both adfluvial and resident bull trout populations. It would be desirable if distinctions in bull trout in this drainage could be detected (genetically) and determine if these 150-350 mm fish interact. Therefore, we recommend a genetic study be designed and funded to address these issues.*

Response 8: Although we recognize the value of genetic studies in the upper Lewis River basin, streams already known to contain bull trout (i.e. Pine Creek, Rush Creek, the upper Lewis River, and the Muddy River) were not included in PacifiCorp's Scope of Work for this study. As a result, evaluations in these streams were not included in the Bull trout LFA Study Plan.

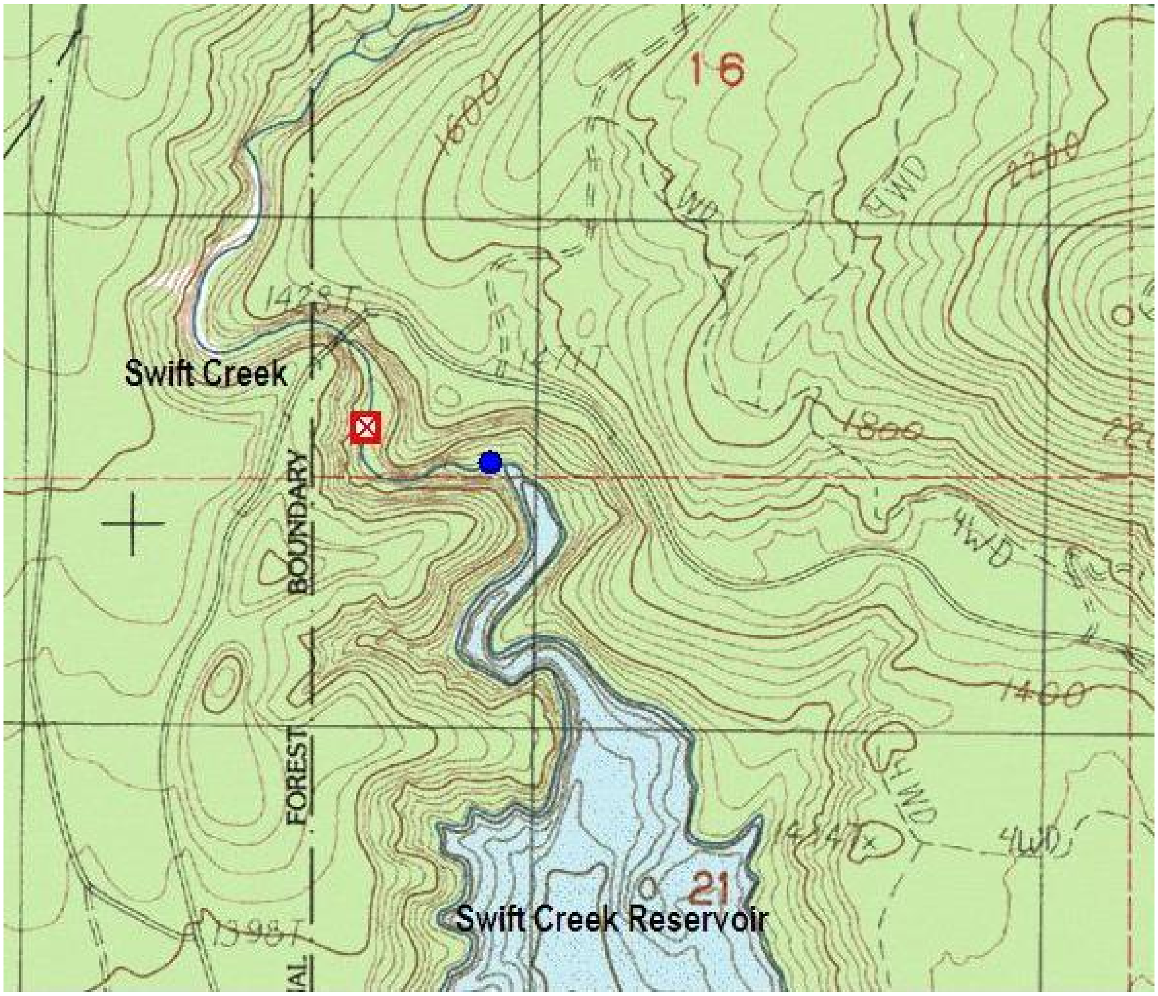
Comment 9: *On page 21 of the Qualitative Habitat Assessment (QHA) users Guide Version 1.1 it states, "As presently constituted, QHA is designed for use with streams and stream habitat characteristics. It does not contain a module for dealing with adfluvial populations once these enter the lake or reservoir." It appears this is not an appropriate methodology. All adult Lewis River bull trout spend half of the year in reservoirs.*

Response 9: The LFA is designed to address limiting factors within the tributaries to Lake Merwin and Swift creek reservoir not within the reservoir habitat. The Settlement Agreement language calls for a "...limiting factors analysis for bull trout occurring in Lake Merwin tributary streams and Swift Creek Reservoir tributary streams". Regardless, QHA can be modified to incorporate lake or reservoir habitats.

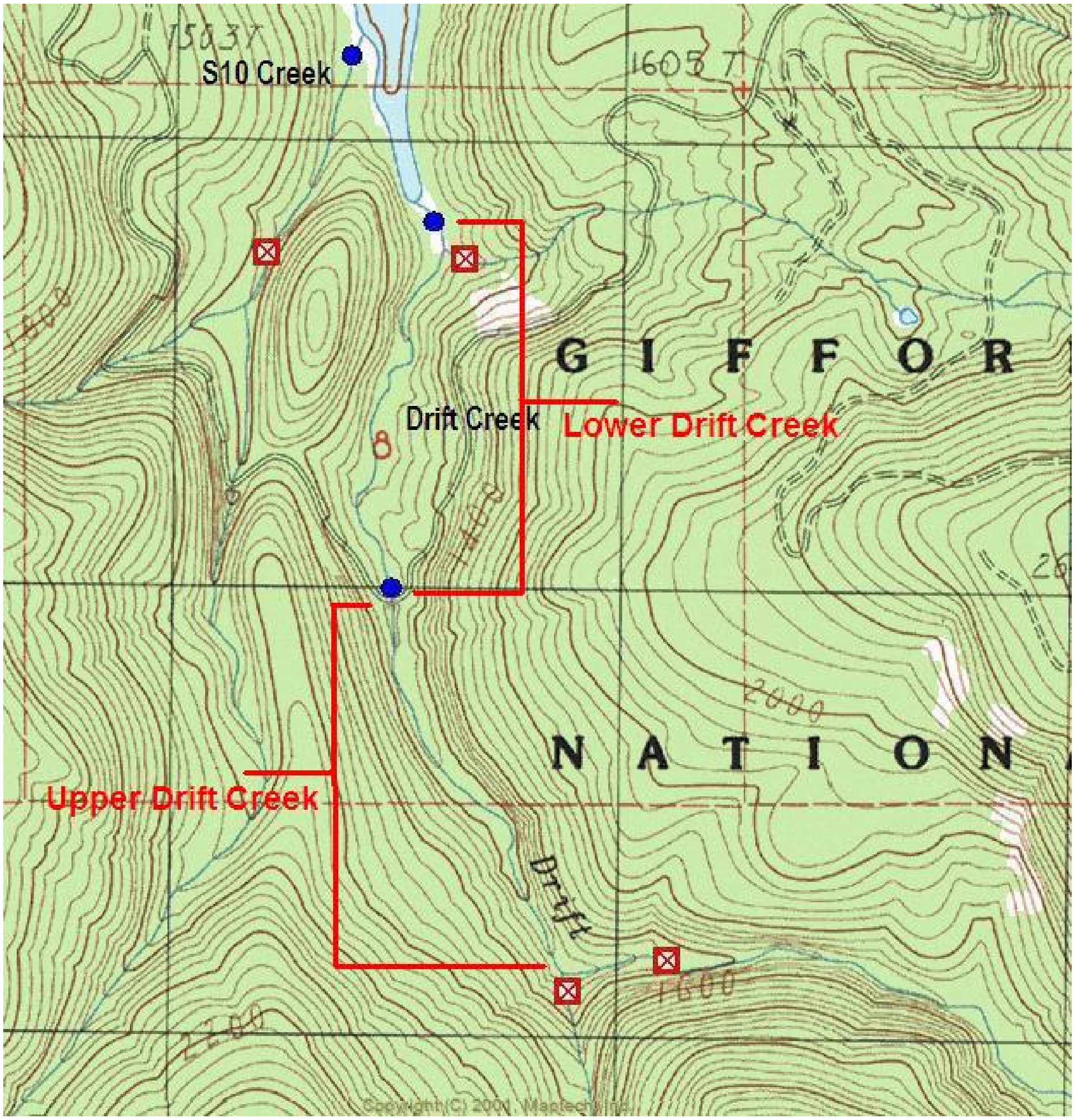
Appendix C

Tributary Maps

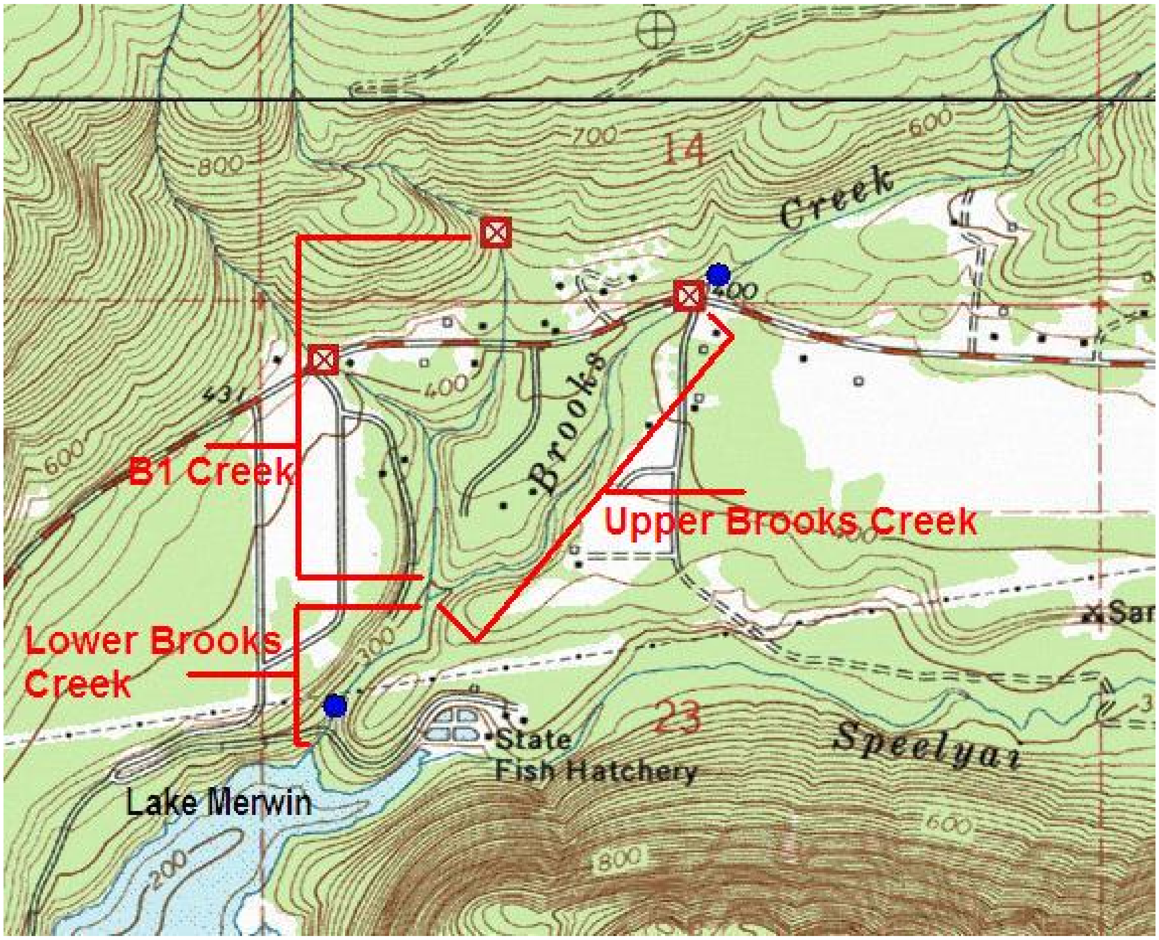
Swift Creek (blue-dot = temperature logger site, red-x = barrier)



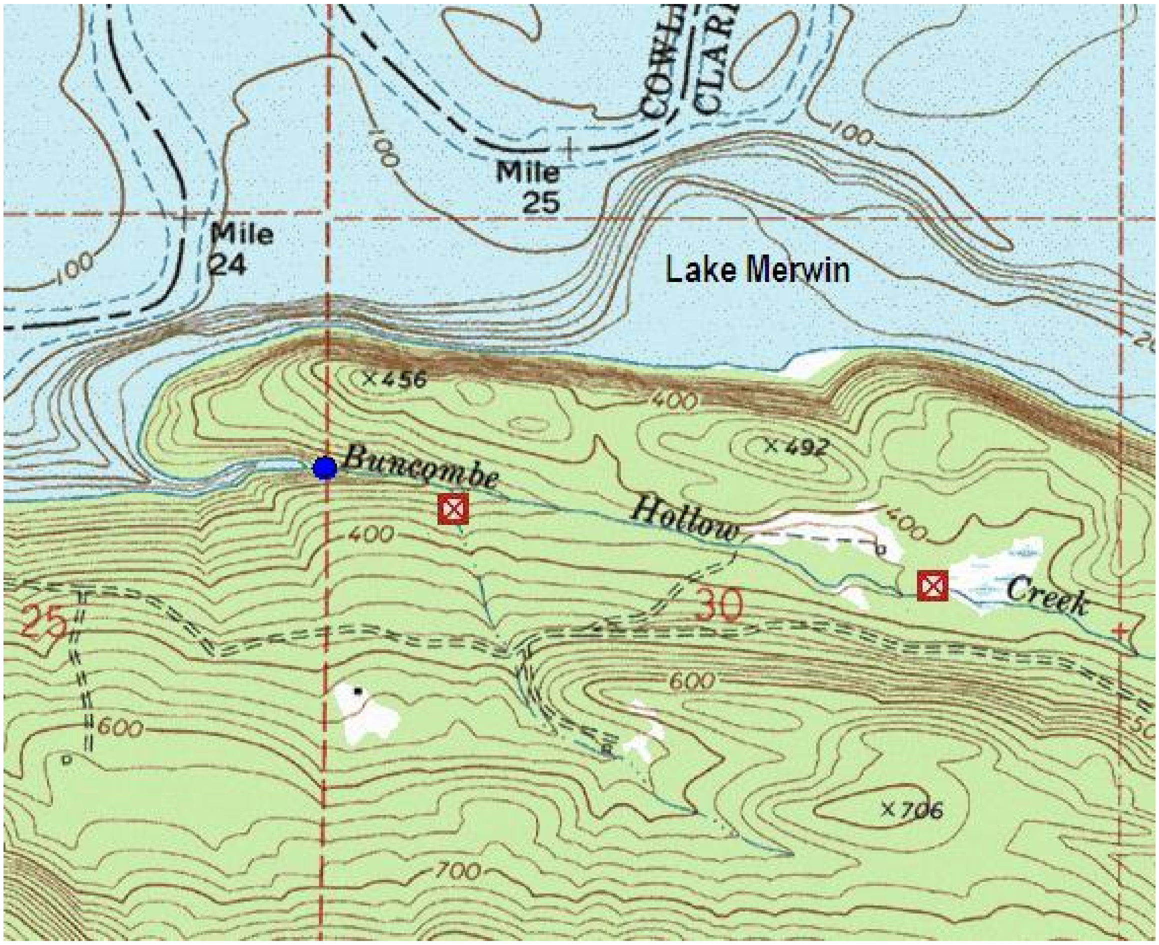
S10 and Drift creeks (blue-dot = temperature logger site, red-x = barrier, QHA reaches delineated by redlines)



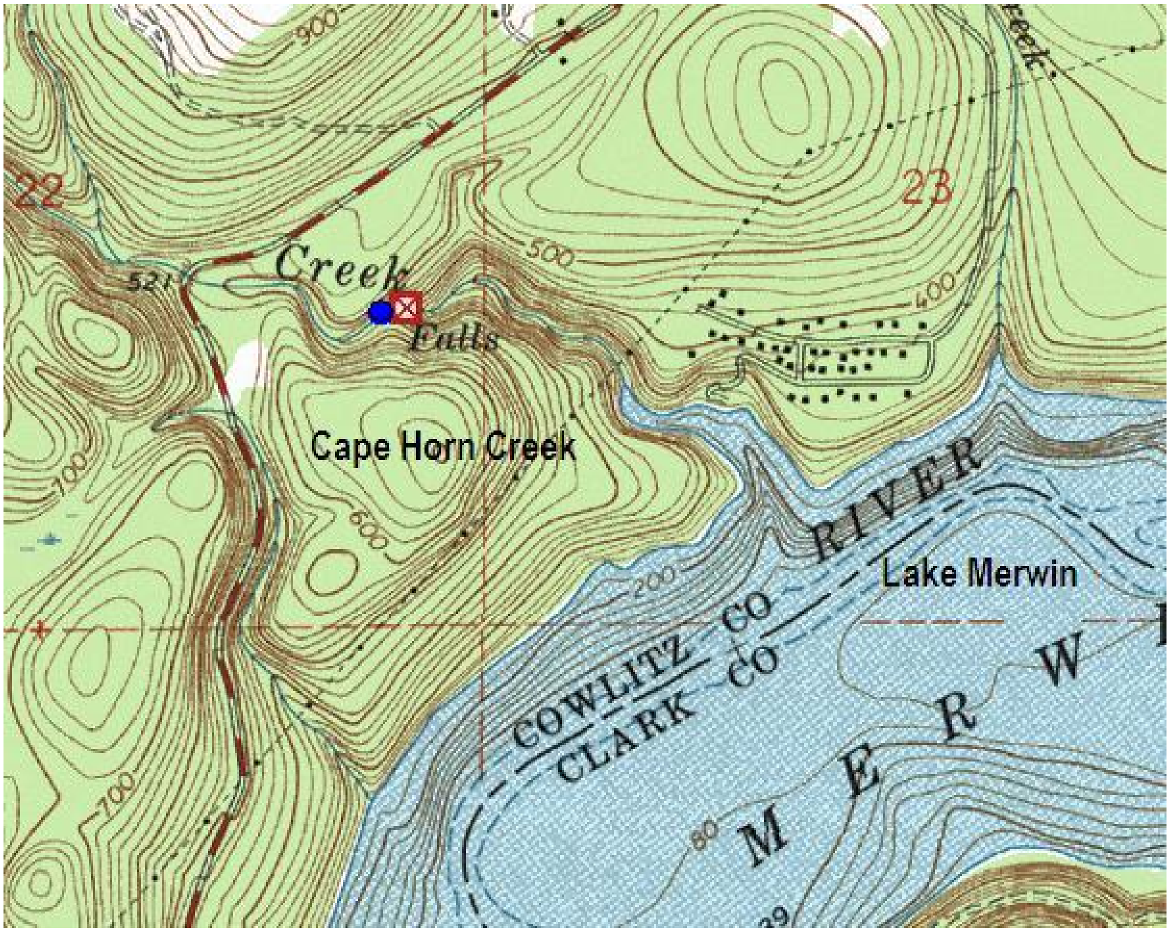
Brooks Creek (blue-dot = temperature logger site, red-x = barrier, QHA reaches delineated by redlines)



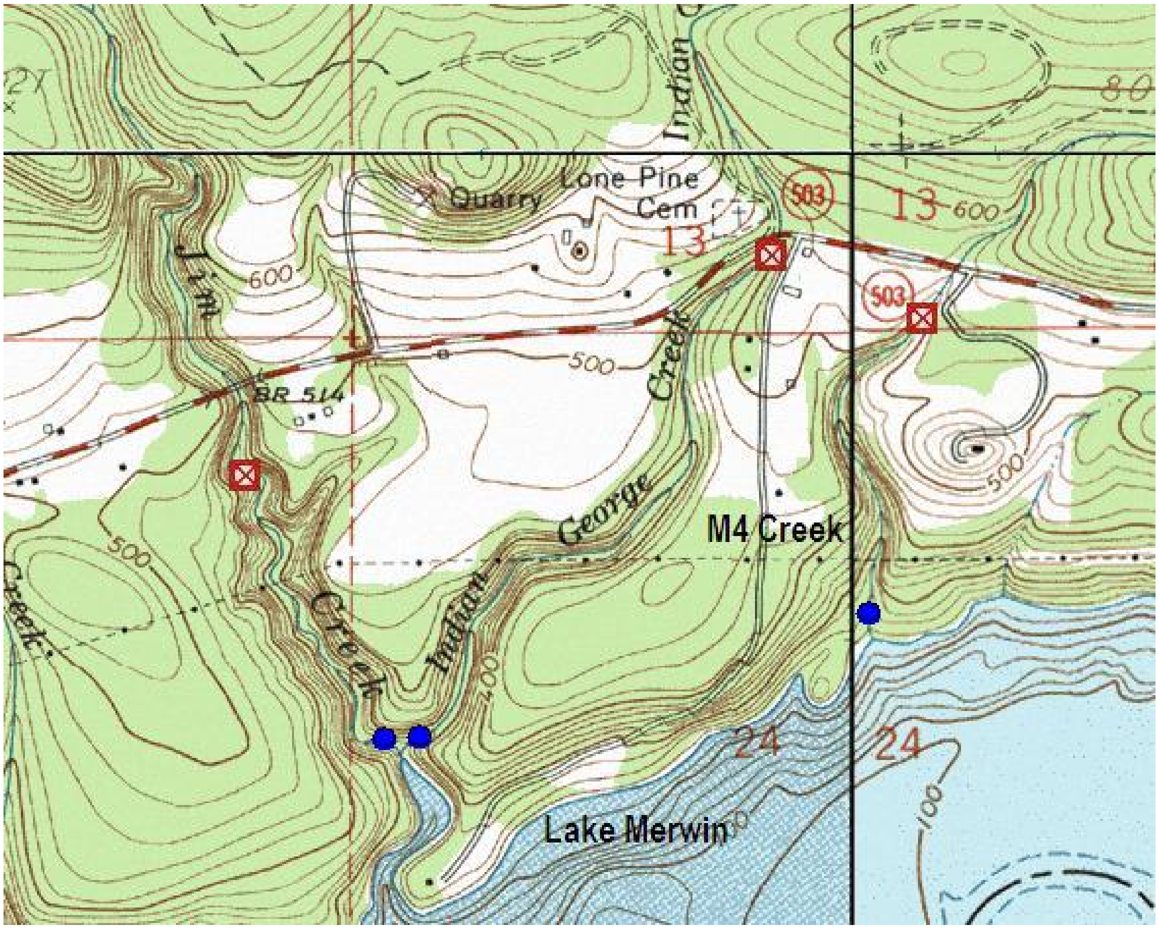
Buncombe Hollow Creek (blue-dot = temperature logger site, red-x = barrier)



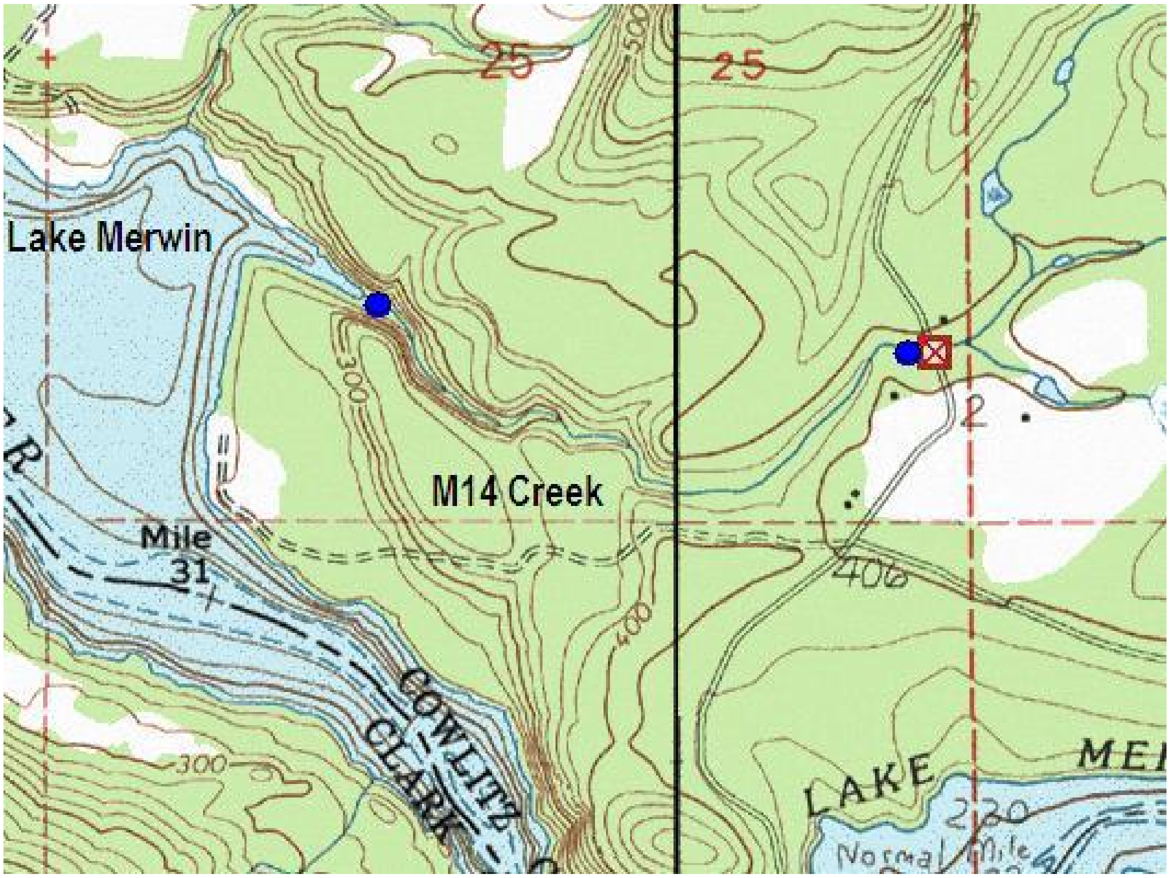
Cape Horn Creek (blue-dot = temperature logger site, red-x = barrier)



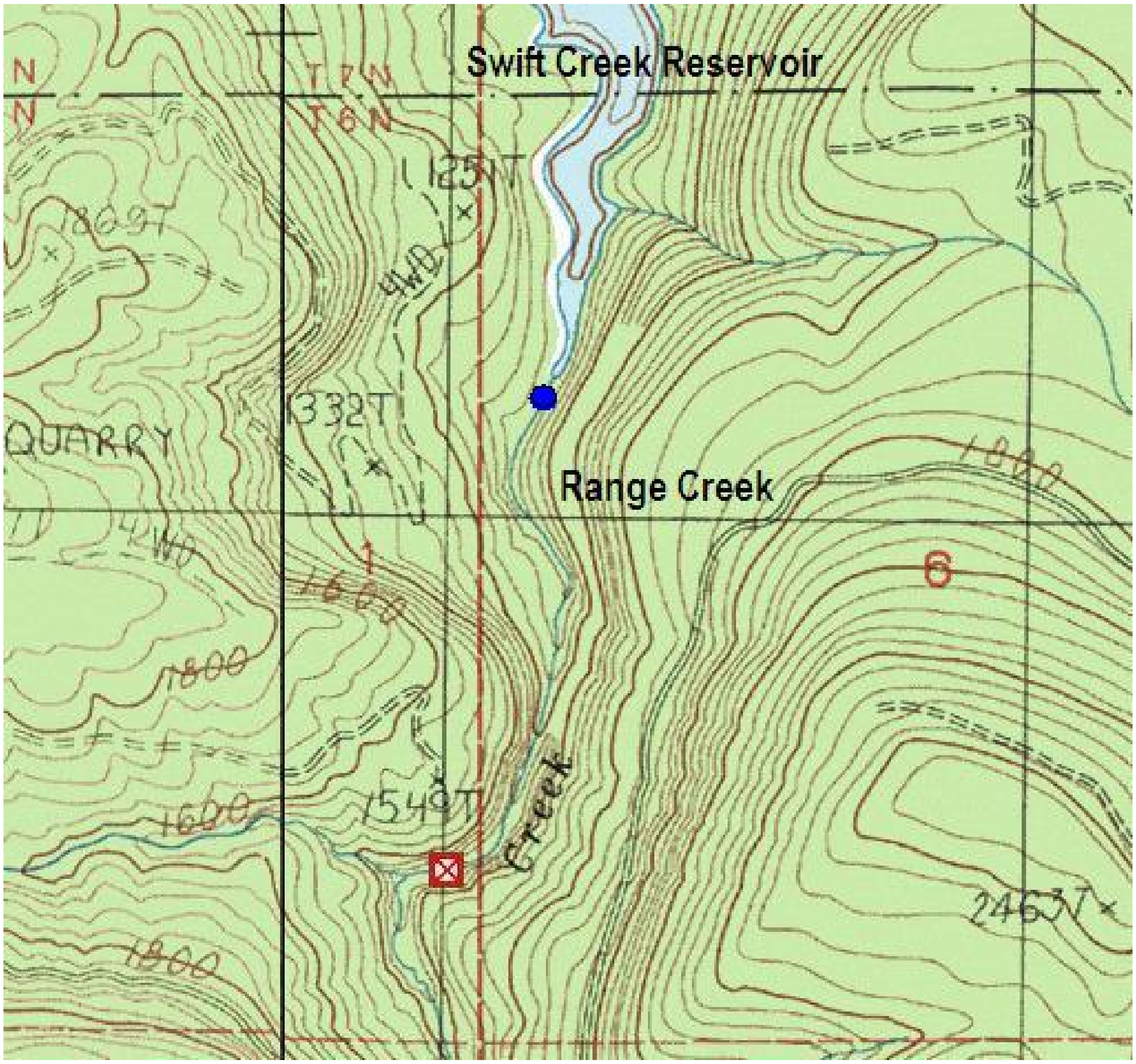
Jim, Indian, and M4 creeks (blue-dot = temperature logger site, red-x = barrier)



M14 Creek (blue-dot = temperature logger site, red-x = barrier)



Range Creek (blue-dot = temperature logger site, red-x = barrier)



S15 Creek (blue-dot = temperature logger site, red-x = barrier)