Bear Creek Reach 6 Restoration Project, Phase II, SRFB Project 15-1059

Basis of Design Report

5-1-2017

For
Adopt-A Stream Foundation, Sponsor

Prepared by
Jay Kidder, P. E.
Civil Engineer
Fisheries Biologist

Chinook Engineering
860 Windrose Drive
Coupeville, WA 98239
360.678.4747

The technical material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seal as a professional engineers licensed to practice as such in the State of Washington, are affixed below.

Jay S. Kidder, P. E.

Civil Engineer
and Fisheries Biologist

Table of Contents

Page Number

List of Figures

Page Number

List of Tables

Chapter 1

Introduction

Introduction

Project Goals and Criteria

The goal of this project is to complete a final design for habitat restoration of the Reach 6 of Bear Creek. This reach is low in the Bear Creek stream system. The project under this grant includes the completion of a topographic survey, preliminary design and a final design to install restoration improvement elements.

The design when completed with this current funding request will be used for a future restoration project that will directly address priorities for Bear/Cottage Lake Creeks in the WRIA 8 Conservation Strategy for Chinook salmon (threatened), including protecting and restoring riparian vegetation and floodplain connectivity. This project will address these habitat-limiting factors by focusing design on: installing Large Woody Debris (LWD), re-vegetating the riparian buffer, increasing flood plain connectivity and re-establishing stream processes.

Restoration elements will be designed using the techniques and methods identified in the Integrated Stream Bank Protection Guidelines and the Stream Habitat Restoration Guidelines and other fisheries engineering restoration technology currently being used in the Puget Sound Basin.

Site Description

The site is located at approximately River Mile 2.3 upstream on Bear Creek from the Sammamish River/Slough above Evans Creek. The project is located all within the property line of the Friendly Village neighborhood and is specifically located on the most downstream area of open ground that floods annually near the community swimming pool.

The grounds are all located between the most downstream property line of Friendly village and the vehicle bridge crossing Bear Creek on Snohomish Drive.

The downstream end of the work area is bounded by a log weir believed to be placed to prevent scouring of the stream bed to protect the sanitary sewer

crossing under the stream at this location. The long profile of Bear Creek in this reach is approximately 0.77'/543', S = 0.0014, 0.14%. The crown of the pipe of the sanitary sewer pipe is approximately 2' below the top of the log and the stream bed upstream, and about even with the stream bed downstream of the log. This is very close to the streambed and will be strictly protected.

Figure 1 The main section of the site showing low slope area.

Access to the site is from the Friendly Village neighborhood roads and specifically Snohomish Drive and Sealth Drive adjacent to the community swimming pool.

The site is open and easily accessed and includes room for staging equipment and materials for the construction.

Chapter 2

Flow Analysis

Flows in Bear Creek

Hydrology

The nearest gage, is a county maintained gage known as King County-Union Hill Road 02a, and is located at approximately River Mile 1.3 and about 1 mile downstream of the restoration site on Bear Creek.

The exceedence curve of the daily average flow rate record is presented below and shows the 100 year flood to be approximately 1283 cfs at this location.

Specific return intervals are also shown using a best fit line with R=0.865

RI (yr)	P (%)	Q (cfs)
1.0101	99	23
1.25	80	28
2	50	42
5	20	93
10	10	171
25	4	382
50	2	700
100	1	1283

Figure 2 Estimated daily average return intervals for lower Bear Creek, Union Hill 02a Gage

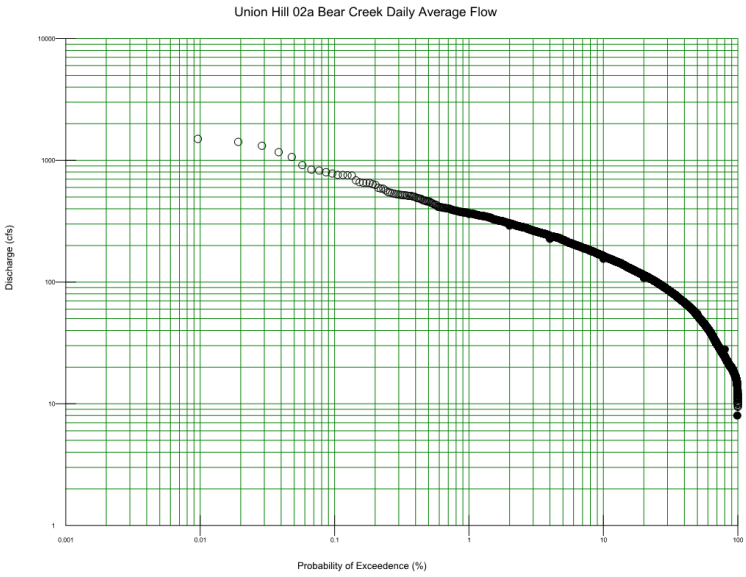

Figure 3 Exceedance curve for Bear Creek at the Union Hill 02a gage for daily average flow

Hydraulics

After the hydrology for the site is established, the hydraulic sizing of the stream restoration is conducted. This is an iterative process that is completed during the final design phase and fine-tuned during the preconstruction phase of work just prior to issuance of the contract drawings for construction.

Stream sizing of the preliminary bottom width and top width of the restored reach is established first by simply mimicking the existing dimensions. Plan forms were established in the conceptual design phase and include bend wavelength and radius of curvature.

This is seen in the table below and shows the averages found adjacent to the project. The radius of curvature used in the preliminary design is 75 feet. This conservative and will reduce streambank erosion seen now at the site.

Planform		***Bend***									
Dimensions in feet		***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***Average***
Meander Wavelength	L	105.5	96.5	143.25	150	200.75	146	119	237	237	159
BFW avg	W	22.5	30.5	23.8	30.5	30.1	32.25	27.75	35.25	43.5	31
Meander amplitude	Ma	74	36.5	40	44	250	250	250	250	141	148
Radius of Curvature	Rc	37.25	25.875	38	31.5	103	111	33.5	97	77.6	62
Belt width	B	88	88	88	88	260	260	260	260	260	184

Table 1 Planforms found in Bear Creek adjacent to the project site.

Design of pools and riffles is accomplished using the bend count and setting each bend to associate with a pool as its exhibited in natural streams. Four pools are established and a stream profile is designed after this is complete.

The large wood (LWD) placed in the pools will help scour the fine sands and silt that are present in the reach. Riffles will scour in low water times and the pools will transport and scour during the 2 year and higher event flow rates. The LWD is anchored and will not float. The pools have the potential to aggrade during conditions that deliver sand to the reach. During the times of the antecedent leg of the hydrograph in which the sediment load is lower, the pools will tend to scour and transport sediment with the velocities increased around and through the LWD.

Hydraulic Modeling

During final design hydraulic modelling of the project will be completed using the SRH two-dimensional model developed by the USBOR. This model will assist in the shaping and geometry of the final streambank and flood connection terraces. It will calculate water surface elevations, water velocities and sediment transport estimates. This model will be used to iterate geometries that will transport sediment during 2-year flow events

through the pools. Riffles will be sized using this technique as well and will provide for higher velocities and shallower depths and widths that are narrower to produce a natural stream channel.

Snohomish Avenue Bridge Hydraulic Modeling

Final design hydraulic modelling of the stream cross section just downstream of the Snohomish Avenue Bridge was completed during the final design. The proposed stream profile slope and the stream cross section is entered into the Flowmaster, Bentley 2009, calculator for solution of Mannings equation to determine the high water stage estimate for 100 year flow event of Q_{100}=1,283 cfs.

The existing stream reach slope is S=0.0135 ft/ft. The existing and proposed cross sections are kept similar at the immediate downstream section to the bridge. Slopes are also kept constant. The pool just downstream of the bridge is created and filled with LWD but is backwatered by the adjacent downstream riffle.

The resultant solution for the existing condition indicates when the extreme high flow is Q_{100}=1,283 cfs the stage under the Snohomish Avenue Bridge for the proposed habitat improvement is Elevation(EL)=54.21. The existing bottom cord elevation of the Snohomish Avenue Bridge is EL=55.69. This shows a freeboard of 1.48 feet.

The resultant stage calculation for the proposed habitat installation in which the immediate cross section just downstream of the Snohomish Avenue Bridge remains the same as existing and when the extreme high flow is Q_{100}=1,283 cfs, shows the stage under the Snohomish Avenue Bridge to remain at EL=54.21. Approximately 55 feet downstream and purposefully designed, the right bank is excavated down to provide overbank relief of the extreme high flow conditions. The precise flood relief terrace elevation will be determined with the full 2D model of the reach to be completed for construction.

This overbank flood connected terrace along the right bank will provide a relief to the backwater elevation of the stream stage at the Snohomish Avenue Bridge and effectively lower it. The depth of the cut of the terrace proposed is approximately 2 feet deep and about 20’ wide and will be designed to provide a significant reduction in the backwater stage at the bridge. This reduction will compensate for the increased roughness caused by the LWD and also lower the stage at the bridge due to the slope and cross section of the existing stream remaining constant.

Habitat improvement will be significant at the overbank terrace. Revegetation and refuge areas for high flow will be constructed. Significant increase in water surface areas will also occur.

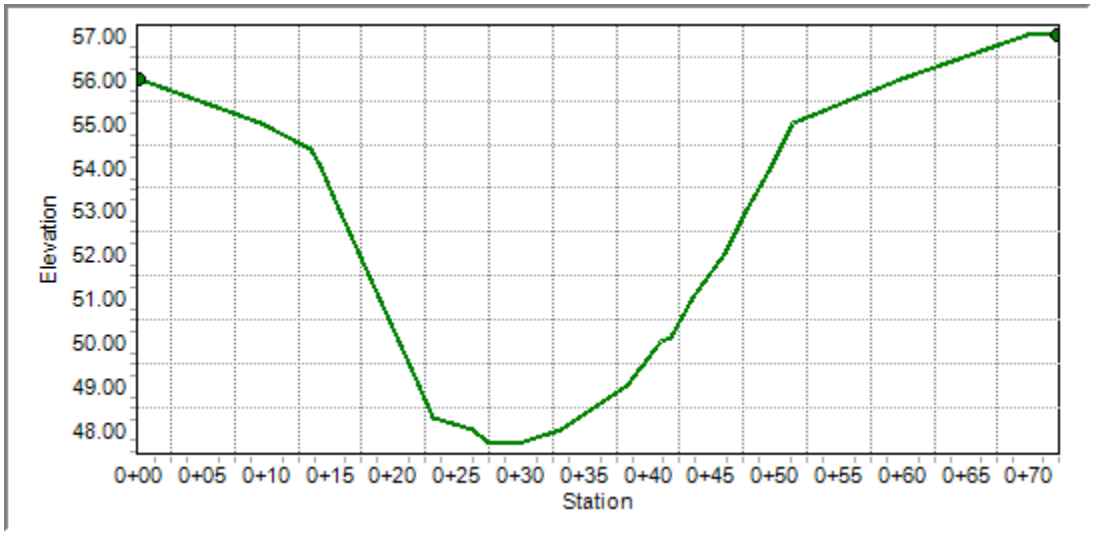

Figure 4 Hydraulic cross section just downstream from Snohomish Avenue Bridge

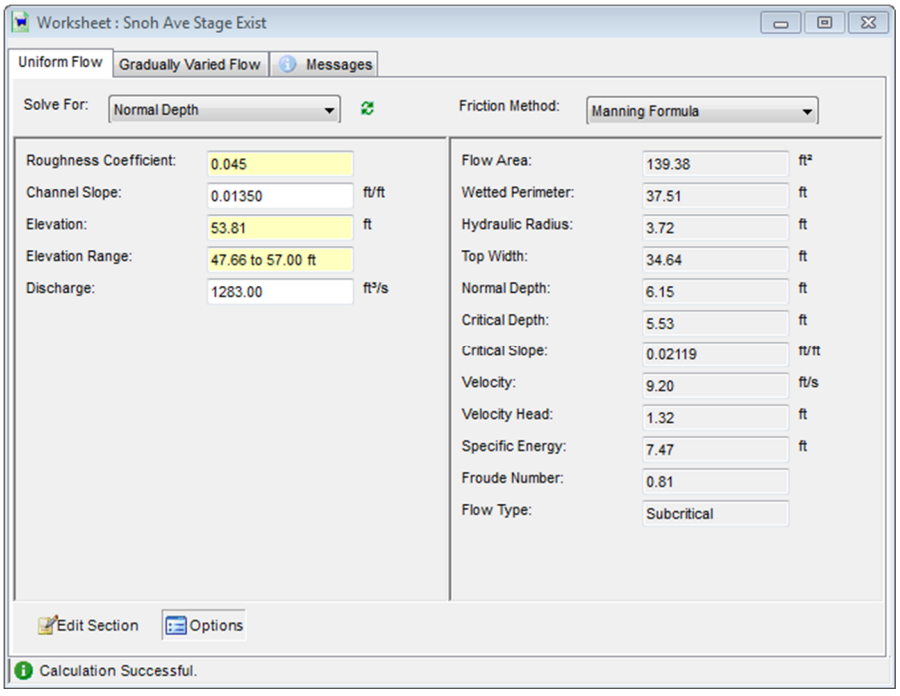

Figure 5 Existing hydraulic stage for 100 year high flow of Q=1283 cfs at Snohomish Avenue Bridge

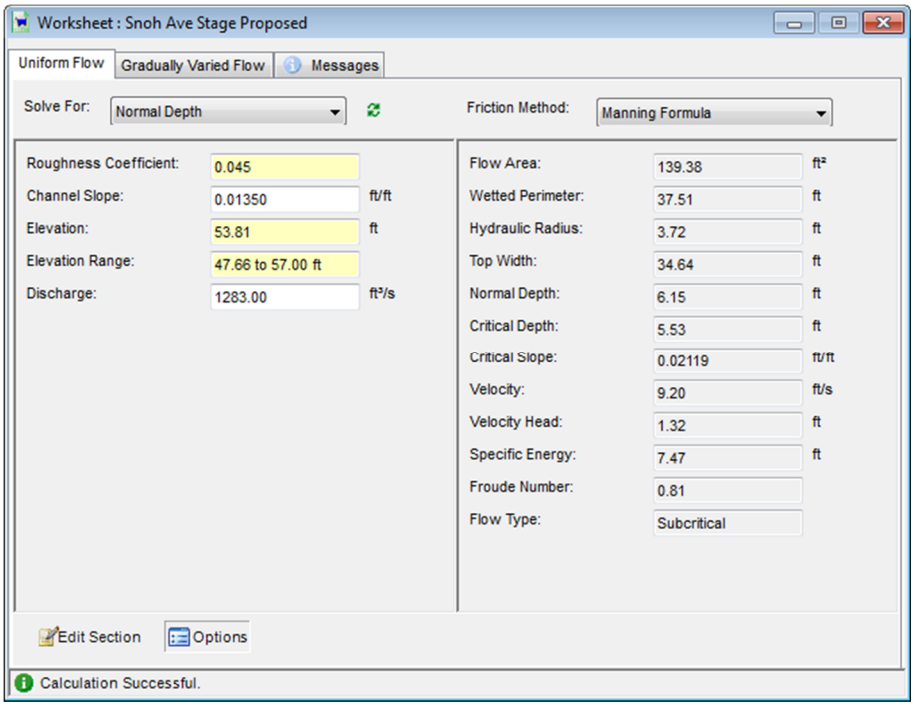

Figure 6 Proposed hydraulic stage for 100 year high flow of Q=1283 cfs at Snohomish Avenue Bridge

Chapter 3

Preliminary Design

Preliminary Design Descriptions

The preliminary design of the of the stream restoration has been initiated in the August 3, 2016 drawing set. This is the first rendition of the geometry and layout. The constraints and criteria used are as follows;

1. Landowners interests
2. Sanitary sewer alignments and depth
3. Downstream shallow sanitary sewer location and log weir hydraulic control elevation
4. Four pools goal
5. Three riffles goal
6. Large wood complex structures full width of stream
7. Flood plain connectivity
8. Fish habitat for primarily rearing and some limited spawning sites

Initial layout and profiles are based on the completed topographic and bathymetric stream bed information for the site. This geometry is driven by the planforms and goals for the project.

Bends were established at approximately 75' radii. The profile was modified to reflect riffles and pools coincidental with the horizontal plan. LWD is placed for habitat and sediment sorting. Floodplain terraces were placed on the two inside bends.

Upon receiving comments, we will iterate the alignment and wood placement as well as the channel width to depth ratios to first check flood elevations for no net rise. Then using the model, the channel final geometry is teased out of the anticipated results.

Chapter 4

Final Design

Final Design Descriptions

The final design of the of the stream restoration is now complete. The date of the drawing set is 12-18-2016. The final design incorporates comments from the Lead Entity that included the following items;

1. Downstream shallow sanitary sewer location and log weir hydraulic control elevation must be protected.
2. Four pools created.
3. Three riffles created.
4. Straighten out the meanders to reduce the flattening of the stream slope.
5. Large wood complex structures full width of stream completed.
6. Flood plain connectivity created that also provides anticipated backwater reductions.
7. Fish habitat for primarily rearing and some limited spawning sites complete.
8. Reevaluate hydraulics during Permitting and Construction Issue drawings and contract prior to construction with 2D hydraulics for reach backwater calculations.

The final design incorporated comments and requests made during Lead Entity reviews and comments. These aspects to the design are presented in the final design drawings issued for final design.

The most important aspect of the final design to note is the use of the flood connected terraces along the right and lower left banks that are sloped to provide an always connected wetted edge margin that will be excellent for salmonid rearing conditions and will follow along the terrace as the flood stage increases. Backwater created by the stage of the Sammamish Slough finally governs and the entire area is inundated.

Final design includes components of construction that includes stream and bank excavation and subsequent upland fill, installation of LWD, installation of streambed gravel cobble and boulders, boulder anchors, revegetation of over bank terraces, and protection of the downstream nick point of the sanitary sewer crossing and the log weir.

Costs

Engineer's Construction Cost estimate is complete.

Quantities are based on the final design drawings as issued for Final Design dated 12-18-2016. The quantity of materials is estimated using to scale CAD drawings and are appropriate for this phase of the work. Construction Engineering services and sales tax are included in both estimates.

The total construction delivery cost is reported below.

Final Cost Estimate follows;

Friendly Village Version 5/1/2017

Bear Creek Reach 6 Restoration Phase II 15-1059

Final Design Construction Cost Estimate

Project Name: Bear Creek Reach 6 Restoration Phase II 15-1059
RCO Project #: 15-1059
Date: 05/01/17
Estimate By: Jay S. Kidder, PE
Stream: Bear Creek
Proposed Correction: Habitat Improvements and LWD Installation

Description	Unit	Quantity	Cost	Amount	Sub Total
Mobilization / Site Preparation					
Mobilize	L.S.	1	$10,000.00	$10,000	
Access Improvements and traffic	L.S.	1	$2,000.00	$2,000	
Stream Diversions and Bypass	L.S.	1	$6,000.00	$6,000	
Erosion Control	L.S.	1	$2,000.00	$2,000	
Dewater	L.S.	1	$1,000.00	$1,000	
Fish Removal	L.S.	1	$1,000.00	$1,000	
Mobilization and Site Prep SUBTOTAL					$22,000
Excavation Stream and Terrace					
Excavation, Common Stream	C.Y.	361	$25.00	$9,028	
Excavation, Common Terrace	C.Y.	722	$20.00	$14,444	
Excavation fill and grading	C.Y.	1083	$10.00	$10,833	
Rmv. & Disp. Timber Bridge	EA	1	$2,000.00	$2,000	
Excavation SUBTOTAL					$36,306
LWD Installation					
Purchase LWD Stump w/ 40' Sten	EA	40	$500.00	$20,000	
Purchase LWD Stump. w/ 20' Ste	EA	40	$400.00	$16,000	
Purchase LWD 40' logs	EA	20	$400.00	$8,000	
Purchase LWD 20' logs	EA	20	$300.00	$6,000	
Racking wood	EA	200	$100.00	$20,000	
Transport LWD	EA	300	$80.00	$24,000	
Install LWD 20' and 40'	EA	120	$250.00	$30,000	
Install LWD racking pieces	EA	200	$60.00	$12,000	
Anchor Habitat Boulders with eye	EA	100	$120.00	$12,000	
Chain, eyes and hardware	LF	1000	$4.50	$4,500	
Habitat boulders	EA	25	$100.00	$2,500	
Stream Sediment Fish Mix	CY	271	$65.00	$17,604	
Riffle construction and placement	EA	3	$1,000.00	$3,000	
LWD Installation SUBTOTAL					$175,604
Terrace Construction					
LWD on terrace	EA.	50	$300.00	$15,000	
Trim and topology	C.Y.	300	$15.00	$4,500	
Streambed Gravel, Fishmix	C.Y.	25	$65.00	$1,625	
Habitat boulders	EA	20	$100.00	$2,000	
Revegetation	LS	1	$15,000.00	$15,000	
Rake and reseed	LS	1	$500.00	$500	
Terrace Construction SUBTOTAL					$38,625
TOTAL CONSTRUCTION TOTAL					$272,535
Sales Tax	10.00%				$27,253
Engineering and CM	20%				$54,507
Admin/Planning					
Permit fees					
PROJECT TOTAL					$354,295

Figure 7 Final Construction and Delivery Cost Estimate

Appendices

Hydraulic Calculations

Worksheet for Snoh Ave Stage Exist

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01350	ft/ft
Discharge	1283.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	56.00
0+10	55.00
0+13	54.41
0+14	54.00
0+16	53.00
0+17	52.00
0+19	51.00
0+20	50.00
0+22	49.00
0+23	48.26
0+26	48.00
0+27	47.70
0+30	47.66
0+33	48.00
0+38	49.00
0+41	50.00
0+42	50.10
0+44	51.00
0+46	52.00
0+48	53.00
0+50	54.00
0+51	55.00
0+60	56.00
0+70	57.00
0+72	57.00

Roughness Segment Definitions

Worksheet for Snoh Ave Stage Exist

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+00, 56.00)	(0+72, 57.00)	0.045

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		6.15	ft
Elevation Range	47.66 to 57.00 ft		
Flow Area		139.38	ft²
Wetted Perimeter		37.51	ft
Hydraulic Radius		3.72	ft
Top Width		34.64	ft
Normal Depth		6.15	ft
Critical Depth		5.53	ft
Critical Slope		0.02119	ft/ft
Velocity		9.20	ft/s
Velocity Head		1.32	ft
Specific Energy		7.47	ft
Froude Number		0.81	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	6.15	ft

Worksheet for Snoh Ave Stage Exist

GVF Output Data

Critical Depth	5.53	ft
Channel Slope	0.01350	ft/ft
Critical Slope	0.02119	ft/ft

Worksheet for Snoh Ave Stage Proposed

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.01350	ft/ft
Discharge	1283.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
0+00	56.00
0+10	55.00
0+13	54.41
0+14	54.00
0+16	53.00
0+17	52.00
0+19	51.00
0+20	50.00
0+22	49.00
0+23	48.26
0+26	48.00
0+27	47.70
0+30	47.66
0+33	48.00
0+38	49.00
0+41	50.00
0+42	50.10
0+44	51.00
0+46	52.00
0+48	53.00
0+50	54.00
0+51	55.00
0+60	56.00
0+70	57.00
0+72	57.00

Roughness Segment Definitions

Worksheet for Snoh Ave Stage Proposed

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+00, 56.00)	(0+72, 57.00)	0.045

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		6.15	ft
Elevation Range	47.66 to 57.00 ft		
Flow Area		139.38	ft²
Wetted Perimeter		37.51	ft
Hydraulic Radius		3.72	ft
Top Width		34.64	ft
Normal Depth		6.15	ft
Critical Depth		5.53	ft
Critical Slope		0.02119	ft/ft
Velocity		9.20	ft/s
Velocity Head		1.32	ft
Specific Energy		7.47	ft
Froude Number		0.81	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	6.15	ft

Worksheet for Snoh Ave Stage Proposed

GVF Output Data

Critical Depth	5.53	ft
Channel Slope	0.01350	ft/ft
Critical Slope	0.02119	ft/ft