# White Salmon River Bull Trout: Patches, Occupancy and Distribution

2008 Progress Report

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## Introduction

Bull trout (*Salvelinus confluentus*) were listed threatened in the coterminous United States November 1, 1999 (USFWS 1999). Previously, the Columbia River distinct population segment (DPS) of bull trout had been listed as threatened since June 10, 1998. Factors contributing to the listing of bull trout include range wide declines in distribution, abundance and habitat quality. Land and water uses that alter or disrupt habitat requirements of bull trout can threaten the persistence of the species. Examples of such activities include: water diversions, dams, timber extraction, mining, grazing, agriculture, nonnative fish competition and/or hybridization, poaching, past fish eradication projects, and channelization of streams. Threats to the persistence of bull trout are prevalent throughout the Columbia River basin (USFWS 2000, 2002).

Flowing from the south side of the 3,742 m peak of Mount Adams, the White Salmon River drains into the Columbia River at river km 269 (Figure 1). Many of the upper tributaries of the White Salmon River are high gradient seasonal streams created by snow and glacial run off. Relatively low gradient tributaries such as Trout Lake Creek enter the mainstem from the west. Core habitat has been identified for bull trout within the White Salmon River (USFWS 2002), but recent investigations have yet to produce observations (Byrne et al. 2001, Thiesfeld et al. 2001). Two sightings above Condit Dam have been recorded in the past two decades by Washington Department of Fish and Wildlife biologists, a gillnet operation in 1986 and a creel census in 1989 (USFWS 2002).

Within the drainage, Condit Dam lies approximately 5.3 km upstream from the Columbia River confluence. PacifiCorp, a utilities company that owns and operates Condit dam, has proposed to decommission this dam and remove it in the fall of 2010. This dam was constructed in 1913 and has since been a barrier to migrating fish. Upon removal, the subbasin will be reconnected with the Columbia River. The objective of our work is to delineate bull trout patches (putative population boundaries) in the White Salmon River subbasin (following Dunham and Rieman, 1999, as modified in RMEG 2008). Patches are intended to represent areas conducive to spawning and early rearing. Bull trout occupancy of the patches as well as bull trout distribution within occupied patches will be determined both pre- and post-dam removal. Given the unique circumstances of this situation (i.e., removal of a dam behind which bull trout are likely functionally extirpated), this initial work will provide a quantitative baseline against which to compare changes in occupancy and distribution of bull trout in the White Salmon River subbasin subsequent to reconnection of the system with the mainstem Columbia River.

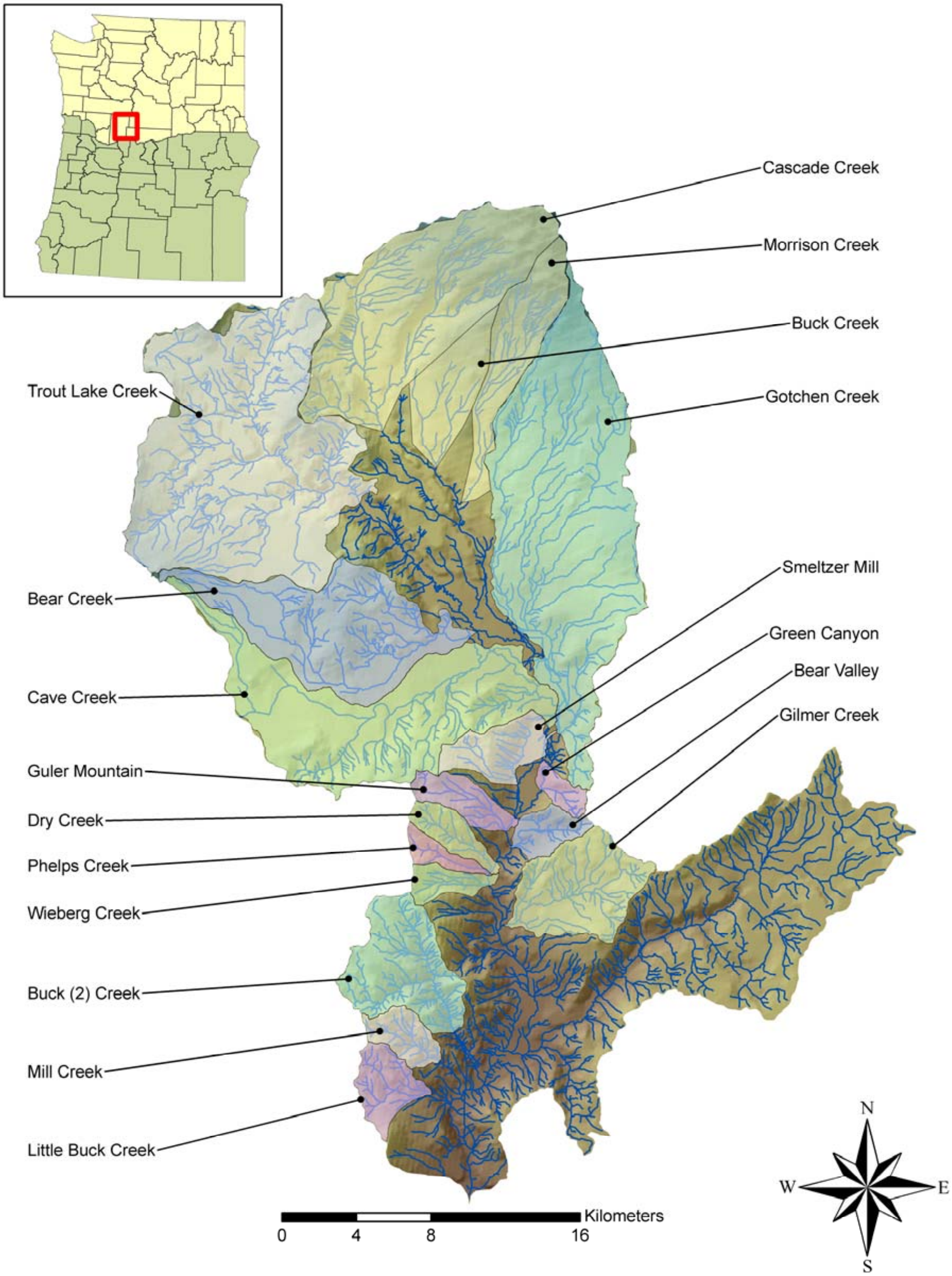


Figure 1. The White Salmon River subbasin and delineated patches.

Guidance from the Bull Trout Recovery Monitoring and Evaluation Technical Workgroup (RMEG 2008) recommends utilizing maximum annual stream temperature, stream size and catchment area as filters for determining potential bull trout habitat. Many other factors identified by Dunham and Rieman (1999) may also influence bull trout distribution (e.g., connectivity, stream gradient, geology, hydrologic regimes, presence of nonnative species, road density, solar radiation). However, maximum annual stream temperature (and the corresponding elevation) effectively dictates the range of this species (Rieman and McIntyre 1995) and patch size (catchment area) may be the most important factor determining bull trout occurrence (Dunham and Rieman 1999). Utilizing these three filters, provides the opportunity to evaluate this approach as a tool using information that most managers can readily acquire.

Maximum annual stream temperature can be determined from any stream temperature monitoring efforts occurring in a subbasin through the summer months. This type of data can be linked to a location, and subsequently to an elevation. Gathering this information from state and federal agencies, academic institutions, and other reliable sources can go a long way toward building a useful dataset to build temperature:elevation relationships within a subbasin. Should this information not be readily available or the resulting dataset be insufficient to build temperature:elevation relationships due to large data gaps, it may be possible to acquire this information from a similar subbasin proximate in geographic location.

Stream size and catchment area can be determined for watersheds or subwatersheds within a subbasin using information easily acquired from the internet. Recent digital elevation models (DEMs) and stream layers can be obtained free of charge from government agencies. This information can then be analyzed using ArcGIS to identify stream size and determine catchment area above the elevation that is within the acceptable temperature threshold for bull trout. Streams too large and catchment areas smaller than may be necessary for persistence of bull trout populations can then be dropped from further consideration.

The use of these three filters provides a starting point for determining a framework by which the distribution of bull trout within a subbasin can be evaluated. There may be exceptions to the potential distribution identified using this tool. Some bull trout populations may exist outside these patches due to geologic anomalies or other factors in the subbasin. Bull trout distribution within an identified patch may be limited or nonexistent due to barriers, hydrologic regimes or other factors. However, by using this tool, it is possible to implement a sampling approach that focuses limited resources in areas that may have a higher probability of supporting bull trout populations in a subbasin.

By researching the possible distribution of bull trout within the White Salmon River drainage, we can improve our understanding of this threatened species. This work will establish a quantitative baseline for bull trout occupancy and distribution in 18 defined patches prior to the removal of Condit Dam. Implementation of this approach through a long-term monitoring program subsequent to dam removal will provide information on recolonization of bull trout. This understanding will allow us to work towards restoration and recovery of bull trout populations within the Lower Columbia Recovery Unit as well as range wide. Specific tasks for 2008 are to assess bull trout occupancy in five patches within the White Salmon River subbasin.

## Methods

*Patch Delineation*

Patches were delineated in 2007 (Figure 1, Table 1). Methods and results are presented in Silver et al. (2009).

Table 1. Delineated patches and number of sample sites drawn.

| Patch Name | Total Number of Sites Drawn |
|---|---|
| **Bear Creek** | 240 |
| **Bear Valley** | 39 |
| **Buck (2) Creek** | 34 |
| **Buck Creek** | 34 |
| **Cascade Creek** | 134 |
| **Cave Creek** | 282 |
| **Dry Creek** | 10 |
| **Gilmer Creek** | 26 |
| **Gotchen Creek** | 281 |
| **Green Canyon** | 14 |
| **Guler Mountain** | 40 |
| **Little Buck Creek** | 19 |
| **Mill Creek** | 8 |
| **Morrison Creek** | 67 |
| **Phelps Creek** | 8 |
| **Smeltzer Mill** | 61 |
| **Trout Lake Creek** | 166 |
| **Wieberg Creek** | 7 |

*Sample Design*

Sample sites were determined for all patches in 2007 (Silver et al. 2009). No site-specific detection probability information is available for the White Salmon River, so available data from the Lewis River was used as a surrogate. The site-specific detection probability for bull trout in the Lewis River, a similar watershed, was 37.5% (Cook et al. 2009). Given this detection probability, guidance provided by RMEG (2008) indicates that if three sites per patch were sampled with a backpack electrofisher and less than two age classes of bull trout were captured, we could be 80% certain that the patch was unoccupied by a population. Given the lack of empirical information in the White Salmon subbasin, seven sites were sampled to ensure at least an 80% confidence level that bull trout were not present when not detected. If two age classes (as determined by size classes > 30 mm difference in fork length) of bull trout were captured within the patch, it was considered occupied by a population.

*Sample Approach*

Sampling was conducted for occupancy and distribution assessments using backpack electrofishing. Each 50 m reach was sampled from the downstream to the upstream boundary. All fish encountered were captured and identified. Length and mass were documented to facilitate size class determination. *Salvelinus* species were to be carefully scrutinized for distinguishing features before identification, as both bull trout and brook trout (*Salvelinus fontinalis*) may inhabit these watersheds and hybridization between the two could occur. Trout fry (TF) were identified as *Oncorhynchus* spp. when too small to reliably differentiate as *O. clarki* or *O. mykiss*. All fish captured were released alive within the sampled reach.

After the completion of fish sampling, habitat data was collected from the study reach. The gradient of each sampling site was measured using a hand-held clinometer. Gradient was measured and recorded twice at each site, from the top of the reach to the middle, and again from the middle to the bottom of the reach. The eye level height of the person sighting the gradient was measured against the person standing downstream. One surveyor stood level with the water's edge upstream and measured the percent gradient against the second surveyor standing downstream at level with the water's edge.

Transects were flagged along the thalweg at every 10 meter mark from 0 to 50 meters. Channel dimensions were then measured along each of the six designated transects within the 50 meter sampling reach. For each transect, measurements were completed for the current wetted width, maximum depth along the transect line, and depth recordings at ¼, ½, and ¾ marks across the wetted width. Total length of the reach measured along the bank was also recorded as an index of sinuosity.

Within each reach, large woody debris (LWD) was categorized and counted. Wood was classified into four categories: LWD > 10 cm in diameter and > 3 m in length, LWD > 60 cm in diameter and > 10 m in length, root wads and LWD piles (aggregates of > 4 pieces of wood together). Only pieces of wood directly within the channel or within one meter of the water's surface were considered.

The number, type and size of undercut banks were measured along both sides of the sampling reach. Undercuts were defined as areas under boulders, banks, wood, or bedrock along the stream bank that were > 5 cm deep, > 10 cm in length, and > 5 cm in height (e.g., PIBO; Kershner et al. 2004). Only undercuts within 0.5 meter of the stream surface were considered.

**Results**

*Sample Approach 2008*

Field work in the White Salmon River basin occurred between June 11 and June 27, 2008. Four patches were completed (Dry Creek, Wieberg Creek, Mill Creek, and Little Buck Creek; Figure 2). Among these patches a total of 20 sites were sampled and 10 sites were not sampled due to unviable locations (Table 2). Salmonids were found in 10 sites. The Phelps creek patch was not completed. Two sites were sampled and both contained salmonids. Electrofishing efforts for all reaches of the White Salmon subbasin totaled 5,969 seconds, with an average of 271 seconds electrofished in each site.

Phelps Creek was the first patch sampled in the White Salmon River subbasin (Figure 4). A black bear (*Ursus americanus*) and her cub were encountered at site 6 preventing further sampling in the upper remote sites of Phelps Creek. Downstream at site 5, four *Oncorhynchus mykiss* were captured below a culvert located on Hwy 141. Site 7 was approximately 150 m upstream from the Hwy 141 culvert, eleven *O. mykiss* were captured and tailed frog tadpoles were observed. There are five sites remaining upstream to be sampled, this patch was not completed due to time constraints and to avoid further sow and cub contact.

The sites in the Dry Creek patch were sampled within 1 km of the confluence with the White Salmon River (Figure 5). Site 3 was located approximately 300 m upstream from the confluence with the White Salmon River, water was shallow (mean depth 0.04 m., mean max. depth 0.10 m, mean wetted width 2.27 m; see Table 4) and no fish or amphibians were found. The temperature was relatively high (12.4 °C) and there were no pools. Site 1 was also shallow (mean depth 0.11 m., mean max. depth 0.24 m, mean wetted width 4.05 m); there was small woody debris (< 3.0 m and < 0.10 m) not captured by the habitat data within the channel. No fish or amphibians were present. A nearby landowner said Dry Creek usually dries up in mid-May. This was the latest he had seen it flow in 30 years, and he had never seen fish in the creek. No further sampling was conducted upstream given this information and the previous findings.

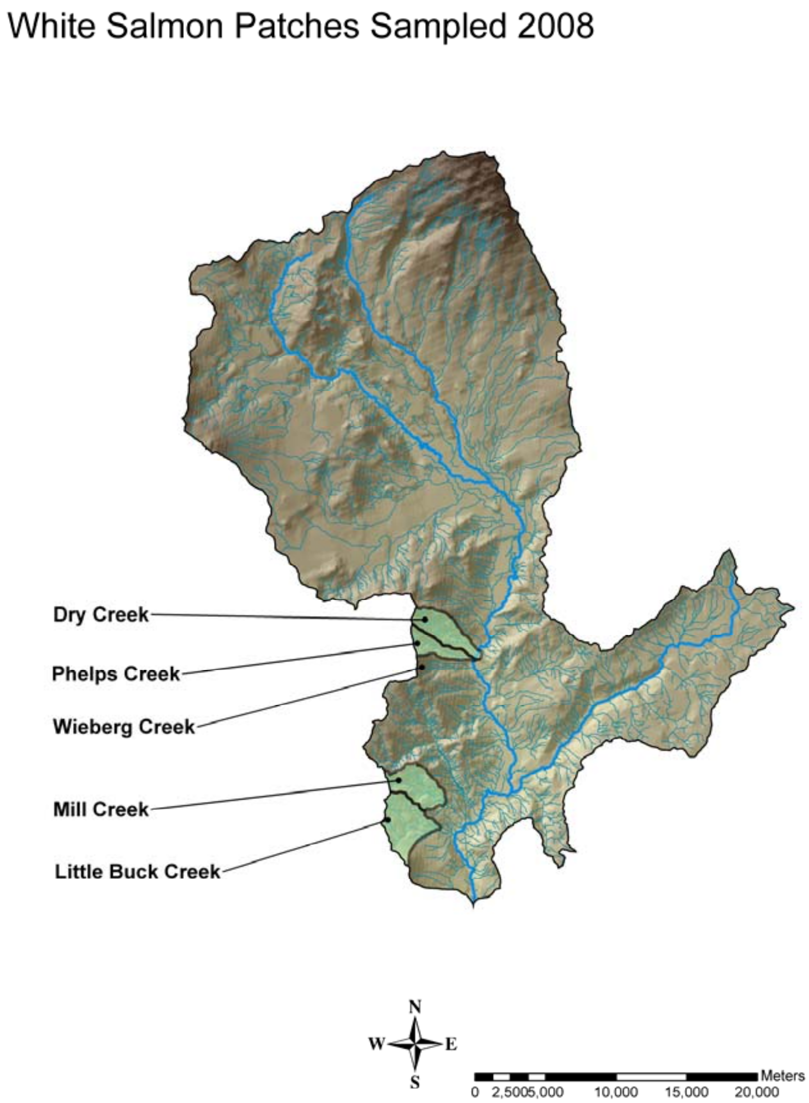


Figure 2. Sites sampled in the White Salmon subbasin in 2008.

Table 2. Sites surveyed and species found 2008

*Oncorhynchus clarki* (CCT), *Oncorhynchus* sp. Fry (TF), CCT /*O. mykiss* Hybrid (HYB)

| Patch | Site | Date | Sample Status | Salmonid Species | Non-Salmonid Species Comments |
|---|---|---|---|---|---|
| Phelps Creek | 1 | | Not Sampled | | Near bear and cub |
| | 2 | | Not Sampled | | Near bear and cub |
| | 3 | | Not Sampled | | Near bear and cub |
| | 4 | | Not Sampled | | Near bear and cub |
| | 5 | 6/11/2008 | Sampled | *O. mykiss* | |
| | 6 | 6/10/2008 | Not Sampled | | Black Bear and cub |
| | 7 | 6/11/2008 | Sampled | *O. mykiss* | Tailed Frog Tadpoles |
| | 8 | | Not Sampled | | Near bear and cub range |
| Dry Creek | 1 | 6/12/2008 | Sampled | | |
| | 3 | 6/12/2008 | Sampled | | |
| | 4 | | Not Sampled | | Located above site 10-Dry |
| | 5 | | Not Sampled | | Located above site 10-Dry |
| | 6 | | Not Sampled | | Located above site 10-Dry |
| | 7 | | Not Sampled | | Located above site 10-Dry |
| | 8 | | Not Sampled | | Located above site 10-Dry |
| | 9 | | Not Sampled | | Located above site 10-Dry |
| | 10 | 6/12/2008 | Sampled | | |
| Wieberg Creek | 1 | | Not Sampled | | Located above waterfall |
| | 2 | 6/13/2008 | Sampled | | |
| | 3 | | Not Sampled | | Located above waterfall |
| | 4 | 6/20/2008 | Sampled | | Dicamp., Tailed Frog adult/tadpoles |
| | 6 | | Not Sampled | | Located above waterfall |
| | 7 | | Not Sampled | | Located above waterfall |
| | 9 | 6/13/2008 | Sampled | | Tailed Frog Tadpoles |
| Mill Creek | 1 | 6/19/2008 | Sampled | CCT | Dicamp., Tailed Frog, Bobcat |
| | 2 | 6/17/2008 | Sampled | CCT, *O. mykiss*, HYB | Cottid |
| | 3 | 6/17/2008 | Sampled | CCT, TF | Tailed Frog |
| | 4 | 6/18/2008 | Sampled | CCT | Tailed Frog |
| | 5 | 6/19/2008 | Sampled | | Dicamp., Tailed Frogs |
| | 6 | 6/18/2008 | Sampled | CCT | Dicamp., Tailed Frogs |
| | 7 | 6/19/2008 | Sampled | | Dicamptodon |
| Little Buck Creek | 1 | 6/27/2008 | Sampled | CCT | Dicamp., Tailed Frog tadpoles |
| | 2 | 6/26/2008 | Sampled | CCT | Dicamptodon |
| | 3 | 6/26/2008 | Sampled | CCT | Dicamptodon., Tailed Frogs |
| | 4 | 6/27/2008 | Sampled | | Dicamptodon, Tailed Frogs |
| | 5 | 6/26/2008 | Sampled | CCT | |
| | 6 | 6/23/2008 | Sampled | | Dicamp., Tailed Frog adult/tadpole |
| | 7 | 6/23/2008 | Sampled | CCT | Dicamp., Tree Frogs |

Wieberg Creek was sampled within 2 km of the confluence with the White Salmon River (Figure 6). Temperature at all three sites was relatively high (mean 11.7°C). Site 2 was approximately 30 m upstream of the Hwy 141 culvert. Banks were unstable and erosion was observed; substrate was composed of gravel, cobbles and boulders. Habitat unit configuration appeared to have potential bull trout habitat (riffle-pool). Vegetative cover consisted of alders that provided no canopy, no fish were found. Site 9 was a wide (mean wetted width 3.1 m), cobbled floodplain with low growing alders and unstable banks. No fish were found, tailed frog tadpoles were present. Site 4 was located on a 50 m waterfall, certainly a fish barrier (Figure 3). The survey was conducted 80 meters downstream, no fish were found, Dicamptodons and tailed frogs were present (both adult and tadpole). No sites were surveyed upstream above the waterfall (sites 1, 3, 6, 7).

All seven sites were surveyed in the Mill Creek patch (Figure 7). Site 2 contained coastal cutthroat trout (*Oncorhynchus clarki clarki*), *O. mykiss* fry, a hybridized cutthroat/*O. mykiss*, and cottids. Approximately 3 fish were missed while fishing in the reach but did not appear to be other species than those captured. Site 3 was located approximately 500 m upstream; cutthroat and *Oncorhynchus* spp. fry were captured, tailed frogs were present. At site 4, cutthroat and tailed frogs were present. Site 6 had cutthroat, tailed frogs, and one Dicamptodon present. There were no fish found at sites 5 and 7, Dicamptodons and tailed frogs were present. These two sites had similar abundances of LWD and old growth in the forest (Table 2). Site 1 was downstream from sites 5 and 7 and contained cutthroat, Dicamptodons, and tailed frogs. There were no clear barriers to fish distribution observed between sites 1 and 5. The Mill Creek patch had the largest amount of undercutting (39%) with 17% of the undercuts formed by the large woody debris (Figure 9). Mill Creek also had the most LWD in all the sites sampled in the White Salmon River subbasin (Table 3).

The last patch to be surveyed was Little Buck Creek (Figure 8). Site 7 was located on a small stream (mean wetted width 1.95 m) that appeared to be year-round given that it had water flowing at the end of June. Cutthroat, Dicamptodons, tree frogs, and tailed frogs were found. This site had the lowest conductivity (29.3 µs) of all sites sampled in the White Salmon River subbasin. Site 6 contained pool and riffle habitat with cobble/gravel substrate. A natural gas pipeline is approximately 570 m downstream. No fish were found, but Dicamptodons, a tree frog adult, and tailed frog tadpoles were present. Site 3 was a flat (3.5% gradient) reach with cutthroat present. Site 2 was approximately 300 m upstream of site 3. This was a low gradient stream (8%) with a channel braiding halfway, cutthroat and Dicamptodons were present. Site 5 was upstream approximately 300 m from site 2 and cutthroat trout were present. The undercuts were longer (mean 6.7 m) than all other sites in the White Salmon River subbasin which ranged from 1.0-5.8 m in length. No fish were found in Site 4.

**Figure 3. Wieberg Creek fish barrier**

Dicamptodons and tailed frog tadpoles were present. Finally, Site 1 was high-gradient (18%) in a deep, confined valley with many (14 units) shallow undercut banks. Cutthroat trout were present along with Dicamptodons and tailed frog tadpoles.

**Discussion / Findings**

Field work in 2008 improved our knowledge of the White Salmon River drainage and potential bull trout habitat. Based on water temperatures, catchment areas and stream size, 18 patches had been identified as potential habitat supporting bull trout in the White Salmon River subbasin (Silver et al. 2009). Sampling in four of these patches resulted in observations of fish species at 10 sites. However, these samples did not include bull trout. Thus, we conclude that 0% (0 of 4) of the patches completed in 2008 and 0% (0 of 9) of the patches sampled since 2007 in the White Salmon River subbasin are occupied by bull trout (see Silver et al. 2009). Field work has also resulted in documentation of fish passage barriers within patches that would result in a presumed patch no longer being considered a patch due to a size less than 400 hectares (i.e., Wieberg Creek). If surveys above these barriers confirm that fish are not present, these patches will be removed from consideration in future bull trout monitoring activities within the White Salmon River subbasin. Work in 2009 will focus on continuing to assess occupancy of remaining patches in the White Salmon River subbasin, finishing incomplete sampling of 2008 field work, and confirming end of fish distribution at potential fish migration barriers.

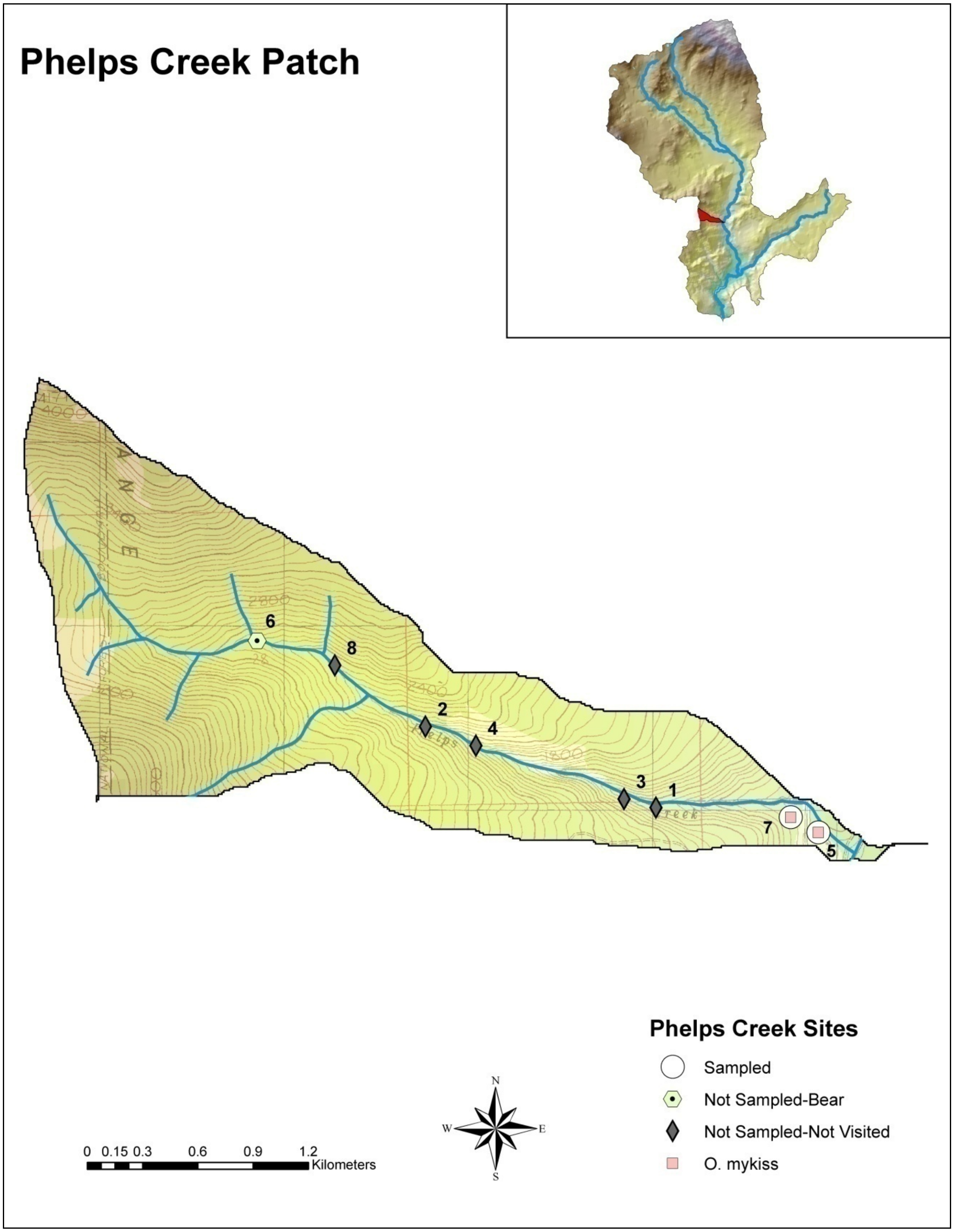


Figure 4. Phelps Creek sites 2008.

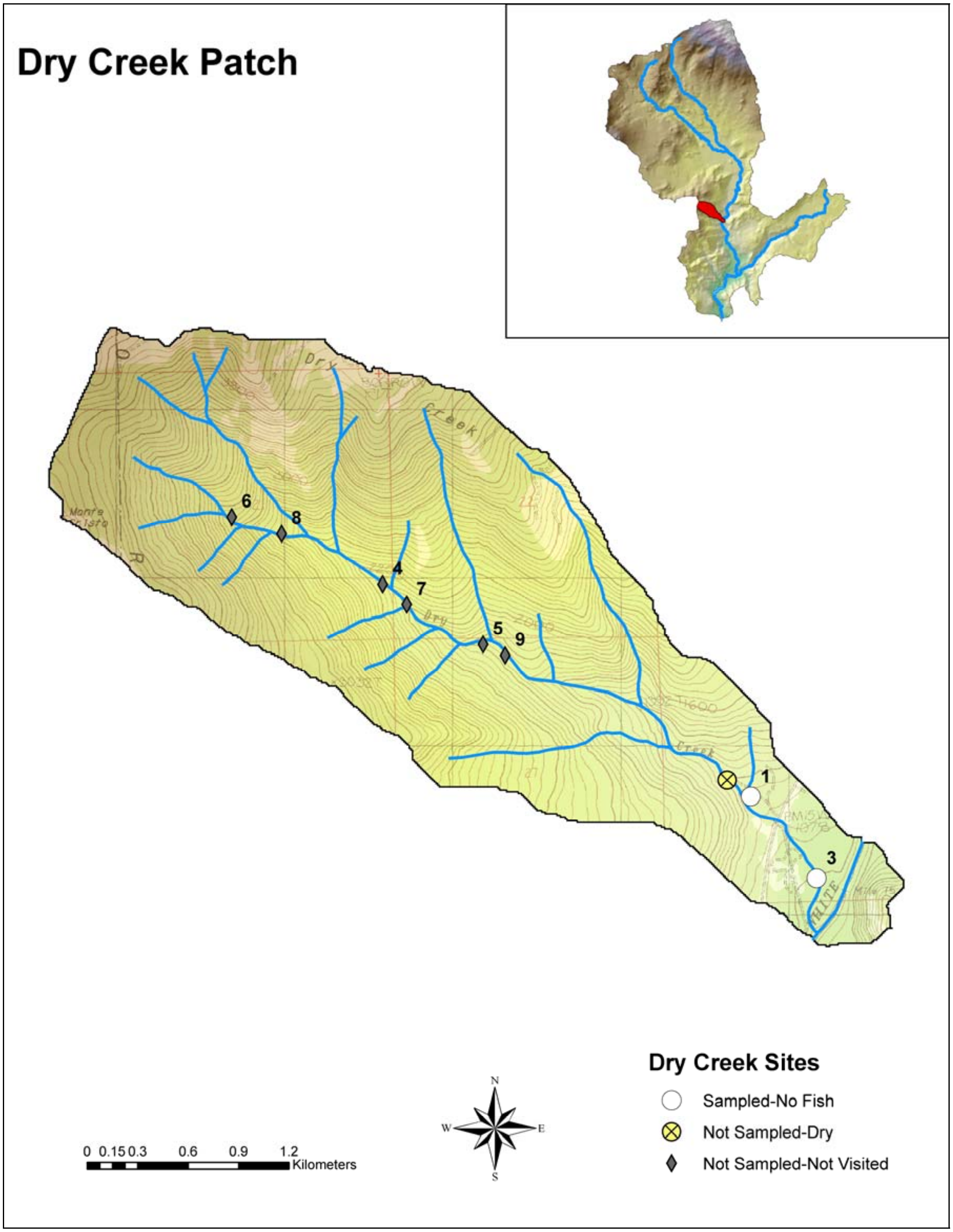


Figure 5. Dry Creek sites 2008.

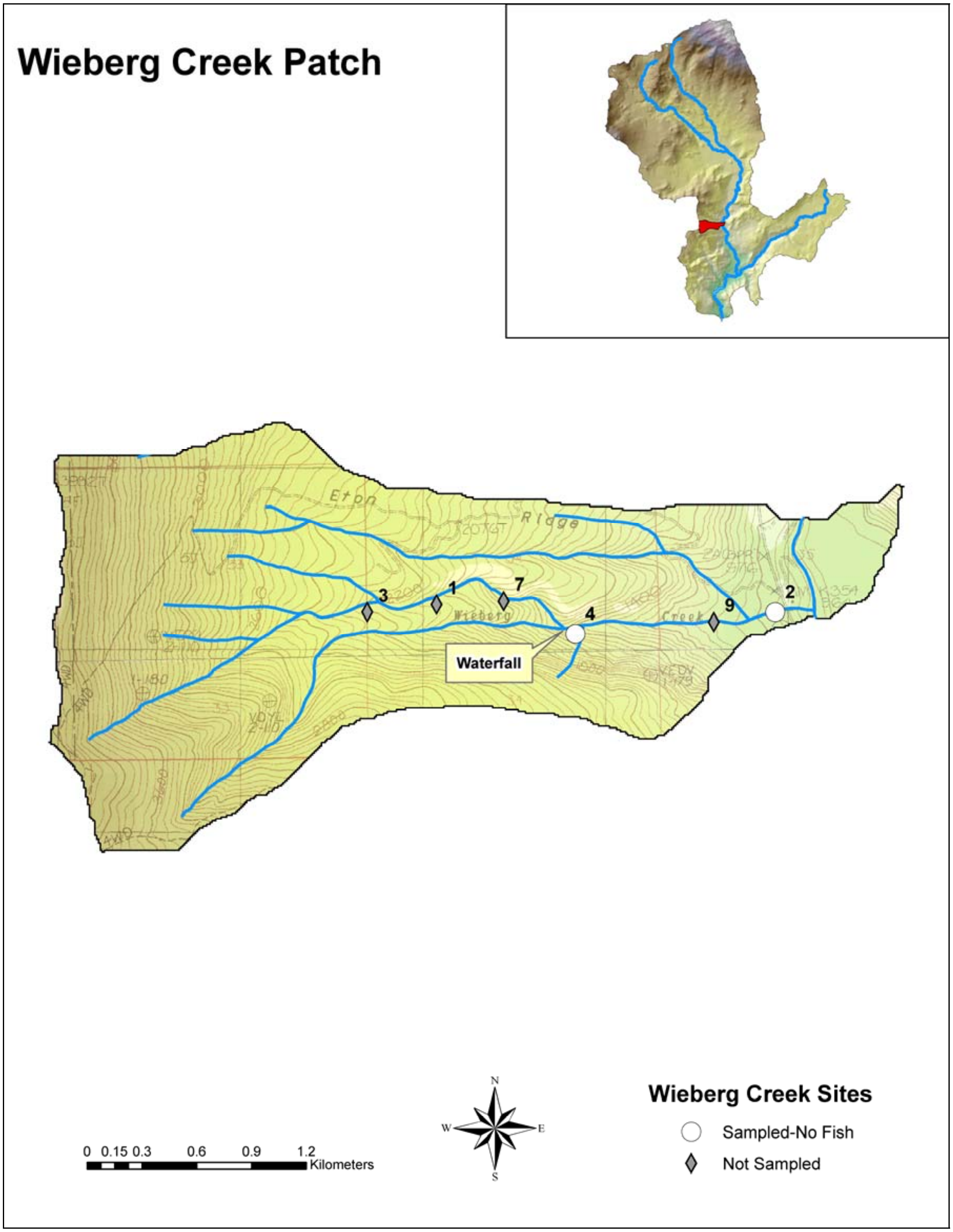


Figure 6. Wieberg Creek sites 2008.

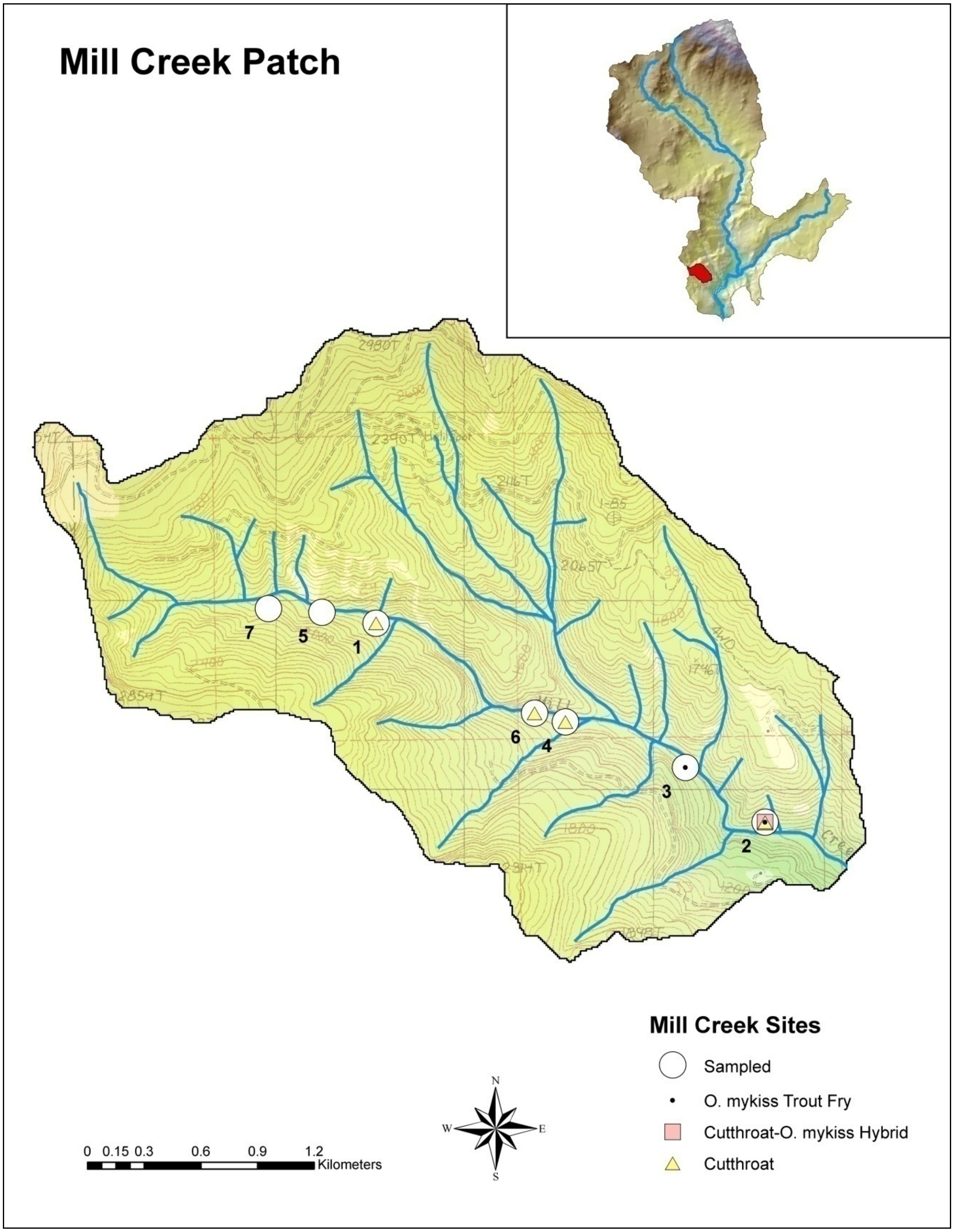


Figure 7. Mill Creek sites 2008.

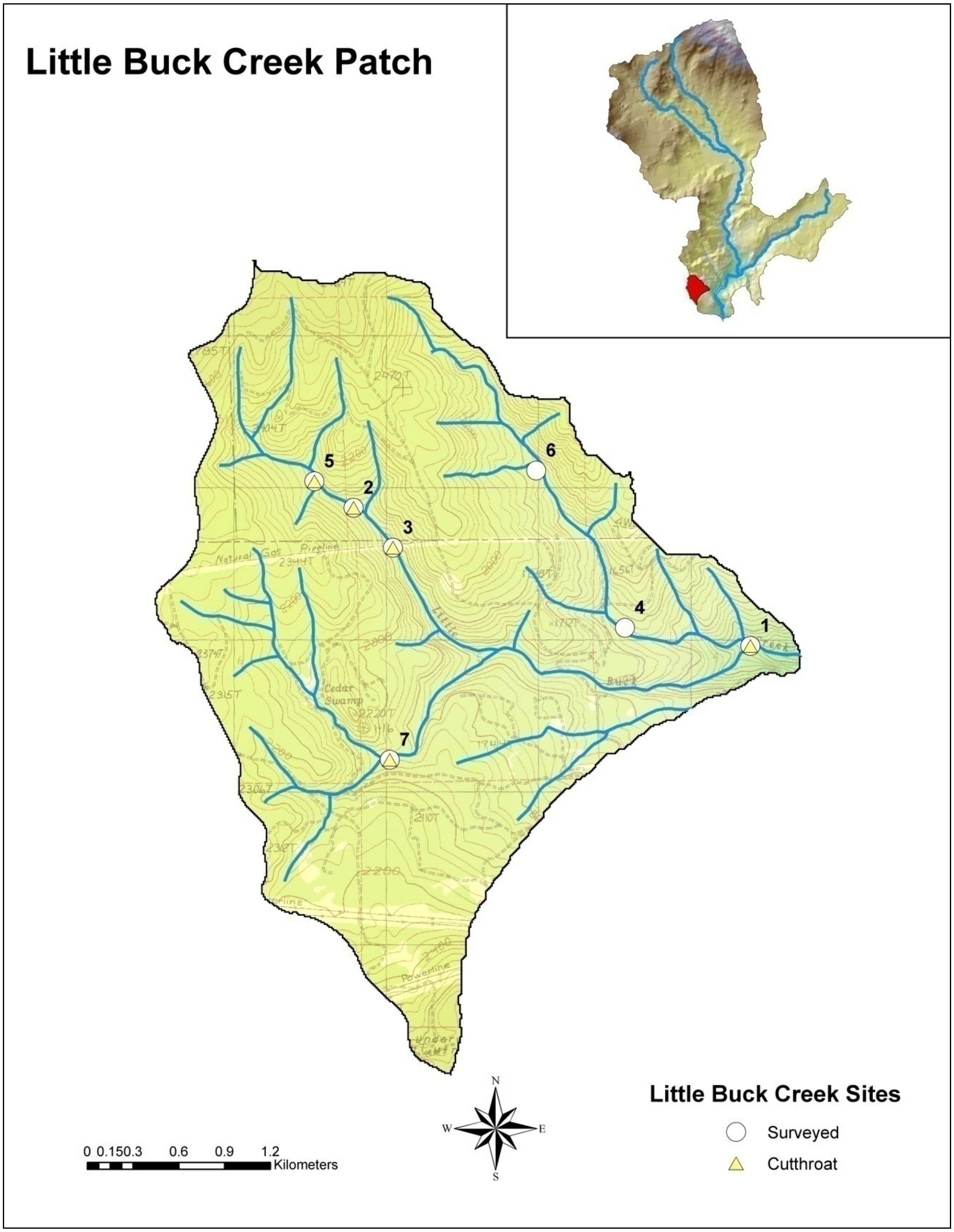


Figure 8. Little Buck Creek sites 2008.

Table 3. Habitat Data 2008.

| | | Phelps Creek | | Dry Creek | | | Wieberg Creek | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Site** | 5 | 7 | 1 | 3 | 10 | 2 | 4 | 9 |
| | **Date** | 6/11 | 6/11 | 6/12 | 6/12 | 6/12 | 6/13 | 6/20 | 6/13 |
| | **Time Start** | 11:03 | 13:09 | 12:28 | 11:05 | 13:25 | 10:32 | 9:44 | 11:22 |
| | **Time End** | NA | 14:20 | 13:10 | 11:40 | 14:00 | 11:05 | 10:34 | 12:03 |
| | **Temperature (°C)** | 8.2 | 8.6 | 8.8 | 12.4 | 8.9 | 11.7 | 11.4 | 12.1 |
| | **Conductivity (μs)** | 47.1 | 45.8 | 37.1 | 45.3 | 38.5 | 50.2 | 52.9 | 47.4 |
| | **Bank Length** | 50.3 | 50 | 47.3 | 49.3 | 49 | 48.1 | 50 | 49.5 |
| | **Thalweg Length** | 50 | 47.3 | 50 | 50 | 50 | 50 | 50 | 50 |
| | **Pools?** | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| **Gradient** | **Clinometer Top (%)** | 6 | 8 | 8 | 4 | 7 | 6 | 10 | 8 |
| | **Clinometer Bottom (%)** | 6 | 8 | 6 | 4 | 1 | 9 | 11 | 8 |
| | **Clinometer Average (%)** | 6 | 8 | 7 | 4 | 4 | 7.5 | 10.5 | 8 |
| **Large Woody Debris** | **# >3m length >10cm diameter** | 4 | 6 | 2 | 1 | 1 | 9 | 2 | 0 |
| | **LWD Piles (>4 pieces of LWD together)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **# >10 m in length >60 cm diameter** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | **# Root Wads** | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 1 |

| | | Mill Creek | | | | | | | Little Buck Creek | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Site** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | **Date** | 6/19 | 6/17 | 6/17 | 6/18 | 6/19 | 6/18 | 6/19 | 6/27 | 6/26 | 6/26 | 6/27 | 6/26 | 6/23 | 6/23 |
| | **Time Start** | 12:50 | 12:24 | 14:10 | 10:30 | 11:10 | 12:40 | 9:56 | 13:00 | 11:43 | 10:18 | 10:00 | 13:07 | 11:43 | 9:32 |
| | **Time End** | 13:45 | 13:38 | 15:05 | 11:50 | 11:56 | 13:56 | 10:45 | 14:13 | 12:34 | 11:20 | 10:40 | 13:59 | 12:25 | 10:21 |
| | **Temperature (°C)** | 8.5 | 10.5 | 9.9 | 8.5 | 8.0 | 9.0 | 7.4 | 10.7 | 8.3 | 8.6 | 8.8 | 7.8 | 8.6 | 9.4 |
| | **Conductivity (μs)** | 87.3 | 78.3 | 79 | 92.4 | 83.3 | 80.9 | 83.3 | 94.9 | 68.8 | 73.4 | 97.4 | 74.6 | 84.6 | 29.3 |
| | **Bank Length** | 45.5 | 51 | 50 | 50.0 | 46.0 | 51.0 | 48 | 49.1 | 42 | 50 | 49.7 | 48.3 | 47.5 | 48 |
| | **Thalweg Length** | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| | **Pools?** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Gradient** | **Clinometer Top (%)** | 14.00 | 5 | 7 | 11 | 12 | 8 | 15 | 18.00 | 8.00 | 5 | 6 | 9 | 7 | 6 |
| | **Clinometer Bottom (%)** | 11.00 | 5 | 6 | 8 | 14 | 10 | 6 | 18.00 | 8.00 | 2 | 5 | 9 | 9 | 9 |
| | **Clinometer Average (%)** | 12.50 | 5 | 6.5 | 9.5 | 13 | 9 | 10.5 | 18.00 | 8.00 | 3.5 | 5.5 | 9 | 8 | 7.5 |
| **Large Woody Debris** | **# >3m length >10cm diameter** | 24 | 6 | 7 | 26 | 26 | 25 | 14 | 13 | 6 | 8 | 5 | 14 | 9 | 18 |
| | **LWD Piles (>4 pieces of LWD together)** | 4 | 0 | 0 | 5 | 3 | 5 | 4 | 1 | 0 | 0 | 0 | 3 | 0 | 2 |
| | **# >10 m in length >60 cm diameter** | 12 | 0 | 1 | 9 | 13 | 6 | 3 | 5 | 3 | 5 | 2 | 5 | 2 | 0 |
| | **# Root Wads** | 3 | 3 | 0 | 3 | 2 | 4 | 1 | 2 | 0 | 1 | 0 | 1 | 1 | 1 |

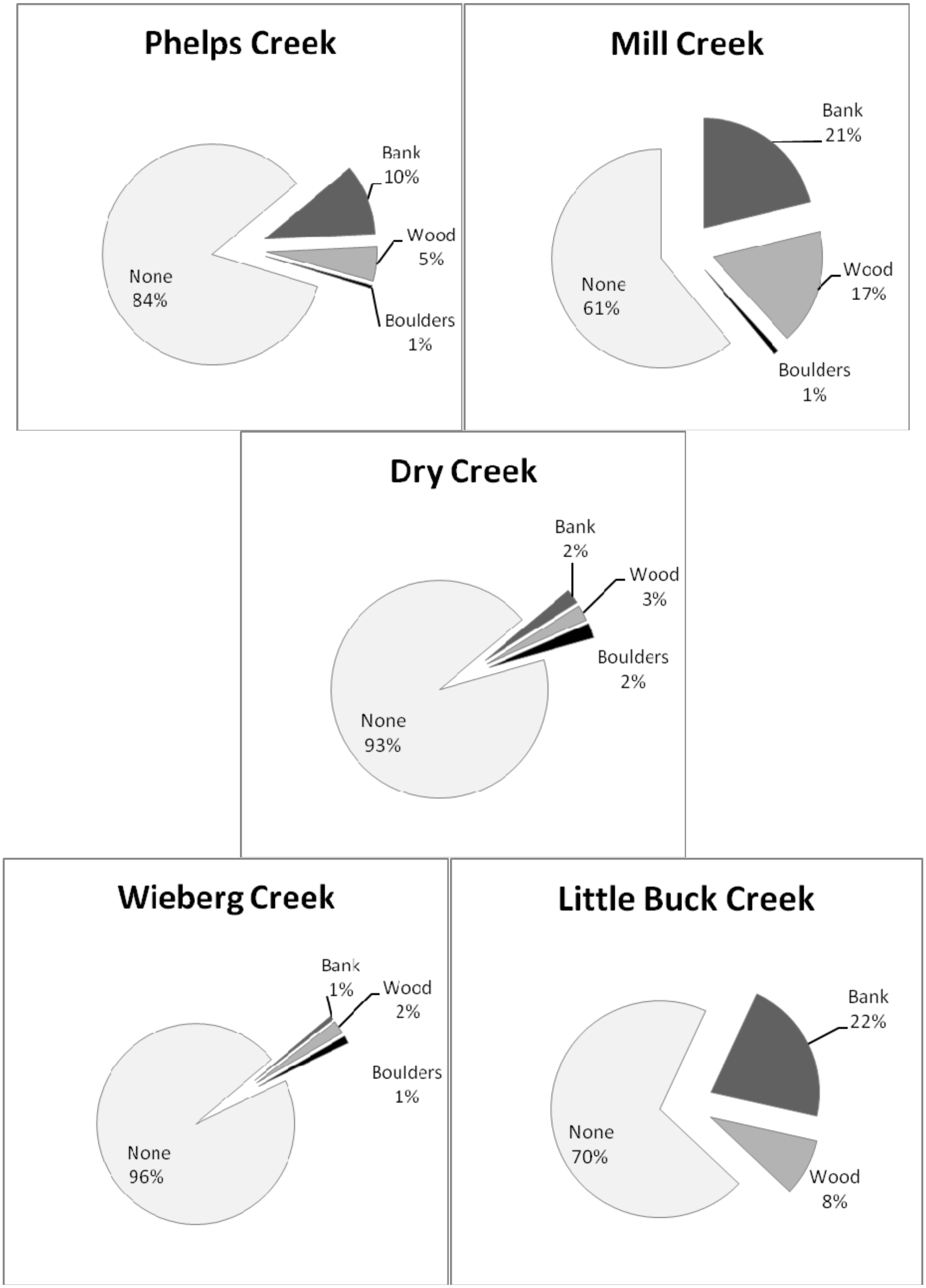


Figure 9. Bank undercut composition.

Table 4.  Channel Dimension Transect Data.

| Patch | Site | Transect | 1/4 | 1/2 | 3/4 | Max Depth | Wetted Width |
|---|---|---|---|---|---|---|---|
| Phelps Creek | 5 | 1 | 0.2 | 0.25 | 0.1 | 0.45 | 2.9 |
| | | 2 | 0.05 | 0.1 | 0.2 | 0.3 | 3.3 |
| | | 3 | 0.1 | 0.15 | 0.1 | 0.25 | 3.4 |
| | | 4 | 0.2 | 0.3 | 0.2 | 0.35 | 2.4 |
| | | 5 | 0.1 | 0.3 | 0.2 | 0.3 | 2.3 |
| | | 6 | 0.1 | 0.15 | 0.05 | 0.2 | 3.5 |
| | 7 | 1 | 0.05 | 0.1 | 0.25 | 0.25 | 4 |
| | | 2 | 0.03 | 0.05 | 0.2 | 0.2 | 3.8 |
| | | 3 | 0.3 | 0.25 | 0.15 | 0.35 | 2.9 |
| | | 4 | 0.2 | 0.22 | 0.05 | 0.22 | 3.2 |
| | | 5 | 0.15 | 0.15 | 0.05 | 0.25 | 4.7 |
| | | 6 | 0.25 | 0.17 | 0.05 | 0.30 | 5.8 |
| Dry Creek | 1 | 1 | 0.13 | 0.01 | 0.05 | 0.15 | 3.9 |
| | | 2 | 0.17 | 0.2 | 0.2 | 0.22 | 2.0 |
| | | 3 | 0.36 | 0.22 | 0 | 0.42 | 4.4 |
| | | 4 | 0.03 | 0.12 | 0.13 | 0.18 | 3.8 |
| | | 5 | 0.08 | 0.01 | 0.03 | 0.2 | 4.7 |
| | | 6 | 0.01 | 0.05 | 0.2 | 0.26 | 5.5 |
| | 3 | 1 | 0.05 | 0.05 | 0.01 | 0.05 | 1.9 |
| | | 2 | 0.05 | 0.01 | 0.0 | 0.15 | 1.5 |
| | | 3 | 0.03 | 0.03 | 0.01 | 0.05 | 2.4 |
| | | 4 | 0.10 | 0.06 | 0.05 | 0.15 | 2.5 |
| | | 5 | 0.03 | 0.01 | 0.01 | 0.10 | 3.2 |
| | | 6 | 0.01 | 0.03 | 0.10 | 0.10 | 2.1 |
| | 10 | 1 | 0.05 | 0.2 | 0.19 | 0.21 | 2.3 |
| | | 2 | 0.05 | 0.27 | 0.15 | 0.31 | 2.7 |
| | | 3 | 0.20 | 0.4 | 0.21 | 0.40 | 2.7 |
| | | 4 | 0.19 | 0.15 | 0.05 | 0.28 | 3.9 |
| | | 5 | 0.05 | 0.15 | 0.20 | 0.25 | 2.5 |
| | | 6 | 0.20 | 0.1 | 0.10 | 0.27 | 3.0 |
| Wieberg Creek | 2 | 1 | 0.2 | 0.13 | 0.1 | 0.2 | 3.2 |
| | | 2 | 0.05 | 0.2 | 0.13 | 0.2 | 2.5 |
| | | 3 | 0.1 | 0.15 | 0.05 | 0.15 | 3.3 |
| | | 4 | 0.15 | 0.15 | 0.05 | 0.2 | 1.8 |
| | | 5 | 0.05 | 0.1 | 0.05 | 0.25 | 3.2 |
| | | 6 | 0.1 | 0.27 | 0.05 | 0.3 | 2.6 |
| | 9 | 1 | 0.18 | 0.18 | 0 | 0.2 | 2.4 |
| | | 2 | 0.13 | 0.18 | 0.13 | 0.3 | 3.3 |
| | | 3 | 0.05 | 0.05 | 0.02 | 0.15 | 4.9 |
| | | 4 | 0.15 | 0.06 | 0.08 | 0.15 | 3.6 |

| Patch | Site | Transect | 1/4 | 1/2 | 3/4 | Max Depth | Wetted Width |
|---|---|---|---|---|---|---|---|
| | | 5 | 0.2 | 0.28 | 0.12 | 0.28 | 2 |
| Wieberg Creek cont'd. | | 6 | 0.1 | 0.18 | 0.02 | 0.2 | 2.8 |
| | 4 | 1 | 0.09 | 0.1 | 0.05 | 0.11 | 2.8 |
| | | 2 | 0.26 | 0.19 | 0.01 | 0.26 | 4.3 |
| | | 3 | 0.21 | 0.21 | 0.26 | 0.26 | 3.9 |
| | | 4 | 0.11 | 0.13 | 0.16 | 0.17 | 3.3 |
| | | 5 | 0.01 | 0.11 | 0.02 | 0.13 | 2.8 |
| | | 6 | 0.12 | 0.16 | 0.03 | 0.16 | 2.8 |
| Mill Creek | 2 | 1 | 0.14 | 0.18 | 0.17 | 0.3 | 2.5 |
| | | 2 | 0.01 | 0.15 | 0.2 | 0.33 | 3 |
| | | 3 | 0.05 | 0.15 | 0.12 | 0.2 | 3.7 |
| | | 4 | 0.1 | 0.2 | 0.12 | 0.2 | 3.1 |
| | | 5 | 0.1 | 0.21 | 0.16 | 0.35 | 3.2 |
| | | 6 | 0.05 | 0.25 | 0.1 | 0.39 | 2.2 |
| | 3 | 1 | 0.12 | 0.2 | 0.25 | 0.25 | 3.7 |
| | | 2 | 0.17 | 0.12 | 0.21 | 0.22 | 3.9 |
| | | 3 | 0.11 | 0.2 | 0.04 | 0.21 | 3.5 |
| | | 4 | 0.16 | 0.18 | 0.06 | 0.2 | 3 |
| | | 5 | 0.2 | 0.19 | 0.16 | 0.21 | 4.1 |
| | | 6 | 0.1 | 0.21 | 0.14 | 0.21 | 5.2 |
| | 4 | 1 | 0.05 | 0.1 | 0.15 | 0.15 | 2.8 |
| | | 2 | 0.01 | 0.13 | 0.1 | 0.2 | 2.9 |
| | | 3 | 0.1 | 0.02 | 0.02 | 0.15 | 2.7 |
| | | 4 | 0.01 | 0.1 | 0.15 | 0.3 | 5.3 |
| | | 5 | 0.02 | 0.07 | 0.05 | 0.1 | 2.8 |
| | | 6 | 0.15 | 0.2 | 0.1 | 0.21 | 1.7 |
| | 6 | 1 | 0.01 | 0.19 | 0.28 | 0.32 | 3.6 |
| | | 2 | 0.14 | 0.13 | 0.35 | 0.35 | 3 |
| | | 3 | 0.05 | 0.02 | 0.1 | 0.12 | 3.8 |
| | | 4 | 0.06 | 0.02 | 0.03 | 0.08 | 2.8 |
| | | 5 | 0 | 0.04 | 0.02 | 0.12 | 2.9 |
| | | 6 | 0.01 | 0.06 | 0.25 | 0.28 | 4.2 |
| | 7 | 1 | 0.1 | 0.12 | 0.01 | 0.2 | 2 |
| | | 2 | 0.01 | 0.1 | 0.17 | 0.17 | 1.7 |
| | | 3 | 0.25 | 0.27 | 0.3 | 0.35 | 2.1 |
| | | 4 | 0.15 | 0.02 | 0.15 | 0.15 | 2.4 |
| | | 5 | 0.15 | 0.12 | 0.05 | 0.2 | 2.6 |
| | | 6 | 0.1 | 0.01 | 0.1 | 0.11 | 3.2 |
| | 5 | 1 | 0.1 | 0.16 | 0.02 | 0.18 | 3.3 |
| | | 2 | 0.06 | 0.11 | 0.06 | 0.12 | 2.1 |
| | | 3 | 0.1 | 0.08 | 0.05 | 0.11 | 2.3 |
| | | 4 | 0.05 | 0.06 | 0.05 | 0.07 | 2.7 |
| . | | 5 | 0.11 | 0.15 | 0.01 | 0.17 | 2.8 |

| Patch | Site | Transect | 1/4 | 1/2 | 3/4 | Max Depth | Wetted Width |
|---|---|---|---|---|---|---|---|
| | | 6 | 0.2 | 0.06 | 0.05 | 0.21 | 1.9 |
| Mill Creek cont'd. | 1 | 1 | 0.01 | 0.01 | 0.3 | 0.3 | 2.5 |
| | | 2 | 0.25 | 0.17 | 0.1 | 0.25 | 2.1 |
| | | 3 | NA | 0.15 | 0.12 | 0.3 | 3.7 |
| | | 4 | 0.05 | 0.25 | 0.05 | 0.4 | 4.6 |
| | | 5 | 0.1 | 0.05 | 0.15 | 0.16 | 1.5 |
| | | 6 | 0.01 | 0 | 0.1 | 0.2 | 3.5 |
| Little Buck Creek | 7 | 1 | 0.05 | 0.2 | 0.12 | 0.2 | 1.5 |
| | | 2 | 0.1 | 0.05 | 0.05 | 0.1 | 2.7 |
| | | 3 | 0.19 | 0.16 | 0.02 | 0.24 | 2.8 |
| | | 4 | 0.05 | 0.05 | 0.01 | 0.06 | 1.1 |
| | | 5 | 0.05 | 0.1 | 0.05 | 0.11 | 1.2 |
| | | 6 | 0.05 | 0.05 | 0.1 | 0.15 | 2.4 |
| | 6 | 1 | 0.06 | 0.07 | 0.05 | 0.09 | 0.8 |
| | | 2 | 0.03 | 0.02 | 0.08 | 0.1 | 1.7 |
| | | 3 | 0.1 | 0.05 | 0.03 | 0.14 | 1.9 |
| | | 4 | 0.01 | 0.08 | 0.05 | 0.09 | 1.3 |
| | | 5 | 0.1 | 0.08 | 0.04 | 0.1 | 1.1 |
| | | 6 | 0.01 | 0.05 | 0.05 | 0.07 | 2.3 |
| | 3 | 1 | 0.05 | 0.1 | 0.1 | 0.13 | 1.1 |
| | | 2 | 0.02 | 0.05 | 0.05 | 0.1 | 1.3 |
| | | 3 | 0.1 | 0.01 | 0.01 | 0.12 | 4.1 |
| | | 4 | 0.05 | 0.1 | 0.05 | 0.11 | 1.9 |
| | | 5 | 0.05 | 0.05 | 0.05 | 0.06 | 1.8 |
| | | 6 | 0.1 | 0.15 | 0.2 | 0.2 | 1.6 |
| | 2 | 1 | 0.03 | 0.05 | 0.04 | 0.05 | 1.5 |
| | | 2 | 0.01 | 0.05 | 0.05 | 0.07 | 2.6 |
| | | 3 | 0.02 | 0.02 | 0.01 | 0.05 | 2 |
| | | 4 | 0.02 | 0 | 0.01 | 0.07 | 5.7 |
| | | 5 | 0.01 | 0.01 | 0.04 | 0.07 | 4.8 |
| | | 6 | 0.04 | 0.08 | 0.15 | 0.2 | 2.8 |
| | 5 | 1 | 0.05 | 0.05 | 0.02 | 0.05 | 1.5 |
| | | 2 | 0.02 | 0 | 0.08 | 0.08 | 3.8 |
| | | 3 | 0.05 | 0.08 | 0.01 | 0.08 | 2 |
| | | 4 | 0.03 | 0.02 | 0.04 | 0.05 | 1.9 |
| | | 5 | 0.03 | 0.01 | 0.01 | 0.08 | 1.7 |
| | | 6 | 0.06 | 0.03 | 0.01 | 0.07 | 1.9 |
| | 4 | 1 | 0.05 | 0.02 | 0.05 | 0.07 | 3.9 |
| | | 2 | 0.1 | 0.12 | 0.05 | 0.13 | 1.6 |
| | | 3 | 0.02 | 0.05 | 0.1 | 0.11 | 2.6 |
| | | 4 | 0.13 | 0.01 | 0.01 | 0.15 | 2.4 |
| | | 5 | 0.05 | 0.05 | 0.01 | 0.07 | 2.6 |
| | | 6 | 0.05 | 0.13 | 0.1 | 0.13 | 2.1 |

| Patch | Site | Transect | 1/4 | 1/2 | 3/4 | Max Depth | Wetted Width |
|---|---|---|---|---|---|---|---|
| Little Buck Creek cont'd. | 1 | 1 | 0.1 | 0.15 | 0.13 | 0.18 | 3 |
| | | 2 | 0.08 | 0.1 | 0.04 | 0.1 | 2.2 |
| | | 3 | 0.13 | 0.14 | 0.11 | 0.15 | 2 |
| | | 4 | 0.02 | 0.04 | 0.05 | 0.15 | 4.5 |
| | | 5 | 0.01 | 0.13 | 0.05 | 0.14 | 4.3 |
| | | 6 | 0.25 | 0.17 | 0.05 | 0.3 | 5.8 |

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