Rock Creek Fish and Habitat Assessment for Prioritization of Restoration and Protection Actions

2009 Annual Report

Performance Period

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The Confederated Tribes and Bands of the Yakama Nation

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Introduction

The overall project goal is to characterize the fish habitat conditions of the Rock Creek subbasin to prioritize sites for future restoration projects. This report describes the preliminary results of the data collection for salmonid fish populations and habitat in the Rock Creek subbasin in south-eastern Washington. The Rock Creek subbasin is of great significance to the Yakama Nation, and to the Rock Creek Band in particular. Oral history regarding historic runs of anadromous and resident fish and perennial flows in the subbasin indicate that fish populations and habitat conditions have been significantly altered between historic and present conditions. The subbasin has been identified as a unique watershed with high potential productivity for steelhead (as evidenced by spawner surveys) but with significant habitat limitations (low flow, high stream temperatures, and riparian, channel and floodplain degradation). NOAA-Fisheries identified Rock Creek as critical habitat for Middle Columbia threatened Steelhead DPS (NOAA 2005). Though a potentially productive system, there are substantial gaps in knowledge about habitat conditions limiting fish populations in Rock Creek. For example, while steelhead (*Oncorhynchus mykiss*) spawner abundance was high in some reaches, prior to this project there was no information about where perennial fish habitat occurred in sufficient quantity and quality to produce the high spawner abundance. The project includes monitoring and evaluation activities that develop, analyze, and report information pertaining to fish distribution, natural production, genetics, and disease profiling in order to prioritize restoration and protection actions.

The project also addresses many of the information gaps identified in the NOAA-Fisheries Rock Creek Steelhead Recovery Plan and the Rock Creek Subbasin Plan, which state that there is a significant need for ongoing monitoring and evaluation within the Rock Creek watershed, and that it is considered a high priority.

Environmental and biological attributes were collected for this project throughout the subbasin, ranging from the headwaters originating in the Simcoe Mountains to the confluence with the Columbia River. The collection, evaluation and input of data into the Ecosystem Diagnosis and Treatment (EDT) model is a continuous process. The EDT model was used in the watershed analysis to assist in determining the appropriate sites for future restoration activities, while understanding that data collected through this project were needed to help further refine the EDT model for the basin.

This report summarizes progress and results for the following major objectives under this contract:

1. Monitoring and Evaluation- to assess current habitat conditions, limiting factors and status of salmonid populations in the subbasin, including juvenile fish abundance, distribution, movement, habitat use, life history, growth, survival to adulthood and adult distribution, relative abundance, and spawning behavior e.g. kelting

2. EDT modeling- to evaluate habitat quality and identify areas with high potential for habitat restoration

3. Genetics- to determine the genetic composition of resident trout and steelhead (*O. mykiss*) population, and to compare genetic samples for heterogeneity within the subbasin

4. Revegetation- Riparian re-vegetation along stream corridor to increase stream shading and lower stream temperatures

Description of Project Area – Rock Creek subbasin

The Rock Creek subbasin encompasses an area of approximately 223 square miles of southeastern Washington. Rock Creek joins the Columbia River at river mile (RM) 230 or river kilometer (RKm) 370, approximately 12 miles or 19.2 kilometers upstream of John Day Dam (Figure 1). From its headwaters in the Simcoe Mountains, Rock Creek flows in a southerly to southeasterly direction to the Columbia River. Elevations range from 200 feet at the confluence of Rock Creek and the Columbia River to over 3200 feet in the Simcoe Mountains. Major tributaries to Rock Creek include Quartz Creek, Badger Gulch, Luna Gulch, Harrison Creek, and Squaw Creek.

Rock Creek and its tributaries originate on a plateau which transitions from coniferous forest to shrub-steppe; land use in the uplands is managed forest, grazing, and some rural residential. The uplands are also seeing increased wind power development. From the plateau, the stream enters steep-walled canyons where the channel becomes confined. Land cover in the canyon ranges from coniferous forest to mixed conifer-deciduous forest. Downstream of the canyons, streams enter alluvial valleys where channels transition from moderately confined to unconfined channels. The predominant land use activity within the alluvial valley and on the adjacent terrace slopes is cattle grazing.

Rock Creek currently supports fall Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon, summer steelhead (*O. mykiss*), resident rainbow trout (*O. mykiss*), and other native and introduced fish species. Non-native species are primarily found in the lower reaches of the subbasin. Rock Creek steelhead are part of the Middle Columbia River steelhead Distinct Population Segment (DPS), listed as "threatened" under the Endangered Species Act (ESA), originally listed as part of the Middle Columbia River steelhead Evolutionarily Significant Unit (ESU) on March 25, 1999. The lowest 2.5 river miles of Rock Creek contain essential spawning habitat for coho and fall Chinook populations during the fall and winter months. Juvenile steelhead, coho, fall Chinook, and resident rainbow trout rear in Rock Creek and its tributaries throughout the year.

Acknowledgements

We would like to take this opportunity to thank all those individuals and organizations that have helped contribute in some way to this project. A special thanks to private landowners for their cooperation and allowing access through their property for monitoring. The following Yakama Nation technicians assisted in collecting valuable fish and habitat information: Bronsco Jim Jr., Sandy Pinkham, Rodger Begay, Roger Stahi, Jeremy Takala and Andrew Nomee. Mike Babcock, YN Data Systems Manager, provided assistance with data management. Bill Sharp, YN Fisheries Research Scientist, provided assistance and management of the project. Brady Allen, Carrie Munz, and Ian Jezorek with United States Geological Survey (USGS) were cooperators with set-up of PIT-tag interrogation system (PTIS), collection of fish population and habitat data, PIT-tagging, and monitoring. Ken Luhan, microbiologist with the United States Fish and Wildlife Service (USFWS), provided pathogen analysis information.

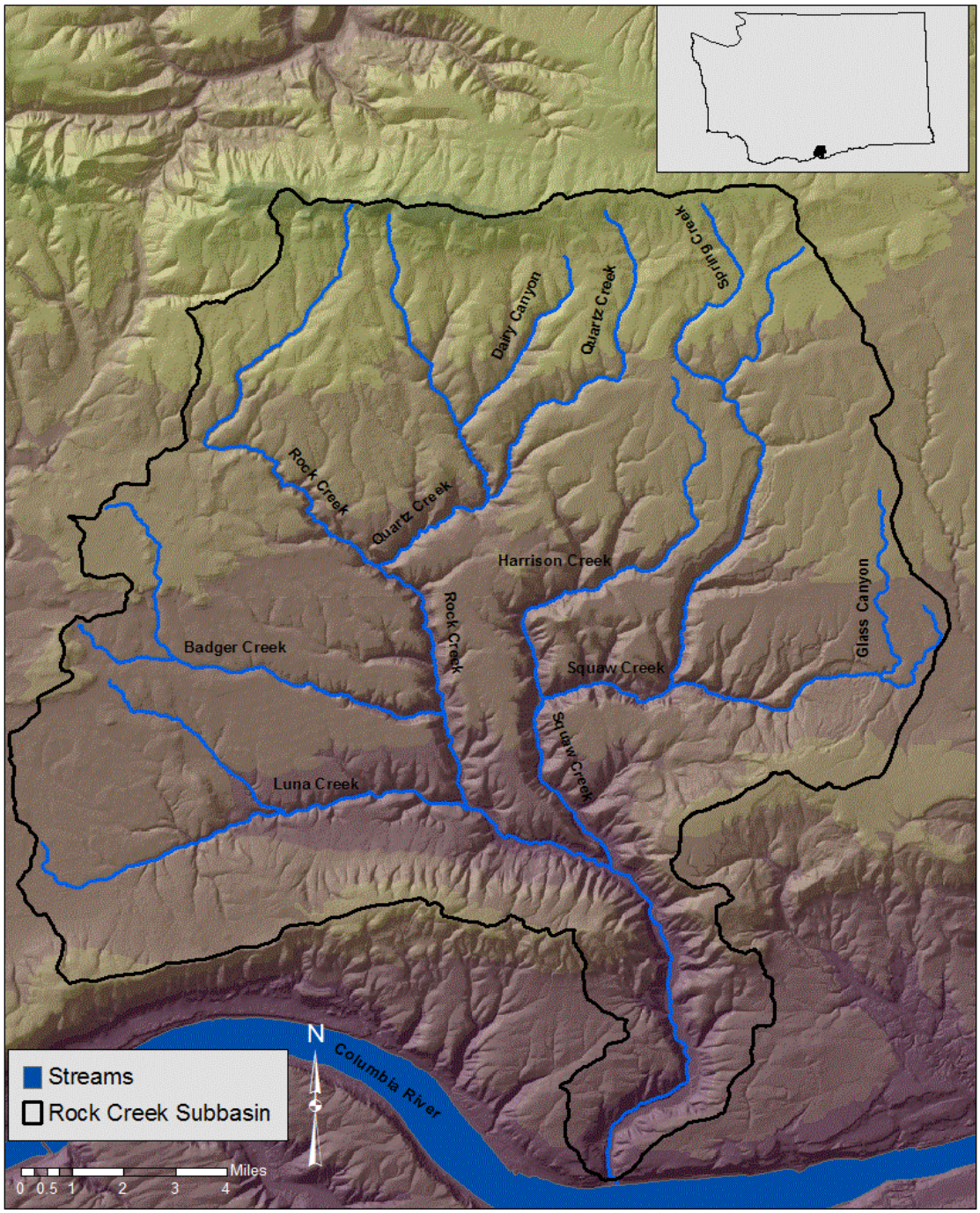


Figure 1. Rock Creek subbasin in southeastern Washington.

1. Monitoring & Evaluation

Overall Objective: Gather baseline environmental and biological data throughout the subbasin to understand the current conditions of native salmonids and associated habitat conditions. This fish and habitat assessment is the first to be conducted throughout the entire Rock Creek subbasin. Monitoring and evaluation allows for continuous assessment of fish and habitat conditions and for identification of possible restoration project opportunities.

Task 1.a Spawning ground surveys (redd counts) and scale collection

Objective: Redd counts and spawner surveys were employed to monitor spatial and temporal redd distribution of fall Chinook, coho, and steelhead, and to collect biological data from carcasses. Spawning ground surveys provide a means of monitoring annual adult escapement as well as spawner distribution.

Methods: Regular foot and one-man pontoon surveys were conducted within the known geographic range for each target species. Individual redds were counted and their locations recorded using handheld Global Positioning System (GPS) units. Counts of live fish and carcasses were also recorded. Carcasses were examined for sex determination, egg/milt retention (percent spawned), and presence of Coded Wire Tags (CWT) or external experimental marks. Attempts were made to cover the entire known spawning range of each species, although for steelhead some gaps in survey coverage exist. Stream reaches were surveyed multiple times during the spawning seasons, with most reaches receiving at least 2-3 passes, conducted approximately two weeks apart in each reach. Subsequent survey passes generally continued in each reach until no live spawners were observed. Methods generally followed those of Gallagher et al. (2007). Scale samples were also taken from carcasses using methods outlined in Crawford et al. (2007).

Fall Chinook surveys were conducted from mid-October through mid-December; coho surveys were conducted from late October through late February; steelhead surveys began in January and continued through late May. The lower reaches of Rock Creek have intermittent flow and no connectivity during the summer and early fall months: fall Chinook and coho spawning habitat availability is limited to years when there is actual instream flow during the spawning season.

Results: Spawner survey results are discussed below. Figures 2 and 3 exhibit the observed 2008 and 2009 spawning distribution for fall Chinook and steelhead, respectively. A tabular summary of spawning ground survey results by species is presented in Appendix A.

Fall Chinook

Fall Chinook surveys were conducted from early November through late December, covering approximately 2.5 river miles during the 2007 and 2008 spawning seasons. Fall Chinook spawning activity was observed between RM 1 and RM 2.5. The majority of observed spawning occurs adjacent to the Rock Creek Lake (Army Corps park) near the mouth of Rock Creek. For the 2008 spawning season, two live adults and two redds were observed and recorded. For the 2009 fall and winter months there was insufficient instream flow and connectivity to allow fish passage upstream of the mouth of Rock Creek.

Coho

Coho surveys were conducted between November and January, covering nearly 2.5 river miles. The majority of observed spawning occurs from RM 1 to RM 2.5. For the 2008-09 spawning season, no coho redds, no carcasses and one live adult were located and recorded within the spawning reach. During the 2009-10 spawning season there was a total of 5 live adults, 16 redds, and eight carcasses (5 with floy tags

and 3 without floy tags) observed and recorded in the survey reach. Scale samples were collected from three coho carcasses, and no adipose-clipped carcasses were encountered. All fish were 3-year-olds; one was male and two females. Fork lengths ranged from 24 -27 cm. In future years of monitoring and evaluation of coho spawning, spawning surveys will be extended above RM 2.5.

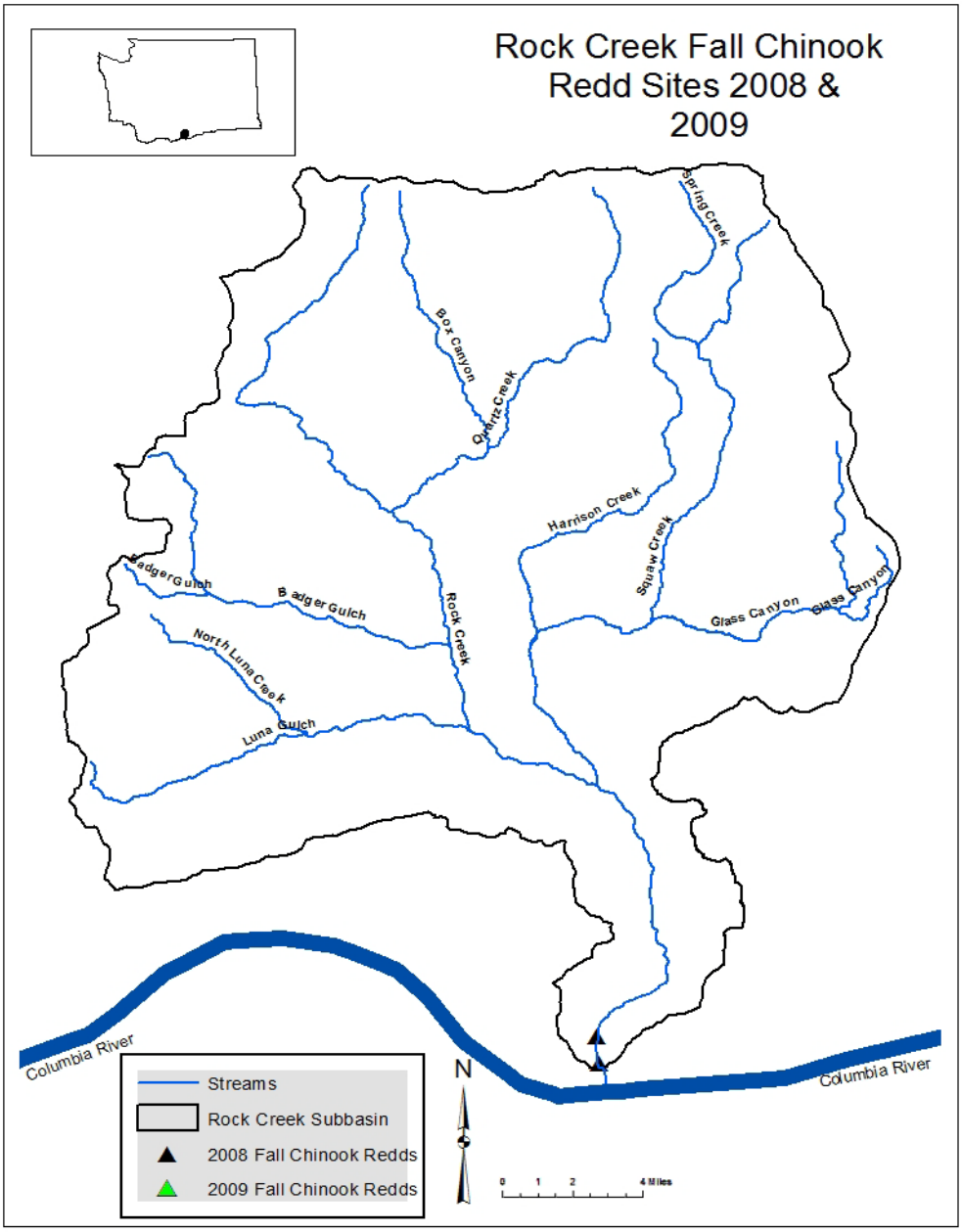


Figure 2. Rock Creek fall Chinook redd distribution map 2008 and 2009.

Steelhead

Steelhead surveys were conducted between January and May, covering approximately 14.7 miles with between 2 – 3 passes at each survey reach. Survey reach lengths varied based on accessibility and consent to cross private land. Spawning surveys were conducted in the mainstem Rock Creek (RM 1- RM 13.5), Squaw Creek (RM 0- RM 5.5), Luna Gulch (RM 0 –RM 1), and Badger Gulch (RM 0 – RM .5). High spring flows and turbidity often limited the timing and safe access to survey reaches. Steelhead spawning is widespread through the lower to mid reaches of the Rock Creek and Squaw Creek. A total of 45 redds, 37 live adults, and no carcasses were enumerated during the 2008-09 spawning season. A total of 127 redds, 104 live adults, and 3 carcasses were enumerated during the 2009-10 spawning season. The majority of steelhead redds were observed and documented in the mainstem Rock Creek from RM 1- RM 13.5 and in Squaw Creek from RM 0 – RM 5.5. We will attempt to cover the entire steelhead spawning range in the subbasin in the 2010-11 and 2011-12 spawning seasons.

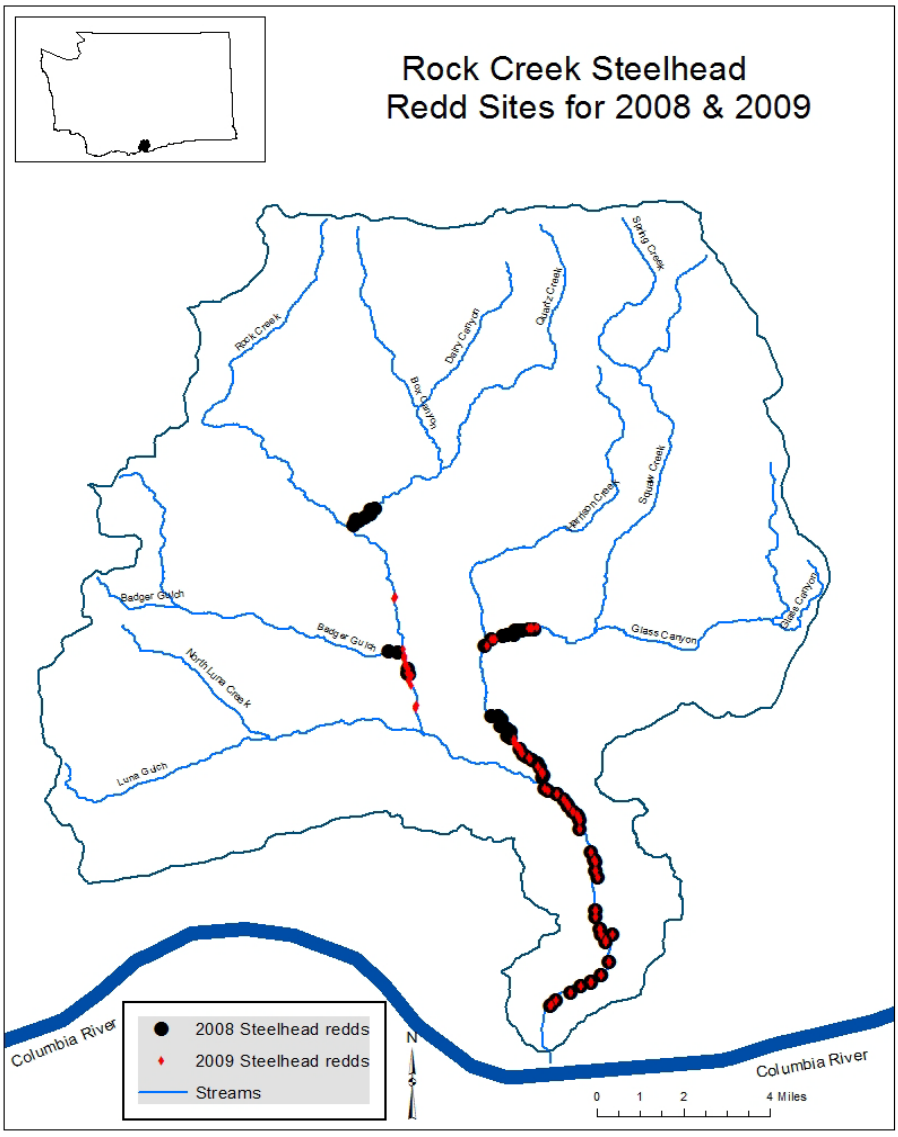


Figure 3. Rock Creek steelhead redd distribution map 2008 and 2009.

Task 1.b Juvenile and resident salmonid population survey and scale collection

Objective: Gather baseline information to determine juvenile anadromous and resident salmonid spatial distribution and relative abundance throughout the basin.

Methods: Fish distribution, relative abundance, length frequency, weights, and population density were determined from backpack electrofishing data. We used a stratified, randomized systematic sampling design. Habitat surveys were conducted prior to electrofishing to measure the length, width, and depth of pools and non-pools in all anadromous fish-bearing reaches with landowner permission and access. Electrofishing was stratified to pools only (most riffles were too shallow to sample in the fall when temperatures were appropriate for electrofishing). We randomly selected the starting pool and systematically electrofished every third subsequent pool. Fish sampling consisted of single-pass electrofishing up and back within each pool. In future sampling in the fall, we will conduct mark-recapture population estimates in a randomly selected subset of these pools. Captured fish were transferred into a 5-gallon bucket holding stream water until processed. Fish were anesthetized with Tricane Methane Sulphonate (MS-222) prior to data collection. Fish identification, weight and length were recorded from sampled fish. All trout greater than 70 mm fork length were PIT-tagged as described in Task 1.c. All fish species' presence and relative abundance were noted during the electrofishing surveys to get an understanding of fish biodiversity and distribution in the subbasin.

Results: Rainbow trout, shorthead sculpin, speckled dace, redside shiner, and bridgelip suckers were found in the sampled reaches of Rock Creek and Squaw Creek. Juvenile coho were present in only 2 pools in 2009 (rkm 6.9 and 15.3, Table A). Rainbow trout were rare in Rock Creek downstream of the Squaw Creek confluence (rkm 13), with only 4 individuals captured. However, rainbow trout were common and even abundant upstream of rkm 15 and in Squaw Creek. Northern pikeminnow, smallmouth bass and brown bullheads were found only in the lowermost pools in Rock Creek. Additional distribution, relative abundance, length frequency, weights and relative density information will be included in the 2010-2011 annual report. This is the first year (spring 2009) of actual on-the-ground fish population surveys with the NOAA Section 10 permit in place authorizing electrofishing surveys.

Table 1. Presence and absence of fish species found in Rock Creek in the fall of 2009. P = present, A = absent.

Reach	Rainbow trout	Shorthead sculpin	Speckled dace	Redside shiner	Bridge-lip sucker	Coho	Northern pikeminnow	Smallmouth bass	Brown bullhead
Rock Creek									
RKm 2 to RKm 13	P	P	P	P	P	P	P [a]	P [b]	P [c]
RKm 13 to RKm 22	P	P	P	P	P	P	A	A	A
Squaw Creek	P	P	P	P	P	A	A	A	A

[a] Collected up to river kilometer (RKm) 5.
[b] Collected up to river kilometer (RKm) 4.
[c] Collected up to river kilometer (RKm) 2.

Task 1.c Juvenile steelhead PIT-tagging and United States Geological Survey (USGS) subcontract

Objective: Monitor juvenile steelhead movement within Rock Creek and its tributary streams. Additional benefits include monitoring movements through Columbia River dams and estimation of smolt-to-adult returns. Maintain two instream multiplexing PIT-tag units at two sites located in Rock Creek and Squaw Creek (Figure 4).

Methods: In order to track movements, growth, and other life history attributes of juvenile steelhead, we PIT-tagged fish over 70 mm fork length captured during our stream surveys as described in Task 1.b, up to 1200 steelhead per year. This project is the first to conduct in-depth fish population surveys in the Rock Creek subbasin. The ISO FDX-B, 134.2 kHz (12 mm) PIT tags were used to detect fish movement at the remote instream PIT-tag readers in Rock Creek. Fish tagged in 2009 and 2010 during our electrofishing surveys and recaptured provide growth and movement information. Tagged fish that migrate downstream and exhibit a potadromous or anadromous life history can be detected at Columbia mainstem dams as well as the estuary. All PIT-tag data were entered in the PTAGIS database, which is maintained by Pacific States Marine Fisheries Commission. PIT-tagged fish returning as adults can be detected at mainstem dams. The two remote instream PIT-tag readers installed in Rock Creek in fall of 2009 were able to detect adult steelhead as strays, as pre-spawn adults, and as post-spawn kelts, and detect the movement of adult steelhead into and out of Rock Creek. The PIT-tag interrogation systems (PTIS) installed by USGS and maintained by the Yakama Nation are able to detect the timing and movement of adult PIT-tagged steelhead into the Columbia River and Rock Creek watershed.

Results: We PIT-tagged a total of 555 juvenile rainbow trout in the fall of 2009. Most rainbow trout with fork lengths greater than 70 mm were collected in Rock Creek between RKm 16 and 21, and Squaw Creek RKm 1 through RKm 3 and RKm 7 and 8 (Table B). We conducted no fish surveys upstream of RKm 21, although we observed abundant rainbow trout in that area. A high proportion (35%) of those PIT-tagged fish were subsequently detected at one or more PIT-tag interrogation systems (PTIS) the following spring (Table B). A total of 182 fish were detected at the Squaw Creek PTIS, and 172 of those fish were detected at the Rock Creek Longhouse PTIS (Table B, Figure 5). We are currently calculating detection efficiencies at these arrays; however, preliminary analysis indicates very high detection efficiencies (>90%) for PIT-tagged fish at both sites. Fewer fish tagged in Rock Creek were detected in the Columbia River; detection probabilities ranged between 4 - 13% at John Day Dam and 3 - 7% at Bonneville Dam during the 2010 spring outmigration period (Faulkner et al 2010).

Rainbow trout outmigrated from Rock Creek from late March through mid-May (Figure 1). Several fish migrated past the Squaw Creek PTIS in the winter, reared for several months in lower Rock Creek, and then outmigrated in the spring. This indicates that lower Rock Creek is used seasonally by rainbow trout prior to outmigrating as smolts. Fish tagged in RKm 1 through RKm 3 of Squaw Creek outmigrated earlier than fish tagged in RKm 7 and RKm 8 of Squaw Creek (Figure 1). Further PIT-tagging and analysis of PTIS detections will allow us to determine the primary areas of smolt productivity, which will aid in prioritizing areas for restoration and/or preservation.

Adult steelhead detections Sept. 2009 to May 2010.

From September 2009 to June 2010, a total of 12 adult steelhead PIT-tagged by other agencies were detected spending a portion of their life history in Rock Creek. Five steelhead were tagged as juveniles at Lower Granite Dam and transported downriver by barge. Two steelhead were tagged and released from hatcheries in Idaho: one at the Hagerman Hatchery, and one at the Irrigon Hatchery. Five of the 12 steelhead were tagged as adults at the Bonneville Dam adult fish facility and had unknown juvenile rearing locations. Four of the 12 steelhead were of hatchery origin; the other 8 fish were of wild origin.

Nine of the 12 steelhead were detected about 100 km upriver of Rock Creek at the McNary Dam adult fish ladder several months prior to traveling into Rock Creek. The adult steelhead entered Rock Creek beginning in January, with most entering in March and the last one entering on April 9, 2010. Four of the 12 steelhead traveled, and likely spawned, upstream of the Squaw Creek interrogation system.

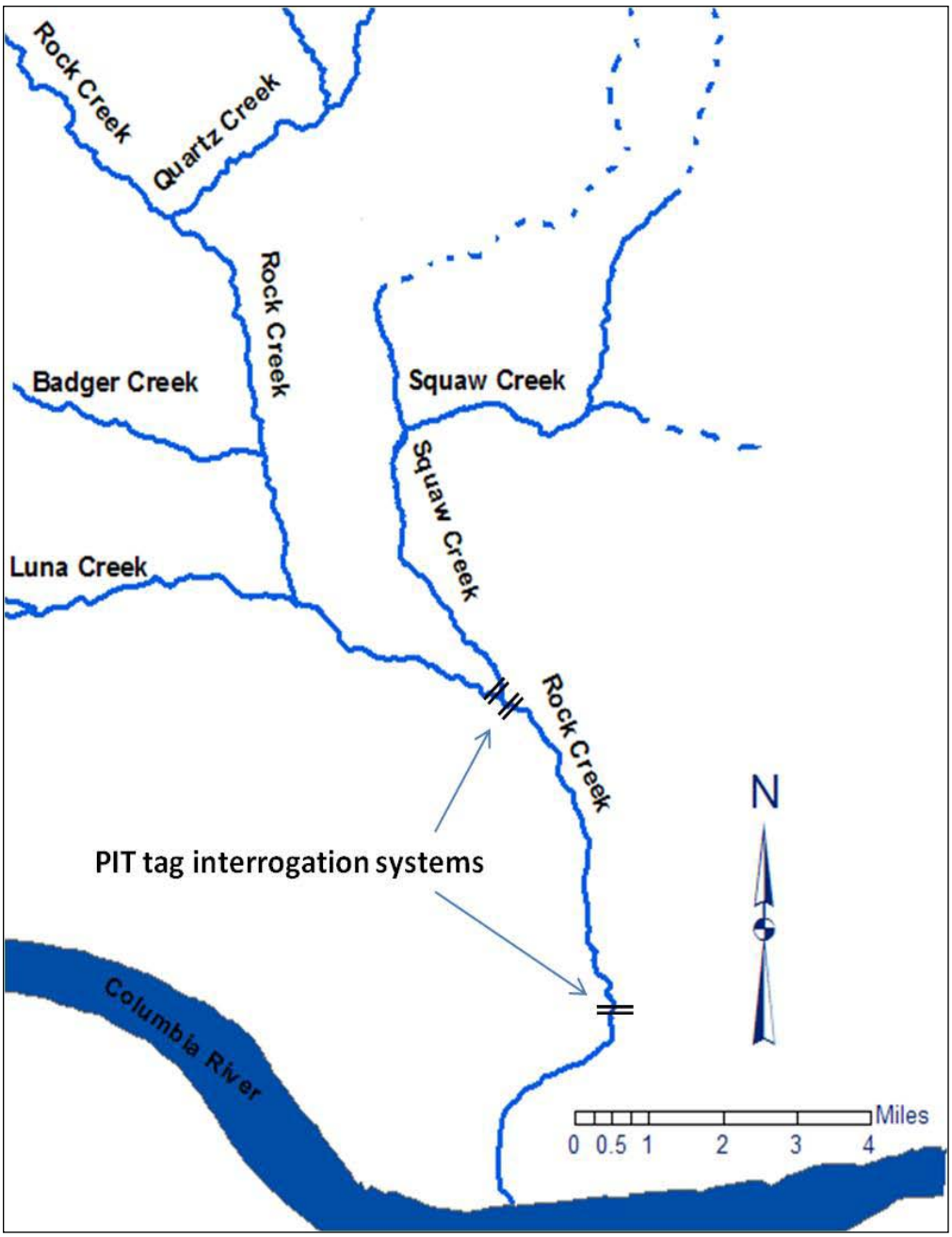


Figure 4. Locations of PIT-tag interrogation systems (PTIS) in Rock Creek subbasin.

Table 2. Total number of rainbow trout PIT tagged in the Rock Creek subbasin in the fall of 2009 and the number of tag detections and interrogations through June 1, 2010. The number in parentheses is the percentage of tagged fish detected at any site.

Reach			Rock Creek interrogations		Columbia River interrogations		
River kilometer	PIT tags deployed	Total number of fish detected	RCS (RKm 13)	RCL (RKm 5)	John Day Dam	Bonneville Dam	Estuary Trawl
Rock Cr. mouth to Squaw Cr.							
2	3	0	0	0	0	0	0
Rkm 13 (Squaw Cr. confluence) to RKm 22							
15	7	2 (29)	2	1	0	0	0
16	99	34 (34)	28	29	8	14	0
20	116	28 (24)	25	23	7	5	0
21	78	40 (51)	36	35	13	4	1
Squaw Creek							
1	24	10 (42)	10	9	3	2	1
2	54	26 (48)	26	22	9	4	1
3	99	35 (35)	34	33	13	7	0
7	54	16 (30)	16	15	3	1	0
8	21	5 (24)	5	5	2	2	0
Total	**555**	**196 (35)**	**182**	**172**	**58**	**39**	**3**

The following is an example of a single adult steelhead life history gained via interrogation systems in Rock Creek coupled with the Columbia River interrogation systems: one wild steelhead, tagged at the adult fish facility in Bonneville Dam on 8/11/2009, was detected in the McNary Dam adult fish ladder on 9/7/2009. It then presumably fell back over McNary Dam, entered Rock Creek on 2/6/2010 and traveled past the Squaw Creek PTIS into Squaw Creek on 2/8/2010. The steelhead passed downstream past the Squaw Creek PTIS on 3/13/2010, likely after spawning in Squaw Creek, and traveled downstream past the Longhouse PTIS on 3/22/2010. The fish was detected at the Bonneville Dam Corner Collector (BCC) PTIS on 4/14/2010 after passing through John Day and The Dalles dams (presumably) on its way back to the ocean. A more detailed analysis of all adult steelhead movements will be presented after additional detections are recorded and patterns become more evident.

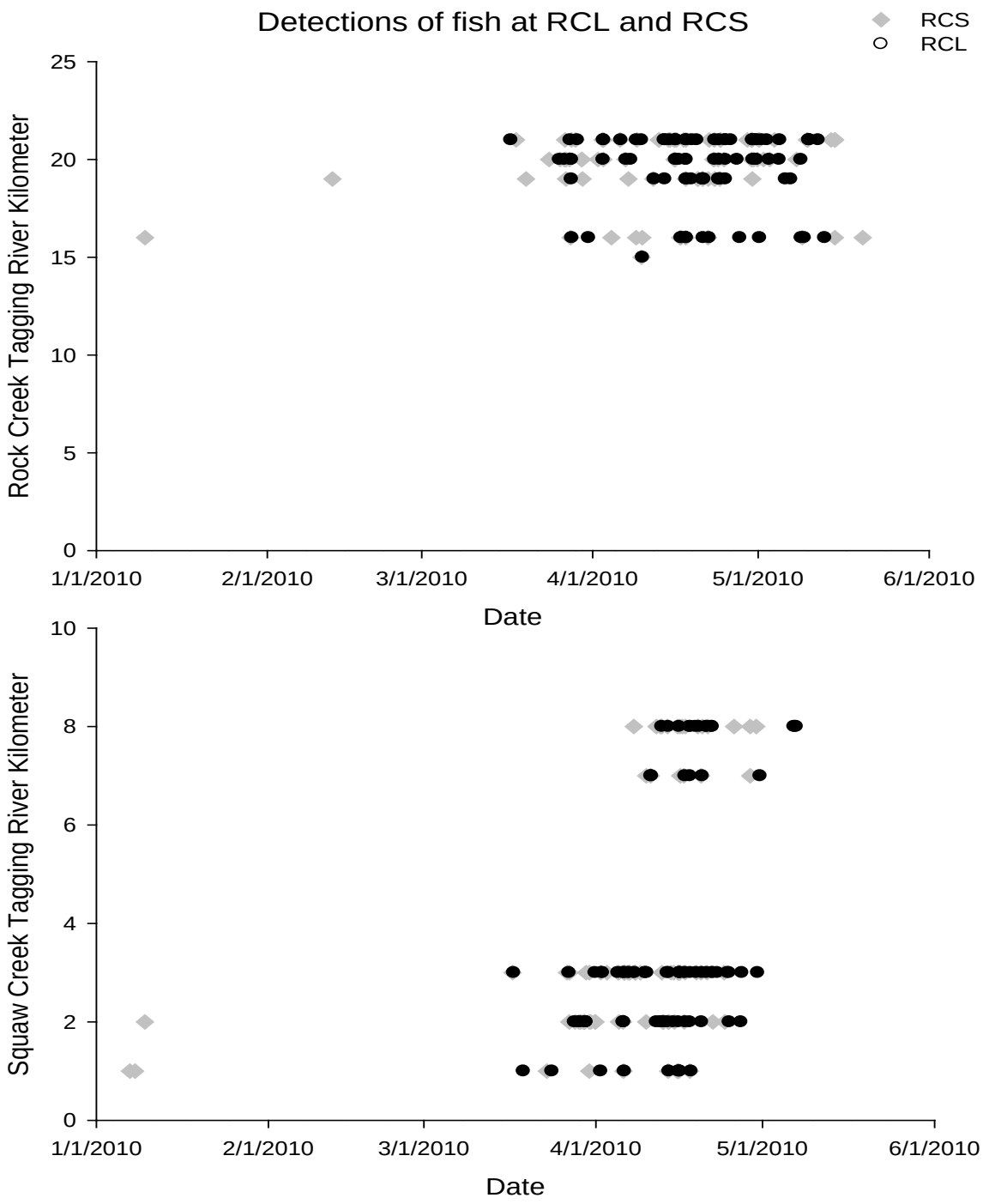


Figure 5. The river kilometer of tagging in Rock and Squaw creeks and the date of detection at PIT-tag interrogation sites at the confluence of Rock and Squaw creeks (RCS, RKm 13) and at the Rock Creek Longhouse (RCL, RKm 5). Fish were tagged in the fall of 2009 and detected in the spring of 2010.

Task 1.d Sediment Monitoring

Objective: To monitor sediment and substrate conditions at selected sites in the Rock Creek subbasin.

Methods: Surface substrate was sampled at two spawning sites in the mainstem Rock Creek and one in Squaw Creek in 2008 and 2009. The first site is of particular interest for continuous monitoring due to the Klickitat County 2009 bridge replacement project at the Bickleton Bridge crossing. The second site is near the Rock Creek confluence where there has been observed fall Chinook, coho, and steelhead spawning in recent years. The third site is located in Squaw Creek within primary steelhead spawning habitat. Data collected is represented in Appendix B.

Wolman pebble count methodologies were used to conduct the sampling. Each pebble count used a systematic method of sampling material on the surface of the streambed and was used to develop a particle size distribution. Each measured particle represented a portion of the streambed covered by particles of a certain size, and not the percent by volume or weight. The procedure required an observer with a metric ruler or gravelometer to wade the stream and the second person to take notes. Particles are tallied using size classes that are either grouped or further refined using Wentworth size classes. Basically, size doubles with each class or smaller class; intervals are based on ½ phi values. The latter classes were generally used when detailed particle size data were needed.

To conduct the Wolman count, personnel selected a transect perpendicular to the stream in a scour pool tail-out or in a low-gradient riffle. At a minimum, one transect per habitat unit and/ or ten transects per stream segment are required. Starting at the bankfull stage mark, steps were made along the transect and the first particle encountered when placed in front of their toe was sampled. Each particle was measured at the intermediate axis with a metric ruler. For each transect, the particle counts for each size class are recorded on the Substrate Field Data Form.

The numbers generated from the Wolman pebble counts created a characterization of the composition of the streambed at one particular point in time at three observed spawning reaches. The composition of the streambed represented characteristics of the stream such as effects of flooding, sedimentation, or other physical impacts to the stream. The Wolman pebble count method is a tried and tested method of measurement of sediment size on the bed surface.

Results: This year (2009) was the second year of monitoring, and future pebble counts will be conducted in additional reaches of Rock Creek to collect substrate attribute data to for the EDT model in 2010-2011. The results of the pebble count data collected during the one-year comparison monitoring effort at three spawning locations in the subbasin indicate the average substrate type for the Army Corps Park site was the coarse gravel type. The average substrate type found at both the Bickleton Bridge and the Squaw Creek sites was small cobble. The Bickleton Bridge and Squaw Creek sites are both located higher in the subbasin (Figure 6). The Army Corps Park site has a higher evidence of sand and sediments in 2009 than in the 2008 sampling season. The one-year comparison for the Bickleton Bridge and Squaw Creek site indicate that there was an actual lower presence of sands and fine sediments in 2009 than in 2008.

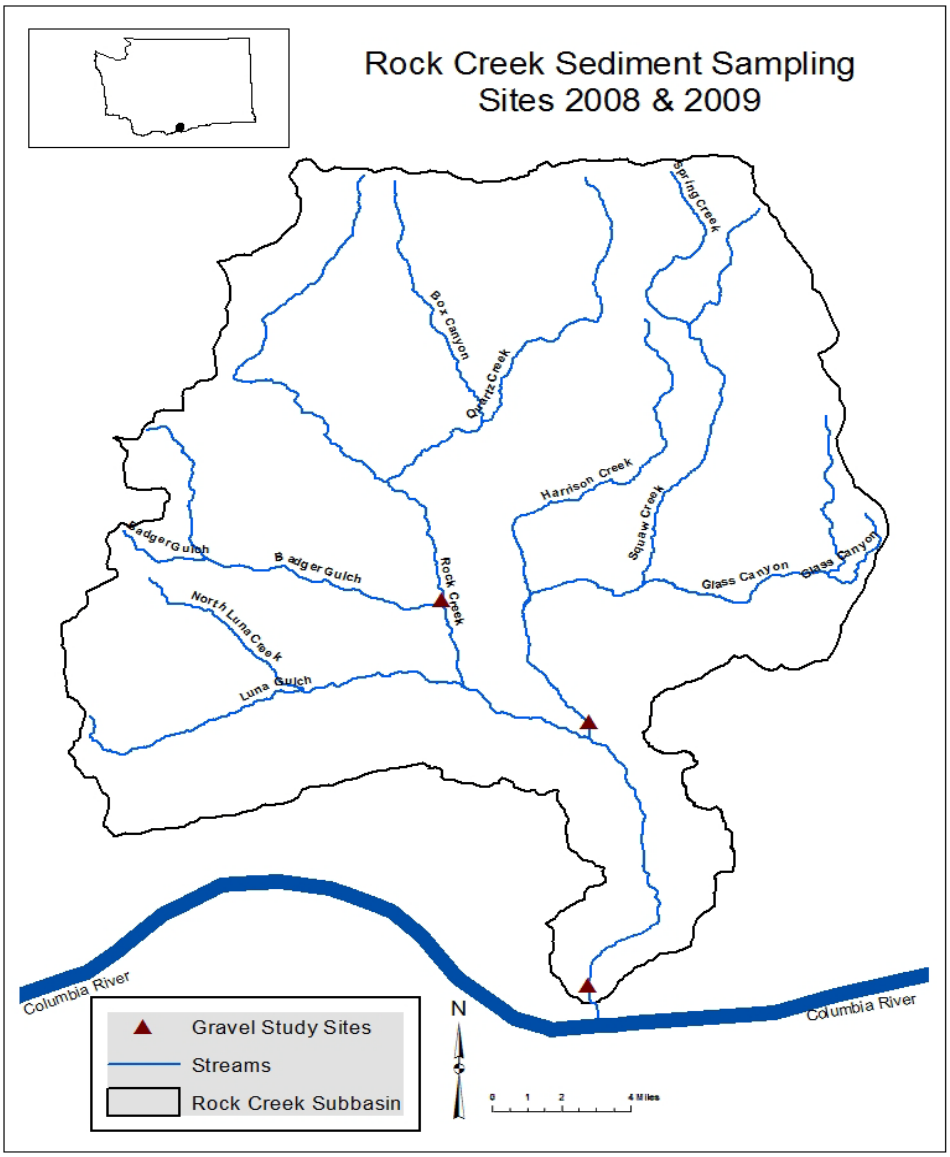


Figure 6. Sediment sampling sites.

Task 1.e Temperature and water quality monitoring

Objective: Monitor stream temperature and water quality at selected sites on a seasonal basis to characterize the chemical and physical conditions of the subbasin at key locations.

Methods: Water temperature was monitored at ten sites throughout the mainstem Rock Creek and its tributaries (Squaw, Harrison, Luna Gulch, Badger Gulch, and Quartz creeks). Water temperature measurements were taken at 30-minute increments using Onset Corporation Hobo temperature probes.

Air temperature was monitored at three locations in the subbasin with the Hobo temperature probes. Basic water quality parameter measurements were recorded seasonally at eight sites (3 – 10 times per year). Water quality measurements were taken using the YSI-85 water quality meter. Parameters collected included dissolved oxygen, conductivity, turbidity and pH.

Results: Summaries of water and air temperature data for each location are presented in Appendix C (Table C1). These summaries include (for each month during the reporting period): the number of days during which temperature was recorded; the number of times the daily minimum temperature was less than 0.5°C and 4.4°C; the number of times the daily average temperature was less than 0.5°C and 4.4°C; the number of times the daily maximum temperature was greater than 23°C and 24°C; the number of times the 7-day average daily maximum temperature was greater than 12°C, 16°C, 17.5°C, 18°C, and 22°C (the 7-day average daily maximum was calculated by averaging the daily maximum temperatures across the time period that started 3 days prior to and ended 3 days after a given day); the monthly 1-day maximum temperature (the highest instantaneous temperature recorded in a given month); the monthly 1-day maximum range (the largest daily range in temperature recorded during a given month); and the monthly average daily range (the average daily range in temperature recorded during a given month).

Water quality and temperature data were incorporated into the EDT Stream Reach Editor. Water quality measurements were conditional on the presence of actual instream flow. Sections of Rock Creek and its tributaries turn intermittent during the warmer summer months; groundwater-fed pools are distributed throughout the subbasin. Water quality was not recorded if there was no instream flow at the time of monthly site visit. The turbidity meter was not functioning correctly; therefore, there were no continuous data recorded for this parameter.

Task 1.f Habitat assessment

Objective: The purpose of assessing habitat is to characterize the present state and processes that create and maintain it so that appropriate restoration options and obstacles can be identified and prioritized.

Methods: Rock Creek and its tributaries were stratified into reaches using a USGS topographical map (1:24,000) and stream geomorphologic features (e.g. gradient, channel confinement, and tributary confluences). Habitat surveys were conducted on 20 stream reaches throughout the subbasin using EDT methodologies. Each habitat survey reach assesses similar geomorphic characteristics throughout, such as pattern, slope, confinement, or sediment size. The information collected for each survey section included width measurements at wetted channel and high watermark; habitat type frequency and length; large woody debris and log jam counts; confinement; riparian function; and embeddedness observations (Murphy & Willis, 1996); (Harrelson et al., 1994).

Habitat types were divided into seven categories: primary pool, large cobble riffle, small cobble riffle, pool tailout, glide, off-channel habitat, or side channel. Large woody debris information was also included in the habitat surveys such as enumeration of wood pieces in the stream channel and tally of logs in log jams. Riparian function attributes and condition were also documented for each surveyed stream reach.

Results: Habitat data were input into the Rock Creek EDT. Original habitat survey data (2008-2009) are stored in the EDT Access database. Habitat surveys will continue to be conducted for two more years (2010-2012) and the data incorporated into the EDT model.

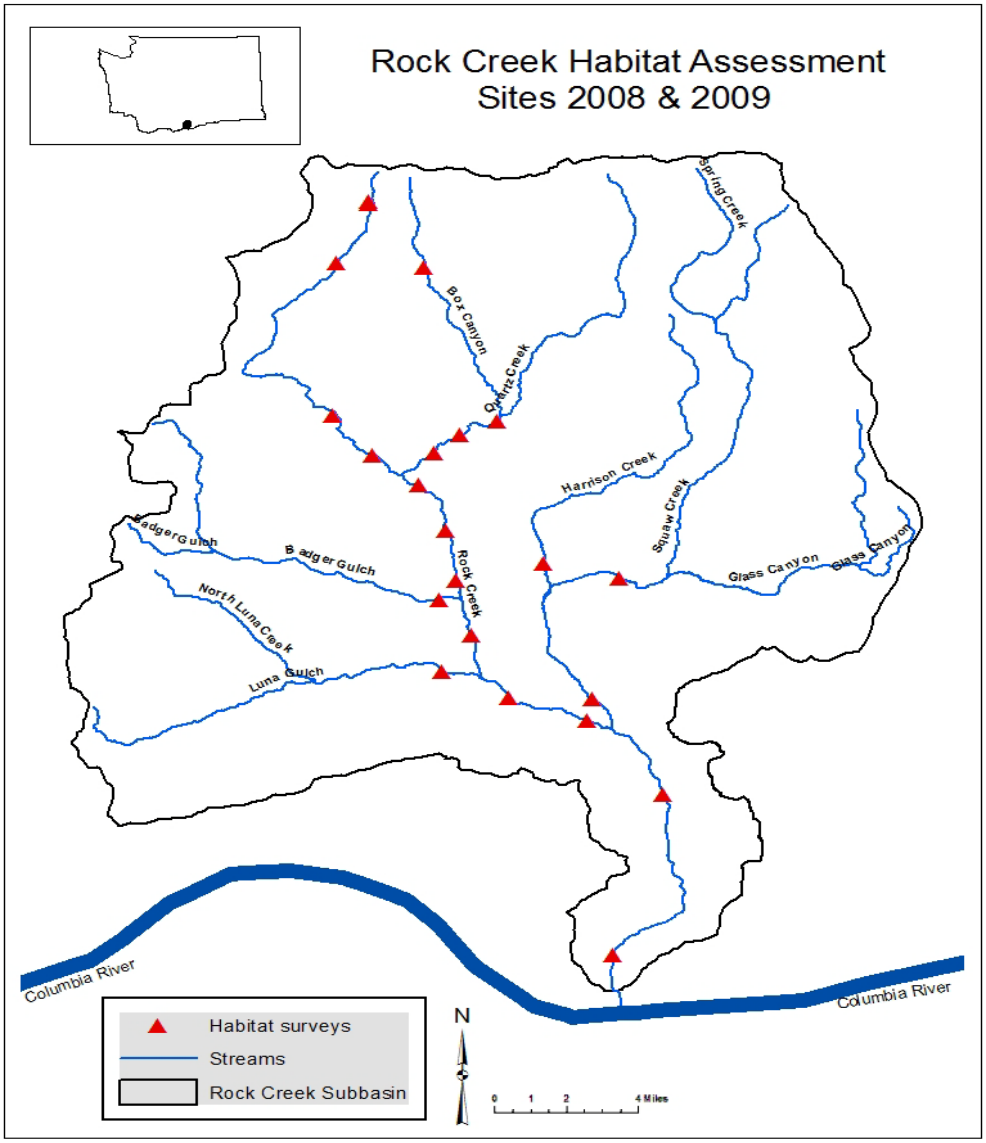


Figure 7. Rock Creek subbasin habitat assessment sites.

Task 1.g Pathogen Sampling

Objective: Document pathogen presence and severity within the watershed. A sub-sample of fish captured during population studies and all fish incidentally killed during sampling for distribution and abundance will be put on ice and delivered to the U.S. Fish and Wildlife Service's Lower Columbia River Fish Health Center (LCRFHC) which will provide a thorough disease profile as part of the U.S Fish and Wildlife Service's National Wild Fish Health Survey. An approximate total of 60 samples of steelhead and 20-60 samples of other resident species were collected from the mainstem Rock Creek and Squaw Creek site locations including three survey sites in lower, middle, and upper reaches of mainstem Rock Creek. A baseline data set describing existing levels of pathogens in the watershed's salmonids will be uploaded to the Rock Creek database to contribute to the development of a disease profile.

Methods: A total of 120 fish were collected for pathogen sampling of Rock Creek juvenile steelhead/rainbow trout and other resident species longnose dace (*Rhinichthys cataractae)*, redside shiner (*Richardsonius balteatus*)]. 48 specimens were rainbow trout, 12 were redside shiners, and 60 longnose dace were collected for the pathogen analysis. A sub-sample of fish captured during population studies and all fish incidentally killed during sampling for distribution and abundance were preserved and taken to the U.S. Fish and Wildlife Service's Lower Columbia River Fish Health Center (LCRFHC) for a pathogen analyses following the National Wild Fish Health Survey - Laboratory Procedures (Heil, 2009).

Results: The Rock Creek fish health report indicates that the mainstem Rock Creek fish samples were in good health and no pathogens were detected. During the population surveys some of the rainbow trout and other native species had blackspot (*Uvulifer ambloplitis)* infestation and some of the fish had copepods (*Salmincola californiensis*) that were noted in the field notes. See Appendix E. for more detail.

2. EDT Modeling

Overall Objective: The Ecosystem Diagnosis and Treatment (EDT) model was utilized in this fish and habitat assessment to compare the historical and current habitat conditions of Rock Creek and its tributaries. The EDT model was applied to understand the effects of environmental attributes on each life history stage of each species to guide protection strategies and restoration measures consistent with the Rock Creek Steelhead DPS Recovery Plan.

Task 2.a EDT Database and modeling

Objective: The project's goals include establishing baseline data for watershed and habitat conditions in Rock Creek to prioritize sites for restoration. Data were collected, compiled, analyzed, and put into the EDT model. Historic watershed conditions were also researched and incorporated into the EDT model. EDT modeling assessed the Rock Creek watershed and field investigations were conducted to assess the impact and magnitude of past land use activities, as well as identifying restoration opportunities and their potential benefits.

Methods: Stream reaches were delineated based on the geomorphic channel classification system according to characteristics such as stream gradient, confinement, channel morphology, bed material, and bedform pattern (Montgomery & Buffington, 1998). Environmental and biological attribute data was collected in fifteen geomorphic reaches throughout the subbasin. Data was compiled, analyzed, and put into the EDT model. Historic watershed conditions (e.g. GLO maps, air photos, flow data) was researched and incorporated into the EDT model. All data was evaluated and incorporated into the EDT Stream Reach Editor Access database. Model iterations and baseline reports were received from the Jones and Stokes EDT website http://www.edt.icfi.com/edt/.

Results: Baseline reports were created from the online EDT website. A baseline report for each species was conducted and broken into four sections. The first report illustrated affects on each life history stage by species of the current state of environmental attributes (e.g. channel stability, flow, food, harassment). The second report illustrated affects to compare each EDT stream reach with environmental attributes modeling various protection and restoration strategies (e.g. protection and restoration benefits). The third report gave a graphical view of each reach with percent potential change in abundance, productivity, and diversity index for both degradation and restoration of each reach. The fourth report represented a reach-by-reach analysis of overall restoration benefit or preservation benefit for each life history trajectory and productivity change. EDT Model results for each species are included in Appendix E. All baseline

reports will be used in the evaluation process of future restoration projects in Rock Creek and its tributaries. A list of potential key restoration and protection projects from the resultant EDT baseline reports was created for the Rock Creek subbasin. The NMFS Middle Columbia Steelhead Recovery Plan and Rock Creek Subbasin Plan goals and objectives were also considered in the process of creating the priority list. Overall, EDT modeling assisted in subbasin and field investigations to further pinpoint the impact and magnitude of past land use activities. The EDT model will continue to be updated as additional information is incorporated.

Priority list for restoration and protection projects

1. *Restore riparian condition and function in locations that will support seedling survival*

   Actions:
   - Restore and enhance natural riparian vegetative communities
   - Develop grazing strategies that promote riparian recovery
   - Eradicate invasive plant species from riparian areas

   Fish species: Fall Chinook, coho, steelhead, other native species

   Life Histories: 0-active rearing to 2+ age transient

   Location: mainstem Rock Creek from mouth to Luna Gulch confluence; Luna Gulch; Badger Gulch; Squaw Creek

2. *Improve degraded water quality, reduce summer water temperatures*

   Actions:
   - Restore natural functions and processes through actions identified in strategies above
   - Construct water and sediment control basins

   Fish Species: Fall Chinook, coho, steelhead, other native species

   Life Histories: spawning to 1-age active rearing

   Location: mainstem Rock Creek from mouth to Badger Creek confluence, Luna Gulch, Badger Gulch, Squaw Creek, Harrison Creek

3. *Restore degraded upland processes*

   Actions:
   - Restore native upland plant communities.
   - Implement Best Management Practices (BMPs) to forest, agriculture, and grazing practices that mimic natural runoff and sediment production
   - Implement road management actions to reduce erosion and fine sediment inputs

   Fish Species: Fall Chinook, coho, steelhead, other native species

   Life Histories: Spawning to 0-age active rearing

Location: mainstem Rock Creek, Luna Gulch, Badger Gulch

4. *Restore floodplain function and channel migration processes*

Actions:

- Reconnect side channels
- Remove dikes
- Reconnect floodplain to channel
- Relocate or improve floodplain infrastructure and roads

Fish species: Fall Chinook, coho, steelhead, other native species

Life Histories: Spawning to 2+age transient rearing

Location: mainstem Rock Creek, Squaw Creek, Luna Gulch

3. Genetics

Overall objective: Utilize genetic techniques to determine the genetic population structure of Rock Creek steelhead trout. These analyses will be coupled with genetic sampling in adjacent subbasins and will aid in understanding genetic similarities and differences with other populations in the Columbia River Basin. Genetic sampling and analysis will also determine the extent to which unmarked hatchery steelhead stray into the subbasin.

Task 3.a Genetic sample collection, data synthesis and analysis

Objective: Compare genetic samples collected from fish population sampling sites for heterogeneity and population differences within the subbasin.

Methods: Samples were collected from a total of seven sampling sites in the mainstem and in Squaw Creek. A total of 59 genetic samples were collected. 30 samples were collected in Squaw Creek at Rkm 3 and Rkm7 and a total of 29 samples were collected from the mainstem Rock Creek at Rkm 16 and Rkm 20. Tissue samples (fin clips) from a sub-sample of juvenile steelhead captured during electrofishing were removed and preserved (95% ethanol) for genetic analysis.

Results: These samples were saved and the results of the analysis will be included in the 2010-11 Annual Report. There were not enough genetic samples collected for this 2009 season, but after the 2010 fish population surveys, there will be enough genetic samples to send in for this analysis. It was recommended by the geneticist that we collect our samples taking a stratified approach for our next submission of samples. A stratified approach was used during our spring 2010 sampling season.

4. Revegetation

Overall objective: Plant native trees in Rock Creek riparian zones. Native trees and shrubs include alder *(Alnus spp.),* black cottonwood *(Populus trichocarpa),* ponderosa pine *(Pinus ponderosa),* red-osier dogwood *(Cornus stolonifera),* chokecherry *(Prunus virginiana)* and coyote willow *(Salix exigua).* All of the chosen plant species are native to the Rock Creek watershed, and these plantings will increase the vegetative diversity of the area. The riparian plantings will aid in protecting streambanks, reduce bank

erosion, provide habitat complexity, and decrease surface water temperatures through increased riparian cover.

Task 4.a Tree revegetation and weed removal

Objective: Identify key sites for revegetation from an evaluation of orthophotos, topographic maps and site visits. Locate willow stands for future cutting collection. Prepare planting sites prior to planting, and plant trees. Manually remove invasive weeds within the tree-planting locations and dispose of weeds.

Methods: Site visits were conducted throughout the Rock Creek subbasin to identify native vegetation in various riparian zones. Large and healthy willow bunches were identified for future willow-cutting sites. The Rock Creek subbasin turns very dry through the summer months and sufficient soil moisture is essential for the survival and growth of the trees. Topographic maps were used to identify where springs and higher groundwater may be available to support tree plantings, and revegetation sites were chosen based on their proximity to these sites and soil moisture. Site preparation was conducted prior to tree planting. Five fence enclosures were constructed to keep cattle out of the planting sites, with one third of the trees planted within the enclosures. Planting areas were cleared of brush and other debris. Trees were planted during the early spring months (late February and early March) when the soil was saturated to allow for root establishment and growth. Weed mats were tacked onto the earth below the trees with pins. Star thistle, bull thistle, and other invasive weeds were hand removed from tree planting sites and areas nearby to prevent encroachment.

Results: 200 live-stake willow cuttings and 150 rooted trees were planted along 2.0 riparian acres of Rock Creek (between RM 3.5 and RM 5). Hand watering each plant once a week during the summer sustained them until the fall rains. Weeds were controlled over a total of 2.5 riparian acres including some hand removal in upland areas to discourage encroachment into planting sites. There was approximately 65% survival of total trees and shrubs planted.

Task 4.b Willow nursery

Objective: Create nursery of native willow cuttings (coyote willow, *Salix exigua*) collected from Rock Creek to plant in containers for future planting opportunities in Rock Creek. The objective is to plant native willows, adapted to local conditions, from Rock Creek at sites throughout the subbasin. From previous year's (2008) experience, the coyote willow had higher survival in the nursery (from live cutting to root and stem development).

Methods: 200 willow cuttings were collected from three sites for growing in containers. Coyote willow was collected from large, healthy bunches. Willows were taken back to the nursery and soaked in water for two weeks. A nursery was constructed to house the containerized willows. Rooted willow cuttings were planted in the containers and watered 2-3 times per week.

Results: 200 willows were planted in the nursery with a 55% survival. The coyote willows did survive and are currently healthy with well-established root systems; however, the dogwood species did not survive as well. Willows are watered 2-3 times per week during the warm summer months. During the spring of 2010, additional willow cutting will be collected and planted in the nursery for future revegetation purposes.

5. Appendices

Appenidix A. Spawning ground survey results for fall Chinook, coho and steelhead

Table A1. Fall Chinook spawning survey tabular data.

Results of 2009-10 Fall Chinook spawning surveys in the Rock Creek Subbasin

				Reach		Live Observed			Morts		
			#	Redds	Redds						
Stream	Reach	Miles	Passes	Totals	/Mile	Floy Tag	No Floy	Unknown	Floy Tag	No Floy	Unknown
Mainstem	Rock Creek conflu. to gas line	2.5	2	0	0	0	0	0	0	0	0
	Mainstem Totals (surveyed reach)	2.5		0	0	0	0	0	0	0	0

Results of 2008-09 Fall Chinook spawning surveys in the Rock Creek Subbasin

				Reach		Live Observed			Morts		
			#	Redds	Redds						
Stream	Reach	Miles	Passes	Totals	/Mile	Floy Tag	No Floy	Unknown	Floy Tag	No Floy	Unknown
Mainstem	Rock Creek conflu. to gas line	2.5	2	2	0.8	0	0	2	0	0	0
	Mainstem Totals (surveyed reach)	2.5		2	0.8	0	0	2	0	0	0

Table A2. Coho spawning survey tabular data.

Results of 2009 Coho spawning surveys in the Rock Creek Subbasin

				Reach		Live Observed			Morts		
			#	Redds	Redds						
Stream	Reach	Miles	Passes	Totals	/Mile	Floy Tag	No Floy	Unknown	Floy Tag	No Floy	Unknown
Mainstem	Rock Creek conflu. to gas line	2.5	3	16	6.4	0	0	5	5	3	0
	Mainstem Totals (surveyed reach)	2.5		16	6.4	0	0	5	5	3	0

Results of 2008 Coho spawning surveys in the Rock Creek Subbasin

				Reach		Live Observed			Morts		
			#	Redds	Redds						
Stream	Reach	Miles	Passes	Totals	/Mile	Floy Tag	No Floy	Unknown	Floy Tag	No Floy	Unknown
Mainstem	Rock Creek conflu. to gas line	2.5	2	0	0	0	0	1	0	0	0
	Mainstem Totals (surveyed reach)	2.5		0	0	0	0	1	0	0	0

Table A2. Steelhead spawning survey tabular data

Results of 2009 Steelhead spawning surveys in the Rock Creek Subbasin

Stream	Reach	Miles	# Passes	Reach Redds Totals	Redds /Mile	Live Observed			Morts		
						Floy Tag	No Floy	Unknown	Floy Tag	No Floy	Unknown
Mainstem	Rock Creek Boat Launch to Squaw Cr.	6.7	3	63	9.40	0	45	0	1	2	2
	Rock Creek Luna confl. to Bick Br.	2.5	3	26	10.40	0	18	0	0	0	0
	Mainstem Totals (surveyed reaches)	9.2		89	19.80	0	63	21	1	2	0
Tributaries	Luna Creek	1.5	3	0	0.00	0	0	0	0	0	0
	Squaw Creek at confluence	1.25	3	27	21.60	0	0	10	0	0	0
	Squaw Creek at Harrison conflu.	1.25	2	11	8.80	0	0	10	0	0	0
	Harrison Creek confluence	1	2	0	0.00	0	0	0	0	0	0
	Badger Gulch at confluence	0.5	3	0	0.00	0	0	0	0	0	0
	Tributary Totals (surveyed reaches)	5.5		38	30.40	0	0	20	0	0	0
	Rock Creek subbasin Totals	**14.7**		**127**		**0**	**63**	**41**	**1**	**2**	**0**
	Mainstem Contribution %			*70*		~	*100*	*51*	~	*100*	~
	Tributary Contribution %			*30*		~	*0*	*49*	~	*0*	~

Results of 2008 Steelhead spawning surveys in the Rock Creek Subbasin

Stream	Reach	Miles	# Passes	Reach Redds Totals	Redds /Mile	Live Observed			Morts		
						Floy Tag	No Floy	Unknown	Floy Tag	No Floy	Unknown
Mainstem	Rock Creek Boat Launch to Gas Line	2.5	3	12	4.8	0	1	4	0	0	0
	Rock Creek Luna confl. to Bick Br.	2.5	3	0	0.0	0	0	2	0	0	0
	Mainstem Totals (surveyed reaches)	5		12	4.8	0	1	6	0	0	0
Tributaries	Luna Creek	1.5	3	2	1.3	0	0	5	0	0	0
	Squaw Creek at confluence	1.5	3	10	6.7	0	0	12	0	0	0
	Squaw Creek at Harrison conflu.	1.5	2	16	10.7	0	0	9	0	0	0
	Harrison Creek confluence	1	2	0	0.0	0	0	0	0	0	0
	Badger Creek at confluence	0.5	3	0	0.0	0	0	0	0	0	0
	Quartz Creek at confluence	1.5	2	5	3.3	0	0	4	0	0	0
	Tributary Totals (surveyed reaches)	7.5		33	22.0	0	0	30	0	0	0
	Rock Creek subbasin Totals	**12.5**		**45**		**0**	**1**	**36**	**0**	**0**	**0**
	Mainstem Contribution %			*36*		~	*100*	*17*	~	~	~
	Tributary Contribution %			*73*		~	*0*	*83*	~	~	~

Appendix B. Sediment sampling data from 2008 -2009

Table B1. Army Corps of Engineers Park of lower Rock Creek (RM 2) tabular data

Reference (2008) and Study (2009) Particle size comparisons (2mm, 4mm, 8mm)

2mm

	<	> or =	Total
Reference	6	101	107
Study	22	95	117
Total	28	196	224

Reference <	Study <	Average <	Average >=
5.6%	18.8%	12.5%	87.5%
0.131959	0.123013		2.780692
0.008946	0.044238		
10.9%			0.997288
0.017893			
		p-value	0.0027

4 mm

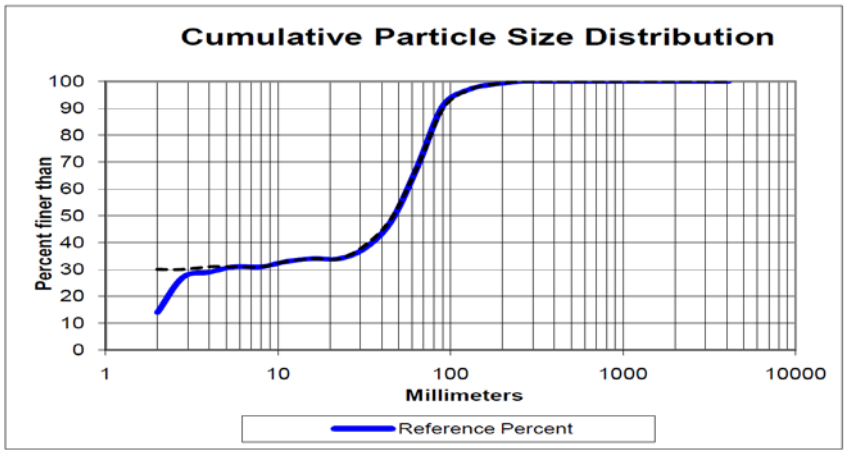
	<	> or =	Total
Reference	29	71	100
Study	31	69	100
Total	60	140	200

Reference <	Study <	Average <	Average >=
29.0%	31.0%	30.0%	70.0%
0.02	0.01		0.154303
0.01	0.064807		
0.21			0.561315
0.02			
		p-value	0.4387

8 mm

	<	> or =	Total
Reference	31	69	100
Study	31	69	100
Total	62	138	200

Reference <	Study <	Average <	Average >=
31.0%	31.0%	31.0%	69.0%
0	-0.01		-0.15289
0.01	0.065406		
0.2139			0.439242
0.02			
		p-value	0.5608



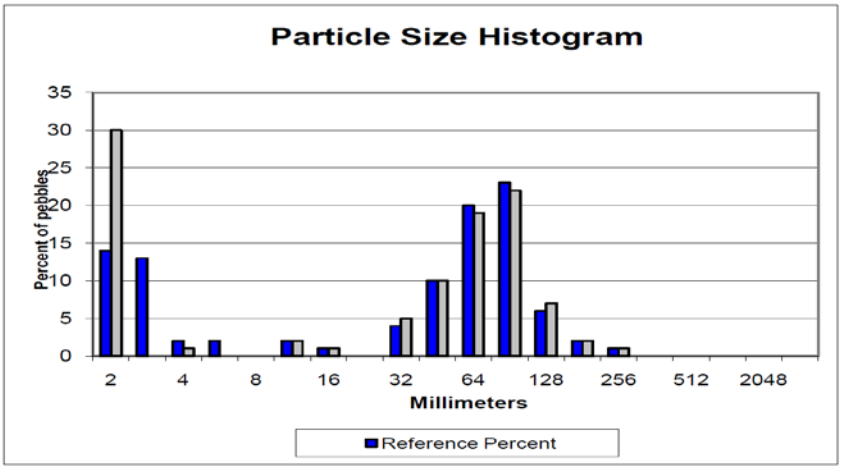


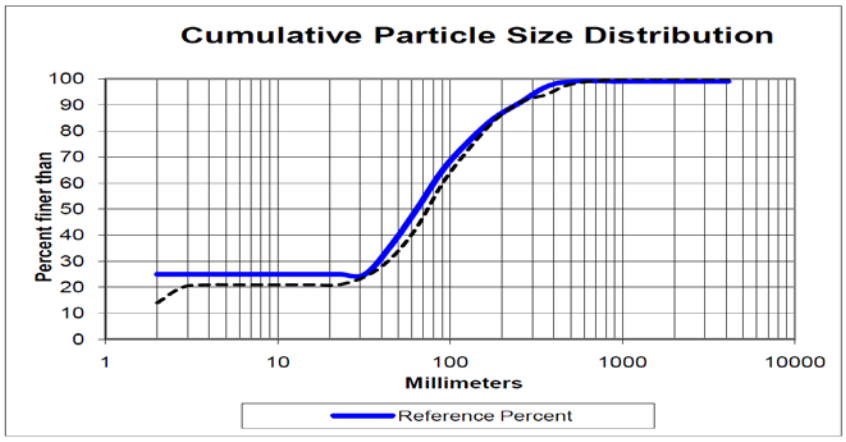
Table B2. Bickleton Bridge (Bridge Replacement Site) of Rock Creek (RM 13) tabular data

Reference (2008) and Study (2009) Particle size comparisons (2mm, 4mm, 8mm)

2mm			
	<	> or =	Total
Reference	6	101	107
Study	22	95	117
Total	28	196	224
Reference <	Study <	Average <	Average >=
5.6%	18.8%	12.5%	87.5%
0.131959	0.123013		2.780692
0.008946	0.044238		
10.9%			0.997288
0.017893			
		p-value	0.0027

4 mm			
	<	> or =	Total
Reference	25	75	100
Study	21	79	100
Total	46	154	200
Reference <	Study <	Average <	Average >=
25.0%	21.0%	23.0%	77.0%
0.04	0.03		0.504077
0.01	0.059515		
0.1771			0.692896
0.02			
		p-value	0.3071

8 mm			
	<	> or =	Total
Reference	25	75	100
Study	21	79	100
Total	46	154	200
Reference <	Study <	Average <	Average >=
25.0%	21.0%	23.0%	77.0%
0.04	0.03		0.504077
0.01	0.059515		
0.1771			0.692896
0.02			
		p-value	0.3071



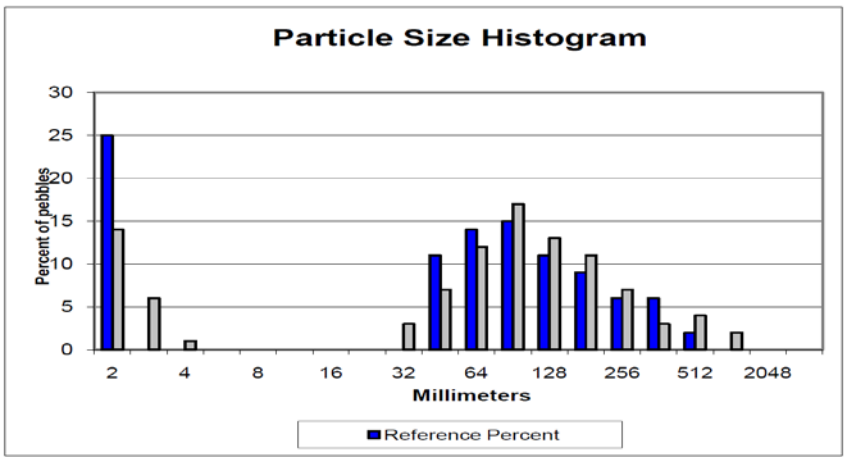


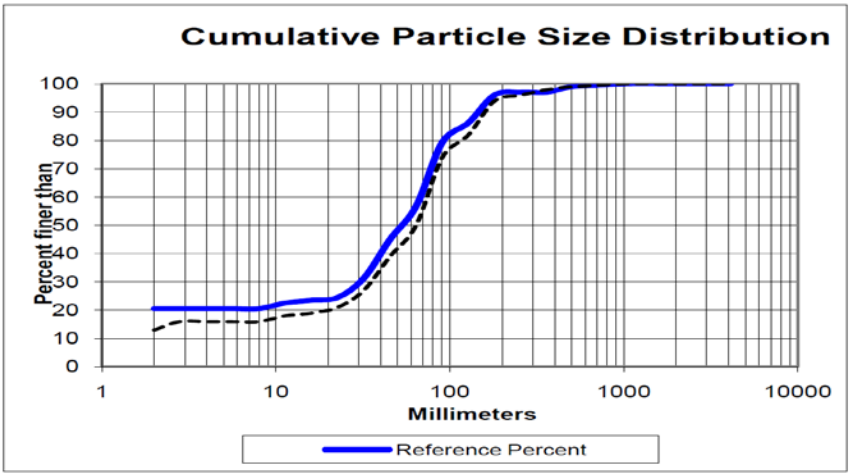
Table B3. Squaw Creek (RM 1) tabular data

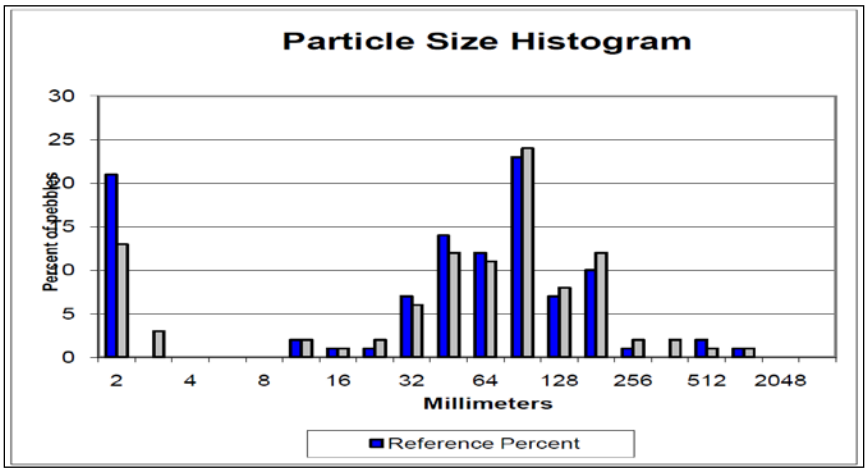
Reference (2008) and Study (2009) Particle size comparisons (2mm, 4mm, 8mm)

2mm			
	<	> or =	Total
Reference	6	101	107
Study	22	95	117
Total	28	196	224
Reference <	Study <	Average <	Average >=
5.6%	18.8%	12.5%	87.5%
0.131959	0.12301302		2.780692
0.008946	0.044238279		
10.9%			0.997288
0.017893			
		p-value	0.0027

4 mm			
	<	> or =	Total
Reference	21	81	102
Study	16	84	100
Total	37	165	202
Reference <	Study <	Average <	Average >=
20.6%	16.0%	18.3%	81.7%
0.045882	0.03598		0.660996
0.009902	0.054434		
0.149618			0.745693
0.019804			
		p-value	0.2543

8 mm			
	<	> or =	Total
Reference	21	81	102
Study	16	84	100
Total	37	165	202
Reference <	Study <	Average <	Average >=
20.6%	16.0%	18.3%	81.7%
0.045882	0.03598		0.660996
0.009902	0.054434		
0.149618			0.745693
0.019804			
		p-value	0.2543





Appendix C. Temperature monitoring

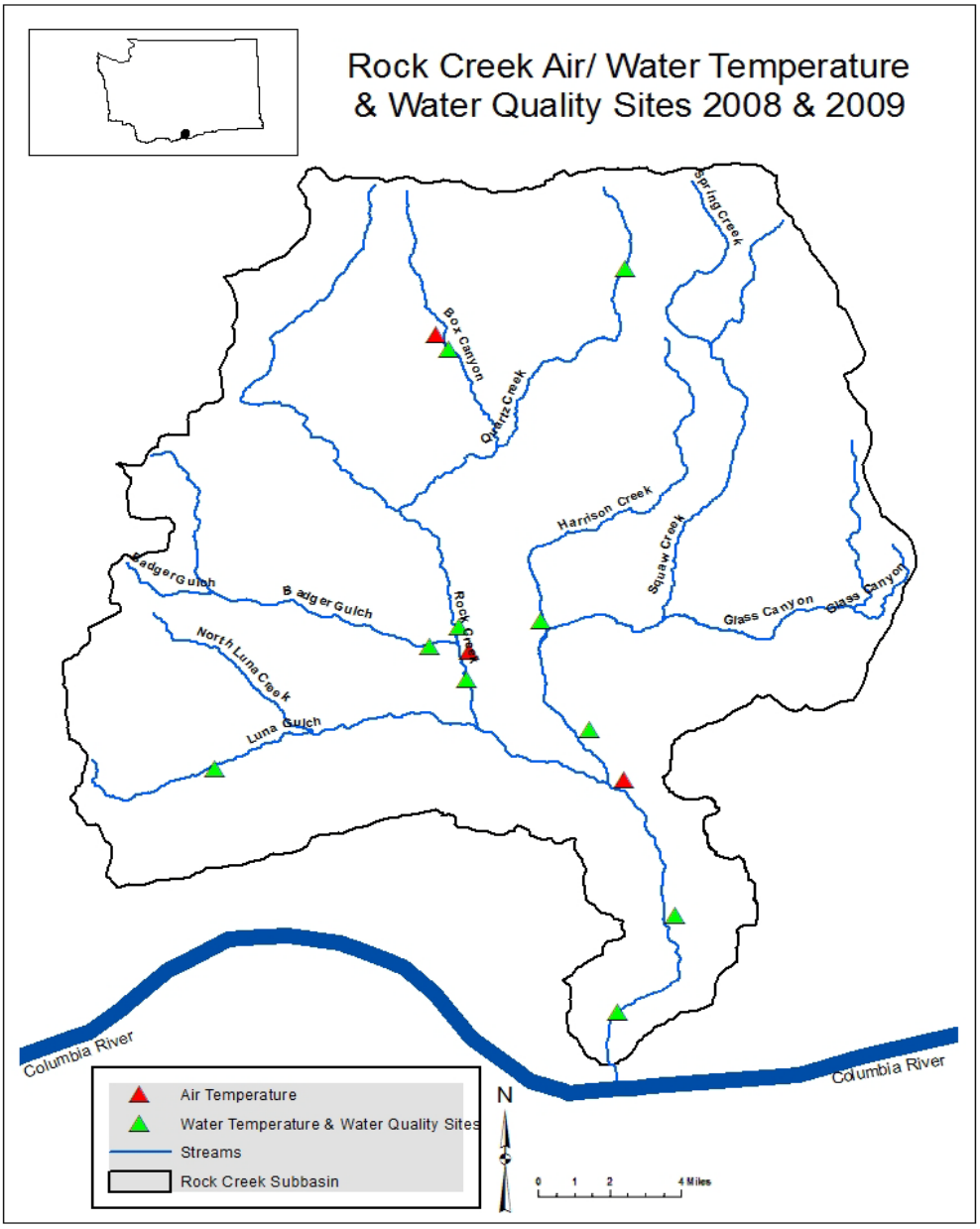


Figure C1. 2008 and 2009 Rock Creek air/water temperature and water quality monitoring sites.

Table C1. Monthly stream and air temperature summaries from 13 sites (10 stream sites, 3 air sites) in the Rock Creek subbasin for the reporting period (6/1/2008 – 5/31/2009). All temperatures and ranges in degree Celsius. "—" indicates no data. See description under Temperature monitoring section in the narrative for an explanation of metrics used.

Monthly Temperature Summaries (degrees C)

Army Corps Park Water Temperature

2009	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
June	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
July	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
August	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
September	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
October	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
November	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
December	21	0	13	0	9	0	0	0	0	0	0	0	7.0	1.4	0.8

Army Corps Park Water Temperature

2010	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
January	31	0	4	0	3	0	0	0	0	0	0	0	7.9	2.0	1.1
February	28	0	4	0	0	0	0	0	0	0	0	0	9.7	3.9	2.1
March	31	0	0	0	0	0	0	2	0	0	0	0	12.7	5.5	3.9
April	30	0	0	0	0	0	0	22	0	0	0	0	16.1	6.4	4.6
May	31	0	0	0	0	0	0	31	23	8	6	0	19.5	7.0	4.8

Bickleton Bridge Water Temperature

2009	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly 1-Day	Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
June	30	0	0	0	0	0	0	30	30	20	14	0	19.1	4.7	3.4
July	31	0	0	0	0	1	0	31	31	31	31	7	23.1	5.1	4.1
August	31	0	0	0	0	2	0	31	31	31	31	5	23.6	4.2	3.4
September	30	0	0	0	0	0	0	30	28	22	19	0	20.7	3.4	2.8
October	31	0	0	0	0	0	0	12	0	0	0	0	15.2	2.9	1.8
November	30	0	1	0	0	0	0	0	0	0	0	0	10.2	2.3	1.7
December	31	5	30	0	30	0	0	0	0	0	0	0	6.2	1.9	1.0

Bickleton Bridge Water Temperature

2010	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	-1 Monthly 1-Day	Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
January	31	0	24	0	17	0	0	0	0	0	0	0	6.0	1.7	1.0
February	28	0	10	0	5	0	0	0	0	0	0	0	7.7	2.7	1.6
March	31	0	12	0	1	0	0	0	0	0	0	0	10.1	4.9	3.1
April	30	0	5	0	0	0	0	1	0	0	0	0	12.8	4.9	3.4
May	31	0	0	0	0	0	0	20	0	0	0	0	16.0	5.2	3.0

Bickleton Bridge Air Temperature

2009	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly 1-Day	Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
June	30	0	0	0	0	26	24	30	30	30	30	30	29.7	20.3	13.8
July	31	0	0	0	0	30	28	31	31	31	31	31	37.1	21.2	16.9
August	31	0	0	0	0	30	29	31	31	31	31	31	38.2	20.6	15.0
September	30	0	2	0	0	21	20	30	30	30	30	27	31.6	19.9	15.4
October	31	6	18	0	3	0	0	28	12	0	0	0	20.2	18.7	11.1
November	30	21	30	0	17	0	0	4	0	0	0	0	15.1	14.8	10.3
December	31	27	31	24	31	0	0	0	0	0	0	0	9.2	14.4	7.2

Bickleton Bridge Air Temperature

2010	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	>16	>17.5	>18	>22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
January	31	19	31	4	21	0	0	0	0	0	0	0	13.0	13.5	6.1
February	28	12	26	0	10	0	0	12	0	0	0	0	17.6	18.7	10.6
March	31	18	28	0	4	0	0	27	13	0	0	0	21.1	21.0	14.6
April	30	7	18	0	2	3	0	29	20	14	10	1	24.0	20.4	13.8
May	31	2	12	0	0	6	4	31	27	18	17	6	28.0	21.9	13.5

Box Canyon Road Air Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	>16	>17.5	>18	>22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	30	0	10	0	0	11	9	30	30	30	30	16	26.9	23.6	16.0
July	31	0	4	0	0	26	25	31	31	31	31	31	34.8	23.4	19.2
August	31	1	6	0	0	23	22	31	31	31	31	31	36.5	27.8	18.7
September	30	3	9	0	0	19	19	30	29	28	28	22	32.7	25.7	18.9
October	31	20	29	3	11	0	0	14	0	0	0	0	18.3	19.5	11.8
November	30	30	30	10	30	0	0	0	0	0	0	0	11.7	14.4	8.7
December	31	31	31	25	31	0	0	0	0	0	0	0	5.9	17.9	7.5

Box Canyon Road Air Temperature

2010	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	>16	>17.5	>18	>22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
January	31	30	31	9	31	0	0	0	0	0	0	0	7.9	11.8	5.6
February	28	22	28	5	27	0	0	0	0	0	0	0	12.4	16.1	9.3
March	31	28	31	3	22	0	0	8	0	0	0	0	16.4	18.7	13.0
April	30	20	29	2	9	0	0	17	5	0	0	0	21.2	19.8	12.3
May	31	16	24	0	4	2	0	24	8	6	5	0	23.6	20.9	13.1

Box Canyon Road Water Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
July	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
August	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
September	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
October	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
November	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
December	31	18	31	9	31	0	0	0	0	0	0	0	4.9	2.4	0.9

Box Canyon Road Water Temperature

2010	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
January	31	0	31	0	31	0	0	0	0	0	0	0	4.4	1.6	1.0
February	28	0	28	0	26	0	0	0	0	0	0	0	5.9	2.8	1.6
March	31	0	31	0	21	0	0	0	0	0	0	0	7.0	4.1	2.8
April	30	0	16	0	9	0	0	0	0	0	0	0	10.4	6.1	3.8
May	31	0	4	0	0	0	0	5	0	0	0	0	13.3	6.4	4.4

Longhouse Site Water Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly -1 Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	30	0	0	0	0	11	5	30	30	30	30	21	24.9	8.5	5.9
July	31	0	0	0	0	30	29	31	31	31	31	31	34.4	12.0	8.9
August	31	0	0	0	0	30	30	31	31	31	31	31	40.5	27.3	16.3
September	30	0	0	0	0	28	28	30	30	30	30	30	39.1	27.3	20.8
October	31	1	4	0	1	6	5	30	18	11	11	8	26.4	24.0	10.4
November	30	0	0	0	0	0	0	0	0	0	0	0	13.5	4.9	2.2
December	31	0	8	0	1	0	0	0	0	0	0	0	9.8	2.4	1.1

Longhouse Site Water Temperature

2010	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
January	31	0	2	0	2	0	0	0	0	0	0	0	7.5	1.7	0.9
February	28	0	3	0	0	0	0	0	0	0	0	0	9.4	3.7	2.0
March	31	0	0	0	0	0	0	0	0	0	0	0	12.2	4.9	3.7
April	30	0	0	0	0	0	0	20	0	0	0	0	15.1	5.5	4.3
May	31	0	0	0	0	0	0	31	15	2	0	0	18.2	6.3	4.1

Luna Gulch Water Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
July	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
August	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
September	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
October	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
November	25	0	0	0	0	0	0	0	0	0	0	0	8.0	1.4	0.9
December	31	2	25	1	24	0	0	0	0	0	0	0	7.2	4.3	0.9

Luna Gulch Water Temperature

2010	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
January	31	0	31	0	25	0	0	0	0	0	0	0	6.2	2.2	1.3
February	28	0	13	0	6	0	0	0	0	0	0	0	8.2	4.3	2.4
March	31	0	12	0	0	0	0	0	0	0	0	0	10.4	5.4	3.9
April	30	0	6	0	0	0	0	18	0	0	0	0	13.8	6.7	4.9
May	31	0	0	0	0	0	0	30	0	0	0	0	15.0	5.9	3.8

Newell Spring Water Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
July	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
August	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
September	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
October	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
November	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
December	18	0	13	0	11	0	0	0	0	0	0	0	7.8	2.9	1.4

Newell Spring Water Temperature

2010	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
January	31	0	3	0	1	0	0	0	0	0	0	0	10.0	3.0	1.6
February	28	0	2	0	0	0	0	0	0	0	0	0	12.3	5.8	3.0
March	31	0	2	0	0	0	0	12	0	0	0	0	13.2	6.9	5.0
April	30	0	0	0	0	0	0	23	0	0	0	0	15.8	7.3	4.8
May	31	0	0	0	0	0	0	25	0	0	0	0	17.1	5.7	3.4

Newell Road Air Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	30	0	0	0	0	28	26	30	30	30	30	30	33.4	23.4	15.8
July	31	0	0	0	0	31	31	31	31	31	31	31	41.5	24.6	19.5
August	31	0	0	0	0	31	31	31	31	31	31	31	43.0	26.5	18.3
September	30	0	5	0	0	27	26	30	30	30	30	29	36.0	25.5	19.2
October	31	6	17	0	1	0	0	31	18	14	13	0	22.7	21.8	13.2
November	30	23	30	0	13	0	0	9	0	0	0	0	16.0	16.2	11.8
December	31	27	31	23	30	0	0	0	0	0	0	0	12.2	17.4	9.1

Newell Road Air Temperature

2010	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
January	31	15	31	2	18	0	0	5	0	0	0	0	16.5	16.7	7.8
February	28	13	25	0	8	0	0	19	2	1	0	0	19.8	21.6	13.0
March	31	20	28	0	1	1	0	31	23	16	16	0	23.8	23.3	17.5
April	30	7	17	0	1	4	4	30	24	21	21	7	27.3	22.7	15.8
May	31	3	11	0	0	10	8	31	31	31	29	10	30.5	23.2	15.3

Quartz Creek Water Temperature

2009	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
June	30	0	0	0	0	0	0	30	0	0	0	0	14.6	5.8	4.2
July	31	0	0	0	0	0	0	31	0	0	0	0	13.9	2.4	1.1
August	31	0	0	0	0	0	0	31	11	5	4	0	20.7	11.3	4.5
September	30	0	2	0	0	0	0	29	5	3	2	0	21.0	9.5	5.3
October	31	0	0	0	0	0	0	0	0	0	0	0	12.4	7.2	0.9
November	30	0	0	0	0	0	0	0	0	0	0	0	10.2	0.9	0.5
December	31	0	23	0	21	0	0	0	0	0	0	0	6.1	3.3	1.0

Quartz Creek Water Temperature

2010	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
January	31	0	31	0	31	0	0	0	0	0	0	0	4.8	1.6	1.0
February	28	0	28	0	21	0	0	0	0	0	0	0	6.0	2.4	1.5
March	31	0	28	0	10	0	0	0	0	0	0	0	7.3	3.9	2.6
April	30	0	15	0	7	0	0	0	0	0	0	0	10.0	4.9	3.5
May	31	0	6	0	0	0	0	3	0	0	0	0	12.6	6.7	4.5

Site 2 Trees Water Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	30	0	0	0	0	2	0	30	30	30	30	13	23.1	7.0	5.2
July	31	0	0	0	0	25	21	31	31	31	31	31	29.5	6.7	5.0
August	31	0	0	0	0	30	27	31	31	31	31	31	31.4	13.6	8.2
September	30	0	0	0	0	12	9	30	30	29	28	19	31.9	15.4	7.7
October	31	0	0	0	0	0	0	25	1	0	0	0	16.6	4.2	2.1
November	30	0	0	0	0	0	0	0	0	0	0	0	12.3	2.1	1.4
December	31	6	24	3	20	0	0	0	0	0	0	0	8.4	3.3	1.2

Site 2 Trees Water Temperture

2010	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
January	31	0	11	0	5	0	0	0	0	0	0	0	7.2	2.0	1.0
February	28	0	5	0	0	0	0	0	0	0	0	0	8.8	3.6	2.0
March	31	0	2	0	0	0	0	0	0	0	0	0	12.1	5.5	3.8
April	30	0	0	0	0	0	0	18	0	0	0	0	15.1	6.1	4.5
May	31	0	0	0	0	0	0	31	15	4	3	0	18.9	7.3	4.9

Squaw Creek 1 Water Temperature

2009	# Days Recorded	# 1Day Min < 0.5	# 1Day Min < 4.4	# 1Day Avg <0.5	# 1Day Avg <4.4	# 1Day Max >23	# 1Day Max >24	#7Day Avg Daily Max >12	#7Day Avg Daily Max >16	#7Day Avg Daily Max >17.5	#7Day Avg Daily Max >18	#7Day Avg Daily Max >22	Monthly 1-Day Max	Monthly 1-Day Max Range	Monthly Avg Daily Range
June	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
July	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
August	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
September	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
October	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
November	25	0	0	0	0	0	0	0	0	0	0	0	8.2	1.8	1.3
December	31	6	30	4	29	0	0	0	0	0	0	0	6.6	2.3	1.1

Squaw Creek 1 Water Temperature

2010	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
January	31	0	31	0	28	0	0	0	0	0	0	0	5.6	1.8	1.0
February	28	0	19	0	7	0	0	0	0	0	0	0	7.1	3.3	1.8
March	31	0	15	0	0	0	0	0	0	0	0	0	9.1	4.3	3.2
April	30	0	4	0	0	0	0	0	0	0	0	0	12.0	5.1	3.6
May	31	0	0	0	0	0	0	11	0	0	0	0	14.0	4.3	2.8

Squaw Confluence Water Temperature

2009	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
June	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
July	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
August	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
September	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
October	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
November	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--
December	21	0	13	0	10	0	0	0	0	0	0	0	7.2	2.5	1.1

Squaw Confluence Water Temperature

2010	# Days	# 1Day Min		# 1Day Avg		# 1Day Max		#7Day Avg Daily Max					Monthly	1- Monthly	1-Day Monthly Avg
	Recorded	< 0.5	< 4.4	<0.5	<4.4	>23	>24	>12	>16	>17.5	>18	>22	Day Max	Max Range	Daily Range
January	31	0	5	0	3	0	0	0	0	0	0	0	7.3	1.8	1.0
February	28	0	4	0	0	0	0	0	0	0	0	0	9.1	3.3	1.9
March	31	0	0	0	0	0	0	0	0	0	0	0	11.5	5.0	3.6
April	30	0	0	0	0	0	0	18	0	0	0	0	14.3	5.5	4.1
May	31	0	0	0	0	0	0	31	8	0	0	0	18.4	7.5	4.6

NOTE: All Temperatures and Ranges in degrees C, -- Indicates No Available Data.

Appendix D. Pathogen results

Table D1. Rock Creek and Squaw Creek pathogen results.

FISH HEALTH REPORT 2009

U.S. FISH & WILDLIFE SERVICE
LOWER COLUMBIA RIVER FISH HEALTH CENTER
201 Oklahoma Road
Willard, WA 98605
Phone: 509-538-2400
Fax: 509-538-2404

Fish source	Species	# of fish	IPNV	IHNV	VHS	SVCV	AS	YR	ESC	BCD	CD	RS	WD	Comments
Rock Creek (RM 15.9)	Rainbow trout	21	o	o	o	o	o	o	o	o	o	o	o	Fish appeared to be in good health
Rock Creek (RM 15.9)	Redside shiner	12	o	o	o	o	o	o	o	o	o	□	□	Fish appeared to be in good health
Rock Creek (RM 15.9)	Longnose dace	60	o	o	o	o	o	o	o	o	o	□	□	Fish appeared to be in good health
Rock Creek (RM 17)	Rainbow trout	10	o	o	o	o	o	o	o	o	o	□	o	Fish appeared to be in good health
Squaw Creek	Rainbow trout	17	o	o	o	o	o	o	o	o	o	o	o	Fish appeared to be in good health
	Total # fish	120												
	o	not detected												
	◊	detected												
	□	not tested												

[1] **IPNV** Infectious Pancreatic Necrosis Virus, **IHNV** Infectious Hematopoietic Necrosis Virus, **VHS** Viral HemorrhagicSepticemia Virus, **SVCV** Spring Viremia of Carp Virus, **AS** Furunculosis (*Aeromonas salmonicida),* **YR** Enteric Redmouth (*Yersinia ruckeri),* **ESC** Emphysematous Putrefactive Disease *(Edwardsiella ictaluri),* **BCD** Coldwater Disease (*Flavobacterium psychrophilum),* **CD** Columnaris (*Flavobacterium columnare),* **RS** BKD (*Renibacterium salmoninarum*), **WD** Whirling Disease (*Myxobolus cerebralis*), **CS** Salmonid Ceratomyxosis (*Ceratomyxa Shasta*

Appendix E. EDT modeling results

Table E1. Rock Creek fall Chinook protection and restoration summary.

Rock Creek (YN) Fall Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Luna	○	○	•				•	●	●	•					•			●
Rock Below Squaw	○	○	●				•	●	●		•			•	•			●
Rock Between Squaw and Luna	○	○	•				●	●	•						•	•		◉
Squaw Cr	○	○	•				•	●	●		◉					•		●

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
○ / ● High	○ / ● Medium	○ / • Low	Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Table E2. Rock Creek fall Chinook life stage summary.

Rock Creek (YN) Fall Chinook
Life Stage Summary Across All Geographic Areas

Life stage	Relevant months	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival: Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Nov	-8.0%	3							•	•						•		●
Egg incubation	Nov-May	-22.3%	1	●												●			•
Fry colonization	Apr-May	-9.4%	2	•			•	•	●	●					•				○
0-age active rearing	Mar-Oct	-0.6%	6						●	•					•				○
0-age migrant	Oct-Nov	0.0%	7																
0-age inactive	Oct-Mar	0.0%	7																
1-age active rearing	Mar-May	0.0%	7																
1-age migrant	Mar-Jun	0.0%	7																
1-age transient rearing	Jan-Dec	0.0%	7																
2+-age transient rearing	Jan-Dec	0.0%	7																
Prespawning migrant	Sep-Oct	-0.5%	5					●		•		•							●
Prespawning holding	Oct-Nov	-6.6%	4					•		●	•								●

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	◉	◉

Table E3. Rock Creek fall Chinook relative importance areas for protection and restoration measures.

Rock Creek (YN) Fall Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Luna	A	4	A	3						
Rock Below Squaw	A	1	A	1						
Rock Between Squaw and Luna	A	2	A	2						
Squaw Cr	A	3	A	4						

-55% 0% 55% Percentage change

-55% 0% 55% Percentage change

-55% 0% 55% Percentage change

Table E4. Rock Creek coho protection and restoration summary.

Rock Creek (YN) Coho

Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Luna	○	○	●				●	●	●	●					●			●
Rock Below Squaw	○	○	●		●		●	●	●					●	●	●		●
Rock Between Luna and Badger	○	○	●				●	●	●									●
Rock Between Squaw and Luna	○	○	●				●	●	●						●	●		●
Squaw Cr	○	○	●				●	●	●		●					●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

A ○ ● High

B ○ ● Medium

C ○ ● Low

D & E Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Table E5. Rock Creek coho life stage summary.

Rock Creek (YN) Coho
Life Stage Summary Across All Geographic Areas

Life stage	Relevant months	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
				Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Jan	-7.7%	5							●	•					•			●
Egg incubation	Oct-May	-24.6%	2	●												●			●
Fry colonization	Mar-May	-19.9%	3	●			•	●	●	●					•	•			○
0-age active rearing	Mar-Oct	-42.7%	1	•		•	•	●	●	●				•	•	•	●		•
0-age migrant	Oct-Nov	-1.6%	7							●					•				●
0-age inactive	Oct-Mar	8.8%	17	•				•	●	○									○
1-age active rearing	Mar-May	-14.0%	4	•		•		•	●	●									○
1-age migrant	Mar-Jun	-0.3%	8							•					•				○
1-age transient rearing	Jan-Dec	0.0%	10																
2+-age transient rearing	Jan-Dec	0.0%	10																
Prespawning migrant	Sep-Nov	0.0%	9																●
Prespawning holding	Oct-Dec	-6.6%	6					•		●	•								●

1/ Ranking based on effect over entire geographic area.

2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Table E6. Rock Creek coho relative importance of areas for protection and restoration measures.

Rock Creek (YN) Coho
Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Luna	A	4	A	2						
Rock Below Squaw	A	2	A	1						
Rock Between Luna and Badger	A	4	A	5						
Rock Between Squaw and Luna	A	2	A	3						
Squaw Cr	A	1	A	4						
					-3675% 0% 3675%		-3675% 0% 3675%		-3675% 0% 3675%	
					Percentage change		Percentage change		Percentage change	

Table E7. Rock Creek steelhead protection and restoration summary.

Rock Creek (YN) Summer Steelhead
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Badger Gulch							●	●	●				●		●	●		●
Luna	○	○	●				●	●	●	●	●	●			●			●
Quartz	○	○					●	●	●		●		●		●	●		●
Rock Above Quartz	○	○						●			●				●			●
Rock Below Squaw	○	○	●		●		●	●	●				●	●	●	●		●
Rock Between Badger and Unnamed	○	○					●	●	●						●	●		●
Rock Between Luna and Badger	○	○	●		●		●	●	●				●			●		●
Rock Between Squaw and Luna	○	○	●				●	●	●		●		●		●	●		●
Rock Between Unnamed and Quartz	○	○					●	●	●		●				●	●		●
Squaw Cr	○	○	●				●	●	●		●		●		●	●		●
Unnamed Trib	○	○	●				●	●	●		●		●		●	●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A ○ ● High
B ○ ● Medium
C ○ ● Low
D & E Indirect or General

Table E8. Rock Creek steelhead life stage summary.

Rock Creek (YN) Summer Steelhead
Life Stage Summary Across All Geographic Areas

Life stage	Relevant months	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival															
				Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Feb-May	-4.9%	6							●	•					•	•		●
Egg incubation	Mar-Jun	-31.2%	2	●												●	●		●
Fry colonization	Apr-Jul	-15.2%	4	•				●	●	●		●			•		●		●
0-age active rearing	May-Oct	-40.7%	1	•		•		●	●	●				●	•	•	●		●
0,1-age inactive	Oct-Mar	-17.5%	3	•				•	●	●									●
1-age migrant	Mar-Jun	-0.4%	9							•					•				○
1-age active rearing	Mar-Oct	-14.0%	5					•	●	●							•		●
2+-age active rearing	Mar-Oct	-12.9%	8					•		●									●
2+-age migrant	Mar-Jun	-0.1%	14							•					•				○
2+-age transient rearing	Jan-Dec	0.0%	15																
Prespawning migrant	Jun-Feb	-0.1%	12																○
Prespawning holding	Sep-Apr	-0.2%	11																○

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY
NA = Not applicable

	Loss	Gain
None		
Small	•	○
Moderate	●	○
High	●	○
Extreme	●	○

Table E9. Rock Creek steelhead relative importance of areas for protection and restoration measures.

Rock Creek (YN) Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Badger Gulch	E	11	D	11						
Luna	A	3	A	3						
Quartz	A	9	A	3						
Rock Above Quartz	A	4	A	7						
Rock Below Squaw	A	1	A	1						
Rock Between Badger and Unnamed	A	6	A	9						
Rock Between Luna and Badger	A	8	A	6						
Rock Between Squaw and Luna	A	5	A	5						
Rock Between Unnamed and Quartz	A	6	A	8						
Squaw Cr	A	2	A	2						
Unnamed Trib	A	9	A	10						
					-210% 0% 210%		-210% 0% 210%		-210% 0% 210%	
					Percentage change		Percentage change		Percentage change	

Appendix F. Rock Creek revegetation

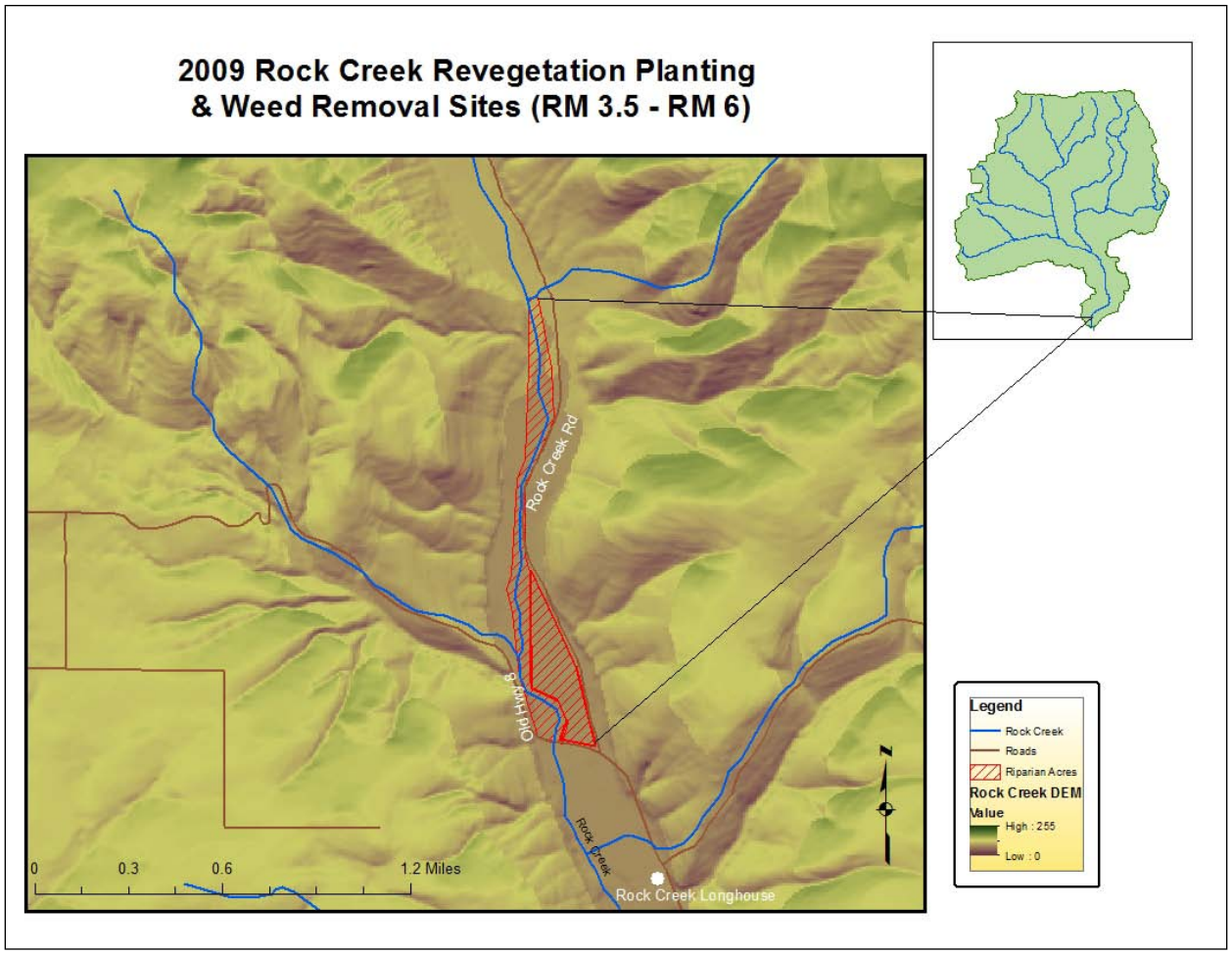


Figure F1. 2009 spring Rock Creek revegetation sites.

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