APPENDIX J

DESIGN EXAMPLE - HYDRAULIC DESIGN OPTION (REHABILITATE CULVERT WITH BAFFLE)

Hydraulic Design Option
(Baffles)

Problem Statement

At Ripple Creek in Mendocino County crossing Route 555, adult Coho salmon are unable to move through the existing 8-foot diameter x 8-foot length culvert. From past monitoring, Coho salmon have been sighted congregated just below this culvert during normal migration periods, which has triggered this site as a high priority for CA Fish & Game and NOAA Fisheries. After using Fish Xing software to analyze existing conditions and identify barriers to fish movement, low depths and high velocities were found inside this culvert.

The existing culvert is in good condition. The only problem is some localized scour on the banks of the creek near the culvert inlet. Within the project scope, Maintenance Design will provide rock slope protection on the creek banks and bed to control future scour and protect the culvert facility. Other than this scour issue, the culvert is free of structural damage from abrasion or excessive debris loading. Also, the existing culvert is believed to have more than adequate hydraulic capacity, and again is not subjected to heavy or damaging bedloads.

In order to improve fish passage through the Ripple Creek culvert and protect the culvert inlet, Caltrans District Maintenance Design will dedicate Minor B funds, and apply to CA Fish & Game for a matching grant. The design and construction management of this cooperative project will be performed by Caltrans.

NOTE: Route 555 and Ripple Creek are fictitious and created for presenting a design example for this fish-passage training guidance.

Form 1-Existing Data and Information Summary

Form 1 provides a list of suggested data references that would be beneficial to collect before the beginning of the design process.

For this particular example, USGS topographic quadrangle map, DEM data, as-built drawings, target fish species and life stage data, and stream flow gage data was available for reference.

The USGS topographic quadrangle data and DEM data was downloaded from the USGS website, www.usgs.gov.

The FEMA Map Service Center, http://msc.fema.gov/, was accessed to determine if a previous hydrologic study, hydraulic study, and floodplain mapping had been performed. For Ripple Creek, no previous detailed or approximate studies had been performed; therefore, no effective data was available for reference.

As-built drawings were found in District Hydraulics archives. CA Fish and Game provided target species and life stage data for Ripple Creek.

California Department of Water Resources (CDEC, http://cdec.water.ca.gov/), was searched for precipitation and stream flow gage data. Unfortunately, no recording stream flow gages are located on Ripple Creek; however, an adjacent watershed with similar basin characteristics has recording data that will be appropriate for basin transfer. The adjacent watershed gage data was downloaded off of CDEC's website.

As for site access status, the field investigations can be done within Caltrans Right-of - Way, therefore, rights-of-entry will not be required.

EXISTING DATA AND INFORMATION SUMMARY — FORM 1

Project Information Fish Passage Improvement Route 555	Computed: EKB	Date: 7-1-06	
	Checked: LEF	Date: 7-2-06	
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Proposed Project Type	☐ New Culvert	☐ New Bridge
	☐ Replacement Culvert	☐ Replacement Bridge
	☒ Retrofit Culvert	☐ Retrofit Bridge
	☒ Proposed Culvert Length= 60 ft	☐ Proposed Bridge Length= ft
	☐ Other	☐ Other

Design Species/Life Stage	☐ All Species	Source: John Bait Contact: NOAA Fisheries Date: contacted on 6/25/06 1-678-555-3322
	☒ Adult Anadromous Salmonids – adult coho salmon	
	☐ Adult Non-Anadromous Salmonids	
	☐ Juvenile Salmonids	
	☐ Native Non-Salmonids	
	☐ Non-Native Species	

Collect Existing Data

Included in Caltrans Culvert Inventory	☐ Yes	☒ No
As-Built Drawings	☒ Yes	☐ No
Assessor's Parcel Map	☐ Yes	☒ No
Previous Studies Performed: (i.e. FEMA Flood Insurance Studies, Army Corps of Engineering Studies, Other)		
Hydrology Analysis	☐ Yes	☒ No
Hydraulics Analysis	☐ Yes	☒ No
Floodplain Mapping	☐ Yes	☒ No
Other Studies Types Available: (i.e. Watershed Management Plans, Stream Restoration Plans, Other)	☐ Yes	☒ No
Existing Land Use Map	☐ Yes	☒ No
Proposed Land Use Map	☐ Yes	☒ No
Precipitation Gage Data	☐ Yes	☒ No
Stream Flow Gage Data	☒ Yes	☐ No

EXISTING DATA AND INFORMATION SUMMARY	FORM 1
Topographic Mapping: (i.e. USGS Topographic Quadrangle, DEM Data, LIDAR Data, Other)	☒ Yes ☐ No
District Hydraulics Library	☐ Yes ☒ No

Obtain Access Permission

Will Project study limits extend beyond Caltrans R/W? ☐ Yes ☒ No

If yes, obtain right-of-entry.

Contact Report Index Attached ☒ Yes ☐ No

Existing Information Index Attached ☒ Yes ☐ No

CONTACT REPORT INDEX

Project Information Fish Passage Improvement - Route 555		Computed: EKB	Date: 7/1/06
		Checked: LEF	Date: 7/2/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Date of Contact	Person Contacted	Subject Discussed
6/25/06	John Bait @ NOAA	Coho Salmon design
	Fisheries	Species data
	678-555-3322	

EXISTING INFORMATION INDEX

Project Information		Computed: EKB	Date: 7/1/06
Fish Passage Improvement - Route 555		Checked: LEF	Date: 7/2/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Report Date	Report Name and Source
8/1982	As-builts drawings for culvert
5/20/2006	Stream Flow gage data downloaded from CDEC
6/22/2006	USGS Topographical Map

Form 2- Site Visit Summary

Form 2 captures the existing conditions of the hydraulic structure including channel and structure roughness values. By completing the Site Visit Summary form, the drainage designer will have all necessary parameters required to complete any of the fish passage design options.

At the Ripple Creek site, various culvert and creek properties were investigated. These include layout configuration, roughness, velocity, and flow regime.

As mentioned above, it was noted in the field, as well as the As-Built plans that a headwall/endwall exists at the culvert inlet and outlet. Also, the existing culvert lies at a 2% slope matching the upstream and downstream channel invert.

For the creek, roughness characteristics of the main channel, the left overbank channel, and the right overbank channel were also investigated and ultimately Manning's n-values were estimated. Based on field observation, the left and right overbank channels were found to have the same n-values in the vicinity of the culvert crossing and the project study area.

Flow in the creek at the time of the field visit was determined from appropriate measurements. The flow was calculated by measuring a velocity and depth, calculating wetted area from a field developed creek cross-section, and dividing velocity by wetted area to achieve flow according to the continuity of flow equation. By placing a small leaf in the creek and timing its travel over a set length, a velocity was determined. In order to find a representative velocity for the creek, this operation was performed three times, where the leaf was placed near the left bank, near the right bank, and around the center of the creek. The velocity corresponding to each leaf placement was added together and averaged to find a representative velocity.

Finally, the flow regime for the creek was estimated in the field by tossing a small rock in the center of the creek and noting the propagation of the ripples. When ripples propagate upstream, the flow regime is subcritical, while supercritical flow is denoted by downstream ripple propagation. For Ripple Creek, subcritical flow was occurring upstream and downstream of the culvert.

SITE VISIT SUMMARY		FORM 2

Project Information	Computed: EKB	Date: 7-7-06
Fish Passage Improvement Route 555	Checked: LEF	Date: 7-8-06

Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Obtain Physical Characteristics of Existing Culvert

Confined Spaces

Is the culvert height 5 ft or greater?	☒ Yes ☐ No
Can you stand up in the culvert?	☒ Yes ☐ No
Can you see all the way through the culvert?	☒ Yes ☐ No
Can you feel a breeze through the culvert?	☒ Yes ☐ No

If answer is "No" to any of the above questions, do not enter the culvert without confined spaces equipment for surveying.

Inlet Characteristics

Inlet Type	☐ Projecting	☒ Headwall	☐ Wingwall	
	☐ Flared end section	☐ Segment connection		
Inlet Condition	☒ Channel scour	☐ Excessive deposition	☐ Debris accumulation	☐ None applicable
Inlet Apron	☒ Channel scour	☐ Excessive deposition	☐ Debris accumulation	☐ None applicable

Skew Angle: None °	Upstream Invert Elevation: 516.2 ft (NGVD 29 or NAVD 88 [circled: NAVD 88])

Barrel Characteristics

Diameter: — in	Fill height above culvert: 12 ft
Height/Rise: 8 ft	Length: 60 ft
Width/Span: 8 ft	Number of barrels: 1

Culvert Type	☐ Arch	☒ Box	☐ Circular
	☐ Pipe-Arch	☐ Elliptical	
Culvert Material	☐ HDPE	☐ Steel Plate Pipe	☒ Concrete Pipe
	☐ Spiral Rib / Corrugated Metal Pipe		
Barrel Condition	☐ Corrosion	☐ Debris accumulation	☐ Structural damage
	☐ Abrasion	☐ Bedload accumulation	☒ None applicable

SITE VISIT SUMMARY	FORM 2
Horizontal alignment breaks: NONE ft	Vertical alignment breaks: NONE ft

Outlet Characteristics

Outlet Type	☐ Projecting	☒ Headwall	☐ Wingwall	
	☐ Flared end section	☐ Segment connection		
Outlet Condition	☐ Scour hole	☐ Backwatered	☐ Debris accumulation	☒ None applicable
	☐ Perched	Outlet elevation drop: ft		
		Outlet drop condition:		
		Scour hole depth: ft		
Outlet Apron	☐ Channel scour	☐ Excessive deposition	☐ Debris Accumulation	☒ None Applicable

Skew Angle: NONE °	Downstream Invert Elevation: 514.96 ft (NGVD 29 or NAVD 88 [circled])

Bridge Physical Characteristics N/A

Elevation of high chord (top of road): ft		Elevation of low chord: ft		
Channel Lining	☐ No lining	☐ Concrete	☐ Rock	☐ Other
Skew Angle: °		Bridge width (length): ft		

Pier Characteristics (if applicable) ☐ N/A

Number of Piers: ft		Upstream cross-section starting station: ft	
Pier Width: ft		Downstream cross-section starting station: ft	
Pier Centerline Spacing: ft			
Pier Shape	☐ Square nose and tail	☐ Semi-circular nose and tail	☐ 90° triangular nose and tail
	☐ Twin-cylinder piers with connecting diaphragm	☐ Twin-cylinder piers without connecting diaphragm	☐ Ten pile trestle bent
Pier Condition	☐ Scour	☐ Corrosion	☐ Debris accumulation
Skew angle °			

Channel Characteristics

Hydraulic Structure Roughness Coefficients

(Source: Caltrans Highway Design Manual Table 864.3A)		(Source: HEC-RAS User's Manual)	
Type of Structure	**n- value**	**Type of Structure**	**n- value (normal)**

SITE VISIT SUMMARY — FORM 2

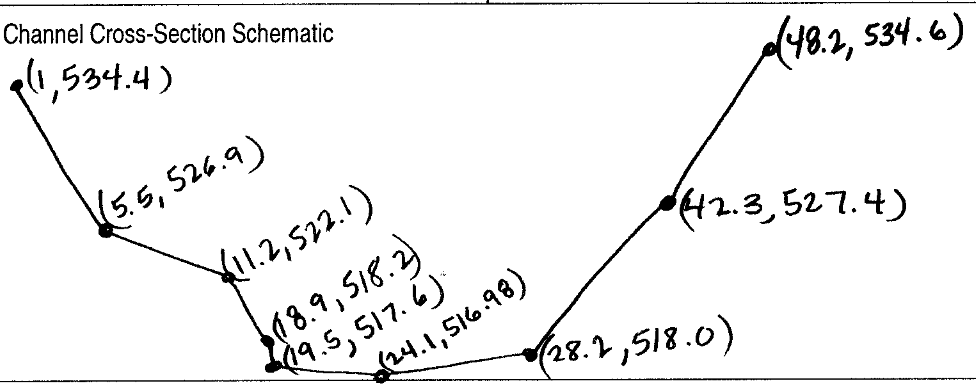
Linned Channels:		Corrugated Metal:	
Portland Cement Concrete	0.014	Subdrain	0.019
Air Blown Mortar (troweled)	0.012	Storm drain	0.024
Air Blown Mortar (untroweled)	0.016	**Wood:**	
Air Blown Mortar (roughened)	0.025	Stave	0.012
Asphalt Concrete	0.018	Laminated, treated	0.017
Sacked Concrete	0.025	**Brickwork:**	
Pavement and Gutters:		Glazed	0.013
Portland Cement Concrete	0.015	Lined with cement mortar	0.015
Asphault Concrete	0.016		
Depressed Medians:			
Earth (without growth)	0.040		
Earth (with growth)	0.050		
Gravel	0.055		

Recommended Permissible Velocities for Unlined Channels (Source: Caltrans Highway Design Manual, Table 862.2)

Type of Material in Excavation Section	Intermittent Flow (f/s)	Sustained Flow (f/s)
Fine Sand (Noncolloidal)	2.6	2.6
Sandy Loam (Noncolloidal)	2.6	2.6
Silt Loam (Noncolloidal)	3.0	3.0
Fine Loam	3.6	3.6
Volcanic Ash	3.9	3.6
Fine Gravel	3.9	3.6
Stiff Clay (Colloidal)	4.9	3.9
Graded Material (Noncolloidal)		
Loam to Gravel	6.6	4.9
Silt to Gravel	6.9	5.6
Gravel	7.5	5.9

SITE VISIT SUMMARY		FORM 2
Coarse Gravel	7.9	6.6
Gravel to Cobbles (Under 150mm)	(8.8) circled	(6.9) circled
Gravel and Cobbles Over 200mm)	9.8	7.9
Flow Estimation 5 cfs	☐ Supercritical flow	☒ Subcritical flow

Channel Cross-Section Schematic



Channel depth = 0.5 ft

Average Active Channel Width
Take at least five channel width measurments to determine the active channel width. The active channel stage or ordinary high water level is the elevation delineating the hightest water level that has been maintained for a sufficient period of time to leave evidence on the landscape.

Average Active Channel Width = 8.3 ft

1) 6.2 ft	2) 4.9 ft	3) 10.2 ft	4) 12.1 ft	5) 8.0 ft

Boundary Conditions
The normal depth option (slope area method) can only be used as a downstream boundary condition for an open-ended reach. Is normal depth appropriate? If no, what is the known starting water surface elevation? yes

Upstream NORMAL DEPTH	slope 0.02 ft/ft
Downstream NORMAL DEPTH	slope 0.02 ft/ft
Known starting water surface elevation Source:	—— ft

General Considerations

Identify Physical restrictions			
	☐ Right-of-way	☐ Utility conflict	☐ Vegetation
	☐ Man-made features	☐ Natural features	☐ Other

Cross-Section Sketches Attached ☒ Yes ☐ No

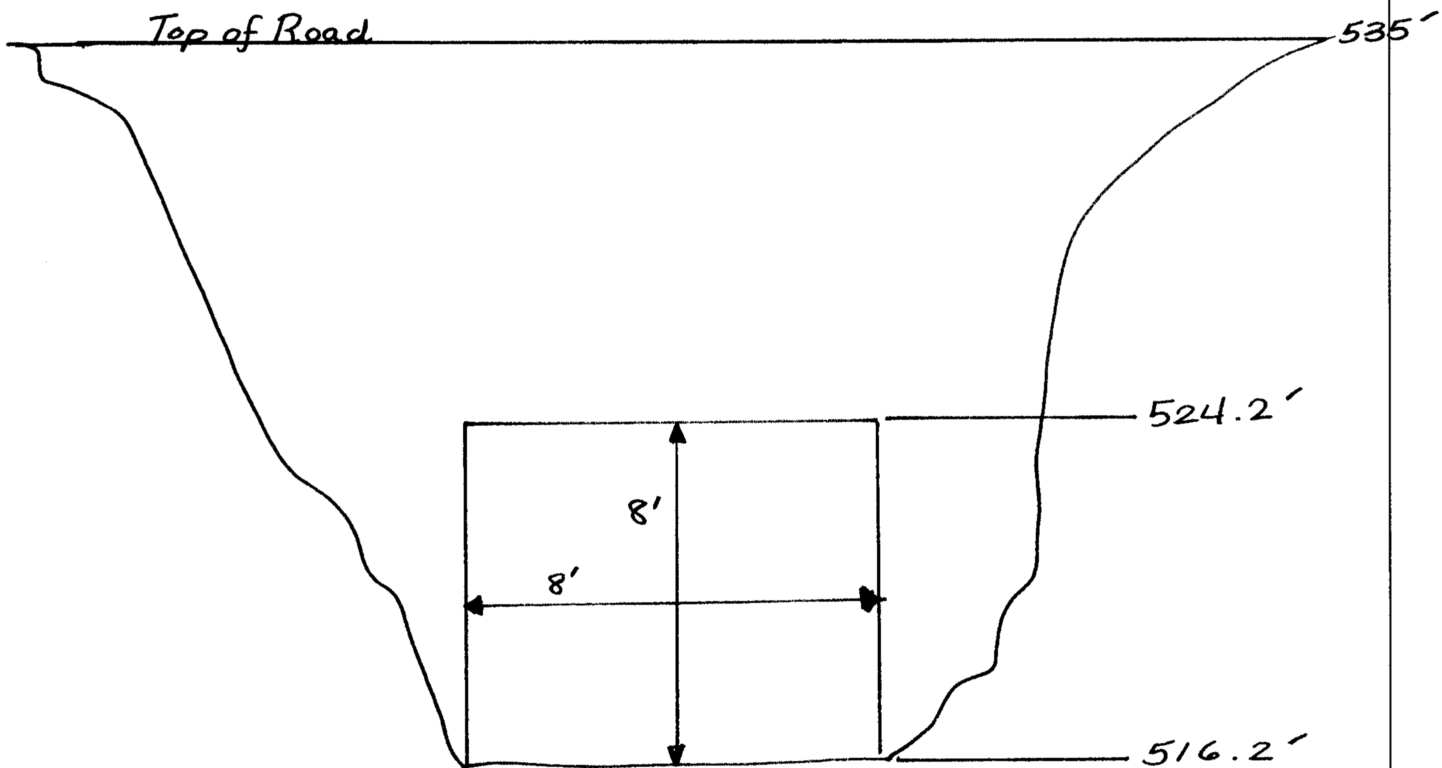
Site Photograph Documentation Attached ☒ Yes ☐ No

Channel / Overbank Manning's n-value Calculation Attached ☒ Yes ☐ No

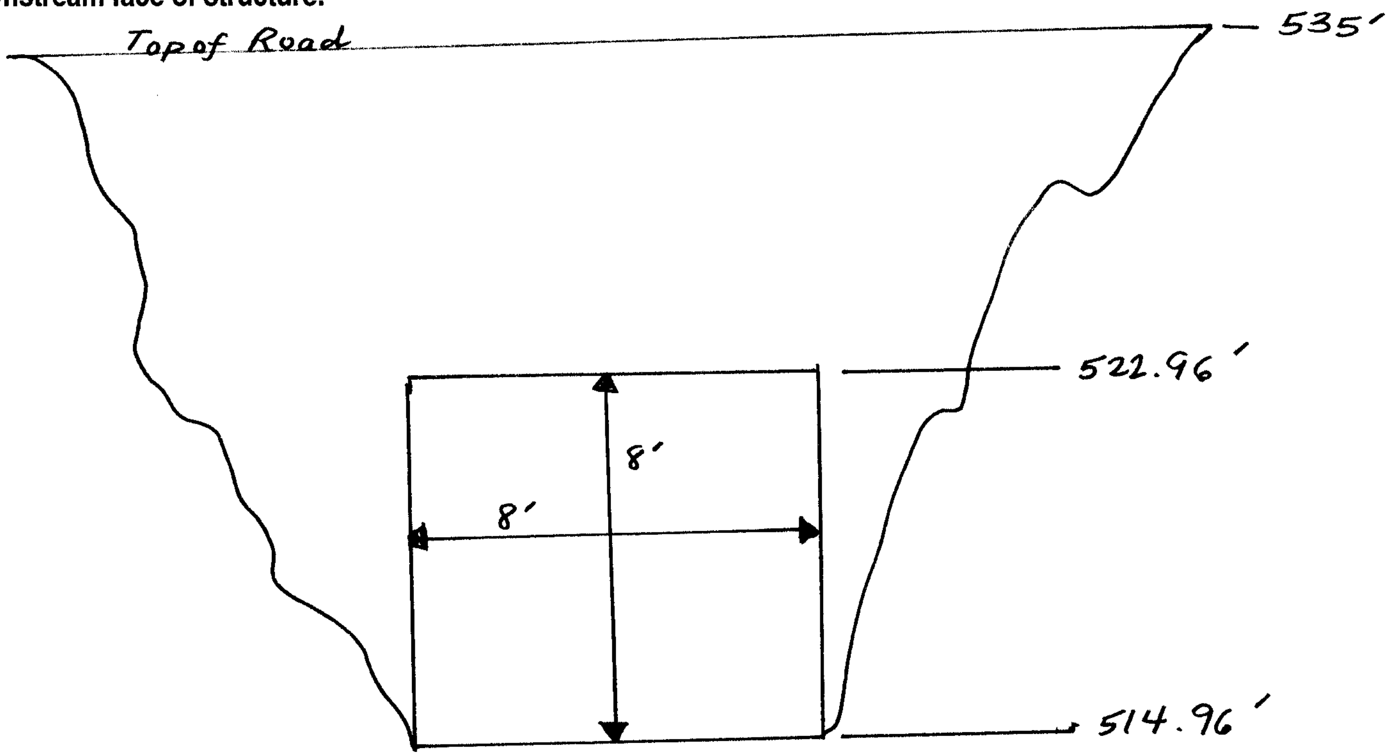
Field Notes Attached ☒ Yes ☐ No

Cross-Section Sketch

Upstream face of structure:

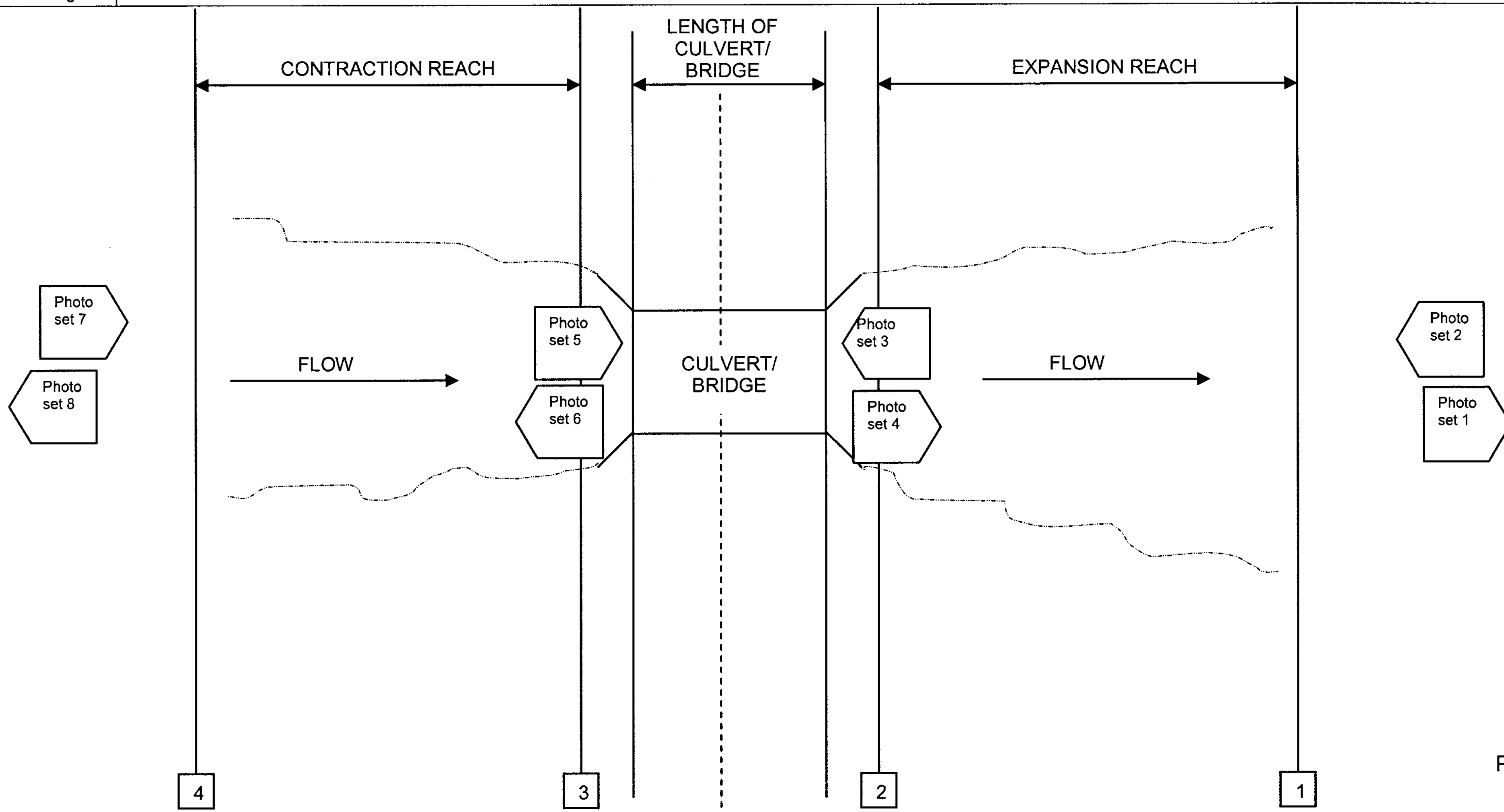


Downstream face of structure:



SITE PHOTOGRAPH DOCUMENTATION

Project Information Fish Passage Improvement Route 555				Computed: EKB		Date: 7/7/06	
				Checked: LEF		Date: 7/8/06	
Stream Name Ripple Creek		City/County Mendocino		Road 555		Postmile 20.2	
Crossing Type	☒ Culvert		☐ Bridge		☐ Other Type/Comments		
Distance From:	X-sec. 1 to X-sec. 2: 28 ft		X-sec. 2 to DS face of culvert 1 ft		US face of culvert to X-Sec. 3 1 ft	X-sec. 3 to X-sec. 4 40 ft	
Distance From:	Photo Sets 1 & 2 to DS face of culvert 100 ft		Photo Sets 3 & 4 to DS face of culvert 10 ft		Photo Sets 5 & 6 to US face of culvert 12 ft	Photo Sets 7 & 8 to US face of culvert 60 ft	
Length of Culvert/Bridge:	ft						



SITE PHOTOGRAPH DOCUMENTATION

Photo Descriptions:

Photo Set 1	Looking at Downstream Channel
Photo Set 2	—
Photo Set 3	Looking at Culvert outlet
Photo Set 4	—
Photo Set 5	Looking at Culvert inlet
Photo Set 6	Looking at Upstream channel
Photo Set 7	—
Photo Set 8	—

Downstream channel

Culver Outlet

Culvert Inlet

Upstream channel

Downstream channel

Culvert Outlet

Manning's n Computation Summary

Project Information		Computed: EKB	Date: 7/7/06
Fish Passage Improvement – Route 555		Checked: LEF	Date: 7/8/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Aerial Picture Attached: NONE

Photographs (#'s and locations) #1, 3, 5, 6

Summary of n-Values:

Reach	Left Overbank	Main Channel	Right Overbank
	0.054	0.048	0.054

Notes:

- Rock slope protection added for proposed conditions at inlet. n=0.040
- concrete culvert box n=0.012

Manning's n Computation - Main Channel

Project Information		Computed: EKB	Date: 7/7/06
Fish Passage Improvement Route 555		Checked: LEF	Date: 7/8/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2
Aerial Picture Attached: NONE			
Photographs (#'s and locations) # 1, 3, 5, 6			

Is roughness uniform throughout the reach? NO

Note: If not, n-value should be assigned for the AVERAGE condition of the reach

Is roughness uniformly distributed along the cross section? NO

Is a division between the channel and floodplain necessary? yes

Calculation of n-value:

n = (nb + n1 + n2 + n3 + n4)m

where:

	Description of Range
nb = base n value for surface	*median size btwn 1" and 2.5"=0.028 to 0.035, btwn 2.5" and 10"=0.030 to 0.050*
n1 = surface irregularity factor	*smooth = 0 up to severe at 0.020*
n2 = cross section variation factor	*gradual = 0 up to alternating frequently at 0.015*
n3 = obstructions factor	*negligible = 0 up to severe (over 50% of cross section) at 0.05*
n4 = vegetation factor	*small = 0.002 to very large (average depth of flow is less than 1/2 height of vegetation) at 0.100*
m = sinuosity/meandering factor	*minor = 1.0, appreciable = 1.15, Severe = 1.30*

Base n value for surface

nb: Sand channel? NO if yes, median size of bed material? ______

nb =

median size (in)	nb
0.008	0.012
0.012	0.017
0.016	0.020
0.020	0.022
0.024	0.023
0.031	0.025
0.039	0.026

All other channels:

median size (in)	nb
→ .04 to .08	0.026 to 0.035
1 to 2.5	0.028 to 0.035
2.5 to 10	0.030 to 0.050
>10	0.040 to 0.070

Notes: Small rock and dirt natural channel

nb = 0.026

Manning's n Computation - Main Channel

Surface Irregularity

n1:	Smooth	Is channel smooth? ________	if yes, n1 = 0
	Minor	Is channel in good condition with slightly eroded or scoured side slopes? →	if yes, n1 = 0.001 - 0.005
	Moderate	Is channel a dredged channel having moderate to considerable bed roughness and moderately sloughed or eroded side slopes in rock?	if yes, n1 = 0.006 - 0.010
	Severe	Is channel badly sloughed, scalloped banks or badly eroded or sloughed sides or jagged and irregular surface?	if yes, n1 = 0.011 - 0.020

Notes: slight eroding of channel. more around culvert inlet

n1 = 0.005

Cross Section Variation Factor

n2:	Gradual	Does the size and shape of the channel cross section change gradually?	if yes, n2 = 0.000
	Alternately occasionally	Does the cross section alternate to large to small, *occasionally* or does the main flow *occasionally* shift from side to side? →	if yes, n2 = 0.001 - 0.005
	Alternately frequently	Does the cross section alternate to large to small, *frequently* or does the main flow *frequently* shift from side to side?	if yes, n2 = 0.010 - 0.015

n2 = 0.003

Notes: occasion shift of flow from left bank to right bank

Obstructions factor

n3:	Negligible	Does the stream have a few scattered obstructions that occupy < 5% of the cross-sectional area? →	if yes, n3 = 0.000 - 0.004
	Minor	Obstructions occupy < 15% of the cross-sectional area and the spacing between obstructions is such that the sphere of influence doesn't extend to other obstructions?	if yes, n3 = 0.005 - 0.015
	Appreciable	Obstructions occupy 15% - 50% of the cross-sectional area and the spacing between obstructions is small enough to be additive?	if yes, n3 = 0.020 - 0.030
	Severe	Obstructions occupy more than 50% of the cross-sectional area or the spacing between obstructions causes turbulence?	if yes, n3 = 0.040 - 0.050

n3 = 0.004

Notes: No large obstructions in channel

Manning's n Computation - Main Channel

Vegetation factor

n4:

Small	Does the channel have dense growth of flexible turf grass or weed growth where the flow is at least 2 times the height of the vegetation; tree seedlings of willows, cottonwoods, etc?	if yes, n4 = 0.002 - 0.010
Medium	Does the channel have turf grass where the average depth of flow is 1 to 2 times the height of the vegetation; moderately stemmy grass, weeds or tree seedlings growing where the flow is 2 to 3 times the height of the vegetation? →	if yes, n4 = 0.010 - 0.025
Large	Does the channel where the average depth of flow is equal to the height of the vegetation; 8 to 10 years-old willows or cottonwoods intergrown with weeds and brush; where the hydraulic radius exceeds1.97 ft or bushy willows about 1 year old intergrown with some weeds along side slopes, and no significant vegetation exists along the channel bottom, where the hydraulic radius is greater than 2.0 ft.	if yes, n4 = 0.025 -0.050
Very large	Does the channel have turf grass growing where the average depth of flow < 1/2 the height of the vegetation; bushy willows about 1 year old. with weeds intergrown on side slopes; dense cattails in channel bottom; trees intergrown with weeds and brush?	if yes, n4 = 0.050 - 0.100

n4 = 0.010

Notes: Leafy-Low vegetation

Sinuosity/meandering factor

m	Minor	Ratio of the channel length to valley length in 1.0 to 1.2	if yes, m = 1.00
	Appreciable	Ratio of the channel length to valley length in 1.2 to 1.5	if yes, m = 1.15
	Severe	Ratio of the channel length to valley length > 1.5	if yes, m = 1.30

m = 1.00

Notes:

Manning's n - Main Channel n = 0.048

Manning's n Computation - Overbank

Project Information		Computed: EKB	Date: 7/7/06
Fish Passage Improvement - Route 555		Checked: LEF	Date: 7/8/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Aerial Picture Attached: NONE

Photographs (#'s and locations) #1, 3, 5, 6

Is roughness uniform throughout the reach? NO

Note: If not, n-value should be assigned for the AVERAGE condition of the reach

Is roughness uniformly distributed along the cross section? NO

Is a division between the channel and floodplain necessary? yes

Calculation of n-value:

n = (nb + n1 + n2 + n3 + n4)m

where:

	Description of Range
nb = base n value for surface	*median size between 1" and 2.5"=0.028 to 0.035, between 2.5" and 10"=0.030 to 0.050*
n1 = surface irregularity factor	*smooth = 0 up to severe at 0.020*
n2 = cross section variation factor	*gradual = 0 up to alternating frequently at 0.015*
n3 = obstructions factor	*assumed to equal 0*
n4 = vegetation factor	*small = 0.002 to very large (average depth of flow is less than 1/2 height of vegetation) at 0.100*
m = sinuosity/meandering factor	*equals 0 for floodplains*

Base n value for surface

nb: Sand channel? NO if yes, median size of bed material? ______

nb =

median size (in)	nb
0.008	0.012
0.012	0.017
0.016	0.020
0.020	0.022
0.024	0.023
0.031	0.025
0.039	0.026

All other channels:

median size (in)	nb
→ .04 to .08	0.026 to 0.035
1 to 2.5	0.028 to 0.035
2.5 to 10	0.030 to 0.050
>10	0.040 to 0.070

Notes: Overbanks consist of small rocks and dirt

nb = 0.026

Surface Irregularity

n1:			
	Smooth	Compares to the smoothest, flattest floodplain in a given bed material.	if yes, n1 = 0
	Minor	Is the floodplain slightly irregular in shape. A few rises and dips or sloughs may be more visible on the floodplain.	→ if yes, n1 = 0.001 - 0.005
	Moderate	Has more rises and dips. Sloughs and hummocks may occur.	if yes, n1 = 0.006 - 0.010
	Severe	Floodplain very irregular in shape. Many rises and dips or sloughs are visible.	if yes, n1 = 0.011 - 0.020

n1 = 0.005

Notes: Slight eroding of overbanks

Manning's n Computation - Overbank

Cross Section Variation Factor

n2 = 0.000

Notes: Not applicable to floodplains.

Obstructions factor

n3:

Negligible	Does the stream have a few scattered obstructions that occupy < 5% of the cross-sectional area?	if yes, n3 = 0.000 - 0.004
Minor	Obstructions occupy < 15% of the cross-sectional area and the spacing between obstructions is such that the sphere of influence doesn't extend to other obstructions? →	if yes, n3 = 0.005 - 0.015
Appreciable	Obstructions occupy 15% - 50% of the cross-sectional area and the spacing between obstructions is small enough to be additive?	if yes, n3 = 0.020 - 0.030

n3 = 0.005

Notes: large boulders present in overbank area

Vegetation factor

n4:

Small	Does the channel have dense growth of flexible turf grass or weed growth where the flow is at least 2 times the height of the vegetation; tree seedlings of willows, cottonwoods, etc where the average depth of flow is at least three times the height of the vegetation?	if yes, n4 = 0.002 - 0.010
Medium	Does the channel have turf grass where the average depth of flow is 1-2 times the height of the vegetation; moderately stemmy grass, weeds or tree seedlings growing where the flow is 2-3 times the height of vegetation? Brushy, moderately dense vegetation, similar to 1-2 year old willow trees in dormant season. →	if yes, n4 = 0.010 - 0.025
Large	Does the channel where the average. depth of flow is equal to the height of the vegetation; 8 to 10 year old. willows, cottonwoods intergrown with weeds and brush; where the R = 1.97 ft or bushy willows of 1 year old are in the channel bottom, where R =2.00 ft?	if yes, n4 = 0.025 -0.050
Very large	Does the channel have turf grass growing where the average depth of flow < 1/2 the height of the vegetation; bushy willows about 1 year old. with weeds intergrown on side slopes; dense cattails in channel bottom; trees intergrown with weeds and brush?	if yes, n4 = 0.050 - 0.100
Extreme	Does the channel have dense bushy willow, mesquite, and salt cedar (full foliage), or heavy stand of timber, few down trees, depth of reaching branches?	if yes, n4 = 0.100 - 0.200

n4 = 0.018

Notes: Leafy vegetation, low to ground ~5 ft tall

Sinuosity/meandering factor

m = 1.00

Notes: Not applicable to floodplains.

Manning's n - Overbank n = 0.054

Form 3- Guidance on Selection of Fish Passage Design Option

This form summarizes requirements for each design option in order for the designer to select the appropriate fish-passage design option.

Since the existing culvert is in good structural and hydraulic condition, it should be rehabilitated instead of replaced to allow for adult, Coho salmon migration. By rehabilitation, the Caltrans portion of the project cost can be funded through a Minor B, and of course fewer impacts to the stream and habitat are probable during construction.

The best method of rehabilitation is to construct baffles inside the culvert. This would qualify as a Hydraulic Design option, and velocity/depth requirements will have to be addressed. As identified in the CA Fish & Game *Culvert Criteria for Fish Passage*, the velocity/depth criteria should be the goal for improvement, not the required threshold. With this statement in mind, the design engineer must still make reasonable effort to meet the velocity/depth requirements through the culvert baffling.

GUIDANCE ON SELECTION OF FISH PASSAGE DESIGN OPTION — FORM 3

Project Information Fish Passage Improvement Route 555		Computed: EKB	Date: 7/10/06
		Checked: LEF	Date: 7/11/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Design Species/ Life Stage	☐	All Species
	☒	Adult Anadromous Salmonids
	☐	Adult Non-Anadromous Salmonids
	☐	Juvenile Salmonids
	☐	Native Non-Salmonids
	☐	Non-Native Species

☐ **Active Channel Design Option -** The Active Channel Design Option is a simplified design method that is intended to size a crossing sufficiently large and embedded deep enough into the channel to allow the natural movement of bedload and formation of a stable streambed inside the culvert. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this option since with stream hydraulic charagcteristics within the culvert are intended to mimic the stream conditions upstream and downstream of the crossing. However, hydraulic analyses for traffic safety, hydraulic impacts, and scour are required.

Criteria for choosing option:

- ☐ New and replacement culvert/bridge installations
- ☐ Passage required for all species
- ☒ Proposed culver/bridge length less than 100 feet
- ☒ Channel slope less than 3%

☒ **Hydraulic Design Option** - The Hydraulic Design Option is a design process that matches the hydraulic performance of a culvert with the swimming ablitities of a target species and age class of fish. This method targets distinct species of fish and, therefore, does not account for ecosystem requirments of non-target species.

Criteria for choosing option:

- ☐ New and replacement culvert/bridge installations (If retrofit installation, see Baffle or Rock Weir Design Options)
- ☒ Target species identified for passage
- ☒ Low to moderate channel slopes (less than 3%)
- ☒ Active channel design or stream simulation design options are not physically feasible

Retrofit Culvert/Bridge Installations

☒ **Baffle Design Option -** The Baffle Design Option is a Hydrualic Design process that is intended to increase flow depth, or to add roughness elements as a measure to reduce flow velocity within the culvert/bridge structure. Determination of the high and low fish passage design flows, water velocity, and water depth is required for this option.

- ☒ Retrofit culvert/bridge installation
- ☒ Little bedload material movement

- ☒ Existing culvert/bridge is structurally sound
- ☒ Target species identified for passage
- ☒ Low to moderate channel slopes
- ☒ Active channel design or stream simulation design options are not physically feasible

☐ **Rock Weir Design Option -** The Rock Weir Design Option is a Hydraulic Design process that is intended to increase flow depth, or add roughness elements as a measure to reduce flow velocity, or to increase the channel slope downstream of the culvert/bridge. Determination of the high and low fish passage design flows, water velocity, and water depth is required for this option.

- ☐ Retrofit culvert/bridge installations
- ☐ Perched condition at outlet
- ☐ Steep slope at inlet
- ☒ Target species identified for passage
- ☒ Active channel design or stream simulation design options are not physically feasible

☐ **Stream Simulation Design Option -** The Stream Simulation Design Option is a design process that is intended to mimic the natural stream processes within a culvert. Fish passage, sediment transport, flood and debris conveyance within the crossing are intended to function as they would in a natural channel. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this options since the stream hydraulic characteristics within the culvert are designed to mimic the stream conditions upstream and downstream of the crossing.

Criteria for choosing option:

- ☐ New and replacement culvert/bridge installations
- ☐ Passage required for all species
- ☐ Culvert/bridge length greater than 100 feet
- ☒ Channel width should be less than 20 feet
- ☒ Minimum culvert/bridge width no less than 6 feet
- ☒ Culvert/bridge slope does not greatly exceed slope of natural channel, slopes of 6 % or less
- ☐ Narrow stream valleys

Selected Design Option: Hydraulic Baffle Design Option

Basis for Selection:
- Retrofit culvert
- target species identified: coho salmon
- need to increase depth w/in culvert
- need to decrease velocities w/in culvert

Seek Agency Approval: ☐ Yes ☒ No

Form 4- Guidance on Methodology for Hydrologic Analysis

Form 4 summarizes methods for estimating peak design discharges that will be used in a hydraulic analysis. Data requirements, limitations, and guidance are provided to assist in the hydrologic method selection.

For this particular example, all data requirements needed to calculate peak discharges by regional regression equations were readily available.

Stream flow data was also available allowing a stream flow hydrograph and stream duration curve to be created. Upper and lower fish passage flows were calculated.

GUIDANCE ON METHODOLOGY FOR HYDROLOGIC ANALYSIS [1, 2] FORM 4

Project Information	Computed: EKB	Date: 7/11/06
Fish Passage Improvement - Route 555	Checked: LEF	Date: 7/12/06
Stream Name: Ripple Creek / County: Mendocino	Route: 555	Postmile: 20.2

Summary of Methods for Estimating Peak Design Discharges for Use in Hydraulic Analysis

Ungaged Streams

☒ **Regional Regression[3, 4]**

Data Requirements	Limitations	Guidance
▪ Drainage area ▪ Mean annual precipitation ▪ Altitude index	▪ Peak discharge value for flow under natural conditions unaffected by urban development and little or no regulation by lakes or reservoirs ▪ Ungaged channel	The most recently published USGS report for estimating peak discharges may be used. The user should exercise caution to ensure that the reports are used only for the conditions and locations for which they are recommended.

Rainfall-Runoff Models

☐ **NRCS (TR 55)[5]**

Data Requirements	Limitations	Guidance
▪ 24-hour Rainfall ▪ Rainfall distribution ▪ Runoff curve number ▪ Concentration time ▪ Drainage area	▪ Small or midsize catchment (<8 km^2) ▪ Maximum of 10 subwatersheds ▪ Concentration time range from 0.1-10 hour (tabular hydrograph method limit <2 hour) ▪ Runoff is overland and channel flow ▪ Simplified channel routing ▪ Negligible channel storage	TR-55 focuses on small urban and urbanizing watersheds.

☐ **HEC-1/HEC-HMS[6, 7] (SCS Dimnesionless, Snyder Unit, Clark Unit Hydrographs)**

Data Requirements	Limitations	Guidance
▪ Watershed/subbasin parameters ▪ Precipitation depth, duration, frequency, and distribution ▪ Precipitation losses ▪ Unit hydrograph parameters ▪ Streamflow routing and diversion parameters	▪ Simulations are limited to a single storm event ▪ Streamflow routing is performed by hydrologic routing methods and is therefore not appropriate for unsteady state routing conditions.	Can be used for watersheds which are: small or large, simple or complex, and developed or undeveloped.

[1] Caltrans Highway Design Manual, Chapter 810 Hydrology, Topic 819 Estimating Design Discharge
[2] FEMA Guidelines and Specifications, Appendix C, Section C.1
[3] USGS Water-Resources Investigation 77-21 (Magnitude and Frequency of Floods in California)
[4] USGS Open-File Report 93-419 (Methods for Estimating Magnitude and Frequency of floods in the Southwestern United States)
[5] United States Department of Agriculture, Natural Resources Conservation Service, Urban Hydrology for Small Watersheds Technical Release 55, June 1986. ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/tr55/tr55.pdf
[6] HEC-1 User's Manual
[7] HEC-HMS User's Manual
[8] Bulletin 17B

GUIDANCE ON METHODOLOGY FOR HYDROLOGIC ANALYSIS [1, 2] FORM 4

GAGED STREAMS

☐ **Statistical Methods**[8]

Data Requirements	Limitations	Guidance
▪ 10 or more years of gaged flood records	▪ Gage data is usually only available for midsized and large catchments ▪ Appropriate station and/or generalized skew coefficient relationship applied	For watersheds with less than 50 years of record, compare with results of appropriate USGS regional regression equations. For watersheds with less than 25 years of record, compare with results of appropriate USGS regional regresssion equations and/or HEC-1/HEC-HMS model results.

☐ **Basin Transfer of Gage Data**

Data Requirements	Limitations	Guidance
▪ Discharge and area for gaged watershed ▪ Area for ungaged watershed	▪ Similar hydrologic characteristics ▪ Channel storage	Must obtain approval of transfer technique from hydraulics engineer prior to use.

☒ **Fish Passage Flows**

▪ Streamflow hydrograph ▪ Flow duration curve		Lower and upper fish passage flows define the range of flows a culvert should contain suitable conditions for fish passage.

Selected Hydrologic Method: Regional Regression & Fish Passage Flows

Basis for Selection:

- Data available for Regional Regression analysis
- Required to meet adult anadromous Salmonid depth and velocities

[1] Caltrans Highway Design Manual, Chapter 810 Hydrology, Topic 819 Estimating Design Discharge
[2] FEMA Guidelines and Specifications, Appendix C, Section C.1
[3] USGS Water-Resources Investigation 77-21 (Magnitude and Frequency of Floods in California)
[4] USGS Open-File Report 93-419 (Methods for Estimating Magnitude and Frequency of floods in the Southwestern United States)
[5] United States Department of Agriculture, Natural Resources Conservation Service, Urban Hydrology for Small Watersheds Technical Release 55, June 1986. ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/tr55/tr55.pdf
[6] HEC-1 User's Manual
[7] HEC-HMS User's Manual
[8] Bulletin 17B

Verify Reasonableness and Recommended Peak Discharges

Source	50% Annual Probability (2-Year Flood Event) (cfs)	10% Annual Probability (10-Year Flood Event) (cfs)	2% Annual Probability (50-Year Flood Event) (cfs)	1% Annual Probability (100-Year Flood Event) (cfs)	High Fish Passage Design Flow (cfs)	Low Fish Passage Design Flow (cfs)
Effective Study Peak Discharges	N/A	N/A	N/A	N/A	N/A	N/A
Recommended Peak Discharges	161	337	528	593	81	20

Hydrologic Analysis Index Attached ☒ Yes ☐ No

Hydrologic Analysis Calculations Attached ☒ Yes ☐ No

1 Caltrans Highway Design Manual, Chapter 810 Hydrology, Topic 819 Estimating Design Discharge
2 FEMA Guidelines and Specifications, Appendix C, Section C.1
3 USGS Water-Resources Investigation 77-21 (Magnitude and Frequency of Floods in California)
4 USGS Open-File Report 93-419 (Methods for Estimating Magnitude and Frequency of floods in the Southwestern United States)
5 United States Department of Agriculture, Natural Resources Conservation Service, Urban Hydrology for Small Watersheds Technical Release 55, June 1986. ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/tr55/tr55.pdf
6 HEC-1 User's Manual
7 HEC-HMS User's Manual
8 Bulletin 17B

HYDROLOGIC ANALYSES INDEX — FORM 4

Project Information Fish Passage Improvement - Route 555		Computed: EKB	Date: 7/11/06
		Checked: LEF	Date: 7/12/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Flooding Source/Stream Name	Hydrologic Method/Model Used	Method/Model Analysis Date	Exhibit No.	
			Paper Copy	Electronic Copy
Ripple Creek	USGS-Regional Regression	North Coast Region	1	—
Ripple Creek	Upper and Lower Fish Passage Flows	Flow Duration Curve	—	1

Regional Regression Computation Summary

Project Information: Fish Passage Improvement - Route 555		Computed: EKB	Date: 6/31/2006
		Checked: JJL	Date: 7/1/2006
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Calculations:

-Site Located in North Coast Region

A, Drainage Area = 1.05 mi^2
P, Mean Annual Precipitation = 70 inches
H, Altitude Index = 1 thousands of feet

Regional Regression Equations

Q2 =3.52A^0.90P^0.89H^-0.47
Q2 = 161 cfs

Q10 =6.21A^0.88P^0.93H^-0.27
Q10 = 337 cfs

Q50 = 8.57A^0.87P^0.96H^-0.08
Q50 = 528 cfs

Q100 = 9.23A^0.87P^0.97
Q100 = 593 cfs

The following documentation was taken from:

U.S. Geological Survey Water-Resources Investigations Report 94-4002:
Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993

CALIFORNIA

STATEWIDE RURAL

Summary

California is divided into six hydrologic regions (fig. 1). The regression equations developed for these regions are for estimating peak discharges (QT) having recurrence intervals T that range from 2 to 100 years. The explanatory basin variables used in the equations are drainage area (A), in square miles; mean annual precipitation (P), in inches; and an altitude index (H), which is the average of altitudes in thousands of feet at points along the main channel at 10 percent, and 85 percent of the distances from the site to the divide. The variables A and H may be measured from topographic maps. Mean annual precipitation (P) is determined from a map in Rantz (1969). The regression equations were developed from peak-discharge records of 10 years or longer, available as of 1975, at more than 700 gaging stations throughout the State. The regression equations are applicable to unregulated streams but are not applicable to some parts of the State (see fig. 1). The standard errors of estimate for the regression equations for various recurrence intervals and regions range from 60 to over 100 percent. The report by Waananen and Crippen (1977) includes an approximate procedure for increasing a rural discharge to account for the effect of urban development. The influences of fire and other basin changes on flood magnitudes are also discussed.

Procedure

Topographic maps, the hydrologic regions map (fig. 1), the mean annual precipitation from Rantz (1969), and the following equations are used to estimate the needed peak discharges QT, in cubic feet per second, having selected recurrence intervals T.

North Coast Region

$Q2 = 3.52\ A^{0.90}\ P^{0.89}\ H^{-0.47}$
$Q5 = 5.04\ A^{0.89}\ P^{0.91}\ H^{-0.35}$
$Q10 = 6.21\ A^{0.88}\ P^{0.93}\ H^{-0.27}$
$Q25 = 7.64\ A^{0.87}\ P^{0.94}\ H^{-0.17}$
$Q50 = 8.57\ A^{0.87}\ P^{0.96}\ H^{-0.08}$
$Q100 = 9.23\ A^{0.87}\ P^{0.97}$

Northeast Region

$Q2 = 22\ A^{0.40}$
$Q5 = 46\ A^{0.45}$
$Q10 = 61\ A^{0.49}$
$Q25 = 84\ A^{0.54}$
$Q50 = 103\ A^{0.57}$
$Q100 = 125\ A^{0.59}$

Sierra Region

$Q2 = 0.24\ A^{0.88}\ P^{1.58}\ H^{-0.80}$
$Q5 = 1.20\ A^{0.82}\ P^{1.37}\ H^{-0.64}$
$Q10 = 2.63\ A^{0.80}\ P^{1.25}\ H^{-0.58}$
$Q25 = 6.55\ A^{0.79}\ P^{1.12}\ H^{-0.52}$
$Q50 = 10.4\ A^{0.78}\ P^{1.06}\ H^{-0.48}$
$Q100 = 15.7\ A^{0.77}\ P^{1.02}\ H^{-0.43}$

Central Coast Region

$Q2 = 0.0061\ A^{0.92}\ P^{2.54}\ H^{-1.10}$
$Q5 = 0.118\ A^{0.91}\ P^{1.95}\ H^{-0.79}$
$Q10 = 0.583\ A^{0.90}\ P^{1.61}\ H^{-0.64}$
$Q25 = 2.91\ A^{0.89}\ P^{1.26}\ H^{-0.50}$
$Q50 = 8.20\ A^{0.89}\ P^{1.03}\ H^{-0.41}$
$Q100 = 19.7\ A^{0.88}\ P^{0.84}\ H^{-0.33}$

South Coast Region

$Q2 = 0.14\ A^{0.72}\ P^{1.62}$
$Q5 = 0.40\ A^{0.77}\ P^{1.69}$
$Q10 = 0.63\ A^{0.79}\ P^{1.75}$
$Q25 = 1.10\ A^{0.81}\ P^{1.81}$
$Q50 = 1.50\ A^{0.82}\ P^{1.85}$
$Q100 = 1.95\ A^{0.83}\ P^{1.87}$

South Lahontan-Colorado Desert Region

$$Q2 = 7.3A^{0.30}$$
$$Q5 = 53A^{0.44}$$
$$Q10 = 150A^{0.53}$$
$$Q25 = 410A^{0.63}$$
$$Q50 = 700A^{0.68}$$
$$Q100 = 1080A^{0.71}$$

In the North Coast region, use a minimum value of 1.0 for the altitude index (H). Equations are defined only for basins of 25 mi^2 or less in the Northeast and South Lahontan-Colorado Desert regions.

Reference

Waananen, A.O., and Crippen, J.R., 1977, Magnitude and frequency of floods in California: U.S. Geological Survey Water-Resources Investigations Report 77-21, 96 p.

Additional Reference

Rantz, S.E., 1969, Mean annual precipitation in the California region: U.S. Geological Survey Open-File Map (Reprinted 1972, 1975).

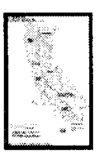


Figure 1. Flood-frequency region map for California. (PostScript file of Figure 1.)

Back to NFF main page

USGS Surface-Water Software Page

U.S. Geological Survey
National Flood Frequency Program
Water-Resources Investigations Report 94-4002

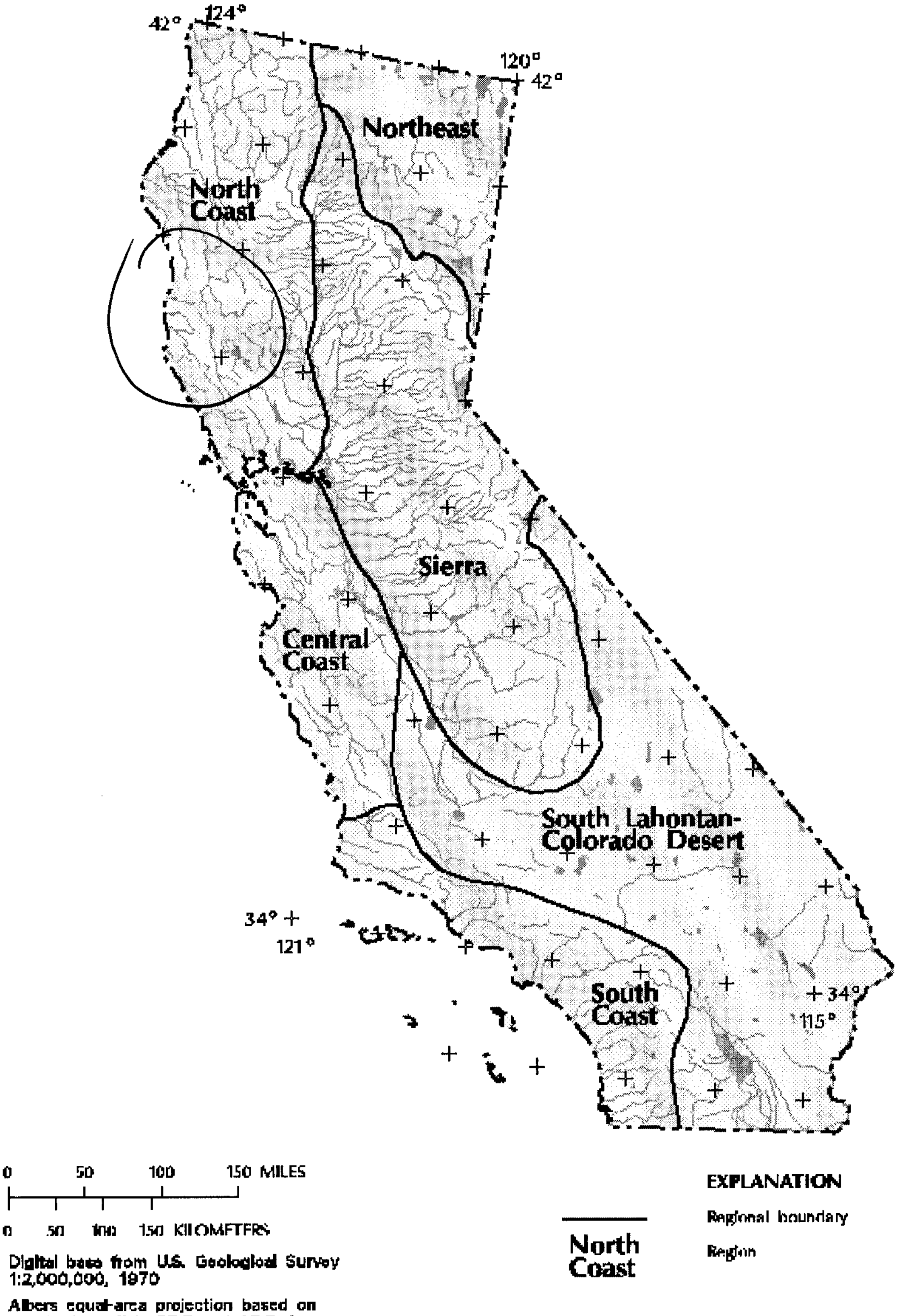
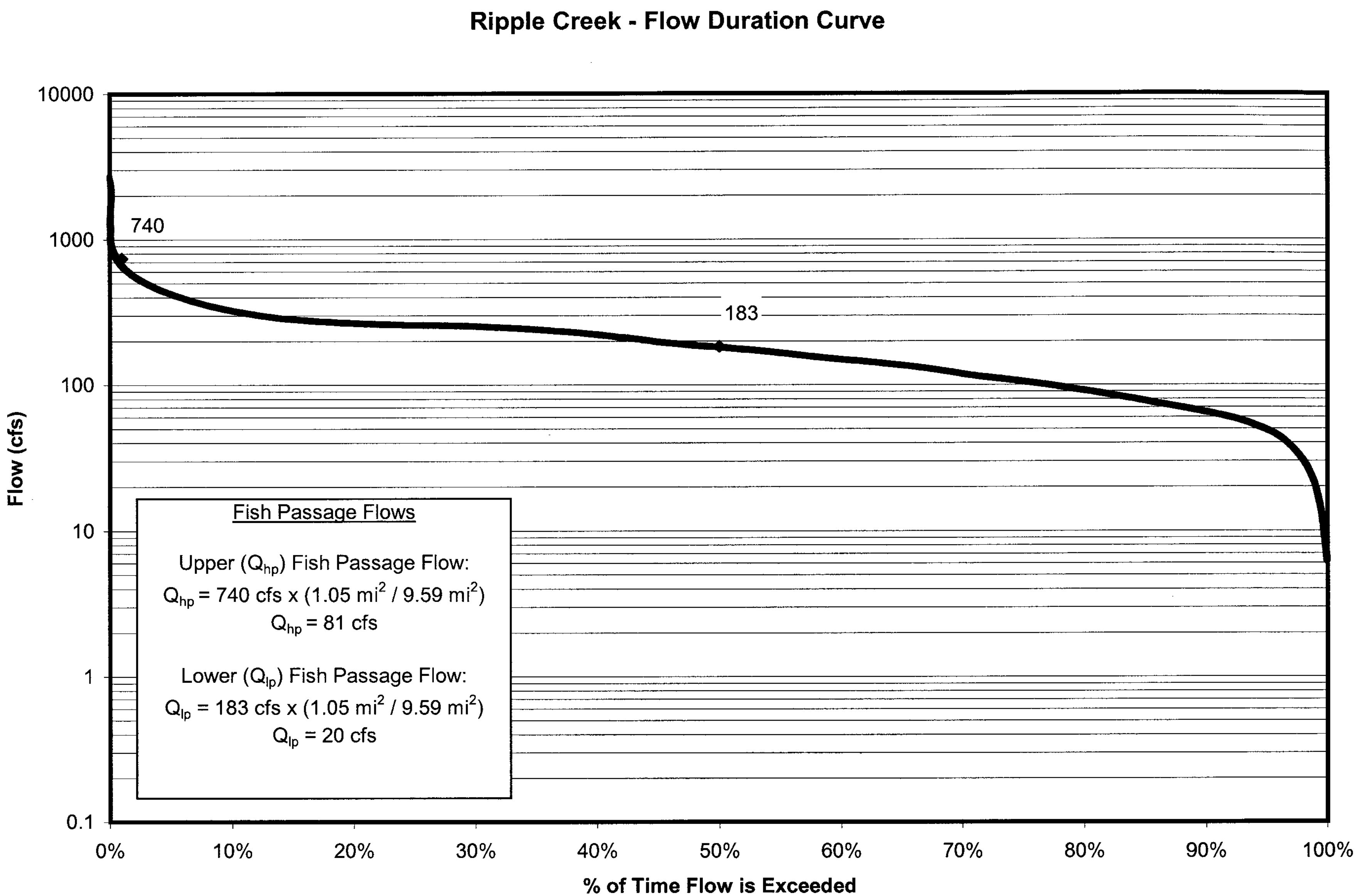


Figure 1. Flood-frequency region map for California.



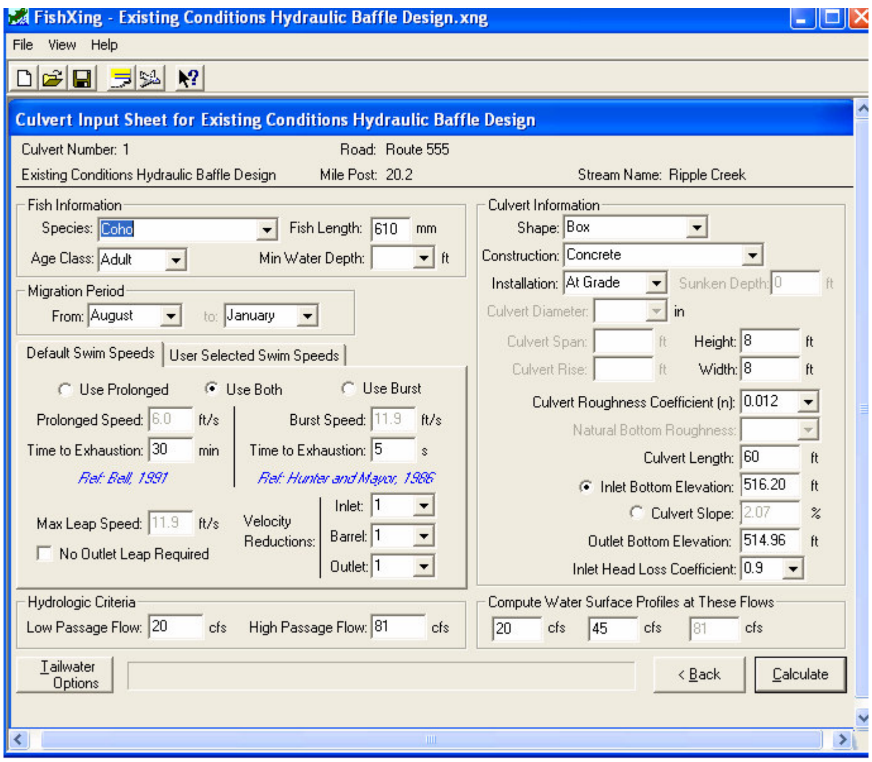
Ripple Creek - Flow Duration Curve
10000
1000
100
10
1
0.1
Flow (cfs)
740
183
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% of Time Flow is Exceeded
Fish Passage Flows
Upper (Q_{hp}) Fish Passage Flow:
Q_{hp} = 740 cfs x (1.05 mi^2 / 9.59 mi^2)
Q_{hp} = 81 cfs
Lower (Q_{lp}) Fish Passage Flow:
Q_{lp} = 183 cfs x (1.05 mi^2 / 9.59 mi^2)
Q_{lp} = 20 cfs

Form 5 - Guidance on Methodology for Hydraulic Analysis

Form 5 summarizes the acceptable methods available for hydraulic analysis. The modeling methods include FHWA Design Charts, HY8 - Culvert Analysis, and HEC-2/HEC-RAS, and Fish Xing for pre or post design assessment.

For this particular example, Fish Xing and HEC-RAS were used to model existing conditions, and HEC-RAS was used to model proposed conditions. Fish Xing was not used to model proposed conditions because it presently cannot analyze baffles in the culvert. HEC-RAS easily allowed a quick comparison between existing and proposed water surface elevations and velocities.

Again, Fish Xing software was used to analyze existing conditions for Ripple Creek. Biological, existing culvert parameters and the tailwater cross section were entered into the Culvert Input sheet shown below.



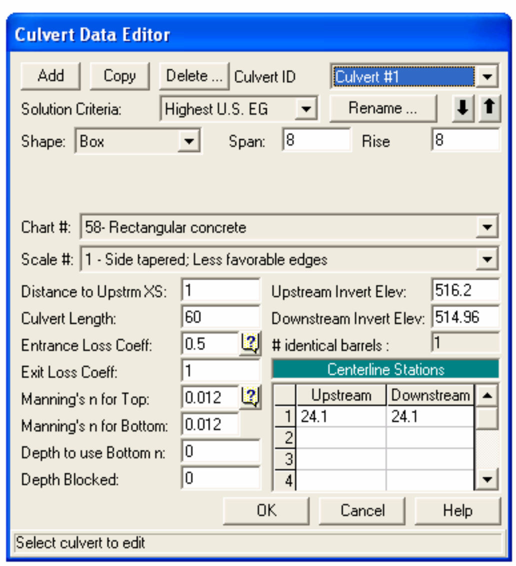
The HEC-RAS model consisted of three plans: Existing, Proposed Low Flow, and Proposed High Flow geometry conditions. Different geometry models for the low flows and high flows were considered as a necessary measure to accurately capture the correct water behavior for the different peak discharges.

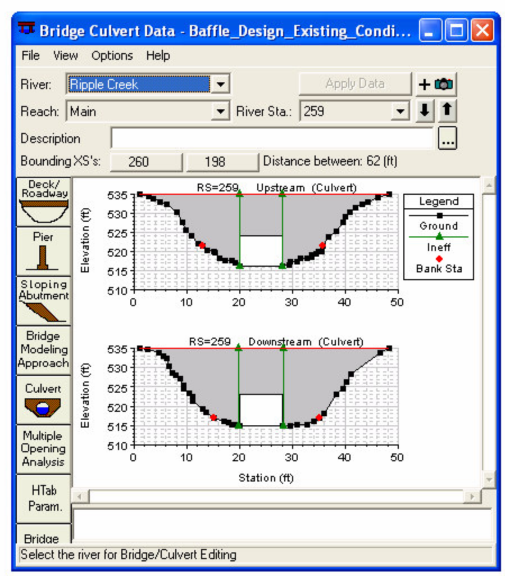
For the low flows, which include the Low and High Fish Passage Design Flows, 2-Year, and the 10-Year Flood Event, the channel geometry was modeled as an open rectangular channel (8’x8’) with three inline structures representing the baffles within the culvert.

For the high flows, which include the 50-Year and 100-Year Flood Event, the culvert and baffles were modeled by allowing flow only through the notch and the 6'x 8' area above the inline structure through the culvert structure. At high flows, the baffle structures within the culvert are flooded out and do not provide control over the culvert velocities and depths. The Manning's n values also decrease due to the flooded out conditions. The Manning's n-values were selected by calibrating the Proposed High Flow, 2-Year flood event water surface elevations, against the Proposed Low Flow, 2-Year water surface elevation upstream and downstream of the culvert until the water surface elevation matched.

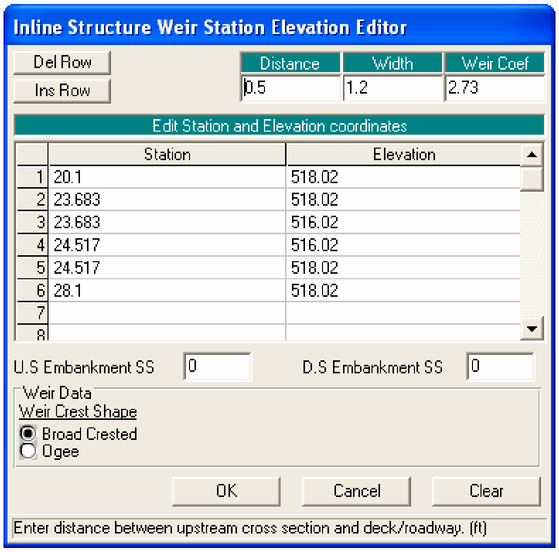
All HEC-RAS plans use the same peak discharges estimated by regional regression analysis and the flow hydrograph and stream duration curve.

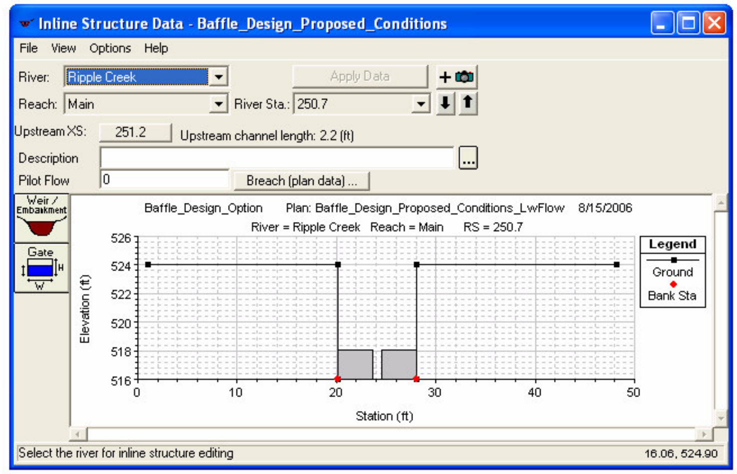
The existing conditions culvert geometry was modeled using the Culvert Data Editor. The existing culvert parameters that had been measured and captured in Form 2 - Site Visit Summary, were entered into the Culvert Data Editor within HEC-RAS. The Culvert Data Editor and Bridge Culvert Data windows are captured below.



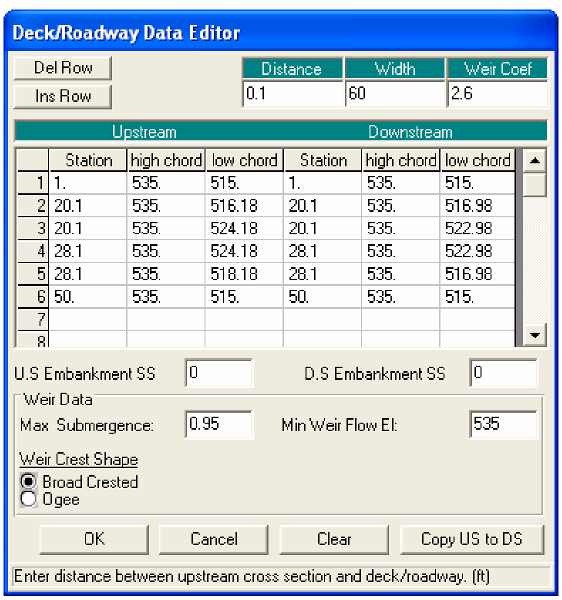


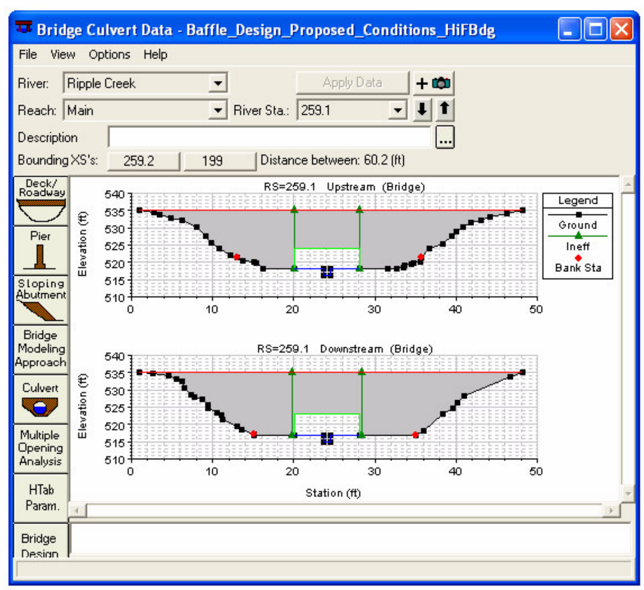
The proposed conditions for low flows geometry were modeled using the Inline Structure Weir Station Elevation Editor in HEC-RAS. Proposed dimensions of the weir were selected and entered into the culvert to determine proposed water surface behaviors for low flows. The Inline Structure Weir Station Elevation Editor and Inline Structure Data windows are captured below.





The proposed conditions for high flows geometry were modeled using the Deck/Roadway Data Editor in HEC-RAS. Culvert geometry for high flows was entered into the Deck/Roadway Data Editor to determine proposed water surface behaviors for high flows. The Deck/Roadway Data Editor and Bridge Culvert Data windows are captured below.





Hand Calculations to determine notch velocity and depth at the three weirs were also performed using the broad-crested weir equation located in Hydraulic Engineering Circular 22, *Urban Drainage Design Manual.*

GUIDANCE ON METHODOLOGY FOR HYDRAULIC ANALYSIS			FORM 5
Project Information Fish Passage Improvement Route-555		Computed: EKB	Date: 7/15/06
		Checked: LEF	Date: 7/16/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Summary of Methods for Hydraulic Analysis

☐ **FHWA Design Charts**

☐ **HY8 - Culvert Analysis or other HDS-5 Based Software**

☒ **HEC-2 / HEC-RAS**

☒ **Fish Xing (Pre-design assessment or post-design assessment when applicable)**

Is the hydraulic model used to create the effective FIRM available? ☐ Yes ☒ No
If yes, update and use this model for the hydraulic model.

Selected Method: HEC-RAS

Basis for Selection: HEC-RAS-
Ability to model inline structures with different weir geometry

Fish Xing -
Pre-design assessment

Verify Reasonableness and Recommended Flows ☒ Yes ☐ No

Hydraulic Analyses Index Attached ☒ Yes ☐ No

Hydraulic Analysis Calculation Attached ☒ Yes ☐ No

HYDRAULIC ANALYSES INDEX			FORM 5
Project Information Fish Passage Improvement - Route 555		Computed: EKB	Date: 7/15/06
		Checked: LEF	Date: 7/16/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

Flooding Source/Stream Name	Hydraulic Method/Model Used	Method/Model Analysis Date	Exhibit No.	
			Paper Copy	Electronic Copy
Ripple Creek	HEC-RAS	Existing Conditions	/	.p07 .g06 .f01
Ripple Creek	HEC-RAS	Proposed Conditions Low Flow Analysis	/	.p02 .g02 .f01
Ripple Creek	HEC-RAS	Proposed Conditions High Flow Analysis	/	.p05 .g05 .f01
Ripple Creek	FISH XING	Existing - Conditions Hydraulic Baffle Design	/	pre-design assessment

Culvert Report for Existing Conditions Hydraulic Baffle Design

Project: Existing_Conditions_Hydraulic_Baffle_Design

Culvert Location Information
- Road: Route 555
- Mile Post: 20.2
- Stream Name: Ripple Creek
- Length of Historical Upstream Habitat: 3000 ft

Biological Data
- Species: Adult Coho
- Fish Length: 610 mm
- Minimum Water Depth: 1 ft
- Migration Period: August to January
- Prolonged Swimming Speed: 6 ft/s
- Prolonged Time to Exhaustion: 30 min
- Burst Swimming Speed: 11.9 ft/s
- Burst Time to Exhaustion: 5 s
- Jumping Speed: 11.9 ft/s
- Velocity Reduction Factors:
  - Inlet: 1.00
  - Barrel: 1.00
  - Outlet: 1.00

Culvert Installation Data
- Culvert Type: 8 X 8 ft Box
- Construction: Concrete
- Installation: At Grade
- Culvert Length: 60 ft
- Culvert Slope: 2.07%
- Culvert Roughness Coefficient: 0.012
- Inlet Invert Elevation: 516.2 ft
- Outlet Invert Elevation: 514.96 ft
- Inlet Headloss Coefficient (Ke): 0.9

Design Flows
- Low Passage Flow: 20 cfs
- High Passage Flow: 81 cfs

Table 1. Uniform Flow Calculations.

Discharge (cfs)	Velocity (ft/s)	Normal Depth (ft)	Critical Depth (ft)	Outlet Velocity (ft/s)	Tailwater Depth (ft)	Pool Depth (ft)	Min Rqd. Leap Velocity (ft/s)	Vert. Leap Distance (ft)	Comments
0.00	0.00	0.00	0.00	0.00	-0.56	0.00			
3.03	3.78	0.10	0.16	3.78	-0.11	0.45	5.21	0.21	Depth; Pool
9.45	5.91	0.20	0.35	5.91	0.13	0.69	0.00	0.00	Depth
18.29	7.62	0.30	0.55	7.02	0.33	0.89	0.00	0.00	Depth; Vel
20.00	7.89	0.32	0.58	7.05	0.35	0.91	0.00	0.00	LPF; Depth; Vel
29.10	9.09	0.40	0.74	7.37	0.49	1.05	0.00	0.00	Depth; Vel
41.58	10.40	0.50	0.94	7.89	0.66	1.22	0.00	0.00	Depth; Vel
55.53	11.57	0.60	1.14	8.49	0.82	1.38	0.00	0.00	Depth; Vel
70.77	12.64	0.70	1.34	9.09	0.97	1.53	0.00	0.00	Depth; Vel
81.00	13.27	0.76	1.47	9.46	1.07	1.63	0.00	0.00	HPF; Depth; Vel
87.18	13.62	0.80	1.55	9.67	1.13	1.69	0.00	0.00	Depth; Vel
104.64	14.53	0.90	1.74	10.24	1.28	1.84	0.00	0.00	Depth; Vel
123.06	15.38	1.00	1.94	10.79	1.43	1.99	0.00	0.00	Vel
142.36	16.18	1.10	2.14	11.33	1.57	2.13	0.00	0.00	Vel

Comment Codes:

- LPF - Low Passage Flow
- HPF - High Passage Flow
- Depth - Insufficient Depth
- Vel - Excessive Velocity
- Leap - Excessive Leap
- Pool - Shallow Leap Pool

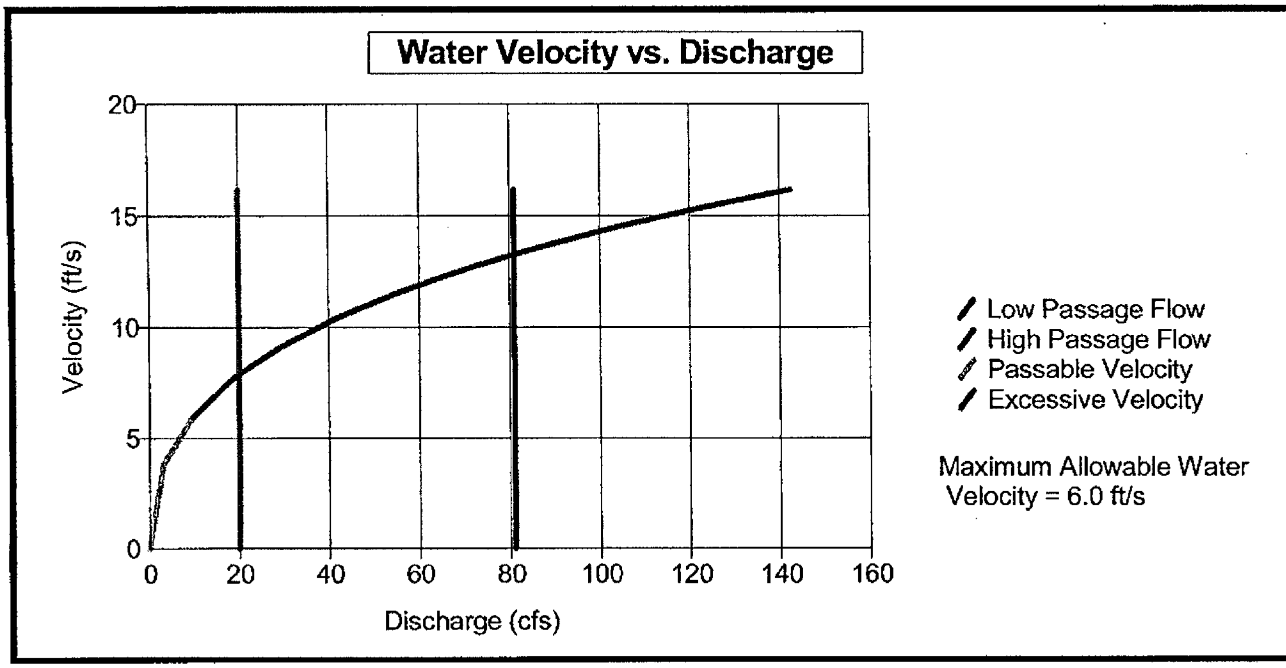


Figure 1. Velocity at Uniform Flow

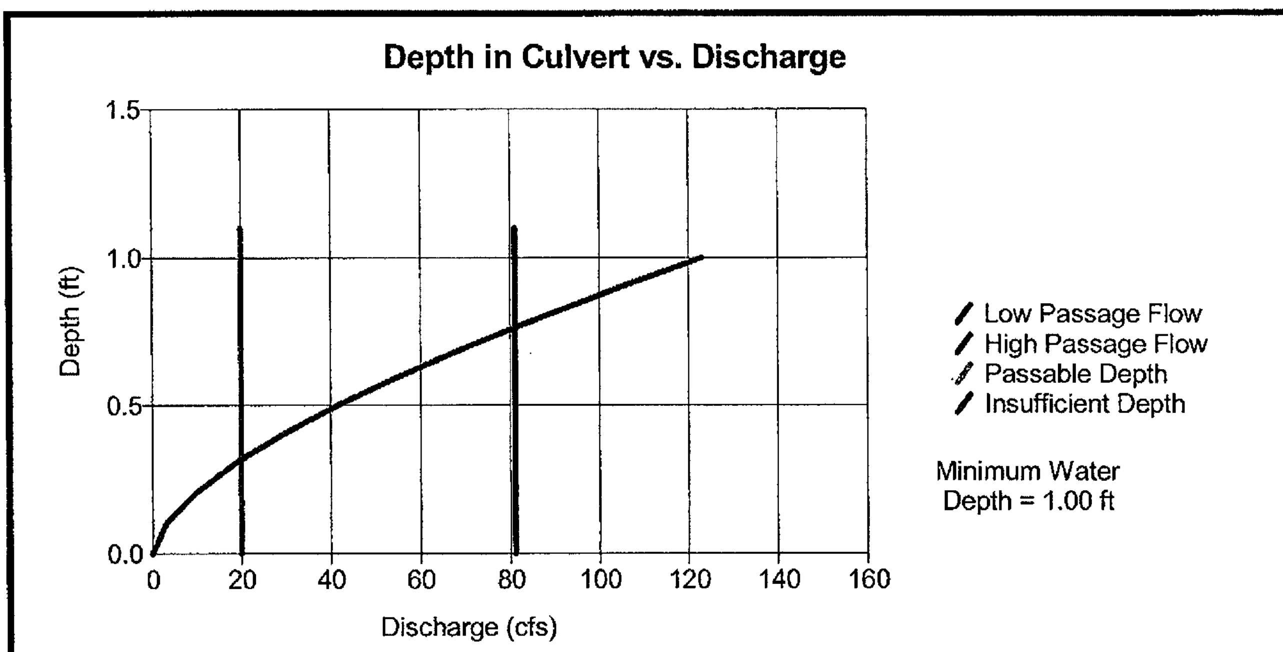


Figure 2. Depth at Uniform Flow

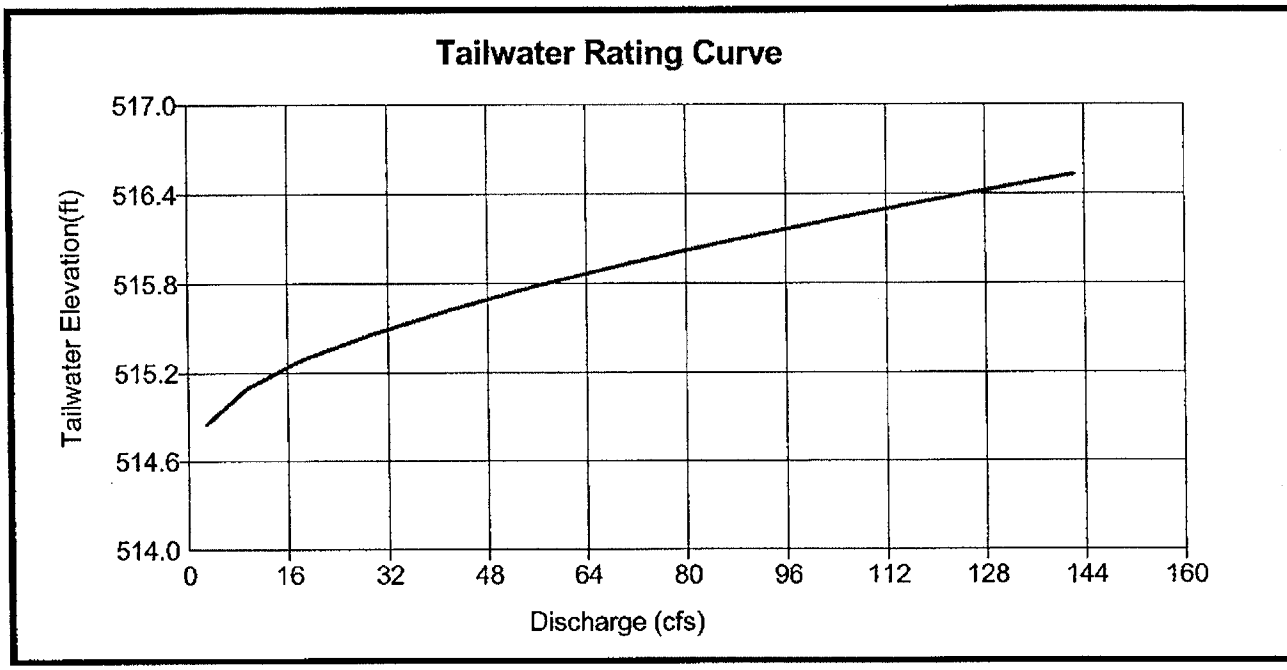


Figure 3. Tailwater Rating Curve at Uniform Flow

Table 2. Gradually Varied Flow Calculations for 20 cfs.

Q = 20.0 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity (ft/s)	Curve	Swim Mode
0	1.13	0.00	Inlet	
3	0.58	5.95	S2	NA
5	0.48	5.22	S2	NA
8	0.44	5.70	S2	NA
11	0.41	6.06	S2	NA
14	0.40	6.32	S2	NA
17	0.38	6.54	S2	NA
20	0.37	6.72	S2	NA
23	0.36	6.86	S2	NA
26	0.36	6.99	S2	NA
29	0.35	7.11	S2	NA
32	0.35	7.20	S2	NA
35	0.34	7.28	S2	NA
38	0.34	7.35	S2	NA
41	0.34	7.42	S2	Exhausted
44	0.33	7.48	S2	Burst
47	0.33	7.52	S2	Burst
50	0.33	7.56	S2	Burst
53	0.33	7.59	S2	Burst
56	0.33	7.63	S2	Burst
60	0.33	7.68	S2	Burst

Table 3. Gradually Varied Flow Specifications for 20 cfs.

	20.0 cfs
Normal Depth (ft)	0.32
Critical Depth (ft)	0.58
Headwater Depth (ft)	1.13
Inlet Velocity (ft/s)	5.95
Tailwater Depth (ft)	0.35
Burst Swim Time (s)	5.00
Prolonged Swim Time (min	0.00
Barrier Code	Depth; EB

Barrier Codes

Depth - Too shallow for substantial distance

EB - Fish exhausted at burst speed

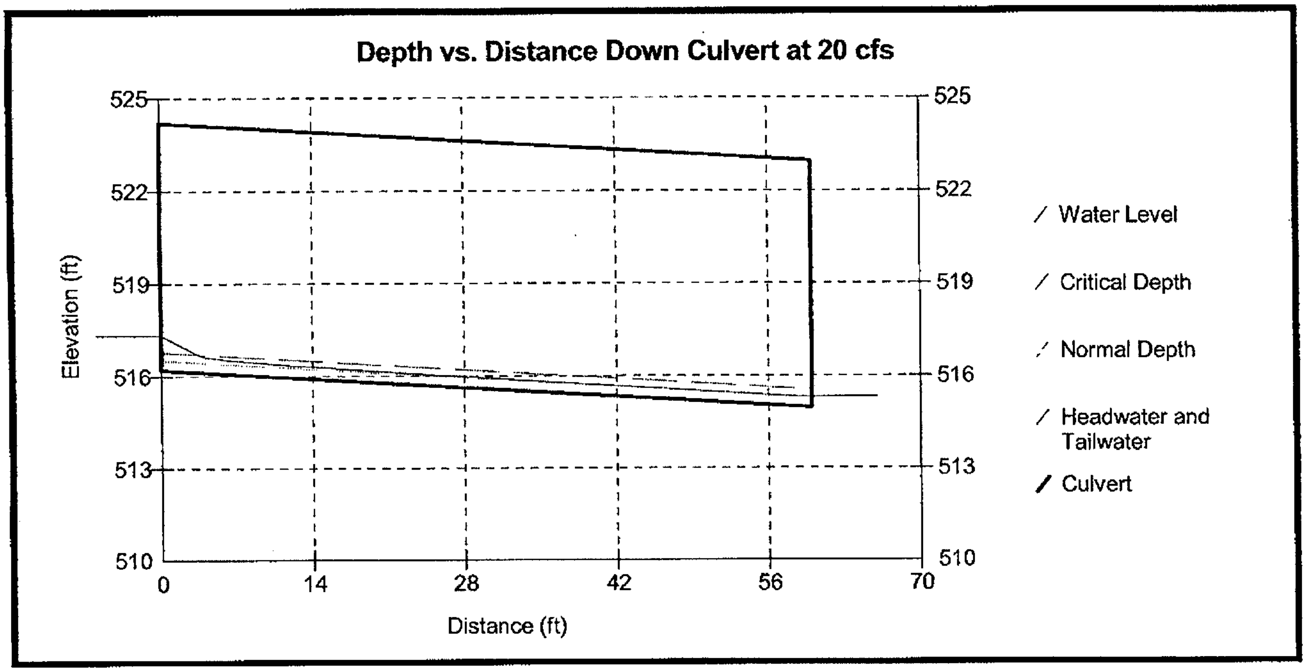


Figure 4. Water Surface Profile at 20 cfs

Table 4. Gradually Varied Flow Calculations for 45 cfs.

Q = 45.0 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity (ft/s)	Curve	Swim Mode
0	1.94	0.00	Inlet	
3	0.99	7.80	S2	NA
5	0.85	6.60	S2	NA
8	0.79	7.11	S2	NA
11	0.75	7.47	S2	NA
14	0.72	7.76	S2	NA
17	0.70	8.00	S2	NA
20	0.68	8.22	S2	NA
23	0.67	8.41	S2	NA
26	0.65	8.59	S2	NA
29	0.64	8.74	S2	NA
32	0.63	8.88	S2	NA
35	0.62	9.01	S2	NA
38	0.62	9.13	S2	NA
41	0.61	9.24	S2	NA
44	0.60	9.34	S2	NA
47	0.60	9.43	S2	NA
50	0.59	9.51	S2	Exhausted
53	0.59	9.60	S2	Burst
56	0.58	9.67	S2	Burst
60	0.58	9.76	S2	Burst

Table 5. Gradually Varied Flow Specifications for 45 cfs.

	45.0 cfs
Normal Depth (ft)	0.53
Critical Depth (ft)	0.99
Headwater Depth (ft)	1.94
Inlet Velocity (ft/s)	7.80
Tailwater Depth (ft)	0.70
Burst Swim Time (s)	5.00
Prolonged Swim Time (min	0.00
Barrier Code	Depth; EB

Barrier Codes

Depth - Too shallow for substantial distance

EB - Fish exhausted at burst speed

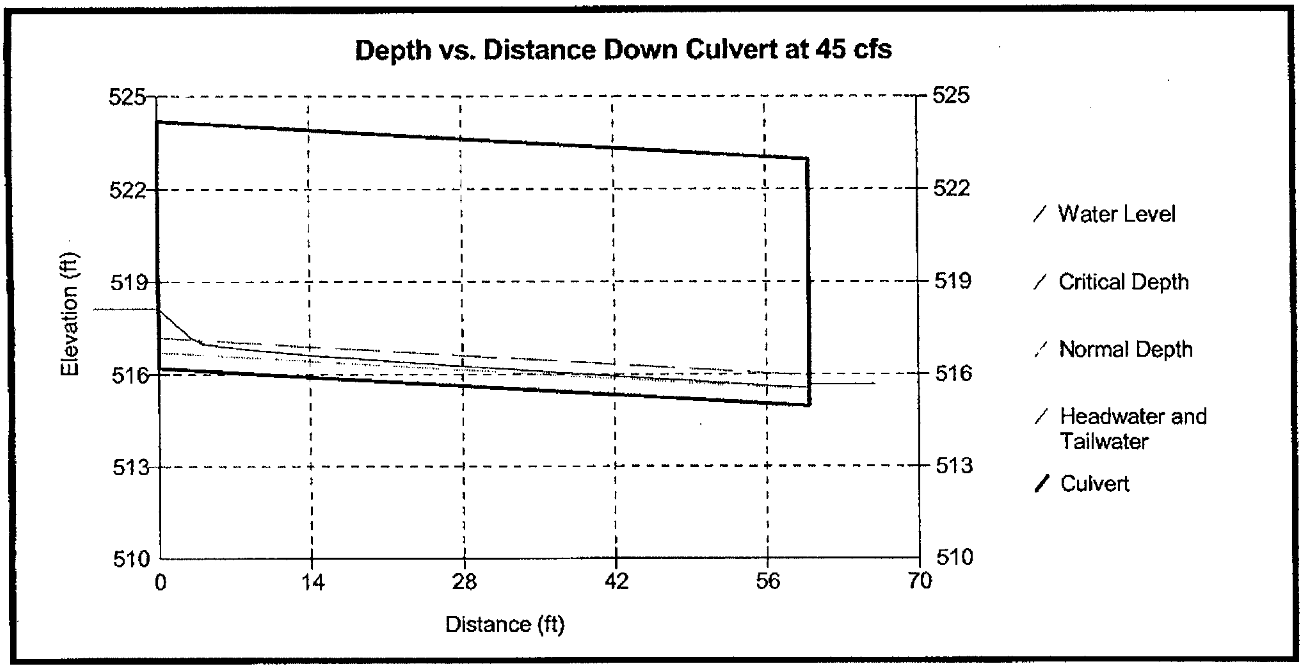


Figure 5. Water Surface Profile at 45 cfs

Table 6. Gradually Varied Flow Calculations for 81 cfs.

Q = 81.0 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity (ft/s)	Curve	Swim Mode
0	2.87	0.00	Inlet	
3	1.47	9.49	S2	NA
5	1.29	7.84	S2	NA
8	1.21	8.34	S2	NA
11	1.16	8.71	S2	NA
14	1.12	9.01	S2	NA
17	1.09	9.27	S2	NA
20	1.07	9.50	S2	NA
23	1.04	9.71	S2	NA
26	1.02	9.90	S2	NA
29	1.00	10.08	S2	NA
32	0.99	10.25	S2	NA
35	0.97	10.40	S2	NA
38	0.96	10.54	S2	NA
41	0.95	10.67	S2	NA
44	0.94	10.79	S2	NA
47	0.93	10.91	S2	NA
50	0.92	11.02	S2	NA
53	0.91	11.11	S2	NA
56	0.90	11.21	S2	NA
60	0.89	11.33	S2	Exhausted

Table 7. Gradually Varied Flow Specifications for 81 cfs.

	81.0 cfs
Normal Depth (ft)	0.76
Critical Depth (ft)	1.47
Headwater Depth (ft)	2.87
Inlet Velocity (ft/s)	9.49
Tailwater Depth (ft)	1.07
Burst Swim Time (s)	5.00
Prolonged Swim Time (min	0.00
Barrier Code	EB

Barrier Codes

EB - Fish exhausted at burst speed*

*Culvert may be a barrier due to depth

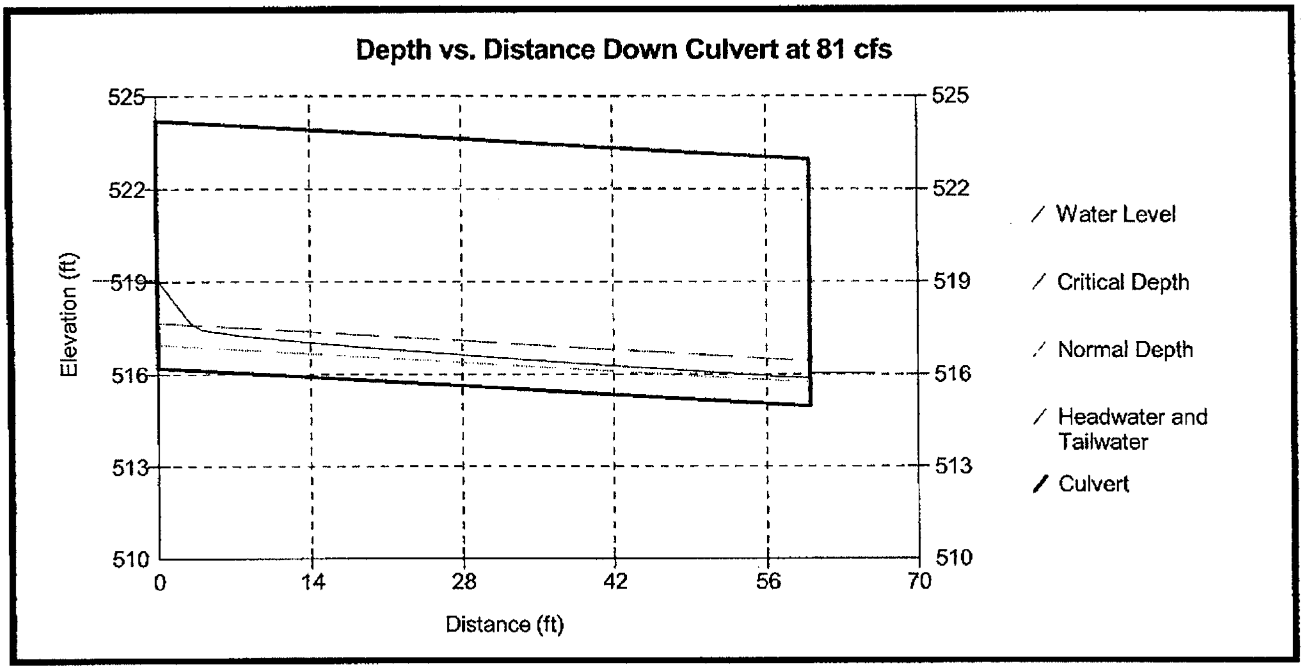


Figure 6. Water Surface Profile at 81 cfs

Tailwater Information

Channel Bottom Slope: 2%

Outlet-Pool Bottom Elevation: 514.4 ft

Manning's Roughness Downstream of Tailwater: 0.048

Table 8. Tailwater Cross Section Data.

Obs. No.	Station (ft)	Elevation (ft)
1	12.36	519.33
2	15.64	515.18
3	17.91	514.86
4	20.85	514.71
5	21.00	514.50
6	21.30	514.61
7	22.27	514.52
8	22.65	514.40
9	23.10	514.52
10	23.39	514.44
11	23.69	514.48
12	24.07	514.40
13	24.47	514.59
14	25.06	514.67
15	25.47	514.74
16	26.10	514.53
17	26.91	514.93
18	27.73	515.18
19	28.69	515.05
20	29.82	515.57
21	31.15	516.61
22	32.79	517.65

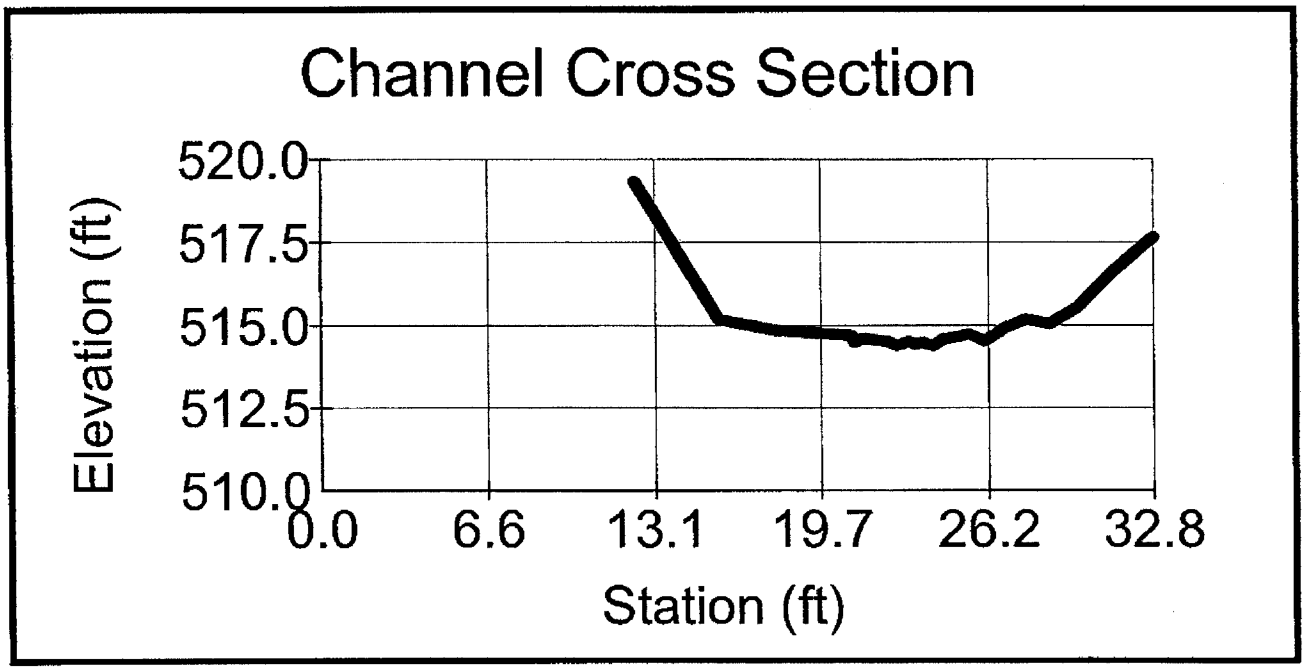
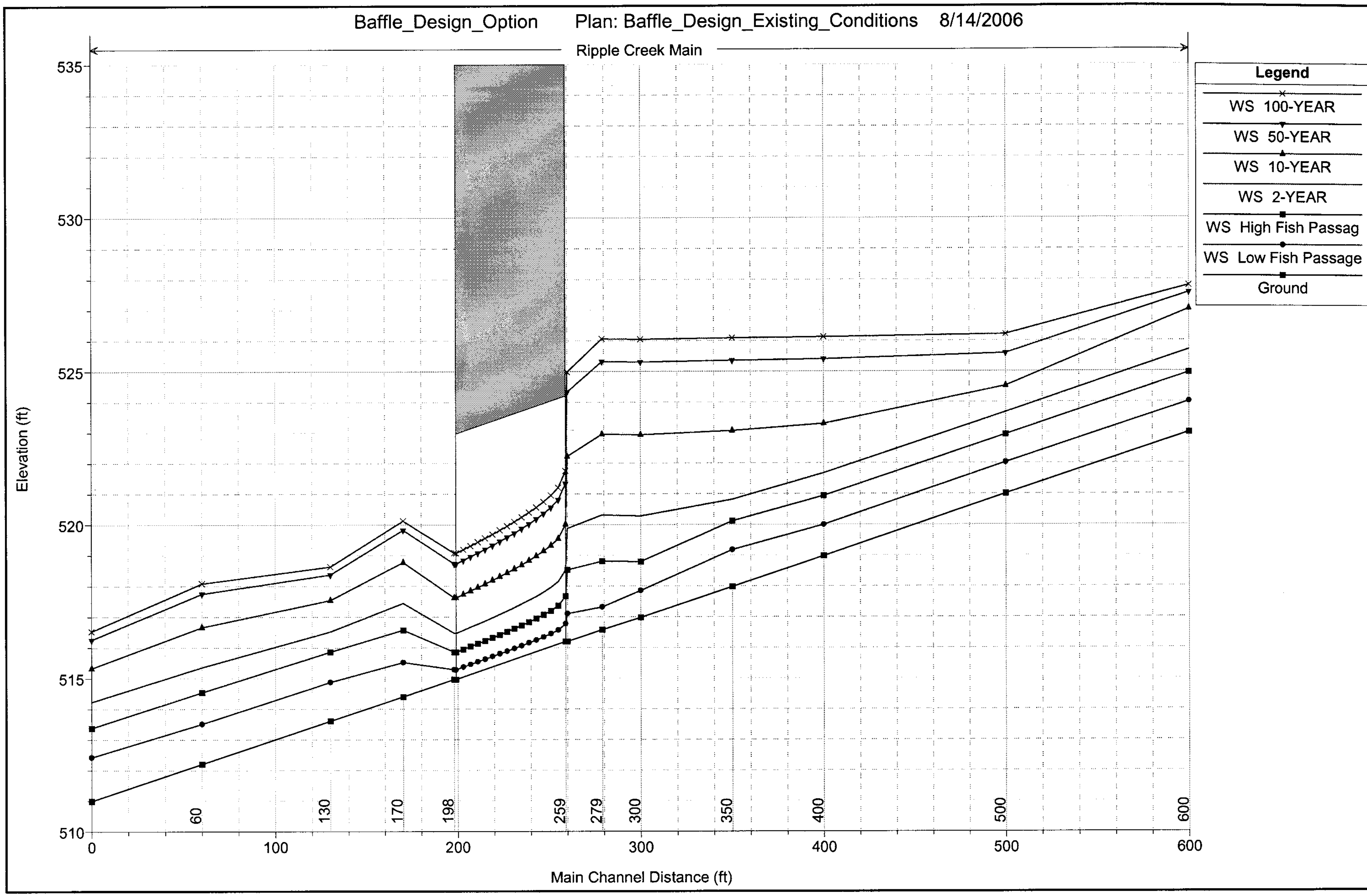
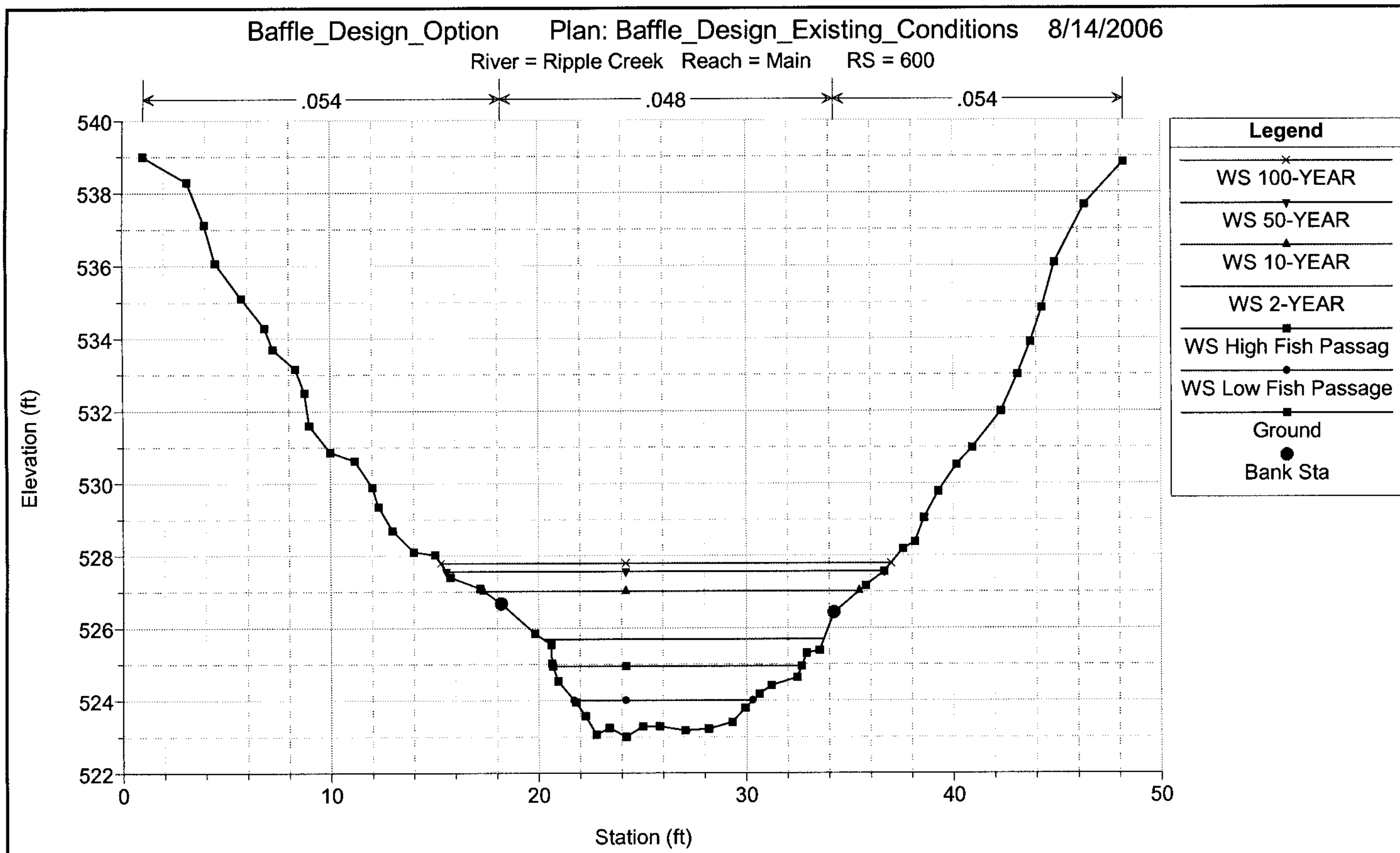


Figure 7. Channel Cross Section at Tailwater Crest.

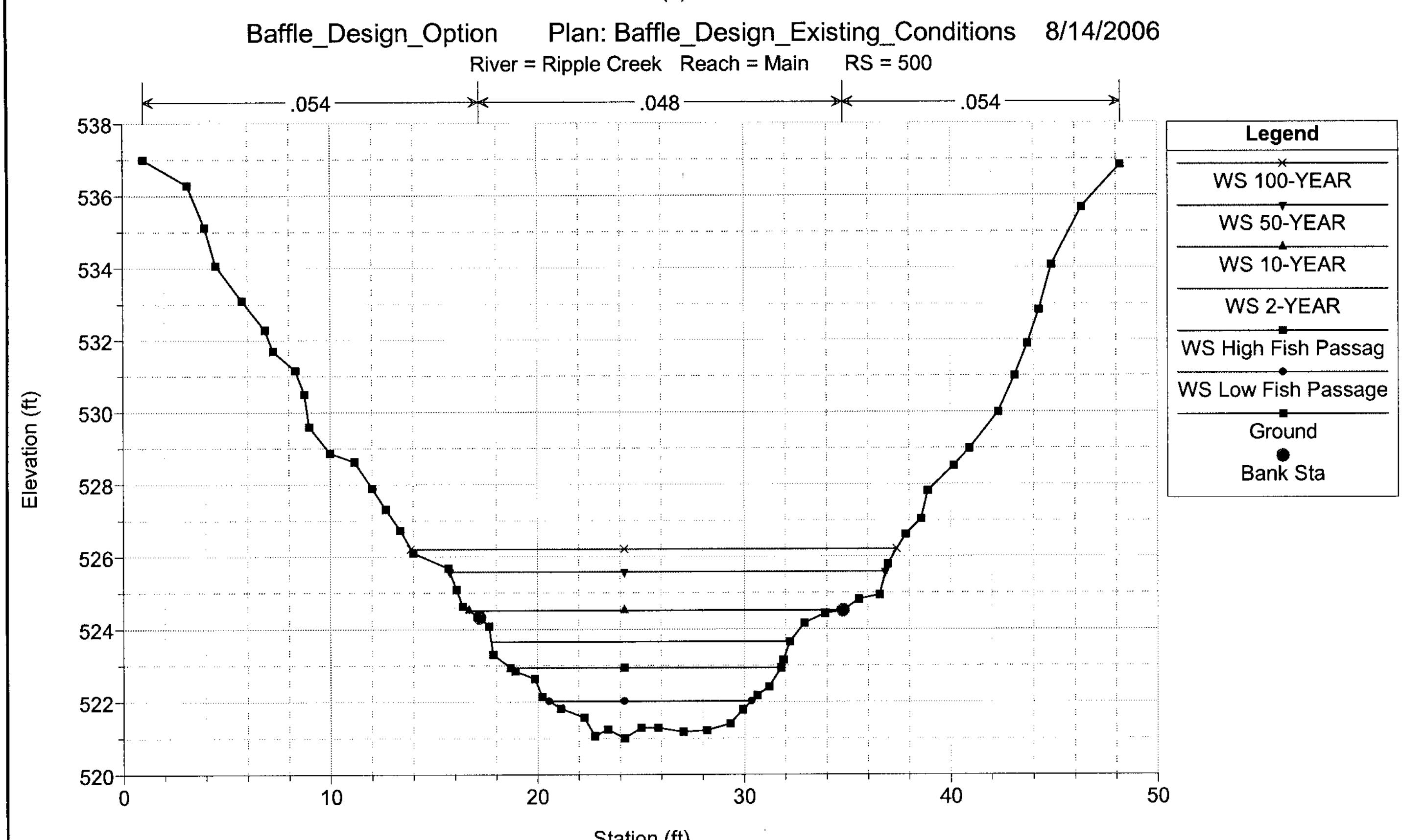
Table 9. Tailwater Rating Table Information.

Discharge (cfs)	Tailwater Elevation (ft)	Wetted Perimeter (ft)	Cross-Sect. Area (sq. ft)
0.0	514.4	0.00	0.00
0.0	514.5	1.87	0.09
0.3	514.6	4.03	0.36
1.0	514.7	5.53	0.82
2.1	514.8	7.90	1.46
3.9	514.9	9.59	2.32
6.6	515.0	10.62	3.29
9.7	515.1	12.17	4.37
13.6	515.2	13.88	5.64
19.1	515.3	14.24	7.00
25.3	515.4	14.61	8.38
32.3	515.5	14.98	9.80
40.0	515.6	15.32	11.24
48.5	515.7	15.61	12.70
57.6	515.8	15.90	14.19
67.3	515.9	16.19	15.70
77.7	516.0	16.48	17.22
88.6	516.1	16.77	18.77
100.1	516.2	17.06	20.34
112.2	516.3	17.35	21.93
124.9	516.4	17.64	23.54
138.2	516.5	17.93	25.17
152.0	516.6	18.22	26.82
166.2	516.7	18.53	28.50
181.0	516.8	18.84	30.19
196.3	516.9	19.16	31.91
212.2	517.0	19.47	33.66
228.7	517.1	19.79	35.43
245.7	517.2	20.10	37.22
263.3	517.3	20.41	39.03
281.4	517.4	20.73	40.87
300.1	517.5	21.04	42.74
319.3	517.6	21.36	44.62
329.1	517.7	21.51	45.58

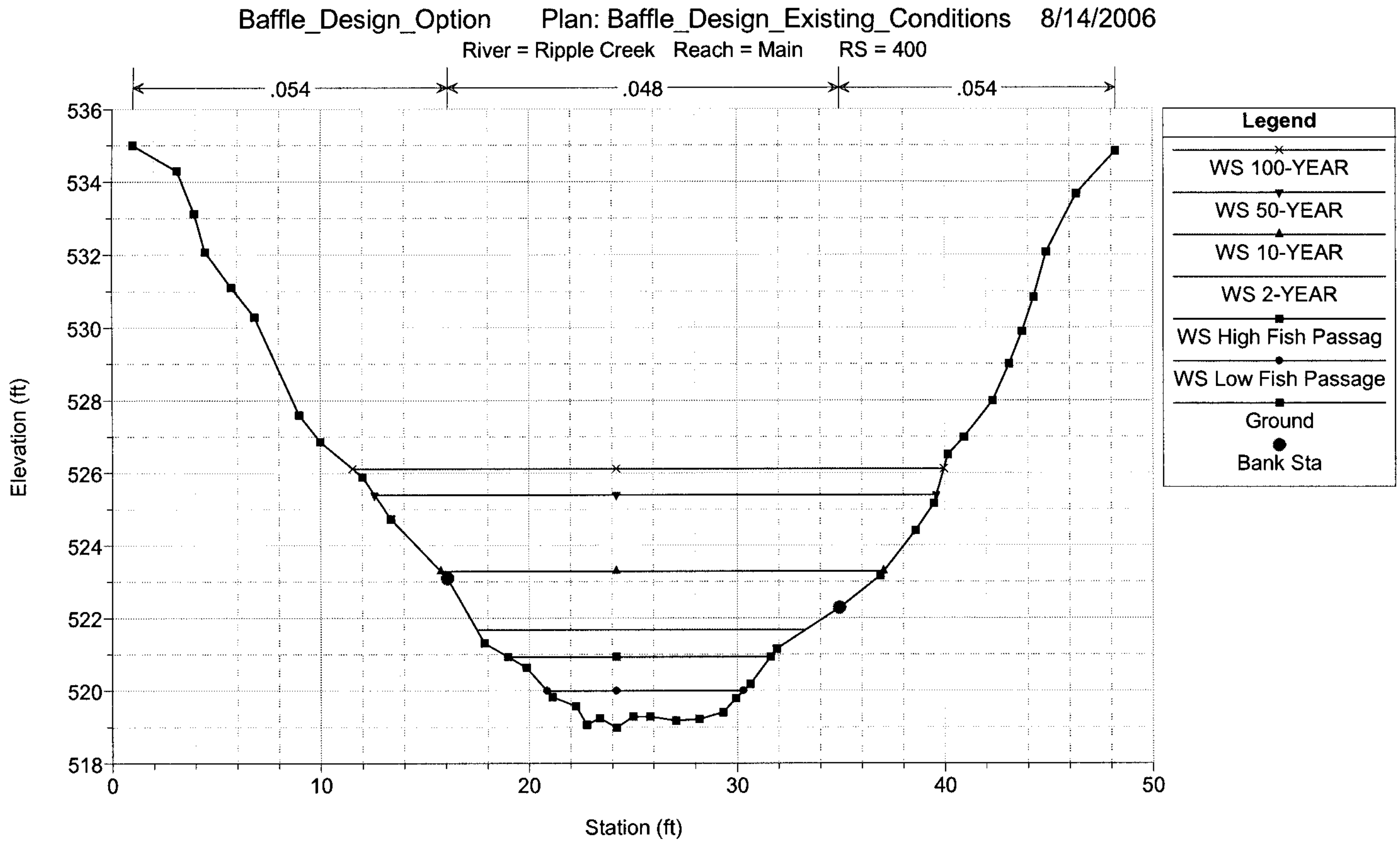

Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
Ripple Creek Main
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Elevation (ft)
535
530
525
520
515
510
60
130
170
198
259
279
300
350
400
500
600
0
100
200
300
400
500
600
Main Channel Distance (ft)

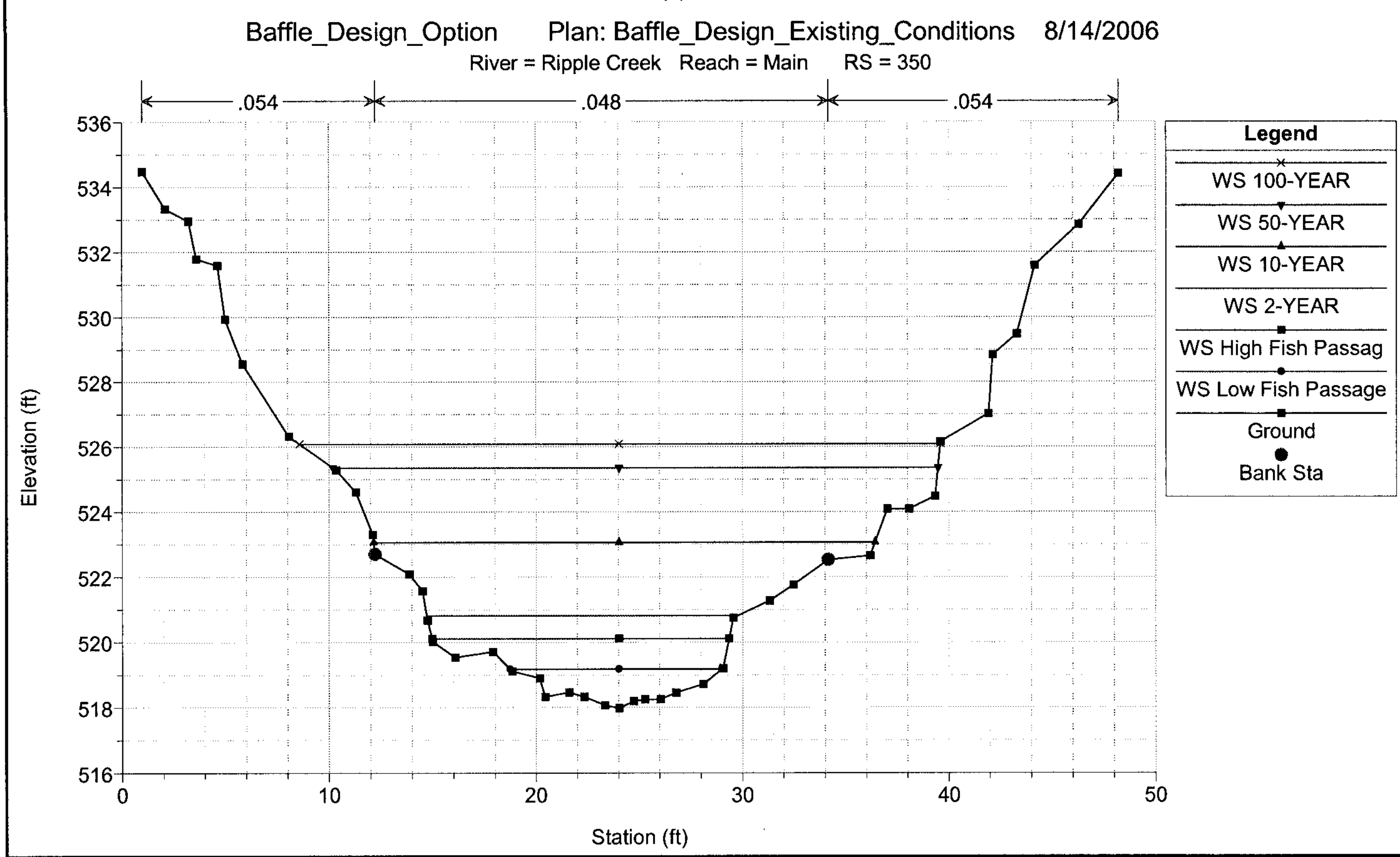


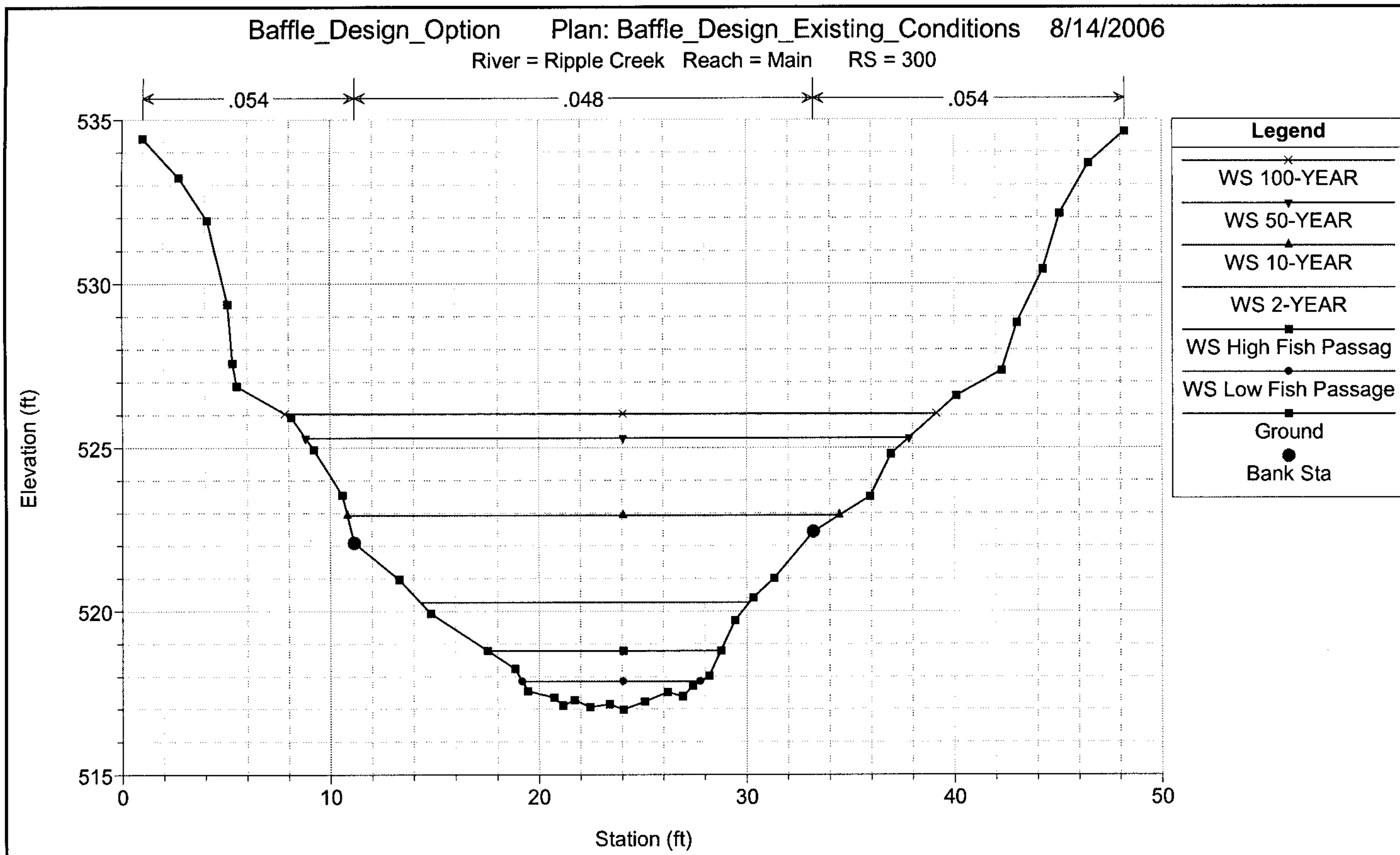
Baffle_Design_Option
Plan: Baffle_Design_Existing_Conditions
8/14/2006
River = Ripple Creek
Reach = Main
RS = 600
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
540
538
536
534
532
530
528
526
524
522
0
10
20
30
40
50



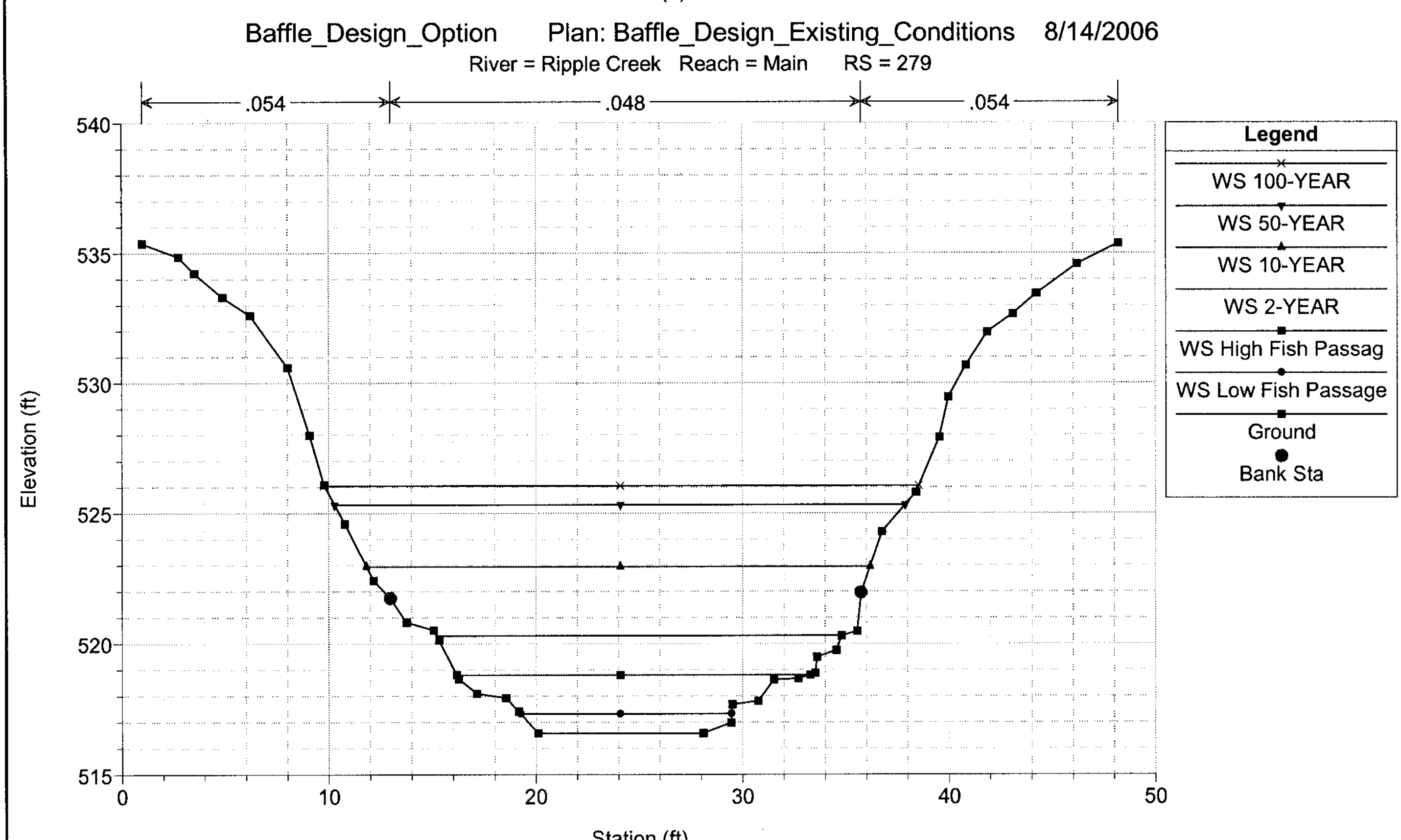
Baffle_Design_Option
Plan: Baffle_Design_Existing_Conditions
8/14/2006
River = Ripple Creek
Reach = Main
RS = 500
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
538
536
534
532
530
528
526
524
522
520
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 400
.054
.048
.054
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta

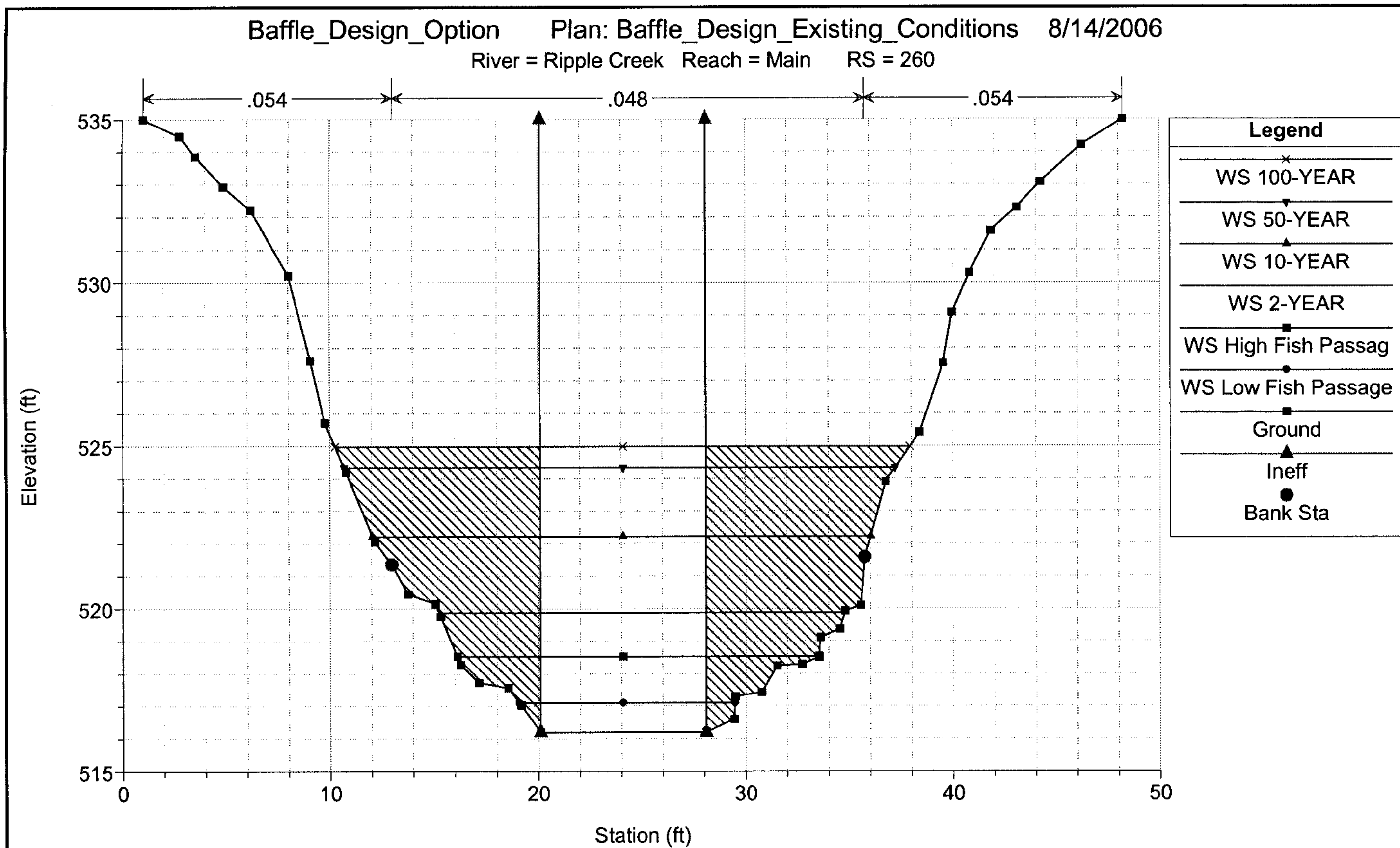

Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 350
.054
.048
.054
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta



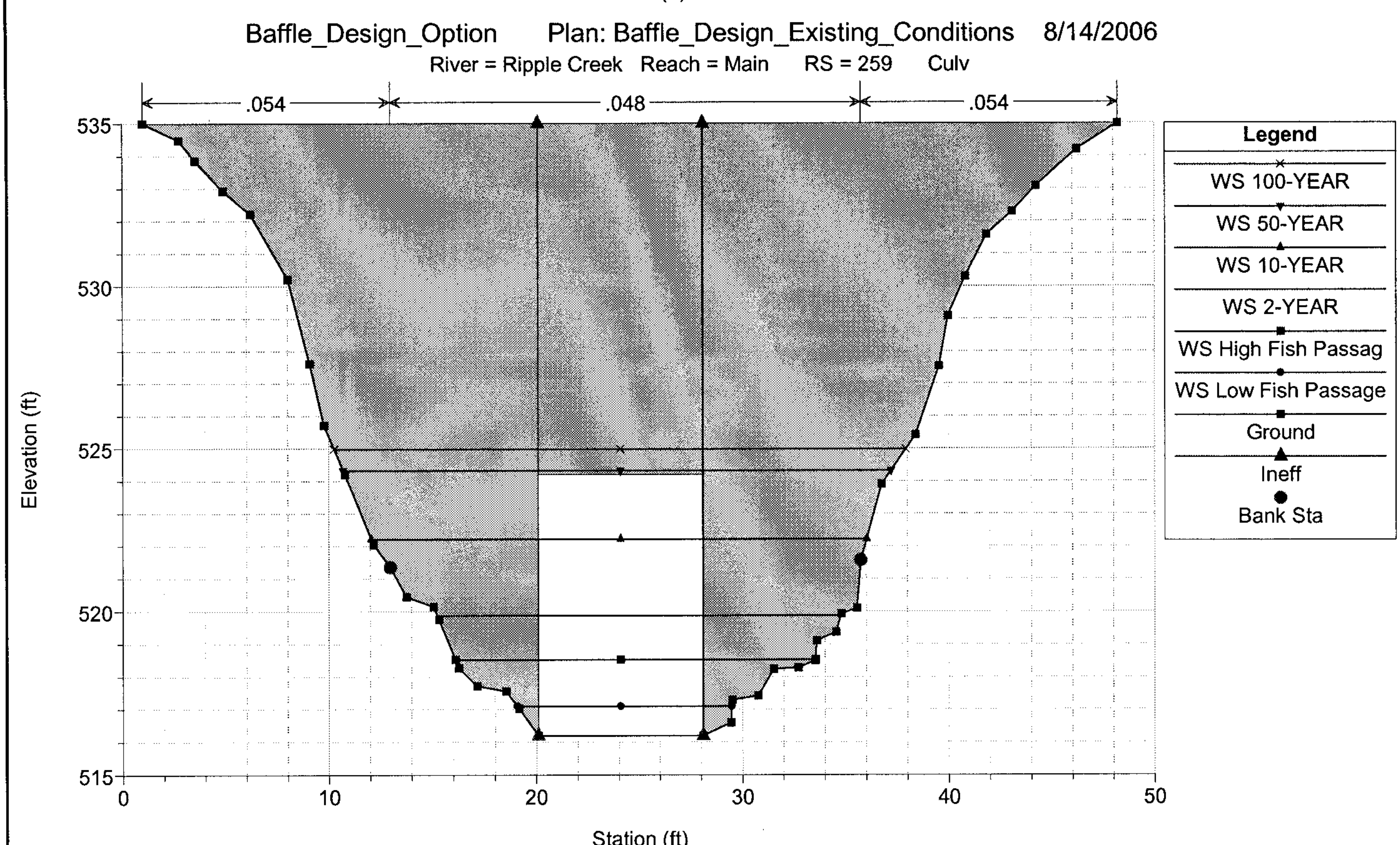
Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 300
.054
.048
.054
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta



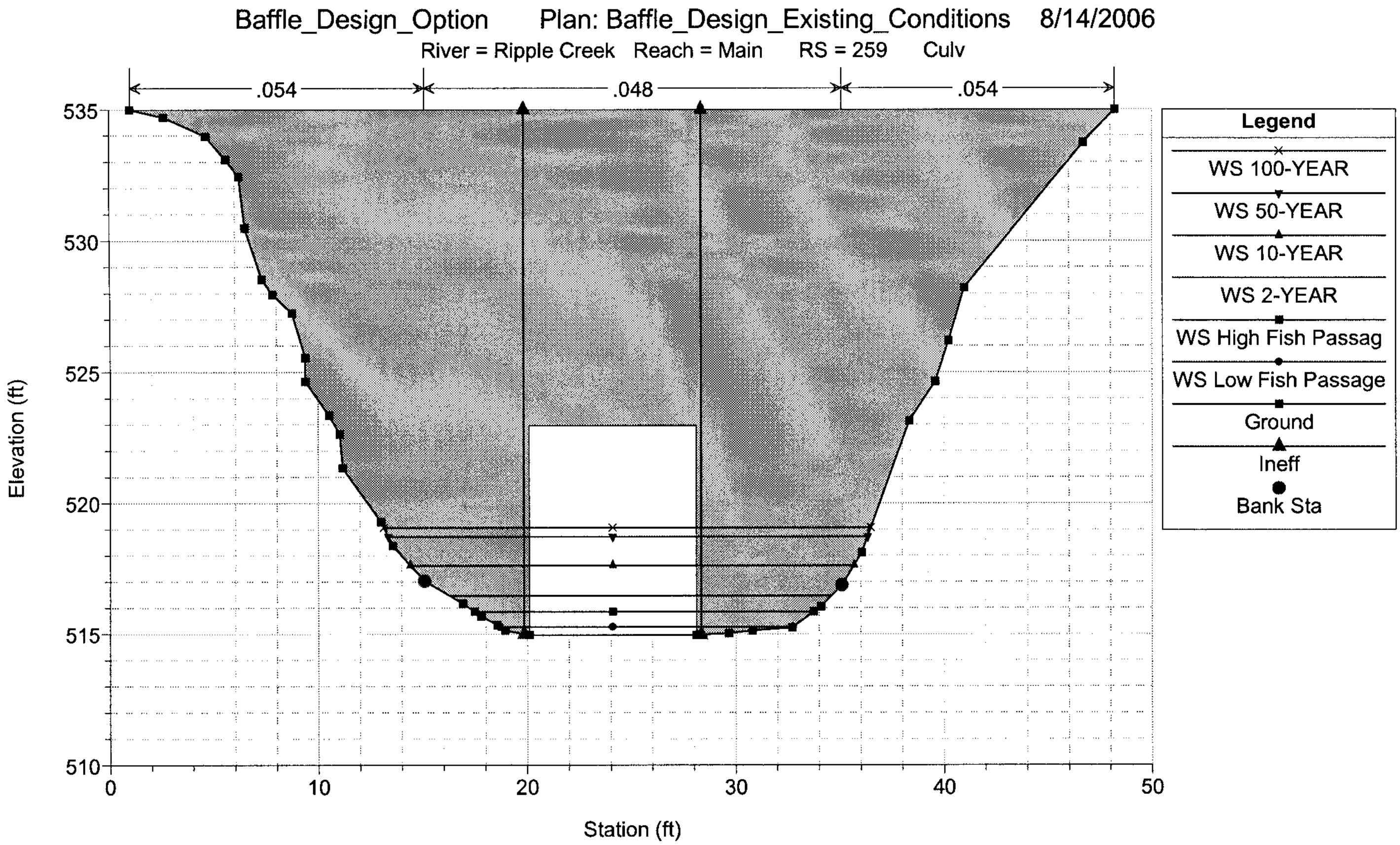
Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 279
.054
.048
.054
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta



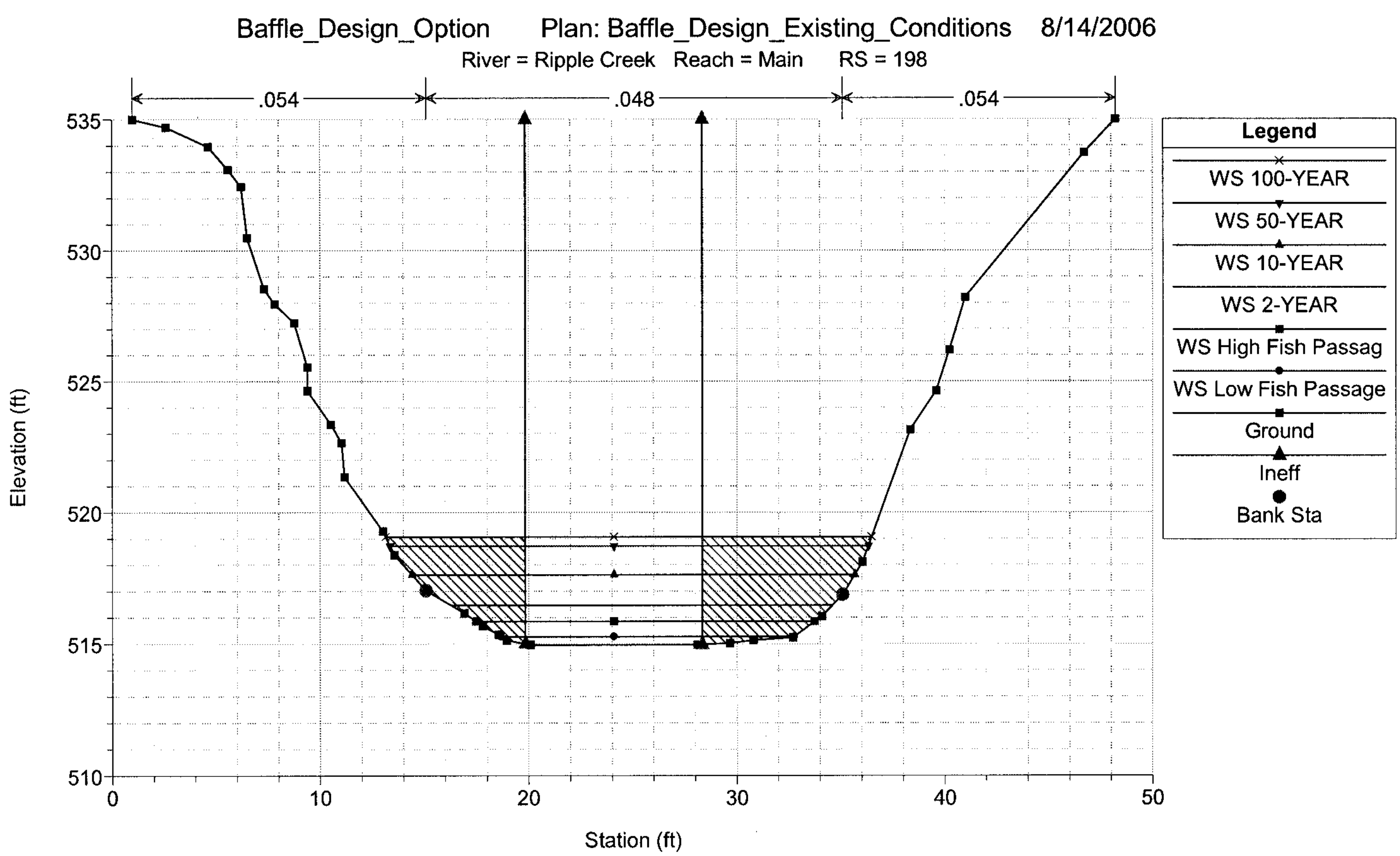
Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 260
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



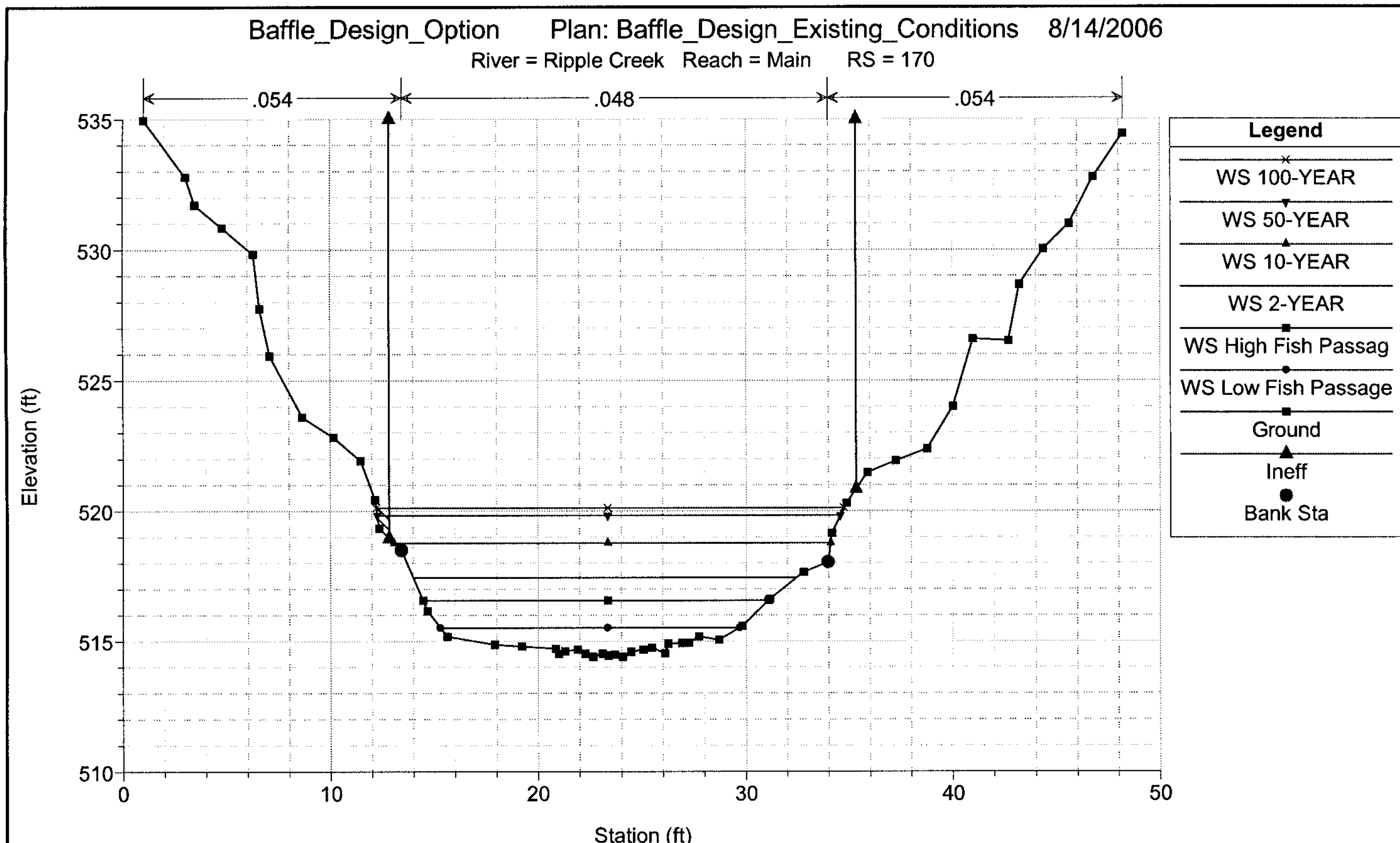
Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 259 Culv
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

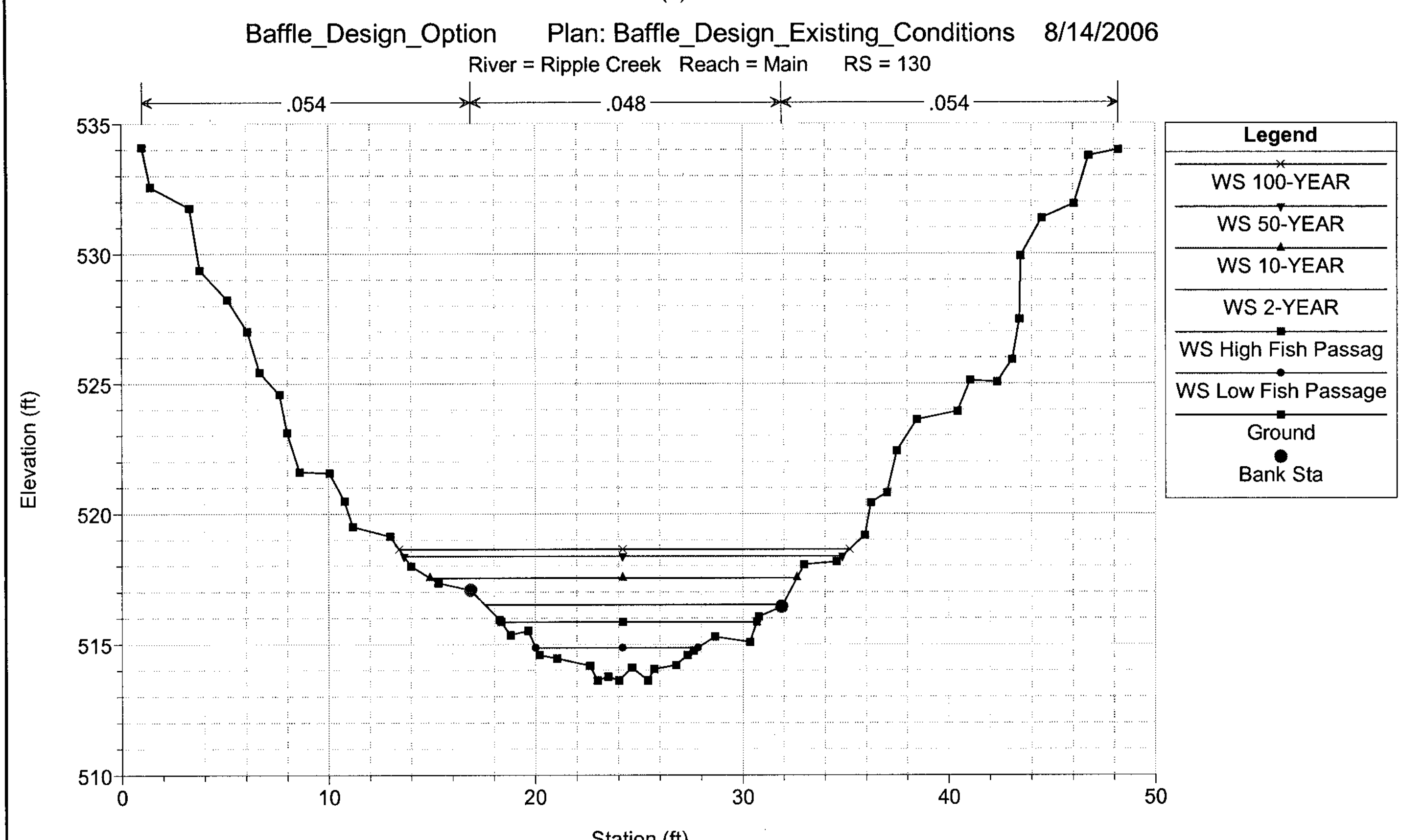


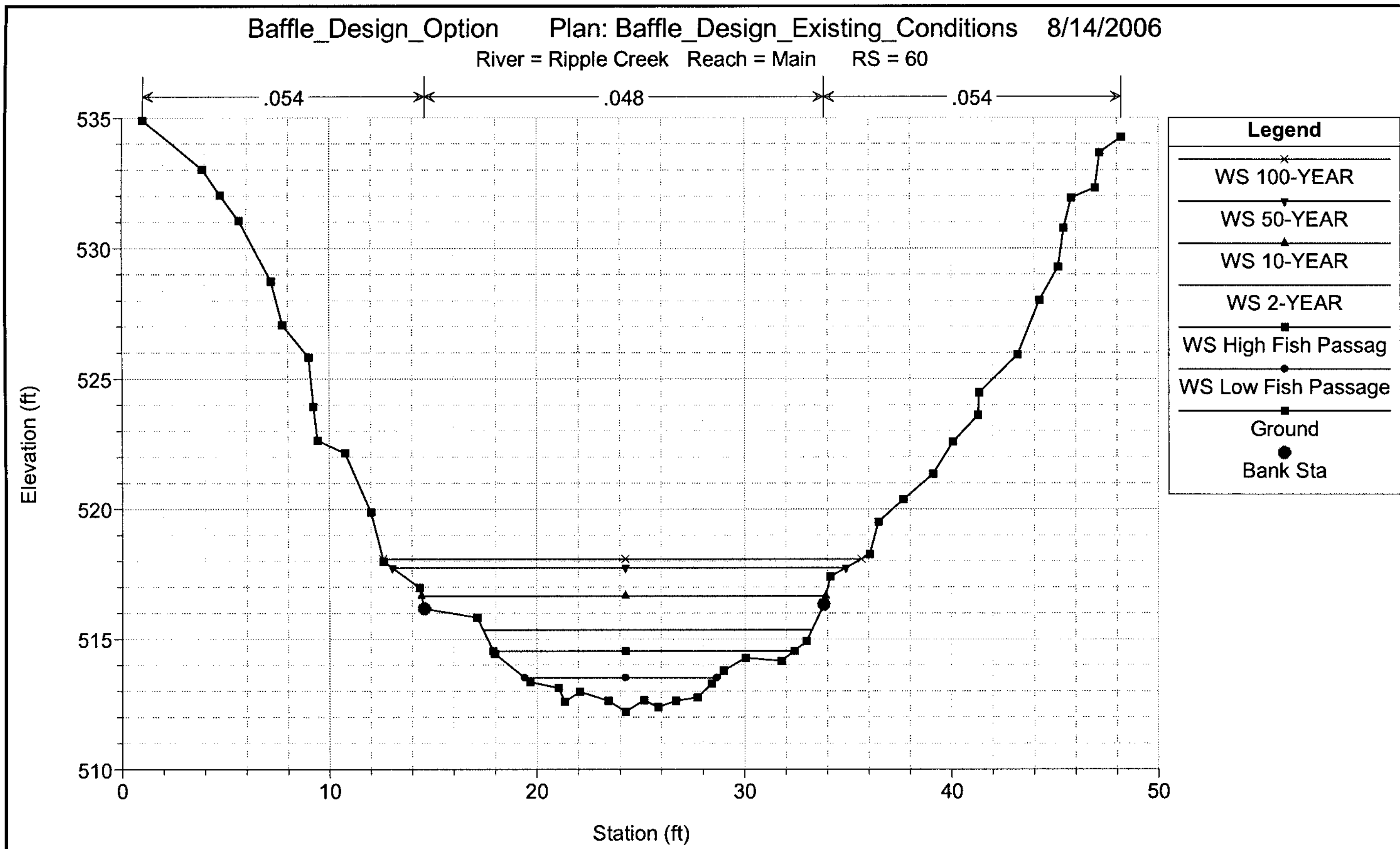
Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 259 Culv
.054
.048
.054
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Ineff
Bank Sta

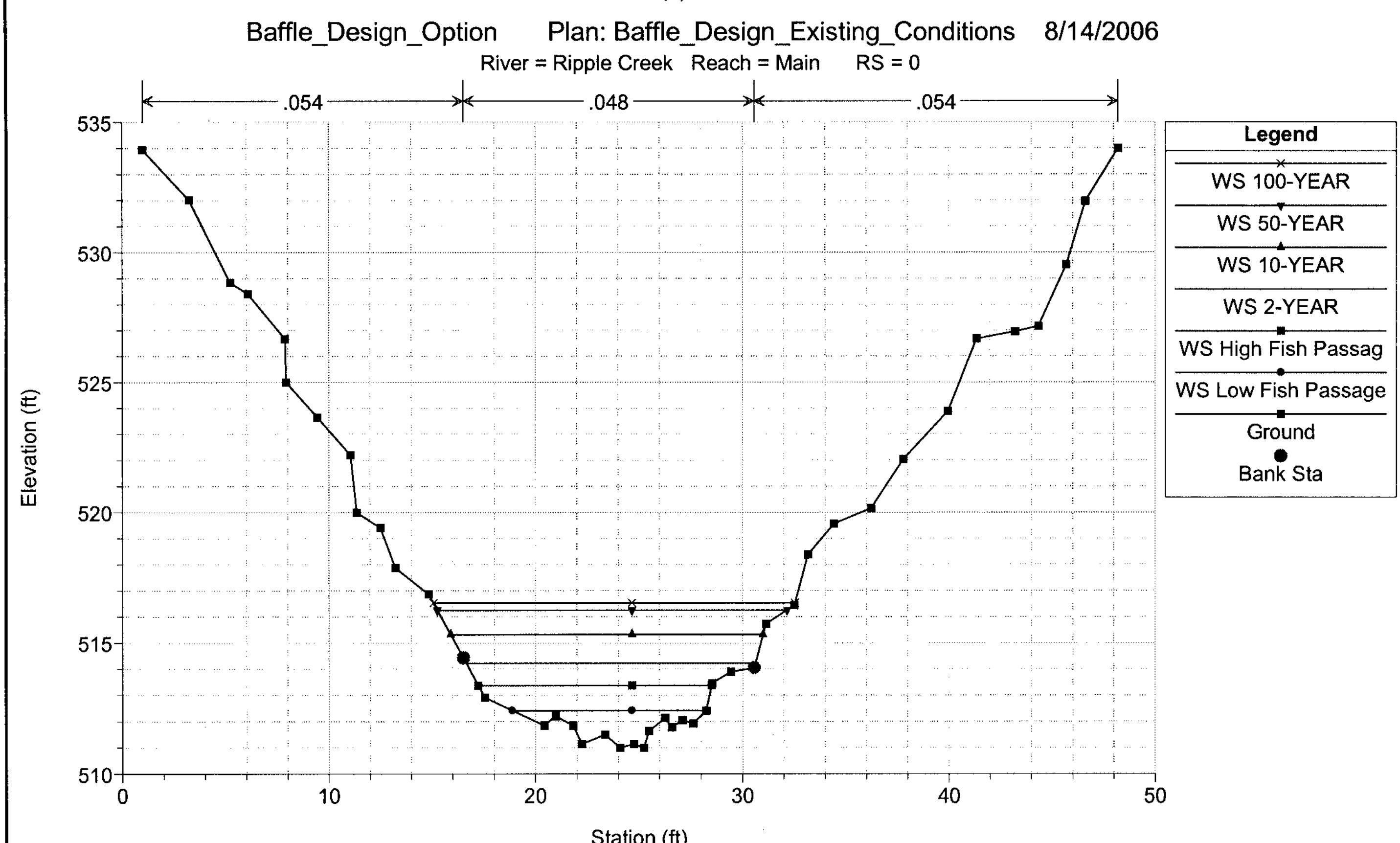


Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 198
.054
.048
.054
Elevation (ft)
Station (ft)
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Ineff
Bank Sta


Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 170
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
520
515
510
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 130
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
520
515
510
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 60
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)


Baffle_Design_Option Plan: Baffle_Design_Existing_Conditions 8/14/2006
River = Ripple Creek Reach = Main RS = 0
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)

Plan: Existing   Ripple Creek   Main RS: 259 Culv Group: Culvert #1   Profile: Low Fish Passage

Q Culv Group (cfs)	20.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	4.32
Q Barrel (cfs)	20.00	Culv Vel DS (ft/s)	7.91
E.G. US. (ft)	517.23	Culv Inv El Up (ft)	516.20
W.S. US. (ft)	517.10	Culv Inv El Dn (ft)	514.96
E.G. DS (ft)	515.89	Culv Frctn Ls (ft)	0.82
W.S. DS (ft)	515.75	Culv Exit Loss (ft)	0.36
Delta EG (ft)	1.34	Culv Entr Loss (ft)	0.16
Delta WS (ft)	1.35	Q Weir (cfs)	
E.G. IC (ft)	517.23	Weir Sta Lft (ft)	
E.G. OC (ft)	517.21	Weir Sta Rgt (ft)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (ft)	516.78	Weir Max Depth (ft)	
Culv WS Outlet (ft)	515.28	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	0.32	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	0.58	Min El Weir Flow (ft)	548.20

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	During supercritical analysis, the culvert direct step method went to normal depth. The program
	then assumed normal depth at the outlet.
Note:	The flow in the culvert is entirely supercritical.

Plan: Existing Ripple Creek Main RS: 259 Culv Group: Culvert #1 Profile: High Fish Passag

Q Culv Group (cfs)	81.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	6.88
Q Barrel (cfs)	81.00	Culv Vel DS (ft/s)	11.39
E.G. US. (ft)	518.82	Culv Inv El Up (ft)	516.20
W.S. US. (ft)	518.53	Culv Inv El Dn (ft)	514.96
E.G. DS (ft)	517.15	Culv Frctn Ls (ft)	0.54
W.S. DS (ft)	516.66	Culv Exit Loss (ft)	0.71
Delta EG (ft)	1.67	Culv Entr Loss (ft)	0.41
Delta WS (ft)	1.86	Q Weir (cfs)	
E.G. IC (ft)	518.82	Weir Sta Lft (ft)	
E.G. OC (ft)	518.77	Weir Sta Rgt (ft)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (ft)	517.67	Weir Max Depth (ft)	
Culv WS Outlet (ft)	515.85	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	0.76	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.47	Min El Weir Flow (ft)	548.20

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	The flow in the culvert is entirely supercritical.

Plan: Existing Ripple Creek Main RS: 259 Culv Group: Culvert #1 Profile: 2-YEAR

Q Culv Group (cfs)	161.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	8.65
Q Barrel (cfs)	161.00	Culv Vel DS (ft/s)	13.37
E.G. US. (ft)	520.34	Culv Inv El Up (ft)	516.20
W.S. US. (ft)	519.88	Culv Inv El Dn (ft)	514.96
E.G. DS (ft)	518.33	Culv Frctn Ls (ft)	0.45
W.S. DS (ft)	517.37	Culv Exit Loss (ft)	0.91
Delta EG (ft)	2.01	Culv Entr Loss (ft)	0.65
Delta WS (ft)	2.51	Q Weir (cfs)	
E.G. IC (ft)	520.34	Weir Sta Lft (ft)	
E.G. OC (ft)	520.27	Weir Sta Rgt (ft)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (ft)	518.53	Weir Max Depth (ft)	
Culv WS Outlet (ft)	516.47	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.20	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.33	Min El Weir Flow (ft)	548.20

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	The flow in the culvert is entirely supercritical.

Plan: Existing Ripple Creek Main RS: 259 Culv Group: Culvert #1 Profile: 10-YEAR

Q Culv Group (cfs)	337.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	11.07
Q Barrel (cfs)	337.00	Culv Vel DS (ft/s)	15.82
E.G. US. (ft)	522.98	Culv Inv El Up (ft)	516.20
W.S. US. (ft)	522.22	Culv Inv El Dn (ft)	514.96
E.G. DS (ft)	520.44	Culv Frctn Ls (ft)	0.40
W.S. DS (ft)	518.62	Culv Exit Loss (ft)	1.07
Delta EG (ft)	2.54	Culv Entr Loss (ft)	1.07
Delta WS (ft)	3.60	Q Weir (cfs)	
E.G. IC (ft)	522.98	Weir Sta Lft (ft)	
E.G. OC (ft)	522.86	Weir Sta Rgt (ft)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (ft)	520.01	Weir Max Depth (ft)	
Culv WS Outlet (ft)	517.62	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.97	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	3.81	Min El Weir Flow (ft)	548.20

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	The flow in the culvert is entirely supercritical.

Plan: Existing   Ripple Creek   Main RS: 259 Culv Group: Culvert #1 Profile: 50-YEAR

Q Culv Group (cfs)	528.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	12.86
Q Barrel (cfs)	528.00	Culv Vel DS (ft/s)	17.56
E.G. US. (ft)	525.35	Culv Inv El Up (ft)	516.20
W.S. US. (ft)	524.32	Culv Inv El Dn (ft)	514.96
E.G. DS (ft)	522.36	Culv Frctn Ls (ft)	0.39
W.S. DS (ft)	519.90	Culv Exit Loss (ft)	1.15
Delta EG (ft)	2.99	Culv Entr Loss (ft)	1.45
Delta WS (ft)	4.42	Q Weir (cfs)	
E.G. IC (ft)	525.35	Weir Sta Lft (ft)	
E.G. OC (ft)	525.18	Weir Sta Rgt (ft)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (ft)	521.33	Weir Max Depth (ft)	
Culv WS Outlet (ft)	518.72	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.70	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	5.13	Min El Weir Flow (ft)	548.20

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	The flow in the culvert is entirely supercritical.

Plan: Existing   Ripple Creek   Main RS: 259 Culv Group: Culvert #1   Profile: 100-YEAR

Q Culv Group (cfs)	593.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	13.36
Q Barrel (cfs)	593.00	Culv Vel DS (ft/s)	18.04
E.G. US. (ft)	526.09	Culv Inv El Up (ft)	516.20
W.S. US. (ft)	524.98	Culv Inv El Dn (ft)	514.96
E.G. DS (ft)	522.95	Culv Frctn Ls (ft)	0.40
W.S. DS (ft)	520.27	Culv Exit Loss (ft)	1.17
Delta EG (ft)	3.13	Culv Entr Loss (ft)	1.57
Delta WS (ft)	4.70	Q Weir (cfs)	
E.G. IC (ft)	526.09	Weir Sta Lft (ft)	
E.G. OC (ft)	525.91	Weir Sta Rgt (ft)	
Culvert Control	Inlet	Weir Submerg	
Culv WS Inlet (ft)	521.75	Weir Max Depth (ft)	
Culv WS Outlet (ft)	519.07	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.93	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	5.55	Min El Weir Flow (ft)	548.20

Errors Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Note:	The flow in the culvert is entirely supercritical.

HEC-RAS Plan: Existing River: Ripple Creek Reach: Main

Reach	River Sta	Profile	Q Total	W.S. Elev	Min Ch El	Diff	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)		(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	0	2-YEAR	161.00	514.23	510.99	3.24	513.78	514.77	0.020033	5.89	27.34	13.97	0.74
Main	0	10-YEAR	337.00	515.33	510.99	4.34	514.90	516.29	0.020006	7.86	43.32	15.10	0.79
Main	0	50-YEAR	528.00	516.25	510.99	5.26	515.82	517.61	0.020037	9.39	57.92	16.90	0.83
Main	0	100-YEAR	593.00	516.53	510.99	5.54	516.13	518.01	0.020027	9.81	62.69	17.47	0.84
Main	0	High Fish Passag	81.00	513.38	510.99	2.39	513.04	513.74	0.020013	4.86	16.68	11.28	0.70
Main	0	Low Fish Passage	20.00	512.42	510.99	1.43	512.21	512.56	0.020003	3.05	6.56	9.37	0.64
Main	60	2-YEAR	161.00	515.36	512.20	3.16		515.77	0.013983	5.19	31.03	15.84	0.65
Main	60	10-YEAR	337.00	516.66	512.20	4.46		517.26	0.012608	6.22	54.22	19.47	0.65
Main	60	50-YEAR	528.00	517.75	512.20	5.55	516.70	518.51	0.010382	7.02	76.25	21.87	0.63
Main	60	100-YEAR	593.00	518.08	512.20	5.88	516.94	518.89	0.009872	7.23	83.84	23.07	0.62
Main	60	High Fish Passag	81.00	514.54	512.20	2.34		514.84	0.016443	4.35	18.62	14.50	0.68
Main	60	Low Fish Passage	20.00	513.51	512.20	1.31		513.65	0.016352	2.97	6.73	9.25	0.61
Main	130	2-YEAR	161.00	516.52	513.61	2.91	516.34	517.18	0.027371	6.50	24.77	14.41	0.87
Main	130	10-YEAR	337.00	517.54	513.61	3.93	517.42	518.63	0.025773	8.39	40.90	17.74	0.91
Main	130	50-YEAR	528.00	518.37	513.61	4.76	518.37	519.83	0.024512	9.81	56.85	21.19	0.93
Main	130	100-YEAR	593.00	518.63	513.61	5.02	518.63	520.17	0.023750	10.13	62.50	21.78	0.92
Main	130	High Fish Passag	81.00	515.86	513.61	2.25		516.26	0.024455	5.07	15.96	12.34	0.79
Main	130	Low Fish Passage	20.00	514.87	513.61	1.26		515.07	0.025172	3.56	5.63	7.82	0.74
Main	170	2-YEAR	161.00	517.44	514.40	3.04	516.41	517.68	0.006248	3.86	41.68	18.47	0.45
Main	170	10-YEAR	337.00	518.77	514.40	4.37	517.37	519.15	0.006288	4.94	68.25	21.04	0.48
Main	170	50-YEAR	528.00	519.82	514.40	5.42	518.18	520.36	0.006132	5.87	90.76	22.31	0.49
Main	170	100-YEAR	593.00	520.12	514.40	5.72	518.42	520.71	0.006206	6.16	97.20	22.54	0.50
Main	170	High Fish Passag	81.00	516.57	514.40	2.17	515.83	516.72	0.006143	3.08	26.30	16.63	0.43
Main	170	Low Fish Passage	20.00	515.52	514.40	1.12	515.20	515.58	0.007501	2.01	9.94	14.40	0.43
Main	198	2-YEAR	161.00	516.47	514.96	1.51	517.20	518.92	0.095296	12.56	12.82	18.35	0.50
Main	198	10-YEAR	337.00	517.63	514.96	2.67	518.62	521.06	0.062527	14.88	22.65	21.28	0.50
Main	198	50-YEAR	528.00	518.72	514.96	3.76	519.90	522.96	0.048667	16.51	31.97	22.98	0.50
Main	198	100-YEAR	593.00	519.07	514.96	4.11	520.27	523.54	0.045675	16.97	34.94	23.35	0.50
Main	198	High Fish Passag	81.00	515.85	514.96	0.89	516.38	517.63	0.139068	10.69	7.58	16.28	0.50
Main	198	Low Fish Passage	20.00	515.28	514.96	0.32	515.52	516.13	0.262353	7.39	2.71	14.08	0.51
Main	259		Culvert										
Main	260	2-YEAR	161.00	519.88	516.20	3.68	518.53	520.34	0.005505	5.47	29.42	19.54	0.50
Main	260	10-YEAR	337.00	522.22	516.20	6.02	520.01	522.98	0.004665	7.00	48.16	23.98	0.50
Main	260	50-YEAR	528.00	524.32	516.20	8.12	521.34	525.35	0.004219	8.13	64.98	26.52	0.50
Main	260	100-YEAR	593.00	524.98	516.20	8.78	521.75	526.08	0.004111	8.45	70.22	27.67	0.50
Main	260	High Fish Passag	81.00	518.53	516.20	2.33	517.68	518.82	0.006420	4.35	18.60	17.44	0.50
Main	260	Low Fish Passage	20.00	517.10	516.20	0.90	516.78	517.22	0.009186	2.77	7.22	10.41	0.51
Main	279	2-YEAR	161.00	520.31	516.58	3.73		520.45	0.002965	2.97	54.28	19.66	0.31
Main	279	10-YEAR	337.00	522.95	516.58	6.37		523.09	0.001462	2.98	113.88	24.36	0.24
Main	279	50-YEAR	528.00	525.32	516.58	8.74		525.47	0.000955	3.12	174.94	27.60	0.20
Main	279	100-YEAR	593.00	526.06	516.58	9.48		526.21	0.000864	3.17	195.78	28.75	0.20
Main	279	High Fish Passag	81.00	518.81	516.58	2.23		518.95	0.006128	3.04	26.64	17.11	0.43
Main	279	Low Fish Passage	20.00	517.32	516.58	0.74	517.12	517.45	0.015594	2.87	6.96	10.21	0.61
Main	300	2-YEAR	161.00	520.27	516.98	3.29		520.62	0.009986	4.73	34.07	15.86	0.57
Main	300	10-YEAR	337.00	522.93	516.98	5.95		523.16	0.003099	3.90	86.89	23.64	0.35
Main	300	50-YEAR	528.00	525.30	516.98	8.32		525.51	0.001494	3.71	149.54	29.01	0.26
Main	300	100-YEAR	593.00	526.04	516.98	9.06		526.25	0.001272	3.69	171.84	31.33	0.25
Main	300	High Fish Passag	81.00	518.79	516.98	1.81	518.71	519.31	0.030243	5.81	13.94	11.24	0.92
Main	300	Low Fish Passage	20.00	517.85	516.98	0.87	517.85	518.13	0.045260	4.25	4.71	8.59	1.01
Main	350	2-YEAR	161.00	520.81	517.98	2.83		521.29	0.016456	5.53	29.10	15.08	0.70
Main	350	10-YEAR	337.00	523.06	517.98	5.08		523.40	0.005848	4.68	72.71	24.27	0.46
Main	350	50-YEAR	528.00	525.36	517.98	7.38		525.62	0.002285	4.18	133.91	29.28	0.31
Main	350	100-YEAR	593.00	526.09	517.98	8.11		526.34	0.001857	4.09	155.98	31.01	0.29
Main	350	High Fish Passag	81.00	520.11	517.98	2.13	519.77	520.40	0.015676	4.31	18.80	14.39	0.66
Main	350	Low Fish Passage	20.00	519.18	517.98	1.20		519.30	0.013709	2.76	7.26	10.29	0.58
Main	400	2-YEAR	161.00	521.68	518.98	2.70		522.23	0.020453	5.95	27.04	15.82	0.80
Main	400	10-YEAR	337.00	523.29	518.98	4.31		523.84	0.010162	5.99	57.12	21.29	0.61
Main	400	50-YEAR	528.00	525.40	518.98	6.42		525.81	0.003804	5.24	108.59	27.01	0.41
Main	400	100-YEAR	593.00	526.12	518.98	7.14		526.49	0.002980	5.06	128.39	28.42	0.37
Main	400	High Fish Passag	81.00	520.93	518.98	1.95		521.31	0.020182	4.94	16.40	12.63	0.76
Main	400	Low Fish Passage	20.00	519.99	518.98	1.01	519.84	520.16	0.021500	3.27	6.12	9.44	0.71
Main	500	2-YEAR	161.00	523.66	521.00	2.66		524.21	0.019361	5.99	26.88	14.47	0.77
Main	500	10-YEAR	337.00	524.52	521.00	3.52	524.47	525.61	0.029050	8.38	40.28	18.14	0.98
Main	500	50-YEAR	528.00	525.58	521.00	4.58	525.30	526.78	0.019417	8.83	61.64	21.09	0.85

HEC-RAS Plan: Existing River: Ripple Creek Reach: Main (Continued)

Reach	River Sta	Profile	Q Total	W.S. Elev	Min Ch El	Diff	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)		(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	500	100-YEAR	593.00	526.21	521.00	5.21	525.55	527.24	0.013523	8.26	75.56	23.51	0.73
Main	500	High Fish Passag	81.00	522.94	521.00	1.94		523.30	0.019505	4.82	16.80	13.09	0.75
Main	500	Low Fish Passage	20.00	522.02	521.00	1.02		522.17	0.019069	3.11	6.43	9.79	0.68
Main	600	2-YEAR	161.00	525.69	523.00	2.69	525.42	526.32	0.022544	6.37	25.28	13.53	0.82
Main	600	10-YEAR	337.00	527.02	523.00	4.02	526.56	527.87	0.017753	7.40	45.93	18.09	0.78
Main	600	50-YEAR	528.00	527.57	523.00	4.57	527.50	528.99	0.023751	9.63	56.69	21.11	0.92
Main	600	100-YEAR	593.00	527.79	523.00	4.79	527.79	529.34	0.023818	10.07	61.52	21.70	0.93
Main	600	High Fish Passag	81.00	524.95	523.00	1.95	524.73	525.35	0.021430	5.10	15.89	11.99	0.78
Main	600	Low Fish Passage	20.00	524.00	523.00	1.00	523.84	524.18	0.021037	3.35	5.97	8.61	0.71

Form 6D - Baffle Design Option

Form 6D provides guidance to correctly design a culvert that meets specific fish passage design criteria, while also considering hydraulic impacts and scour concerns.

For this particular example, the culvert design tried to satisfy the upper and lower fish passage design requirements for depth and velocity. For the adult anadromous salmonids the suggested maximum average velocity at high fish design flow is 5 ft/sec. Velocities had to be satisfied while meeting a minimum flow depth at the low fish design flow of 1 foot at the inlet and outlet of the culvert, while creating resting pools 2 feet in depth between each baffle. Hydraulic analyses for hydraulic impacts and scour were also satisfied.

For proposed conditions at the culvert inlet, velocities and depths were acceptable per the Hydraulic Design Fish Passage requirements.

For proposed conditions through the culvert barrel, the average velocity over the baffles was 2.5 ft/s while 6.8 ft/s velocity was calculated through the notch in the baffle. An increase in velocity through the notch was expected due to the quick decrease of cross-sectional area through the baffle. The 6.8 ft/s velocity through the culvert was deemed acceptable for this particular type of notched baffle design. Higher velocities would have caused greater concern and a redesign would have been necessary.

For proposed conditions at the culvert outlet, velocities and depths were significantly improved from existing conditions and were very close to meeting the 5 ft/s acceptable velocity and 1 foot depth.

Baffle height and spacing was determined by selecting a design that most easily satisfied velocity and depth requirements while keeping the structure dimensions in mind. A baffle spacing of 25 ft was used for the 8 ft x 8 ft, 60 ft long box culvert. Three baffles were installed into the box culvert, one located at the outlet of the culvert, and two installed in the middle of the culvert at the 25 ft spacing.

The weir coefficient of 2.73 $ft^{0.5}/s$ was determined as appropriate for this specific baffle design. The weir coefficient selection processed is outlined below.

Step 1: Estimate the highest possible weir coefficient for the particular design.

For this example, the proposed breadth of crest of weir 1.2 ft, therefore, the highest possible weir coefficient for a broad-crested or sharp-crested weir is 3.32 $ft^{0.5}/s$. (See Hydraulic Engineering Circular 22, *Urban Drainage Design Manual*, pages 8-24 and 8-28). The highest weir coefficient is then entered into the HEC-RAS model and run.

Step 2: Check range of head over baffle in hydraulic model. Does the Low Fish Passage Design depths equal or not exceed the minimum allowable depth per design species? If yes, breath of crest of weir or allowable head is inappropriate for design. Design must be modified and rerun. If no, determine type of weir.

Step 3: Determine type of weir. When the breadth of crest of weir is greater than 0.47 times the head, it is classified as a broad-crested weir.

For this example, the breadth of crest of weir was 1.2 feet. The head from the model results ran with a weir coefficient of 3.32 $ft^{0.5}/s$, equaled 0.51 ft. Since the breadth of crest of weir was greater than the head times 0.47, the weir is classified as a broad-crested weir.

Step 4: Select a more appropriate broad-crested weir coefficient from Table 8-1 from Hydraulic Engineering Circular 22, *Urban Drainage Design Manual.* The weir coefficient is then entered again into the HEC-RAS model and run.

For this example, 2.73 $ft^{0.5}/s$ was selected as a more appropriate broad-crested weir coefficient.

Step 5: Check range of head over baffle in hydraulic model. Does the Low Fish Passage Design depths equal or not exceed the minimum allowable depth per design species? If yes, calculation error occurred in Step 2.

For this example, the average head increase was less than 0.1 feet. Another iteration of weir coefficient selection was unnecessary due to no change in the coefficient value. A weir coefficient value of 2.73 $ft^{0.5}/s$ was used for the HEC-RAS model.

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION			FORM 6D
Project Information Fish Passage Improvement - Route 555		Computed: EKB	Date: 7/18/06
		Checked: LEF	Date: 7/19/06
Stream Name: Ripple Creek	County: Mendocino	Route: 555	Postmile: 20.2

General Considerations

Baffles shall be used in the design retrofitted culverts or bridges in order to meet the hydraulic design criteria.

Hydrology Results - Peak Discharge Values

50% Annual Probability (2-Year Flood Event)	161	cfs	10% Annual Probability (10-Year Flood Event)	337	cfs
2% Annual Probability (50-Year Flood Event)	528	cfs	1% Annual Probability (100-Year Flood Event)	593	cfs
High Fish Passage Design Flow	81	cfs	Low Fish Passage Design Flow	20	cfs

Selecting Weir Coefficient, C

1) Estimate highest possible weir coefficient for design.[1]

Initial estimate of weir coefficient, C 3.32 $ft^{0.5}/sec$

2) Check range of head over baffle in hydraulic model.

Does the Low Fish Passage Design depths equal or not exceed the minimum allowable depth per design species? ☐ Yes ☒ No

If yes, breath of crest of weir or allowable head is inappropriate for design. Modify design to comply and re-run hydraulic anaylses to verify.

Does the High Fish Passage Design velocities over the weir and through the notch exceed the minimum allowable velocities per design species?
☐ Yes ☒ No

If yes, breath of crest of weir or allowable head is inappropriate for design. Modify design to comply and re-run hydraulic anaylses to verify.

If no for both questions above, determine type of weir.

3) Determine type of weir.

When the thickness of the crest of a weir is more than 0.47 times the head, it is classified as a broad-crested weir.[2]

Baffle/Weir width: 1.2 ft	Head: 0.51 ft	Head x 0.47 = 0.24 ft
☒ Broad crested weir	☐ Sharp crested weir	☐ Other

4) Select a more appropriate weir for particular type of weir, C:

Establish range of reasonable C coefficients in accordance with Hydraulic Engineering Circular 22 ☒ Yes ☐ No

5) Check range of head over baffle in hydraulic model.

[1] Hydraulic Engineering Circular 22, *Urban Drainage Design Manual,* Chapter 8 (www.fhwa.dot.gov)
[2] Gupta, Ram S., *Hydrology and Hydraulic Systems,* Chapter 6.

Does the Low Fish Passage Design depths equal or not exceed the minimum allowable depth per design species? ☐ Yes ☒ No

If yes, modify design to comply and rerun hydraulic anaylses to verify.

Does the High Fish Passage Design velocities over the baffle and through the notch exceed the minimum allowable velocities per design species?
☐ Yes ☒ No

If yes, modify design to comply and rerun hydraulic anaylses to verify.

Proposed Baffle Settings and Dimensions

Baffle height:	2.0 ft	Baffle width:	1.2 ft
Baffle spacing (along longitudinal axis):	25 ft	Weir coefficient:	2.73 $ft^{0.5}/sec$

Summarize Retrofitted Culvert Physical Characterstics

Inlet Characteristics - Retrofitted design to inlet: ☐ Yes ☒ No

Inlet Type	☐ Projecting	☐ Headwall	☐ Wingwall
	☐ Flared end section	☐ Segment connection	☐ Skew Angle: °

Barrel Characteristics - Retrofitted design to barrel: ☐ Yes ☒ No

Diameter: in	Fill height above culvert: ft
Height/Rise: ft	Length: ft
Width/Span: ft	Number of barrels:

Culvert Type	☐ Arch	☐ Box	☐ Circular
	☐ Pipe-Arch	☐ Elliptical	
Culvert Material	☐ HDPE	☐ Steel Plate Pipe	☐ Concrete Pipe
	☐ Spiral Rib / Corrugated Metal Pipe		

Horizontal alignment breaks: ft	Vertical alignment breaks: ft

Outlet Characteristics - Retrofitted design to outlet: ☐ Yes ☒ No

Outlet Type	☐ Projecting	☐ Headwall	☐ Wingwall
	☐ Flared end section	☐ Segment connection	Skew Angle: °

Summarize Retrofitted Bridge Physical Characterstics N/A

Bridge Physical Characteristics **Retrofitted design to bridge structure:** ☐ Yes ☐ No

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION — FORM 6D

Elevation of high chord (top of road): ft	Elevation of low chord: ft

Channel Lining: ☐ No lining ☐ Concrete ☐ Rock ☐ Other

Skew Angle: °	Bridge width (length): ft

Pier Characteristics (if applicable) Retrofitted design to piers: ☐ Yes ☐ No N/A

Number of Piers: ft	Upstream cross-section starting station: ft
Pier Width: ft	Downstream cross-section starting station: ft
Pier Centerline Spacing: ft	Skew angle: °

Pier Shape: ☐ Square nose and tail ☐ Semi-circular nose and tail ☐ 90° triangular nose and tail ☐ Twin-cylinder piers with connecting diaphragm ☐ Twin-cylinder piers without connecting diaphragm ☐ Ten pile trestle bent

Establish High Design Flow for Fish Passage - Depending on species, develop high design flows:

Species/Life Stage	**Percent Annual Exceedance Flow**	**Percentage of 2-Yr Recurrence Interval Flow**	**Design Flows (cfs)**
☒ Adult Anadromous Salmonids	(1%)	50%	81
☐ Adult Non-Anadromous Salmonids	5%	30%	
☐ Juvenile Salmonids	10%	10%	
☐ Native Non-Salmonids	5%	30%	
☐ Non-Native Species	10%	10%	

Establish Low Design Flow for Fish Passage - Depending on species, develop low design flows:

Species/Life Stage	**Percent Annual Exceedance Flow**	**Alternate Minimum Flow (cfs)**	**Design Flow (cfs)**
☒ Adult Anadromous Salmonids	(50%)	3	20
☐ Adult Non-Anadromous Salmonids	90%	2	
☐ Juvenile Salmonids	95%	1	
☐ Native Non-Salmonids	90%	1	
☐ Non-Native Species	90%	1	

Establish Maximum Average Water Velocity and Minimum Flow Depth in Culvert (At high design flow) - Depending on culvert length and/or species, select Maximum Average Water Veolcity and Minimum Flow Depth.

Species/Life Stage	**Maximum Average Water Velocity at High Fish Design Flow (ft/sec)**	**Minimum Flow Depth at Low Fish Design Flow (ft)**

☒ Adult Anadromous Salmonids	6 (Culvert length <60 ft)	1.0
	5 (Culvert length 60-100 ft)	
	4 (Culvert length 100-200 ft)	
	3 (Culvert length 200-300 ft)	
	2 (Culvert length >300 ft)	
☐ Adult Non-Anadromous Salmonids	4 (Culvert length <60 ft)	0.67
	4 (Culvert length 60-100 ft)	
	3 (Culvert length 100-200 ft)	
	2 (Culvert length 200-300 ft)	
	2 (Culvert length >300 ft)	
☐ Juvenile Salmonids	1	0.5
☐ Native Non-Salmonids	Species specific swimming performance data is required for the use of the hydraulic design option for non-salmonids. Hydraulic design is not allowed for these species without this data.	
☐ Non-Native Species		

Establish Maximum Outlet Drop

Hydraulic drops between the water surface in the culvert to the pool below the culvert should be avoided for all cases. Where fish passage is required and a hydraulic drop is unavoidable, it's magnitude should be evaluated for both high design flow and low design flow and shall not exceed the values shown below. If a hydraulic drop occurs at the culvert outlet a jump pool of at least 2 feet in depth shall be provided.

Species/Life Stage	Maximum Drop (ft)
☒ Adult Anadromous Salmonids	1
☐ Adult Non-Anadromous Salmonids	1
☐ Juvenile Salmonids	0.5
☐ Native Non-Salmonids	Where fish passage is required for native non-salmonids no hydraulic drop shall be allowed at the culvert outlet unless data is presented which will establish the leaping ability and leaping behavior of the target species of fish.
☐ Non-Native Species	

Maximum Allowable Inlet Water Surface Elevation

Culvert ☒

A culvert is required to pass the 10-year peak	Allowable WSEL: 524.18 ft

discharge without causing pressure flow in the culvert,	
And shall not be greater than 50% of the culvert height or diameter above the top of the culvert inlet for the 100-Year peak flood.	Allowable WSEL: 529.59 ft

Bridge ☐ N/A

A bridge is required to pass the 50-year peak discharge with freeboard, vertical clearance between the lowest structural member and the water surface elevation,	Allowable WSEL: ft
While passing the 100-year peak or design discharge under low chord of the bridge.	Allowable WSEL: ft

Establish Allowable Hydraulic Impacts

Is the crossing located within a floodplain as designated by the Federal Emergency Management Agency or another responsible state or local agency?
☐ Yes ☒ No

If yes, establish allowable hydraulic imacts and hydraulic design requirements with the appropriate agency. Attach results.

Will the project result in the increase capacity of an existing crossing? ☐ Yes ☒ No

If yes, will it significantly increase downstream peak flows due to the reduced upstream attenuation? ☐ Yes ☒ No

If yes, consult District Hydraulics. Further analysis may be needed.

Will the project result in a reduction in flow area for the 100-year peak discharge? ☐ Yes ☒ No

If yes, establish the allowable increase in upstream water surface elevation and establish how far upstream the increased water surface may extend.

Develop and run Hydraulic Models to compute water surface elevations, flow depths, and channel velocities fo the low fish passage design flow, the high fish passage design flow and for the 2-, 10-, 50-, and 100-year peak or design discharges reflecting existing and project conditions.
☒ Yes ☐ No

Evaluate computed water surface elevations, flow depths, and channel velocities: ☒ Yes ☐ No

Maximum average velocity in culvert at high fish design flow: 5 ft/s

Does the velocity exceed the maximum allowable for the culvert length and design species? ☐ Yes ☒ No

If yes, modify design to comply and rerun hydraulic anaylses to verify.

Minimum flow depth in culvert at low fish design flow: 2ft depth for resting pools ft

Does the depth equal or not exceed the mimimum allowable for the culvert length and design species? ☐ Yes ☒ No

If yes, modify design to comply and rerun hydraulic anaylses to verify.

Drop between the water surface elevation in the culvert and the outlet channel for: due to 2' height of baffle

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION — FORM 6D

High Fish Passage Flow: 2.42 ft	Low Fish Passage Flow: 1.91 ft

Does the drop between the water surface in the culvert and the outlet channel at high or low design fish flows exceed the maximum allowable for the design species? ☐ Yes ☒ No Notch in Weir

If yes, modify design to avoid a drop if possible. If a drop is unavoidable modify design to meet criteria and provide a jump pool at least two feet in depth. Rerun hydraulic analyses to verfiy.

Water Surface elevation at inlet for the 10-year peak discharge: 524.02 ft

Does the water surface elevation exceed the allowable? ☐ Yes ☒ No

If yes, modify design to comply and rerun hydraulic analyses to verify.

Maximum Culvert and Channel velocities at inlet and outlet transition for the peak or design discharge: High Fish Passage Flows

Range of velocities for Inlet transition:	2.50	ft/s	to		ft/s
Range of velocities for Culvert portion:	2.50 over baffle	ft/s	to	6.8 through notch	ft/s
Range of velocities for Outlet Transition:	5.60	ft/s	to		ft/s

Do the velocities exceed the permissible scour velocities? ☐ Yes ☒ No

If yes, revise design to reduce velocities and rerun hydraulic analyses to verify, or design erosion protection.

Comparison between existing and project future condition water surface elevations for the 10-Year and 100-Year peak flow:

Cross-Section	10-Yr WSEL	10-Yr WSEL	WSEL Difference	100-Year WSEL	100-Year WSEL	WSEL Difference
	Existing Conditions (ft)	Future Conditions (ft)	(ft)	Existing Conditions (ft)	Future Conditions (ft)	(ft)
1 170	518.77	518.77	0.00	520.12	516.96	-3.16
2 198	517.63	518.62	+0.99	519.07	521.21	+2.14
3 260/259	522.22	523.56	+1.34	524.98	523.57	-1.41
4 279	522.95	524.02	+1.07	526.06	526.44	+0.38

If WSELs increase, does the increase exceed the maximum elevation? ☐ Yes ☒ No — Maximum elevation: 535 ft

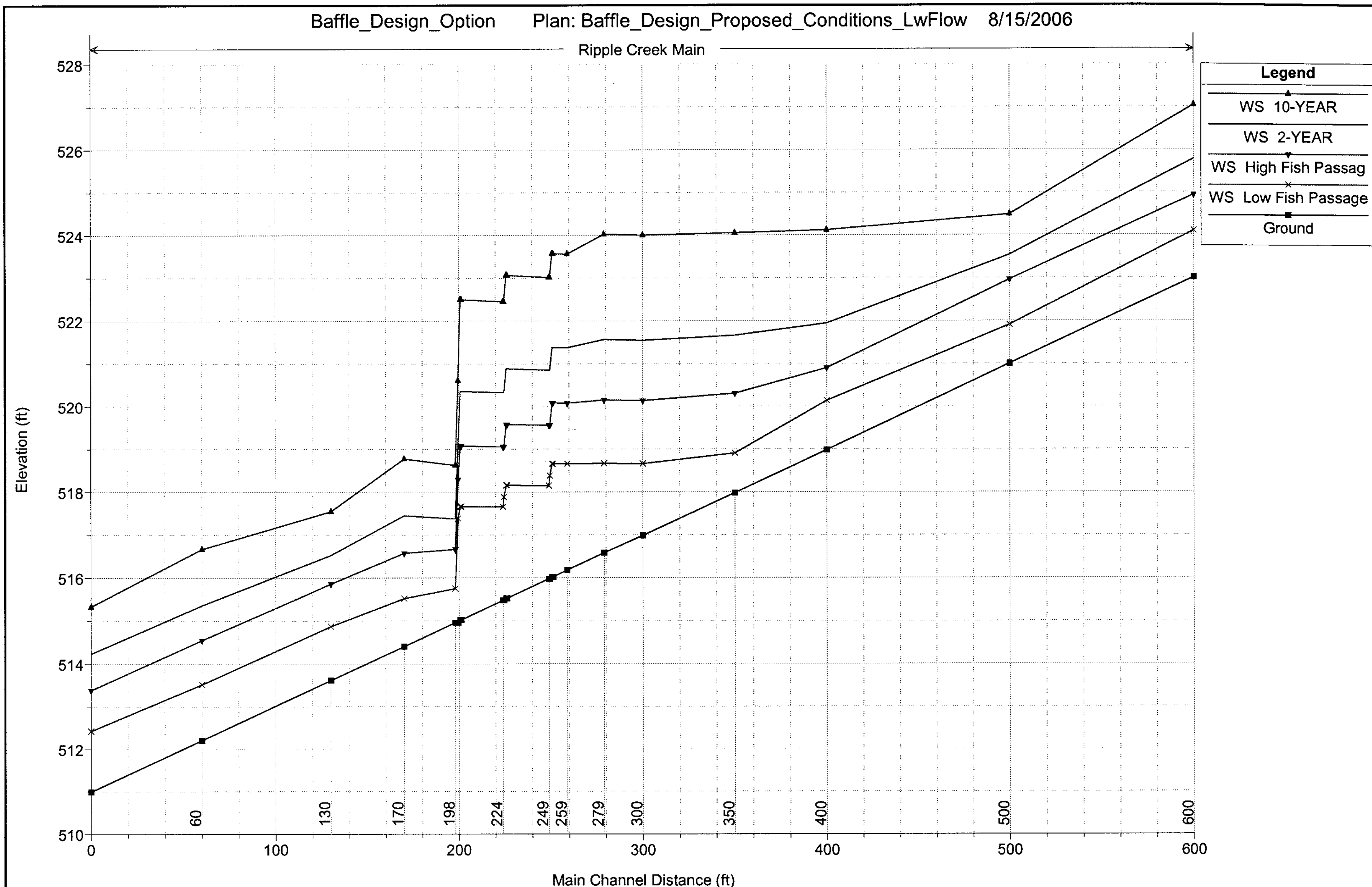
If yes, revise the design and rerun hydraulic analyses to verify.

If WSELs decrease, does it appear that the attenuation of peak flow will significally change? ☐ Yes ☒ No

If yes, evaluate to determine if downstream hydraulic impacts are significant and modify design as appropriate.

Proposed Plan and Profile Drawing Attached ☒ Yes ☐ No

Hydraulic Analysis Index Sheet Attached ☒ Yes ☐ No



Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_LwFlow 8/15/2006
Ripple Creek Main
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Elevation (ft)
Main Channel Distance (ft)
528
526
524
522
520
518
516
514
512
510
0
100
200
300
400
500
600
60
130
170
198
224
249
259
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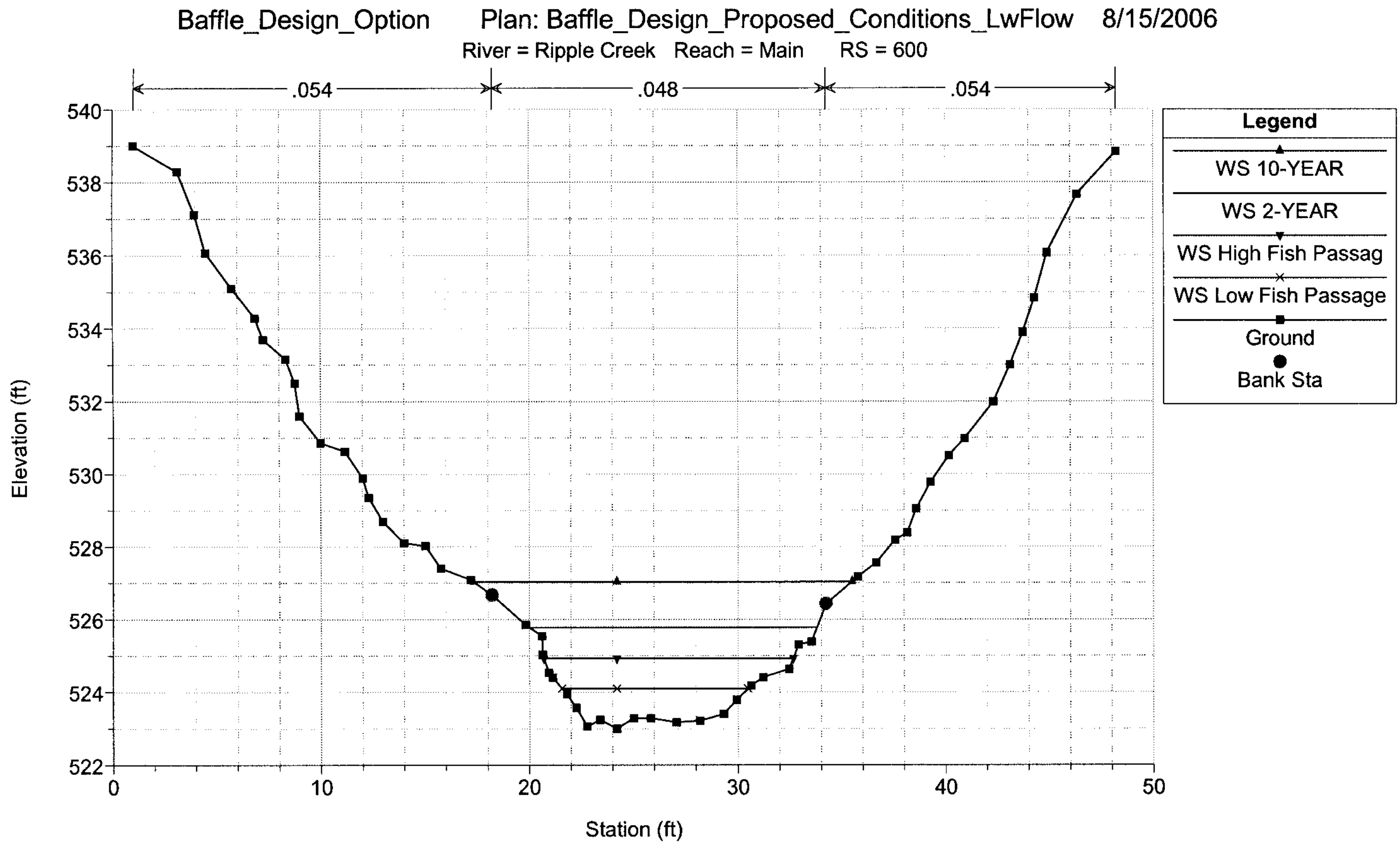
300
350
400
500
600



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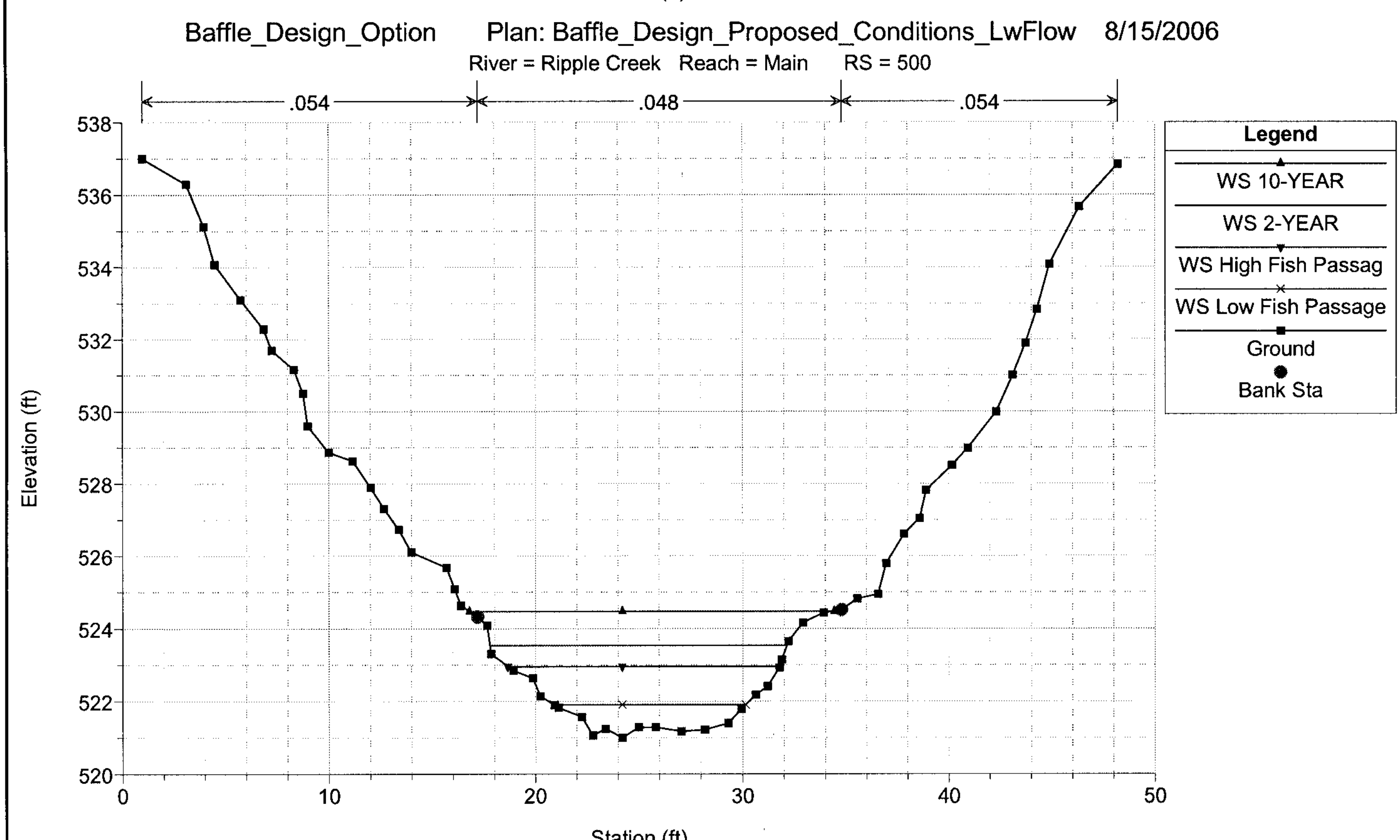
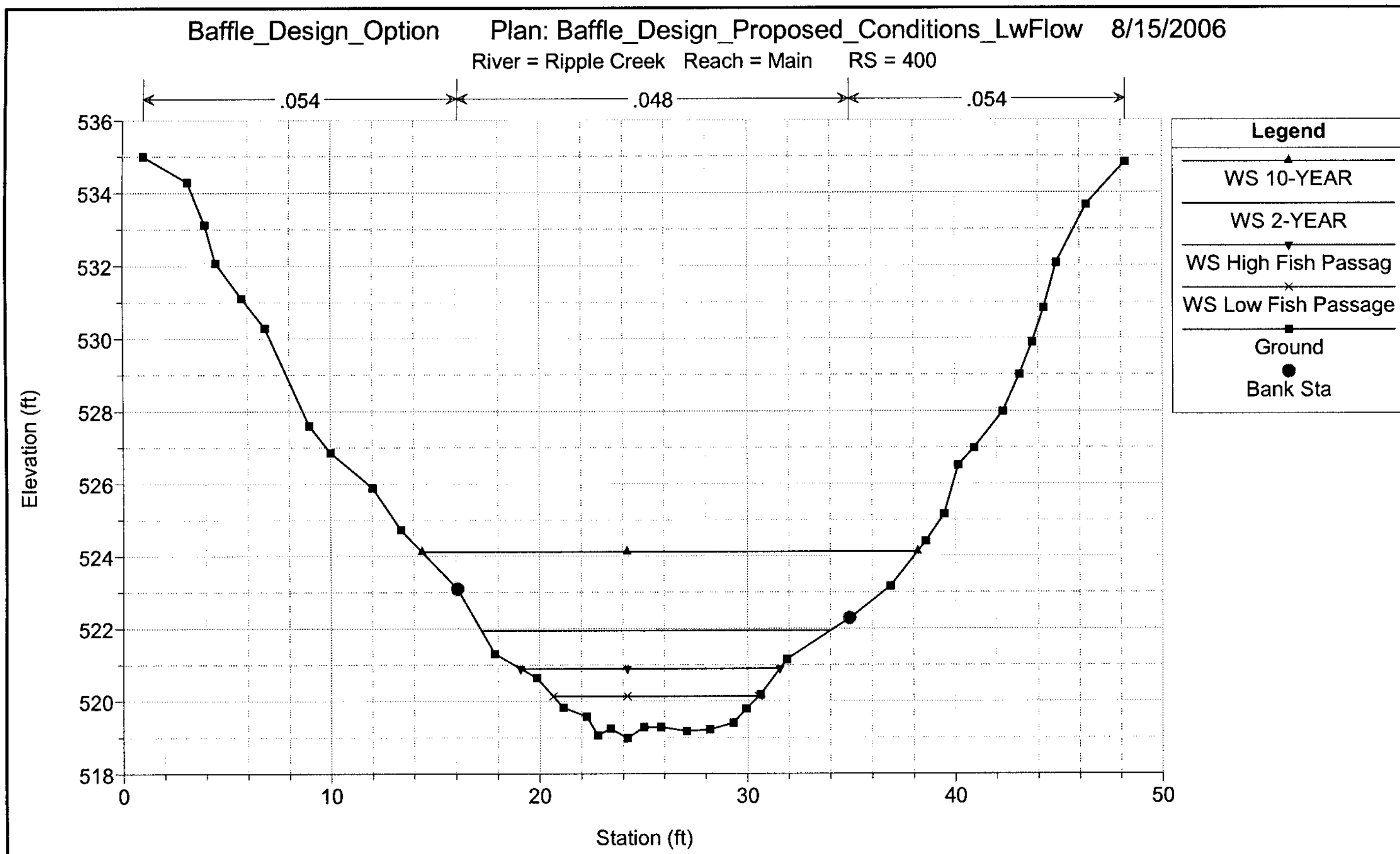
Plan: Baffle_Design_Proposed_Conditions_LwFlow
8/15/2006
River = Ripple Creek
Reach = Main
RS = 600
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
540
538
536
534
532
530
528
526
524
522
0
10
20
30
40
50
Station (ft)



Baffle_Design_Option
Plan: Baffle_Design_Proposed_Conditions_LwFlow
8/15/2006
River = Ripple Creek
Reach = Main
RS = 500
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
538
536
534
532
530
528
526
524
522
520
0
10
20
30
40
50
Station (ft)



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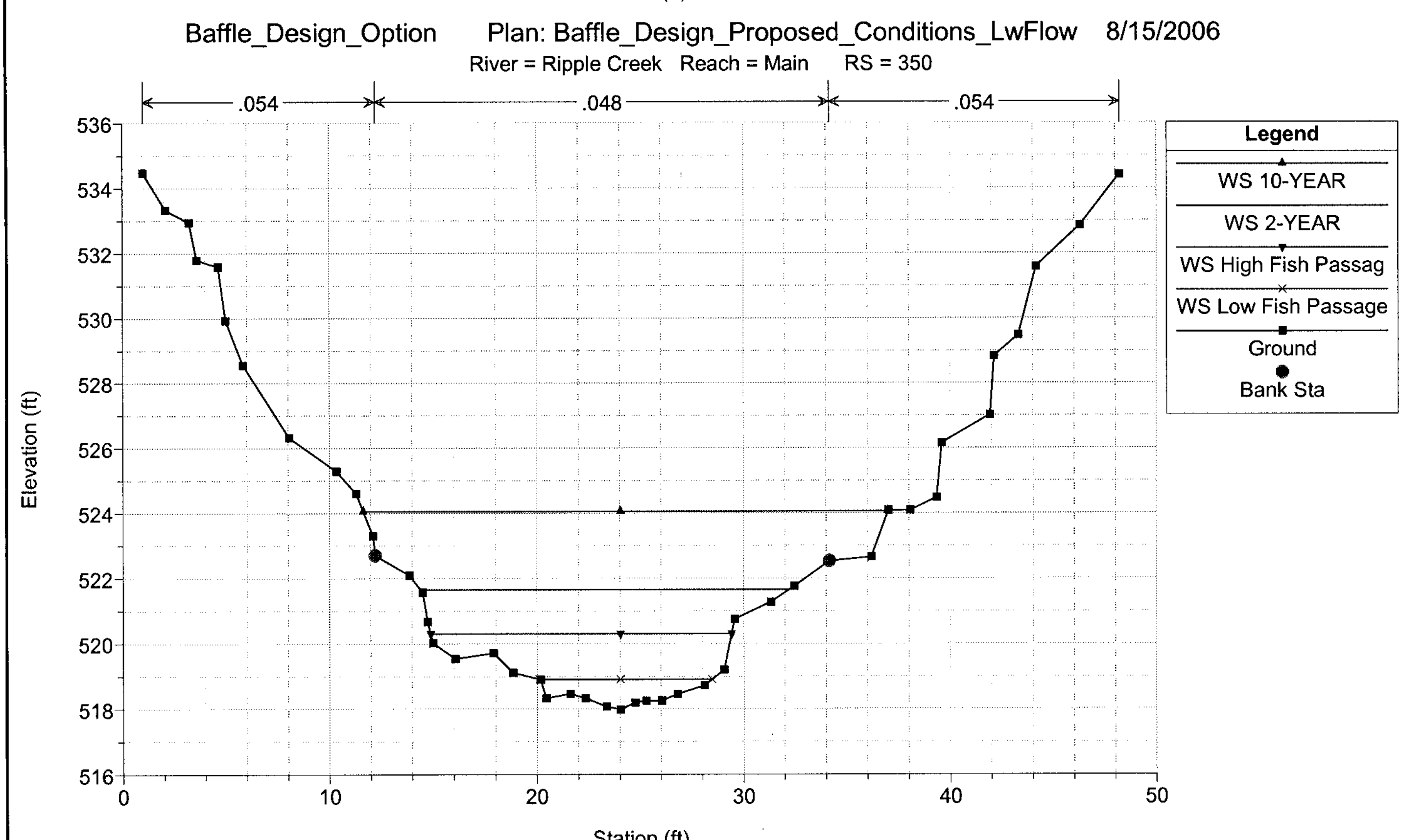
River = Ripple Creek Reach = Main RS = 400
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
536
534
532
530
528
526
524
522
520
518
0
10
20
30
40
50



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River = Ripple Creek Reach = Main RS = 350
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
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534
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516
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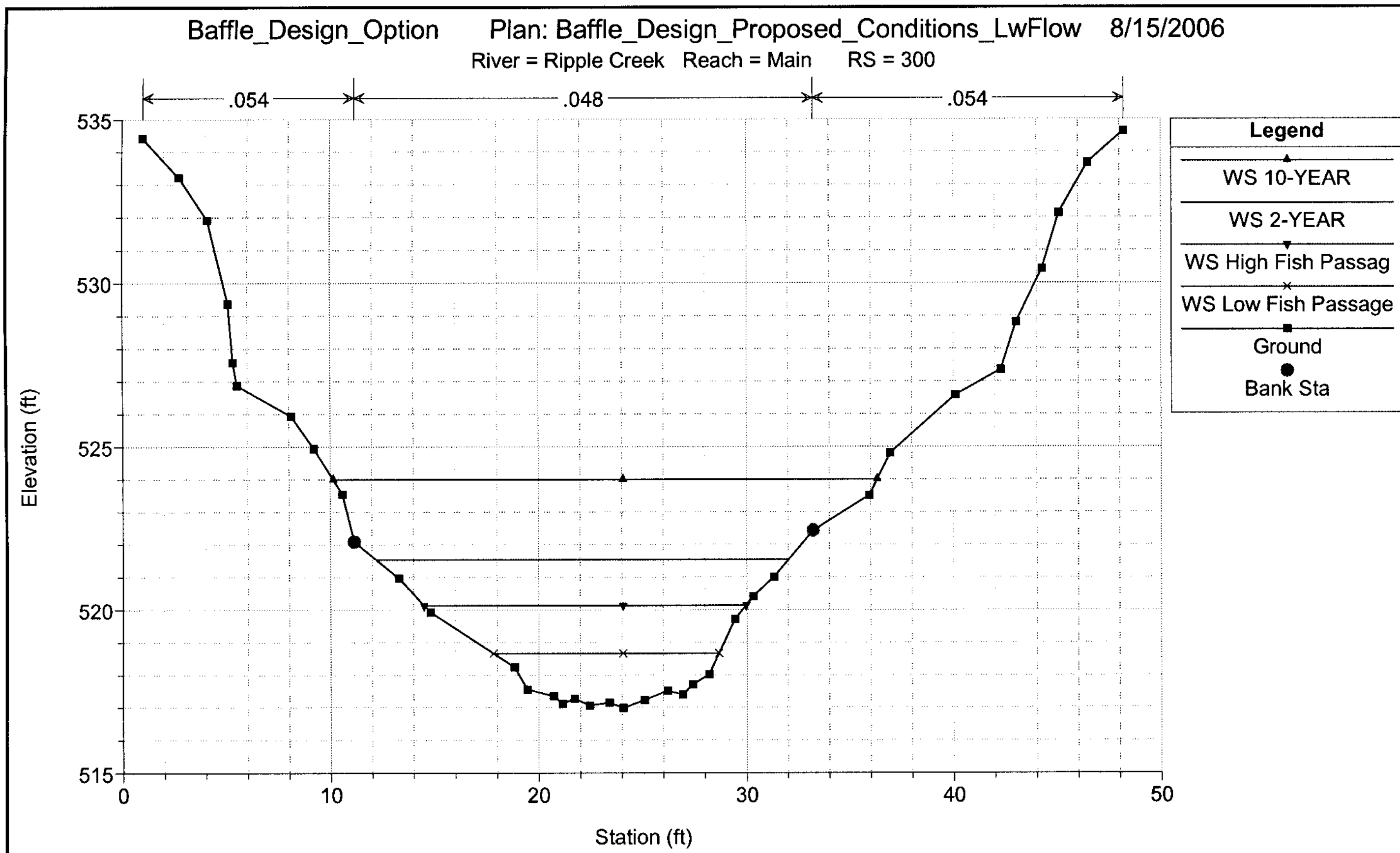
50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River = Ripple Creek Reach = Main RS = 300
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
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515
0
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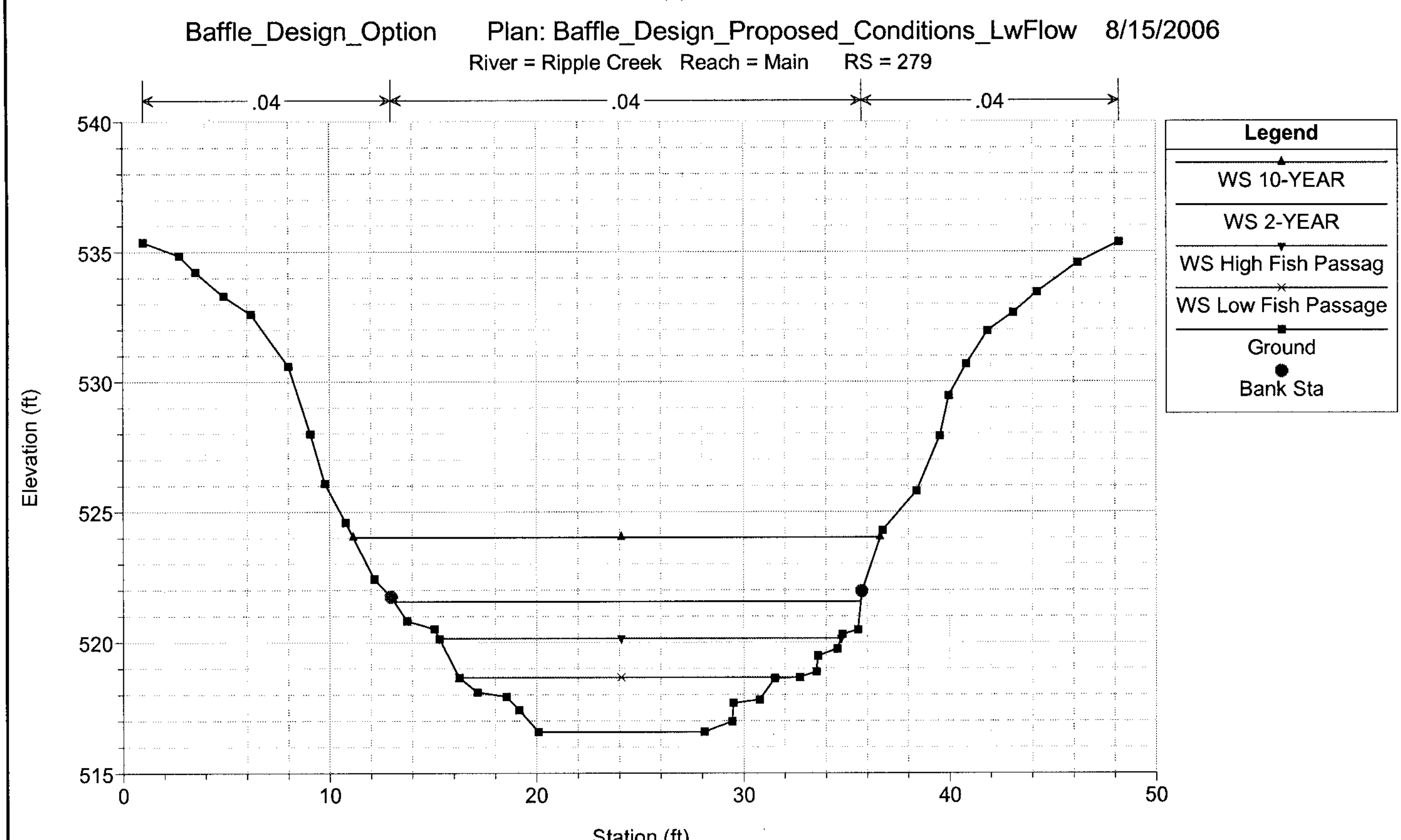
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River = Ripple Creek Reach = Main RS = 279
.04
.04
.04
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
540
535
530
525
520
515
0
10
20
30
40
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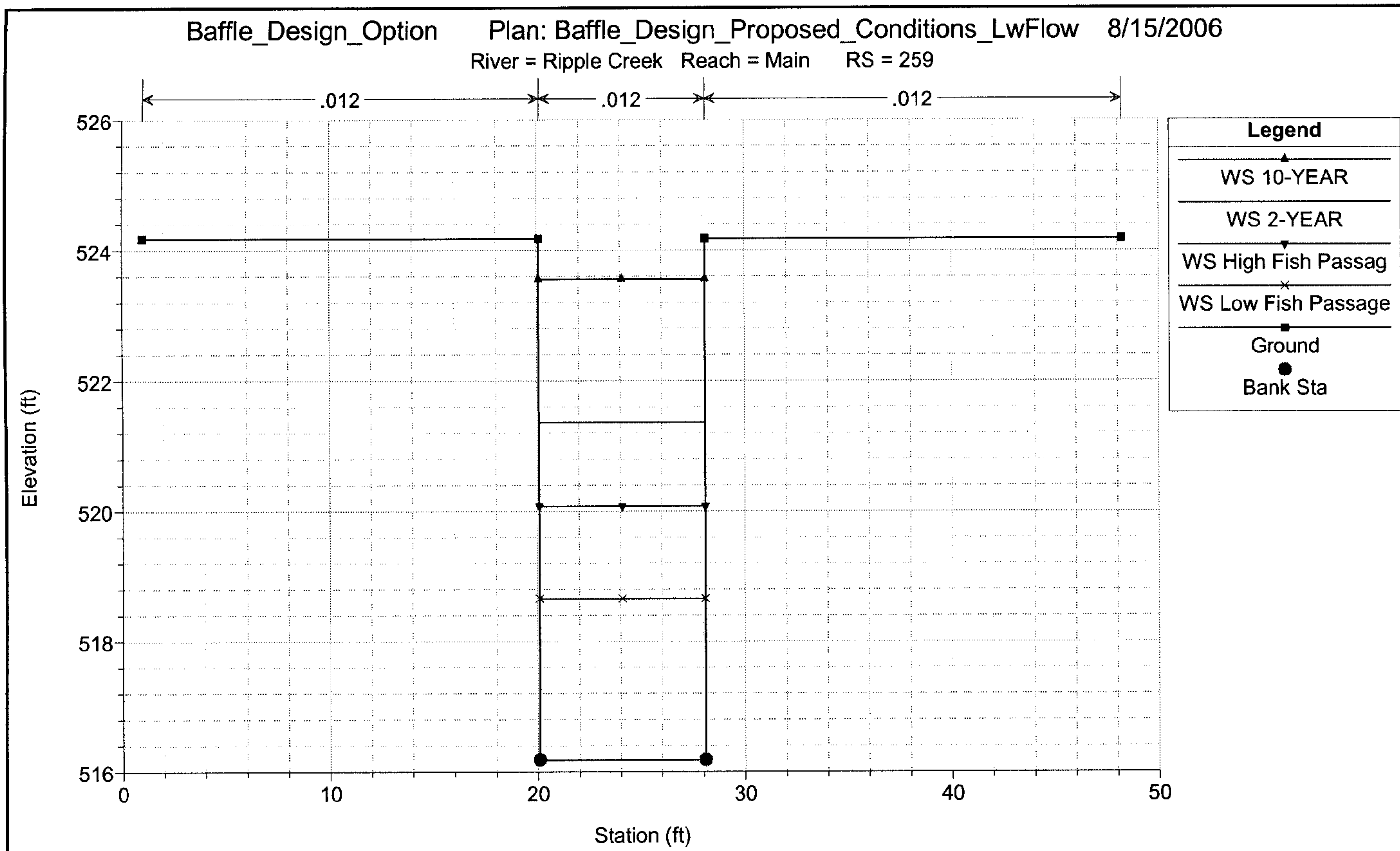
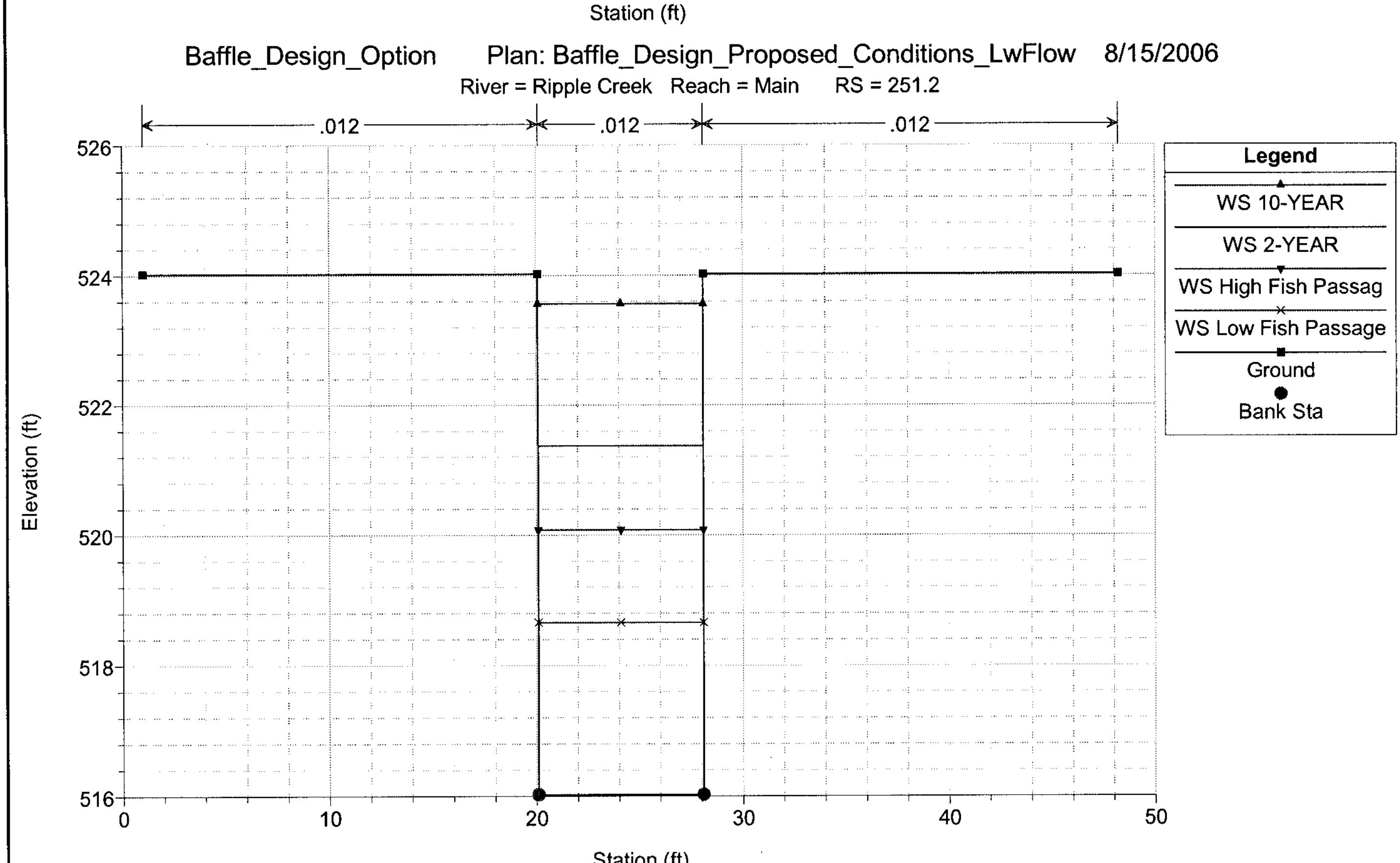


Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_LwFlow 8/15/2006
River = Ripple Creek Reach = Main RS = 259
.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)



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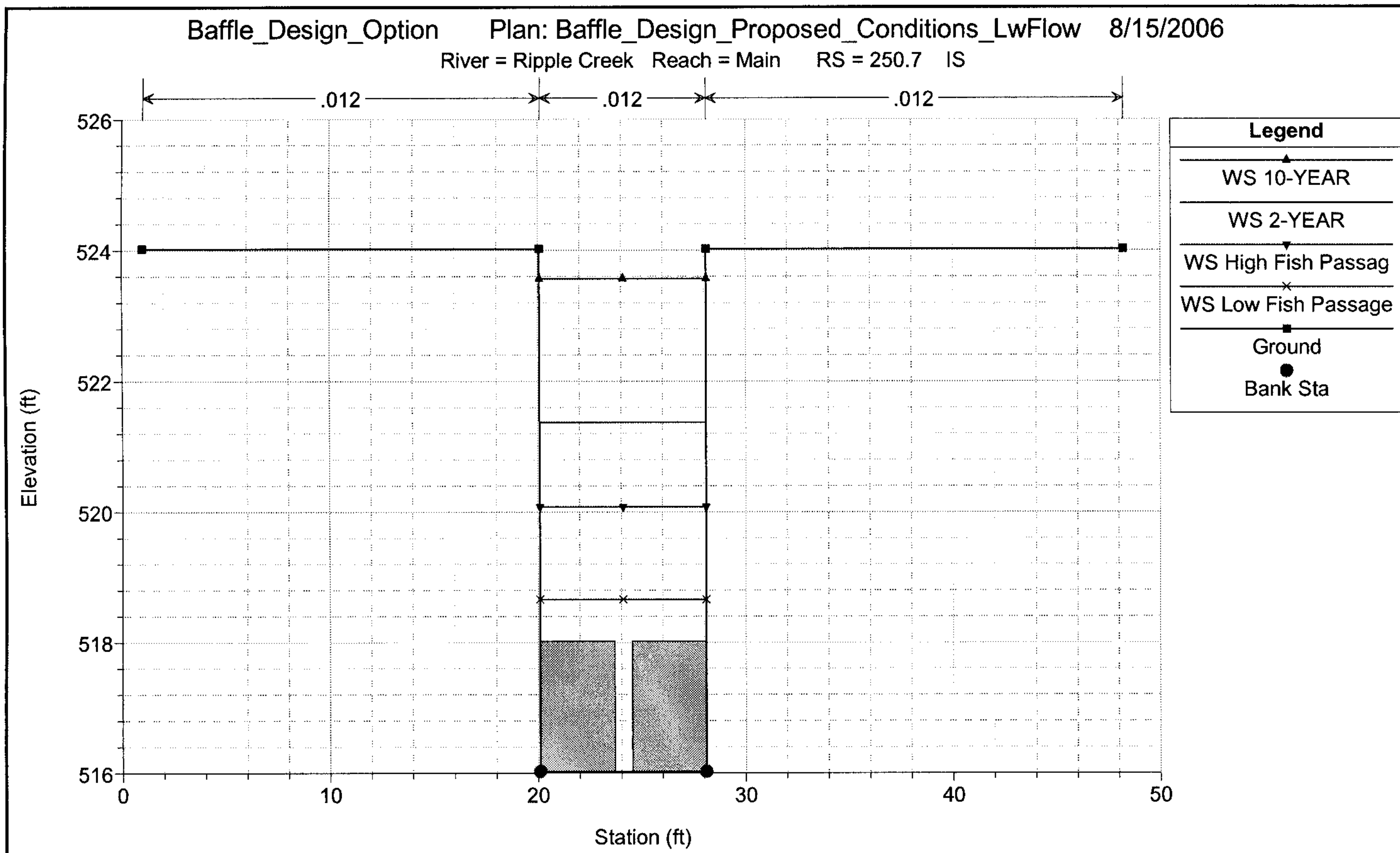
River = Ripple Creek Reach = Main RS = 251.2
.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)



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River = Ripple Creek Reach = Main RS = 250.7 IS
.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
526
524
522
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518
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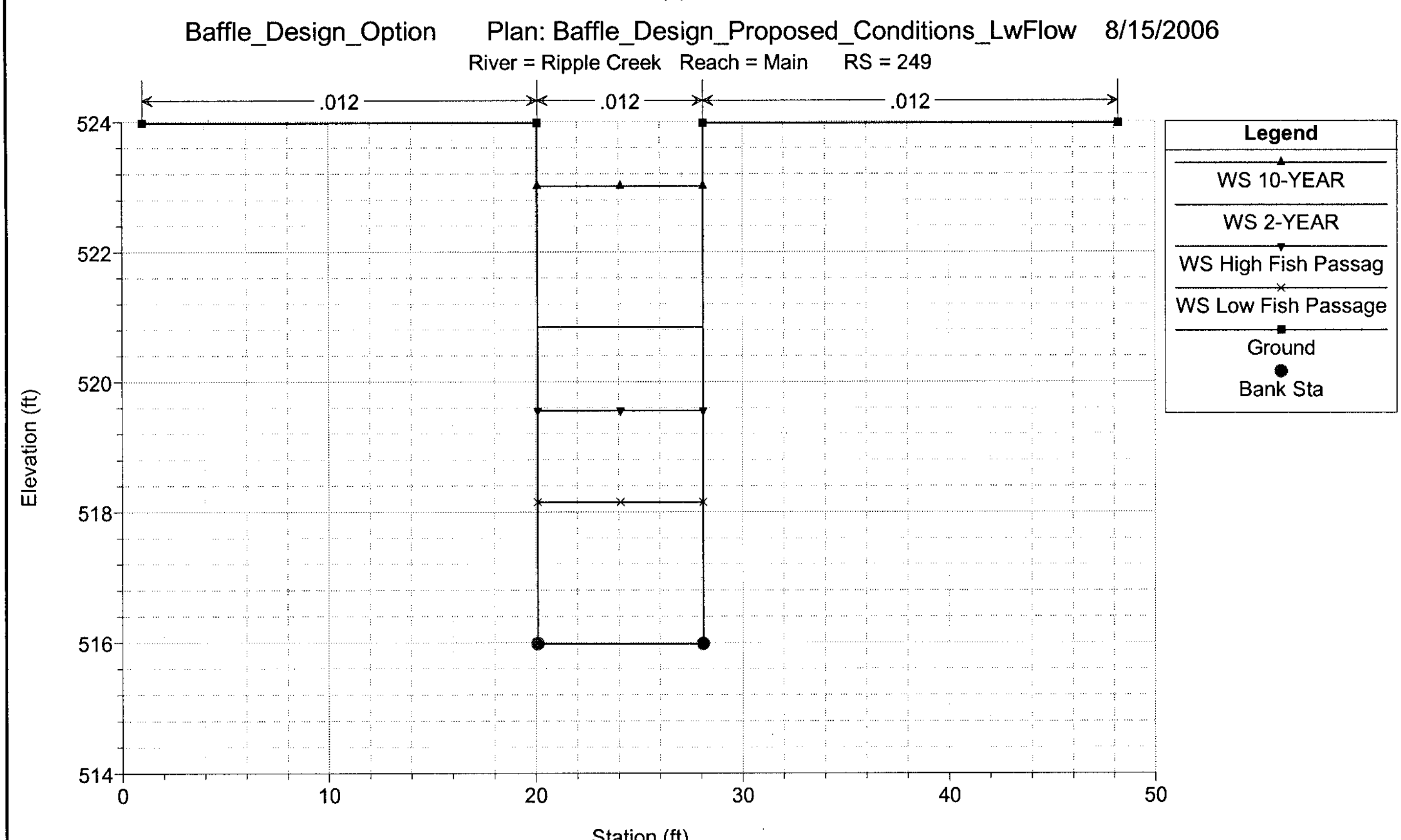
Station (ft)



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.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
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522
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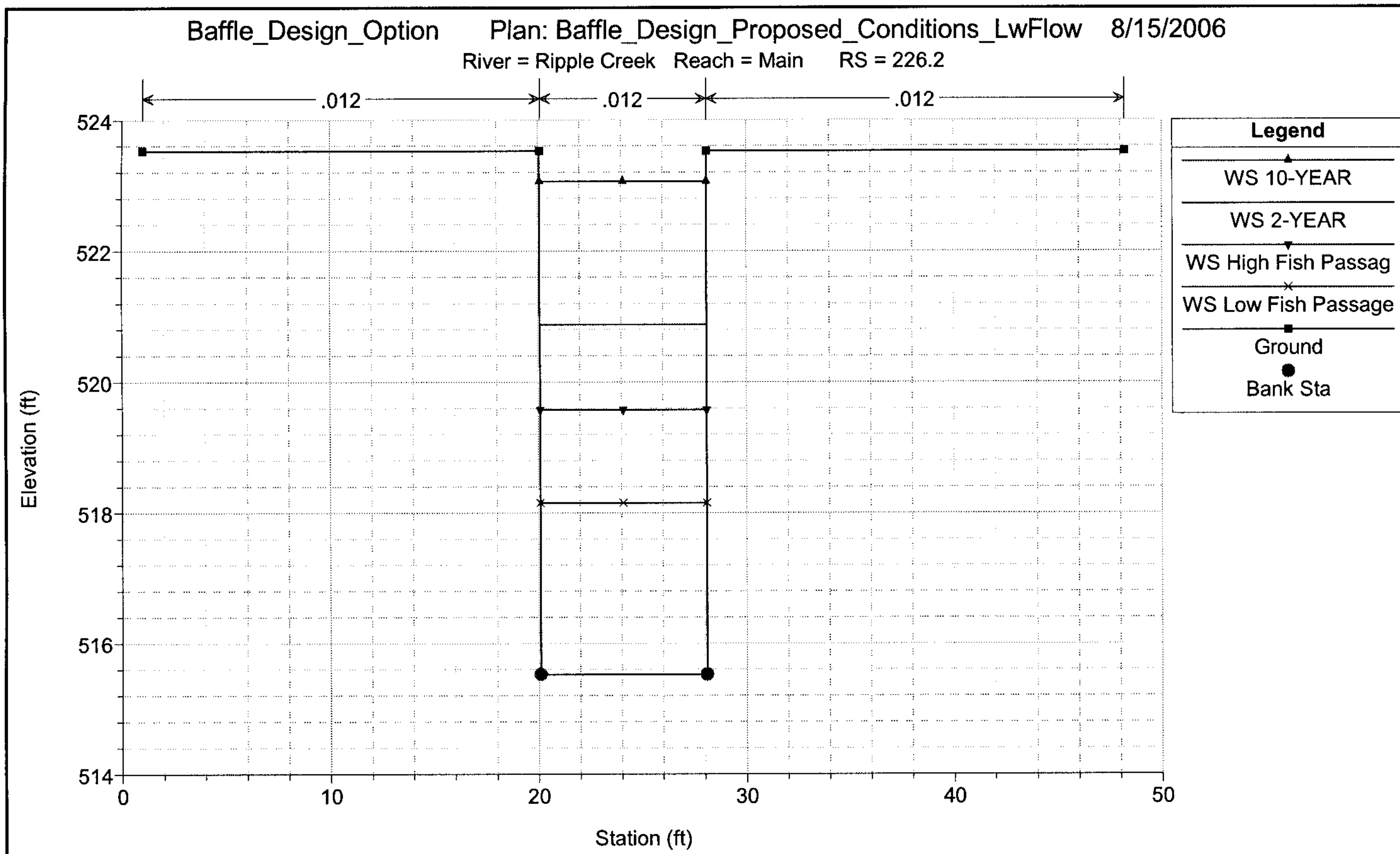
Station (ft)



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.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
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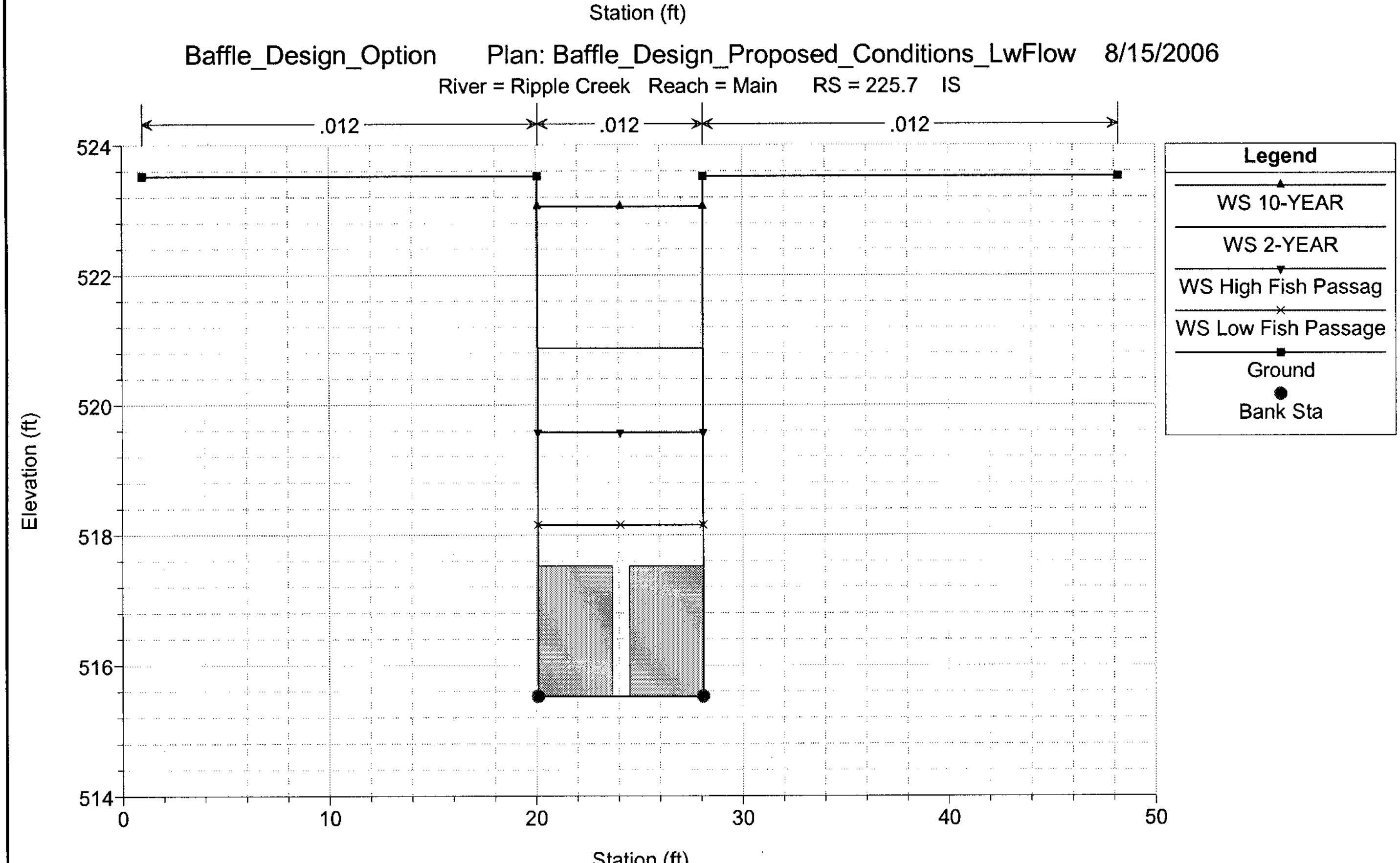

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8/15/2006
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.012
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.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
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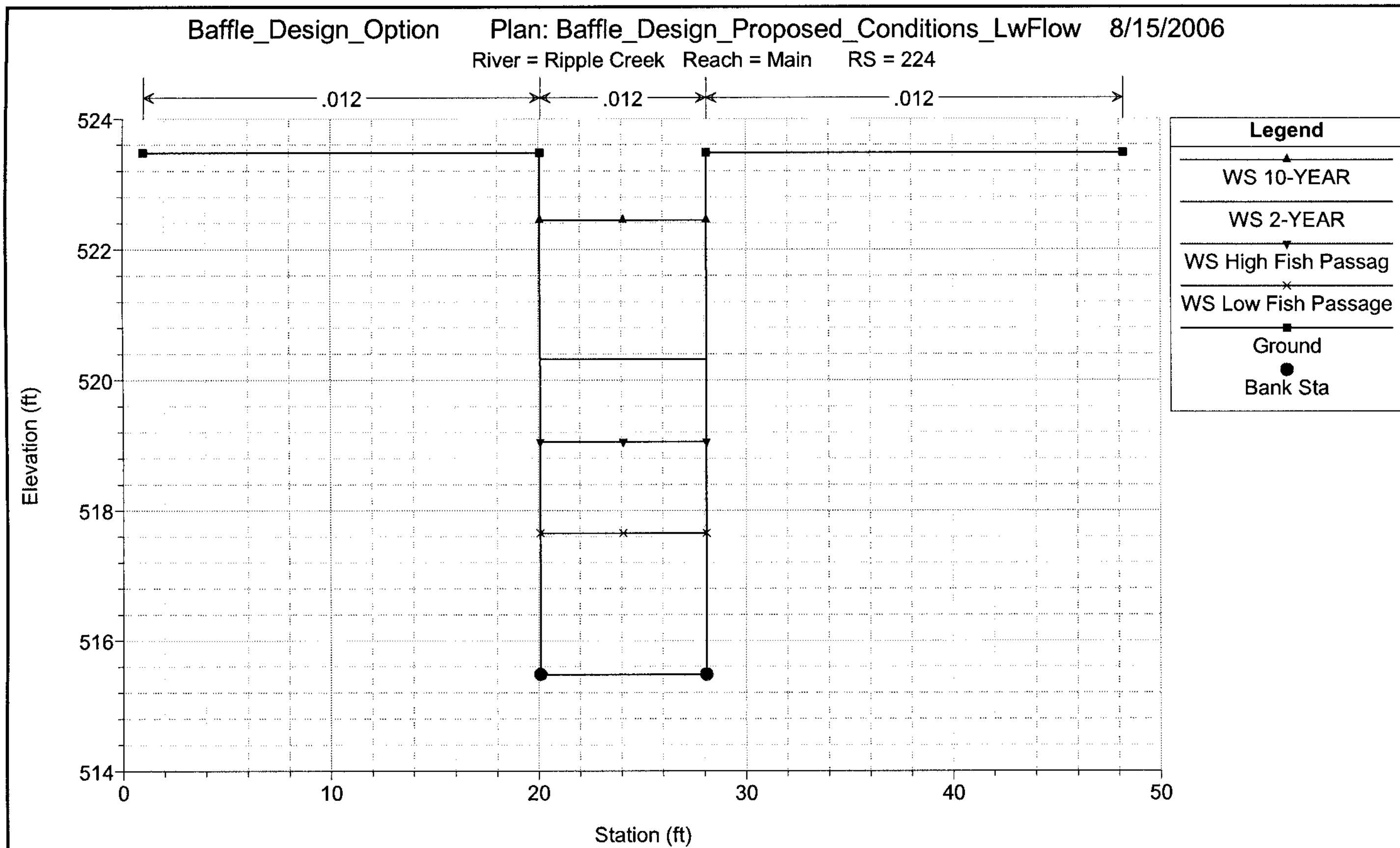
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.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
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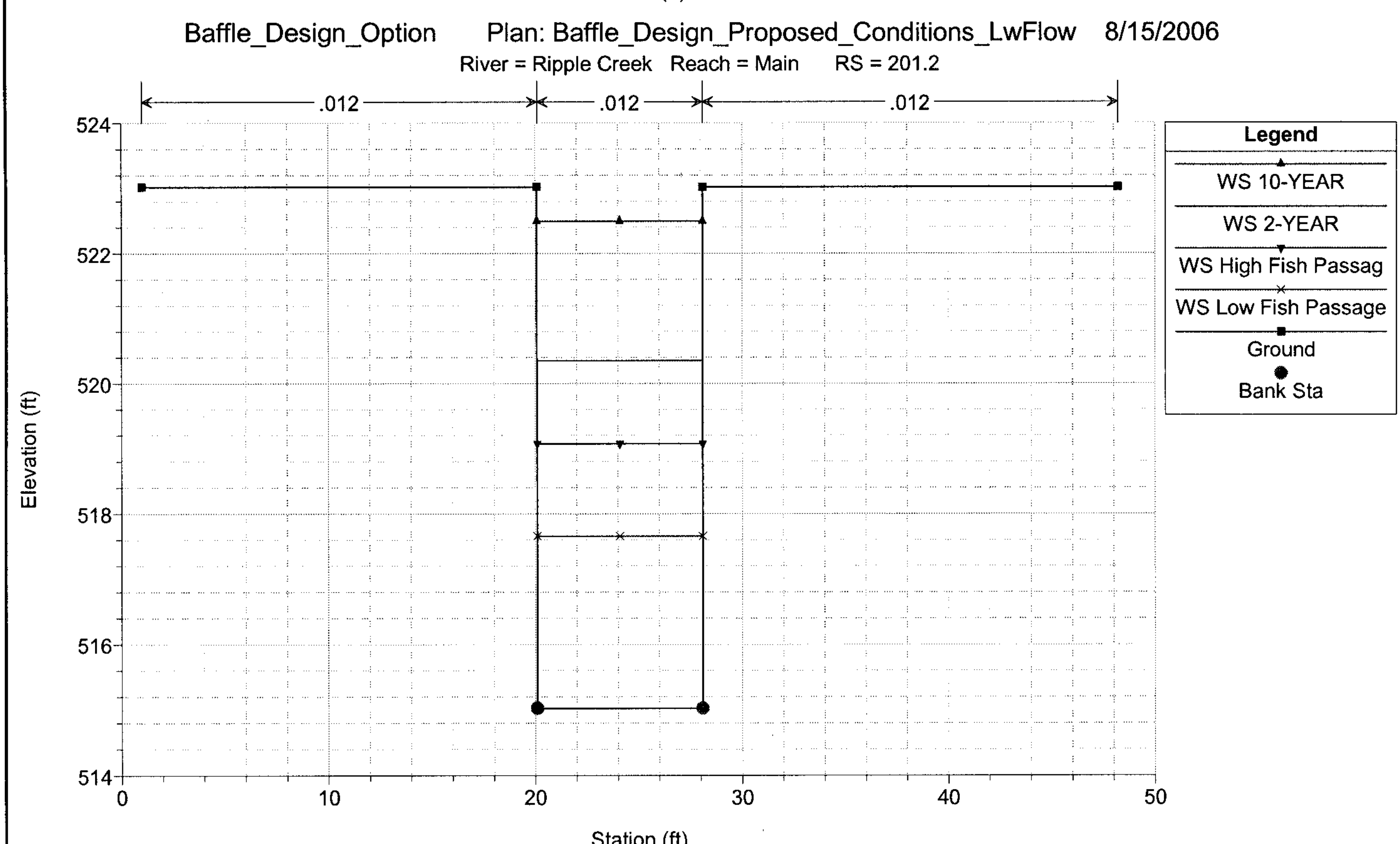
Station (ft)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.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
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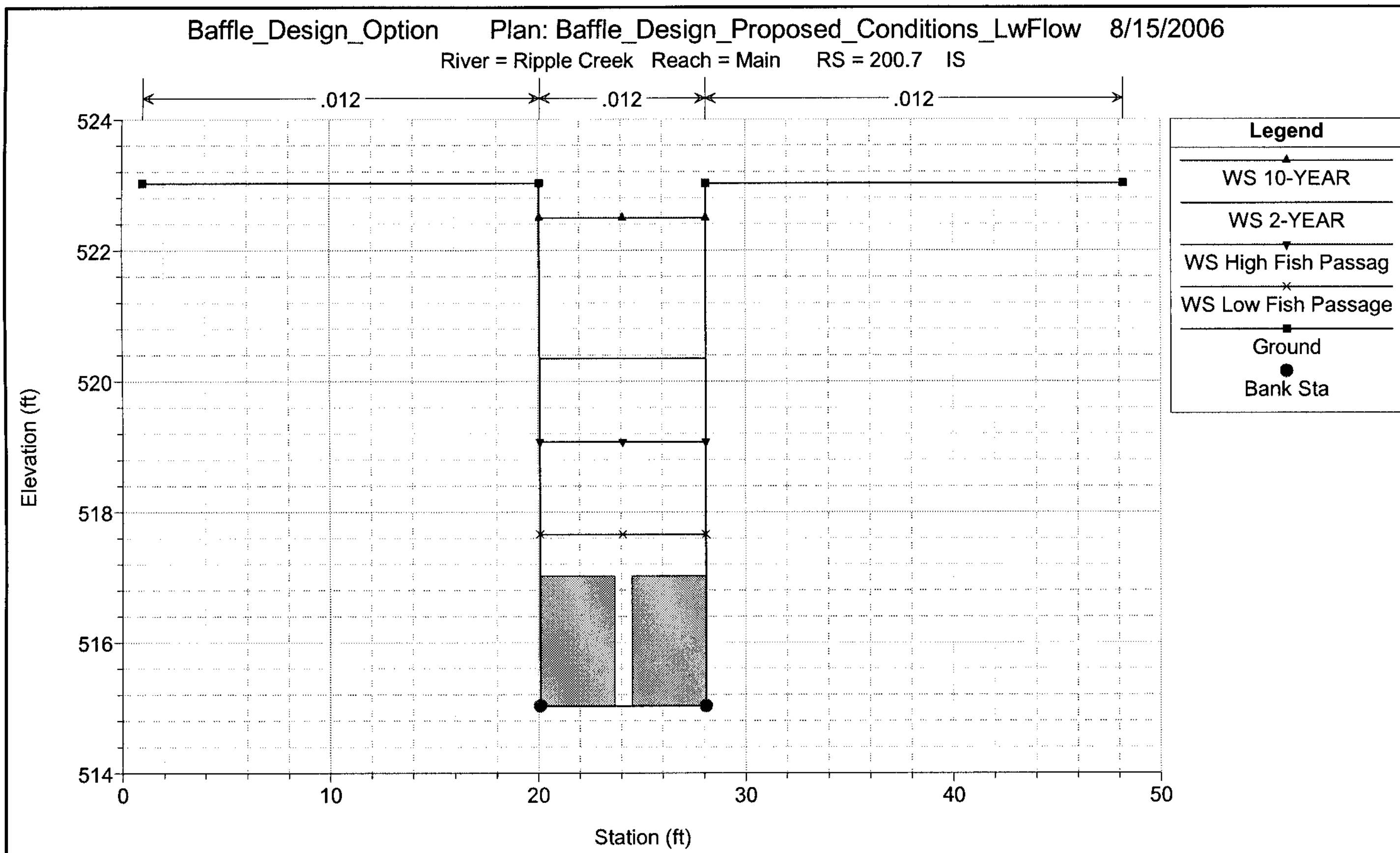
Station (ft)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River = Ripple Creek Reach = Main RS = 200.7 IS
.012
.012
.012
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
Station (ft)
524
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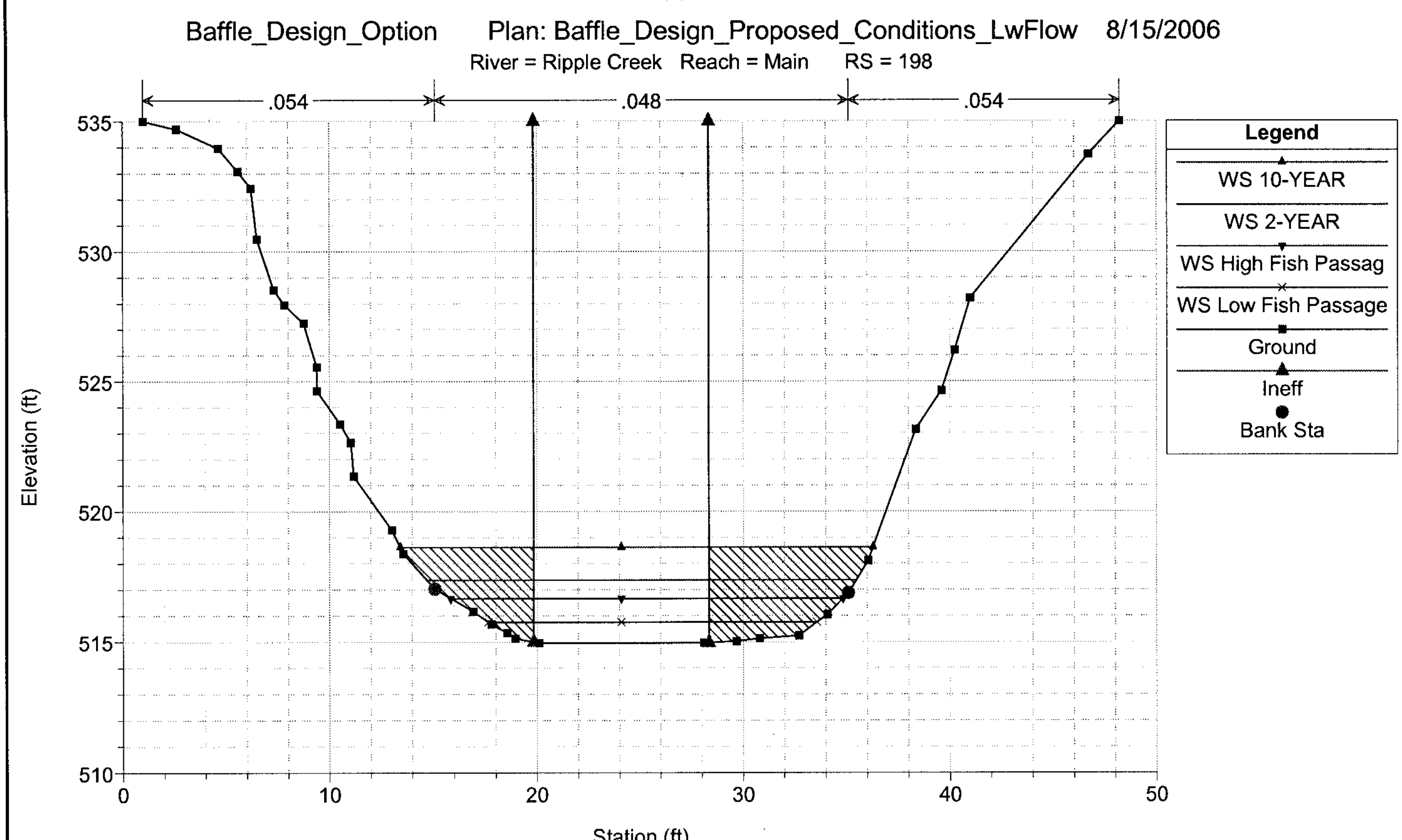
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River = Ripple Creek Reach = Main RS = 198
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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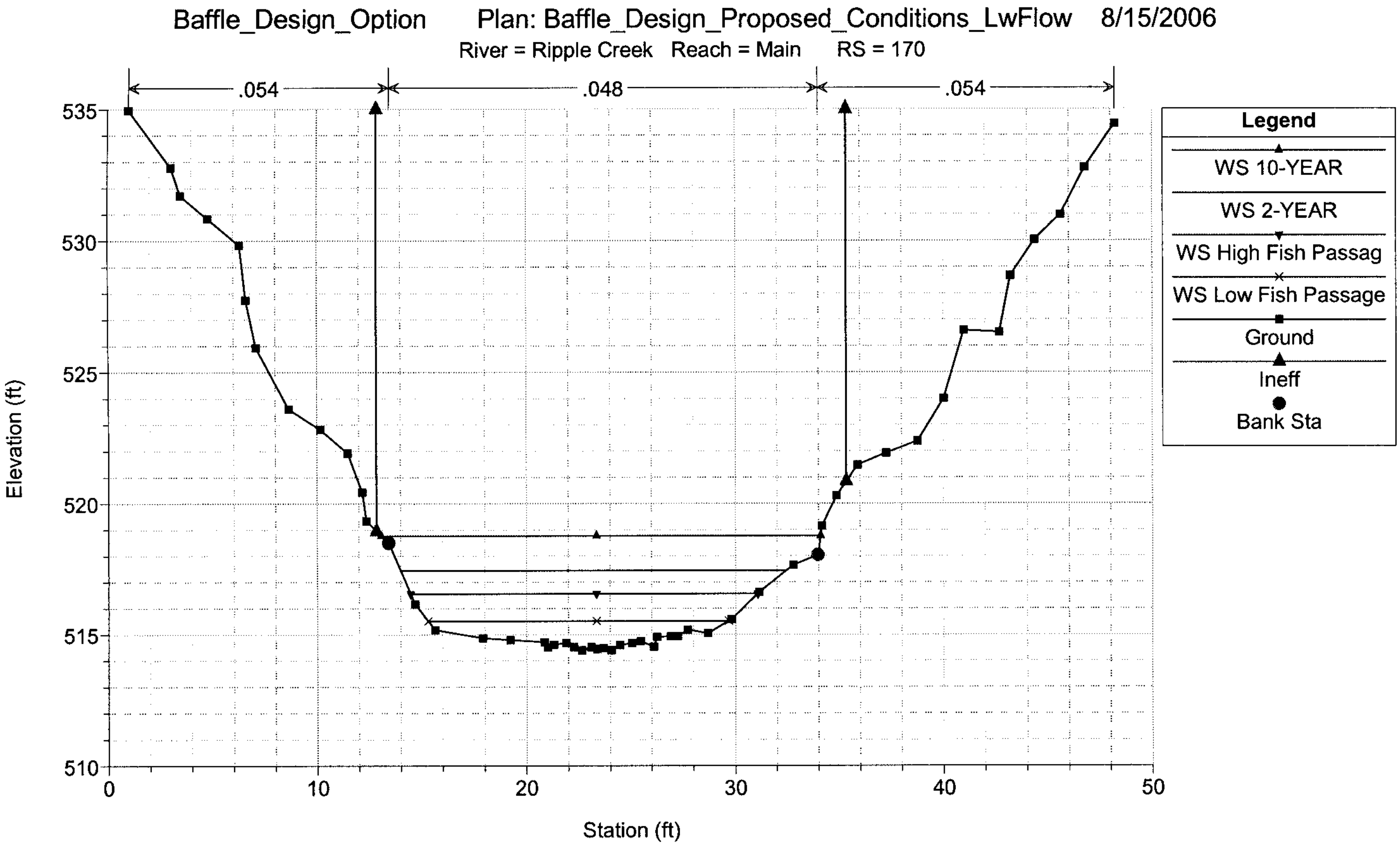
530
525
520
515
510
0
10
20
30
40
50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8/15/2006
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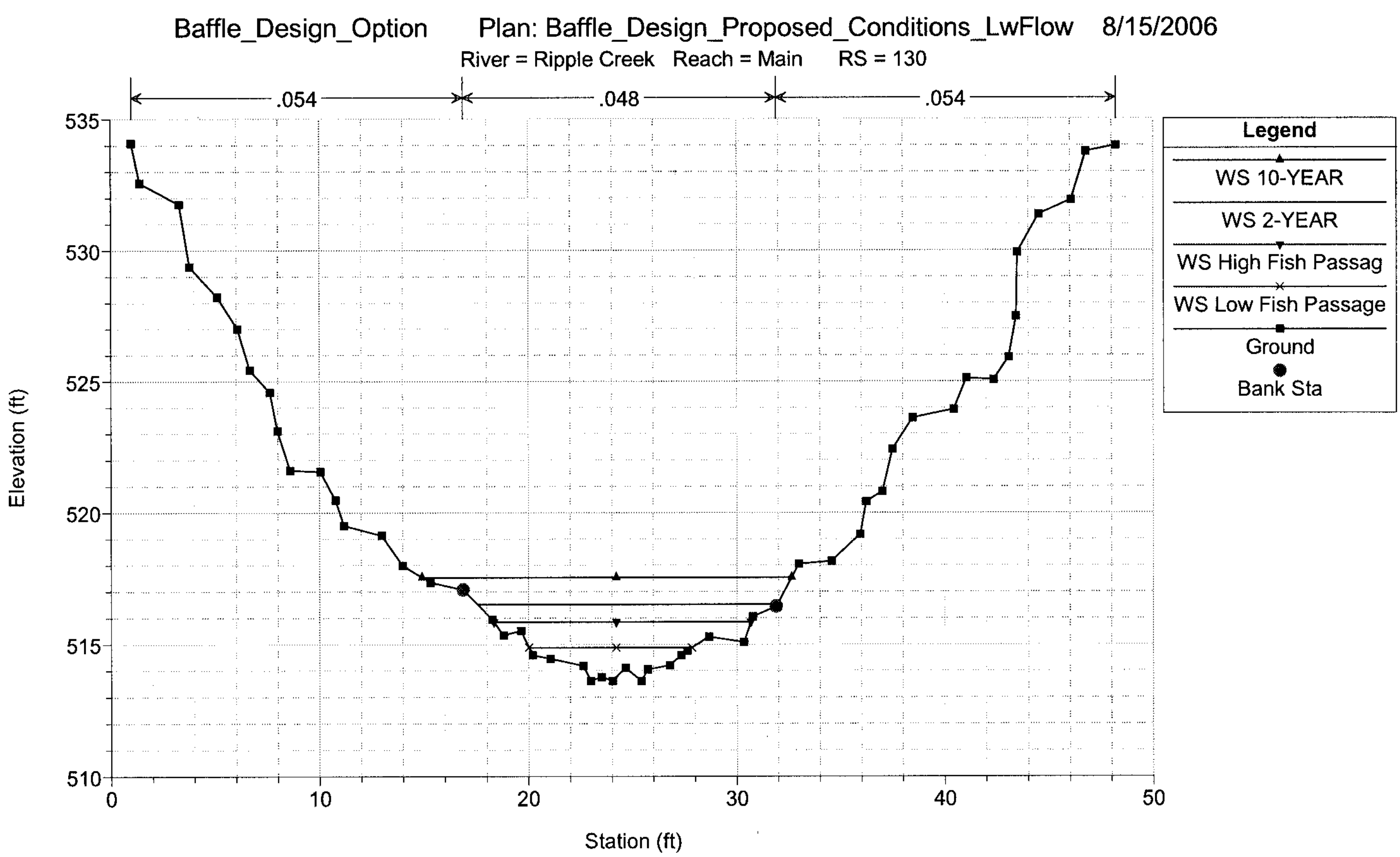
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Ineff
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)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8/15/2006
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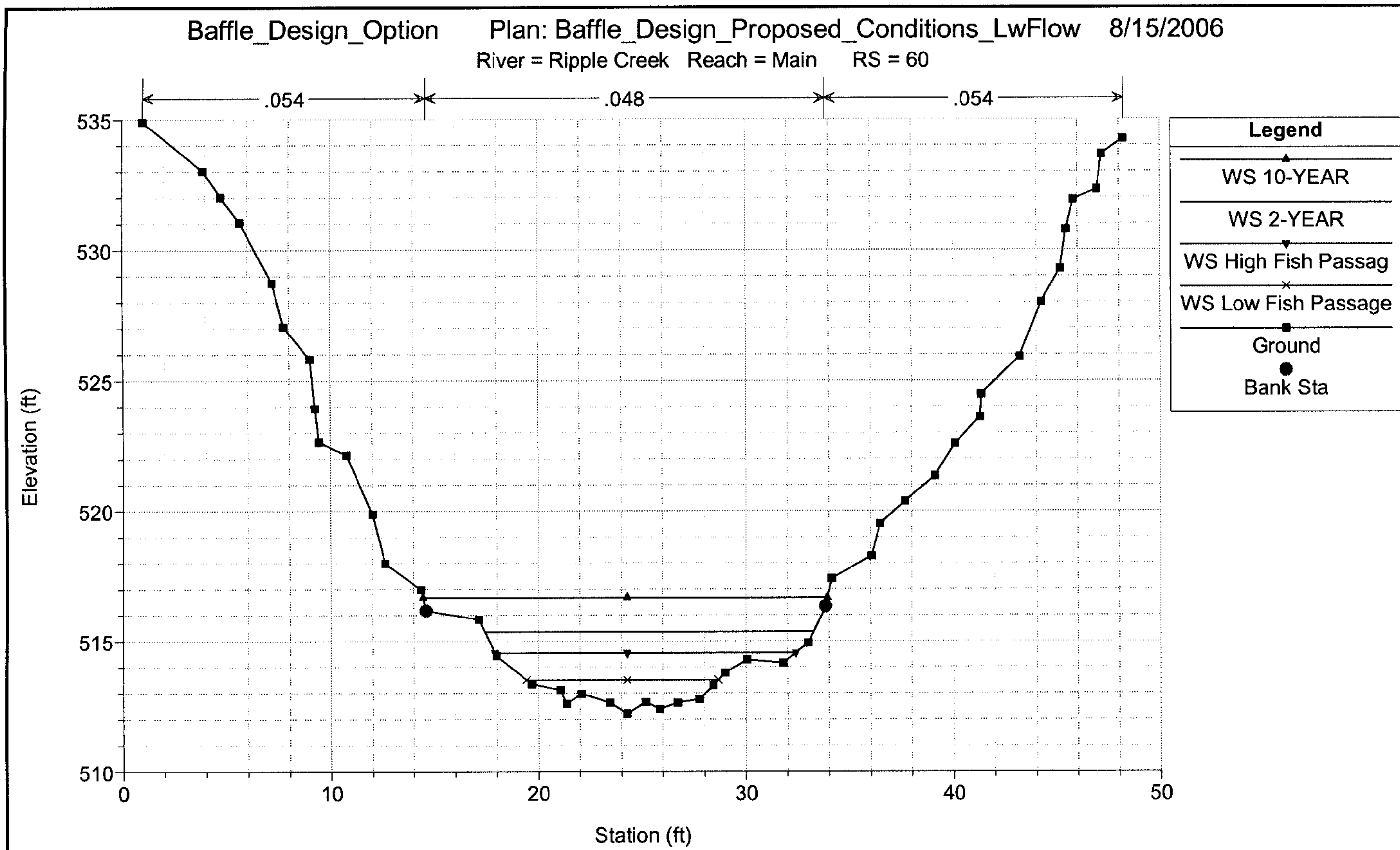
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)



Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_LwFlow 8/15/2006
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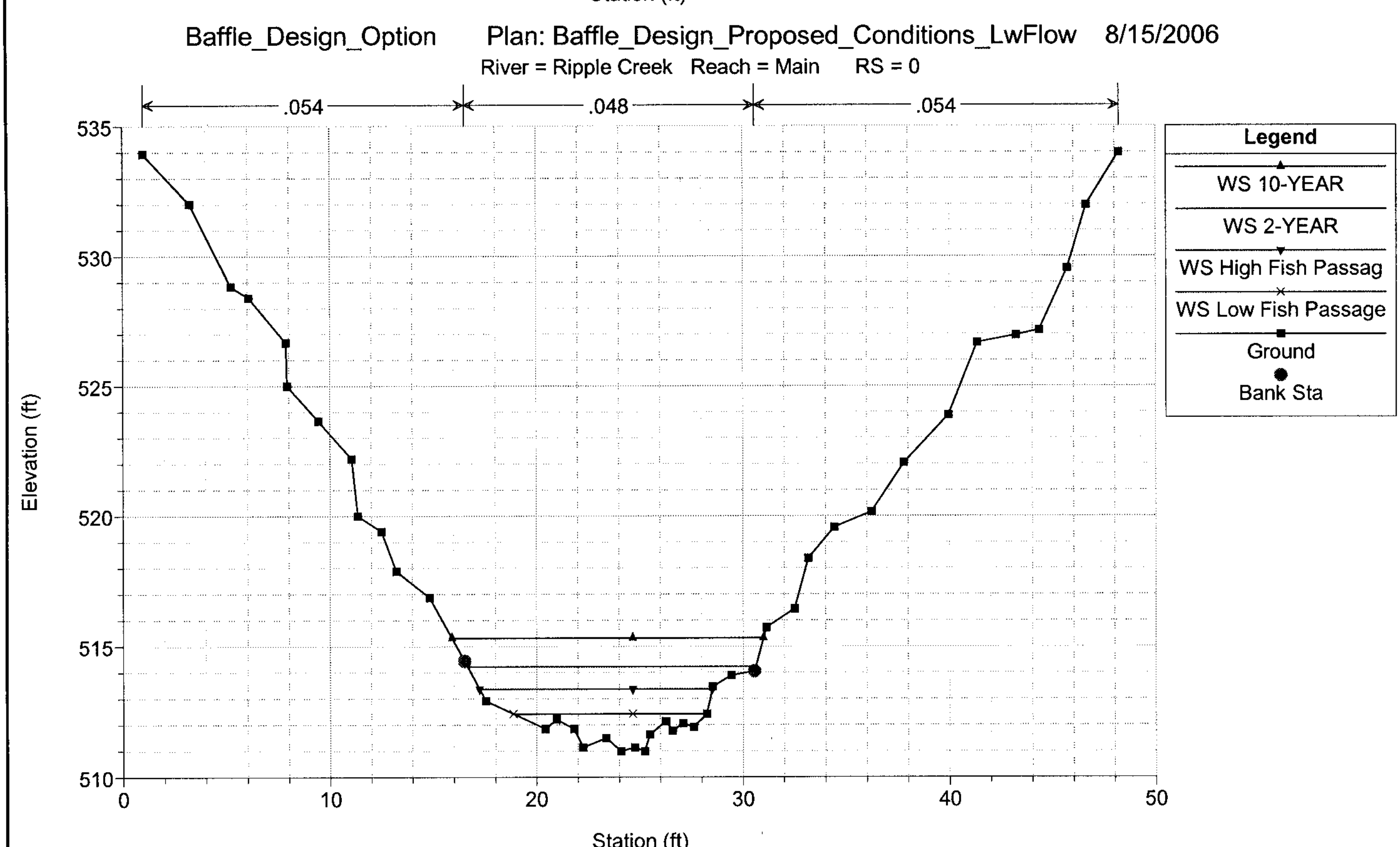
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)



Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_LwFlow 8/15/2006
River = Ripple Creek Reach = Main RS = 0
.054
.048
.054
Legend
WS 10-YEAR
WS 2-YEAR
WS High Fish Passag
WS Low Fish Passage
Ground
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)

Plan: Proposed LwQ Ripple Creek Main RS: 250.7 Inl Struct: Profile: High Fish Passag

E.G. Elev (ft)	520.17	Q Gates (cfs)	
W.S. Elev (ft)	520.08	Q Gate Group (cfs)	
Q Total (cfs)	81.00	Gate Open Ht (ft)	337.29
Q Weir (cfs)	81.00	Gate #Open	337
Weir Flow Area (sq ft)	18.93	Gate Area (sq ft)	
Weir Sta Lft (ft)	20.09	Gate Submerg	
Weir Sta Rgt (ft)	28.11	Gate Invert (ft)	0.00
Weir Max Depth (ft)	4.15		
Weir Avg Depth (ft)	2.36		
Weir Submerg	0.75		
Min El Weir Flow (ft)	516.03		
Wr Top Wdth (ft)	8.01		

Plan: Proposed LwQ Ripple Creek Main RS: 250.7 Inl Struct: Profile: Low Fish Passage

E.G. Elev (ft)	518.67	Q Gates (cfs)	
W.S. Elev (ft)	518.66	Q Gate Group (cfs)	
Q Total (cfs)	20.00	Gate Open Ht (ft)	528.02
Q Weir (cfs)	20.00	Gate #Open	528
Weir Flow Area (sq ft)	6.91	Gate Area (sq ft)	
Weir Sta Lft (ft)	20.10	Gate Submerg	
Weir Sta Rgt (ft)	28.10	Gate Invert (ft)	0.00
Weir Max Depth (ft)	2.65		
Weir Avg Depth (ft)	0.86		
Weir Submerg	0.49		
Min El Weir Flow (ft)	516.03		
Wr Top Wdth (ft)	8.01		

Plan: Proposed LwQ Ripple Creek Main RS: 225.7 Inl Struct: Profile: High Fish Passag

E.G. Elev (ft)	519.67	Q Gates (cfs)	
W.S. Elev (ft)	519.58	Q Gate Group (cfs)	
Q Total (cfs)	81.00	Gate Open Ht (ft)	337.29
Q Weir (cfs)	81.00	Gate #Open	337
Weir Flow Area (sq ft)	18.92	Gate Area (sq ft)	
Weir Sta Lft (ft)	20.09	Gate Submerg	
Weir Sta Rgt (ft)	28.11	Gate Invert (ft)	0.00
Weir Max Depth (ft)	4.15		
Weir Avg Depth (ft)	2.36		
Weir Submerg	0.75		
Min El Weir Flow (ft)	515.53		
Wr Top Wdth (ft)	8.01		

Plan: Proposed LwQ   Ripple Creek   Main RS: 225.7 Inl Struct: Profile: Low Fish Passage

E.G. Elev (ft)	518.17	Q Gates (cfs)	
W.S. Elev (ft)	518.15	Q Gate Group (cfs)	
Q Total (cfs)	20.00	Gate Open Ht (ft)	528.02
Q Weir (cfs)	20.00	Gate #Open	528
Weir Flow Area (sq ft)	6.85	Gate Area (sq ft)	
Weir Sta Lft (ft)	20.10	Gate Submerg	
Weir Sta Rgt (ft)	28.10	Gate Invert (ft)	0.00
Weir Max Depth (ft)	2.64		
Weir Avg Depth (ft)	0.86		
Weir Submerg	0.50		
Min El Weir Flow (ft)	515.53		
Wr Top Wdth (ft)	8.01		

Plan: Proposed LwQ   Ripple Creek   Main RS: 200.7 Inl Struct: Profile: High Fish Passag

E.G. Elev (ft)	519.17	Q Gates (cfs)	
W.S. Elev (ft)	519.08	Q Gate Group (cfs)	
Q Total (cfs)	81.00	Gate Open Ht (ft)	337.29
Q Weir (cfs)	81.00	Gate #Open	337
Weir Flow Area (sq ft)	18.91	Gate Area (sq ft)	
Weir Sta Lft (ft)	20.09	Gate Submerg	
Weir Sta Rgt (ft)	28.11	Gate Invert (ft)	0.00
Weir Max Depth (ft)	4.15		
Weir Avg Depth (ft)	2.36		
Weir Submerg	0.09		
Min El Weir Flow (ft)	515.03		
Wr Top Wdth (ft)	8.01		

Plan: Proposed LwQ   Ripple Creek   Main RS: 200.7 Inl Struct: Profile: Low Fish Passage

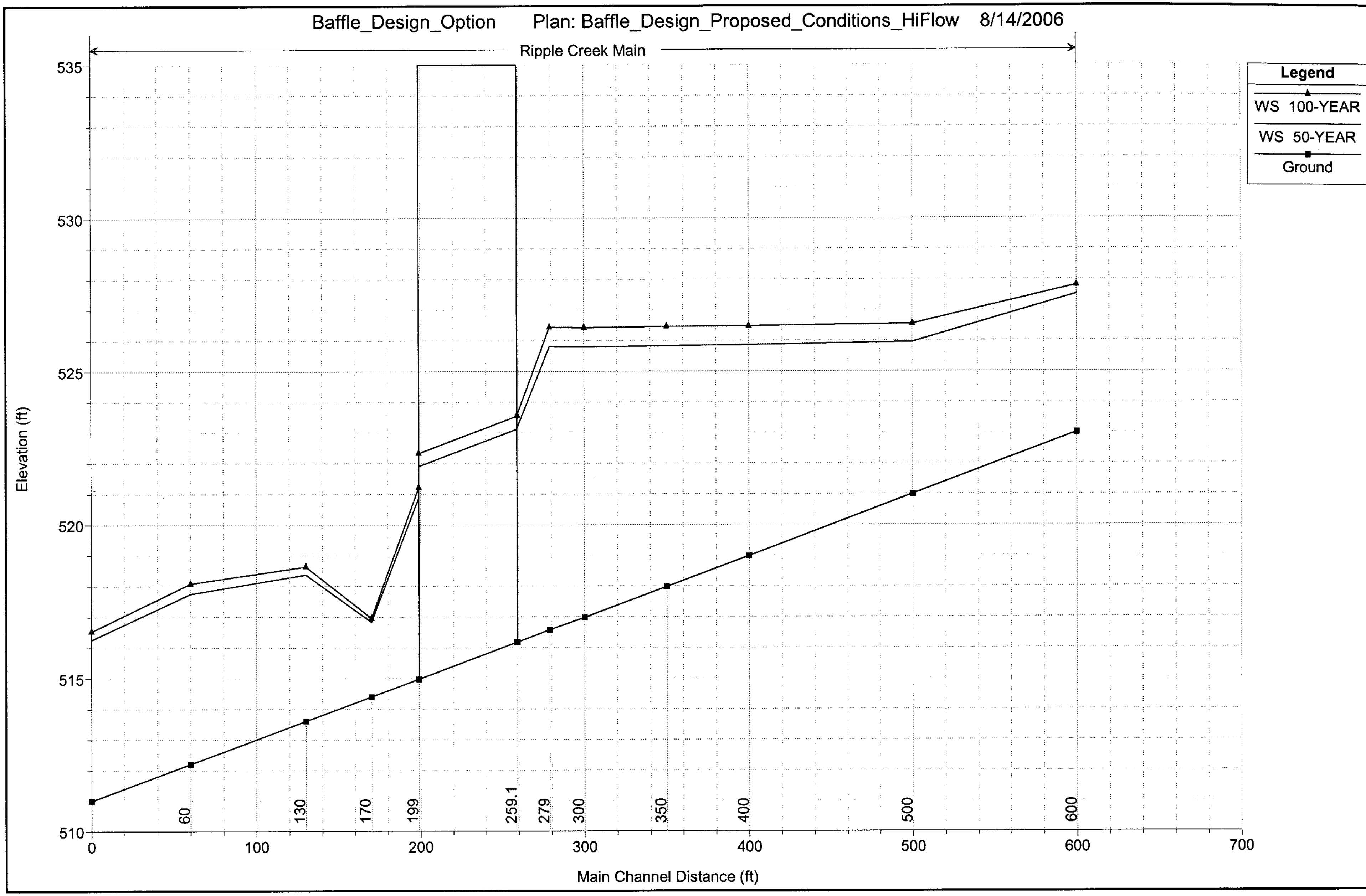
E.G. Elev (ft)	517.67	Q Gates (cfs)	
W.S. Elev (ft)	517.66	Q Gate Group (cfs)	
Q Total (cfs)	20.00	Gate Open Ht (ft)	528.02
Q Weir (cfs)	20.00	Gate #Open	528
Weir Flow Area (sq ft)	6.88	Gate Area (sq ft)	
Weir Sta Lft (ft)	20.10	Gate Submerg	
Weir Sta Rgt (ft)	28.10	Gate Invert (ft)	0.00
Weir Max Depth (ft)	2.65		
Weir Avg Depth (ft)	0.86		
Weir Submerg	0.13		
Min El Weir Flow (ft)	515.03		
Wr Top Wdth (ft)	8.01		

HEC-RAS Plan: Proposed LwQ River: Ripple Creek Reach: Main

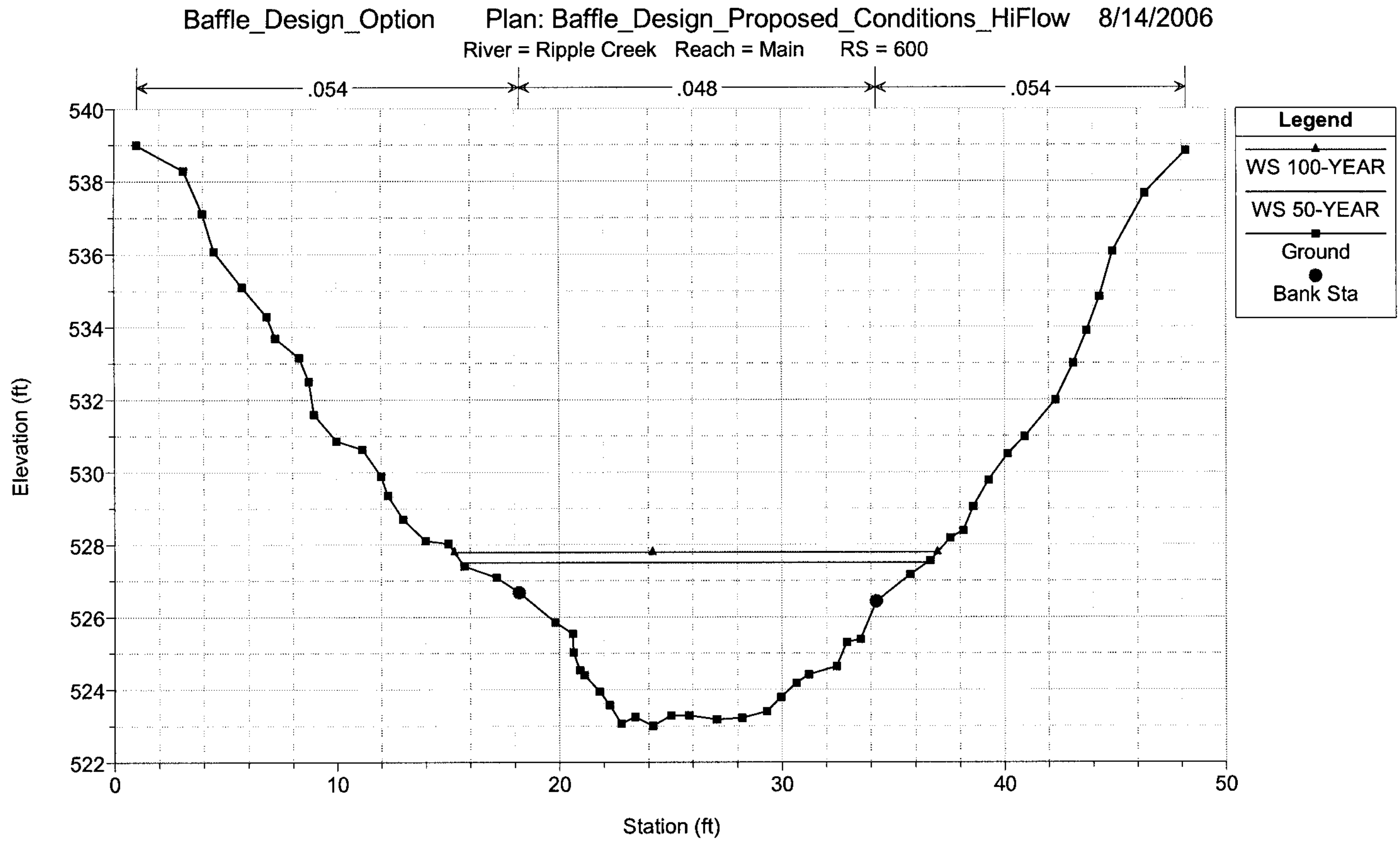
Reach	River Sta	Profile	Q Total	W.S. Elev	Min Ch El	Diff	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)		(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	0	2-YEAR	161.00	514.23	510.99	3.24	513.78	514.77	0.020033	5.89	27.34	13.97	0.74
Main	0	10-YEAR	337.00	515.33	510.99	4.34	514.90	516.29	0.020006	7.86	43.32	15.10	0.79
Main	0	High Fish Passag	81.00	513.38	510.99	2.39	513.04	513.74	0.020013	4.86	16.68	11.28	0.70
Main	0	Low Fish Passage	20.00	512.42	510.99	1.43	512.21	512.56	0.020003	3.05	6.56	9.37	0.64
Main	60	2-YEAR	161.00	515.36	512.20	3.16		515.77	0.013983	5.19	31.03	15.84	0.65
Main	60	10-YEAR	337.00	516.66	512.20	4.46		517.26	0.012596	6.22	54.23	19.47	0.65
Main	60	High Fish Passag	81.00	514.54	512.20	2.34		514.84	0.016443	4.35	18.62	14.50	0.68
Main	60	Low Fish Passage	20.00	513.51	512.20	1.31		513.65	0.016573	2.99	6.70	9.24	0.62
Main	130	2-YEAR	161.00	516.52	513.61	2.91	516.34	517.18	0.027371	6.50	24.77	14.41	0.87
Main	130	10-YEAR	337.00	517.54	513.61	3.93	517.42	518.63	0.025777	8.39	40.90	17.74	0.91
Main	130	High Fish Passag	81.00	515.86	513.61	2.25		516.26	0.024455	5.07	15.96	12.34	0.79
Main	130	Low Fish Passage	20.00	514.87	513.61	1.26		515.07	0.025102	3.55	5.63	7.82	0.74
Main	170	2-YEAR	161.00	517.44	514.40	3.04	516.41	517.68	0.006248	3.86	41.68	18.47	0.45
Main	170	10-YEAR	337.00	518.77	514.40	4.37	517.37	519.15	0.006288	4.94	68.25	21.04	0.48
Main	170	High Fish Passag	81.00	516.57	514.40	2.17	515.83	516.72	0.006143	3.08	26.30	16.63	0.43
Main	170	Low Fish Passage	20.00	515.52	514.40	1.12	515.20	515.58	0.007507	2.01	9.94	14.40	0.43
Main	198	2-YEAR	161.00	517.37	514.96	2.41	517.20	518.33	0.020016	7.87	20.47	20.79	0.89
Main	198	10-YEAR	337.00	518.62	514.96	3.66	518.62	520.44	0.021673	10.83	31.13	22.87	1.00
Main	198	High Fish Passag	81.00	516.66	514.96	1.70	516.38	517.15	0.016131	5.60	14.46	19.00	0.76
Main	198	Low Fish Passage	20.00	515.75	514.96	0.79	515.52	515.89	0.012702	2.98	6.71	15.92	0.59
Main	200.7		Inl Struct										
Main	201.2	2-YEAR	161.00	520.35	515.02	5.33	517.34	520.58	0.000100	3.78	42.68	8.01	0.29
Main	201.2	10-YEAR	337.00	522.50	515.02	7.48	518.82	522.99	0.000142	5.64	59.84	8.02	0.36
Main	201.2	High Fish Passag	81.00	519.08	515.02	4.06	516.49	519.17	0.000063	2.50	32.43	8.01	0.22
Main	201.2	Low Fish Passage	20.00	517.66	515.02	2.64	515.60	517.67	0.000016	0.95	21.08	8.01	0.10
Main	224	2-YEAR	161.00	520.32	515.48	4.84		520.59	0.000137	4.15	38.79	8.01	0.33
Main	224	10-YEAR	337.00	522.45	515.48	6.97		523.01	0.000179	6.05	55.80	8.02	0.40
Main	224	High Fish Passag	81.00	519.06	515.48	3.58		519.18	0.000095	2.83	28.64	8.01	0.26
Main	224	Low Fish Passage	20.00	517.65	515.48	2.17		517.67	0.000031	1.15	17.39	8.01	0.14
Main	225.7		Inl Struct										
Main	226.2	2-YEAR	161.00	520.88	515.52	5.36	517.84	521.10	0.000098	3.76	42.87	8.01	0.29
Main	226.2	10-YEAR	337.00	523.06	515.52	7.54	519.32	523.55	0.000138	5.59	60.37	8.02	0.36
Main	226.2	High Fish Passag	81.00	519.58	515.52	4.06	516.99	519.67	0.000063	2.50	32.45	8.01	0.22
Main	226.2	Low Fish Passage	20.00	518.15	515.52	2.63	516.10	518.17	0.000016	0.95	21.04	8.01	0.10
Main	249	2-YEAR	161.00	520.85	515.98	4.87		521.11	0.000135	4.13	38.98	8.01	0.33
Main	249	10-YEAR	337.00	523.01	515.98	7.03		523.57	0.000174	5.99	56.34	8.02	0.40
Main	249	High Fish Passag	81.00	519.56	515.98	3.58		519.68	0.000095	2.83	28.66	8.01	0.26
Main	249	Low Fish Passage	20.00	518.15	515.98	2.17		518.17	0.000031	1.15	17.36	8.01	0.14
Main	250.7		Inl Struct										
Main	251.2	2-YEAR	161.00	521.38	516.02	5.36	518.34	521.60	0.000099	3.76	42.85	8.01	0.29
Main	251.2	10-YEAR	337.00	523.57	516.02	7.55	519.82	524.05	0.000137	5.58	60.43	8.02	0.36
Main	251.2	High Fish Passag	81.00	520.08	516.02	4.06	517.49	520.17	0.000063	2.50	32.45	8.01	0.22
Main	251.2	Low Fish Passage	20.00	518.66	516.02	2.64	516.60	518.67	0.000016	0.95	21.10	8.01	0.10
Main	259	2-YEAR	161.00	521.37	516.18	5.19		521.60	0.000109	3.88	41.55	8.01	0.30
Main	259	10-YEAR	337.00	523.56	516.18	7.38		524.06	0.000148	5.71	59.09	8.02	0.37
Main	259	High Fish Passag	81.00	520.07	516.18	3.89		520.18	0.000072	2.60	31.18	8.01	0.23
Main	259	Low Fish Passage	20.00	518.66	516.18	2.48		518.68	0.000020	1.01	19.84	8.01	0.11
Main	279	2-YEAR	161.00	521.56	516.58	4.98		521.62	0.000674	1.98	81.31	22.57	0.18
Main	279	10-YEAR	337.00	524.02	516.58	7.44		524.11	0.000525	2.44	140.52	25.51	0.18
Main	279	High Fish Passag	81.00	520.15	516.58	3.57		520.19	0.000623	1.59	51.09	19.43	0.17
Main	279	Low Fish Passage	20.00	518.67	516.58	2.09		518.68	0.000338	0.83	24.21	16.48	0.12
Main	300	2-YEAR	161.00	521.54	516.98	4.56		521.67	0.002493	2.84	56.73	19.87	0.30
Main	300	10-YEAR	337.00	524.00	516.98	7.02		524.14	0.001358	3.03	113.85	26.18	0.24
Main	300	High Fish Passag	81.00	520.13	516.98	3.15		520.23	0.003045	2.54	31.88	15.48	0.31
Main	300	Low Fish Passage	20.00	518.66	516.98	1.68	517.85	518.70	0.002500	1.60	12.52	10.83	0.26
Main	350	2-YEAR	161.00	521.66	517.98	3.68		521.88	0.005667	3.74	43.09	17.87	0.42
Main	350	10-YEAR	337.00	524.05	517.98	6.07		524.25	0.002365	3.55	97.29	25.36	0.30
Main	350	High Fish Passag	81.00	520.30	517.98	2.32		520.52	0.010203	3.75	21.60	14.53	0.54
Main	350	Low Fish Passage	20.00	518.91	517.98	0.93	518.91	519.19	0.045275	4.28	4.67	8.36	1.01

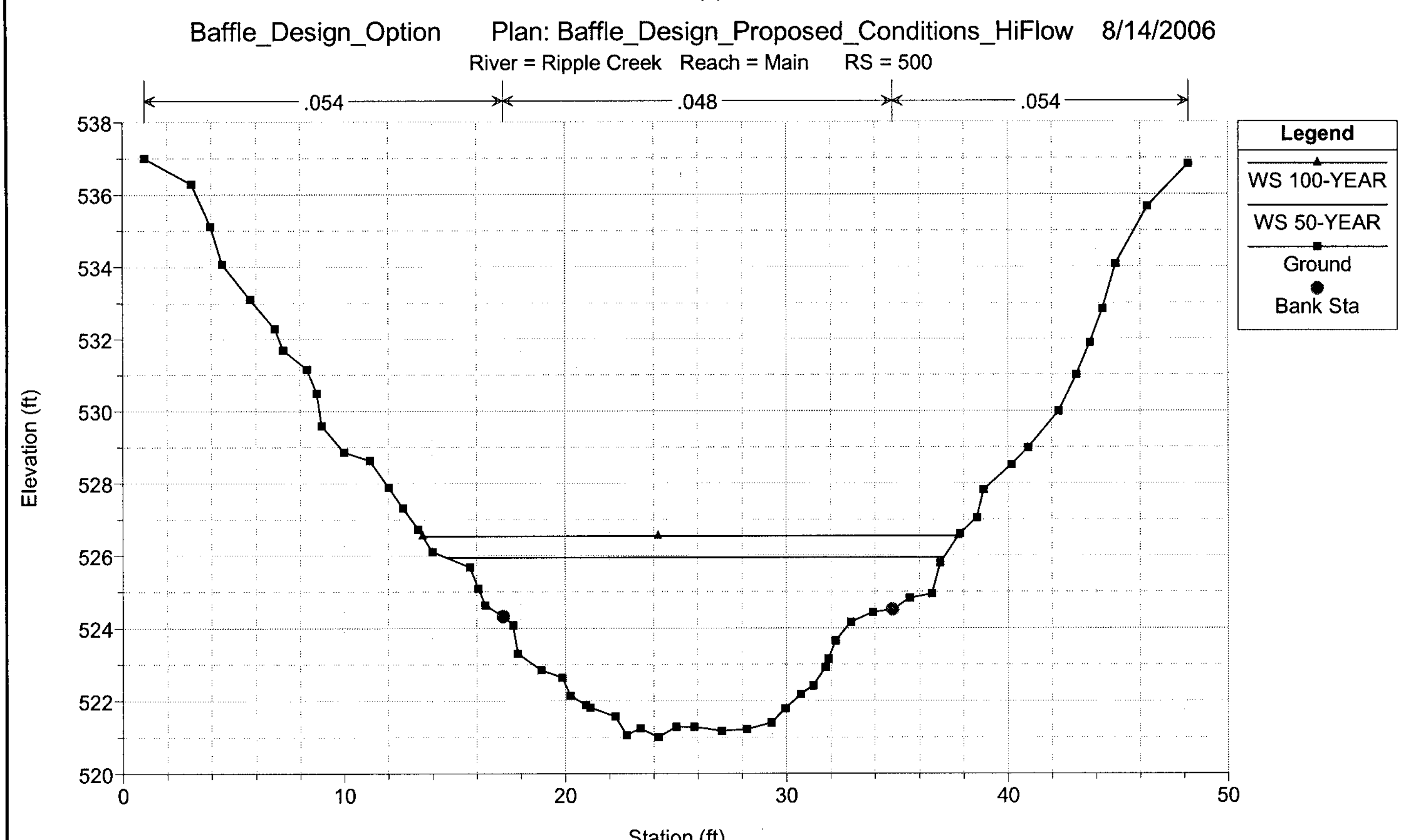
HEC-RAS Plan: Proposed LwQ River: Ripple Creek Reach: Main (Continued)

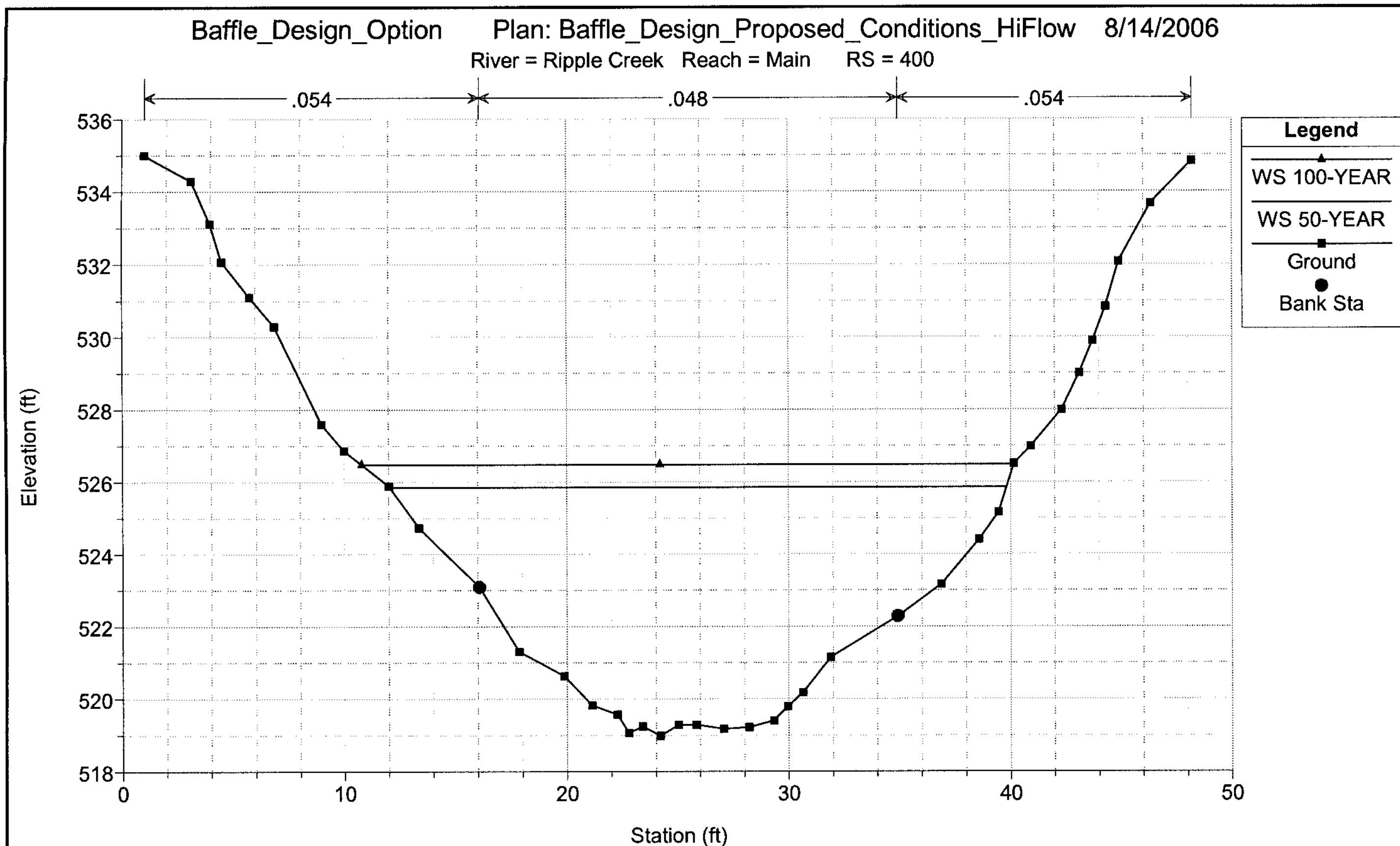
Reach	River Sta	Profile	Q Total	W.S. Elev	Min Ch El	Diff	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)		(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	400	2-YEAR	161.00	521.94	518.98	2.96		522.35	0.013519	5.13	31.41	16.80	0.66
Main	400	10-YEAR	337.00	524.12	518.98	5.14		524.44	0.004354	4.62	75.79	23.80	0.42
Main	400	High Fish Passag	81.00	520.90	518.98	1.92		521.30	0.021778	5.08	15.94	12.48	0.79
Main	400	Low Fish Passage	20.00	520.13	518.98	1.15		520.24	0.011824	2.67	7.48	9.90	0.54
Main	500	2-YEAR	161.00	523.53	521.00	2.53	523.34	524.17	0.023777	6.41	25.10	14.35	0.85
Main	500	10-YEAR	337.00	524.48	521.00	3.48	524.47	525.61	0.030104	8.53	39.55	17.65	0.99
Main	500	High Fish Passag	81.00	522.96	521.00	1.96		523.31	0.018552	4.74	17.09	13.15	0.73
Main	500	Low Fish Passage	20.00	521.91	521.00	0.91	521.85	522.13	0.033253	3.76	5.32	9.26	0.87
Main	600	2-YEAR	161.00	525.78	523.00	2.78	525.43	526.35	0.019958	6.09	26.44	13.80	0.78
Main	600	10-YEAR	337.00	527.04	523.00	4.04	526.56	527.88	0.017319	7.35	46.31	18.19	0.77
Main	600	High Fish Passag	81.00	524.93	523.00	1.93	524.73	525.35	0.022138	5.15	15.72	11.97	0.79
Main	600	Low Fish Passage	20.00	524.10	523.00	1.10	523.84	524.23	0.014520	2.95	6.77	8.91	0.60



Baffle_Design_Option
Plan: Baffle_Design_Proposed_Conditions_HiFlow
8/14/2006
Ripple Creek Main
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Elevation (ft)
535
530
525
520
515
510
60
130
170
199
259.1
279
300
350
400
500
600
0
100
200
300
400
500
600
700
Main Channel Distance (ft)


Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
River = Ripple Creek Reach = Main RS = 600
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
540
538
536
534
532
530
528
526
524
522
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
River = Ripple Creek Reach = Main RS = 500
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
538
536
534
532
530
528
526
524
522
520
0
10
20
30
40
50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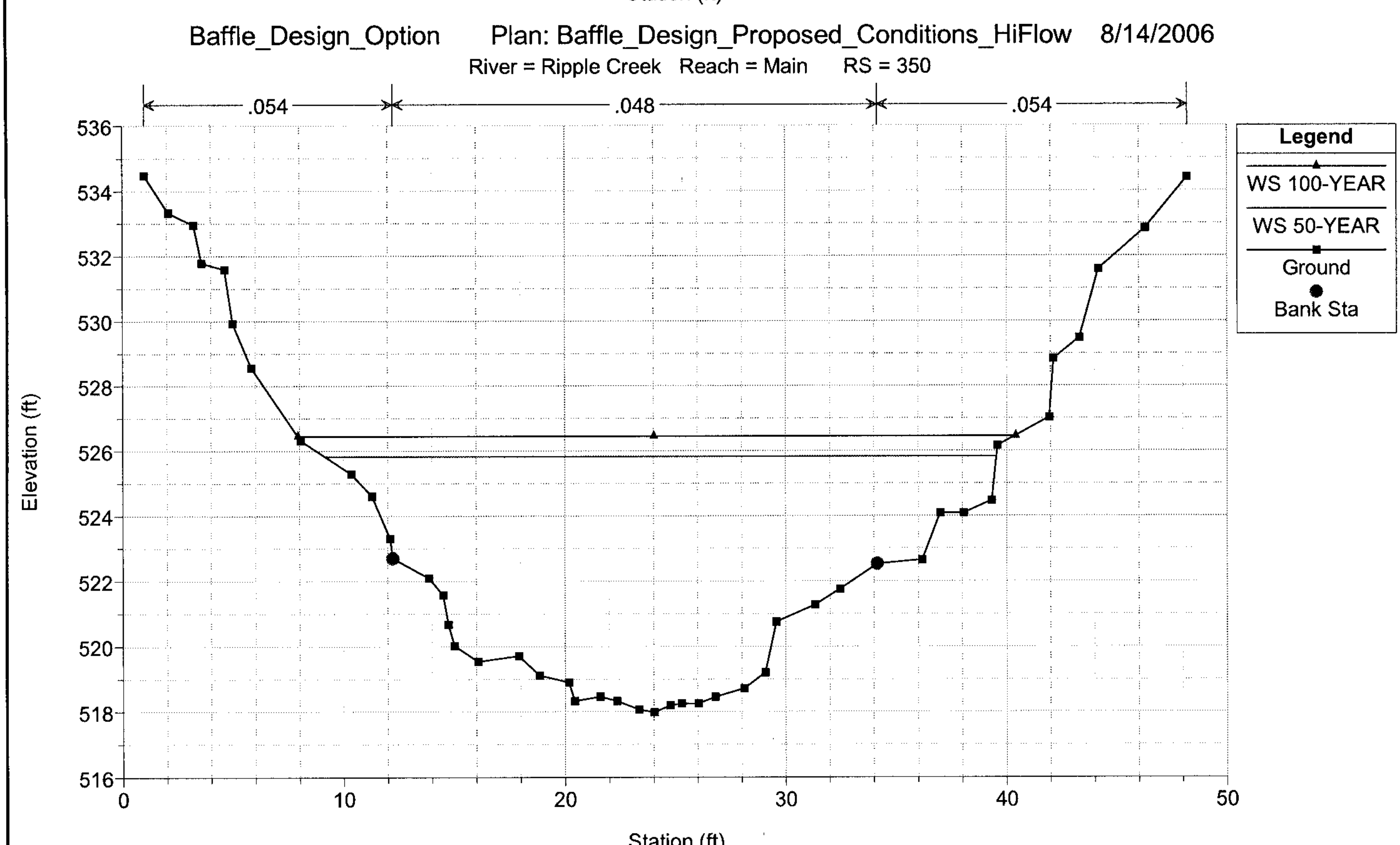
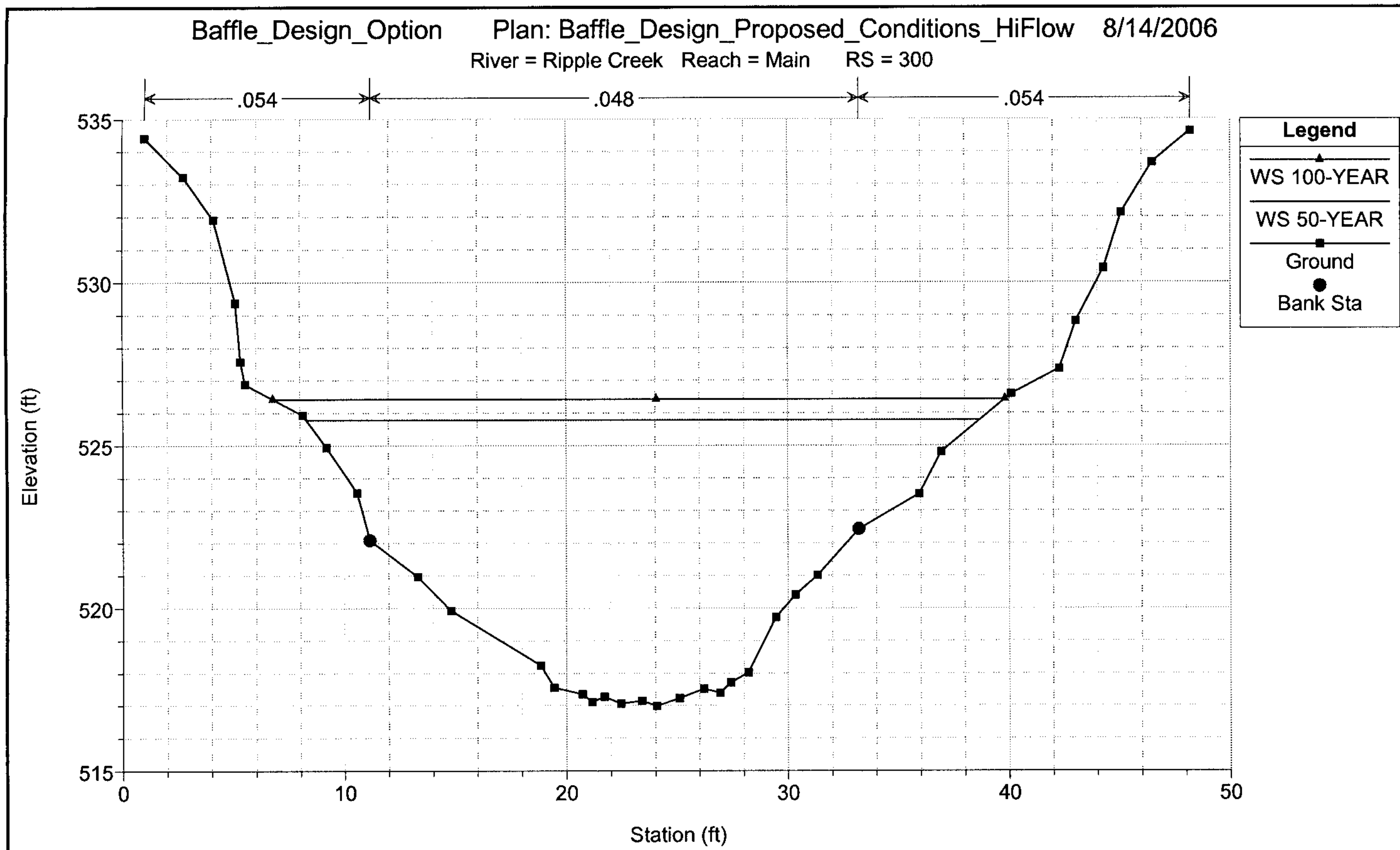
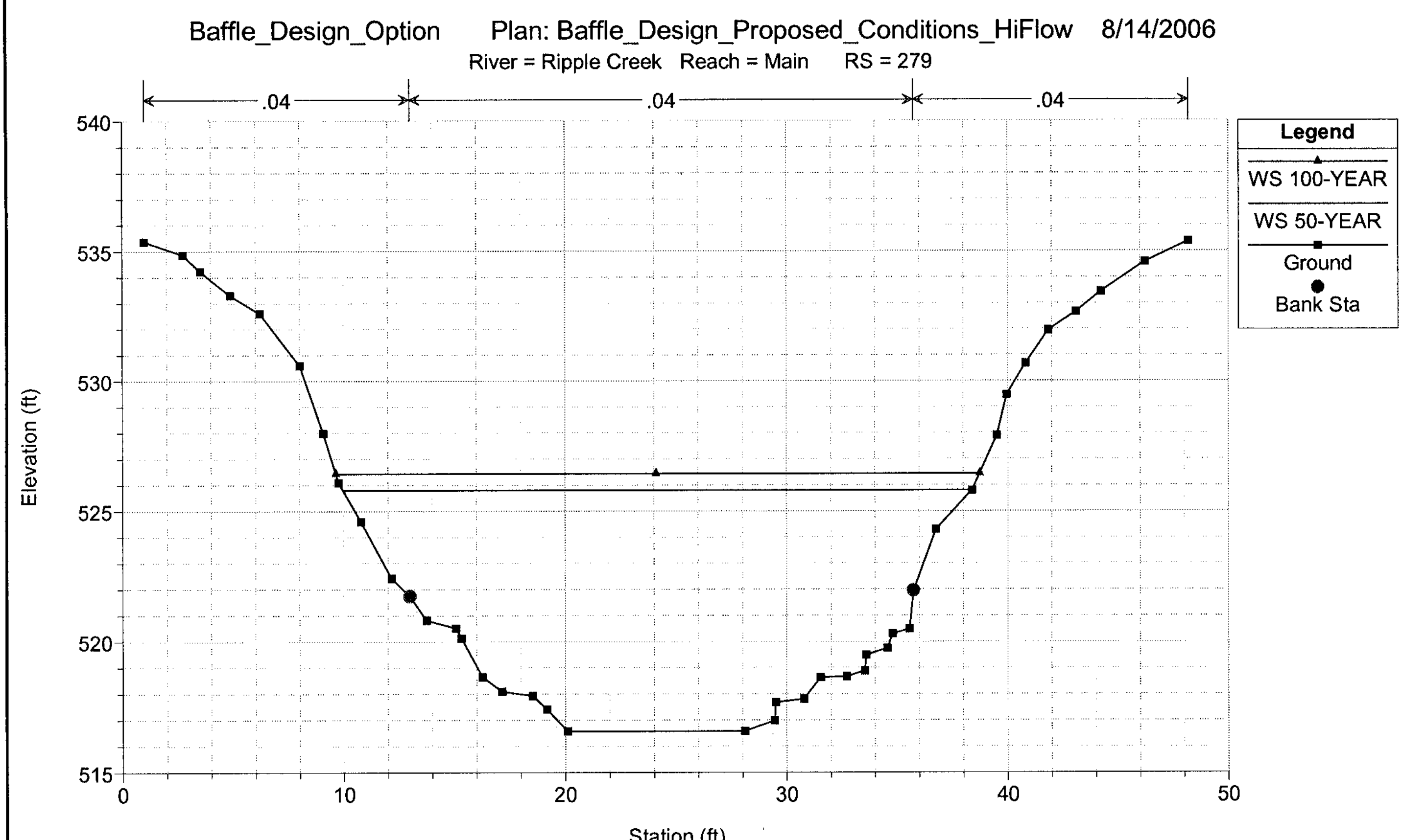
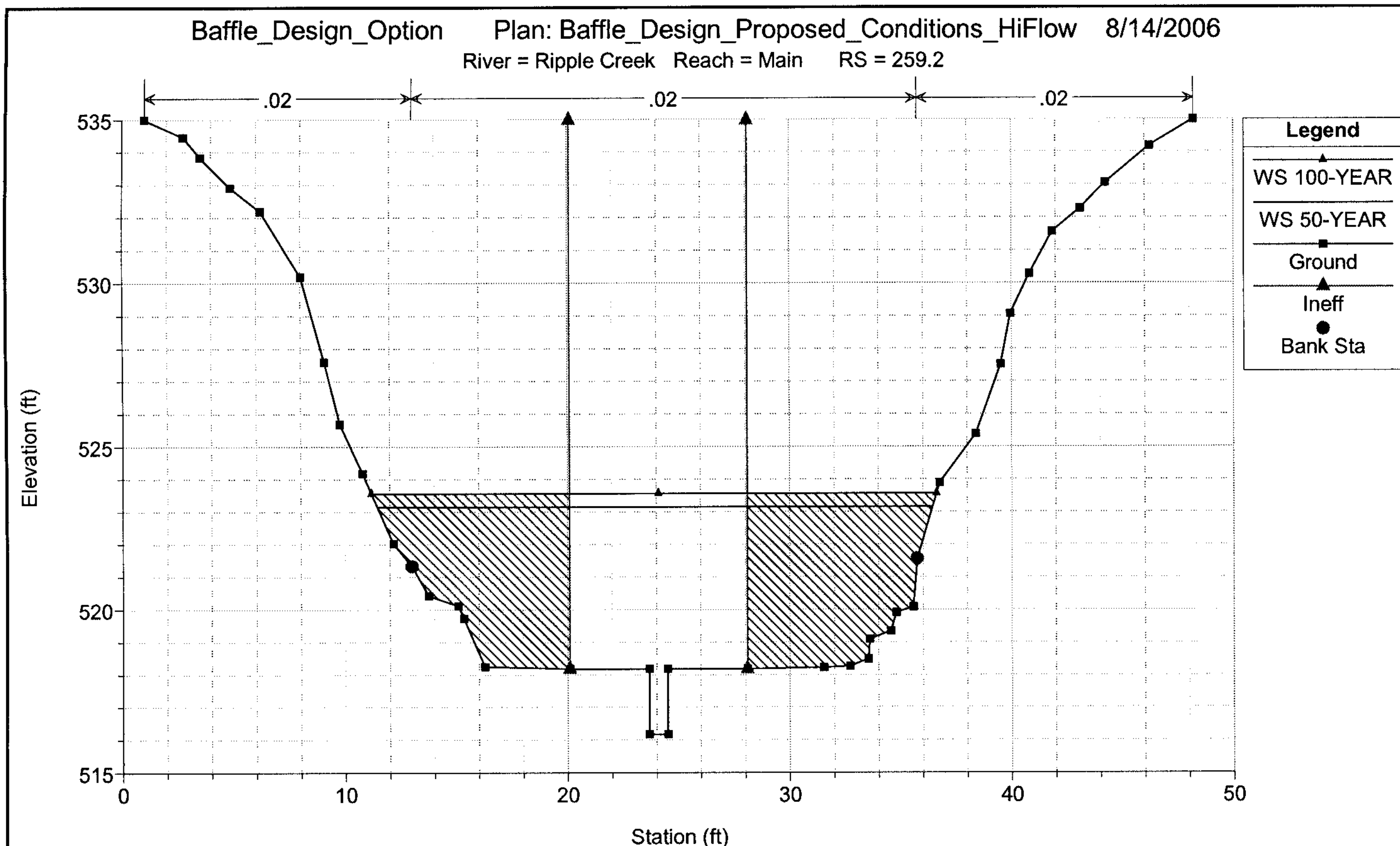
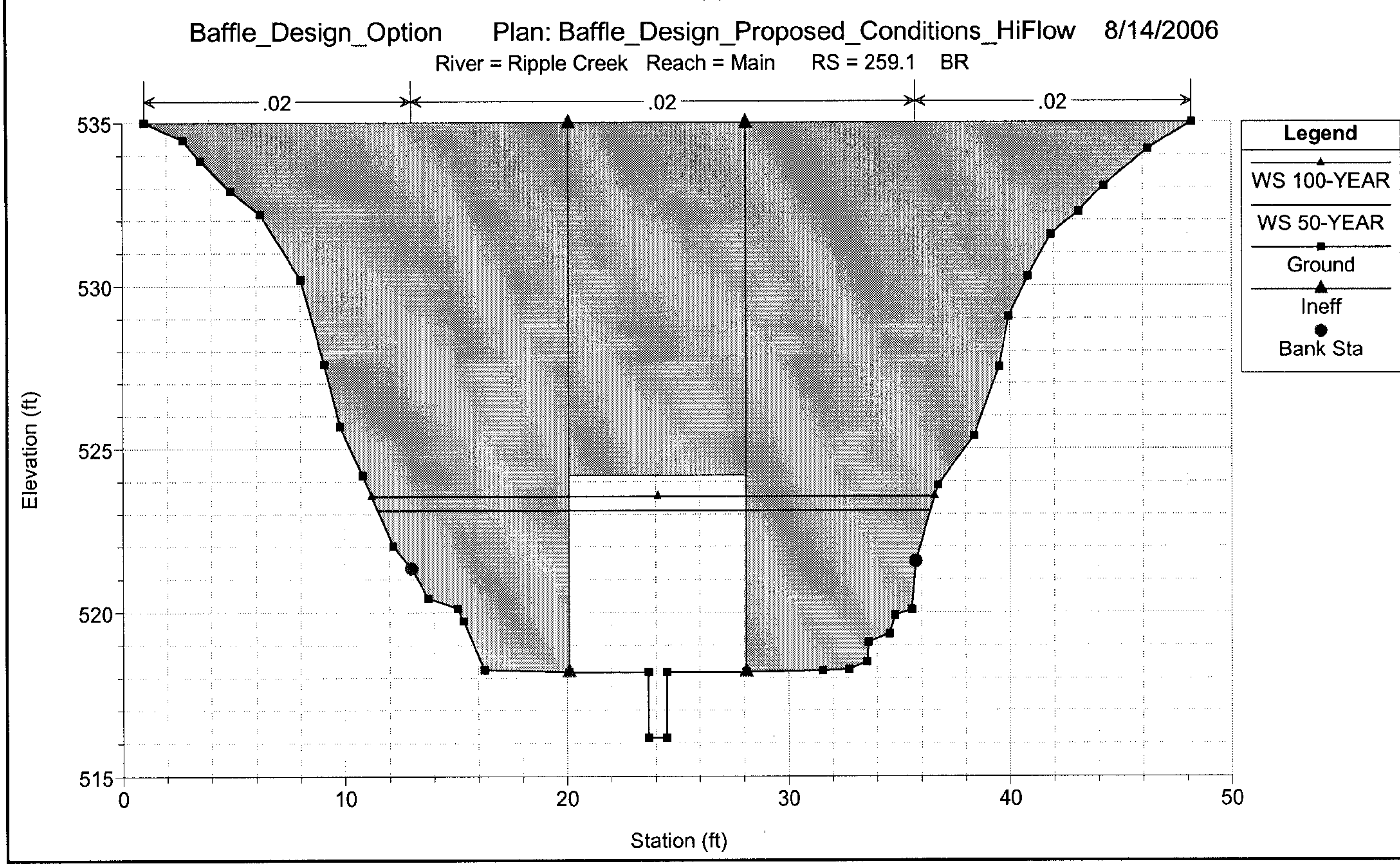
Plan: Baffle_Design_Proposed_Conditions_HiFlow
8/14/2006
River = Ripple Creek
Reach = Main
RS = 400
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
536
534
532
530
528
526
524
522
520
518
0
10
20
30
40
50

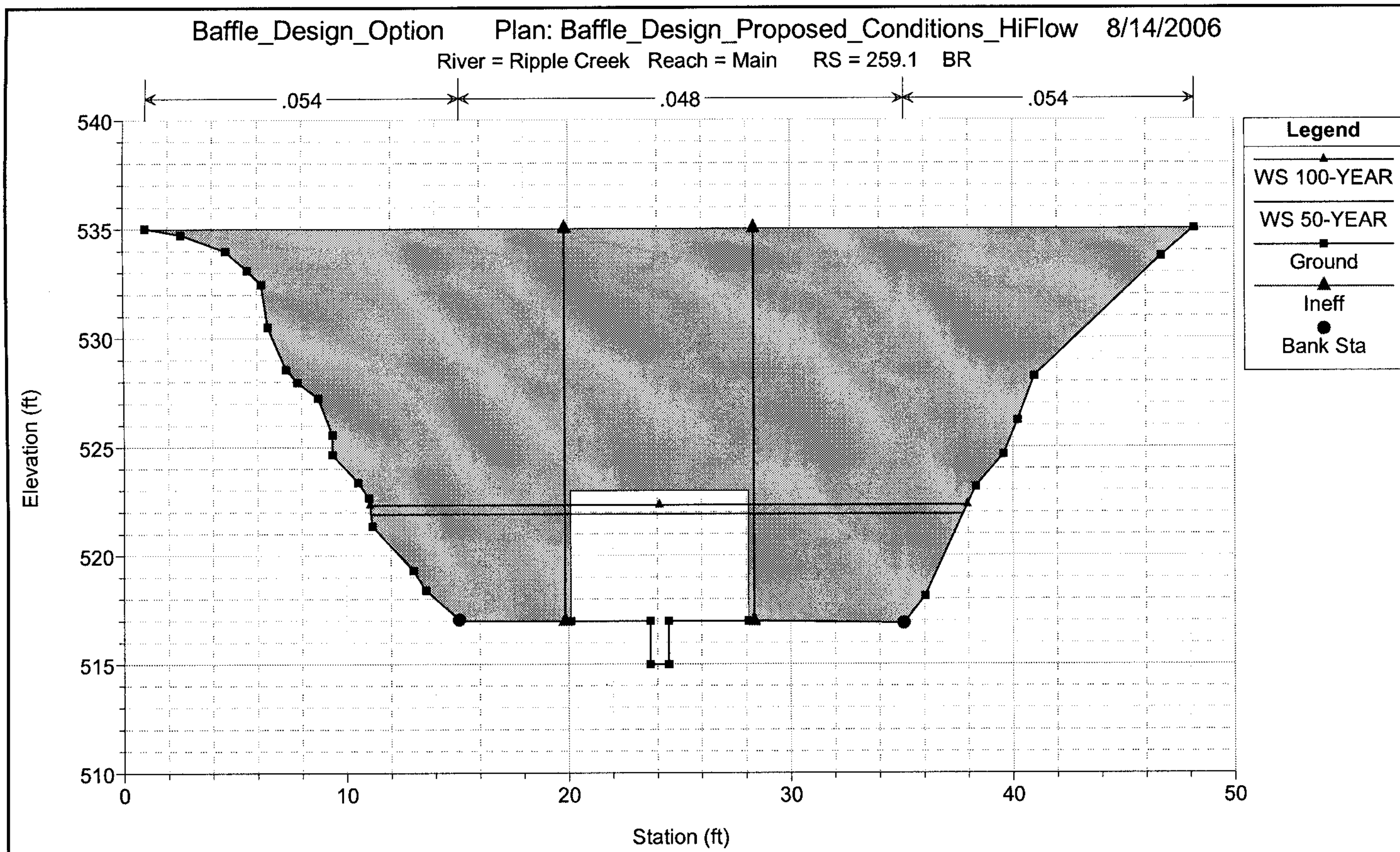

Baffle_Design_Option
Plan: Baffle_Design_Proposed_Conditions_HiFlow
8/14/2006
River = Ripple Creek
Reach = Main
RS = 350
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
536
534
532
530
528
526
524
522
520
518
516
0
10
20
30
40
50

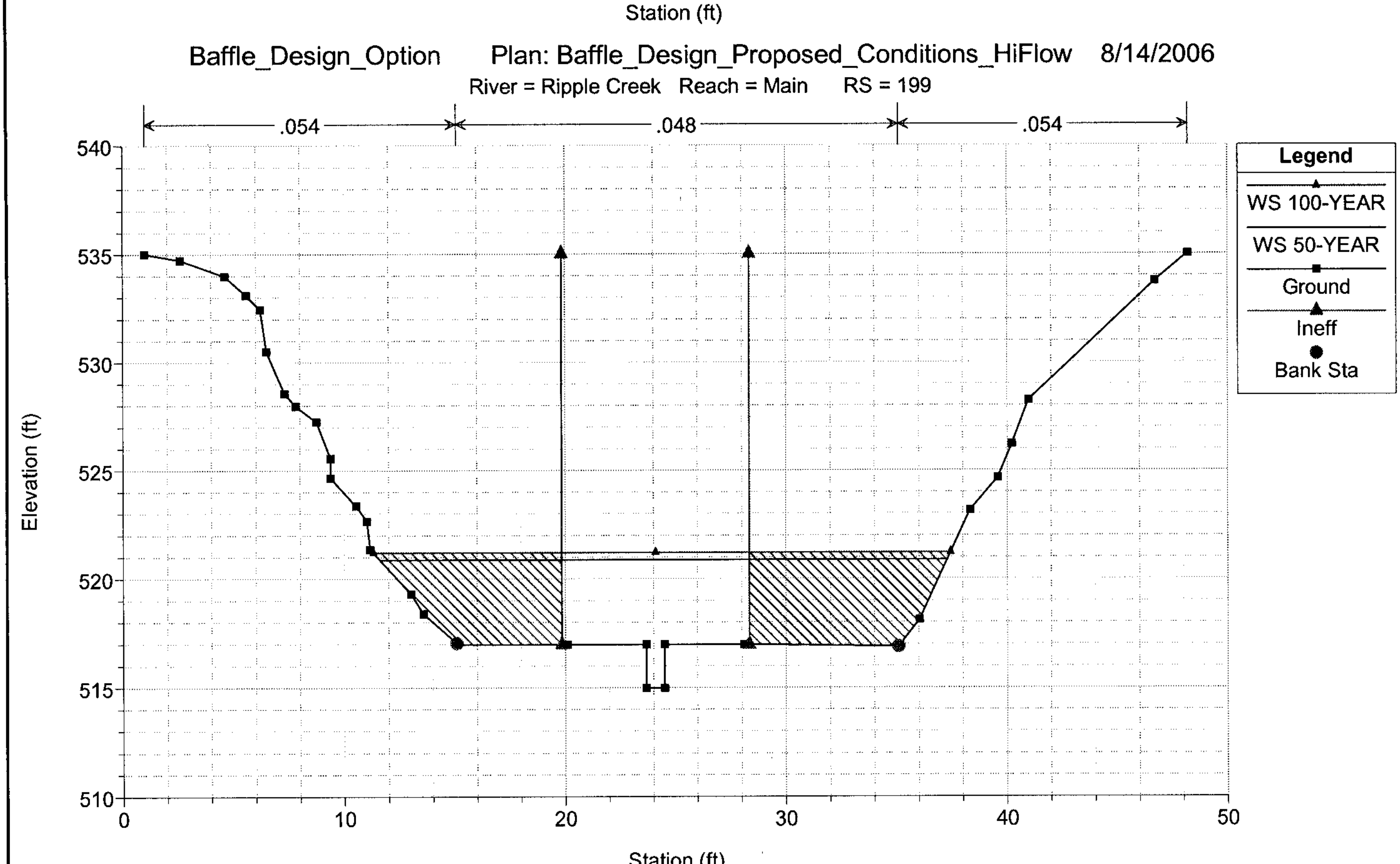

Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
River = Ripple Creek Reach = Main RS = 300
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
520
515
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
River = Ripple Creek Reach = Main RS = 279
.04
.04
.04
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
540
535
530
525
520
515
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
River = Ripple Creek Reach = Main RS = 259.2
.02
.02
.02
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
535
530
525
520
515
Station (ft)
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
River = Ripple Creek Reach = Main RS = 259.1 BR
.02
.02
.02
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
535
530
525
520
515
Station (ft)
0
10
20
30
40
50


Baffle_Design_Option Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
River = Ripple Creek Reach = Main RS = 259.1 BR
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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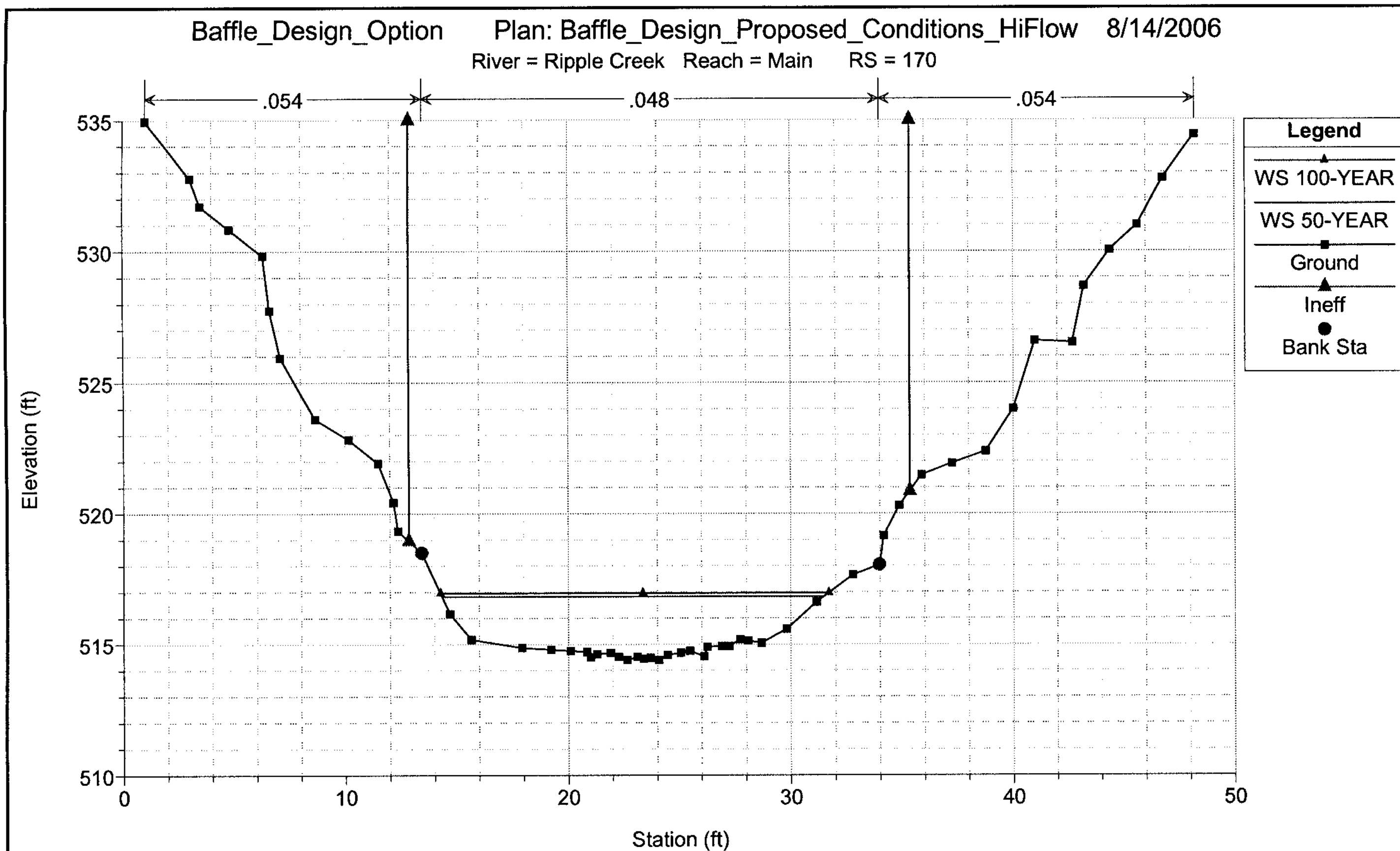
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



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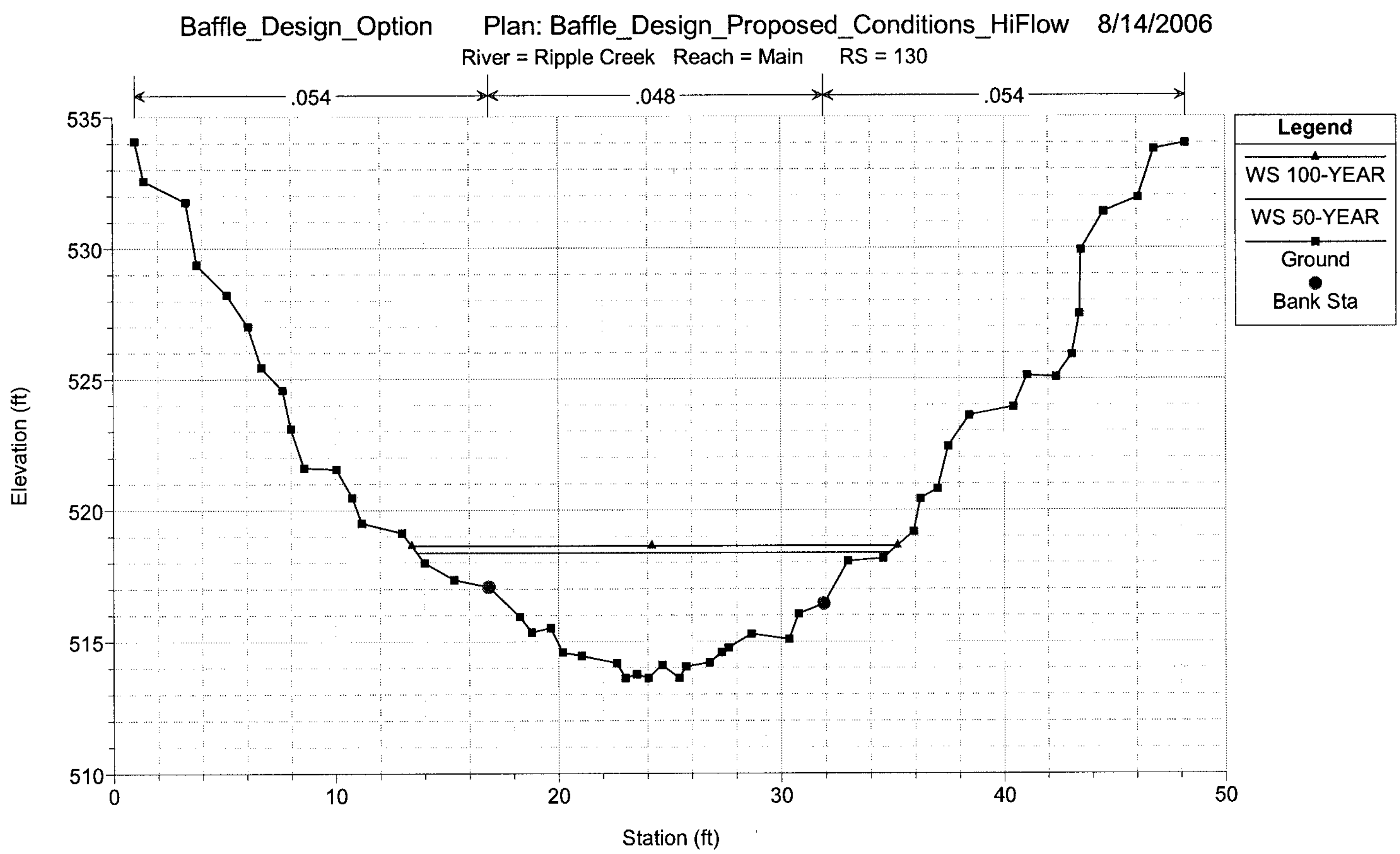
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)



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Plan: Baffle_Design_Proposed_Conditions_HiFlow 8/14/2006
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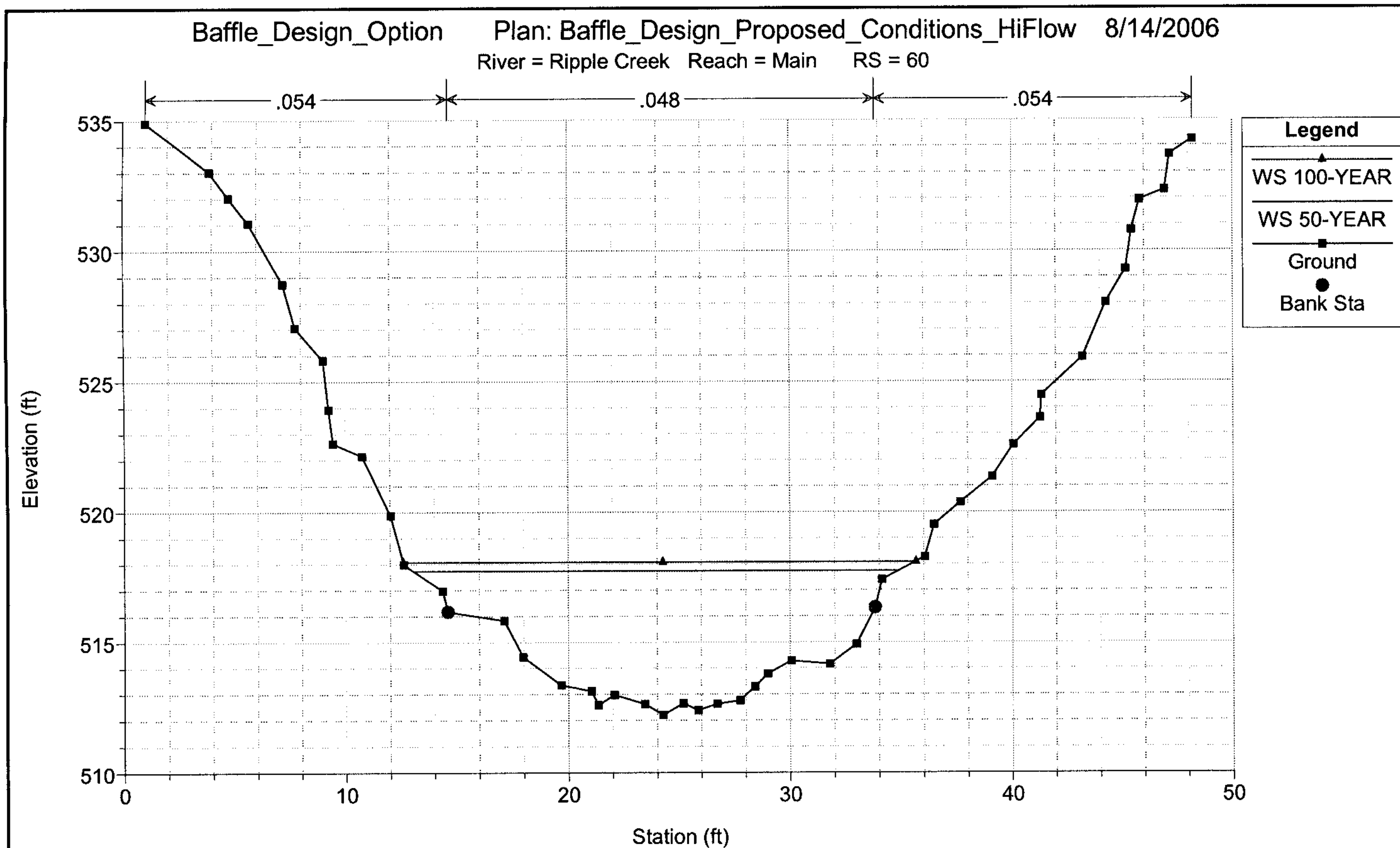
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
535
530
525
520
515
510
0
10
20
30
40
50
Station (ft)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8/14/2006
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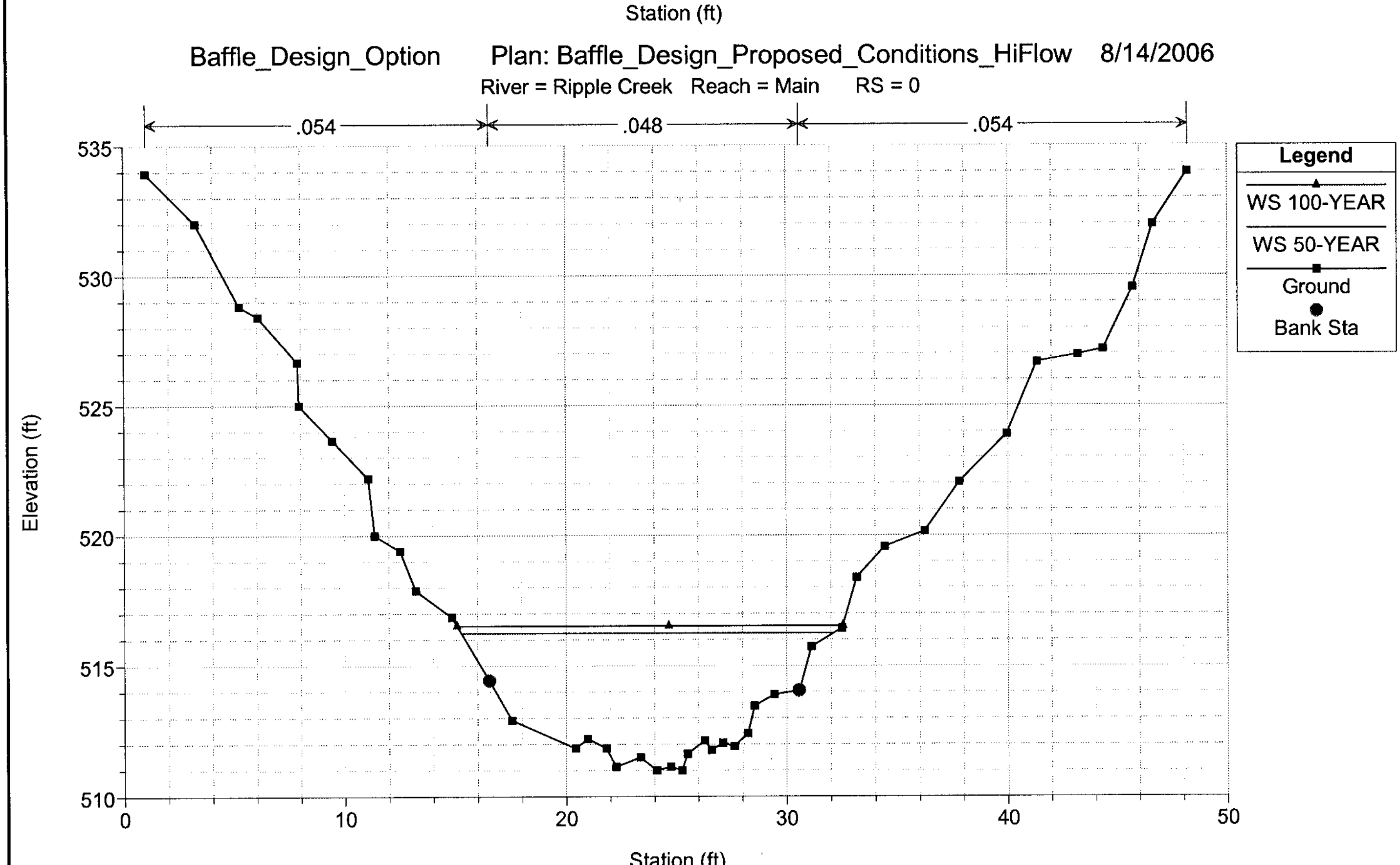
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
520
515
510
0
10
20
30
40
50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Plan: Baffle_Design_Proposed_Conditions_HiFlow
8/14/2006
River = Ripple Creek Reach = Main RS = 0
.054
.048
.054
Legend
WS 100-YEAR
WS 50-YEAR
Ground
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
520
515
510
0
10
20
30
40
50

HEC-RAS Plan: Proposed HiQ River: Ripple Creek Reach: Main

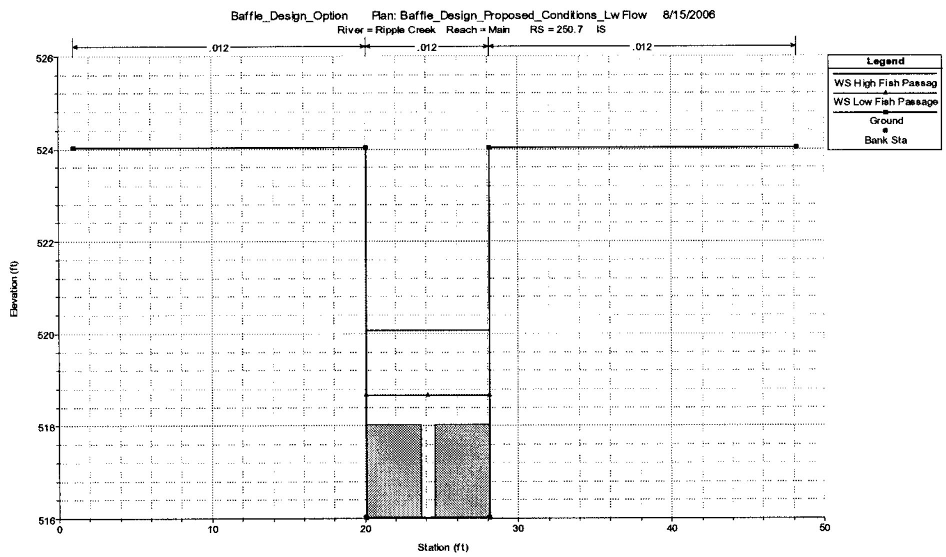
Reach	River Sta	Profile	Q Total	W.S. Elev	Min Ch El	Diff	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)		(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main	0	50-YEAR	528.00	516.25	510.99	5.26	515.82	517.61	0.020037	9.39	57.92	16.90	0.83
Main	0	100-YEAR	593.00	516.53	510.99	5.54	516.13	518.01	0.020027	9.81	62.69	17.47	0.84
Main	60	50-YEAR	528.00	517.75	512.20	5.55	516.70	518.51	0.010381	7.02	76.25	21.87	0.63
Main	60	100-YEAR	593.00	518.08	512.20	5.88	516.94	518.89	0.009872	7.23	83.84	23.07	0.62
Main	130	50-YEAR	528.00	518.37	513.61	4.76	518.37	519.83	0.024512	9.81	56.85	21.19	0.93
Main	130	100-YEAR	593.00	518.63	513.61	5.02	518.63	520.17	0.023750	10.13	62.50	21.78	0.92
Main	170	50-YEAR	528.00	516.83	514.40	2.43	518.18	521.41	0.164079	17.18	30.74	17.17	2.26
Main	170	100-YEAR	593.00	516.96	514.40	2.56	518.42	521.99	0.168783	18.00	32.94	17.44	2.31
Main	199	50-YEAR	528.00	520.88	514.98	5.90	521.69	524.44	0.060925	15.14	34.87	25.71	1.32
Main	199	100-YEAR	593.00	521.21	514.98	6.23	522.12	525.06	0.059482	15.75	37.66	26.15	1.32
Main	259.1		Bridge										
Main	259.2	50-YEAR	528.00	523.15	516.18	6.97	523.11	525.67	0.005636	12.74	41.44	25.00	0.99
Main	259.2	100-YEAR	593.00	523.57	516.18	7.39	523.51	526.29	0.005495	13.25	44.77	25.45	0.99
Main	279	50-YEAR	528.00	525.81	516.58	9.23		525.94	0.000529	2.91	188.61	28.45	0.18
Main	279	100-YEAR	593.00	526.44	516.58	9.86		526.57	0.000509	3.01	206.76	29.10	0.18
Main	300	50-YEAR	528.00	525.79	516.98	8.81		525.97	0.001149	3.42	164.01	30.41	0.23
Main	300	100-YEAR	593.00	526.42	516.98	9.44		526.60	0.001055	3.48	184.00	33.04	0.23
Main	350	50-YEAR	528.00	525.83	517.98	7.85		526.05	0.001710	3.81	148.05	30.40	0.27
Main	350	100-YEAR	593.00	526.46	517.98	8.48		526.68	0.001519	3.84	167.70	32.49	0.26
Main	400	50-YEAR	528.00	525.86	518.98	6.88		526.19	0.002785	4.75	121.13	27.78	0.36
Main	400	100-YEAR	593.00	526.48	518.98	7.50		526.80	0.002393	4.72	138.83	29.36	0.34
Main	500	50-YEAR	528.00	525.95	521.00	4.95	525.30	526.91	0.013553	7.91	69.62	22.52	0.72
Main	500	100-YEAR	593.00	526.54	521.00	5.54	525.55	527.40	0.010187	7.56	83.42	24.19	0.64
Main	600	50-YEAR	528.00	527.50	523.00	4.50	527.50	528.99	0.025353	9.83	55.39	20.90	0.95
Main	600	100-YEAR	593.00	527.79	523.00	4.79	527.79	529.34	0.023816	10.07	61.52	21.70	0.93

Velocity and Depth Hand Calculations Through Baffles

Project Information:				Computed: EKB	Date: 7/18/2006
Fish Passage Improvement Route 555				Checked: JJL	Date: 7/19/2006
Stream Name:	Ripple Creek	County:	Mendocino	Route: 555	Postmile: 20.2

Calculations:

Baffle Structure = 250.7 IS



Broad Crested Weir Q = CLH^1.5

Low Fish Passage Design Flow = 20 cfs

Knowns:

C =	2.73	ft^0.5/sec
Length of weir =	3.583	ft
WSE_LowFlow =	518.66	ft
Top of Weir Elevation =	518.02	ft
Head =	0.64	ft

Q_Baffle = 5.0 cfs
Q_Total_Baffle = 10.02 cfs

Q_Notch = Q_Total - Q_Total_Baffle = 20 cfs - 10 cfs
Q_Notch = 10 cfs

A_Notch = Base*Height = 0.83 ft * 2.64 ft
A_Notch = 2.19 ft^2

V_Notch = Flow / Area = 10 cfs / 2.19 ft^2
V_Notch = 4.56 ft/sec

High Fish Passage Design Flow = 81 cfs

Knowns:

C =	2.73	ft^0.5/sec
Length of weir =	3.583	ft
WSE_HighFlow =	520.08	ft
Top of Weir Elevation =	518.02	ft
Head =	2.06	ft

Q_Baffle = 28.92 cfs
Q_Total_Baffle = 57.84 cfs

Q_Notch = Q_Total - Q_Total_Baffle = 81 cfs - 57.84 cfs
Q_Notch = 23.16 cfs

A_Notch = Base*Height = 0.83 ft * 4.06 ft
A_Notch = 3.37 ft^2

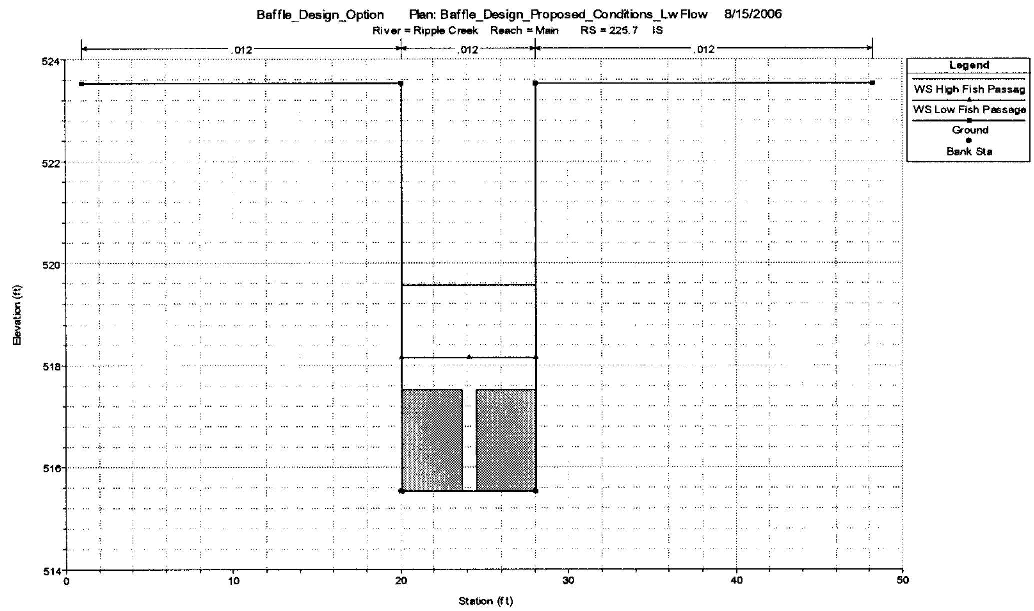
V_Notch = Flow / Area = 23.16 cfs / 3.37 ft^2
V_Notch = 6.87 ft/sec

Velocity and Depth Hand Calculations Through Baffles

Project Information:		Computed: EKB		Date: 7/18/2006	
Fish Passage Improvement Route 555		Checked: JJL		Date: 7/19/2006	
Stream Name: Ripple Creek	County: Mendocino	Route: 555		Postmile: 20.2	

Calculations:

Baffle Structure = 225.7 IS



Broad Crested Weir Q = CLH^1.5

Low Fish Passage Design Flow = 20 cfs

Knowns:

C =	2.73	ft^0.5/sec
Length of weir =	3.583	ft
WSE_LowFlow =	518.15	ft
Top of Weir Elevation =	517.52	ft
Head =	0.63	ft

Q_Baffle = 4.9 cfs
Q_Total_Baffle = 9.78 cfs

Q_Notch = Q_Total - Q_Total_Baffle = 20 cfs - 9.78 cfs
Q_Notch = 10 cfs

A_Notch = Base*Height = 0.83 ft * 2.63 ft
A_Notch = 2.18 ft^2

V_Notch = Flow / Area = 10.22 cfs / 2.18 ft^2
V_Notch = 4.68 ft/sec

High Fish Passage Design Flow = 81 cfs

Knowns:

C =	2.73	ft^0.5/sec
Length of weir =	3.583	ft
WSE_HighFlow =	519.58	ft
Top of Weir Elevation =	517.52	ft
Head =	2.06	ft

Q_Baffle = 28.92 cfs
Q_Total_Baffle = 57.84 cfs

Q_Notch = Q_Total - Q_Total_Baffle = 81 cfs - 57.83 cfs
Q_Notch = 23.17 cfs

A_Notch = Base*Height = 0.83 ft * 4.06 ft
A_Notch = 3.37 ft^2

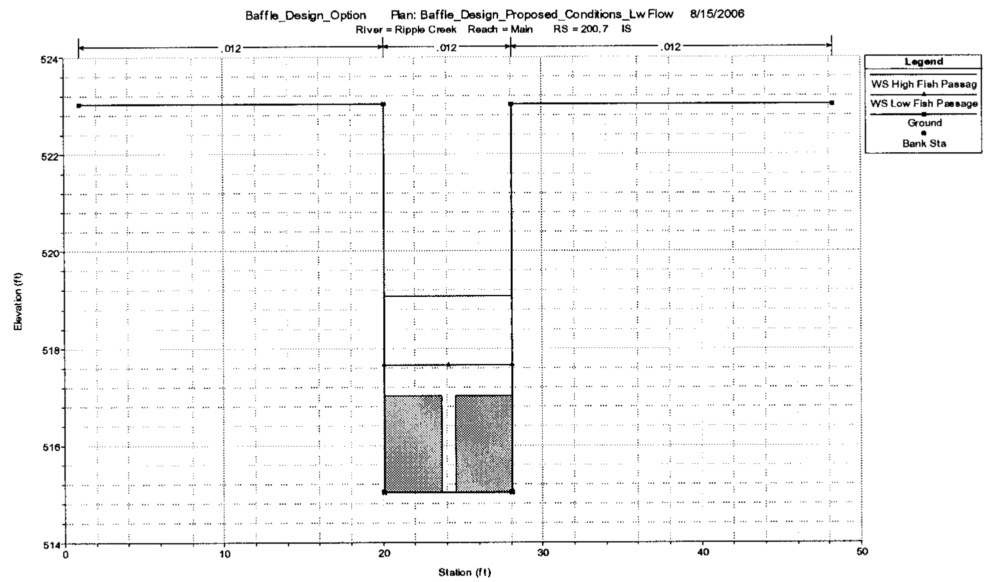
V_Notch = Flow / Area = 23.17 cfs / 3.37 ft^2
V_Notch = 6.88 ft/sec

Velocity and Depth Hand Calculations Through Baffles

Project Information:				Computed: EKB	Date: 7/18/2006
Fish Passage Improvement Route 555				Checked: JJL	Date: 7/19/2006
Stream Name:	Ripple Creek	County:	Mendocino	Route: 555	Postmile: 20.2

Calculations:

Baffle Structure = 200.7 IS



Broad Crested Weir Q = CLH^1.5

Low Fish Passage Design Flow = 20 cfs

Knowns:

C =	2.73	ft^0.5/sec
Length of weir =	3.583	ft
WSE_LowFlow =	517.66	ft
Top of Weir Elevation =	517.02	ft
Head =	0.64	ft

Q_Baffle = 5.0 cfs
Q_Total_Baffle = 10.02 cfs

Q_Notch = Q_Total - Q_Total_Baffle = 20 cfs - 10.02 cfs
Q_Notch = 9.98 cfs

A_Notch = Base*Height = 0.83 ft * 2.64 ft
A_Notch = 2.19 ft^2

V_Notch = Flow / Area = 9.98 cfs / 2.19 ft^2
V_Notch = 4.55 ft/sec

High Fish Passage Design Flow = 81 cfs

Knowns:

C =	2.73	ft^0.5/sec
Length of weir =	3.583	ft
WSE_HighFlow =	519.08	ft
Top of Weir Elevation =	517.02	ft
Head =	2.06	ft

Q_Baffle = 28.92 cfs
Q_Total_Baffle = 57.84 cfs

Q_Notch = Q_Total - Q_Total_Baffle = 81 cfs - 57.84 cfs
Q_Notch = 23.17 cfs

A_Notch = Base*Height = 0.83 ft * 4.06 ft
A_Notch = 3.37 ft^2

V_Notch = Flow / Area = 23.17 cfs / 3.37 ft^2
V_Notch = 6.88 ft/sec

Summary Statement

The initial goals of this retrofit culvert design project included providing fish passage through the 60-foot long culvert for the adult Coho salmon while adding some rock slope protection at the culvert inlet. Retrofitting the culvert with three two feet tall baffles allowed the velocities to decrease and depths increase. Resting pools two feet in depth were also created for the Coho salmon.

Specifically for fish passage, criteria for the Hydraulic Baffle Design Option were successfully met by following the process laid out within the forms. An overview of the steps include researching existing data and available information, collecting all required parameters at the site, selecting the best fish passage design option for the site, completing the hydrology and efficiently brainstorming and completing the hydraulic modeling, and finally meeting requirements of the Hydraulic Baffle Design Option.

Culvert velocities and depths calculated from Fish Xing and HEC-RAS are summarized in Table 1 and 2 below. Existing conditions modeled in both software programs identified problematic velocities and lack of depth in the culvert. The results of the proposed conditions concluded that installing hydraulic baffles through the culvert significantly improved the fish passage conditions.

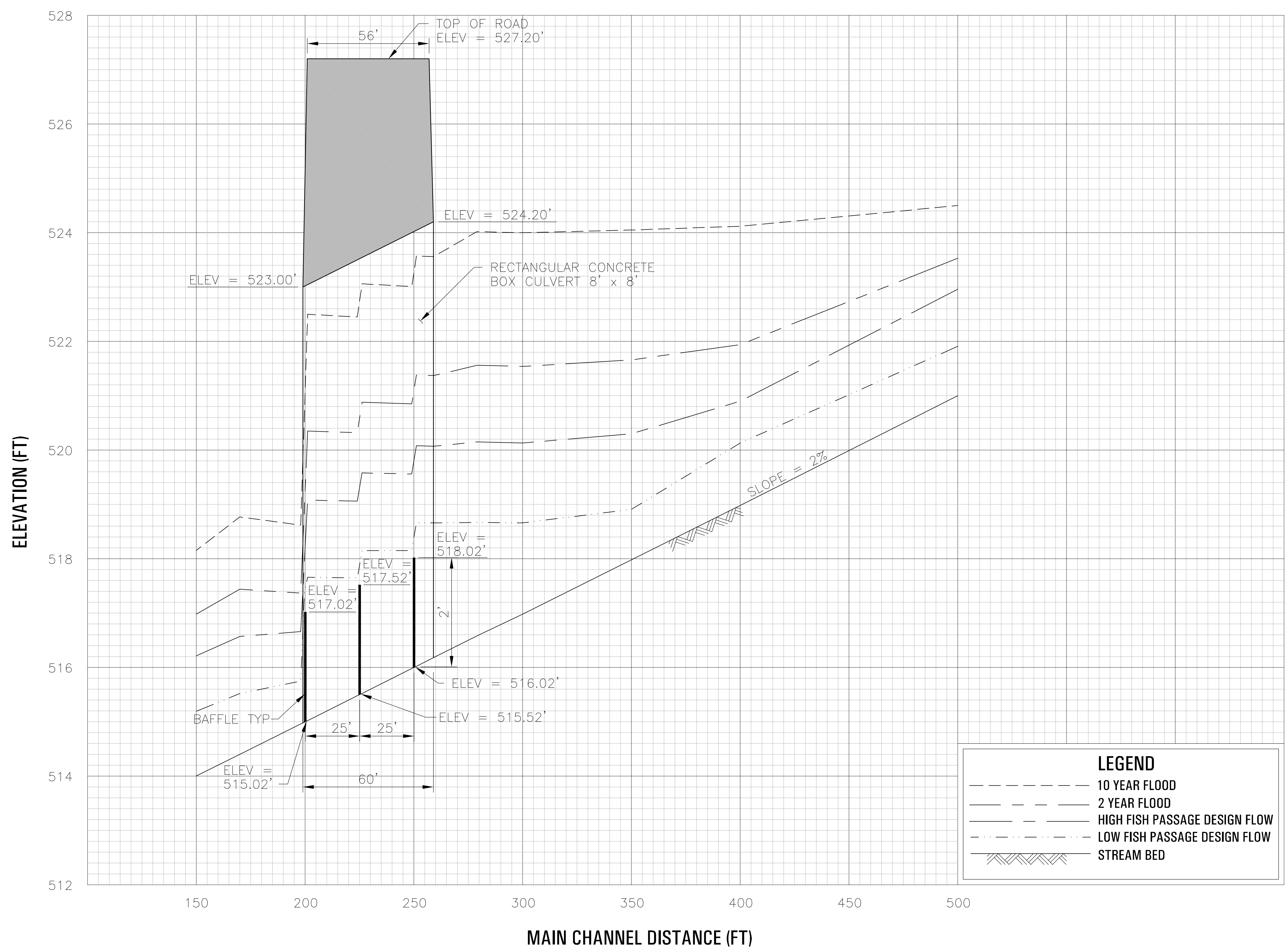
As found in the problem statement, the goal was providing fish passage for Ripple Creek that met hydraulic standards in the Caltrans Hydraulic Design Manual, as well as fish standards in the California Department of Fish and Game Culvert Criteria and the NOAA Fisheries Guidelines for Salmonid Passage at Stream Crossings.

Summary Data Table 1: Culvert Velocities

	Maximum Average Water Velocity at High Fish Design Flow for Adult Anadromous Salmonids (ft/s)	High Fish Design Outlet Velocity (ft/s)	High Fish Design Inlet Velocity (ft/s)	High Fish Design Average Barrel Velocity (ft/s)
Existing Conditions (Fish Xing)	5.00	11.33	9.47	10.05
Existing Conditions (HEC-RAS)	5.00	10.70	4.37	9.14
Proposed Conditions (HEC-RAS)	5.00	5.60	2.50	2.50 (over baffle) 6.80 (through notch)

Summary Data Table 2: Culvert Depths

	Minimum Low Fish Passage Design Depth (ft)	Low Fish Passage Design Outlet Depth (ft)	Low Fish Passage Design Inlet Depth (ft)
Existing Conditions (Fish Xing)	1.00	0.32	0.32
Existing Conditions (HEC-RAS)	1.00	0.89	1.47
Proposed Conditions (HEC-RAS)	1.00	1.70	3.89



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08-29-06 AJACKSON 11:41:21

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

Project Manager: LEF
Designed: EKB
Designed:
Checked: JJL
Drawn: AJ

FISH PASSAGE IMPROVEMENT ROUTE 555

BAFFLE DESIGN

PROPOSED CONDITIONS

Date:
Scale: HORIZ: 1" = 50' VERT: 1" = 2'
Project No. 06938-38713
File Name: Baffle-Design-Improvement.DWG
Drawing No. **1**
Issue: