

Draft

**Gravel Transport Study Report
for
Energy Northwest's
Packwood Lake Hydroelectric Project
FERC No. 2244
Lewis County, Washington**

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1.0 INTRODUCTION

Energy Northwest operates the Packwood Lake Hydroelectric Project (Project) near the town of Packwood in Lewis County, Washington. On November 12, 2004 Energy Northwest filed a Notice of Intent (NOI) to file an application for a new license to operate the hydroelectric project. Energy Northwest also concurrently filed with the Federal Energy Regulatory Commission (FERC) and the resource agencies, a Pre-Application Document (PAD), containing existing, relevant, and reasonably available information describing the existing environment and the potential effects of Project facilities and operations. Additional studies of the potential effects of project operations on large wood in Lake Creek were requested to supplement information contained in the PAD (USFS 2005).

Energy Northwest, in consultation with tribes and agencies, developed and has implemented a study to evaluate the potential effects of Project operations on gravel transport in lower Lake Creek (Watershed GeoDynamics 2005). This report provides results of the gravel transport study.

1.1 Project Area and Study Area

1.1.1 Project Area

Energy Northwest's Packwood Lake Hydroelectric Project, FERC No. 2244, received its initial license in 1960. The majority of the Project is located in the Gifford Pinchot National Forest, east of the town of Packwood (Figure 1.1). The Project consists of an intake canal, a concrete drop structure (dam) and intake building on Lake Creek located about 424 feet downstream from the outlet of Packwood Lake, a 21,691-foot system of concrete pipe and tunnels, a 5,621-foot penstock, a surge tank, and powerhouse with a 26,125 kW turbine generator.

The source of water for the Project, Packwood Lake, is a natural lake situated at an elevation of approximately 2,857 feet above mean sea level (MSL), about 1,800 feet above the powerhouse. Water discharged from the Project is released to the Cowlitz River via a tailrace channel. Power from the Project is delivered over an 8,009-foot 69 kV transmission line to the Packwood substation.

1.1.2 Study Area

The study area includes Lake Creek from the drop structure to the confluence with the Cowlitz River.

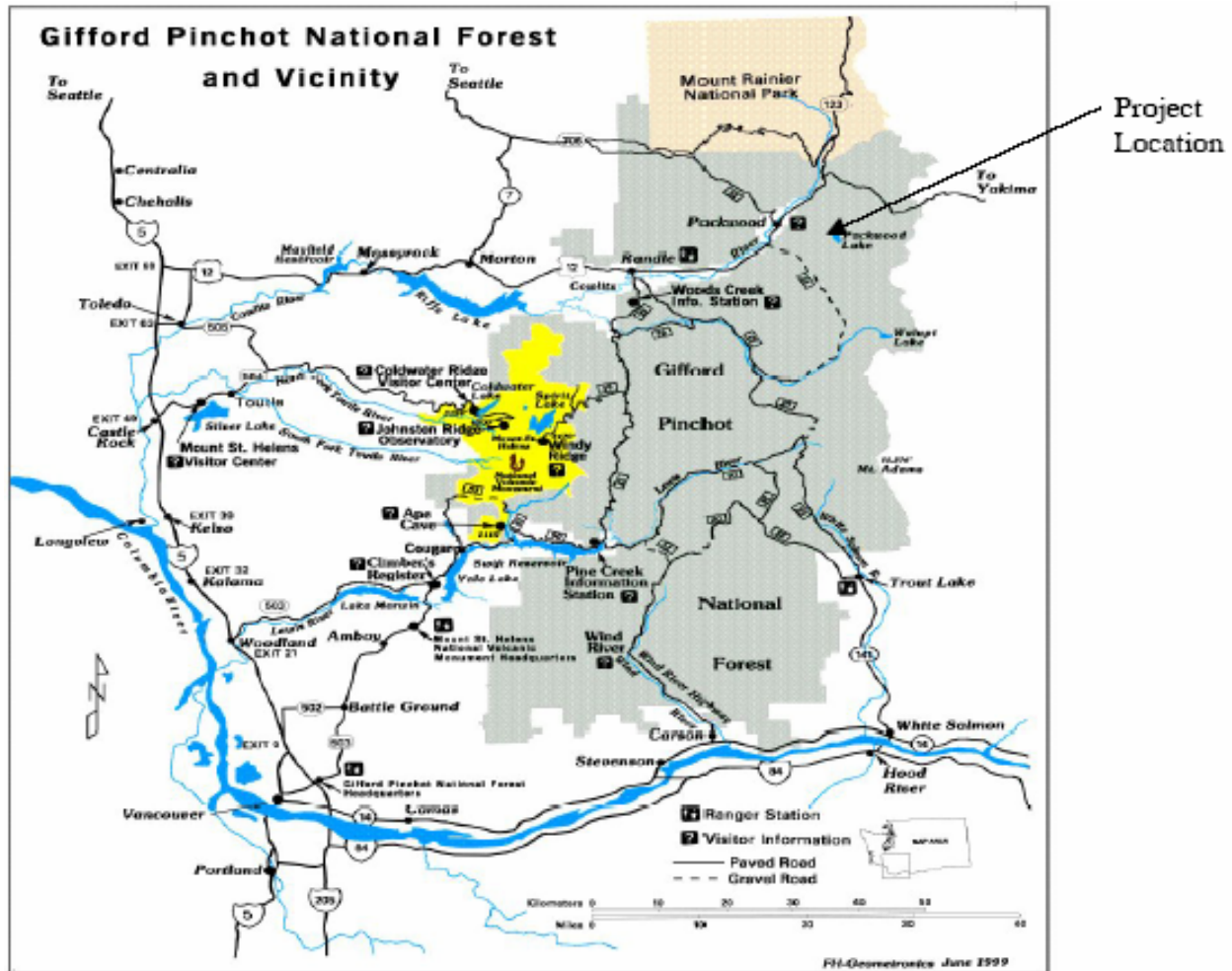


Figure 1.1 – Project location.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study is to assess how operation of the Packwood Lake Hydroelectric Project affects the transport of gravel in the size range suitable for use by spawning fish in Lake Creek downstream of the drop structure. Project operation does not affect the gravel supply to the creek.

Study objectives include:

- Document the relative amount of spawning gravel and its longitudinal distribution in Lake Creek downstream of the drop structure.
- Determine the flows that are necessary to transport spawning-sized gravel down Lake Creek from the drop structure to the mouth of Lake Creek at its confluence with the Cowlitz River.
- Determine if flows that transport spawning-sized gravel from the upstream reaches of Lake Creek will maintain spawning gravel pockets in the lowest 1-2 miles of Lake Creek (the anadromous reach).

- Evaluate the project-induced change in magnitude and frequency of peak flows that are capable of transporting gravel in lower Lake Creek.

3.0 METHODS

3.1 Spawning-sized Gravel Survey in Lake Creek

A survey of existing spawning-sized gravel in Lake Creek downstream of the drop structure was made on September 2, 3, 5, 6, and 7, 2005. Gravel was considered suitably sized for spawning if it was 0.5-4 inches median diameter based on the size range used by anadromous fish that have access to Reach 1. In each 100-foot long section of stream, the area of each gravel patch larger than 25 square feet was recorded. Gravel patches were recorded if more than 50% of the surface area was composed of spawning-sized gravel based on a visual assessment. Gravel within the wetted channel was recorded separately from gravel stored above the wetted, but within the bankfull channel.

3.2 Gravel Movement Study Sites

At seven gravel study sites (shown on Figure 3.1), a more intensive study of gravel size and hydraulic conditions was made. At each of these sites, the following information was collected:

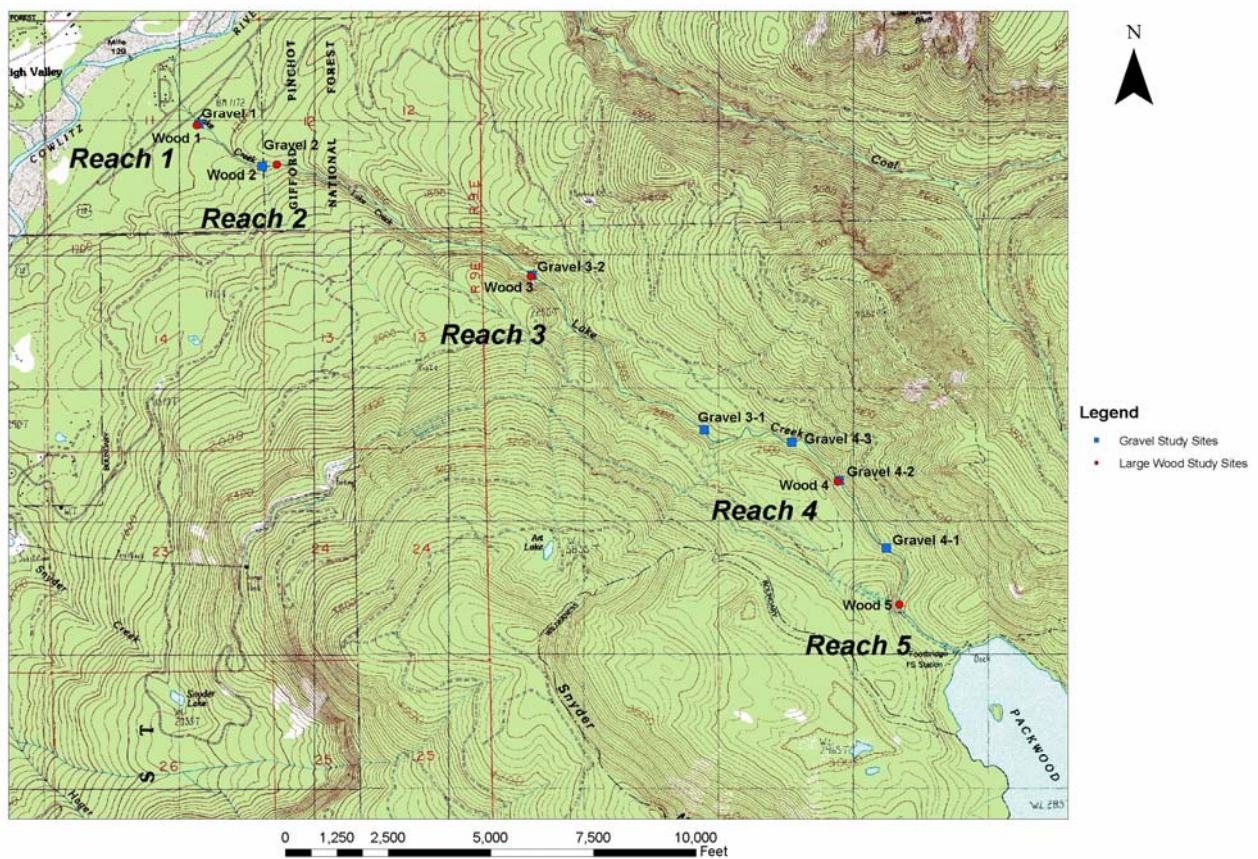


Figure 3.1 – Gravel and large wood study sites.

1. Grain Size Characteristics. The grain size distribution of existing patches of spawning-sized gravel (0.5-4 inches median diameter) was sampled at the locations at each study site. Pebble counts were made to document surface (armor layer) sediment size distribution by measuring the size of 100 grains using a gravelometer. The armor layer was then scraped away and a shovel was used to collect sub-surface sediment. The sub-surface sediment samples were air dried and sieved using a standard shaker (each sieve stack was shaken for 10 minutes). The sediment collected on each sieve was weighed and entered into a spreadsheet for calculation of size distribution.

2. Hydraulic Characteristics. At each grain size sample location, channel cross section and slope were measured using a tape, rod and hand level to provide information for hydraulic calculations. Wetted and bankfull channel edges were noted. High water markers were also noted following the high flow releases to help calibrate hydraulic calculations.

3. Painted Gravel Markers. Painted rocks were deployed at each gravel study site transect to document substrate mobility thresholds. Painted rocks in the following size classes representing spawning-sized gravel were used: 0.5-1 inch; 1-2 inches; 2-3 inches; 3-4 inches. A group of these four gravel sizes was placed at approximately 2-foot intervals across existing gravel deposits on the study site transect. The 3-4 inch rock was placed on the cross section, the 2-3 inch rock one foot upstream of the 3-4 inch rock, the 1-2 inch rock was placed one foot upstream of the 2-3 inch rock, etc. This placement scheme prevented artificial shielding of the smaller marked rocks by the larger ones. Each marked rock was placed on the bed surface so that its exposure mimics that of the surrounding rocks.

The marked rock sites were revisited to document mobility following the controlled release of 15-17 cfs, 30-35 cfs, and 299 cfs. Movement was considered to have occurred if a rock moved more than 2 feet downstream from its set position.

4. Photos. Photos were taken at each site during each field visit to document channel conditions and gravel locations.

3.3 Gravel Transport Calculations

The Andrews Formula (Andrews 1983, Andrews 1984) was used to estimate initiation of substrate movement. The equation has the form:

$$\tau_{ci}^* = 0.0834(d_i/d_{50})^{-0.872}$$

where τ_{ci}^* = critical Shields stress for mobility of particle size d_i
 d_i = particle size at threshold of mobility
 d_{50} = median particle size of *subsurface*

From this value of τ^*_{ci} , the depth D for mobility was computed using the relationship:

$$\tau^*_{ci} = DS / ((\gamma_s / \gamma_w - 1) d_i)$$

where D = depth

S = slope

γ_s and γ_w are the specific weights of sediment and water, respectively.

Discharge versus stage at each of the measured cross sections was computed using the WinXSPRO software (Hardy et al. 2005). Channel elevation and position (xy) coordinates were entered for each cross section, along with measured water slope at low flow and estimated reach-average high flow water gradient. The Jarrett equation for Manning's roughness coefficient option was chosen to estimate the stage:discharge relationship, and was checked against the stage and discharge estimated during low flow and high flow (high flow stage was estimated based on indicators of high water at each transect).

4.0 RESULTS

4.1 Gravel in Lower Lake Creek

Spawning-sized gravel was inventoried in Lake Creek downstream of the drop structure. Gravel was inventoried separately in the wetted channel and stored on the banks within the bankfull channel. Gravel patches over 25 square feet in area were included in the inventory. A total of 42,660 sq. ft. of gravel was inventoried in the wetted channel, and 20,550 sq. ft in the bankfull channel (Table 4.1). The most gravel was located in Reaches 2, 3, and 4; there was less gravel in Reach 1 and very little gravel in Reach 5.

Reach	River Mile	Average Gradient	Gravel in wetted channel		Gravel in bankfull channel	
			Area (sq ft)	Sq ft/mile	Area (sq ft)	Sq ft/mile
1	0-0.7	2.9%	2,775	4,070	2,700	3,960
2	0.7-1.3	7.3%	6,175	11,644	2,375	4,479
3	1.3-3.5	8.0%	22,025	8,946	7,550	3,066
4	3.5-4.9	4.3%	11,635	9,599	7,925	6,538
5	4.9-5.3	8.4%	50	132	0	0
Total	0-5.3	6.3%	42,660	8,102	20,550	3,903

The majority of lower Lake Creek is a relatively high gradient (5-8%) stream flowing in a confined valley. The lower 0.7 mile, designated Reach 1, is lower gradient (3%) and less confined. The stream has a boulder step-pool configuration with cascades and pools the principal habitat type. Substrate is dominantly boulders and cobbles. Most of the gravel stored in the creek or on the banks was in patches downstream of large boulders, along the margins of the stream, or associated with large woody debris. There were very few locations where gravel substrate was the dominant substrate type; only where large woody debris blocked the stream channel and a sediment wedge accumulated upstream of the log jam was gravel present across the entire channel.

Figure 4.1 shows cumulative gravel, starting at the mouth of Lake Creek, along with the longitudinal profile of the stream and log jams identified in the large wood inventory (Watershed GeoDynamics 2006). This figure illustrates that much of the gravel stored in Reach 3 and 4 is associated with log jams.

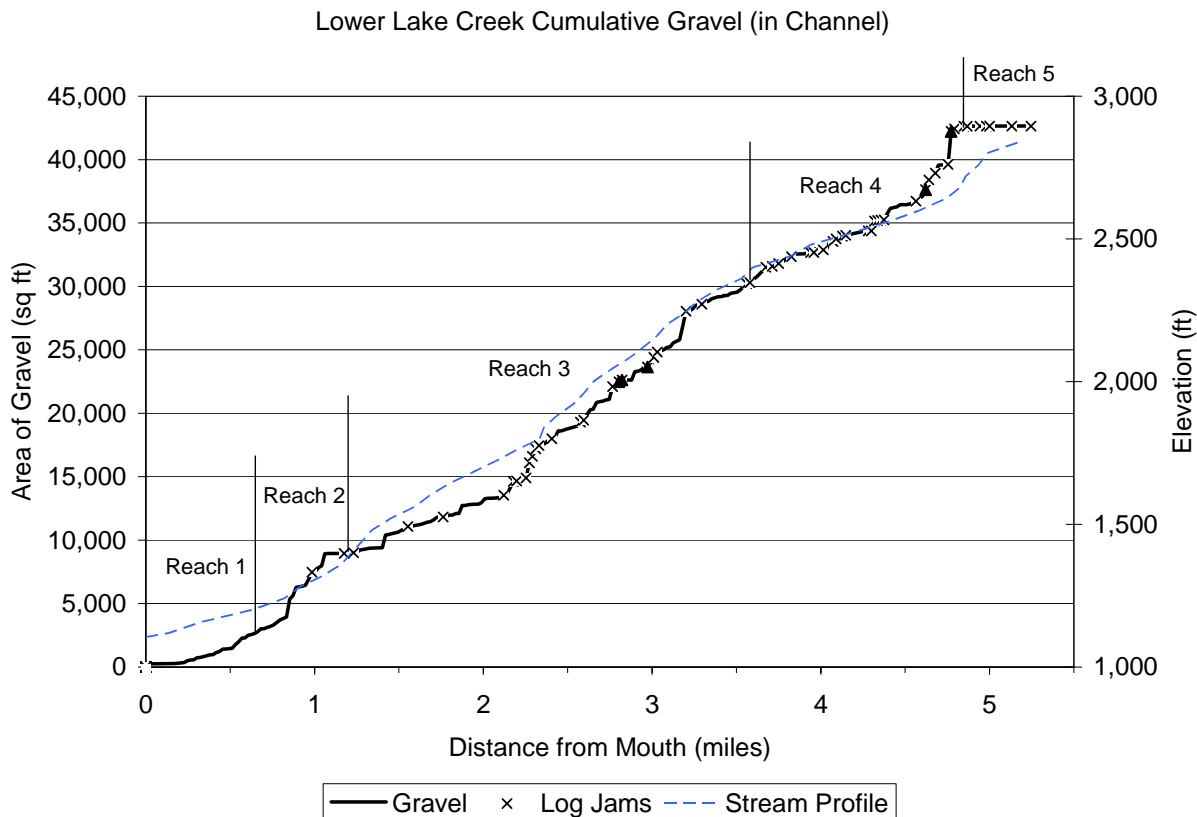


Figure 4.1 – Cumulative spawning-sized gravel in lower Lake Creek wetted channel.

There is a relatively high concentration of gravel in Reach 2 between RM 0.8 and 1.0. This gravel is likely there because it has been transported through the higher gradient, confined reach between RM 1 and RM 2, and has been deposited where the channel gradient drops and is less confined downstream of RM 1. This can be seen in Figure 4.2, which shows area of gravel in each 100-ft section of stream and average stream gradient (from the USGS topographic map). The highest concentrations of gravel deposits are just downstream from high gradient reaches – the upstream end of Reach 4, several locations in Reach 3, and the middle of Reach 2.

Resource agencies are particularly interested in gravel resources in the portion of Lake Creek accessible to anadromous fish. Anadromous fish have access to the lower mile of Lake Creek, and may have access farther upstream. There is potential barrier at approximately RM 1.0, and another at approximately RM 2.0. These barriers are currently being evaluated to determine passage potential. As shown on Figures 4.1 and 4.2 there is a relatively high concentration of gravel between RM 0.8 and RM 1. There is also gravel stored in lower gradient portions of the channel between RM 1 and RM 2, but little in the higher gradient portions.

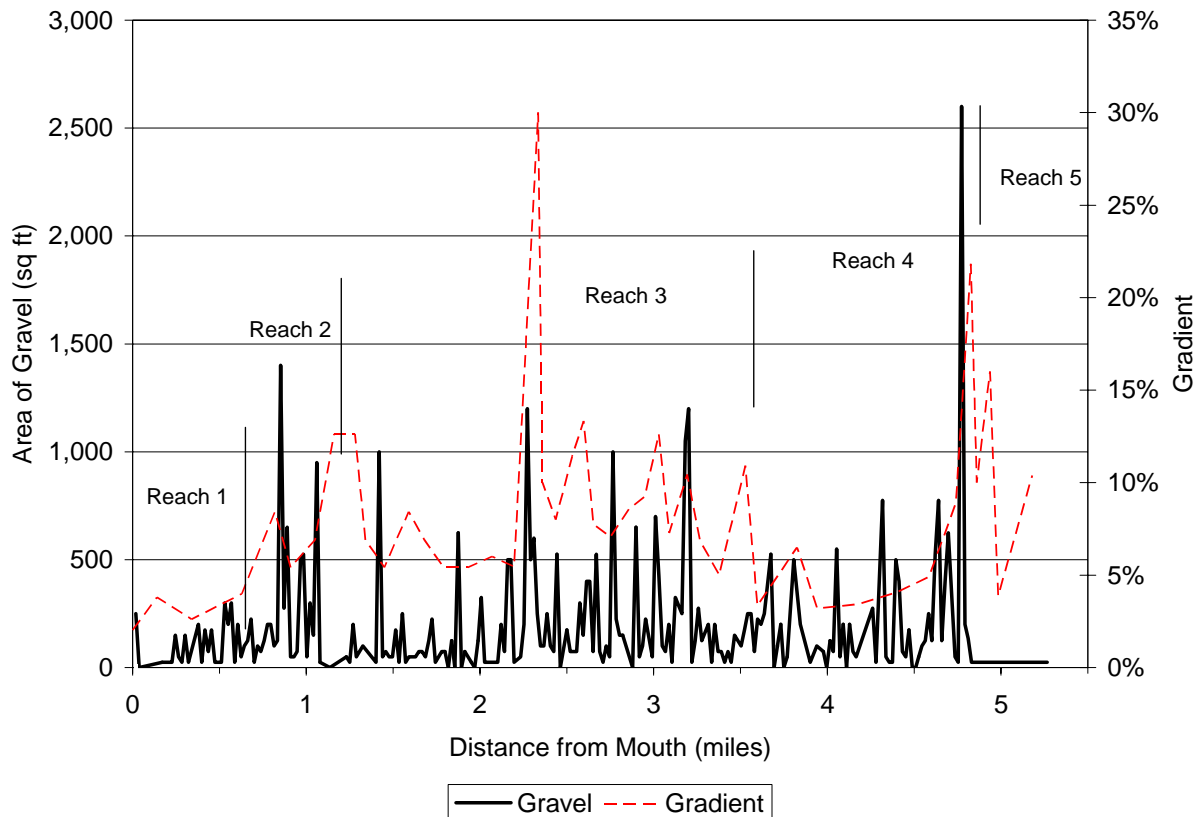


Figure 4.2 – Spawning-sized gravel in wetted channel and stream gradient in lower Lake Creek

Lake Creek between Packwood Lake and the Cowlitz River has relatively little gravel, a condition that is the result of the natural low sediment input rates from the confined bedrock valley, and high stream gradient. Since one of the objectives of this study is to determine if gravel in the channel can be transported downstream and be retained in the lower 1-2 miles, it is important to understand the channel characteristics and features that favor retention of gravel in the areas of Lake Creek that do contain spawning-sized gravel:

- Relatively low gradient in the habitat unit (less than 2%)
- Large-scale roughness elements such as large boulders, large woody debris, or log jams to provide hydraulic conditions that retain gravel (lower velocity zones)
- Low gradient unconfined reaches downstream of higher gradient confined reaches.

Most of the areas in the lower 0.8 miles of Lake Creek are low gradient, but do not contain the large-scale roughness elements to help retain gravel.

4.2 Gravel Size Distribution

Three samples of spawning-sized gravel were taken at each gravel study site. A pebble count of the armor layer was made, and sub-armor samples were sieved to provide information on the size distribution. Figure 4.3 summarizes the size distribution of armor layer samples and Figure 4.4 summarizes the size distribution of armor layer samples. Detailed size distribution data from

each sample is included in Appendix A. It should be noted that the gravel samples were taken to document the grain size of existing spawning-sized gravel patches, and are not representative of total substrate at each site; dominant substrate is boulder and cobble, and the gravel samples taken were generally located behind obstructions where hydraulic conditions allowed retention of gravel and smaller sized particles.

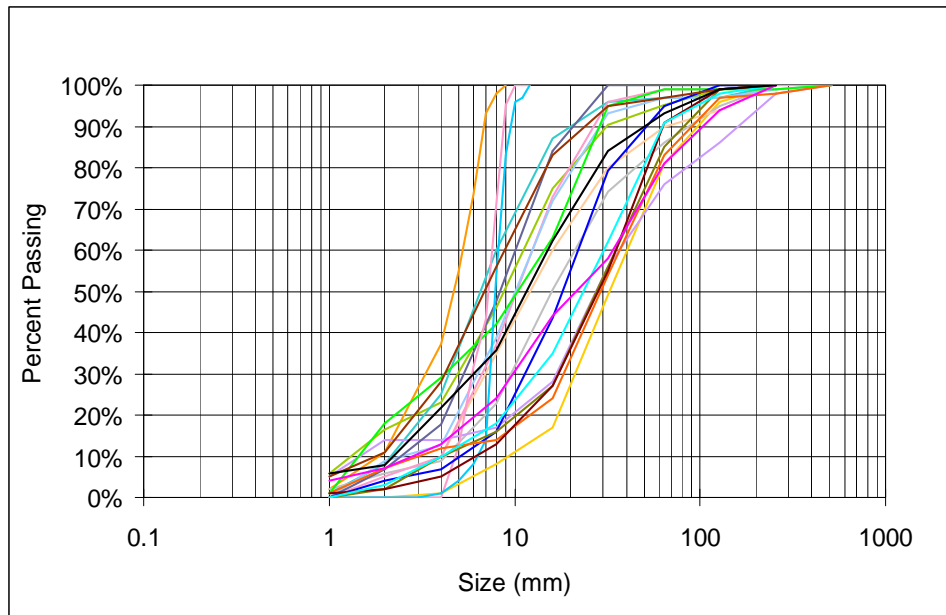


Figure 4.3 – Size distribution of armor layer samples
(Note: each line represents a separate gravel sample)

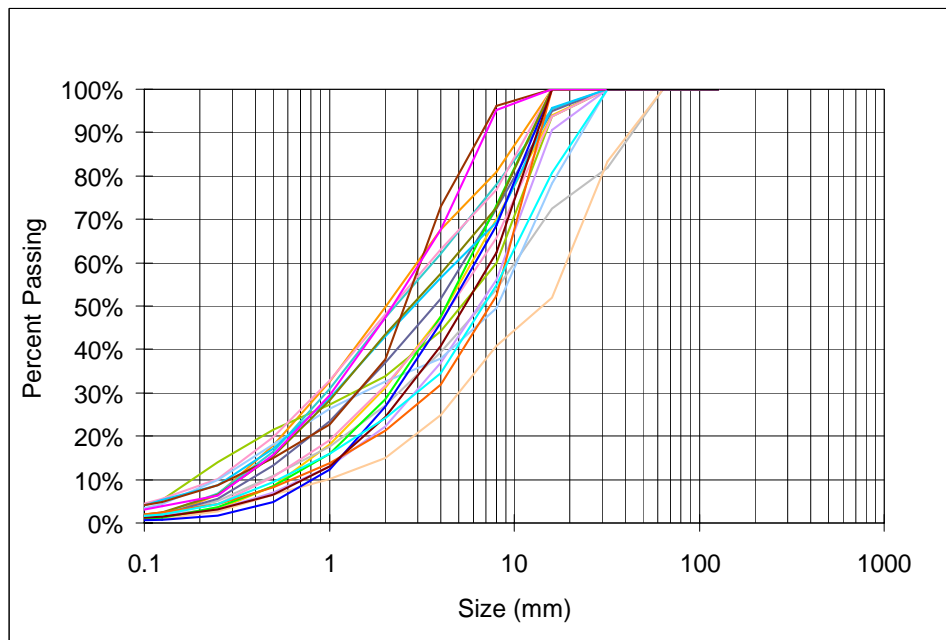


Figure 4.4 – Size distribution of sub-armor layer samples
(Note: each line represents a separate gravel sample)

4.3 Painted Rock Movement

Brightly colored rocks in four size classes (0.5-1 inch, 1-2 inches, 2-3 inches, and 3-4 inches) were placed across the stream at each of the seven gravel study sites (Figure 4.5). The rocks were checked for movement, defined as displacement of more than two feet, following flow releases of approximately 16 cfs, 35 cfs, and 299 cfs (Appendix B). There was very little movement of the painted rocks following the 16 cfs release; a few of the smallest rocks (0.5-1 inch) had moved but the majority of the rocks were in place. A few of the remaining small rocks (0.5-1 inch) shifted positions or moved slightly following the 35 cfs release. There was heavy rain during the 35 cfs release, resulting in over 100 cfs accretion between the drop structure (approximately 35 cfs) and the instream flow study site 1 near the mouth of Lake Creek (estimated total of 144 cfs).



Figure 4.5 – Example of painted rock study site

Many of the rocks, particularly the smaller sized rocks and those in the middle of the transects, had moved after the 299 cfs release. Figure 4.6 shows the painted rocks remaining following the high flow release at each transect. Painted rocks of various sizes still on the transect are displayed as orange squares, diamonds, triangles, or circles on the figure. The top row of orange squares shows the 3-4 inch rocks that remained; the next row of orange diamonds shows the 2-3 inch rocks, the next row of orange triangles shows the 1-2 inch rocks, and the bottom row of

orange circles shows the 0.5-1 inch rocks. This information is summarized in Table 4.3, which shows the measured gradient (at low water), bankfull width, and percent of painted rocks remaining at each of the transects following the 299 cfs release.

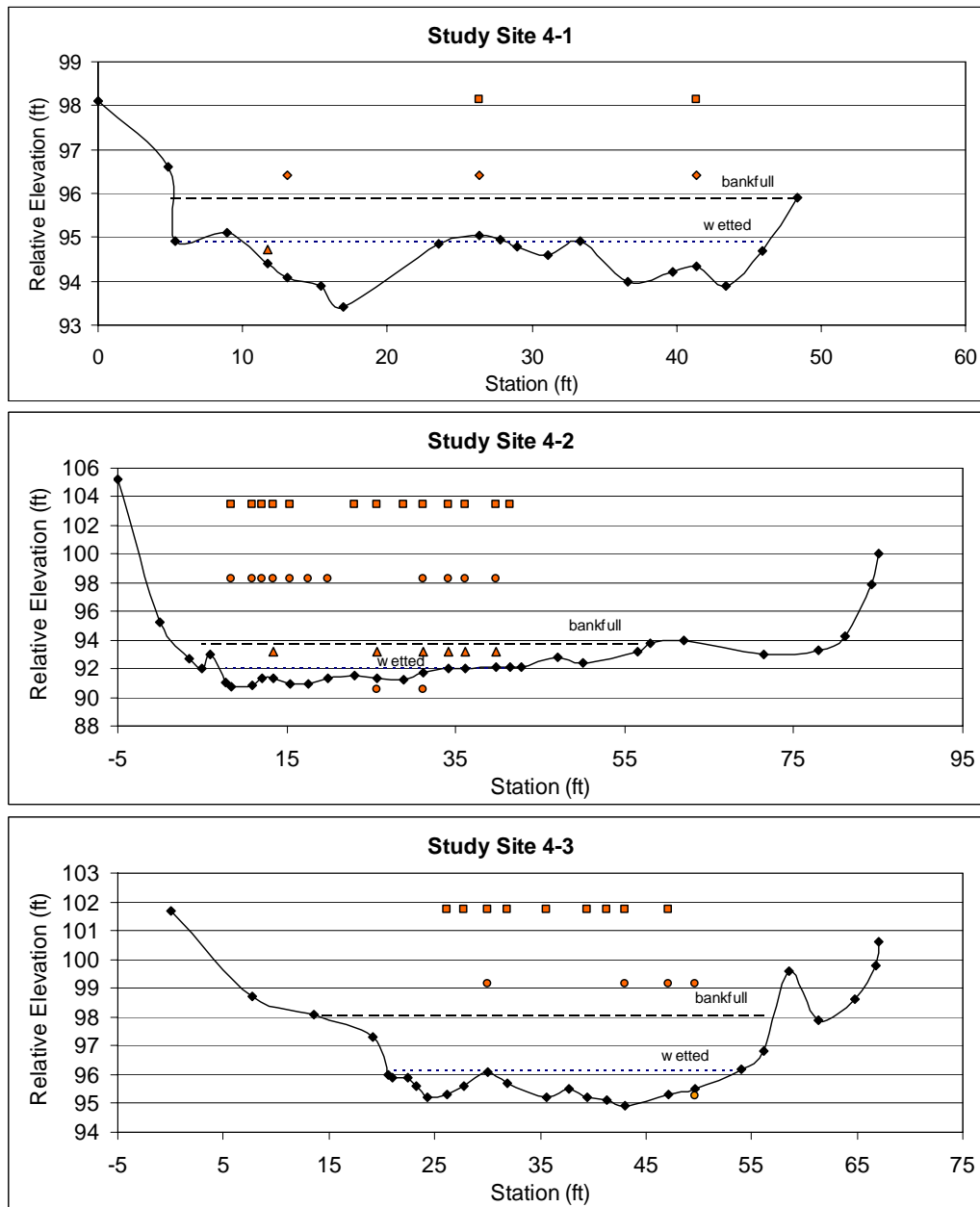


Figure 4.6 – Cross sections and painted rocks remaining after 299 cfs flow release.

(Note: Painted rocks were placed across wetted transect; those remaining are noted with lines of orange symbols. Top squares are 3-4” rocks, diamonds are 2-3” rocks, triangles are 1-2” rocks and bottom circles are 0.5-1” rocks.)

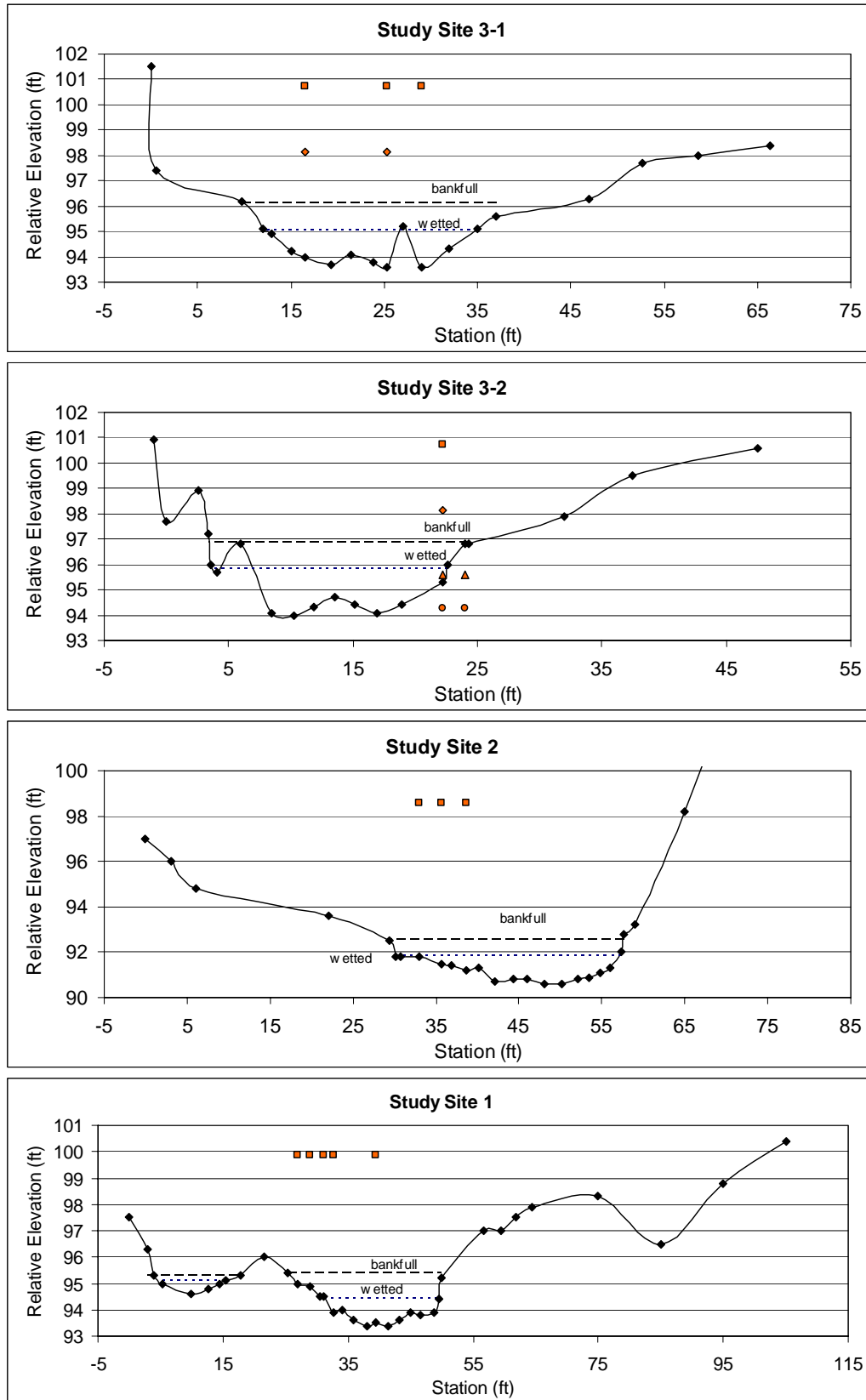


Figure 4.6 (cont'd.) – Cross sections and painted rocks remaining after 299 cfs flow release.
 (Note: Painted rocks were placed across wetted transect; those remaining are noted with lines of orange symbols.)

Table 4.2 – Percent of painted rocks remaining after 299 cfs release.

Sample Location	Gradient (%)	Bankful Width (ft)	Size class of painted rocks			
			0.5-1 in.	1-2 in.	2-3 in.	3-4 in.
4-1	4.5%	40.7	0%	8%	20%	13%
4-2	3.0%	47.6	2%	14%	49%	87%
4-3	4.8%	49.0	8%	0%	40%	80%
3-1	3.9%	42.0	0%	0%	18%	27%
3-2	3.4%	29.5	22%	22%	11%	11%
2	1.4%	35.7	0%	0%	0%	20%
1	2.0%	50.0	0%	0%	0%	33%

The painted rock movement data helps to calibrate the gravel transport calculations, and suggests that spawning-sized gravel would be mobile at many of the transects under approximately bankfull flows (250-300 cfs). However, it also suggests that spawning-sized gravel may not move through some of the reaches (e.g. two of the transects in Reach 4 had little movement), and gravel may not be mobilized from the locations it is currently being stored; along channel margins and behind boulders and logs under bankfull flow conditions.

4.4 Gravel Transport Calculations

A number of different gravel transport formulas have been developed to compute initiation of substrate movement and bedload transport rates in gravel-bedded rivers. Much of this work was done in alluvial rivers with pool/riffle profiles and gravel beds because these rivers have relatively uniform flow characteristics across the channel. Steep, boulder-bedded channels with cascades such as Lake Creek are very difficult to model because the large roughness elements result in non-uniform flow and turbulent eddies (Wohl 2000). Most transport and hydraulic formulas perform poorly in these conditions.

The Andrews equation was used to predict the depth of water necessary to initiate movement of gravel in the 0.5 in. to 4 in. size range, and the WinXSPRO software was used to estimate discharge at those stages (Table 4.3). The equations were calibrated based on the depth at which movement occurred during the painted gravel study. However, it should be noted that little movement took place until the high flow event (299 cfs), when many of the rocks moved, so exact calibration was not possible. In addition, the depth of water at each of the painted gravel locations varied across the transect, so rocks in the deepest parts of the channel would be expected to move at discharges closer to those listed in Table 4.3, and rocks in shallower water or protected locations along the margins would be expected to move at higher flows.

Study Site	0.5-1 in. gravel		1-2 in. gravel		2-3 in. gravel		3-4 in. gravel	
	Depth (ft)	Discharge (cfs)	Depth (ft)	Discharge (cfs)	Depth (ft)	Discharge (cfs)	Depth (ft)	Discharge (cfs)
4-1	1.1 ft	8 cfs	1.5 ft	33 cfs	2.0 ft	96 cfs	2.5 ft	204 cfs
4-2	1.0 ft	18 cfs	1.2 ft	35 cfs	1.5 ft	51 cfs	2.0 ft	118 cfs
4-3	1.9 ft	150 cfs	2.2 ft	240 cfs	2.4 ft	260 cfs	2.8 ft	350 cfs
3-1	1.5 ft	48 cfs	1.6 ft	60 cfs	1.8 ft	80 cfs	2.0 ft	100 cfs
3-2	2.0 ft	74 cfs	2.2 ft	85 cfs	2.5 ft	118 cfs	2.8 ft	150 cfs
2	2.3 ft	175 cfs	2.5 ft	205 cfs	2.8 ft	280 cfs	3.0 ft	311 cfs
1	1.5 ft	47 cfs	1.8 ft	90 cfs	2.2 ft	140 cfs	2.5 ft	184 cfs

The results presented in Table 4.3 vary considerably, and show the challenges of modeling sediment movement in step-pool streams with large roughness elements. In addition, since most of the gravel stored in the channel was not located in the center of the channel, but along the margins or behind large boulders or logs where hydraulic conditions were much different, the modeling results may not be the best tool to use to characterize sediment movement in Lake Creek and should be used with care.

4.5 Hydrologic Conditions

Gravel transport occurs during high flows. Operation of the Packwood Lake Hydroelectric Project could affect transport of gravel through lower Lake Creek by controlling peak flow magnitude and frequency. Bankfull flow is approximated as 285 cfs based from the USGS statistic of the annual peak flow exceedance probability of 0.8 (USGS 1984); this is also approximately the flow that transports spawning-sized gravel in the center of many of the study transects in lower Lake Creek. The highest peak flows in Lake Creek occur in the November-February time period (Figure 4.7). Between 1967 and 2003, 14 of the 36 years had peak annual discharges at the drop structure greater than 285 cfs.

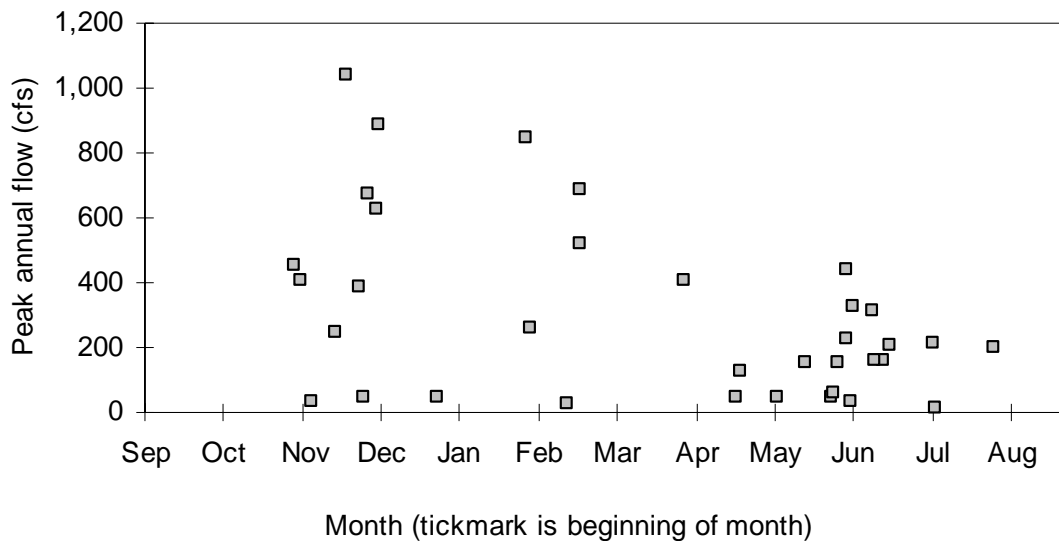


Figure 4.7 – Annual peak flows at Lake Creek near Packwood Gage (1963-2003).

There is considerable inflow in the 7.3 square mile drainage area between the drop structure and the anadromous reach in the lower mile of Lake Creek, particularly during large rainfall or rain-on-snow events that cause peak flows. Estimated inflow during the 35 cfs release when it was raining hard was over 100 cfs. Comparisons of instantaneous peak flow events for the few years when the USGS gage near the drop structure (drainage area 19.2 sq mile) and the gage near the mouth (drainage area 26.5 sq mi) were operating showed inflows of 32-500 cfs, with the lower inflows at lower flows (200-400 cfs) and higher inflows at higher flows (850-1,000 cfs). Inflows during peak flow events will result in higher flows and higher sediment movement potential at the transects in the lower, anadromous reach.

5.0 DISCUSSION AND RECOMMENDATIONS

Gravel is an important component of aquatic habitats because it provides spawning substrate for fish, and habitat for other aquatic organisms. The Forest Service has identified spawning-sized gravel, particularly in the lower mile of Lake Creek where anadromous fish have access, as an important resource. The size of gravel used by fish varies by species, but the majority of anadromous fish (Chinook, coho, chum, steelhead) prefer gravel in the range of 0.5-4 inches; sea-run cutthroat trout prefer gravel between 0.2 and 2 inches in diameter.

Packwood Lake was formed by a large landslide that blocked Lake Creek approximately 1100 years ago (Swanson 1996). Packwood Lake is large and deep enough (452 acres and over 100 feet deep) that it traps all sand, gravel, and larger material that is transported into it from upstream sources. The only source of sand, gravel, cobble, and boulder to Lake Creek downstream of Packwood Lake is from tributaries, landslides, and erosion in the lower stream watershed. Operation of the Project does not change the trap efficiency of sand and larger particles in the lake.

An inventory of spawning-sized gravel between the drop structure and the confluence with the Cowlitz River found a total of 42,660 sq ft of gravel, with the highest concentrations in Reaches 2, 3, and 4 between RM 0.8-RM 4.9 (Table 4.1 and Figure 4.1). The majority of gravel in Lake Creek was stored along the margins of the channel, behind large scale roughness elements such as boulders or logs, or upstream of log jams.

The highest concentration of gravel in the potential anadromous reach was between RM 0.8 and RM 1 where the channel changed from a confined, high gradient reach to a less confined, lower gradient reach. Gravel moving through the upper reach was deposited in this less confined, lower gradient area. There was relatively little gravel in the lower 0.8 mile of Lake Creek or in the high gradient areas between RM 1 and 2. It is likely that the major factor contributing to the lack of gravel in the lower 0.8 mile of Lake Creek is the lack of large woody debris or log jams in this area (Watershed GeoDynamics 2006). Large wood, log jams, and large boulders were closely associated with providing structure and localized hydraulic conditions that favored retention of gravel in upstream reaches.

Movement of the painted rocks placed at gravel study sites throughout the stream suggest that high flows (on the order of 250-300+ cfs) are needed to mobilize the largest-sized spawning gravels (3-4 in. diameter) across the entire channel width. Lower flows would likely mobilize smaller gravels if they occurred in the middle of the channel, but the majority of gravel is stored

on the channel margins or behind boulders/logs, requiring the higher flows to be mobilized. The painted rock study suggested that flows of 250-300 cfs mobilized spawning-sized gravel in Reaches 1, 2, and 3. Higher flows appear to be needed to move the painted rocks in Reach 4, possibly because several of the study transects in this reach were closely associated with log jams.

Operation of the Project affects the magnitude and frequency of peak flows that transport bedload material in lower Lake Creek. Under current conditions, bankfull flows of approximately 285 cfs have occurred 14 out of the past 36 years at the drop structure. Inflow in the 7.2 square mile watershed between the drop structure and the anadromous reach in the lower one mile of Lake Creek result in more frequent flows above 285 cfs in the anadromous reach. It is possible that the more frequent high flows in the anadromous reach result in more movement of gravel than in upstream reaches. However, this is a natural occurrence; operation of the Project has not changed the inflow characteristics in the drainage basin downstream of the drop structure.

5.1 Potential for Spawning Habitat Improvements in the Anadromous Reach of Lake Creek

There is little gravel or large wood in the lower 0.8 miles of Lake Creek, with more abundant gravel and wood between RM 0.8 - RM 1 as well as in upstream reaches. The gravel inventory showed that gravel accumulations in Lake Creek occur in association with large-scale roughness elements such as boulders, large woody debris, and log jams. The lack of gravel in the lower 0.8 mile of Lake Creek is likely the result of the lack of large woody debris, which is not related to Project effects (see Large Wood Study Report, Watershed GeoDynamics 2006). It is possible that an additional factor in the paucity of gravel deposits is the more frequent high flow events in the anadromous zone as a result of inflow from the 7.2 square mile drainage area downstream of the drop structure (not a Project effect). If inflow downstream of the drop structure is a major influence in gravel movement and storage, one would not expect to see the gravel accumulations between RM 0.8 and RM 1.

Because the lack of spawning gravel in the lower 0.8 miles of Lake Creek does not appear to be related to Project effects, no gravel mitigation measures are recommended.

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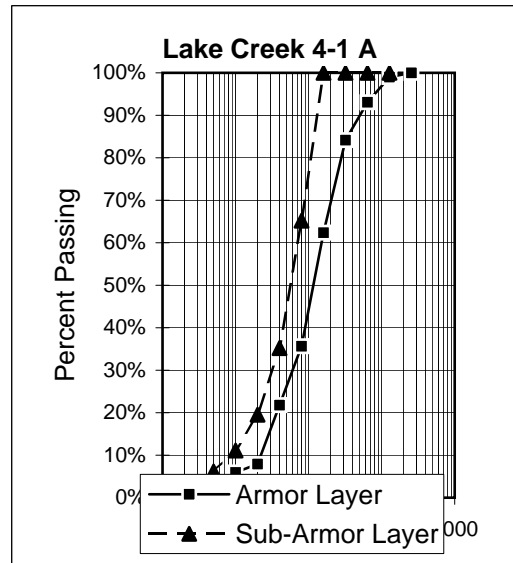
Appendix A

September 2006 Draft

Packwood - Lake Creek Sediment Samples

Station Lake Creek 4-1 A

Armor Layer		D65=	17.9 mm		
		D50=	12.3 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	6%	6%	0.06	6	
2	2%	8%	0.06	2	
4	14%	22%	0.83	14	
8	14%	36%	1.66	14	
16	27%	62%	6.42	27	
32	22%	84%	10.46	22	
64	9%	93%	8.55	9	
128	6%	99%	11.41	6	
256	1%	100%	1.27	1	
			40.71 mm	101	
			0.1336 ft		



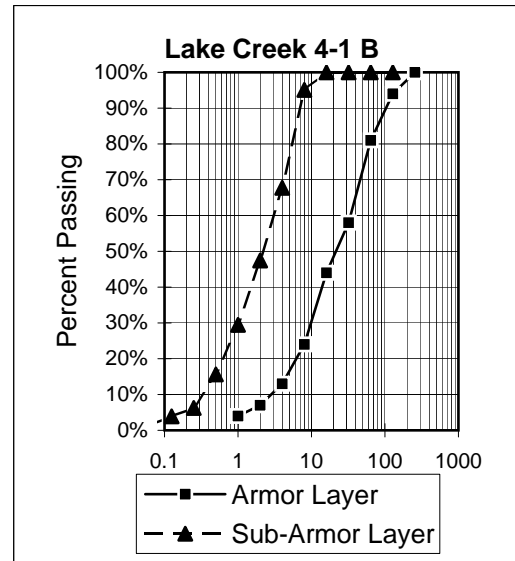
Sub-Armor Layer		D65=	8.0 mm		
		D50=	6.0 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	0	0%	100%	0	
32	0	0%	100%	0	
16	508	35%	100%	8.35068	
8	438	30%	65%	3.6	
4	229	16%	35%	0.9411	
2	123	8%	20%	0.25274	
1	72	5%	11%	0.07397	
0.5	49	3%	6%	0.02517	
0.25	24	2%	3%	0.00616	
0.125	9	1%	1%	0.00116	
0.063	4	0%	1%	0.00026	
0.003	4	0%	0%	9E-05	
pan	1,460			13.25 mm	
			0.0435 ft		



Packwood - Lake Creek Sediment Samples

Station **Lake Creek 4-1 B**

Armor Layer		D65=	41.7 mm		
		D50=	22.9 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	4%	4%	0.04	4	
2	3%	7%	0.09	3	
4	6%	13%	0.36	6	
8	11%	24%	1.32	11	
16	20%	44%	4.80	20	
32	14%	58%	6.72	14	
64	23%	81%	22.08	23	
128	13%	94%	24.96	13	
256	6%	100%	7.68	6	
			68.05 mm	100	
			0.2233 ft		

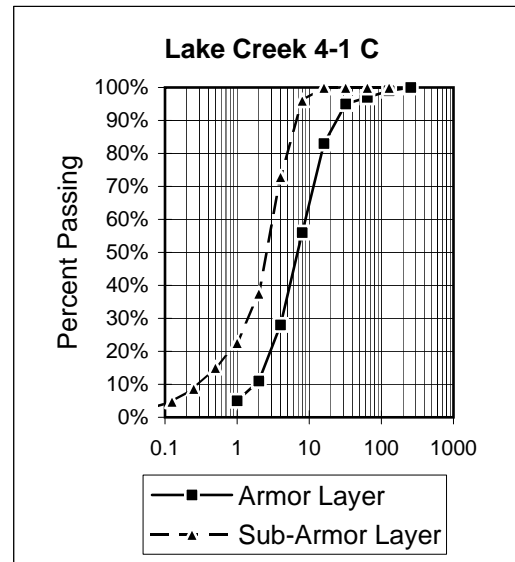


Sub-Armor Layer		D65=	3.7 mm		
		D50=	2.3 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	0	0%	100%	0	
32	0	0%	100%	0	
16	44	5%	100%	1.17857	
8	245	27%	95%	3.28125	
4	182	20%	68%	1.21875	
2	161	18%	47%	0.53906	
1	124	14%	29%	0.20759	
0.5	84	9%	16%	0.07031	
0.25	21	2%	6%	0.00879	
0.125	22	2%	4%	0.0046	
0.063	7	1%	1%	0.00073	
0.003	6	1%	1%	0.00022	
pan	896			6.51 mm	
			0.0214 ft		

Packwood - Lake Creek Sediment Samples

Station **Lake Creek 4-1 C**

Armor Layer		D65=	10.7 mm	D50=		7.1 mm		
Size (mm)	Percent	Cum %	Avg size	No.				
1	5%	5%	0.05	5				
2	6%	11%	0.18	6				
4	17%	28%	1.02	17				
8	28%	56%	3.36	28				
16	27%	83%	6.48	27				
32	12%	95%	5.76	12				
64	2%	97%	1.92	2				
128	2%	99%	3.84	2				
256	1%	100%	1.28	1				
			23.89 mm	100				
			0.0784 ft					

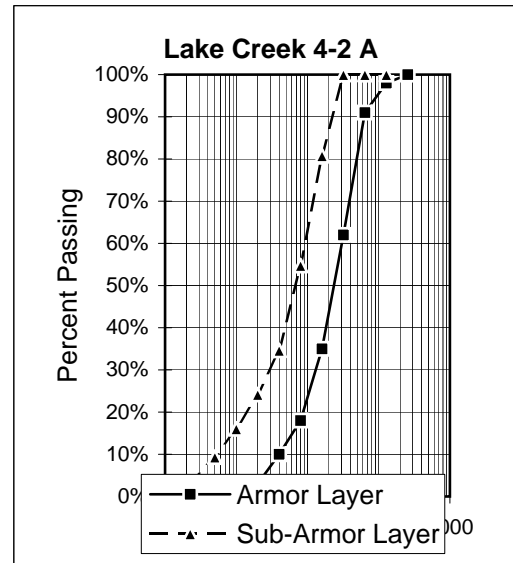


Sub-Armor Layer		D65=	3.6 mm	D50=		2.7 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size				
128	0	0%	100%	0				
64	0	0%	100%	0				
32	0	0%	100%	0				
16	30	4%	100%	0.93628				
8	178	23%	96%	2.77763				
4	272	35%	73%	2.12224				
2	115	15%	38%	0.44863				
1	58	8%	23%	0.11313				
0.5	49	6%	15%	0.04779				
0.25	30	4%	9%	0.01463				
0.125	16	2%	5%	0.0039				
0.063	9	1%	3%	0.0011				
0.003	12	2%	2%	0.00051				
769				6.47 mm				
				0.0212 ft				

Packwood - Lake Creek Sediment Samples

Station **Lake Creek 4-2 A**

Armor Layer		D65=	35.3 mm	D50=		24.9 mm
Size (mm)	Percent	Cum %	Avg size	No.		
1	0%	0%	0.00	0		
2	3%	3%	0.09	3		
4	7%	10%	0.42	7		
8	8%	18%	0.96	8		
16	17%	35%	4.08	17		
32	27%	62%	12.96	27		
64	29%	91%	27.84	29		
128	7%	98%	13.44	7		
256	2%	100%	2.56	2		
			62.35 mm	100		
			0.2046 ft			



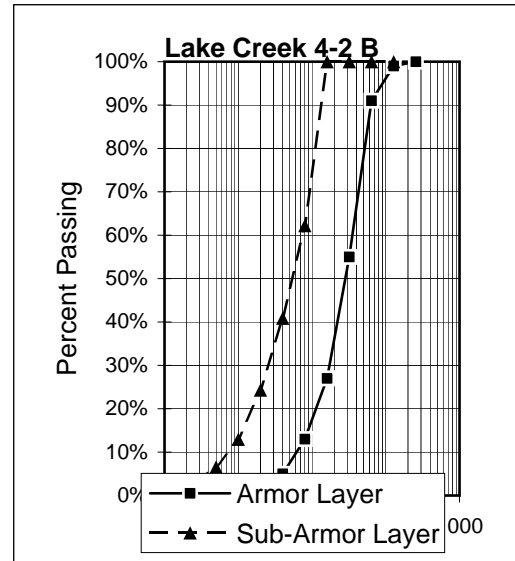
Sub-Armor Layer		D65=	11.2 mm	D50=		7.1 mm
Size (mm)	Weight (g)	Percent	Cum %	Avg size		
128	0	0%	100%	0		
64	0	0%	100%	0		
32	241	19%	100%	9.23224		
16	326	26%	81%	6.24421		
8	252	20%	55%	2.41341		
4	131	10%	35%	0.62729		
2	102	8%	24%	0.24421		
1	84	7%	16%	0.10056		
0.5	64	5%	9%	0.03831		
0.25	29	2%	4%	0.00868		
0.125	13	1%	2%	0.00195		
0.063	5	0%	1%	0.00038		
0.003	6	0%	0%	0.00016		
pan	1,253			18.91 mm		
				0.0620 ft		



Packwood - Lake Creek Sediment Samples

Station **Lake Creek 4-2 B**

Armor Layer		D65=	40.9 mm		
		D50=	29.1 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	1%	1%	0.01	1	
2	1%	2%	0.03	1	
4	3%	5%	0.18	3	
8	8%	13%	0.96	8	
16	14%	27%	3.36	14	
32	28%	55%	13.44	28	
64	36%	91%	34.56	36	
128	8%	99%	15.36	8	
256	1%	100%	1.28	1	
			69.18 mm	100	
			0.2270 ft		

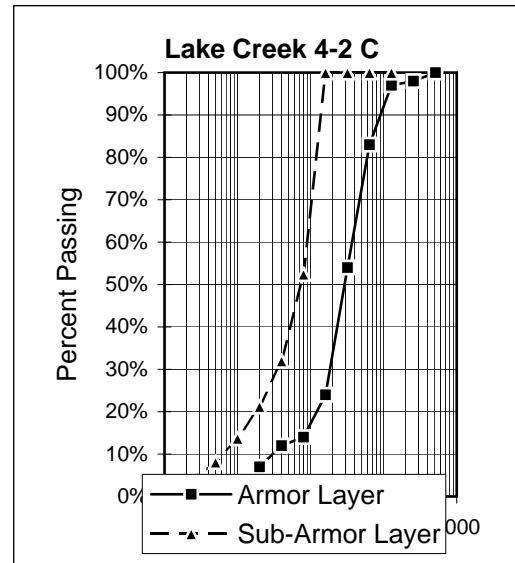


Sub-Armor Layer		D65=	8.6 mm		
		D50=	5.7 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	0	0%	100%	0	
32	0	0%	100%	0	
16	830	38%	100%	9.06691	
8	469	21%	62%	2.56168	
4	364	17%	41%	0.99408	
2	249	11%	24%	0.34001	
1	141	6%	13%	0.09627	
0.5	77	4%	7%	0.02629	
0.25	34	2%	3%	0.0058	
0.125	15	1%	2%	0.00128	
0.063	8	0%	1%	0.00034	
0.003	10	0%	0%	0.00015	
pan	2,197			13.09 mm	
				0.0430 ft	

Packwood - Lake Creek Sediment Samples

Station Lake Creek 4-2 C

Armor Layer		D65=	44.1 mm	
		D50=	29.9 mm	
Size (mm)	Percent	Cum %	Avg size	No.
1	1%	1%	0.01	1
2	6%	7%	0.18	6
4	5%	12%	0.30	5
8	2%	14%	0.24	2
16	10%	24%	2.40	10
32	30%	54%	14.40	30
64	29%	83%	27.84	29
128	14%	97%	26.88	14
256	1%	98%	3.84	1
512	2%	100%	5.12	2
			81.21 mm	100
			0.2664 ft	

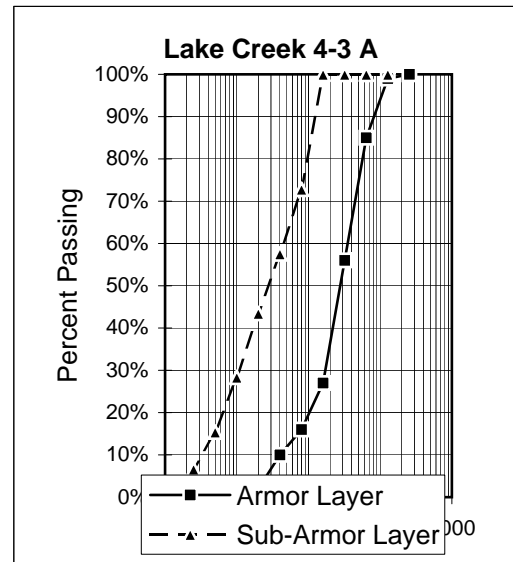


Sub-Armor Layer		D65=	10.1 mm	
		D50=	7.5 mm	
Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	0	0%	100%	0
32	0	0%	100%	0
16	809	48%	100%	11.4145
8	348	20%	52%	2.45503
4	183	11%	32%	0.6455
2	128	8%	21%	0.22575
1	95	6%	14%	0.08377
0.5	65	4%	8%	0.02866
0.25	30	2%	4%	0.00661
0.125	26	2%	3%	0.00287
0.063	8	0%	1%	0.00044
0.003	9	1%	1%	0.00017
pan	1,701			14.86 mm
				0.0488 ft

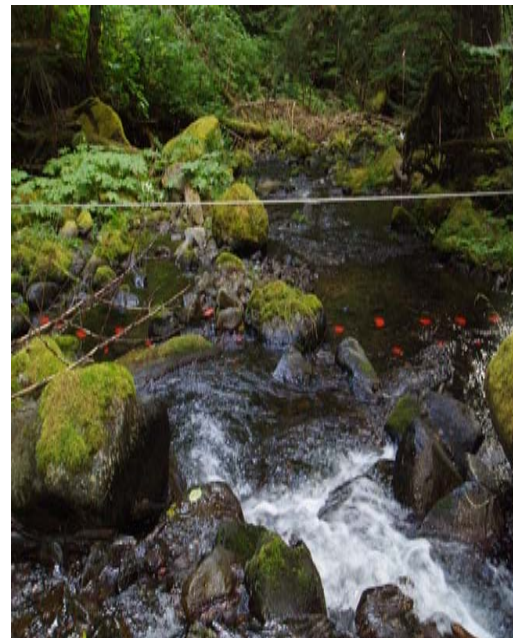
Packwood - Lake Creek Sediment Samples

Station **Lake Creek 4-3 A**

Armor Layer Size (mm)	Percent	Cum %	Avg size	No.
1	0%	0%	0.00	0
2	2%	2%	0.06	2
4	8%	10%	0.48	8
8	6%	16%	0.72	6
16	11%	27%	2.64	11
32	29%	56%	13.92	29
64	29%	85%	27.84	29
128	14%	99%	26.88	14
256	1%	100%	1.28	1
			73.82 mm	100
			0.2422 ft	



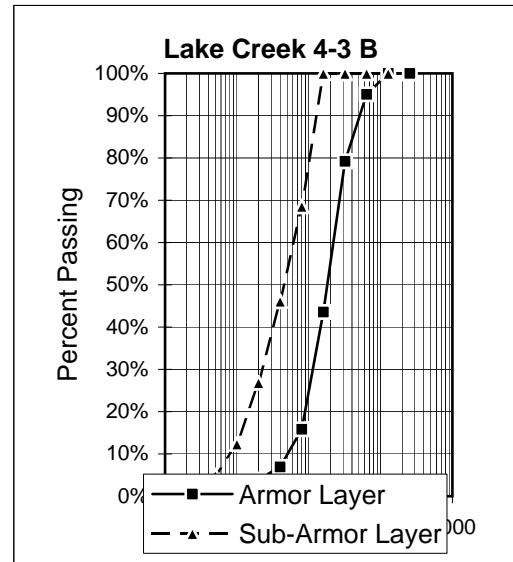
Sub-Armor Layer Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	0	0%	100%	0
32	0	0%	100%	0
16	623	27%	100%	6.52356
8	350	15%	73%	1.83246
4	323	14%	58%	0.84555
2	346	15%	43%	0.45288
1	297	13%	28%	0.19437
0.5	201	9%	15%	0.06577
0.25	94	4%	7%	0.01538
0.125	34	1%	3%	0.00278
0.063	12	1%	1%	0.00049
0.003	12	1%	1%	0.00017
pan	2,292			10 mm
				0.0326 ft



Packwood - Lake Creek Sediment Samples

Station **Lake Creek 4-3 B**

Armor Layer Size (mm)	Percent	Cum %	Avg size	No.
1	0%	0%	0.00	0
2	4%	4%	0.12	4
4	3%	7%	0.18	3
8	9%	16%	1.07	9
16	28%	44%	6.65	28
32	36%	79%	17.11	36
64	16%	95%	15.21	16
128	5%	100%	9.50	5
256	0%	100%	0.00	
			49.84 mm	101
			0.1635 ft	



Sub-Armor Layer Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	0	0%	100%	0
32	0	0%	100%	0
16	568	31%	100%	7.54817
8	405	22%	69%	2.69103
4	348	19%	46%	1.15615
2	262	15%	27%	0.43522
1	134	7%	12%	0.1113
0.5	57	3%	5%	0.02367
0.25	18	1%	2%	0.00374
0.125	7	0%	1%	0.00073
0.063	3	0%	0%	0.00016
0.003	4	0%	0%	7.3E-05
pan	1,806			11.97 mm
				0.0393 ft

Packwood - Lake Creek Sediment Samples

Station **Lake Creek 4-3 C**

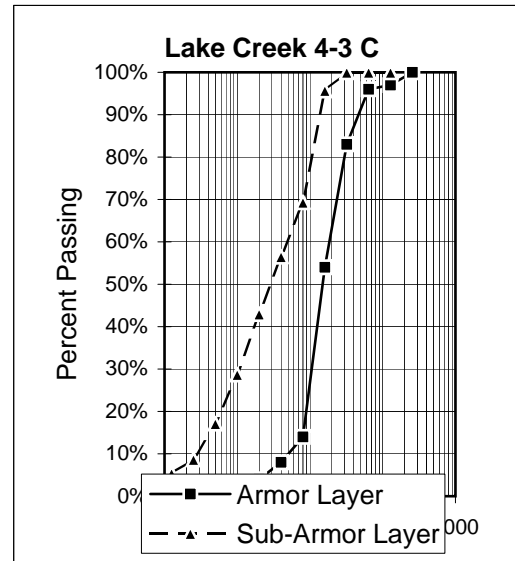
Armor Layer Size (mm)	Percent	Cum %	Avg size	No.
1	1%	1%	0.01	1
2	3%	4%	0.09	3
4	4%	8%	0.24	4
8	6%	14%	0.72	6
16	40%	54%	9.60	40
32	29%	83%	13.92	29
64	13%	96%	12.48	13
128	1%	97%	1.92	1
256	3%	100%	3.84	3
			42.82 mm	100
			0.1405 ft	

D65= 22.1 mm
D50= 15.2 mm

Sub-Armor Layer

Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	0	0%	100%	0
32	66	4%	100%	2.0625
16	405	26%	96%	6.32813
8	197	13%	69%	1.53906
4	208	14%	57%	0.8125
2	219	14%	43%	0.42773
1	178	12%	29%	0.17383
0.5	130	8%	17%	0.06348
0.25	50	3%	9%	0.01221
0.125	61	4%	5%	0.00745
0.063	11	1%	1%	0.00067
0.003	11	1%	1%	0.00024
pan	1,536			11.43 mm
				0.0375 ft

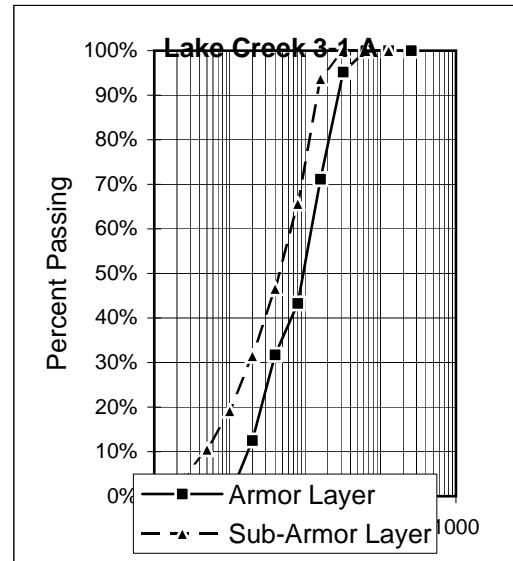
D65= 6.6 mm
D50= 2.0 mm



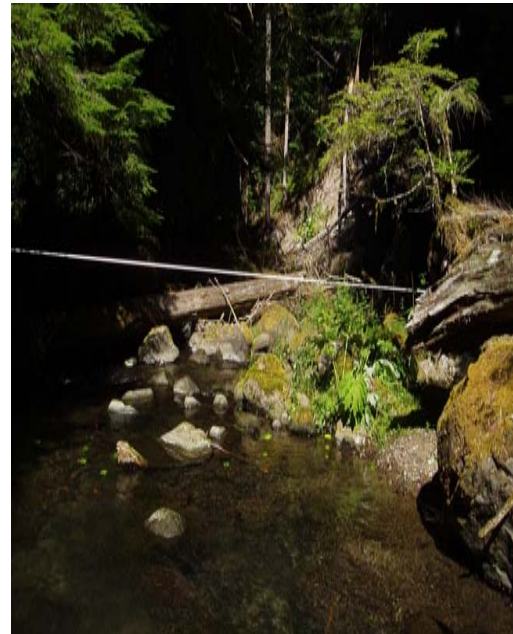
Packwood - Lake Creek Sediment Samples

Station **Lake Creek 3-1 A**

Armor Layer		D65=	14.2 mm		
		D50=	9.9 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	0%	0%	0.00	0	
2	13%	13%	0.38	13	
4	19%	32%	1.15	20	
8	12%	43%	1.38	12	
16	28%	71%	6.69	29	
32	24%	95%	11.54	25	
64	5%	100%	4.62	5	
128	0%	100%	0.00	0	
256	0%	100%	0.00	0	
			25.76 mm	104	
			0.0845 ft		



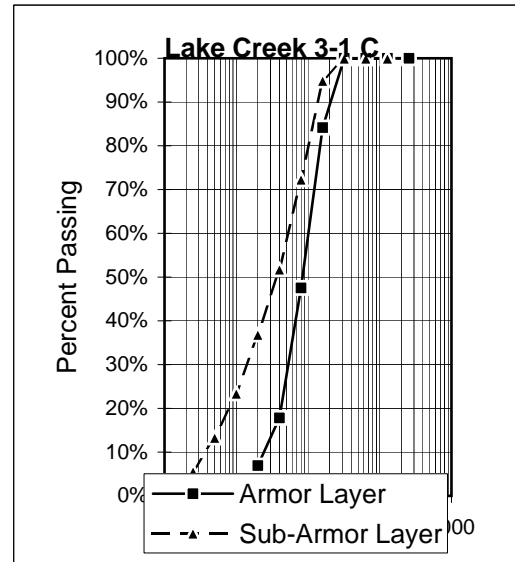
Sub-Armor Layer		D65=	7.9 mm		
		D50=	4.7 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	0	0%	100%	0	
32	117	6%	100%	3.01611	
16	522	28%	94%	6.72825	
8	355	19%	66%	2.28786	
4	281	15%	47%	0.90548	
2	230	12%	32%	0.37057	
1	161	9%	19%	0.1297	
0.5	114	6%	11%	0.04592	
0.25	41	2%	4%	0.00826	
0.125	30	2%	2%	0.00302	
0.063	5	0%	1%	0.00025	
0.003	6	0%	0%	0.00011	
pan	1,862		13.50 mm		
			0.0443 ft		



Packwood - Lake Creek Sediment Samples

Station **Lake Creek 3-1 C**

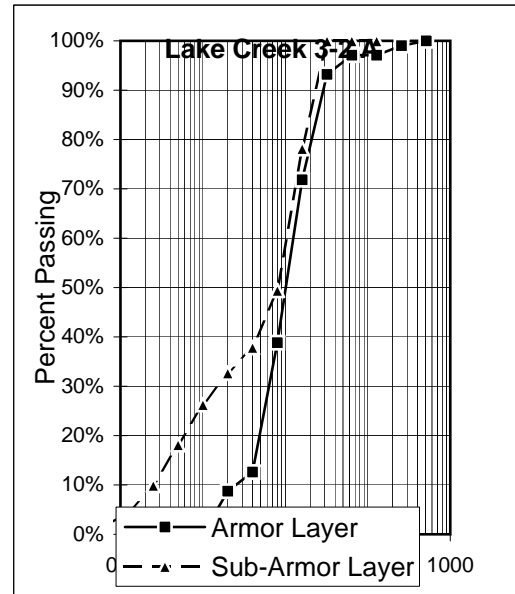
Armor Layer		D65=	11.8 mm		
		D50=	8.5 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	0%	0%	0.00	0	
2	7%	7%	0.21	7	
4	11%	18%	0.65	11	
8	30%	48%	3.56	30	
16	37%	84%	8.79	37	
32	16%	100%	7.60	16	
64	0%	100%	0.00		
128	0%	100%	0.00		
256	0%	100%	0.00		
			20.82 mm	101	
			0.0683 ft		



Packwood - Lake Creek Sediment Samples

Station **Lake Creek 3-2 A**

Armor Layer		D65=	14.3 mm		
		D50=	10.7 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	0%	0%	0.00	0	
2	9%	9%	0.26	9	
4	4%	13%	0.23	4	
8	26%	39%	3.15	27	
16	33%	72%	7.92	34	
32	21%	93%	10.25	22	
64	4%	97%	3.73	4	
128	0%	97%	0.00	0	
256	2%	99%	7.46	2	
512	1%	100%	2.49	1	
			35.49 mm	103	
			0.1164 ft		



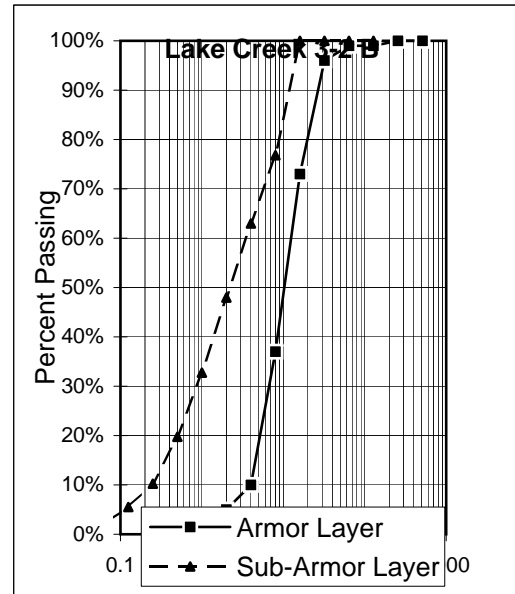
Sub-Armor Layer		D65=	12.3 mm		
		D50=	8.2 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	0	0%	100%	0	
32	548	22%	100%	10.4755	
16	722	29%	78%	6.90084	
8	290	12%	49%	1.3859	
4	130	5%	38%	0.31063	
2	161	6%	33%	0.19235	
1	204	8%	26%	0.12186	
0.5	207	8%	18%	0.06183	
0.25	137	5%	10%	0.02046	
0.125	74	3%	4%	0.00553	
0.063	20	1%	2%	0.00075	
0.003	18	1%	1%	0.00024	
pan	2,511			19.48 mm	
			0.0639 ft		



Packwood - Lake Creek Sediment Samples

Station **Lake Creek 3-2 B**

Armor Layer		D65=	14.2 mm		
		D50=	10.9 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	0%	0%	0.00	0	
2	5%	5%	0.15	5	
4	5%	10%	0.30	5	
8	27%	37%	3.24	27	
16	36%	73%	8.64	36	
32	23%	96%	11.04	23	
64	3%	99%	2.88	3	
128	0%	99%	0.00	0	
256	1%	100%	3.84	1	
512	0%	100%	0.00		
			30.09 mm	100	
			0.0987 ft		



Sub-Armor Layer		D65=	4.6 mm		
		D50=	2.3 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	0	0%	100%	0	
32	0	0%	100%	0	
16	471	23%	100%	5.56573	
8	281	14%	77%	1.66027	
4	305	15%	63%	0.90103	
2	309	15%	48%	0.45643	
1	264	13%	33%	0.19498	
0.5	193	10%	20%	0.07127	
0.25	96	5%	10%	0.01773	
0.125	69	3%	6%	0.00637	
0.063	22	1%	2%	0.00102	
0.003	21	1%	1%	0.00034	
pan	2,031			8.88 mm	
			0.0291 ft		

Packwood - Lake Creek Sediment Samples

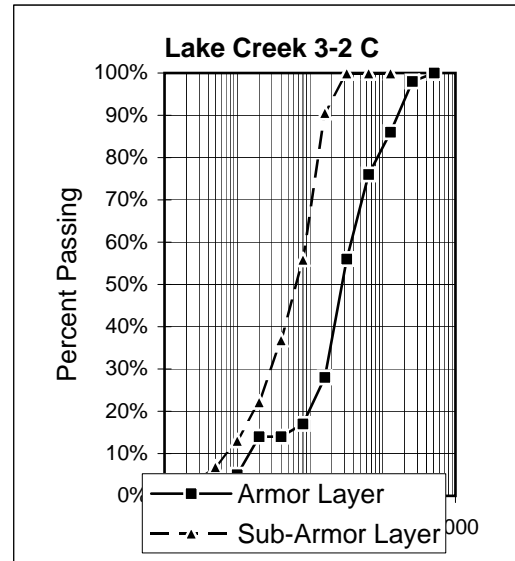
Station Lake Creek 3-2 C

Armor Layer Size (mm)	Percent	Cum %	Avg size	No.
1	5%	5%	0.05	5
2	9%	14%	0.27	9
4	0%	14%	0.00	0
8	3%	17%	0.36	3
16	11%	28%	2.64	11
32	28%	56%	13.44	28
64	20%	76%	19.20	20
128	10%	86%	19.20	10
256	12%	98%	46.08	12
512	2%	100%	5.12	2
			106.36 mm	100
			0.3490 ft	

D65= 46.4 mm
D50= 28.6 mm

Sub-Armor Layer Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	0	0%	100%	0
32	167	9%	100%	4.48824
16	620	35%	91%	8.33147
8	340	19%	56%	2.28443
4	262	15%	37%	0.88018
2	163	9%	22%	0.2738
1	111	6%	13%	0.09323
0.5	69	4%	7%	0.02898
0.25	20	1%	3%	0.0042
0.125	23	1%	2%	0.00241
0.063	5	0%	1%	0.00026
0.003	6	0%	0%	0.00011
pan	1,786			16.39 mm
				0.0538 ft

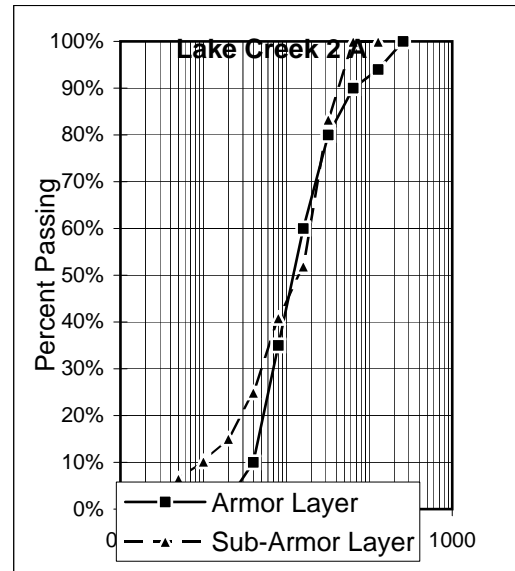
D65= 10.1 mm
D50= 6.8 mm



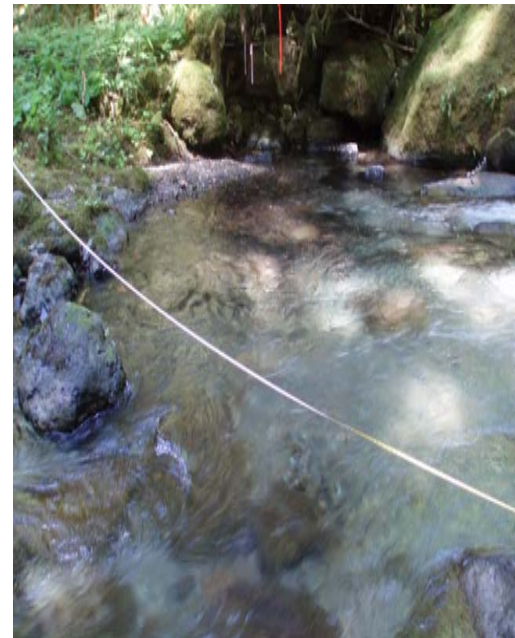
Packwood - Lake Creek Sediment Samples

Station **Lake Creek 2 A**

Armor Layer		D65=	20.0 mm	
		D50=	12.8 mm	
Size (mm)	Percent	Cum %	Avg size	No.
1	1%	1%	0.01	1
2	1%	2%	0.03	1
4	8%	10%	0.48	8
8	25%	35%	3.00	25
16	25%	60%	6.00	25
32	20%	80%	9.60	20
64	10%	90%	9.60	10
128	4%	94%	7.68	4
256	6%	100%	7.68	6
			44.08 mm	100
			0.1446 ft	



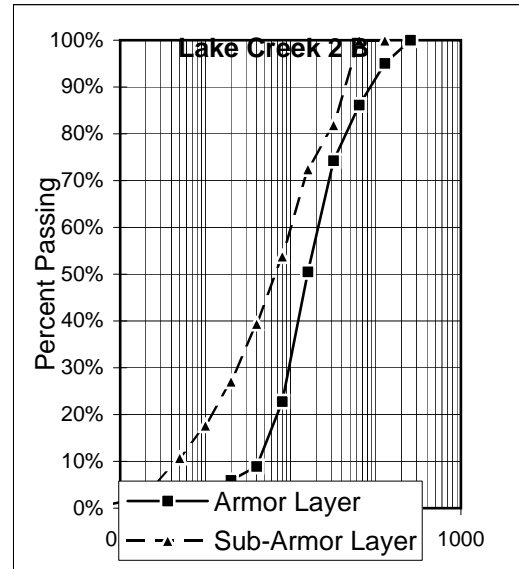
Sub-Armor Layer		D65=	22.7 mm	
		D50=	14.6 mm	
Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	716	17%	100%	16.0037
32	1,348	31%	83%	15.065
16	475	11%	52%	2.65425
8	684	16%	41%	1.91106
4	424	10%	25%	0.59232
2	209	5%	15%	0.14598
1	159	4%	10%	0.05553
0.5	165	4%	7%	0.02881
0.25	78	2%	3%	0.00681
0.125	27	1%	1%	0.00118
0.063	4	0%	0%	8.8E-05
0.003	6	0%	0%	4.6E-05
pan	4,295		36.46 mm	
			0.1196 ft	



Packwood - Lake Creek Sediment Samples

Station Lake Creek 2 B

Armor Layer		D65=	25.8 mm		
		D50=	15.9 mm		
Size (mm)	Percent	Cum %	Avg size	No.	
1	2%	2%	0.02	2	
2	4%	6%	0.12	4	
4	3%	9%	0.18	3	
8	14%	23%	1.66	14	
16	28%	50%	6.65	28	
32	24%	74%	11.41	24	
64	12%	86%	11.41	12	
128	9%	95%	17.11	9	
256	5%	100%	6.34	5	
			54.89 mm	101	
			0.1801 ft		

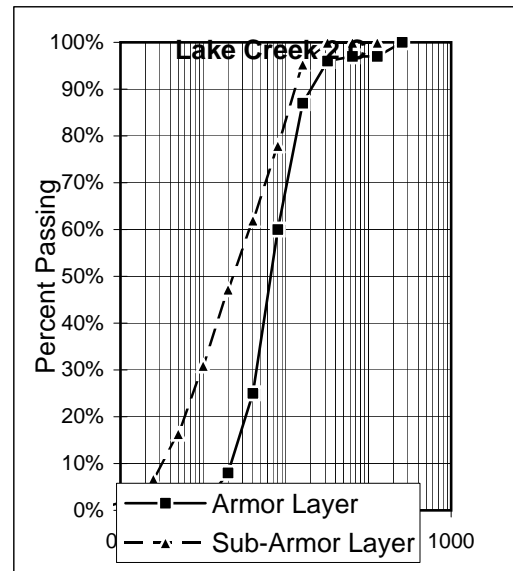


Sub-Armor Layer		D65=	12.8 mm		
		D50=	6.9 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	611	18%	100%	17.3487	
32	319	9%	82%	4.52884	
16	630	19%	72%	4.47205	
8	487	14%	54%	1.72848	
4	417	12%	39%	0.74002	
2	318	9%	27%	0.28217	
1	234	7%	18%	0.10382	
0.5	193	6%	11%	0.04281	
0.25	116	3%	5%	0.01287	
0.125	39	1%	2%	0.00216	
0.063	8	0%	1%	0.00022	
0.003	9	0%	0%	8.8E-05	
pan	3,381			29.26 mm	
			0.0960 ft		

Packwood - Lake Creek Sediment Samples

Station Lake Creek 2 C

Armor Layer		D65=	9.5 mm	
		D50=	6.9 mm	
Size (mm)	Percent	Cum %	Avg size	No.
1	1%	1%	0.01	1
2	7%	8%	0.21	7
4	17%	25%	1.02	17
8	35%	60%	4.20	35
16	27%	87%	6.48	27
32	9%	96%	4.32	9
64	1%	97%	0.96	1
128	0%	97%	0.00	0
256	3%	100%	3.84	3
			21.04 mm	100
			0.0690 ft	



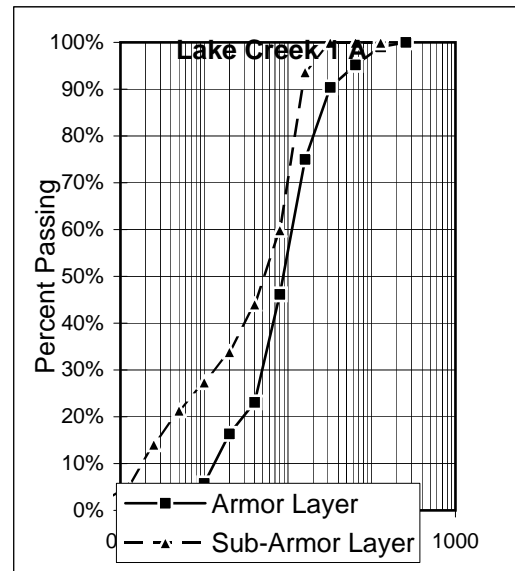
Sub-Armor Layer		D65=	4.8 mm	
		D50=	2.4 mm	
Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	0	0%	100%	0
32	115	5%	100%	2.23844
16	429	17%	95%	4.17518
8	393	16%	78%	1.91241
4	364	15%	62%	0.88564
2	402	16%	47%	0.48905
1	359	15%	31%	0.21837
0.5	238	10%	16%	0.07238
0.25	111	5%	7%	0.01688
0.125	41	2%	2%	0.00312
0.063	7	0%	1%	0.00027
0.003	7	0%	0%	9.4E-05
pan	2,466		10.01 mm	
			0.0328 ft	

Packwood - Lake Creek Sediment Samples

Station **Lake Creek 1 A**

Armor Layer Size (mm)	Percent	Cum %	Avg size	No.
1	6%	6%	0.06	6
2	11%	16%	0.32	11
4	7%	23%	0.40	7
8	23%	46%	2.77	24
16	29%	75%	6.92	30
32	15%	90%	7.38	16
64	5%	95%	4.62	5
128	4%	99%	7.38	4
256	1%	100%	1.23	1
			31.09 mm	104
			0.1020 ft	

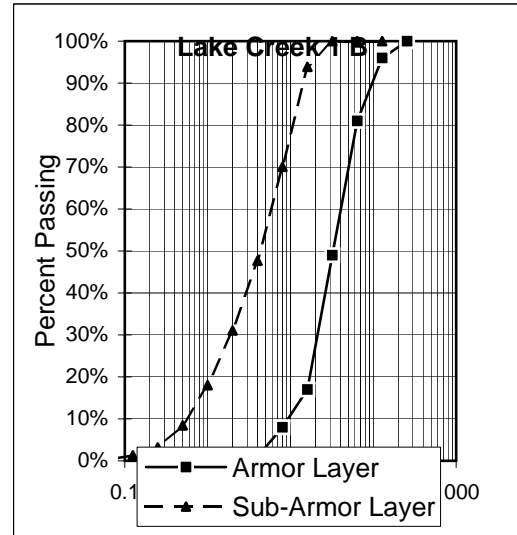
Sub-Armor Layer Size (mm)	Weight (g)	Percent	Cum %	Avg size
128	0	0%	100%	0
64	0	0%	100%	0
32	138	6%	100%	3.02604
16	739	34%	94%	8.10233
8	347	16%	60%	1.90224
4	223	10%	44%	0.61124
2	142	6%	34%	0.19461
1	132	6%	27%	0.09045
0.5	159	7%	21%	0.05448
0.25	194	9%	14%	0.03323
0.125	73	3%	5%	0.00625
0.063	22	1%	2%	0.00094
0.003	20	1%	1%	0.0003
pan	2,189			14.02 mm
				0.0460 ft



Station Lake Creek 1 B

Armor Layer Size (mm)	Percent	Cum %	Avg size	No.
1	0%	0%	0.00	0
2	0%	0%	0.00	0
4	1%	1%	0.06	1
8	7%	8%	0.84	7
16	9%	17%	2.16	9
32	32%	49%	15.36	32
64	32%	81%	30.72	32
128	15%	96%	28.80	15
256	4%	100%	5.12	4
				100
				83.06 mm
				0.2725 ft

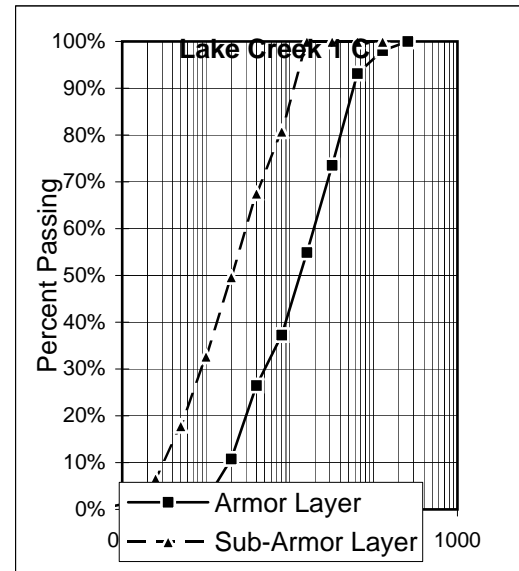
D65= 48.0 mm
D50= 33.0 mm



Packwood - Lake Creek Sediment Samples

Station Lake Creek 1 C

Armor Layer		D65=	24.7 mm		
		D50=	13.8 mm		
Size (mm)	Percent	Cum %	Dg	No.	
1	2%	2%	0.02	2	
2	9%	11%	0.26	9	
4	16%	26%	0.94	16	
8	11%	37%	1.29	11	
16	18%	55%	4.24	18	
32	19%	74%	8.94	19	
64	20%	93%	18.82	20	
128	5%	98%	9.41	5	
256	2%	100%	2.51	2	
			46.44 mm	102	
			0.1524 ft		



Sub-Armor Layer		D65=	3.7 mm		
		D50=	2.0 mm		
Size (mm)	Weight (g)	Percent	Cum %	Avg size	
128	0	0%	100%	0	
64	0	0%	100%	0	
32	0	0%	100%	0	
16	535	19%	100%	4.6071	
8	369	13%	81%	1.58881	
4	498	18%	68%	1.07212	
2	473	17%	50%	0.50915	
1	414	15%	33%	0.22282	
0.5	313	11%	18%	0.08423	
0.25	143	5%	7%	0.01924	
0.125	33	1%	2%	0.00222	
0.063	5	0%	0%	0.00017	
0.003	4	0%	0%	4.7E-05	
pan	2,787			8.11 mm	
			0.0266 ft		

Draft Gravel Transport Study Report

Appendix B

September 2006 Draft

Station: Lake Creek 4-1

Slope: 0.0446429

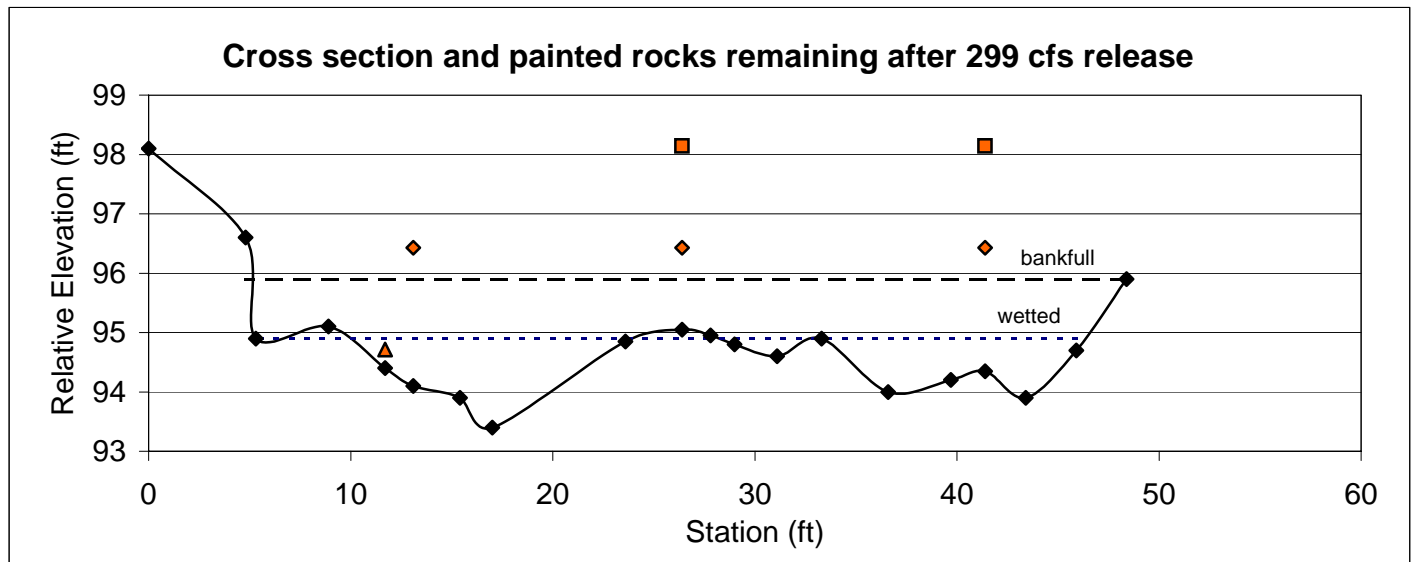
Bankful Width (ft)

40.7

H I: 100.3

Sta	BS	FS	Elev	Notes	Painted Rocks	Movement 16 cfs?	Movement 35 cfs?	Movement high flow?
47.3	0.3		100	BM LBHP				All rocks gone
48.4		4.4	95.9	BF WE				except:
45.9		5.6	94.7	WE				HW 45.5 (1.5D)
43.4		6.4	93.9		2	extra 0.5 here		
41.4		5.95	94.35		4			2", 3"
39.7		6.1	94.2		2		1" moved 1 ft downstream	
36.6		6.3	94		4	0.5 missing		
33.3		5.4	94.9		4			
31.1		5.7	94.6		4			
29		5.5	94.8		4			
27.8		5.35	94.95		4		0.5" moved 3 ft toward RB and 1 ft. downstream	
26.4		5.25	95.05		4			3", 2" moved 1 ft
23.6		5.45	94.85		4	0.5" moved 6 ft laterally	0.5 gone	
17		6.9	93.4		2			
15.4		6.4	93.9		3			
13.1		6.2	94.1		4		2" covered w/ sand	two 2" rocks
11.7		5.9	94.4		3			1"
8.9		5.2	95.1		4		0.5" moved 0.5 ft downstream	
5.3		5.4	94.9	WE				
4.8		3.7	96.6	BF WE				HW 4.8
0		2.2	98.1	HP				

Missing 2'-4" rocks seen up to 20' downstream



Station: Lake Creek 4-2

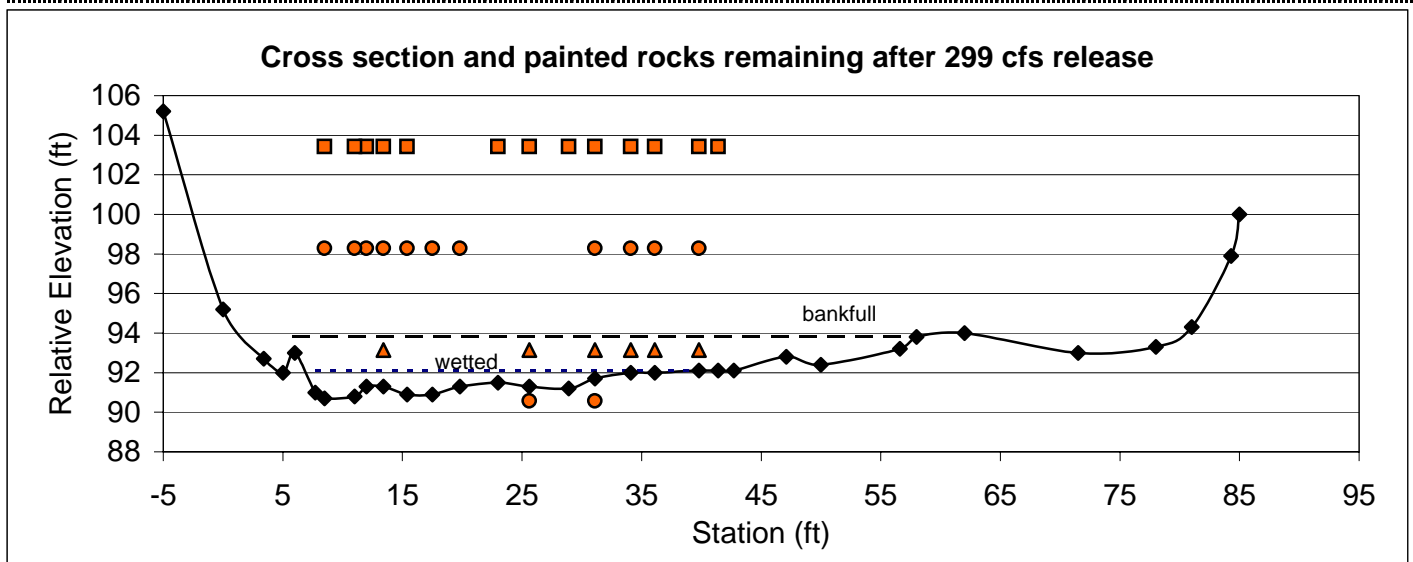
Slope: 0.0303571

Bankfull Width (ft)

47.6

H I: 100.8

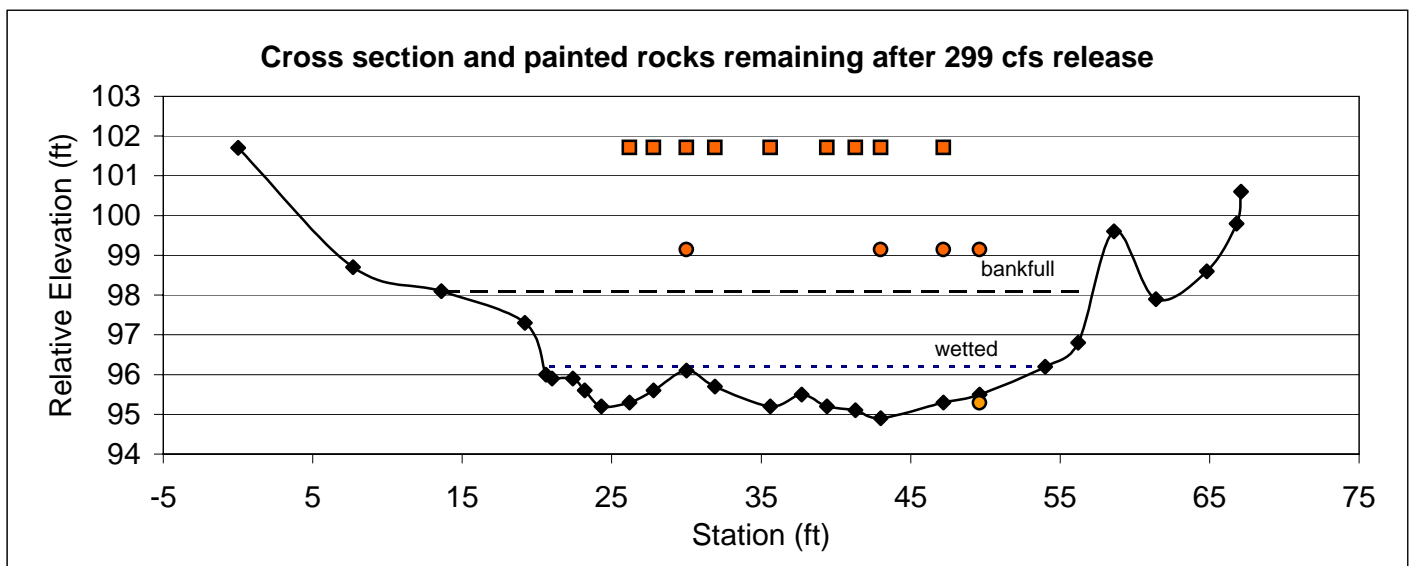
Sta	BS	FS	Elev	Notes	Painted Rocks	Movement 16 cfs?	Movement 35 cfs?	Movement high flow?
BM	0.8		100	BM LBHP				
85		0.8	100					
84.3		2.9	97.9					
81		6.5	94.3					
78		7.5	93.3					
71.5		7.8	93					
62		6.8	94					
58		7	93.8					
56.6		7.6	93.2	BF WE				
50		8.4	92.4					HW 51
47.1		8	92.8				45.2 WE	
42.7		8.7	92.1	WE				
41.4		8.7	92.1		2			2" moved 2'
39.8		8.7	92.1		4			0.5" gone
36.1		8.8	92		4			0.5" gone
34.1		8.8	92		4			0.5" moved 2'
31.1		9.1	91.7		4			
28.9		9.6	91.2		4		2" moved 3-4" DS	0.5", 1", 2" gone
25.6		9.5	91.3		4		2" moved 1" DS	2" moved 2'
23		9.3	91.5		4			0.5", 1" gone; 2" moved 2'
19.8		9.5	91.3		4		0.5" moved .5" DS	0.5", 1", 3" gone
17.5		9.9	90.9		4			0.5", 1", 3" gone
15.4		9.9	90.9		4			0.5", 1" moved
13.4		9.5	91.3		4			0.5" gone
12		9.5	91.3		4			0.5", 1" gone
11		10	90.8		4			0.5", 1" gone
8.5		10.1	90.7		4			0.5", 1" gone
7.7		9.8	91	WE				
6		7.8	93					
5		8.8	92	BF WE				
3.4		8.1	92.7				4.2 WE	HW 3.4
0		5.6	95.2	HP				
-5		-4.4	105.2					



Station: **Lake Creek 4-3** Slope: 0.0482143
H I: 101.7

Bankful Width (ft) 49

Sta	BS	FS	Elev	Notes	Painted Rocks	Movement 16 cfs?	Movement 35 cfs?	Movement high flow?
BM	1.7		100	BM				
67.1		1.1	100.6	RBHP				
66.8		1.9	99.8					
64.8		3.1	98.6					
61.4		3.8	97.9					HW 62
58.6		2.1	99.6					
56.2		4.9	96.8	BF WE				
54		5.5	96.2	WE			WE, 0.4' deep	
49.6		6.2	95.5		4			0.5", 1", 2" gone
47.2		6.4	95.3		4			0.5", 1" gone
43		6.8	94.9		4			0.5", 1" gone, 2" moved 1'
41.3		6.6	95.1		4			1", 3" gone, 0.5" moved 1'
39.4		6.5	95.2		4		1" moved 6"	0.5", 1" gone
37.7		6.2	95.5		4	0.5" rock gone	1" moved 2.5' ds;	0.5", 1" gone
35.6		6.5	95.2		4		0.5" gone	0.5", 1", 2" gone, 3" moved 1'
31.9		6	95.7		4		2" turned over; 1" covered	0.5", 1", 2" gone, 3" moved 1'
30		5.6	96.1		3			all gone
27.8		6.1	95.6		4			0.5", 1", 2" gone
26.2		6.4	95.3		4			0.5", 1", 2" gone, 3" moved 1'
24.3		6.5	95.2		4			0.5", 1" gone 2" moved 1'
23.2		6.1	95.6		4		0.5" moved to 1" space	0.5", 1", 2" gone
22.4		5.8	95.9		4			0.5", 1", 2" gone
21		5.8	95.9		2			all gone
20.6		5.7	96	WE				
19.2		4.4	97.3					
13.6		3.6	98.1	BF WE			15.5 WE	HW 13
7.7		3	98.7					
0		0	101.7	LBHP				



Station: Lake Creek 3-1

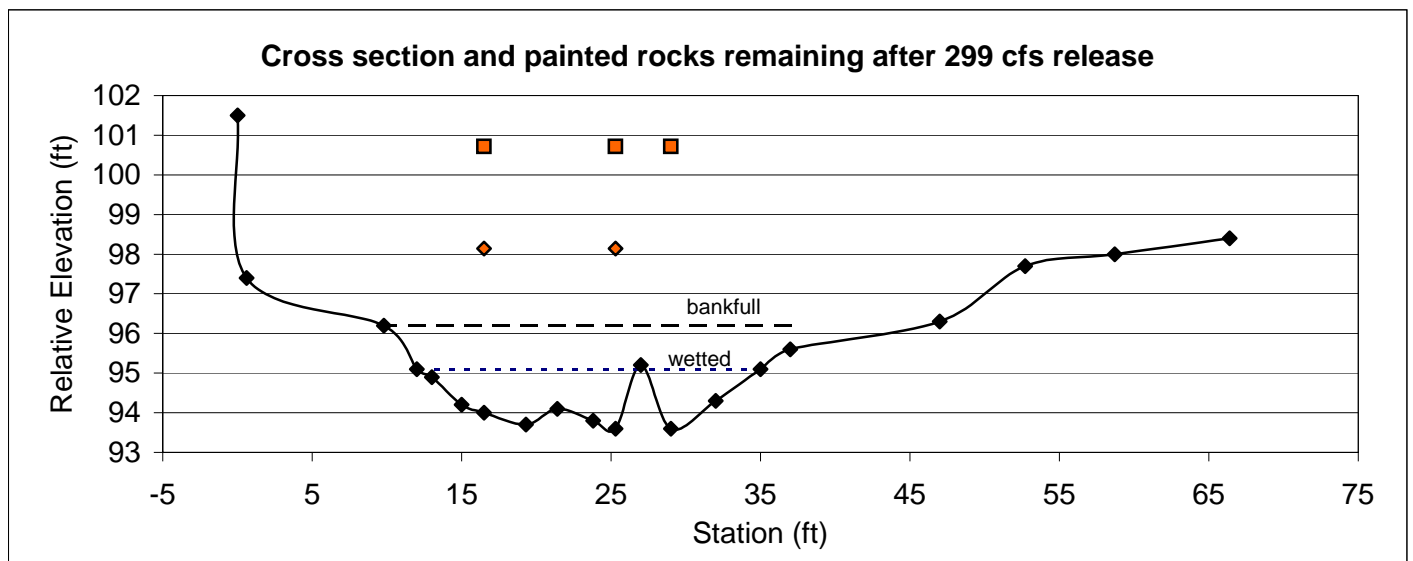
Slope: 0.0392857

Bankful Width (ft)

42

H I: 102.7

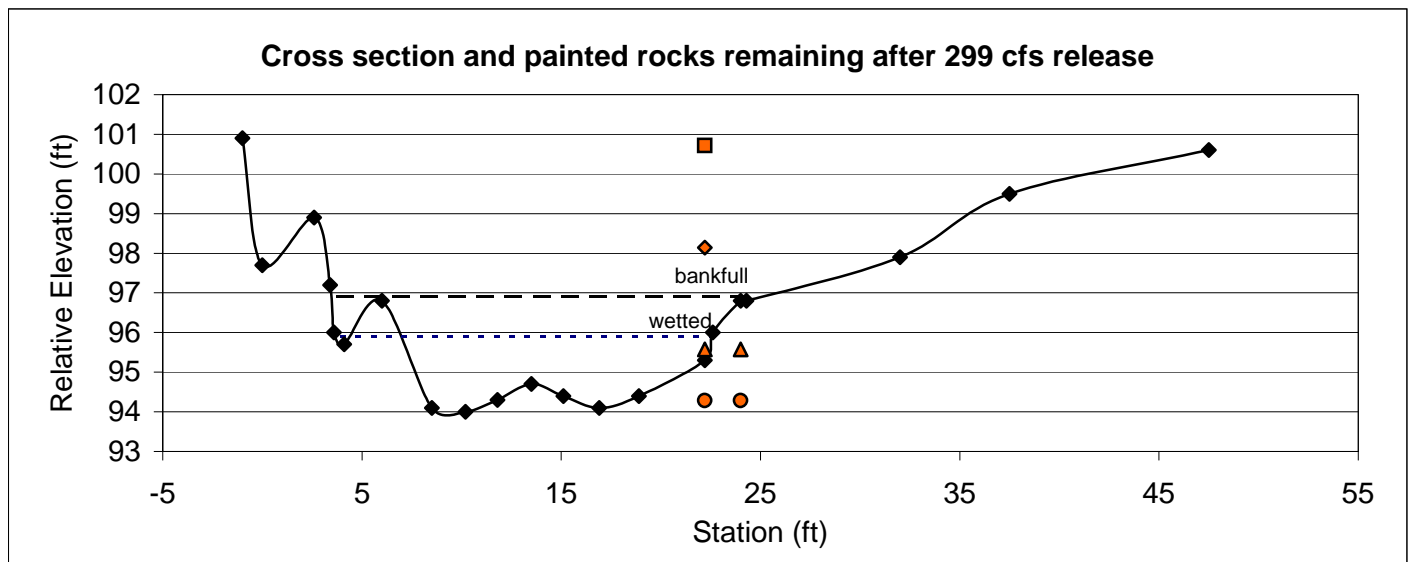
Sta	BS	FS	Elev	Notes	Painted Rocks	Movement 16 cfs?	Movement 35 cfs?	Movement high flow?
BM	2.7		100	BM				
0		1.2	101.5	LBHP				
0.6		5.3	97.4					
9.8		6.5	96.2	BF WE				HW 4
12		7.6	95.1	WE			WE 10.5	
13		7.8	94.9		4			gone or covered
15		8.5	94.2		4			gone or covered
16.5		8.7	94		4			0.5", 1" gone, 2" moved to 3" spot
19.3		9	93.7		4		.5" moved 6" ds and covered w/sand	all gone
21.4		8.6	94.1		4			all gone
23.8		8.9	93.8		4			all gone
25.3		9.1	93.6		4			0.5", 1" gone
27		7.5	95.2	Bldr	4			all gone
29		9.1	93.6		4			0.5", 1", 2" gone
32		8.4	94.3		4			all gone
35		7.6	95.1	WE	4		WE; 0.3' deep	gone or covered
37		7.1	95.6	BF WE				
47		6.4	96.3					HW 46
52.7		5	97.7					
58.7		4.7	98					
66.4		4.3	98.4	RBHP				



Station: **Lake Creek 3-2** Slope: 0.0339286
H I: 102.9

Bankfull Width (ft) 29.5

Sta	BS	FS	Elev	Notes	Painted Rocks	Movement 16 cfs?	Movement 35 cfs?	Movement high flow?
BM	2.9		100	BM				
47.5		2.3	100.6					
37.5		3.4	99.5	RBHP				
32		5	97.9					HW 33 (2' deeper)
24.3		6.1	96.8	BF WE				
24		6.1	96.8		4		0.5", 1" gone	2", 3" gone (upstream)
22.6		6.9	96	WE			0.5" moved	
22.2		7.6	95.3		4		0.5" moved	no movement
18.9		8.5	94.4		4		0.5" gone	all gone
16.9		8.8	94.1		4		0.5" gone	all gone
15.1		8.5	94.4		4			all gone
13.5		8.2	94.7		4		0.5" gone	all gone
11.8		8.6	94.3		4		0.5", 1" gone	all gone
10.2		8.9	94		4		0.5", 1" gone	all gone
8.5		8.8	94.1		4		0.5" moved 1"; 1" gone	all gone
6		6.1	96.8					
4.1		7.2	95.7					
3.6		6.9	96	WE				
3.4		5.7	97.2	BF WE				HW 3.5
2.6		4	98.9					
0		5.2	97.7	LBHP				
-1		2	100.9					



Station: Lake Creek 2

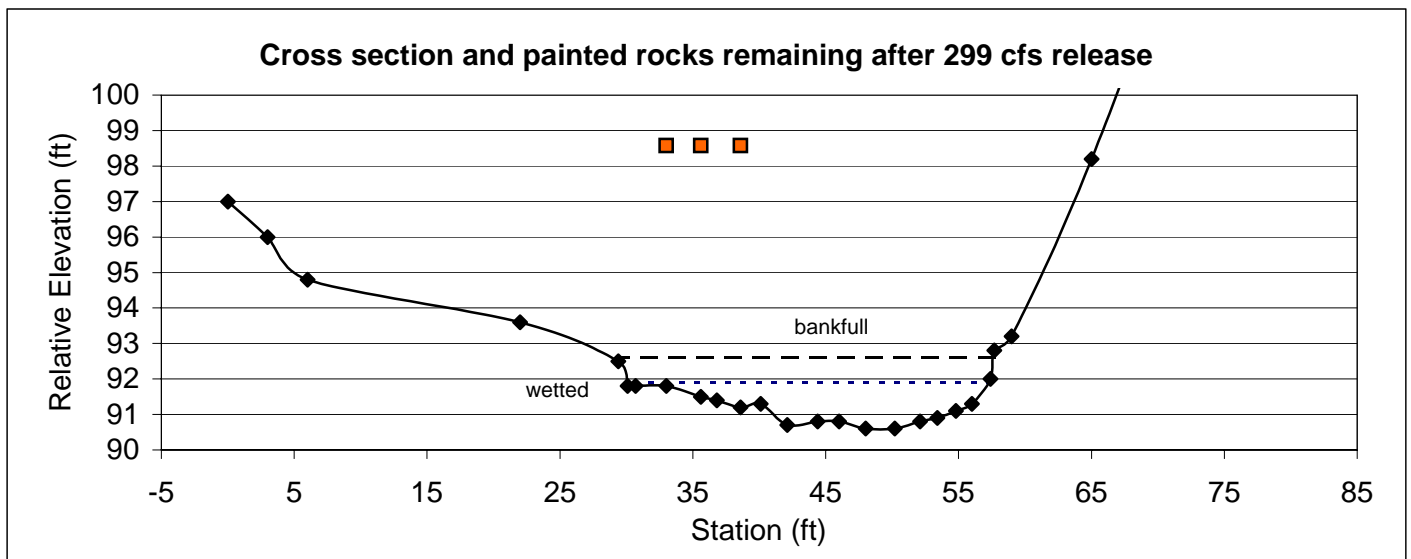
Slope: 0.0142857

Bankfull Width (ft)

35.7

H I: 100.7

Sta	BS	FS	Elev	Notes	Painted Rocks	Movement 16 cfs?	Movement 35 cfs?	Movement high flow?
BM	0.7		100	BM				
0		3.7	97	LBHP				
3		4.7	96					
6		5.9	94.8					
22		7.1	93.6					HW 22
29.4		8.2	92.5	BF WE				
30.1		8.9	91.8	WE				
30.7		8.9	91.8		4			all gone
33		8.9	91.8		4			0.5" 1" 2" gone
35.6		9.2	91.5		4			0.5" 1" 2" gone, 3" moved 1'
36.8		9.3	91.4		4			all gone
38.6		9.5	91.2		4		.5" gone	0.5" 1" 2" gone
40.1		9.4	91.3		4		.5" moved 1.5' ds	all gone
42.1		10	90.7		4	.5" and 1" gone	.5" gone	all gone
44.4		9.9	90.8		4			0.5" 1" 2" gone, 3" moved 2'
46		9.9	90.8		4			all gone
48		10.1	90.6		4			all gone
50.2		10.1	90.6		4			all gone
52.1		9.9	90.8		4			0.5" 1" 2" gone, 3" moved 3'
53.4		9.8	90.9		4		.5" gone	all gone
54.8		9.6	91.1		4			all gone
56		9.4	91.3		4	.5" gone	.5" gone	all gone
57.4		8.7	92	WE				
57.7		7.9	92.8	BF WE				HW; 1.5' deeper
59		7.5	93.2	RBHP				
65		2.5	98.2					
75		-7.5	108.2					
85		-40	140.7					



Station: Lake Creek 1

Slope: 0.0196429

Bankfull Width (ft)

50

H I: 100.8

Sta	BS	FS	Elev	Notes	Painted Rocks	Movement 16 cfs?	Movement 35 cfs?	Movement high flow?
BM	0.8		100	BM				
0		3.3	97.5	LBHP BM				
3		4.5	96.3	BF WE				HW 3
4		5.5	95.3					
5.3		5.8	95	WE				
9.9		6.2	94.6					
12.7		6	94.8		2		0.5" gone	all gone
14.4		5.8	95	WE				
15.4		5.7	95.1		3		0.5" gone	all gone
17.9		5.5	95.3	BF WE				
21.5		4.8	96	bar				HW 1' deep
25.4		5.4	95.4	BF WE				
27		5.8	95		4			0.5", 1", 2" gone
29		5.9	94.9		4			0.5", 1", 2" gone
30.5		6.3	94.5		4			all gone
31		6.3	94.5	WE				0.5", 1", 2" gone
32.7		6.9	93.9		4			0.5", 1", 2" gone
34		6.8	94		4	0.5" moved 2' US	0.5" moved 1.5 ft ds	all gone
35.9		7.2	93.6		4			all gone
38.1		7.4	93.4		3	0.5" gone	0.5 and 1" gone	all gone
39.4		7.3	93.5		4		0.5" moved 1.5 ft ds	0.5", 1", 2" gone
41.5		7.4	93.4		4		0.5" moved 1 ft ds	all gone
43.1		7.2	93.6		4			all gone
44.9		6.9	93.9		4			all gone
46.6		7	93.8		4			all gone
48.8		6.9	93.9		4			all gone
49.6		6.4	94.4	WE				
49.9		5.6	95.2	BF WE				
56.7		3.8	97					HW 53
59.5		3.8	97					
61.8		3.3	97.5					
64.4		2.9	97.9	RBHP				several 2" moved
75		2.5	98.3					five feet downstream
85		4.3	96.5					
95		2	98.8					
105		0.4	100.4					

Cross section and painted rocks remaining after 299 cfs release

