North Fork Snoqualmie River Rainbow Trout Spawning Study Report

For 2014

Black Canyon Hydroelectric Project
FERC Project No. P-14110
December, 2014

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1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION and BACKGROUND

This report documents results of trout spawning studies conducted during 2014 in reaches of the North Fork Snoqualmie River ("North Fork") as part of the Federal Energy Regulatory Commission (FERC) licensing process for the Black Canyon Hydroelectric Project ("Project, FERC No. 14110). The Project has been in the licensing process by Black Canyon Hydro LLC (BCH) since 2009.

Studies conducted by BCH in 2013 revealed that rainbow and cutthroat were the predominant trout species in the North Fork stream reach potentially affected by the Project [the "Bypassed Reach", which extends from the location of Project Intake at Stream Mile (SM) 6.6 to the Project tailrace exit at SM 1.6].

On review of the 2013 trout studies, BCH and consulting resource agencies agreed to conduct studies in 2014 to further document the trout spawning period, as described in this report.

1.2 STUDY OBJECTIVE

The primary objective of the 2014 studies was to estimate the Spawning/Incubation Period, the yearly time span within which trout most likely spawn, incubate and hatch in the Study Area. Because actual spawning activity was difficult to observe in this area, researchers "back-calculated" the spawning period from observed incubation and emergence times, using accepted degree-day accumulation (in "Temperature Units" or "TU") described further in this report. Based on TU requirements from spawning to hatching and those from hatching to emergence, the Spawning/Incubation period could be determined.

1.3 SUMMARY of 2014 STUDY FINDINGS

Based on back-calculation using an emergence criterion of 1029 TU, the spawning period for ninety percent of trout in the North Fork Study Area was between April 15 and June 21. Recommended time period to protect incubating eggs (given that incubation flow requirements were the same as those for spawning) would be from June 21 to August 1. The Spawning/ Incubation Period, then, would be from April 15 to August 1.

TROUT SPAWNING TEMPERATURE STUDY REPORT

BLACK CANYON HYDROELECTRIC PROJECT
FERC PROJECT no. P-14110

December, 2014

2.0 INTRODUCTION and BACKGROUND

2.1 INTRODUCTION

Black Canyon Hydro, LLC, (BCH) plans to file an application for an original license for the proposed 25-megawatt (MW) installed capacity Black Canyon Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) Number P-14110. The Project would be located predominantly on private lands on and near the North Fork Snoqualmie River (North Fork), approximately 4 miles northeast of North Bend in King County, Washington (Figure 1).

The Project would operate in run-of-river mode and would divert water from an approximately 2.7-mile-section of the North Fork referred to as the "Bypassed Reach". At the maximum generation rate, the Project could divert up to 900 cubic feet per second (cfs) of flow from the Bypassed Reach.

2.2 FISH STUDY BACKGROUND

To support environmental information needs for the FERC license application, BCH, though a contractor (Fairbanks Environmental Services, Inc.), conducted fisheries surveys in 2013 focused on determining fish distribution and relative abundance in a defined Study Area (BCH 2014). The Project would seasonally reduce streamflow in the Bypassed Reach, potentially changing physical habitat for fish in terms of depth, velocity, substrate and temperature. To best evaluate effects of altered streamflow on trout life stages would require knowledge of fish "periodicity", or the timing of important fish life stage activities, including spawning, incubation, and emergence.

3.0 STUDY OBJECTIVE

The primary objective of the 2014 studies was to estimate the Spawning/Incubation Period, the yearly time span within which rainbow trout most likely spawn, incubate and hatch in the Project Study Area. Fish observation studies conducted in the Bypassed Reach in 2013 indicated that rainbow trout were the predominant species (BCH 2014). While cutthroat trout were also observed in the Study Area, this study focused on rainbow trout. All references to "trout" in this report are to rainbows.

Because actual spawning activity was difficult to observe, researchers "back-calculated" the spawning period from observed incubation and emergence times, using accepted degree-day accumulation (in "Temperature Units" or "TU") described further in this report.

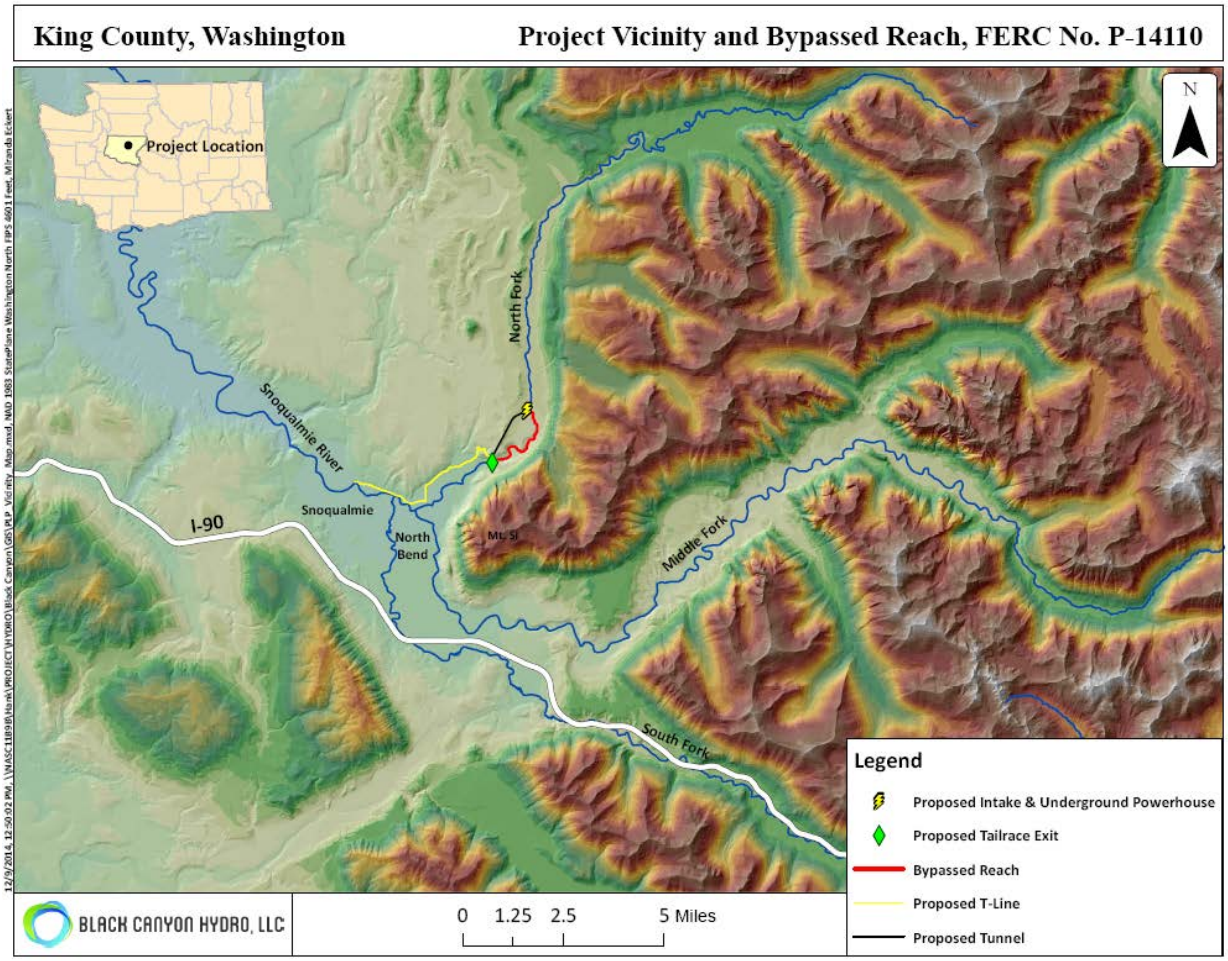

Figure 1. Black Canyon Hydroelectric Project Vicinity Map.

4.0 STUDY METHODS

4.1 GENERAL SPAWNING PERIOD APPROACH

Spawning temperatures were estimated using two principal data sources: 1) measured study area stream temperatures during the suspected spawning period; and 2) observations of timing for trout incubation, hatching and emergence.

Using the daily average temperature calculated from continuous recording temperature loggers at each study site, the spawning date of each individual fish was estimated. This methodology has been used to document the spawning period in Hancock and Calligan creeks (CES 1991), in tributaries to Lake Chelan (Duke Engineering 2001) and by the Yuba County Water Agency (2011).

4.2 STUDY SITES

2014 spawning studies were conducted within the same study area and at the same sites selected for intensive study during the 2013 Aquatic Resources Studies (Figure 2).

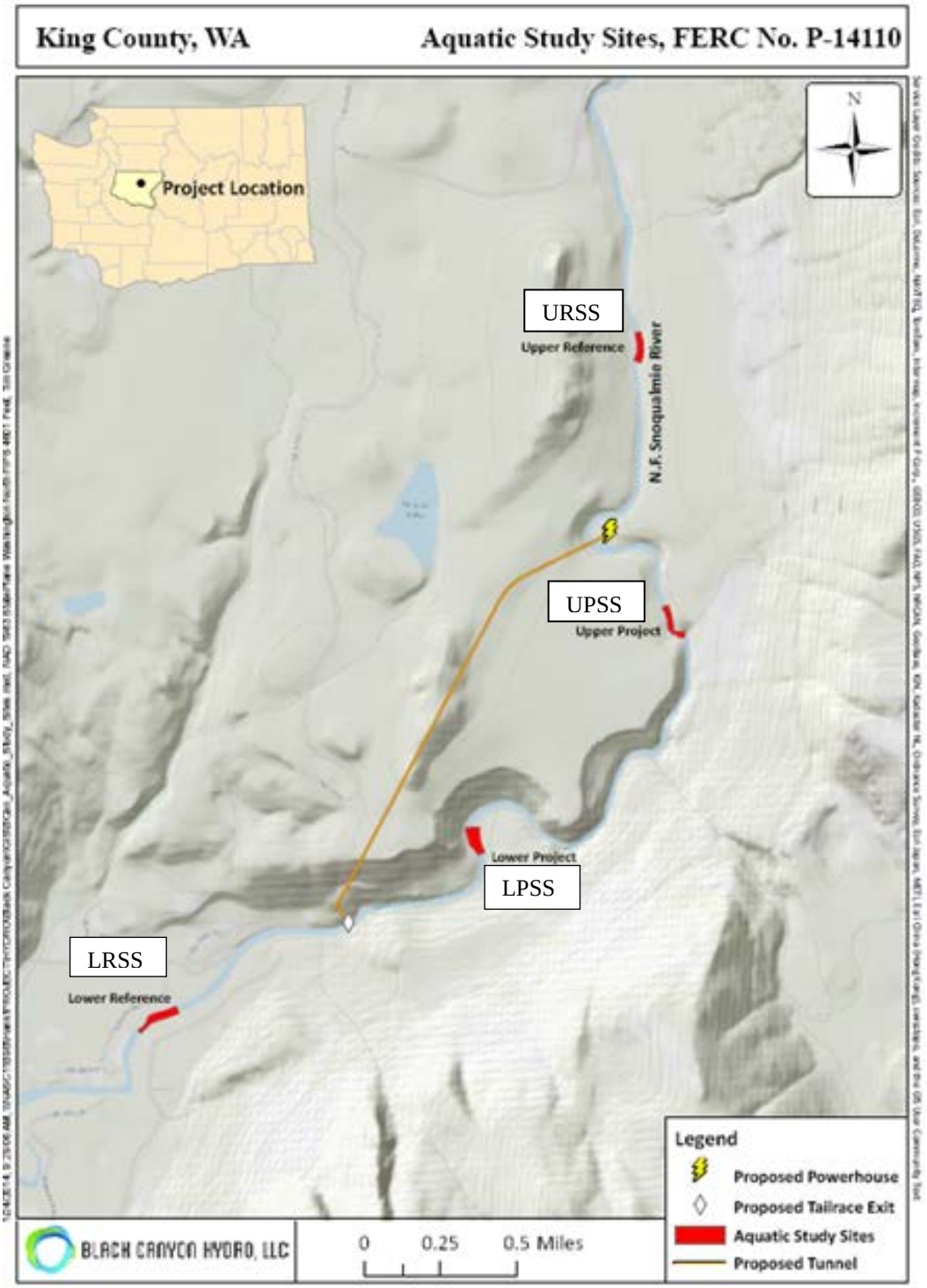

Figure 2. Trout Study Area and Sites.

The four study sites were:

1. The Lower Reference Study Site (LRSS) was 707 feet long. LRSS was located downstream of the Bypassed Reach and adjacent to the Project lower gage site. LRSS was accessed from Ernie's Grove. This study site included one long glide, one long riffle, a short cascade and one deep pool (Figure 3).

Figure 3 Lower Reference Study Site (LRSS); June 24, 2014.

2. The Lower Project Study Site (LPSS) was 505 feet long. It was accessed from the Canyon Springs trail and was downstream from the springs. This site had a moderate gradient with several pools, riffles, and cascades similar to the lower section of the Bypassed Reach (Figure 4).

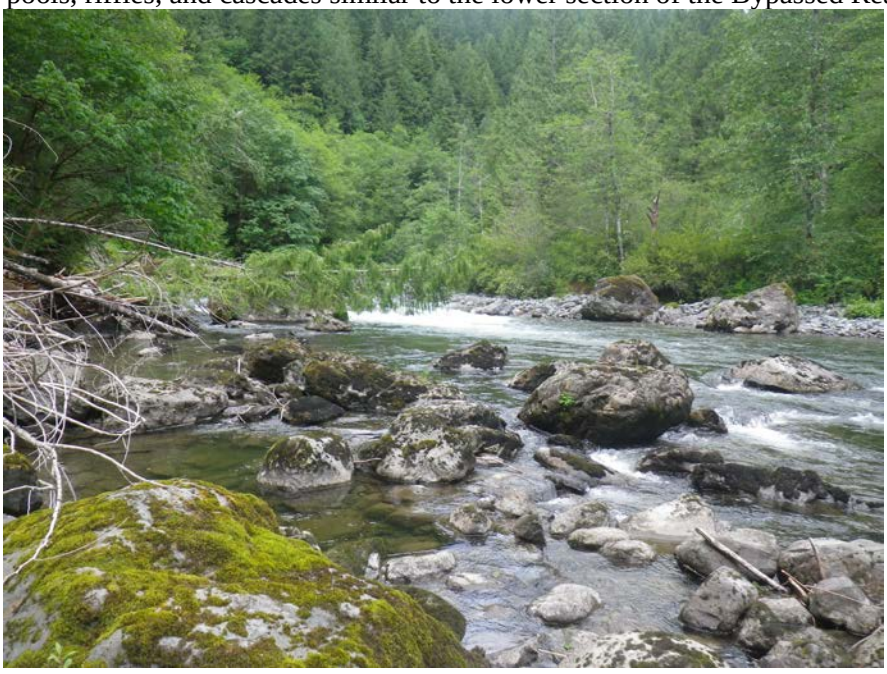

Figure 4. Lower Project Study Site (LPSS), June 24, 2014.

3. The Upper Project Study Site (UPSS) was 673 feet long. It was accessed from an existing logging road and short trail. This study site was at the boundary between the upper segment of Black Canyon and a moderate gradient reach downstream of the proposed intake. The UPSS site included a complex of pools, riffles, and cascades similar to the upper section of the Bypassed Reach (Figure 5).

Figure 5. Upper Project Study Site (UPSS), August 7, 2013.

4. The Upper Reference Study Site (URSS) was 529 feet long. It was accessed from an existing logging road and short trail. and was approximately 0.32 miles upstream of the proposed intake . This site had a low to moderate gradient with pools, riffles and glides (Figure 6).

Figure 6. Upper Reference Study Site (URSS), August 8, 2013.

4.3 CONTINUOUS TEMPERATURE MONITORING

Continuously-recording temperature loggers (Onset Hobo pendent; accuracy = ±0.95°F) were placed in the wetted channel at each North Fork study site on March 26, 2014. At the LRSS site, the stream gage recorded water temperature as well as stage. Temperature data were downloaded from the loggers at two-week intervals.

4.4 EMERGENT FRY OBSERVATIONS

We conducted nineteen field visits to observe trout fry in the four study reaches. Field visits were made at two-week intervals from March 26 through May 27 and then at one-week intervals from May 27 through August 28. Two biologists walked the river margin looking for fry in the shallow water with low velocity. When trout fry were observed, a number were captured with nets and measured for fork-tail length. If an individual fish was less than 30 mm, we assumed that it emerged from the gravel on the previous day (Duke Engineering 2001). After measurement, fry were released alive into slow water at the river margin.

4.5 SPAWNING/INCUBATION PERIOD CALCULATION

Rainbow trout spawning behavior typically begins in the spring when average daily water temperatures reach 42°F to 44°F (Behnke 2002). In the Study Area, this temperature was reached around April 1st, based on temperature data collected from September 2012 through August 2014 at two sites on the North Fork. After spawning, the rate at which trout eggs develop depends on water temperature. Trout hatchery managers have used accumulated temperature units (TU) to predict when eggs will hatch and when larval fish will emerge from their natal gravel beds (Leitritz and Lewis 1980; Senn et al. 1984). A TU is equal to one degree above freezing. An average daily water temperature of 50°F equals 18 TU; 10 days of water at this temperature equals 180 TU, and so forth.

After hatching, larval trout continue to develop within the interstitial gravel spaces until their yolk sac is completely absorbed. Emergence from the gravel occurs when trout fry begin to actively feed on prey items. If the water temperature is known, the beginning of the spawning period can be estimated by back-calculating from the time of emergence of trout fry from gravel.

TU's necessary for rainbow trout hatching and emergence across a temperature range of 45° to 55°F is shown below in Table 1.

Table 1. Accumulated Temperature Units Required for Rainbow Trout from Spawning to Hatching and Emergence.

Average Incubation Temperature °F	Accumulated Temperature Units required for Hatching[1]	Accumulated Temperature Units required for Emergence[2]
45	624	1,029
50	558	963
55	552	957

1. From Leitritz and Lewis 1980
2. From Senn et al. 1984 based on an additional 405 TU before initial feeding

5.0 RESULTS

5.1 TEMPERATURE MONITORING

Average daily temperatures among the five measurement sites for the period of March 26 through July 8, 2014, were quite consistent (Figure 7). The difference between the high and low daily average temperatures for each day was within a range of 0.21°F to 1.10 °F. This range was within the accuracy range for the Hobo pendant temperature loggers (± 0.95°F). Because average daily temperatures within the Study Area from the URSS to the LRSS were consistent, the data could be combined to estimate the daily average temperature for the study period within the Study Area.

The average daily water temperature was less than 40°F on March 1st and was variable from day to day with an increasing trend throughout the study period (See Figure 7). On March 26, when the loggers were deployed, the average daily water temperature was 43°F, above the spawning behavior threshold. The water temperature, however, was variable and the average daily temperature was less than 45°F until May 1 when the temperature continued to rise above this level.

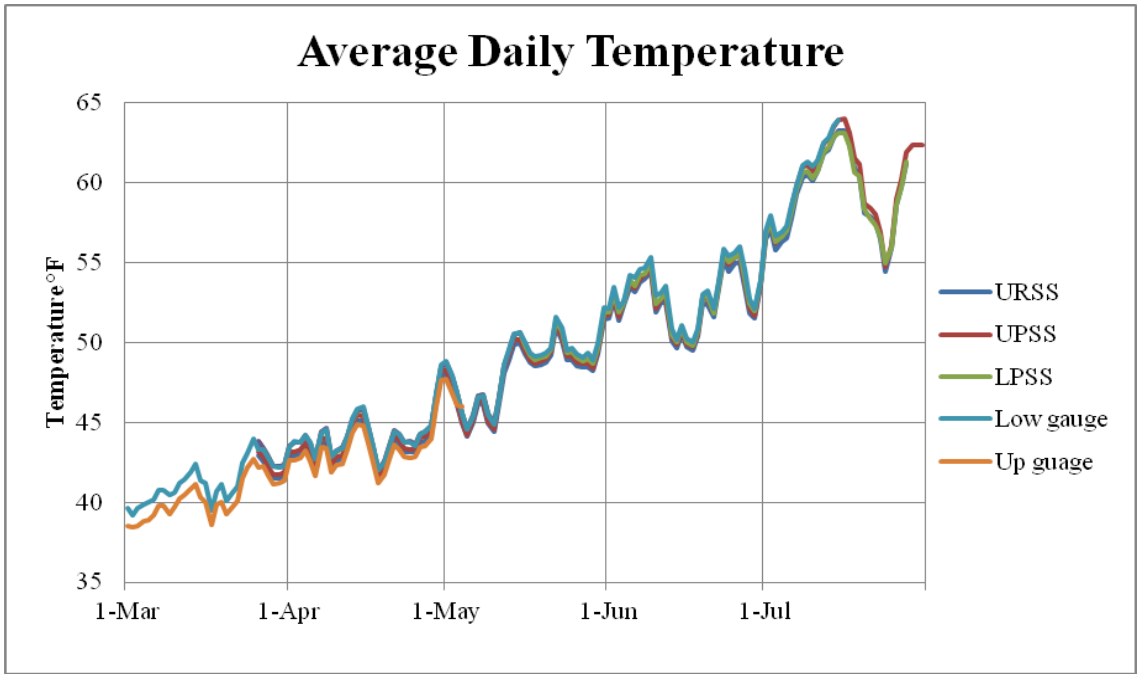

Figure 7. Average Daily Temperatures at North Fork Study Sites and Project Stream Gage Stations.

5.2 EMERGENT FRY OBSERVATIONS

Trout fry were first observed on June 5 at the URSS and the LRSS. These fry ranged from 24 mm to 27 mm (Figure 8) and were assumed to emerge from the gravel on June 4. The first fry were observed in the UPSS and LPSS two weeks later on June 20 (Table 2). A total of 374 trout

fry were observed with the last emergent fry (<30 mm) observed on August 19. The number of fry observed was not evenly distributed between the study sites. The most trout fry were observed in the LRSS (51.6%), and the fewest trout fry were observed in the UPSS (5.1%) (Table 2). The central ninety percent of the emergent fry were observed between June 17 and July 28.

On July 2, largescale sucker fry less than 10 mm in length were observed in dense schools in the LRSS only. These schools of sucker fry were not observed at any other study site.

Figure 8. Emergent Trout Fry Measuring 27 mm.

Table 2. Observations of Emergent Trout Fry (<30 mm) At North Fork Study Sites.

Date	Upper Reference	Upper Project	Lower Project	Lower Reference
March 26	0	0	0	0
April 7	0	0	0	0
April 17	0	0	0	0
April 30	0	0	0	0
May 16	0	0	0	0
May 27	0	0	0	0
June 5	5	0	0	6
June 10	5	0	0	1
June 17	7	0	0	2
June 20	9	2	4	13
June 24	11	3	2	24
June 27	13	1	2	15
July 2	7	5	15	33
July 9	8	4	37	36

July 16	9	2	NS*	12
July 28	2	2	23	33
August 8	2	0	0	12
August 19	0	0	1	6
August 28	0	0	0	0
Subtotal:	**78**	**19**	**84**	**193**
Total:	**374**			
Percent:	20.1%	5.1%	22.5%	51.6%

NS: not sampled due to access issues.

5.3 ESTIMATED SPAWNING/INCUBATION PERIOD

Trout spawning behavior in the Project Study Area began in late March and the earliest spawning dates were estimated to be March 21 in the URSS and March 26 in the LRSS. Figure 9 below shows the total number of emergent trout fry that were observed in the entire Study Area for each site visit. Figure 10 shows the estimated spawning date with the corresponding percentage of observed emergent fry. These data exhibited a normal distribution, or bell-shaped curve. Subtracting the bottom 5 percent and the top 5 percent left 90 percent centered on the median point. The central 90 percent of the observed fry emerged between June 17 and July 28. The estimated Spawning Period of this group was April 15 through June 21 (Figure 10). The combined Spawning and Incubation Period would then be April 15 through July 28.

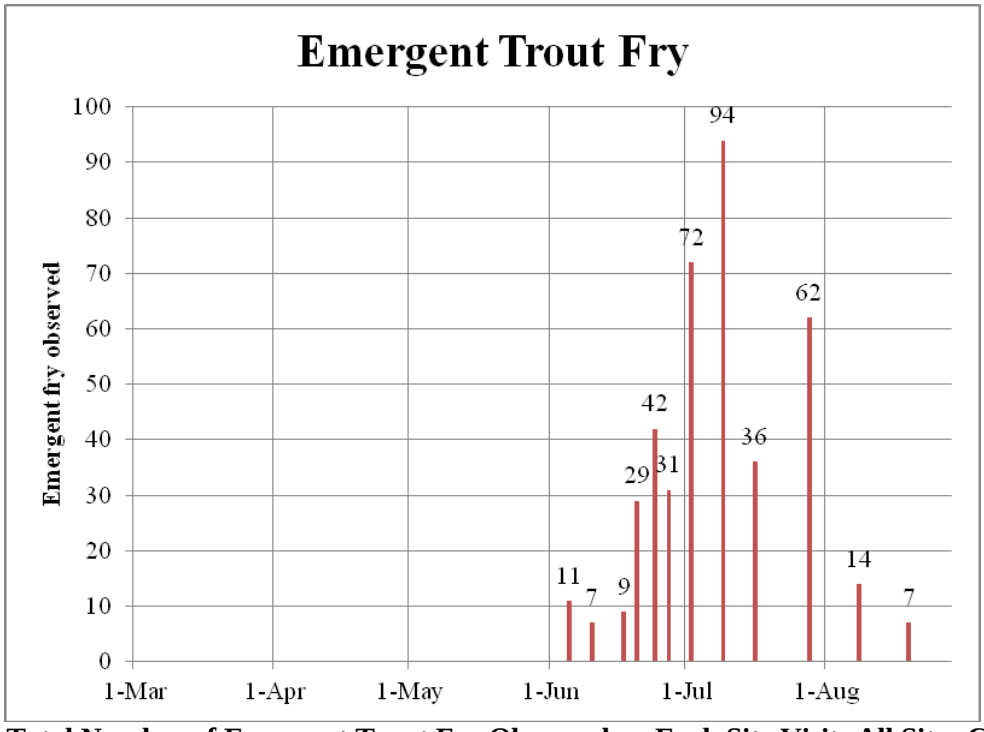

Figure 9. Total Number of Emergent Trout Fry Observed on Each Site Visit; All Sites Combined.

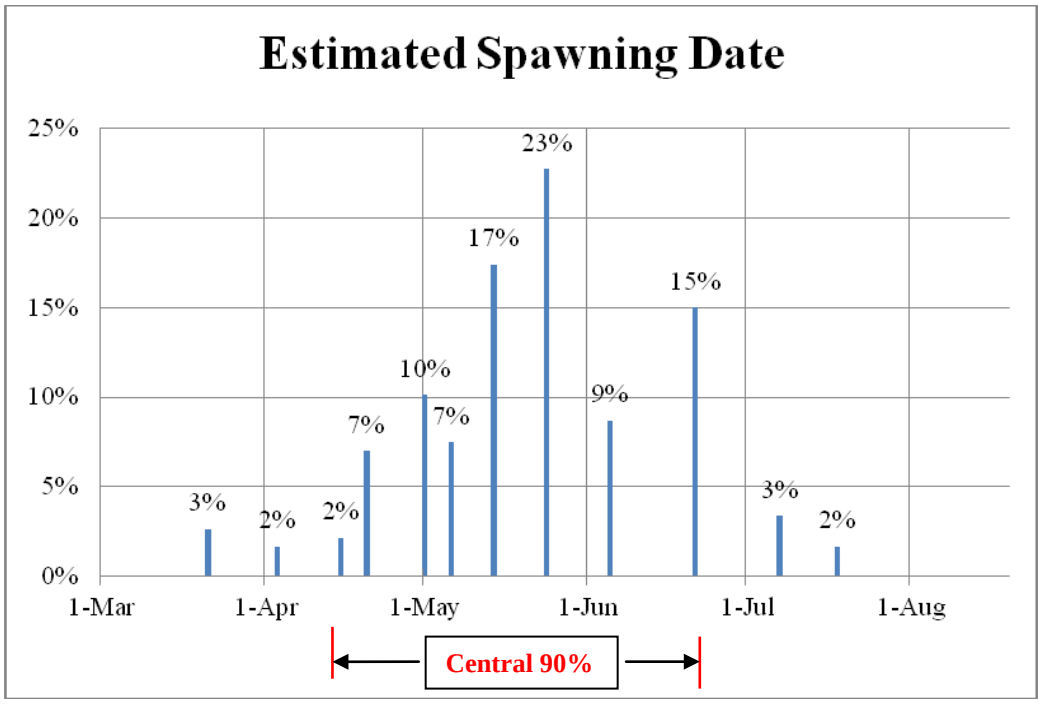

Figure 10. Estimated Spawning Date with Corresponding Percentage of Observed Emergent Fry.

6.0 DISCUSSION

6.1 2013-2014 TEMPERATURE COMPARISONS

A comparison of the average daily temperatures recorded during this study period with the average daily temperature from the Project upper gage station in 2013 is shown in Figure 11. Daily temperature data from the upper and lower Project gauges was included in this data set to extend the study period from March 1 through July 30. Average daily temperatures were nearly equal on March 1 and in general, the temperatures were somewhat higher in 2014 than they were in 2013 (Figure 11).

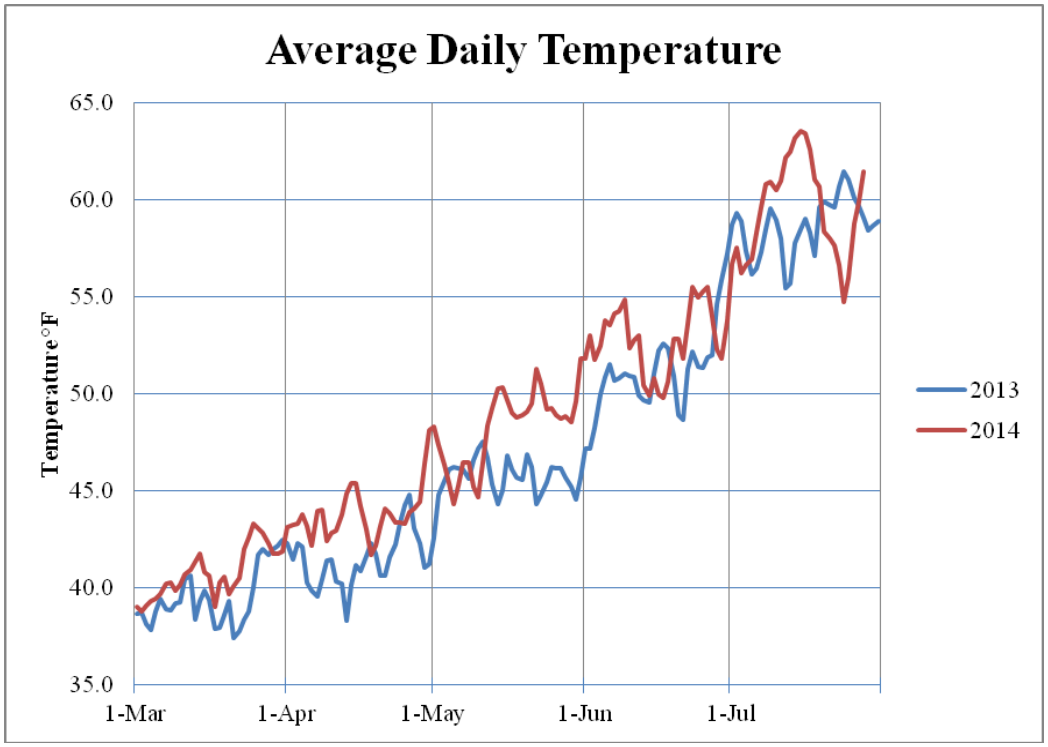

Figure 11. Comparison of Average Daily North Fork Water Temperature Recorded in 2013 and 2014.

Spawning behavior is initiated in the spring when the daily water temperature exceeds 42° to 44°F (Behnke 2002). This condition was achieved somewhat earlier in 2014 than in 2013 and therefore, it is likely that spawning also occurred earlier in 2014.

6.2 RESULTS of SIMILAR STUDIES

6.2.1 Hancock Creek and Calligan Creek Studies

Cascades Environmental Services Inc. (CES 1991) completed a similar study in Hancock and Calligan Creeks as part of instream flow studies for proposed hydropower projects. The CES study estimated spawning timing using 850 TU for incubation through emergence for rainbow trout and based the spawning period on central 80 percent of the emergent fry population. Emergent trout fry were first observed on June 22 in both creeks and the spawning period for these creeks was estimated to be May 12 through June 20.

The Black Canyon Project spawning study was more conservative than these studies, with the use of the central 90 percent of emergent fry and 1,029 TU required for emergence. We believe that use of these criteria assured both a more conservative and a more accurate determination of the spawning/incubation period.

6.2.2 Snoqualmie River Game Fish Enhancement Plan

A study supporting the Snoqualmie River Game Fish Enhancement Plan**,** reported that trout spawning was observed as early as February, 2010, in the lower North Fork near its confluence with the mainstem Snoqualmie River (Thompson, Whitney and Lamb, 2011). February spawning activity was also reported in the lower South Fork Snoqualmie River. Observation of the water temperatures measured at locations on the North and South Fork Rivers explained these early spawning times, and further confirmed the 42°-44° F temperature initiation threshold reported in Behnke, 2002, as described below.

Figures 12 and 13 (From Thompson, Whitney and Lamb, 2011) show the patterns of mean monthly water temperature in the North Fork and South Fork Rivers, respectively.

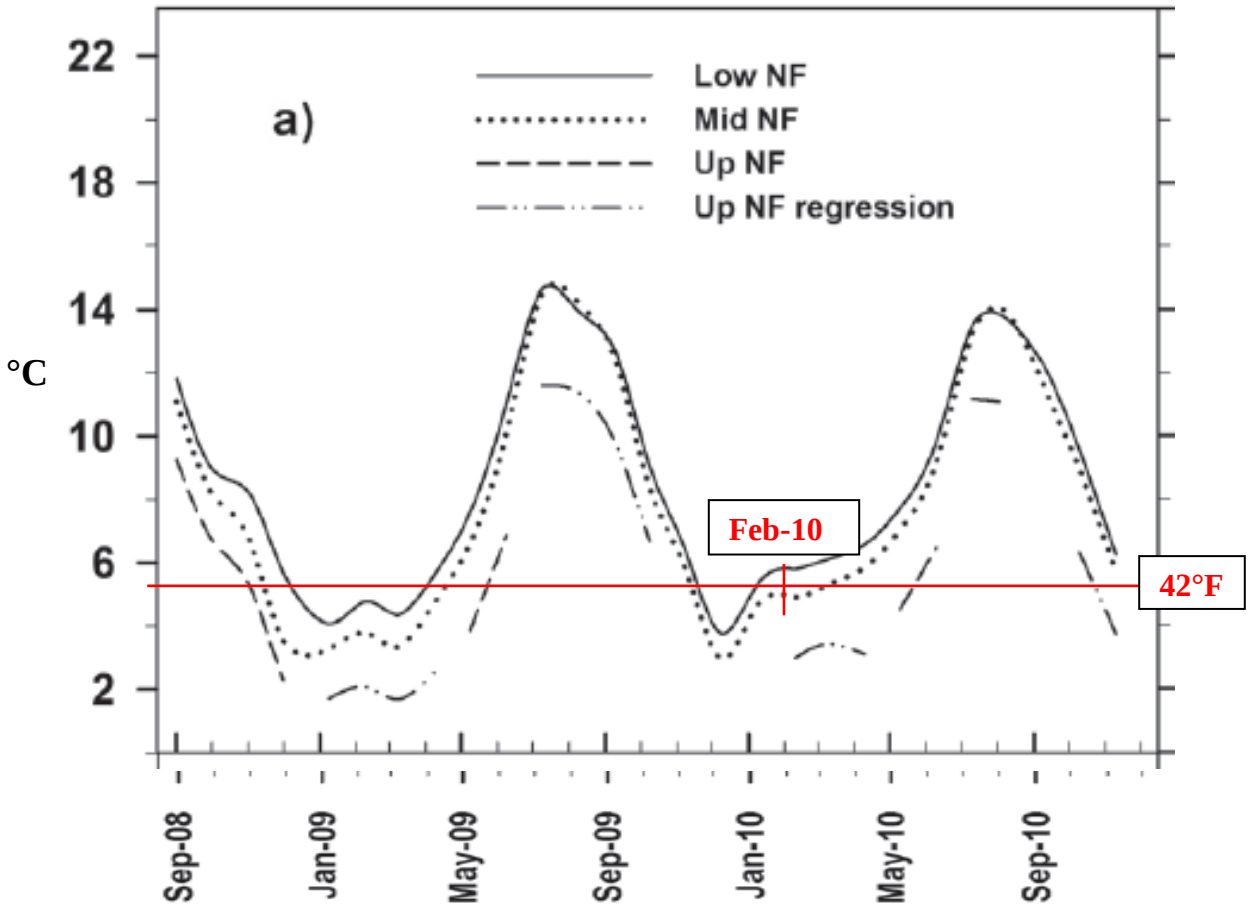

Figure 12. Mean monthly temperature profiles in the North Fork Snoqualmie River from September 2008 through December 2010.

Note that in these Figures, the 42°F requirement for trout spawning initiation (the red line intersection points) occurred on the ascending temperature limb on or about February 10 in both locations. Spawning was not observed in the middle section of the North Fork, the Project Study Area, where temperature was less than 42°F indicated by the dotted line. February spawning in

the South Fork Snoqualmie also occurred when water temperatures exceeded 42° F. These results strongly validate the use of a 42F spawning initiation criterion.

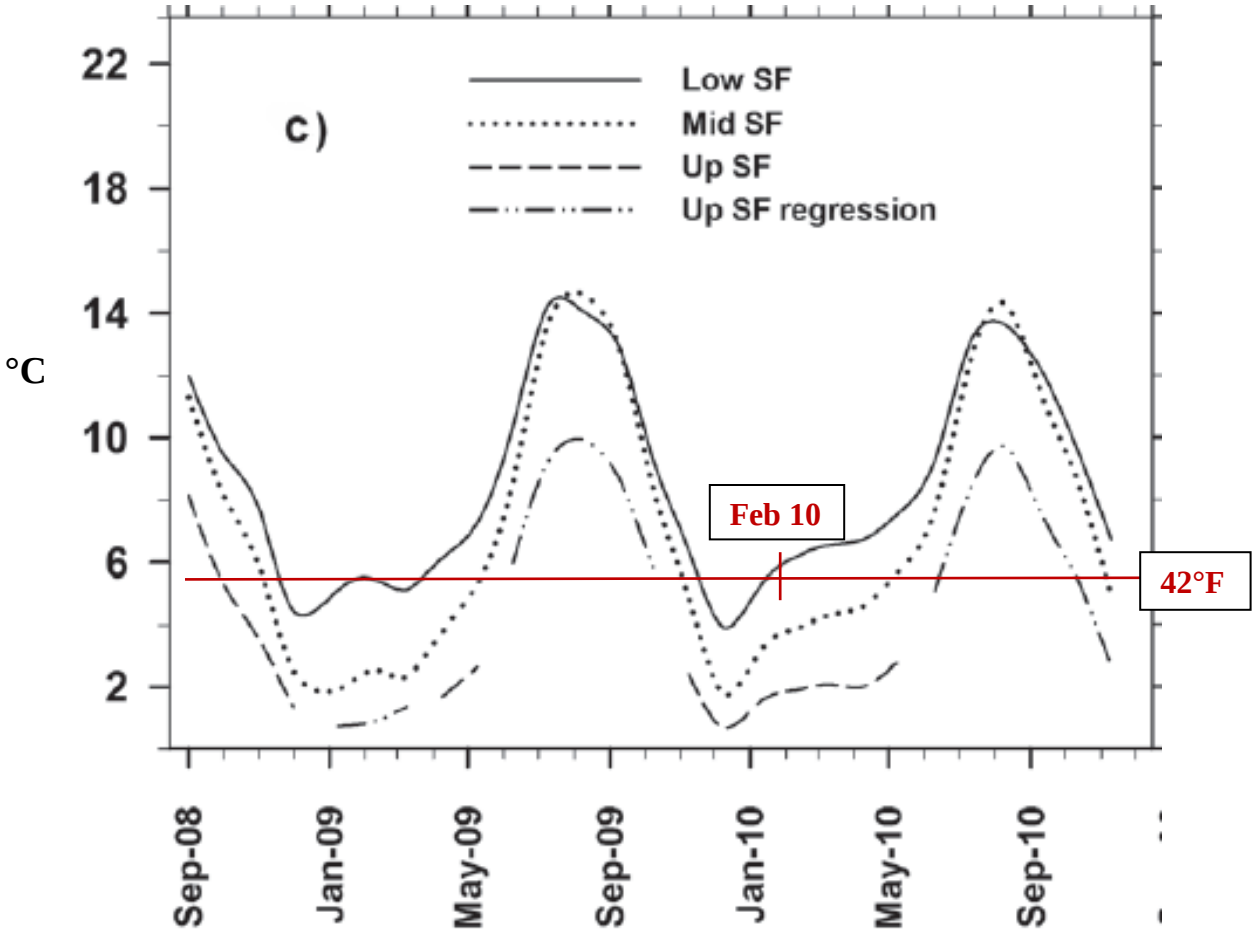

Figure 13. Mean monthly temperature profiles in the South Fork Snoqualmie River from September 2008 through December 2010.

7.0 CONCLUSIONS

Based on results of our studies in the North Fork and those of other researchers in nearby streams, the periodicity for the Spawning/Incubation for rainbow trout in the North Fork Bypassed Reach was estimated to begin on April 15 and to continue to August 1. This periodicity would assure inclusion of the time period when rainbow trout spawned, when eggs were incubating, and when fry emerged from their natal gravel. Results of earlier studies showing spawning as early as February served to confirm the 42° F spawning initiation temperature criterion, but were only applicable to stream reaches much further downstream (and hence warmer) than the Black Canyon Project Bypassed Reach.

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