30 PERCENT DESIGN REPORT

HABITAT RESTORATION OF THE CHELAN RIVER REACH 4 AND TAILRACE

Prepared for

Public Utility District Number 1 of Chelan County

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List of Tables

List of Figures

Appendices

1 INTRODUCTION

This *30 Percent Design Report* (Design Report) accompanies the 30 Percent Design Drawings for the Habitat Restoration of the Chelan River Reach 4 and Tailrace. A separate *Design Memorandum* prepared at the outset of the design efforts describes the restoration objectives and design criteria that are being used to guide the design of the habitat restoration elements.

This Design Report describes the analysis conducted during the preparation of the 30 Percent Design to advance the understanding of the site conditions and support the project design. Many of the analyses are still ongoing and will be further advanced during the next stages of the project design. Since the analyses are continuing, this Design Report is a "working document" that will be refined in content and clarity during the next stages of the project design. All elevations contained in this document are reported in National Geodetic Vertical Datum of 1929 (NGVD29).

2 HYDROLOGY

Flow in the Chelan River Reach 4 is controlled by operation of the Lake Chelan Hydroelectric Project. Under past normal operating conditions, all water stored in Lake Chelan was diverted into the penstocks and powerhouse and returned to the tailrace, which meets the Chelan River at the downstream end of Reach 4. Flow was not released into the Chelan River below the dam except during spill conditions, when the lake level was high and inflow exceeded the turbine capacity. Normal turbine flows are 2,200 cubic feet per second (cfs); maximum capacity is approximately 2,300 cfs.

Under the terms of the new license, a minimum of 80 to 320 cfs will be released from the dam, and additional water will be pumped from the tailrace to meet minimum flow requirements in Reach 4 (Table 1 and Figure 1).

Table 1
Fish Flows Provided into Reach 4 under New License

Flow Provided By	Dry Year	Average Year	Wet Year
Dam outlet or spill	80 cfs all months	80 cfs July 16 to May 14	80 cfs July 16 to May 14
		200 cfs May 15 to July 15	320 cfs May 15 to July 15
Pumped water from tailrace	Additional 240 cfs pumped March 15 to May 15 and October 15 to November 30	Total of 320 cfs (combined spill plus pumped flow) March 15 to May 15 and October 15 to November 30	Total of 320 cfs (combined spill plus pumped flow) March 15 to May 15 and October 15 to November 30

Source: Lake Chelan Comprehensive Plan, Chapter 7, Table 7-3 (District 2003)

In addition to the planned releases, spill will also occur under the new license when lake levels are high and inflow exceeds turbine capacity. In the past, spills occurred occasionally during winter rain-on-snow events and almost every year during spring runoff conditions. Under the new license, new reservoir operating guidelines will likely result in fewer and lower magnitude spring spills. However, the exact result of changes under the new license is not known. Therefore, an analysis of past spills was conducted to provide information on high flow magnitudes and frequencies.

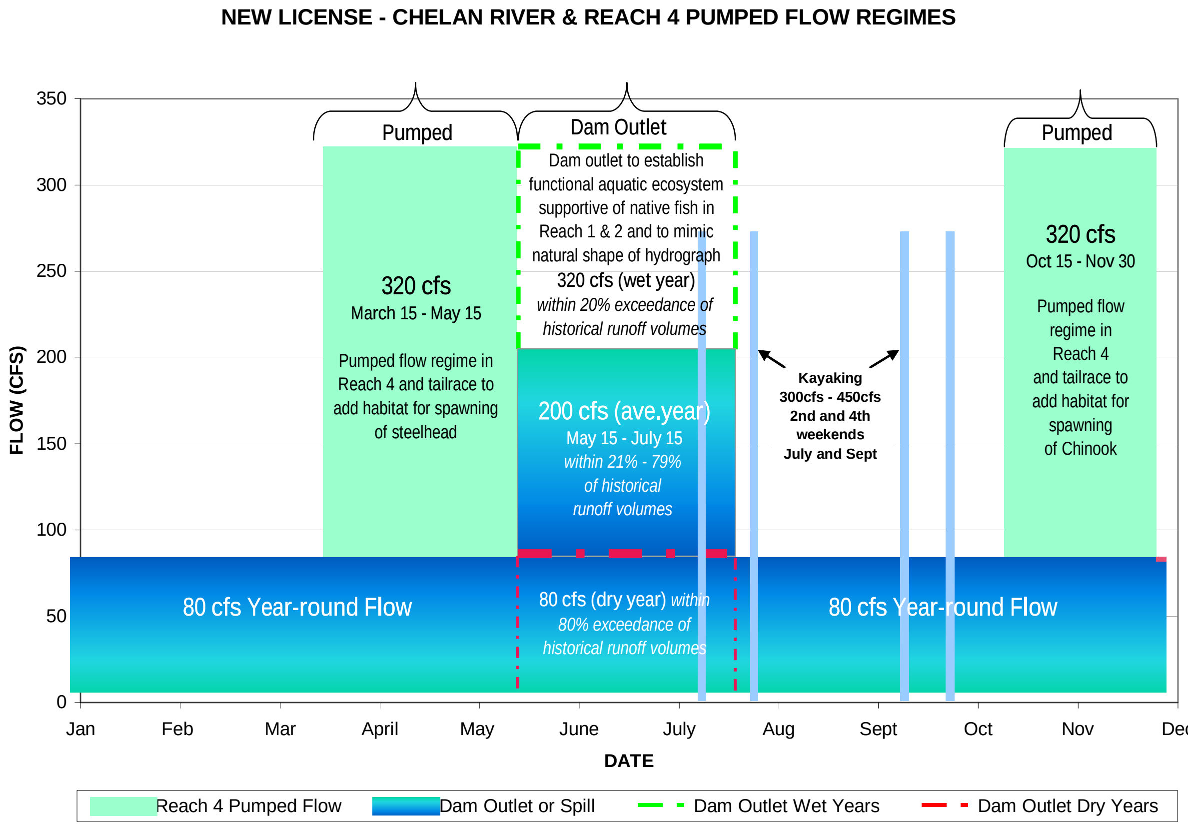


Figure 1
Flows in Reach 4 under New License Settlement Agreement

2.1 Methods

Flow records available for the Chelan River downstream of the dam include:

- U.S. Geological Survey (USGS) Gage 12452500 (Chelan River at Chelan, Washington)
  - Period of Record – (1903 to 2006) Includes mean daily flow and instantaneous peak flows
  - Remarks – Includes flow through turbines (up to 2,300 cfs), flow through two irrigation pipes that divert water from penstock just above the turbines, and spill discharge; the hydroelectric project began diverting flows in 1928
- Actual Spill records
  - Period of Record – (1974 to 2003) Mean daily flows (not instantaneous peak flows)
  - Remarks – Spill records provided by Public Utility District Number 1 of Chelan County (the District)

2.1.1 Mean Daily Flow Analysis

Actual Spill records were entered into an Excel spreadsheet to calculate monthly flow exceedence statistics (see Appendix A).

2.1.2 Peak Flow Analysis

Instantaneous peak flow records from the USGS gage were run through the USGS peak flow analysis program PKFQWin 5.0 to provide peak flow recurrence statistics (Flynn et al. 2005). Analyses were run for the following cases:

- USGS Gage, Period of Record (this includes flow through the turbines)
- USGS Gage, 1928 to 2006 (period of project operation; includes flow through turbines)
- Estimated Spill (i.e., Chelan River flow) – USGS Gage minus 2,200 cfs (the normal turbine flow), 1928 to 2006 (represents likely spill from dam during peak flow measurement)

2.2 Results

2.2.1 Mean Daily Flow Analysis

Spill into the Chelan River downstream of the dam occurs most years during the spring runoff season and occasionally during large fall/winter rain or rain-on-snow events. The 10 percent, 25 percent, and 50 percent mean daily reported spill exceedences for each month were plotted with month on the x-axis and flow on the y-axis (Figure 1). Flow exceedence refers to the percentage of days during each month that a particular flow is exceeded. For example, a 10 percent flow exceedence of 1,402 cfs during May means that for a 30-year analysis period on 10 percent of the days during May, or on average 3 days in May, the mean daily flow was over 1,402 cfs (conversely, 90 percent of the days' flows were less than 1,402 cfs). Flow exceedence values for mean daily recorded spills shows a monthly 50 percent exceedence value of 200 cfs in June and 544 cfs in July (Figure 2 and Appendix B). Note that this analysis groups all days of each month together (e.g., all June days for the 30 years of record are treated as a population, a total of 900 days).

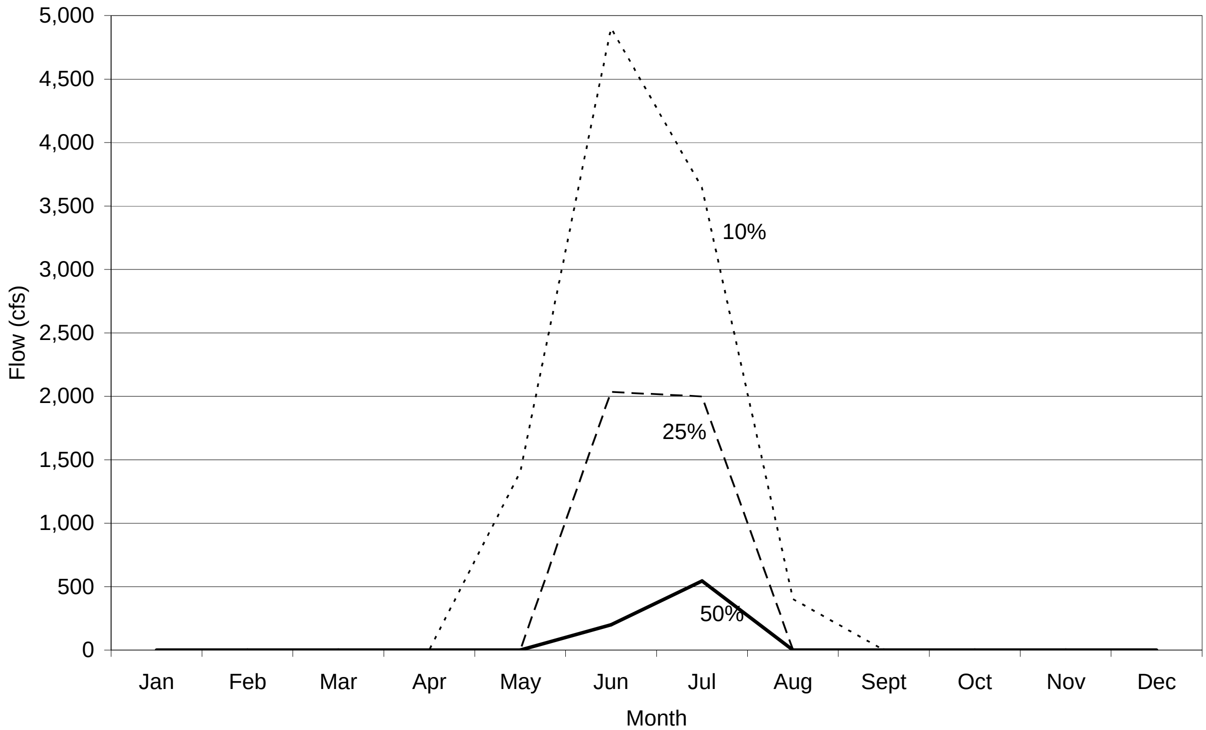


Figure 2
Historic Chelan River Spill Exceedence – 1974 to 2003

To provide additional detail on the likelihood and magnitude of spill during any given year, the percent of days over the period of spill records (30 years) that actually had spill was calculated for each day of the year (Figure 3). This analysis is not grouped by month, but by each day of the year (e.g., the population for June 1 is the flow on June 1st during each of the 30 years, a total of 30 days). Likelihood of spill is low during the fall, winter, and early spring. On over 10 percent of years, the days between mid-May and mid-August had spill. On over 60 percent of the years, days between mid-June and mid-July had spill, with median (50 percent exceedence) spill magnitudes between 250 to 1,400 cfs, and an average spill of 1,000 to 2,000 cfs. There was some spill during 26 of the 30 years of spill record.

Daily spill values for the 1974 to 2003 period are available in Appendix A if more detailed information is needed.

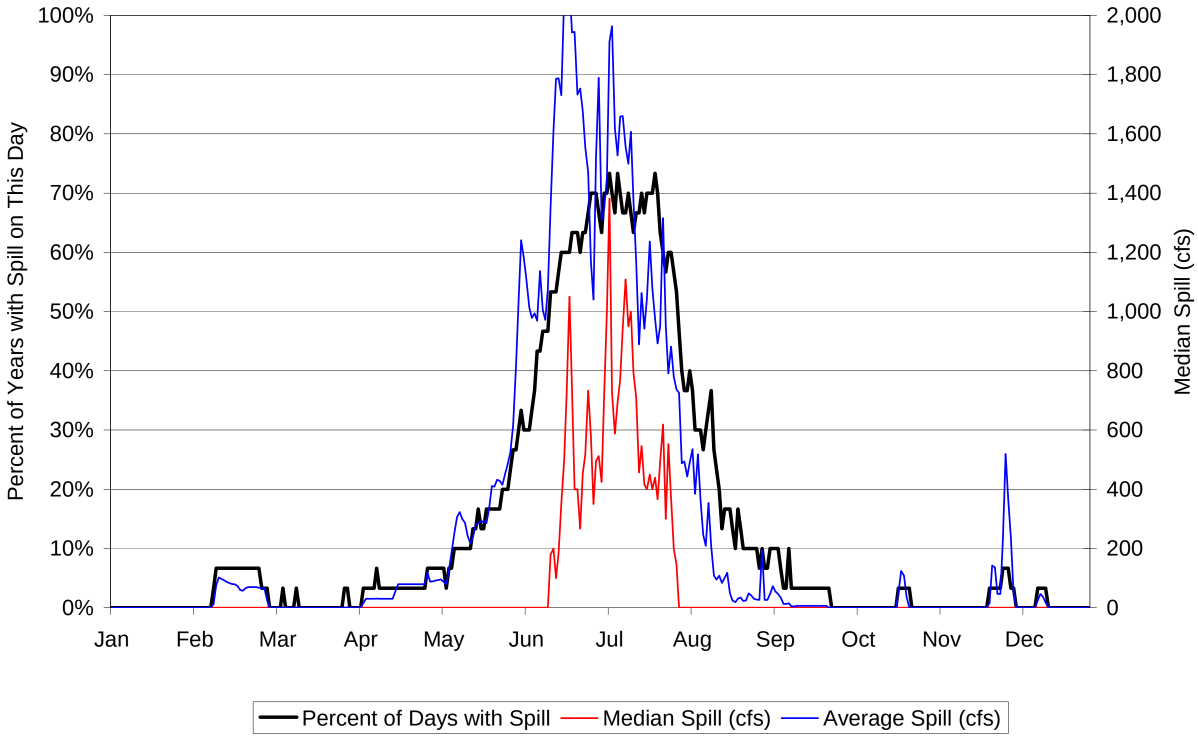


Figure 3
Historic Chelan River Days with Average and Median Spill Magnitude – 1974 to 2003

2.2.2 Peak Flow Analysis

Peak instantaneous flows were used to calculate peak flow recurrence intervals (Table 2). These data were based on the USGS peak instantaneous flow record. Instantaneous flows are higher than mean daily flows. The estimated with-project 5-year spill peak is 10,960 cfs; the 100-year spill peak is 22,400 cfs. This estimate is based on subtracting powerhouse flows (2,200 cfs) from each annual peak flow (which includes spill and powerhouse flow) for the 1928 to 2006 period and computing recurrence intervals based on this modified flow record ("Estimated Spill" column). This produces different flows than just subtracting 2,200 cfs from the results of the analysis of reported USGS flows ("USGS Gage" columns) due to the statistical method the flow recurrence uses to fit the flow distribution.

Table 2
Peak Flow Recurrence

Recurrence Interval (Years)	USGS Gage Period of Record (1903 to 2006) (cfs)	USGS Gage Period of Project Operation (1928 to 2006) (cfs)	Estimated Spill[a] (1928 to 2006) (cfs)
1.5	6,431	6,319	3,949
5	11,530	12,140	10,960
10	13,550	14,600	14,210
25	15,770	17,390	17,900
50	17,200	19,260	20,300
100	18,480	20,960	22,400

Note:
a) Estimated Spill is the estimated flow down the Chelan River.

Note that the 100-year estimated spill peak is higher than the full USGS Gage flow (with powerhouse flow included) peak. This is the result of the probability distribution method used to calculate peak flows, and points out the fact that the absolute magnitude of longer return interval flows is uncertain. The computed 95 percent confidence limit on the 100-year flood is +/-3,000 to 5,000. Therefore, there is statistically no difference between the estimated 100-year flood among the three flow scenarios.

The District has suggested that they may be able to control spills to keep them below approximately 6,000 or 8,000 cfs. Under past spill operations, 6,000 cfs had approximately a 2-year peak flow recurrence interval; 8,000 cfs had approximately a 3.1 year peak flow recurrence interval.

3 SEDIMENT

The geomorphic setting of Reach 4 is an aggrading delta. This setting presents several challenges to the design of the proposed habitat improvements, particularly with the goal of making natural, stable spawning and rearing habitat. River deltas are not naturally stable systems, but rather they aggrade, and channels often change position during large storm events. Challenges identified during initial design include:

- Aggradation (10 to 17 feet of aggradation has occurred since the mid-1970s)
- Multiple, shifting channels (shifts occur during high flow conditions)
- High flows during spill events could transport spawning-sized substrate out of the constructed channel improvement reach.

Figure 4 shows the profile of the Chelan River from the Chelan Dam to the confluence with the Columbia River. This stretch of the river can be divided into four geomorphic zones on the basis of channel slope (gradient) and confinement.

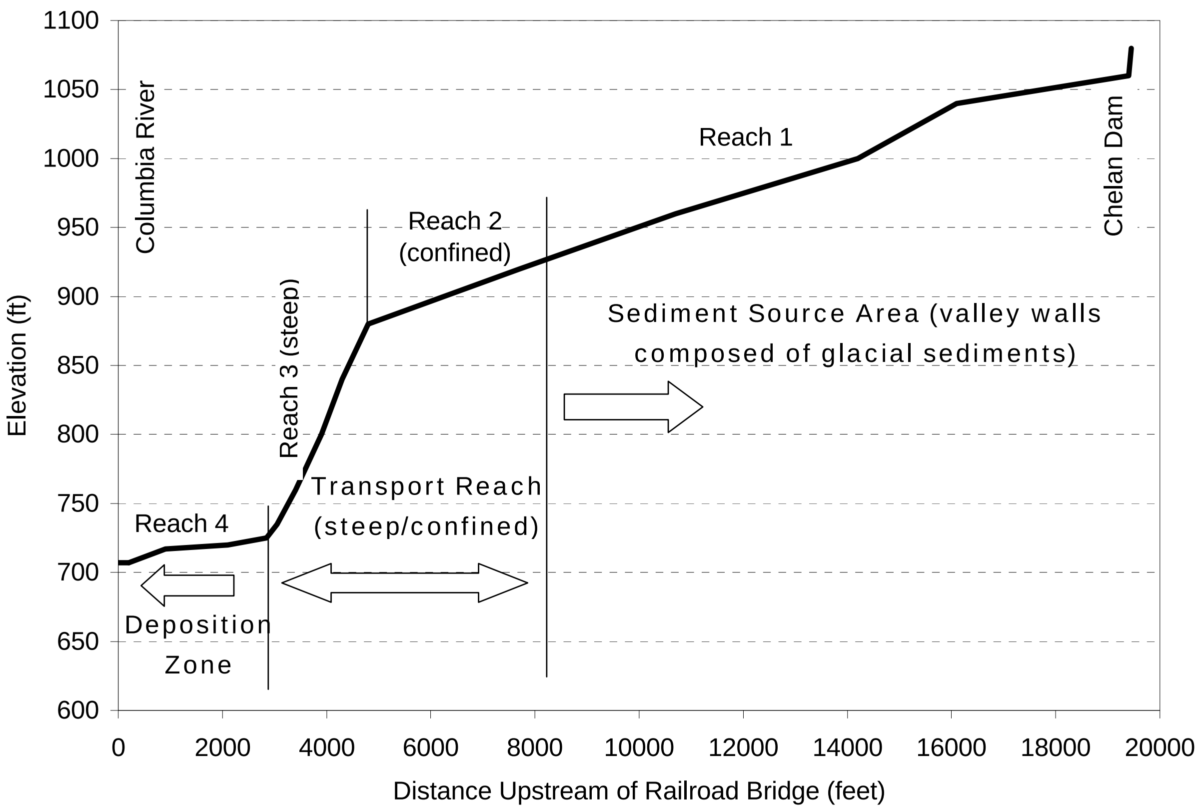


Figure 4
Chelan River Profile and Geomorphic Zones

Reach 1 extends from Chelan Dam downstream for 2.3 miles. This section is relatively low gradient (1 percent) and moderately confined by steep slopes of glacial moraine deposits. The glacial deposits are easily eroded, providing the river with a large source of boulders, cobbles, gravel, and sand when flows are high enough to erode the valley walls. Reach 2 has a similar low gradient but is within the upper portion of the narrow bedrock canyon. Reach 3 is the high gradient portion of the bedrock canyon. This reach is very steep (9 percent) and confined; sediment supplied from upstream reaches is transported quickly through this reach. Reach 4 is a very low gradient (0.4 percent), relatively unconfined reach. As a result of the extreme transition in gradient from Reach 3 to Reach 4, all the boulders, cobbles, and gravel from upstream reaches are deposited in Reach 4.

Based on the initial findings, the following specific items were identified as needing additional study during the design process:

1. Estimate timing and volume of sediment inputs into Reach 4 (primary source is bank erosion in Reach 1)
2. Determine timing and volume of sediment deposition in the pool upstream of the boulder weir and in the remainder of Reach 4
3. Assess stability of substrate placed in the new spawning/rearing channel under high flow conditions.

3.1 Methods

3.1.1 Grain Size Distribution

Sediment samples and pebble counts were taken to characterize the size distribution of sediments in Reach 4 for use in the sediment transport analysis and to determine the suitability of material for use as substrate in the spawning and rearing channel.

Sub-armor sediment samples were taken from each of the pump test pits. Grab samples were taken from the sub-surface deposits during digging of each of the pits. A 5-gallon bucket of sediment was taken using a shovel from each pit. Each bucket was labeled and transported to a sediment lab for dry sieving and Atterberg Limits.

Pebble counts were taken at 11 sites in Reach 4. Pebble count sites were designated based on the stationing marked on the ground by survey stakes: STA 24+00, STA 21+00,

STA 18+56, STA 17+00, STA 15+50, STA 14+00, STA 10+00, STA 9+00, STA 8+00, and STA 4+50. (Note that these stations are different than those used in the HEC-RAS model; HEC-RAS stations are approximately 232 feet higher than corresponding survey locations.) Pebble counts of 100 particles at each site were taken using the Wolman pebble count method—walking heel to toe in the sample area and selecting the particle at the toe of the surveyor's boot. The size of each particle was classified using a gravelometer into one of the following categories: less than 2 millimeter (mm), 2 to 4 mm, 4 to 8 mm, 8 to 16 mm, 16 to 32 mm, 32 to 64 mm, 64 to 128 mm, 128 to 256 mm, 256 to 512 mm, and 512 to 1024 mm. A gravelometer is a metal template with square holes corresponding to each of the noted grain size classes. Data were entered into a spreadsheet for graphing.

3.1.2 Sediment Sources and Deposition

Sediment input from Reach 1 was estimated by comparing bank and channel position in a series of historic aerial photographs (Table 3). Channel and bank position were marked on acetate sheets and overlain on subsequent aerial photographs to determine position and timing of eroding banks. Average length and width of eroded banks were measured, and bank heights were estimated from the USGS topographic map to determine eroded volume. It was assumed that all sediment eroded from banks was a net input of sediment and was transported through Reach 1, 2, and 3 and into Reach 4. These are reasonable assumptions since the eroded banks that were included in the analysis were the high valley walls composed of glacial deposits or historic river terraces (erosion of current, low river banks was not counted since bank erosion on the outside of meander bends is normally offset by deposition on the inside of the meander). The steep gradient, confined channel, and lack of gravel deposits in Reach 2 and 3 are consistent with the assumption that sediment eroded from Reach 1 is transported through to Reach 4.

Table 3
Aerial Photographs Used in Analysis

Date	Photograph	Flight	Source
9/20/26	Pre-project survey and boreholes	Not applicable	District
Spill: 5/30/48 – 13,800 cfs			
4/27/65	Black and white air photos 1:3,000 (Reach 1 and 2 only)	CHEL-65	Washington Department of Transportation (University of Washington Library)
5/23/66	B/W air photos 1:24,000	0409	Washington Department of Transportation
Spill: 6/21/67 – 13,700 cfs			
Spill: 6/3/68 – 16,200 cfs			
7/9/73	Black and white air photos; 1:63,600	CDS-H	Washington Department of Transportation (University of Washington Library)
Spill: 6/22/74 – 12,100 cfs			
Chelan Falls Road Bridge (805A) construction 1975; 5-17 feet of aggradation 1975-2002			
8/26/78	Color air photos 1:6,000	CF-78	Washington Department of Transportation (University of Washington Library)
Spill: 6/3/82 – 16,200 cfs			
1986	Black and white orthophoto 1:24,000	SC-H-86	Washington Department of Natural Resources(University of Washington Library)
9/11/90	Black and white air photos 1:24,000	CHELAN BL	Washington Department of Transportation
Spill: 11/30/95 – 14,800 cfs			
Approximately 2002	Color mosaic (photos are from different flights)	Digital	District

Note:
Timing of large spill events (over 12,000 cfs) are included in the table.

Timing and volume of deposition in Reach 4 was estimated based on comparison of historic maps and aerial photographs, observations made by Project operators, and changes in channel depth measurements made during construction and subsequent inspection of the Chelan Falls road bridge. In the absence of detailed historic topography, the volume of deposition was estimated based on the assumption that deposition filled in the average width (500 feet) and length (2,000 feet) of the delta to an average depth.

3.1.3 Sediment Transport Analysis

Erosion of substrate in Reach 4 under peak flow conditions was estimated for peak flows of 4,000, 6,000, 8,000, 11,000, and 14,000 cfs. These peak flows correspond to flows with a recurrence interval of 1.5, 2, 3.1, 5, and 10 years respectively. The HEC-RAS model output was used to determine water depth and shear stress (τ) in the main channel and left and right overbank at each of the HEC-RAS stations for each of the flows. Shear stress at each cross-section was compared to critical shear stress (τ^*_c) for each flow to determine the particle size that could be entrained by the flow.

The Shields criterion was used to determine the critical shear stress for initiation of substrate movement:

$$\tau^*_c = a(\gamma_s - \gamma_w)d_{50}$$

where τ^*_c = critical Shields stress for mobility of particle size d_{50}
a = constant, chosen as 0.039 for this analysis
γ_s and γ_w are the specific weights of sediment and water, respectively
d_{50} = median particle size at threshold of mobility

The criteria for determining if sediment that is already moving as bedload (e.g. moving through Reach 3 and into Reach 4) will continue to be transported or will settle out on the bed of the river is different than the criteria used to determine entrainment. Deposition of sediment in the pool upstream of the boulder weir and in Reach 4 was estimated using the Meyer-Peter Mueller bedload equation (Meyer-Peter and Muller 1948):

$$Q_{bj} = (39.25\ q^{2/3}\ S - 9.95\ d_j)^{1.5}$$

where Q_{bj} = bedload flux of the j grain size per unit width of river (pound per second per foot)
q = specific water discharge (cfs/foot of channel width)
S = water surface gradient
d_j = diameter of the j grain size (ft)

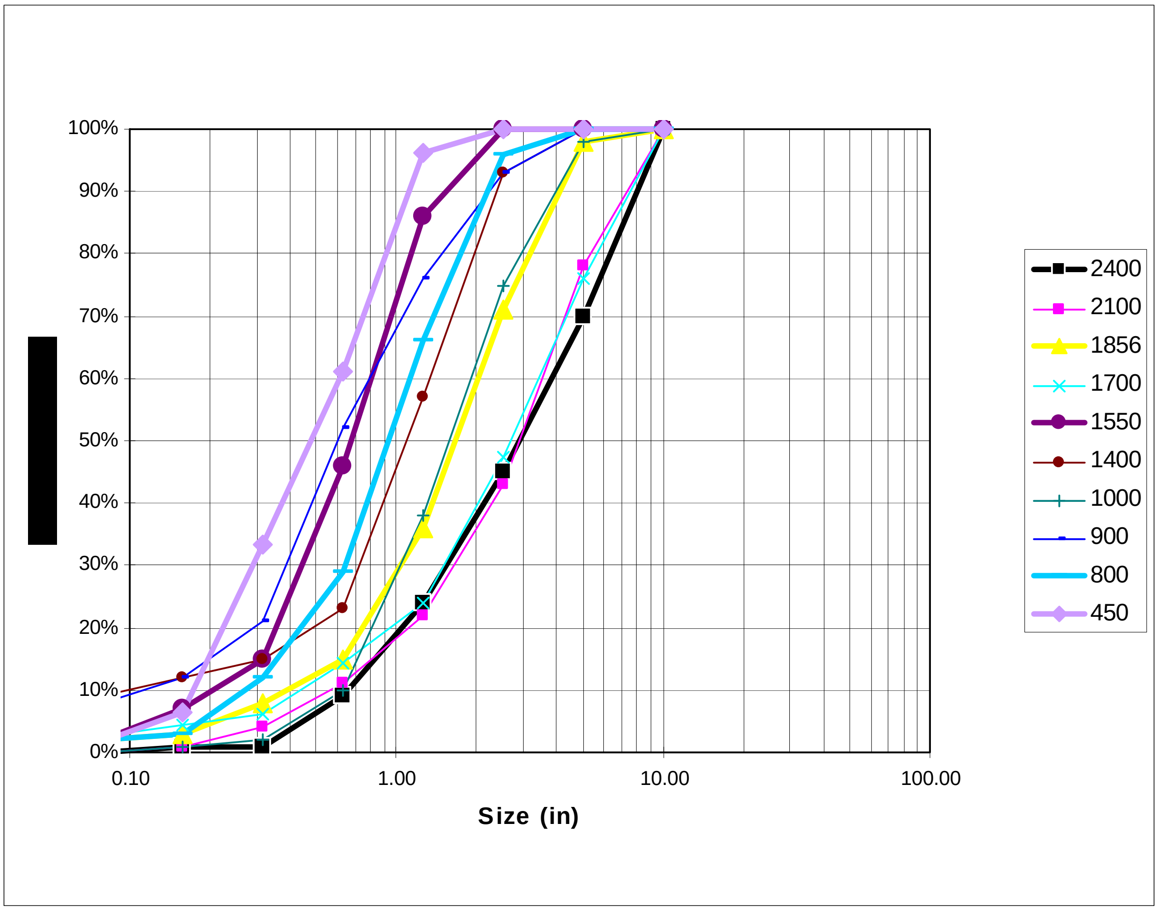
Sediment in each grain size class was assumed to drop out of transport and deposit on the bed when the bedload flux of that grain size equaled zero. The HEC-RAS output (discharge, width, and gradient) was used to determine the size of sediment that would drop out of transport at each cross-section under the different flow scenarios.

3.2 Results

3.2.1 Grain Size Distribution

Surface pebble counts and sub-surface sediment samples were taken in Reach 4. Detailed information on the grain size distribution of all the samples is provided in Appendix C.

Surface pebble count grain size distributions are summarized in Figure 5. Note that the information in Figure 5 is converted to grain size in inches. Graphs and data in Appendix 1 are in mm, the standard unit used for pebble counts and sieving. Median particle size of armor layer samples ranged from 77 mm (3 inches) near the top of Reach 4 to 12 mm (0.5 inches) near STA 4+50. Median particle size of the sub-armor samples (shown in Appendix C) ranged from 15 mm (0.6 inches) to 40 mm (1.5 inches). Sub-armor layers did not include particles larger than cobbles due to sampling constraints.



Note: The station locations described here do not correspond to station locations used in the hydraulic modeling. The hydraulic modeling of the proposed channel design adjusted the station positioning by approximately 232 feet. As a result, STA 4+00 in the test pit analysis corresponds to location 6+32 in the hydraulic modeling analysis.

Figure 5
Armor Layer Pebble Count Grain Size Distribution

3.2.2 Sediment Sources (Reach 1)

A series of historic aerial photographs of Reach 1 were compared to determine the location, timing, and extent of terrace and valley wall erosion between 1966 and 1990 (a more recent color photo mosaic was available, but the dates of the photo mosaic were not precisely known). Valley walls in Reach 1 are composed primarily of unconsolidated glacial deposits (sand, gravel, cobble, and boulder) that are easily eroded if the river impinges upon them at high flows.

The majority of valley wall/terrace erosion in Reach 1 occurred in the 0.5 mile section just upstream of the entrance to the gorge, between River Mile (RM) 1.9 and RM 2.4. Three areas of erosion were noted in this stretch, with 300 to 400 feet of bank retreat between 1966 and 1990. One other very high valley wall (approximately 200 feet high) is also eroding near RM 3.2. However, bank retreat over the period was not large enough to be measured at the scale of the aerial photographs (1:2,000). It was assumed that a total of 1 foot of bank retreat occurred along this bank over the measurement period. Bank erosion rates measured from aerial photographs should be treated as estimates due to errors associated with the small widths being measured at the scale of the photographs and the fact that the photos are not ortho-rectified.

Total estimated erosion between 1966 and 1990 was 860,000 cubic yards (CY). If it is assumed that this material eroded during peak flows over 12,000 cfs, an average of 214,000 CY would have eroded during each of the four peak flows during this period. Grain size samples of valley walls sediments were not taken. However, based on visual observations, the material consists of a mix of sand, gravel, and cobble material with occasional boulders.

Several of the eroding banks have been stabilized by placement of riprap during recent years. This should reduce the frequency and magnitude of erosion in Reach 1 in the future and reduce the amount of sediment transported into Reach 4. Limiting spill events over 10,000 to 12,000 cfs would also reduce future bank erosion.

3.2.3 Sediment Deposition in Reach 4

Reach 4 is a very low gradient (0.4 percent), relatively unconfined reach. As a result of the extreme transition in gradient from Reach 3 to Reach 4, all the boulders, cobbles, and gravel from upstream reaches are deposited in the reach. Reach 4 is an aggrading channel best characterized as an alluvial fan or delta environment with numerous anastamosing, shifting channels. Existing surficial sediments are predominantly boulder and cobble in the main flow channel and cobble to boulder in overbank areas. Construction of the fill for the railroad and road right of way across the mouth of the river in the mid-1970s and the backwater effect of the Rocky Reach pool in the Columbia River further exacerbate aggradation in this reach. Observations by the powerhouse operators suggest the channel has aggraded 8 feet in the past 15 years. This is consistent with bathymetric measurements made for the Chelan County Public Works Department on the Chelan Falls Road Bridge (No. 805A), which show "significant aggradation of the channel, as much as 17 feet between Piers 2 and 3" between 1975 and 2002 (letter report prepared by HPA Engineers, December 2002). Pre-project topographic mapping of Reach 4 is not very detailed but suggests the channel was 10 to 15 feet lower than at present (map dated Sept. 20, 1926, titled Chelan Station Powerhouse Sites, Location of Exploration Holes). Comparison of historic oblique photos during Project construction (1920s) and aerial photographs from 1966, 1973, 1978, 1990, and 2002 also show an aggrading, shifting channel. The long-term aggradation rates in Reach 4 are between 0.5 and 0.6 feet per year based on the different sources of data. However, sediment transport in gravel/cobble/boulder bedded rivers is not gradual but occurs episodically during peak flows. Project operators report deposition occurs in Reach 4 during flows over about 12,000 cfs. Lower flows are reported as clear water, with flows between about 4,000 cfs and 12,000 cfs cutting channels into the deposited sediments. Since the project was constructed in 1928, six flows over 12,000 cfs have occurred (Table 3).

Based on an average aggradation depth of 10 feet between 1974 and 2000, an estimated 370,000 CY of sediment accumulated in Reach 4. During this period, three peak flows over 12,000 cfs occurred. If it is assumed that sediment was transported primarily during these flow events, an average of 123,000 CY of sediment (approximately 3 feet of deposition) would have occurred during each of the three high flows.

Note that the estimated erosion from Reach 1 was approximately 214,000 CY per event, and deposition in Reach 4 was approximately 123,000 CY per event. The difference between these two estimates is due in part to the errors in estimating sediment volumes and in part to the fact that material eroded in Reach 1 includes a mix of sand, gravel, cobble, and boulder material, while the sediment deposited in Reach 4 includes primarily the gravel-, cobble-, and boulder-size fractions with a smaller percentage of sand. Much of the sand and finer-grained material eroded from Reach 1 is transported through Reach 4 and into the Columbia River.

3.2.4 Potential for Erosion of Substrate in Constructed Channel

The potential for erosion of substrate placed in the proposed new enhancement channel was determined based on Shields' criterion and HEC-RAS hydraulic output at each cross-section. Substrate placed in the new spawning/rearing channel is planned to be gravel- and cobble-sized (0.5 to 6 inches). Substrate larger than approximately 1.5 inches is calculated to be stable at all cross-sections downstream from HEC-RAS STA 21+00 at flow up to 8,000 cfs, and at most cross-sections at flows up to 14,000 cfs.

3.3 Conclusions

Based on the analysis of historic aerial photographs, grain size analysis, computations made from the HEC-RAS output, and observations of Project operators, the following conclusions can be drawn about the proposed channel modifications in Reach 4:

1. *Timing and volume of sediment inputs into Reach 4* – In the past, sediment has been eroded from river banks in Reach 1 and transported into Reach 4 when flow in the Chelan River is over approximately 12,000 cfs. An estimated 370,000 CY of sediment has accumulated in Reach 4 over the past 30 to 40 years. This accumulation likely occurred during three peak flow events over this period. Sediment accumulations in Reach 4 should be at a lower rate in the future as a result of armoring of several of the eroding banks in Reach 1 and implementing new operating guidelines that will help to limit the magnitude and frequency of spills. However, it should be anticipated that some peak flows over 12,000 cfs will occur during the new license period (likely recurrence interval 8 to 10 years) that will result in aggradation and/or channel shifting in Reach 4. Channel shifting could affect the new spawning/rearing channel.
2. *Timing and volume of sediment deposition in the pool upstream of the hydraulic control structure* – Particles larger than 3 to 4 inches in diameter are calculated to deposit in the pool during peak flow events large enough to erode streambanks in Reach 1 (estimated 12,000 cfs). Based on the estimate of past erosion and deposition volumes, the pool will fill in a single peak flow event.

3. *Stability of substrate placed in the new spawning/rearing channel under high flow conditions* – Substrate in the greater than 1 to 6-inch-size range should be stable under high flow conditions if the main flow channel remains separate from the enhanced channel. There will likely be winnowing of some particles smaller than 1 inch in diameter, and local scouring of larger particle sizes. If aggradation or a large peak flow occurs and the main (high flow) channel migrates or switches into the enhanced channel, erosion of substrate will occur.

These conclusions are based on the HEC-RAS model of flows through Reach 4 with channel modifications and separate calculations of sediment transport and deposition. The new HEC-RAS version used for the hydraulic analysis has a Beta version of sediment transport analyses. This function will be investigated to determine if it will function properly to calculate sediment erosion and deposition through Reach 4 as part of the ongoing design process.

Additional information on the erosion of sediment in Reaches 1 and 4 could be obtained by the placement of painted rocks at select locations prior to any planned spill events this spring. This information would help ascertain the stability of banks in Reach 1 and substrate in Reach 4 under normal annual spill conditions.

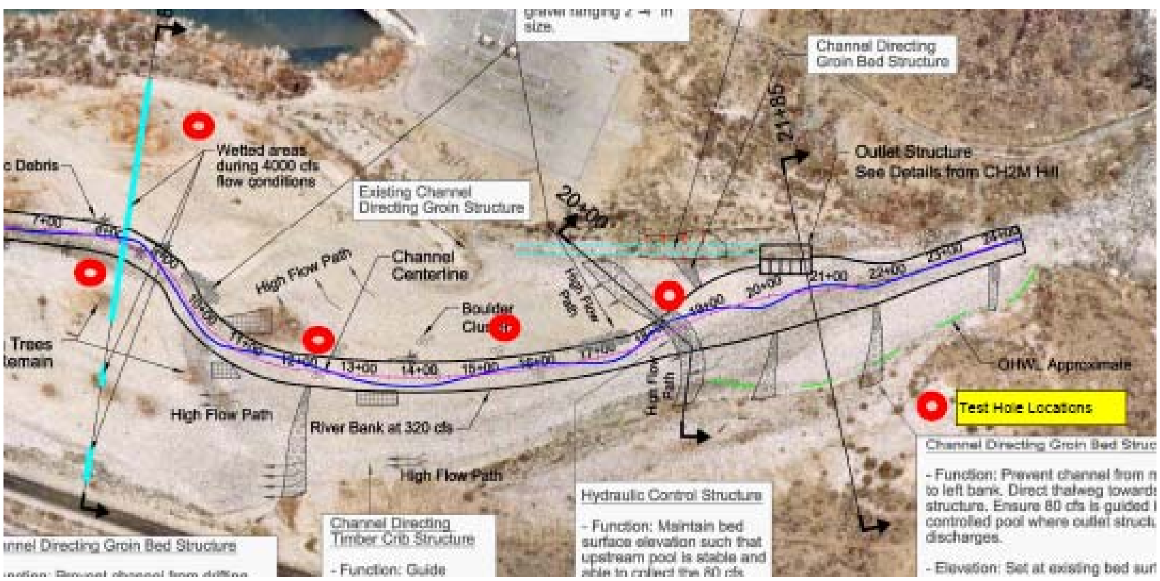
4 PUMP TEST

4.1 Introduction

Field and laboratory testing of surface water percolation rates was conducted to evaluate the ability of the restored channel to hold water at surface.

4.2 Methods

On January 16, 2007, test pits and pumping tests were conducted at the Reach 4 channel. The weather was cold (10 to 20 degrees Fahrenheit and the top 16 inches of substrate was frozen). Six stations distributed throughout Reach 4 were sampled (Figure 6). Station reference is relative to the original Anchor Environmental, L.L.C. (Anchor), drawing and channel alignment that was staked in the field by the District[1]. Station reference starts with STA 0+00 at the downstream end of Reach 4 and increases in number reference moving upstream. Table 4 identifies the tests conducted at each station. Additional tests relevant to sediments were conducted at each station and are reported in the sediment section of this report.



Note: STA 4+00 not shown

Figure 6
Test Pit Locations

[1] The station locations described for the test pits do not correspond to station locations used in the hydraulic modeling. The hydraulic modeling of the proposed channel design adjusted the station positioning by approximately 232 feet. As a result, STA 4+00 in the test pit analysis corresponds to location 6+32 in the hydraulic modeling analysis.

Table 4
Tests Conducted at Each Station

Station	Falling Head Test		Pump Test
	Field	Lab	
STA 4+00		✓	
STA 8+00	✓		
STA 9+00	✓		
STA 12+00	✓		✓
STA 15+50	✓	✓	
STA 18+50	✓		

Test holes were dug 3 to 5 feet deep with a track mounted excavator. Hole radius at the bottom ranged from 5 to 7 feet. Water was pumped into the holes from the Powerhouse Tailrace to provide a water level. The pump was then shut off and the rate of falling water recorded. At STA 12+00, a pump test was conducted at a pumping rate of 200 gallons per minute (gpm).

4.3 Results

Table 5 is a summary of data collected from the falling head tests. Groundwater was never found in the excavation areas. The deepest point of excavation was elevation 704.3 feet at STA 15+50 and 704.7 feet at STA 8+00. Both of these elevations are below the Chelan River Tailrace Water Surface Elevation (WSEL) of 709.1 feet at the time of testing. CH2M Hill did report finding groundwater at one deep excavation along the flume alignment.

Table 5
Summary of Falling Head and Pump Test Data

Station	Rising Time (min)	Falling Time (min)	Pump Rate (gpm)	Hole Volume				Rising Rate (gpm)	Falling Rate in Field (gpm)	Falling Rate in Field (in/hr)	Falling Rate in Lab (gpm)
				Depth (ft)	Radius (ft)	Volume (cf)	Bottom Elevation (ft)				
STA 4+00											70
STA 8+00		6.7		2.5	5.5	950	704.7		1,114	269	
STA 9+00		9.79		2.8	7.1	1,773	706.1		762	253	
STA 12+00	6	8	200	2	6.3	997	710.6	1,243	933	93	
STA 15+50		12.78		2.72	5.2	924	704.3		584	152	423
STA 18+50		22.37		2.96	6.4	1,523	715.4		334	95	

cf = cubic feet
in/hr = inches per hour
min = minutes

Field and laboratory falling head rates ranged from 70 to 423 inches per hour. All field and laboratory results were within the calculated ranges. This equates to an average loss of 0.0045 feet per second (fps). Graphs of the falling rate for each station evaluated in the field are shown in Figures 7 through 11. Photographs of each site showing representative examples of the substrate are also shown in Photographs 1 through 10.

The STA 12+00 pump test included a measurement of a static water elevation at a pumping rate of 200 gpm in a flow area of 79.1 square feet (sf). An apparent velocity was calculated at 1.6 feet per minute (fpm).

4.4 Discussion

The tests were performed within the ranges of the proposed channel and represent a good cross-section of the channel profile. Based on observations of the substrate, results of the falling head tests, and the one static pump test performed, it is apparent Reach 4 of the Chelan River has a very high potential to percolate water into the surrounding floodplain. Not only was groundwater not present (even at levels below the Chelan River Tailrace WSEL), but the sediment size and poorly graded gravel with sand appear to extend deep down into the floodplain.

Applying the average flow rate of 0.0045 fps over the proposed channel length of 1,800 feet and 60 feet wide, potential water loss equals 484 cfs. Powers (1992) developed empirical relationships between groundwater seepage in floodplains relative to spawning channels and measured a reduction factor to account for uncertainties in applying a small test area result to a full channel length. Data showed total groundwater flows were actually 5 to 15 percent of the predicted values. Applying these empirical relationships to the Chelan Reach 4 site, one would expect a water loss in the range of 25 to 75 cfs. The loss would likely be less over time as the Reach 4 area receives continuous flow. Losses in the range to 25 cfs or less would not likely reduce the effective operation of the channel. Given the potential error in estimating the losses, additional monitoring is recommended to measure downstream flow reduction during an 80 cfs flow release.

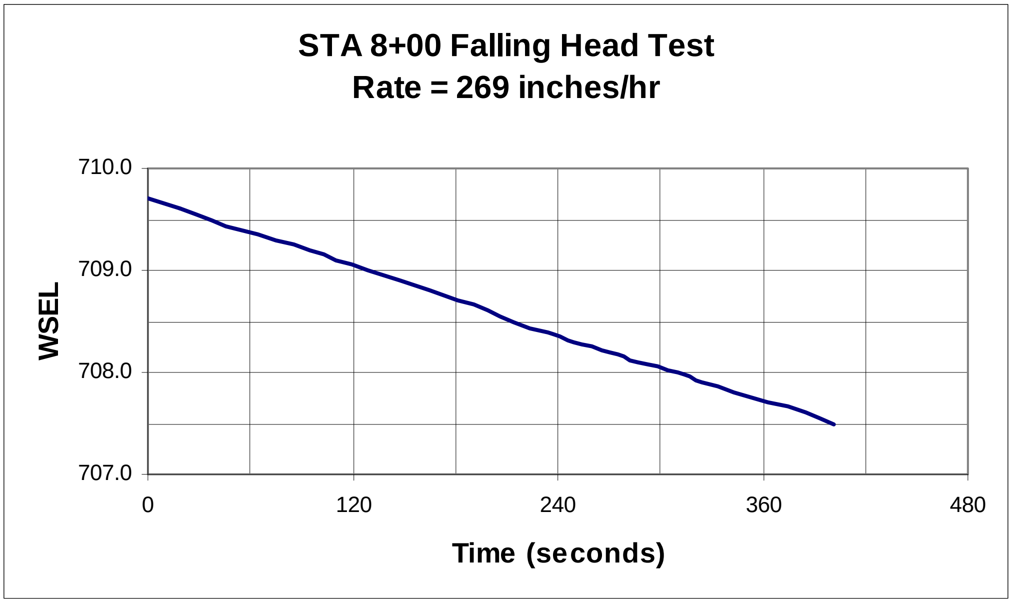


Figure 7
STA 8+00 Falling Head Test

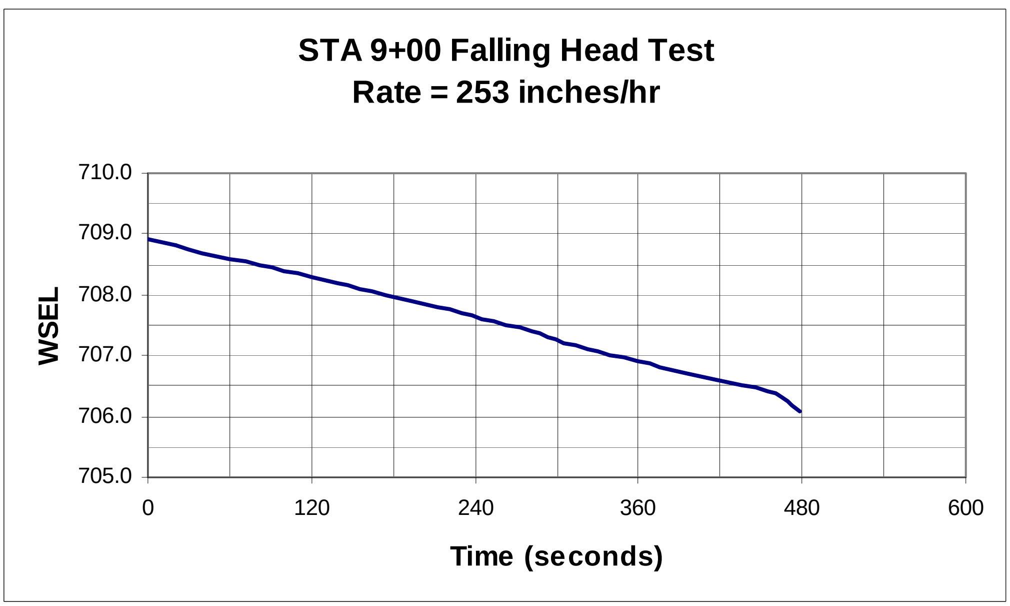


Figure 8
STA 9+00 Falling Head Test

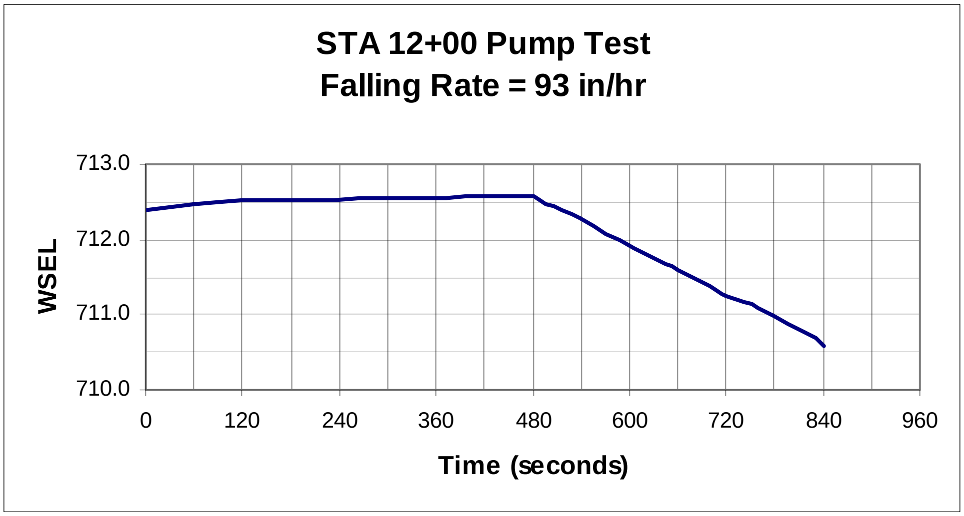


Figure 9
STA 12+00 Pump and Falling Head Test

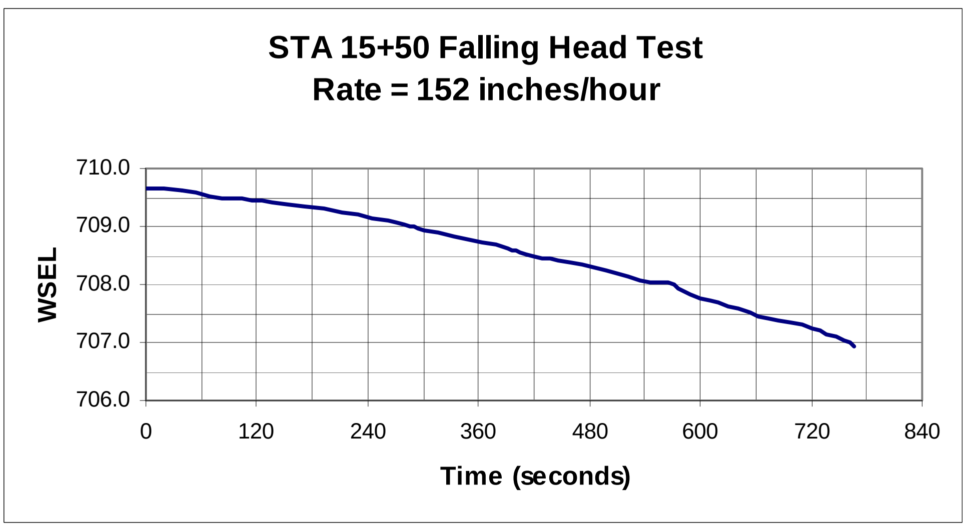


Figure 10
STA 15+50 Falling Head Test

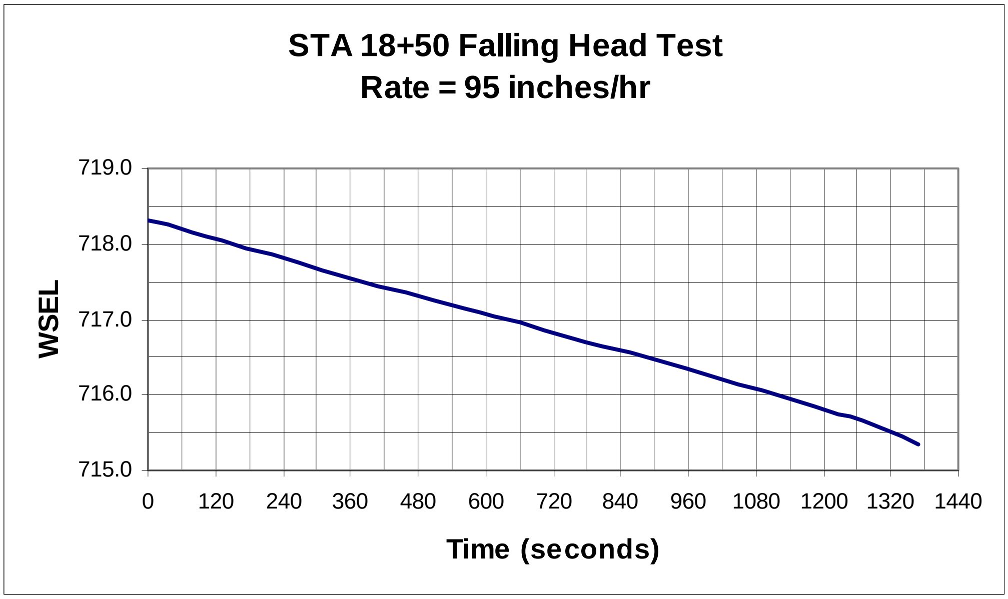


Figure 11
STA 18+50 Falling Head Test

Photograph 1 – STA 8+00 Falling Head Test

Photograph 2 – STA 8+00 Staff Gage

Photograph 3 – STA 9+00 Test Hole

Photograph 4 – STA 9+00 Substrate

Photograph 5 – STA 12+00 Test Hole

Photograph 6 – STA 12+00 Substrate

Photograph 7 – STA 15+50 Charging Test Hole

Photograph 8 – STA 15+50 Substrate

Photograph 9 – STA 18+50 Charging Test Hole

Photograph 10 – STA 18+50 Falling Head Test

5 GEOTECHNICAL ANALYSIS

The hydraulic control structure will consist of a concrete core surrounded by grouted boulders. Quarry rock will be placed on top of the grouted boulders in order to grade the structure to the desired slope. Upstream of the hydraulic control structure, native river cobbles will be the predominant substrate.

A geotechnical analysis of the structure will be performed to evaluate the following factors:

- Bearing capacity of the native subgrade to support the structure
- Sliding stability of the structure under the service loads
- Overturning stability
- Uplift forces resulting from hydraulic pressure differences across the structure
- Potential settlement of the structure
- Seepage through and beneath the hydraulic control structure

The results of the geotechnical analyses will be used to determine the stability of the structure and to evaluate any changes that may be necessary to meet performance requirements. The structure will be evaluated under both static and seismic conditions, with the design earthquake assuming a 100-year return interval. The target factor of safety for static stability will be 1.5 and the target seismic factor of safety will be 1.1.

The limit equilibrium software Slide 5.0 will be used to evaluate bearing capacity and sliding stability. The groundwater module of Slide 5.0 will be used to evaluate seepage and uplift pressures. Settlement and overturning will be evaluated using standard geotechnical engineering computation methods.

6 REFERENCES

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Meyer-Peter, E. and R. Muller, 1948. Formulas for bedload transportation. Proc. Second Meeting Int. Assoc. Hydraulic Res. Stockholm, pp. 39-64.

Powers, P.D. 1992. Draft in Progress. *Hydraulics of groundwater fed spawning channels and rearing ponds*. Washington Department of Fish and Wildlife Habitat Program. Olympia, Washington.

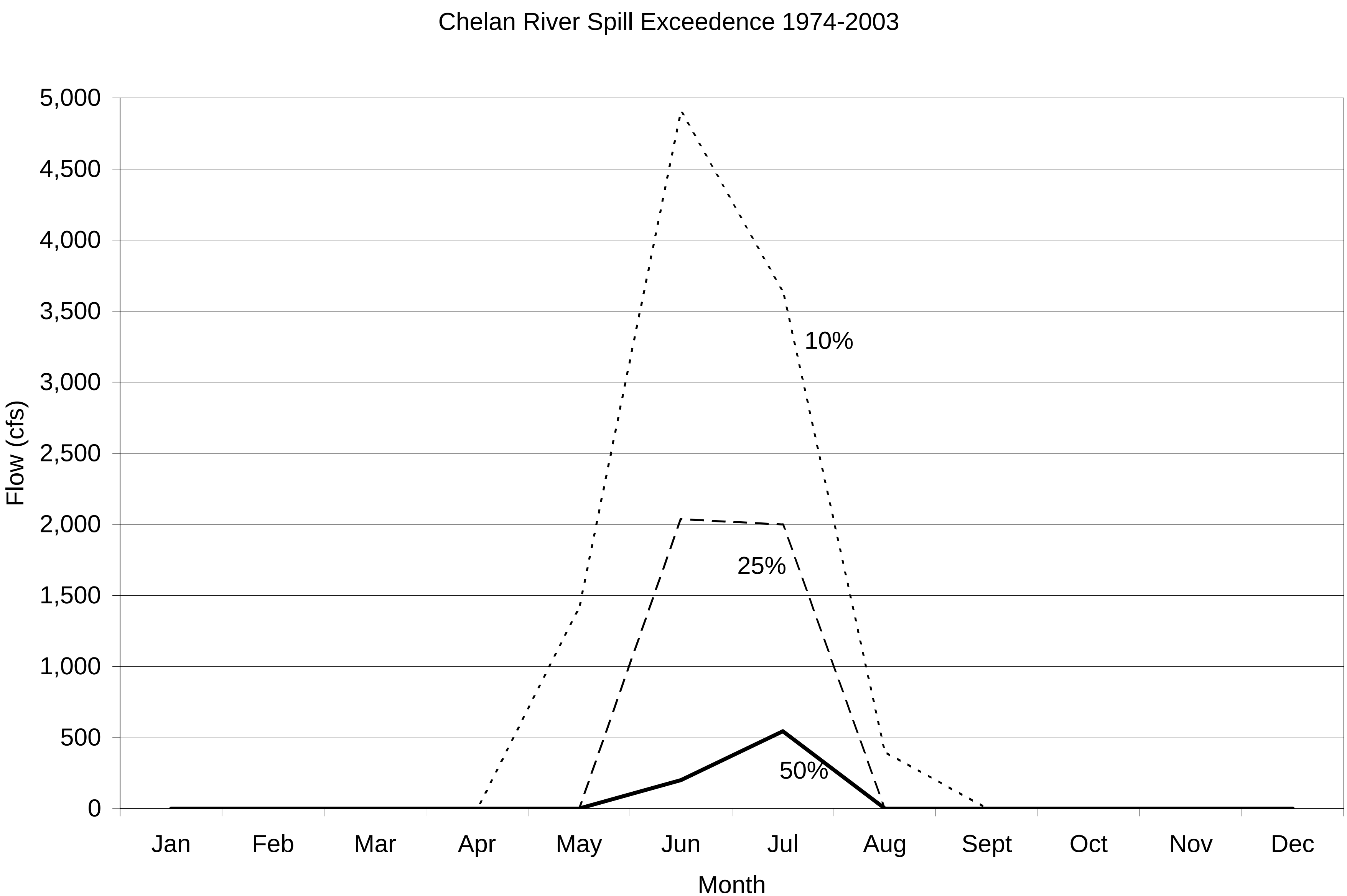
Public Utility District Number 1 of Chelan County (District). 2003. *Lake Chelan Comprehensive Plan*. Attachment B to the Lake Chelan Settlement Agreement. Lake Chelan Hydroelectric Project. FERC Project No. 637. October 8, 2003.

Stillwater Sciences, 2001. Conceptual Alternatives for Chelan River Restoration: Final. Unpublished report prepared for Lake Chelan Caucus and Chelan County PUD. June 20, 2001.

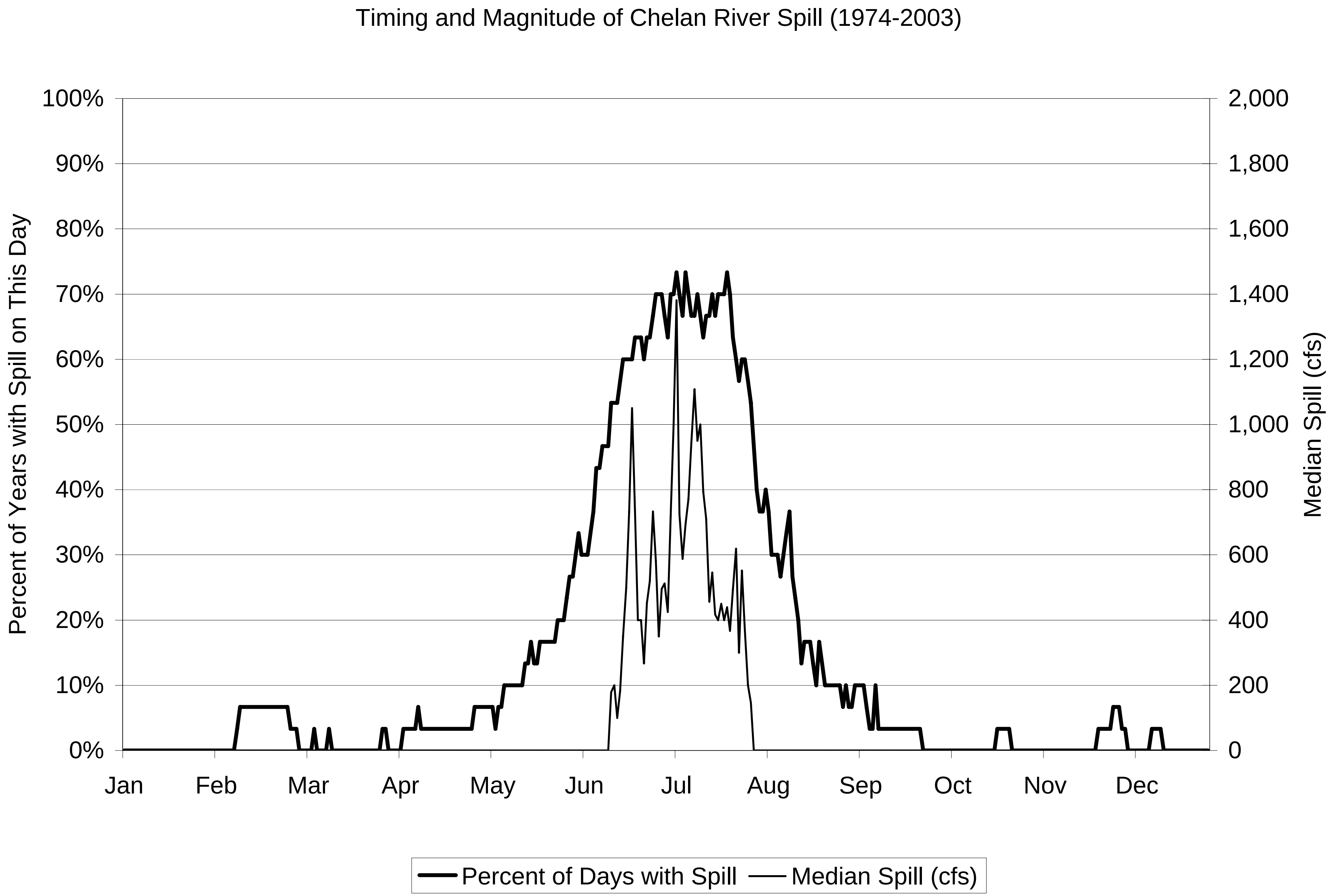
APPENDIX A

CHELAN_SPILL_HYDROLOGY.XLS

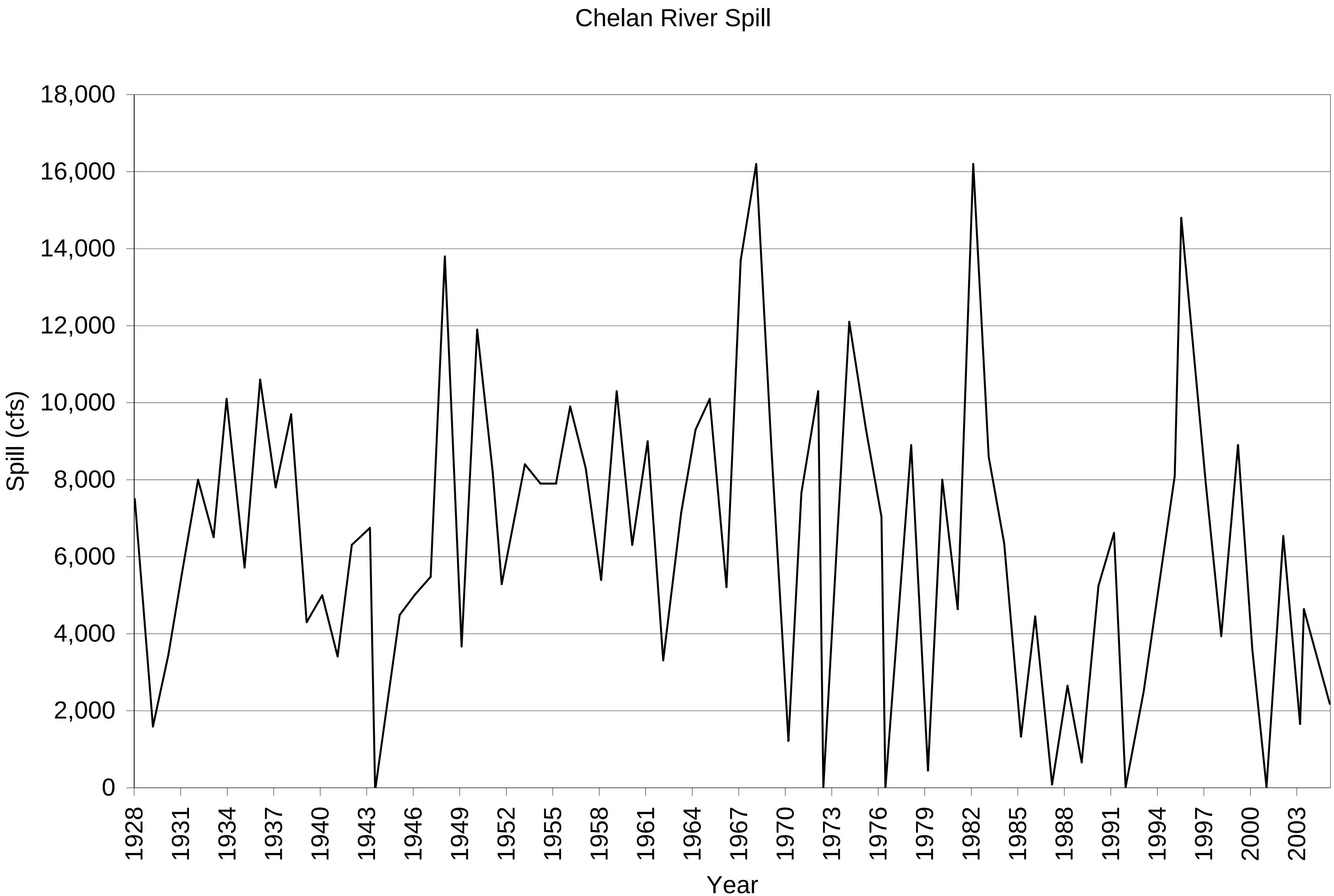
(Excel file with daily and peak flow values and analyses)



Chelan River Spill Exceedence 1974-2003
Flow (cfs)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
10%
25%
50%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Month



Timing and Magnitude of Chelan River Spill (1974-2003)
Percent of Years with Spill on This Day
Median Spill (cfs)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Percent of Days with Spill
Median Spill (cfs)


Chelan River Spill
Spill (cfs)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1928
1931
1934
1937
1940
1943
1946
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
Year

APPENDIX B

MONTHLY FLOW EXCEEDENCE VALUES

Appendix B
Monthly Flow Exceedence Values

Based on mean daily "Actual Spill" flows provided by the District for 1974 to 2003

Percent Exceedence (%)	Jan (cfs)	Feb (cfs)	Mar (cfs)	Apr (cfs)	May (cfs)	Jun (cfs)	Jul (cfs)	Aug (cfs)	Sept (cfs)	Oct (cfs)	Nov (cfs)	Dec (cfs)
0	0	2,000	33	2,400	6,754	12,763	9,896	6,821	1,200	3,750	14,633	10,700
2	0	1,364	0	900	3,500	8,118	6,117	2,544	200	0	0	0
4	0	100	0	0	2,799	6,992	5,000	1,545	25	0	0	0
6	0	0	0	0	2,400	6,076	4,482	1,100	0	0	0	0
8	0	0	0	0	1,954	5,642	3,999	799	0	0	0	0
10	0	0	0	0	1,402	4,902	3,642	400	0	0	0	0
12	0	0	0	0	686	4,026	3,455	240	0	0	0	0
14	0	0	0	0	0	3,751	3,097	200	0	0	0	0
16	0	0	0	0	0	3,303	2,879	141	0	0	0	0
18	0	0	0	0	0	3,034	2,584	100	0	0	0	0
20	0	0	0	0	0	2,805	2,309	46	0	0	0	0
22	0	0	0	0	0	2,482	2,094	0	0	0	0	0
24	0	0	0	0	0	2,149	2,000	0	0	0	0	0
25	0	0	0	0	0	2,035	1,998	0	0	0	0	0
26	0	0	0	0	0	2,000	1,863	0	0	0	0	0
28	0	0	0	0	0	1,789	1,683	0	0	0	0	0
30	0	0	0	0	0	1,566	1,526	0	0	0	0	0
32	0	0	0	0	0	1,303	1,400	0	0	0	0	0
34	0	0	0	0	0	1,100	1,250	0	0	0	0	0
36	0	0	0	0	0	1,000	1,100	0	0	0	0	0
38	0	0	0	0	0	900	1,071	0	0	0	0	0
40	0	0	0	0	0	653	1,000	0	0	0	0	0
42	0	0	0	0	0	400	898	0	0	0	0	0
44	0	0	0	0	0	378	800	0	0	0	0	0
46	0	0	0	0	0	300	786	0	0	0	0	0
48	0	0	0	0	0	200	683	0	0	0	0	0
50	0	0	0	0	0	200	544	0	0	0	0	0
52	0	0	0	0	0	30	400	0	0	0	0	0
54	0	0	0	0	0	0	400	0	0	0	0	0
56	0	0	0	0	0	0	333	0	0	0	0	0
58	0	0	0	0	0	0	210	0	0	0	0	0
60	0	0	0	0	0	0	200	0	0	0	0	0
62	0	0	0	0	0	0	200	0	0	0	0	0
64	0	0	0	0	0	0	124	0	0	0	0	0
66 to 100	0	0	0	0	0	0	0	0	0	0	0	0

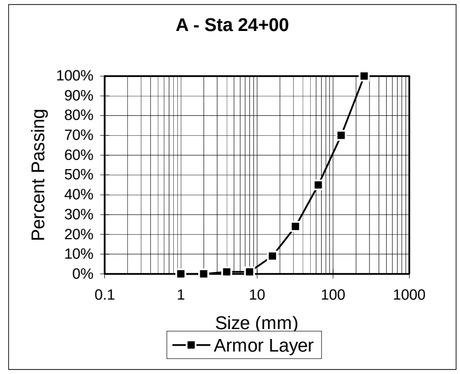
APPENDIX C

REACH 4 GRAIN SIZE DATA

Pebble Count (Armor Layer) Data

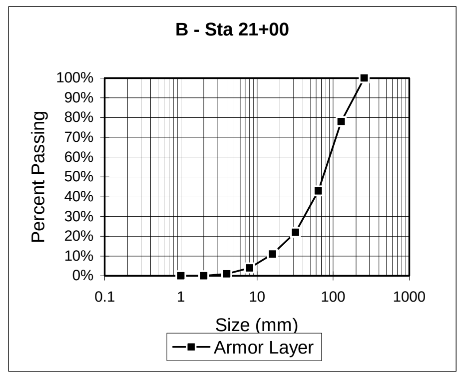
Station **A - Sta 24+00**

Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	115.2	mm	
			D50=	76.8	mm	
1	**0.04**	0%	0%	0.00		0
2	**0.08**	0%	0%	0.00		0
4	**0.16**	1%	1%	0.06		1
8	**0.31**	0%	1%	0.00		0
16	**0.63**	8%	9%	1.92		8
32	**1.26**	15%	24%	7.20		15
64	**2.52**	21%	45%	20.16		21
128	**5.04**	25%	70%	48.00		25
256	**10.08**	30%	100%	38.40		30
			Dg	115.74	mm	100
				0.3797	ft	



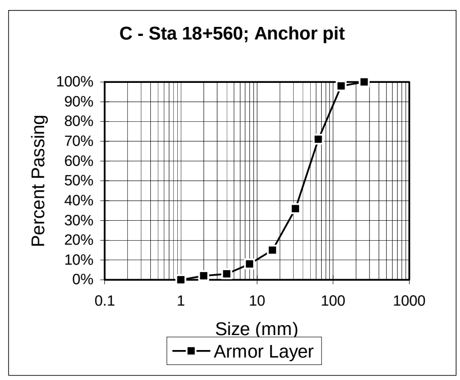
Station **B - Sta 21+00**

Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	104.2	mm	
			D50=	76.8	mm	
1	**0.04**	0%	0%	0.00		0
2	**0.08**	0%	0%	0.00		0
4	**0.16**	1%	1%	0.06		1
8	**0.31**	3%	4%	0.36		3
16	**0.63**	7%	11%	1.68		7
32	**1.26**	11%	22%	5.28		11
64	**2.52**	21%	43%	20.16		21
128	**5.04**	35%	78%	67.20		35
256	**10.08**	22%	100%	28.16		22
			Dg	122.90	mm	100
				0.4032	ft	



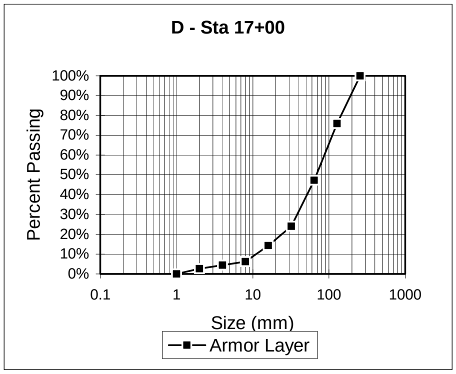
Station **C - Sta 18+560; Anchor pit**

Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	58.5	mm	
			D50=	44.8	mm	
1	**0.04**	0%	0%	0.00		0
2	**0.08**	2%	2%	0.06		2
4	**0.16**	1%	3%	0.06		1
8	**0.31**	5%	8%	0.60		5
16	**0.63**	7%	15%	1.68		7
32	**1.26**	21%	36%	10.08		21
64	**2.52**	35%	71%	33.60		35
128	**5.04**	27%	98%	51.84		27
256	**10.08**	2%	100%	2.56		2
			Dg	100.48	mm	100
				0.3297	ft	



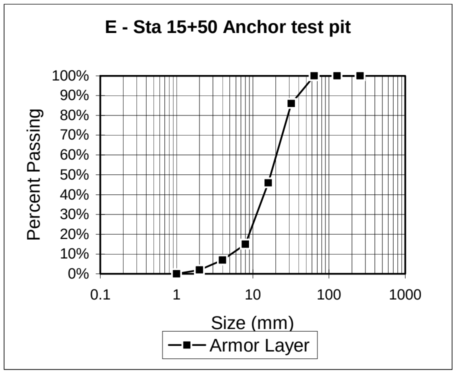
Station **D - Sta 17+00**

Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	103.6	mm	
			D50=	70.0	mm	
1	**0.04**	0%	0%	0.00		0
2	**0.08**	3%	3%	0.08		3
4	**0.16**	2%	4%	0.11		2
8	**0.31**	2%	6%	0.21		2
16	**0.63**	8%	14%	1.93		9
32	**1.26**	10%	24%	4.71		11
64	**2.52**	23%	47%	22.29		26
128	**5.04**	29%	76%	54.86		32
256	**10.08**	24%	100%	30.86		27
			Dg	115.04	mm	112
				0.3774	ft	



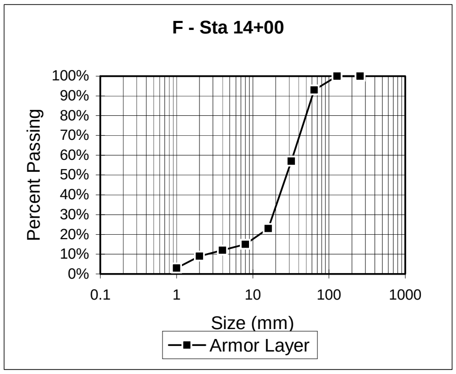
Station **E - Sta 15+50 Anchor test pit**

Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	23.6	mm	
			D50=	17.6	mm	
1	**0.04**	0%	0%	0.00		0
2	**0.08**	2%	2%	0.06		2
4	**0.16**	5%	7%	0.30		5
8	**0.31**	8%	15%	0.96		8
16	**0.63**	31%	46%	7.44		31
32	**1.26**	40%	86%	19.20		40
64	**2.52**	14%	100%	13.44		14
128	**5.04**	0%	100%	0.00		0
256	**10.08**	0%	100%	0.00		0
			Dg	41.40	mm	100
				0.1358	ft	

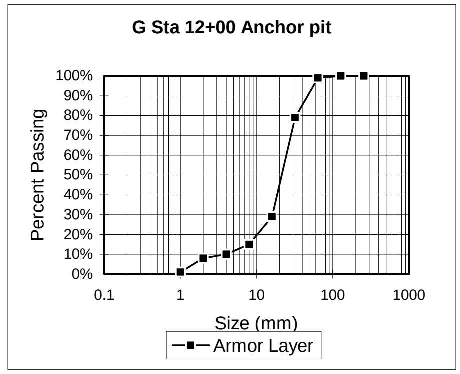


Station **F - Sta 14+00**

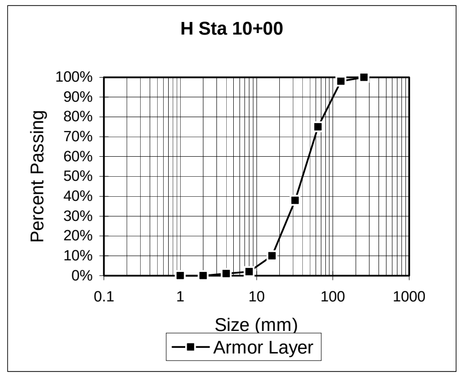
Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	39.1	mm	
			D50=	28.7	mm	
1	**0.04**	3%	3%	0.03		3
2	**0.08**	6%	9%	0.18		6
4	**0.16**	3%	12%	0.18		3
8	**0.31**	3%	15%	0.36		3
16	**0.63**	8%	23%	1.92		8
32	**1.26**	34%	57%	16.32		34
64	**2.52**	36%	93%	34.56		36
128	**5.04**	7%	100%	13.44		7
256	**10.08**	0%	100%	0.00		0
			Dg	66.99	mm	100
				0.2198	ft	



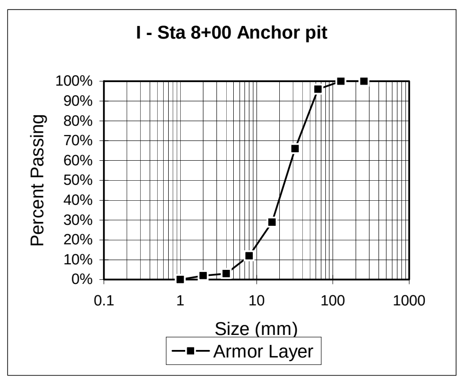
Station		G Sta 12+00 Anchor pit				
			D65=	27.5 mm		
Armor Layer	Armor Layer		D50=	22.7 mm		
Size (mm)	Size (in)	Percent	Cum %	Avg size		No.
1	**0.04**	1%	1%	0.01		1
2	**0.08**	7%	8%	0.21		7
4	**0.16**	2%	10%	0.12		2
8	**0.31**	5%	15%	0.60		5
16	**0.63**	14%	29%	3.36		14
32	**1.26**	50%	79%	24.00		50
64	**2.52**	20%	99%	19.20		20
128	**5.04**	1%	100%	1.92		1
256	**10.08**	0%	100%	0.00		0
			Dg	49.42	mm	100
				0.1621	ft	



Station		H Sta 10+00				
			D65=	55.4 mm		
Armor Layer	Armor Layer		D50=	42.4 mm		
Size (mm)	Size (in)	Percent	Cum %	Avg size		No.
1	**0.04**	0%	0%	0.00		0
2	**0.08**	0%	0%	0.00		0
4	**0.16**	1%	1%	0.06		1
8	**0.31**	1%	2%	0.12		1
16	**0.63**	8%	10%	1.92		8
32	**1.26**	28%	38%	13.44		28
64	**2.52**	37%	75%	35.52		37
128	**5.04**	23%	98%	44.16		23
256	**10.08**	2%	100%	2.56		2
			Dg	97.78	mm	100
				0.3208	ft	

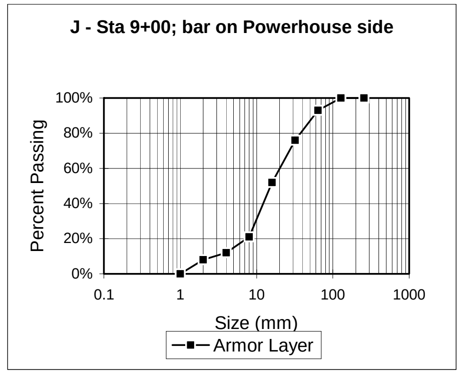


Station		I - Sta 8+00 Anchor pit				
			D65=	31.6 mm		
Armor Layer	Armor Layer		D50=	25.1 mm		
Size (mm)	Size (in)	Percent	Cum %	Avg size		No.
1	**0.04**	0%	0%	0.00		0
2	**0.08**	2%	2%	0.06		2
4	**0.16**	1%	3%	0.06		1
8	**0.31**	9%	12%	1.08		9
16	**0.63**	17%	29%	4.08		17
32	**1.26**	37%	66%	17.76		37
64	**2.52**	30%	96%	28.80		30
128	**5.04**	4%	100%	7.68		4
256	**10.08**	0%	100%	0.00		0
			Dg	59.52	mm	100
				0.1953	ft	



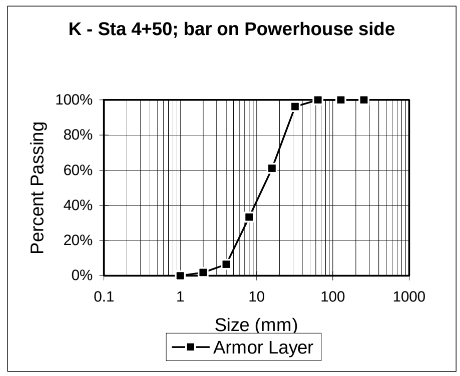
Station **J - Sta 9+00; bar on Powerhouse side**

Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	24.7	mm	
			D50=	15.5	mm	
1	**0.04**	0%	0%	0.00		0
2	**0.08**	8%	8%	0.24		8
4	**0.16**	4%	12%	0.24		4
8	**0.31**	9%	21%	1.08		9
16	**0.63**	31%	52%	7.44		31
32	**1.26**	24%	76%	11.52		24
64	**2.52**	17%	93%	16.32		17
128	**5.04**	7%	100%	13.44		7
256	**10.08**	0%	100%	0.00		0
			Dg	50.28	mm	100
				0.1650	ft	



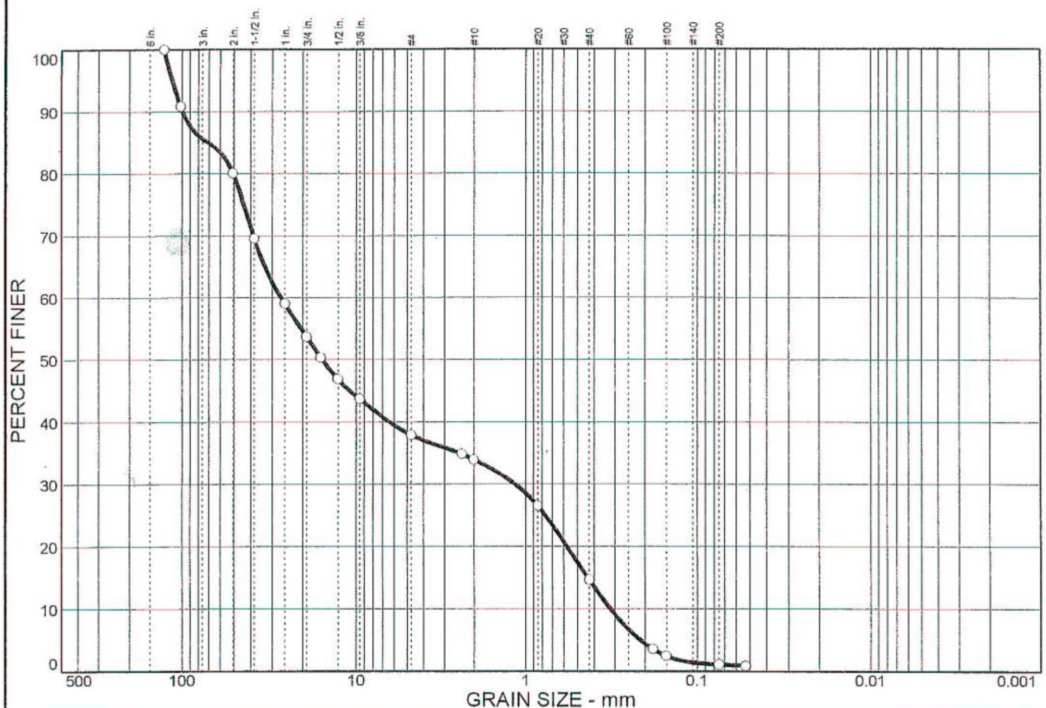
Station **K - Sta 4+50; bar on Powerhouse side**

Armor Layer Size (mm)	Armor Layer Size (in)	Percent	Cum %	Avg size		No.
			D65=	17.8	mm	
			D50=	12.8	mm	
1	**0.04**	0%	0%	0.00		0
2	**0.08**	2%	2%	0.06		2
4	**0.16**	5%	6%	0.28		5
8	**0.31**	27%	33%	3.22		29
16	**0.63**	28%	61%	6.67		30
32	**1.26**	35%	96%	16.89		38
64	**2.52**	4%	100%	3.56		4
128	**5.04**	0%	100%	0.00		0
256	**10.08**	0%	100%	0.00		0
			Dg	30.67	mm	108
				0.1006	ft	



Sieve Data from Pump Test Pit Samples (Sub-armor Layer)

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
14.3	47.8	36.8	1.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5 in.	100.0		
4 in.	90.8		
2 in.	80.1		
1.5 in.	69.5		
1 in.	59.0		
.75 in.	53.7		
.625 in.	50.4		
.5 in.	46.9		
.375 in.	43.7		
#4	37.9		
#8	34.8		
#10	33.9		
#20	26.5		
#40	14.6		
#80	3.6		
#100	2.5		
#200	1.1		
#270	0.9		

* (no specification provided)

Soil Description

Poorly graded gravel with sand
4+00 60' Left
Dated 2-02-2007

Atterberg Limits

PL= LL= PI= NP

Coefficients

D_{85}= 70.2 D_{60}= 26.7 D_{50}= 15.5
D_{30}= 1.15 D_{15}= 0.435 D_{10}= 0.319
C_u= 83.74 C_c= 0.16

Classification

USCS= GP AASHTO= A-1-a

Remarks

F.M.=3.58

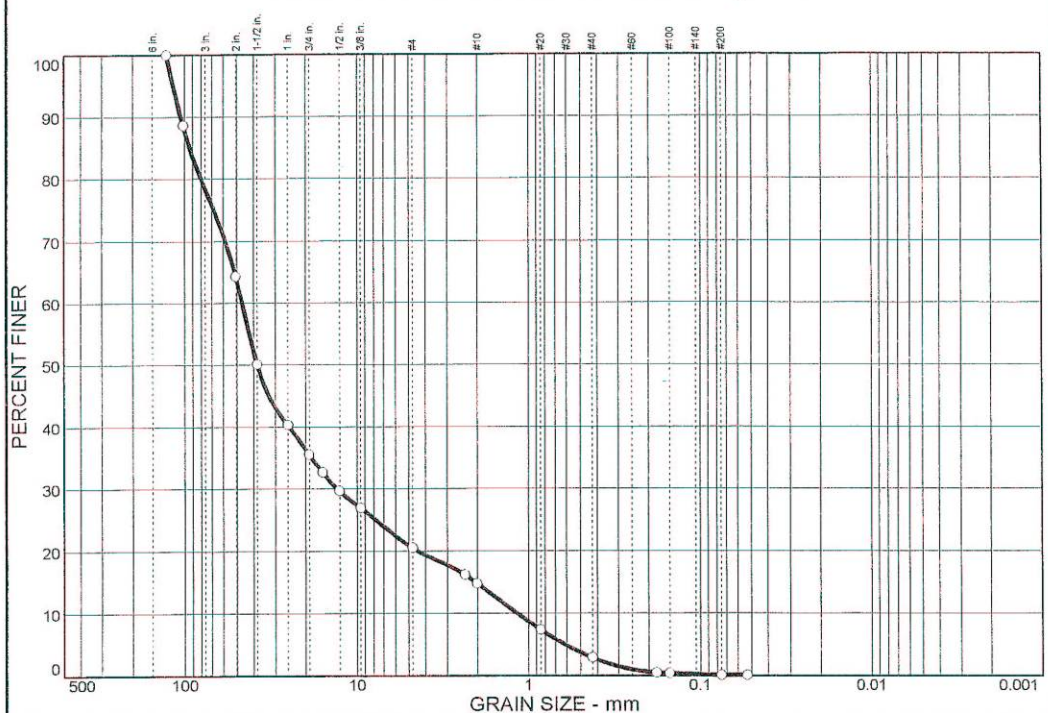
Sample No.: 6784 **Date:** 2-12-2007
Location: **Elev./Depth:**

CASCADE TESTING LABORATORY, INC.
TESTING & INSPECTION / ENGINEERS
12919 N.E. 126TH PLACE
KIRKLAND, WASHINGTON 98034 (206) 823-9800

Client: Anchor Envirmental
Project: Chelan River Project
Project No: 0702-07
Technician: Nick Averill **Inspector:**

AE, CH, 2/20

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
21.6	57.9	20.4	0.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5 in.	100.0		
4 in.	88.6		
2 in.	64.3		
1.5 in.	50.1		
1 in.	40.3		
.75 in.	35.5		
.625 in.	32.6		
.5 in.	29.6		
.375 in.	26.9		
#4	20.5		
#8	16.2		
#10	14.8		
#20	7.4		
#40	2.9		
#80	0.5		
#100	0.4		
#200	0.1		
#270	0.1		

* (no specification provided)

Soil Description

Poorly graded gravel with sand
8+00 60' Right
Dated 2-02-2007

Atterberg Limits

PL= LL= PI= NP

Coefficients

D_{85}= 93.1 D_{60}= 46.6 D_{50}= 38.0
D_{30}= 13.1 D_{15}= 2.05 D_{10}= 1.16
C_u= 40.04 C_c= 3.19

Classification

USCS= GP AASHTO= A-1-a

Remarks

F.M.=4.50

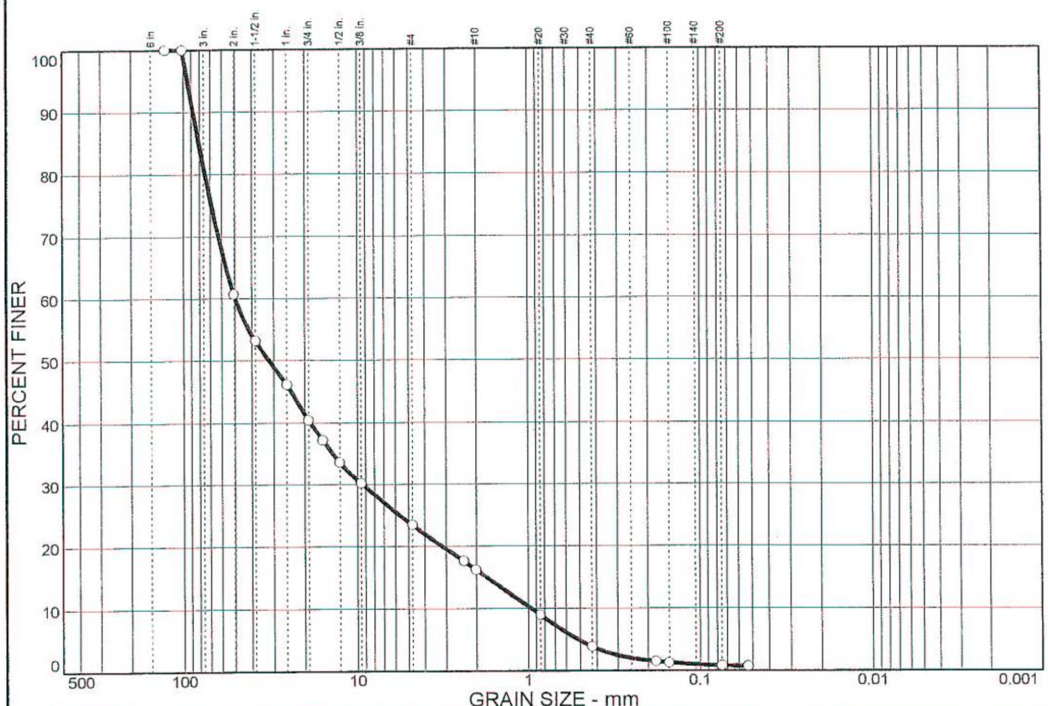
Sample No.: 6785 **Date:** 2-12-2007
Location: **Elev./Depth:**

CASCADE TESTING LABORATORY, INC.
TESTING & INSPECTION / ENGINEERS
12919 N.E. 126TH PLACE
KIRKLAND, WASHINGTON 98034 (206) 823-9800

Client: Anchor Envirmental
Project: Chelan River Project
Project No: 0702-07
Technician: Nick Averill **Inspector:**

AE, CH 2/22

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
18.8	57.8	22.6	0.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5 in.	100.0		
4 in.	100.0		
2 in.	60.7		
1.5 in.	53.2		
1 in.	46.1		
.75 in.	40.4		
.625 in.	37.2		
.5 in.	33.6		
.375 in.	30.2		
#4	23.4		
#8	17.6		
#10	16.2		
#20	9.0		
#40	3.9		
#80	1.5		
#100	1.3		
#200	0.8		
#270	0.7		

* (no specification provided)

Soil Description

Well-graded gravel with sand
15+50 60' Right
Dated 2-02-2007

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 80.9 D_{60}= 49.8 D_{50}= 31.8
D_{30}= 9.34 D_{15}= 1.74 D_{10}= 0.958
C_u= 51.98 C_c= 1.83

Classification

USCS= GW AASHTO=

Remarks

F.M.=4.34

Sample No.: 6788 **Date:** 2-12-2007
Location: **Elev./Depth:**

CASCADE TESTING LABORATORY, INC.
TESTING & INSPECTION / ENGINEERS
12919 N.E. 125TH PLACE
KIRKLAND, WASHINGTON 98034 (206) 823-9800

Client: Anchor Envirnmental
Project: Chelan River Project
Project No: 0702-07
Technician: Nick Averill **Inspector:** [signature]

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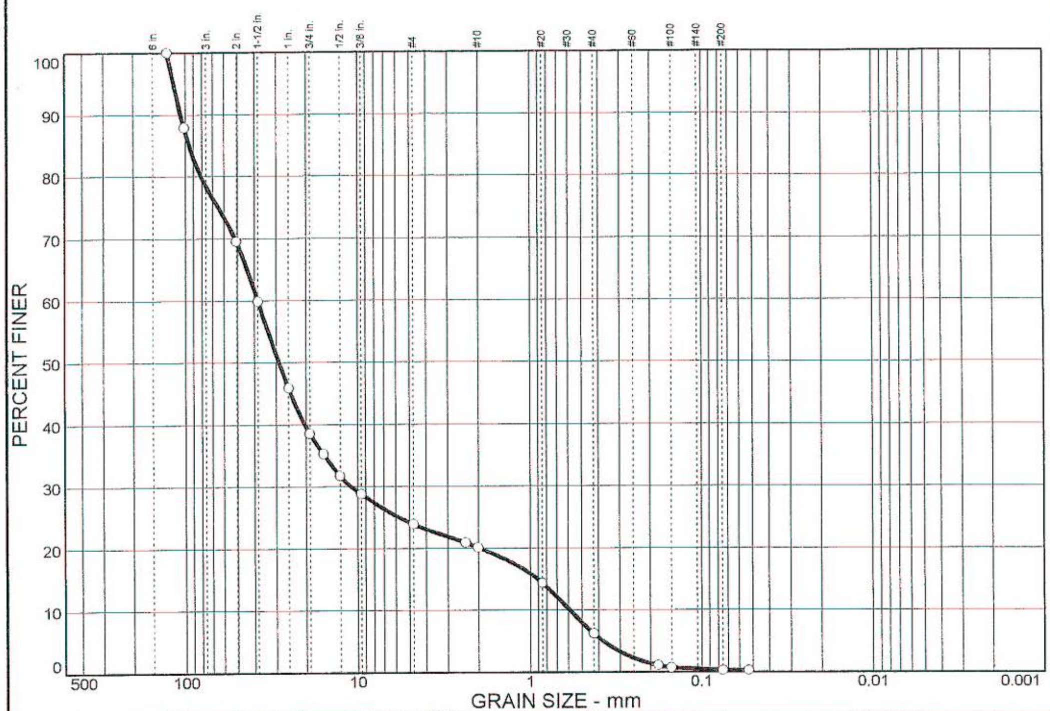
Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
21.6	54.5	23.6	0.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5 in.	100.0		
4 in.	87.9		
2 in.	69.5		
1.5 in.	59.9		
1 in.	45.9		
.75 in.	38.5		
.625 in.	35.2		
.5 in.	31.7		
.375 in.	28.8		
#4	23.9		
#8	20.9		
#10	20.1		
#20	14.4		
#40	6.2		
#80	1.1		
#100	0.7		
#200	0.3		
#270	0.3		

* (no specification provided)

Soil Description

15+50 60' Left
Dated 2-02-2007

Atterberg Limits

PL= LL= PI= NP

Coefficients

D_{85}= 94.8 D_{60}= 38.2 D_{50}= 28.8
D_{30}= 10.9 D_{15}= 0.903 D_{10}= 0.587
C_u= 65.12 C_c= 5.32

Classification

USCS= AASHTO=

Remarks

F.M.=4.27

Sample No.: 6789 **Date:** 2-12-2007
Location: **Elev./Depth:**

CASCADE TESTING LABORATORY, INC.
TESTING & INSPECTION / ENGINEERS
12919 N.E. 125TH PLACE
KIRKLAND, WASHINGTON 98034 (206) 823-9800

Client: Anchor Envirmental
Project: Chelan River Project
Project No: 0702-07
Technician: Nick Averill **Inspector:** [signature]

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