TETRA TECH

SUPPLEMENTAL REPORT

HARTLAND DIVERSION FISH PASSAGE
ALTERNATIVE IV
DELTA, CO

DECEMBER 2009

Prepared for:
Painted Sky Resource
Conservation and Development Council, Inc.
690 Industrial Blvd
Delta, CO 81416

Prepared by:
Tetra Tech
130 Ski Hill Road, Ste 130
P.O. Box 1659
Breckenridge, CO 80424
T. 970.453.6394
F. 970.453.4579

Table of Contents

List of Figures and Tables

Appendices

1.0 INTRODUCTION

The purpose of this Supplemental Report is to present design recommendations for establishing fish and boat passage at the Hartland diversion dam on the Gunnison River located approximately 2 ½ miles northeast of Delta, Colorado. See **Figure 1**, Vicinity Map. A previous study was conducted, titled *Conceptual Development Report, Hartland Diversion Dam, Fish Passage Structure, Delta Colorado (Conceptual Report)*, dated June 12, 2000 (Tetra Tech 2000). The Conceptual Report presented three alternatives, two of which incorporated fish by-pass structures (fish ladders) and a third alternative with two sets of chutes and pools for both fish and boat passage. A fourth alternative (Alternative IV), presented herein, proposes a series of low head drops. See Drawings 1 and 2 in **Appendix A**.

Much of the background information and data established for the Conceptual Report are utilized for the development of Alternative IV. The Conceptual Report should be referred to for detailed background information, data collection and previous analyses. The Conceptual Report is included in **Appendix B** for ease in reference.

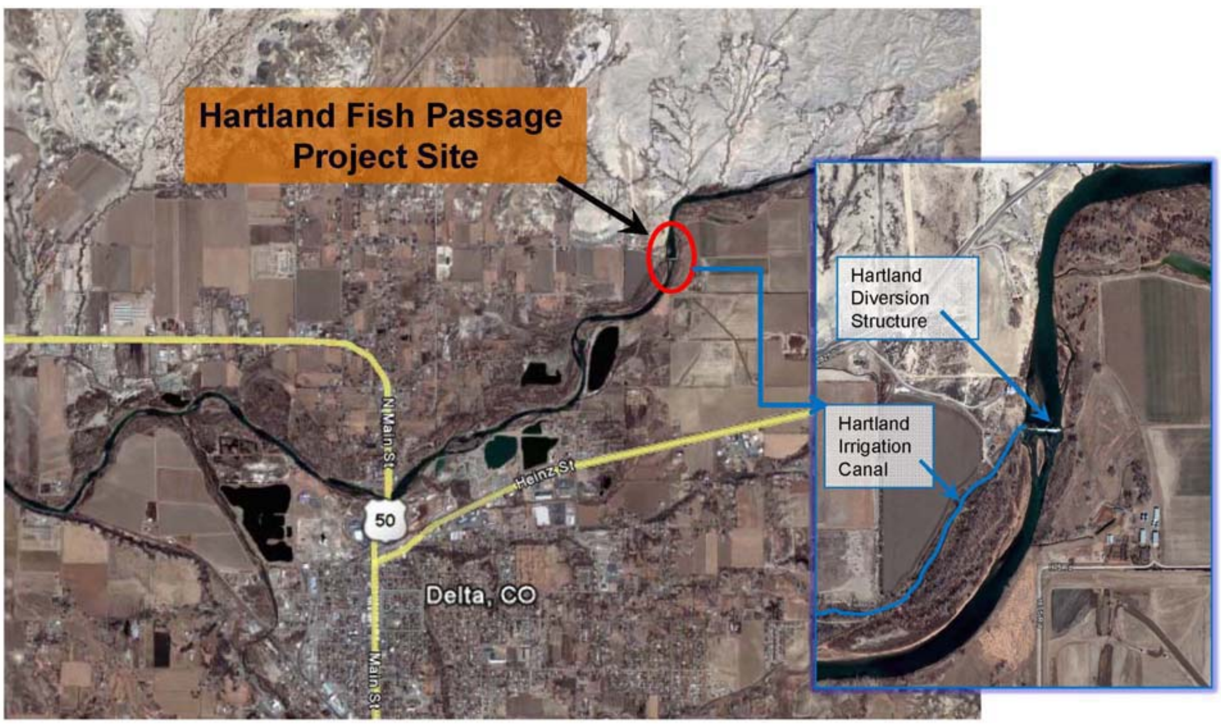


Figure 1: Vicinity Map

2.0 DESIGN CRITERIA FOR ALTERNATIVE IV

2.1 Hartland Diversion Operations

The operation and flow requirements for fish passage cannot interfere with the operation of the Hartland ditch diversions. This is an absolute design criterion and is of primary concern during low flow conditions. Based on the Conceptual Report, diversions to the ditch have averaged 40 cubic feet per second (cfs) with peak days of 60 to 70 cfs. The highest diversion reached 80 cfs once with 10 cfs return flows. The minimum hydraulic head required at the headgate is approximately 4952.5 to maintain diversions of 60 to 70 cfs.

2.2 Fish Passage Criteria

At the direction of the U.S. Fish and Wildlife Service (USFWS) the target species for Alternative IV are three Colorado native fish (roundtail chub, flannelmouth sucker and bluehead sucker). However, guidelines for water depths and velocities are based on the endangered razorback sucker as there is some understanding of swimming capabilities based on research and monitoring information conducted by the USFWS and the U.S. Bureau of Reclamation (USBR). The razorback sucker is believed to be a weaker swimmer relative to the other native species including the three target species. Thus establishing design criteria based on the razorback sucker will provide conservative guidelines for the targeted native fish.

Based on observations at the Redlands Fish Passageway, native species in the Gunnison appear to migrate both upstream and downstream throughout the year with most movement occurring during the months of June, July and August. Thus, one of the criteria for this project is to provide for hydraulic conditions that allow for movement of fish throughout the year, and most importantly during the summer months of June, July and August. However, upstream migration specifically during the peak spring runoff season, typically required for spawning purposes, is not a requirement of this project (Burdick).

Both the USFWS and USBR have indicated that the best success observed for fish migration has been achieved on projects employing a maximum of 0.5 foot drops and maximum velocities over the drops of 4 feet per second (Medford). Specific design criteria developed cooperatively with the USFWS and USBR and employed for the Hartland Diversion Fish Passage, Alternative IV include the following:

- ✓ Maximum vertical height at drop structures: 0.5 feet
- ✓ Maximum velocities at the toe of drops: 4 feet per second
- ✓ Maximum burst time in high velocity areas (toe of drops): 3 to 5 seconds
- ✓ Minimum water depth at top of drops: 2 feet depth
- ✓ Maximum velocities in the pools: 2 feet per second
- ✓ Depth of pools: typically greater than 2 feet
- ✓ Pool length: 20 feet minimum or as dictated by boater requirements

Under high flood conditions, flows and velocities begin to increase beyond the swimming capabilities of the target species. Typically under these conditions the fish will move to the channel banks and continue to move along the bank line. Recommendations for the banks design includes a maximum of 3 to 1 (horizontal to vertical) side slope with some diversity built into the bankline to create pockets of refuge.

2.3 Boat Passage Criteria

Given that boat passage is in the downstream direction of the river flow, design criteria is typically less restrictive than those required for fish passage in terms of velocities. Typically the maximum recommended drop height is 4 feet, with ramp slopes at approximately 10% and Froude numbers less than 1.5 (UDFCD). In the case of Alternative IV as presented herein, the maximum drop is 0.5 feet as dictated by fish passage. Pool lengths shall be 25 feet to allow for a typical raft to enter the pool without physically spanning the top of drops. Pilot rocks and signage is recommended at the upstream drop to help direct and funnel boat passage away from the Hartland headgate and into the drop and pool series.

2.4 Hydrologic and Hydraulic Criteria

Hydrology is required to analyze hydraulic conditions during the times when fish migration is expected to occur, specifically in June, July and August. A detailed hydrologic study was conducted in the Conceptual Report using gage records (Gunnison River at Delta, CO, USGS 09144250) for 1976 through 1999. This included analysis of mean daily flows by month, exceedence values for mean daily flows and flood frequencies. The results of the Conceptual Report hydrologic analyses are applied herein with some modifications. These modifications are in response to the Draft Environmental Impact Statement (DEIS) prepared by USBR for reoperations of a water storage system (referred to as the Aspinall Unit) for the purpose of avoiding jeopardy to four endangered fish in the Gunnison and Colorado Rivers further downstream (USBR 2009). The DEIS contemplates alterations to flow releases which will result in increased flows during certain times of the year to meet a variety of purposes. As noted in the DEIS the action alternatives …"will result in increased spring flows and, as a consequence, reduce flows at other times" (USBR 2009).

The DEIS modeled a variety of flow conditions to predict flow changes as a result of the action alternatives. The cursory review of the output presented in the DEIS Technical Appendices indicate that the flows at the Delta gage during the month of May (peak spring time flows) will increase under the preferred Alternative when compared to the no-action alternative. The median May flow increases from 6,900 cfs in the no-action alternative to an average flow of 7,400 cfs for the preferred Alternative, or approximately a 7% increase. As previously noted, the average flows in the winter months are predicted to drop in order to offset the increase in summer flows, however, minimum flows at the Delta gage are expected to be at or above 350 cfs. For the purpose of this feasibility study and analysis, a range of flows is evaluated from 350 cfs to 7,400 cfs for typical seasonal conditions and to evaluate impacts at the Hartland Diversion. In addition the 5-year and 100-year flow are analyzed to review impacts on existing peak flood conditions. In total, six flows conditions are analyzed as described in **Appendix C** and summarized in **Table 1**.

Table 1. Summary of Flows as Measured at the Delta Gage

Target flow		Description
350 cfs	90% exceedence flow in August	This flow is representative of low flow condition in late summer when fish movement is relatively frequent. Depth of flow at the top of the drops will be the limiting factor for fish passage under these conditions. Also headwater depth at the Hartland diversion is critical to maintain as compared to existing conditions.
650 cfs	Average lowest daily flow 1976 to 1999	This flow is representative of low flow condition that could occur during any time of the year.
1,200 cfs	Average daily flows for August	This flow is selected to represent average daily flows in August when fish movement is relatively frequent; also typical winter flows.
3,460 cfs	Estimated bank full flows	This is the 1.25-year event estimated from the Conceptual Report and is selected here to represent the beginning of spring runoff. This flow is used to check velocities along the river banks.
4,800 cfs	Average daily flows in May	This is the mean daily flows for the month of May as determined in the 2000 gage analysis for 1976 to 1999.
7,400 cfs	Peak flows in May	Average peak flows in May based on DEIS for Aspinall Units reoperations. This flow is used to check depths and velocities at both the top of drops and along the river banks.
11,600 cfs	5-year return period	Determine water surface elevations and compare to existing conditions.
21,200 cfs	100-yr return period	Determine water surface elevations and compare to existing conditions.

3.0 ALTERNATIVE IV DESCRIPTION

Alternative IV proposes a sequence of low head sloping drops and pools as depicted on Drawing 1. The top of the drop is a trapezoidal weir, 10 feet wide at the bottom and 20 to1 side slopes. The weir depth is 2 feet for a total width of 90 feet. From the top of the weir section the proposed channel extends with at 1 to 2% slope to tie into the existing channel banks, lined by a ½ to 1 foot high riprapped bank. Total channel width varies. See Details on Drawings 2 and 3.

The weir section drops 0.5 foot at a 10% slope into a 25 foot long pool. There are 14 weir structures, of which 13 are drops to provide a vertical drop of 6.5 feet spanning from elevation 4951.0 to 4944.5. The 14th structure is a grade control structure. The upstream drop begins approximately 150 feet upstream of the existing diversion structure and the downstream drop extends downstream of the existing dam by approximately 380 feet for a total of approximately 530 feet. There are two existing islands within the project reach, one upstream and one downstream of the existing dam, both of which will be removed with this alternative. The channel will be slightly narrowed to match the channel widths upstream and downstream of the project reach. Large boulders are also proposed as boater guides to direct boat traffic through the drops and away from the diversion.

The Hartland irrigation canal will be extended upstream with a solid wall of either concrete or grouted boulders and tied into the upstream drop as shown on Drawing 1. The top of the existing dam will be partially or totally removed. Each drop consists of boulders partially buried for stability and set to create some irregularity in the channel bottom, however, at the recommendation of the USBR a highly roughened bottom will be avoided as it creates excessive turbulence for upstream migration (Medford 2009). The bank side slopes however will be created with roughened banks using varied boulder sizes and vegetated banks to create refuge.

4.0 EVALUATION OF ALTERNATIVE IV

Alternative IV is evaluated for hydraulic conditions to determine if the proposed structure will meet the criteria for fish and boater passage, and to evaluate impacts on diversions at the Hartland diversion structure. To perform this evaluation, the proposed alternative is modeled with HEC-RAS using field surveyed cross sections from the Conceptual Report, modified to reflect the proposed drop structures. All six flows presented in section 2 are evaluated. Cross sections locations are noted on Drawing 1. For this analysis it is assumed that 80 cfs is being diverted into the Hartland irrigation canal and 10 cfs is returned below the diversion structure. Results of the hydraulic analysis are addressed in this section and presented in detail in Appendix B.

4.1 Hartland Diversion Operations

Under proposed conditions the headwater diversion will occur at cross section 1511, approximately 150 feet upstream of the existing headgate. Flows will be directed through a constructed canal up to the headgate area. The headgate area contains both the headgate to the canal and a roller sluice gate. The roller sluice gate, headgate to the canal, and the canal will not be physically altered under the proposed conditions for Alternative IV. The sluice gate outlets below the dam and will be directed back to the main channel via a short return channel, lined with riprap for bank protection.

Headwater conditions at the gate are controlled by water surface elevations at cross section 1511. Calculations indicate that for flows between 350 cfs and 1200 cfs, the headwater at cross section 1511 is at or above elevation 4953. The water surface drop within the canal from cross section 1511 to the headgate (150 feet in length) is typically less than 0.1 feet. Thus under low flow conditions the headwater at the headgate is at or above 4952.5, meeting the noted criteria for the Hartland diversions.

4.2 Fish and Boat Passage Criteria

Alternative IV is designed to meet the physical criteria established for fish and boat passage including a maximum drop height of 0.5 feet, pool depths of 3 feet, pool lengths of 25 feet and 3 to 1 side slopes along the channel banks. Other criteria including velocities and depths at the top of weirs are evaluated using HEC-RAS. One of the most limiting criteria is the maximum velocities and the length of burst time. Velocities in the drops are limited to 4 feet per second and the burst time is limited to 3 to 5 seconds. This translates to ramp lengths of 12 to 20 feet where the drop slopes into the pool. In the case of Alternative IV, the ramp is sloped at 10% over a 0.5 foot drop for a length of 5 feet to meet and exceed the burst length criteria. Calculations indicate that flows at and below the August flows (1,200 cfs) generally meet the established criteria at the drop structures. Velocities that occur during bankfull discharge (3,460 cfs) are slightly above the established criteria, however at this point flows are in the overbanks and the channel banks are accessible for fish migration and resting areas.

A summary of velocities through the drop structures and pools and in the channel overbanks is presented in Table 2. Plots of velocity distributions for bankfull flows and the 5-year flood event are included in the appendix for review of velocities under high flow conditions. Velocity increments are plotted in steps of 1 foot per second to identify areas of high velocities and areas of acceptable velocities for fish migration. Based on the velocity distributions, the following can be concluded:

- Velocities along the banks will be predominately within swimming tolerances for the target species for all flows analyzed with the exception of the 100-year event.
- Under bankfull conditions (3,460 cfs), velocities along the channel banks are less than 4 feet per second at the locations of the drops
- Under bankfull conditions (3,460 cfs), between the drop structures the velocities along the channel banks are 1 to 2 feet per second.
- The 5-year event (11,6000 cfs), which generally overtops the high channel banks, also displays velocities that range between 2 and 4 feet per second, again occurring at the pools and drops respectively.

Table 2. Summary of Velocities at the Toe of Drop Structures, Alternative IV

	Velocity through pools, feet per second (fps)			Velocity through pools, feet per second (fps)			Velocity in overbanks, feet per second (fps)			
Flows at Delta Gage, cfs	Average	High	Low	Average	High	Low	Average left	Average right	High	Low
350	2.5	3.0	0.9	1.1	1.2	0.7	0.2	0.2	0.2	0.1
650	3.0	3.7	1.3	1.6	1.8	1.0	0.4	0.3	0.2	0.3
1200	3.4	4.2	1.7	2.2	2.5	1.5	0.8	0.7	2.1	0.5
3460	4.6	5.9	3.0	3.7	4.1	2.7	1.7	1.7	4.0	1.2
4800	5.0	6.3	3.4	4.3	4.7	3.2	1.9	2.1	4.6	1.4
7400	5.3	6.5	4.1	4.8	5.4	3.9	2.2	2.8	5.0	1.5
11600	5.8	6.9	4.9	5.5	5.9	4.7	2.8	3.5	5.3	1.9
21200	6.8	8.0	6.1	6.6	6.9	6.0	4.1	4.5	6.0	3.0

The depth of flow is also reviewed at the weir structure. Calculations indicate that the depth of flow is generally at and above 2 feet for all flows with the shallowest depth of 1.95 feet occurring in the upper most drop with river flows at 350 cfs.

4.3 Riprap Protection and Scour Depths

Riprap sizing, bedding gradations and scour depth analysis are not included in this conceptual design. Further analyses shall be part of the final design effort. For purposes of the project layout, details, quantity estimates and unit price estimates, the following assumptions are made regarding riprap and boulder sizes:

- Guide rocks shall be single boulder placements using approximately 6 foot diameter boulders.
- Boulders weirs shall be comprised of a graded material with the average rock diameter of 3 feet.
- Riprap bank protection shall be comprised of a graded material with an average rock diameter of 2 feet.

4.4 Flood Conditions

Water surface elevations for the bankfull, 5-year, and 100-year event are calculated for both existing and proposed conditions to evaluate the impacts of the proposed improvements on flood conditions. For all three flood conditions elevation increases are calculated at the proposed drops. These increases range from 1.1 to 1.6 feet for the 100-year event to 0.1 to 0.7 feet for the bankfull event and span approximately 1500 feet between cross sections 1000 and a point midway between 1700 and 1800. All three flood events show no change in water surface elevations immediately downstream of the proposed drop structures and small to negligible (or negative) changes upstream of the midway point between 1700 and 1800.

The increase in flood water is inherent to the design criteria for this project. The minimum water elevation for diversions combined with a minimum water depth in the drop structure for fish migration all at velocities that are notably lower than those seen under existing conditions results in the increase to flood water depths. Under existing conditions, the Hartland Diversion Structure essentially acts as a 5' high dam with an upstream reservoir of pooled water. As water levels exceed the dam height, the discharge travels over the dam, which acts as a broad crested weir, and the flow converges on critical depth. The critical depth is lower than normal depth resulting in decreased water surface elevations, decreased flow area and increased velocities. However, under the proposed conditions, the grade breaks have been reduced from one large break (5' at the existing dam) to a series of smaller breaks (0.5 ft drops over 14 structures). At the smaller structures, the discharge is high enough to submerge the grade breaks, preventing the discharge from passing through critical flow. Because the discharge over the drops remains at normal depth, the water surface elevations are higher than are found under existing conditions. Calculated water surface elevations and changes for all three flow conditions are presented in **Table 3**.

In final design the flood water increases need to be reviewed in more detail to determine if structures or buildings will be affected and/or to determine the impacts on adjacent properties. This should include a review of the existing FEMA flood study, mapping and hydrology. A levee or berm might be required along the east or left bank, as proposed for Alternative III.

Table 3. Changes in Water Surface Elevations for Existing vs Proposed Conditions

River Station Exist/Prop	Q, cfs		Water Surface Elevations, ft		
	cfs	event	Existing	Proposed	Change
1900	3520	bank full	4958.0	4957.6	-0.4
1900	11670	5-yr	4962.2	4961.8	-0.4
1900	21270	100-yr	4964.8	4964.8	0.0
1800	3520	bank full	4957.4	4956.6	-0.7
1800	11670	5-yr	4961.3	4960.7	-0.6
1800	21270	100-yr	4963.9	4963.9	0.0
1700	3520	bank full	4956.1	4956.0	-0.2
1700	11670	5-yr	4959.4	4959.8	0.4
1700	21270	100-yr	4961.8	4962.9	1.1
1600	3520	bank full	4955.5	4955.6	0.1
1600	11670	5-yr	4958.5	4959.3	0.8
1600	21270	100-yr	4960.8	4962.4	1.5
1300	3440	bank full	4955.0	4954.5	-0.5
1300	11590	5-yr	4957.6	4958.5	0.8
1300	21190	100-yr	4959.8	4961.5	1.6
1100	3440	bank full	4952.7	4953.4	0.7
1100	11590	5-yr	4956.7	4957.8	1.1
1100	21190	100-yr	4959.2	4960.6	1.4
1000	3440	bank full	4951.7	4951.7	0.0
1000	11590	5-yr	4955.9	4955.9	0.0
1000	21190	100-yr	4958.3	4958.3	0.0
900	3440	bank full	4950.8	4950.8	0.0
900	11590	5-yr	4954.8	4954.8	0.0
900	21190	100-yr	4957.0	4957.0	0.0
800	3440	bank full	4948.9	4948.9	0.0
800	11590	5-yr	4952.4	4952.4	0.0
800	21190	100-yr	4954.9	4954.9	0.0

5.0 OPINION OF PROBABLE COSTS

Based on this conceptual design as shown on the appended plans and details, a preliminary cost estimate is developed for the construction of Alternative IV. The unit prices are based on 2009 prices and prevailing wages for the area and assume this project is competitively bid by a private contractor. Assumptions and backup for unit prices are included in the appendix. Costs do not include easement acquisition, wetland mitigation, permitting, and operation and maintenance costs.

Table 4. Opinion of Probable Costs, Alternative IV

ITEM DESCRIPTION	UNIT	UNIT PRICE	TWELVE CELLS (1/2 FT DROPS) QUANTITY	TWELVE CELLS (1/2 FT DROPS) SUBTOTAL
Mobilization/demobilization	LS	$26,000	1	$26,000
Site preparation	LS	$14,000	1	$14,000
Water Control/Dewatering	LS	$32,000	1	$32,000
Headwall				
Remove existing dam	LS	$16,000	1	$16,000
Concrete headwall	CY	$1,000	200	$200,000
Riprap wall protection, d_{50}=24 in	CY	$45	4000	$180,000
Earthwork				
Excavation	CY	$10	10500	$105,000
Use excess-grade on site	CY	$5	2600	$13,000
Boat/Fish Passageway				
Subgrade grading and bed compaction	EA	$4,000	14	$56,000
Boulders - guide rocks, 6 ft diam	CY	$60	40	$2,400
Boulder Weirs, d_{50}=36 in	CY	$50	3700	$185,000
Engineered stream bed	CY	$40	4100	$164,000
Riprap bank protection, d_{50}=24 in	CY	$45	1200	$54,000
Native Seeding	AC	$5,000	6	$30,000
Ditch crossing-temporay access road	LS	$5,000	1	$5,000
		SUBTOTAL		**$1,082,400**
DESIGN/ SURVEYING/ INSPECTION (8%)				**$87,500**
CONTINGENCY (20%)				**$218,800**
TOTAL ESTIMATED COST				**$1,388,700**

6.0 PERMITTING

The two primary regulatory requirements for the project are NEPA compliance and permitting from the US Army Corps of Engineers for a Section 404 permit. In addition, approval will be required from the Federal Emergency Management Agency, National Flood Insurance Program to alter floodplain elevations. Required Colorado Department of Public Health and Environment permits include a Stormwater Management Discharge Permit and a Construction Dewatering Permit. Local permits may also be required for excavation, dewatering, grading and erosion control.

7.0 RECOMMENDATIONS PRIOR TO FINAL DESIGN

Prior to final design of Alternative IV, there are several additional evaluations that are recommended. These are listed as follows:

1. Extend the field survey to cover the length of project and to include floodplain elevations beyond the river banks, particularly on the left river bank where increased flood elevations could impact adjacent properties.
2. Delineate existing wetlands and determine impacts to the existing wetlands based on the current layout.
3. Prepare a Conditional Letter of Map Revision to ensure that the project can be implemented as proposed without impacting existing structures or damaging overbank property.
4. Secure easements from property owner(s) for construction and long term access for maintenance.
5. Coordinate with the City and County of Delta on project for guidance on local requirements for plan approval.
6. Perform geotechnical investigation for gradation analysis of existing materials, foundation analysis and soil conditions.
7. Determine riprap and boulder sizes as well as scour depths. Prepare bedding design. Locate rock sources. Investigate and secure commitment for rock donations.

8.0 REFERENCES

Burdick, Bob. U.S. Fish and Wildlife Service. November 2009. Telephone conversation.

Gary Flosi, Scott Downie, James Hopelain, Michael Bird, Robert Coey and Barry Collins. 1998. *California Salmonid Stream Habitat Restoration Manual, Section XII, Fish Passage Design and Implementation*, revised April 2009. Department of Fish and Game, State of California.

Medford, Brent, U.S. Bureau of Reclamation. November 2009. Telephone conversation.

Tetra Tech, Inc. 2000. *Conceptual Development Report, Hartland Diversion Dam, Fish Passage Structure, Delta, Colorado*. Prepared for the U.S. Bureau of Reclamation, Grand Junction, Colorado. December 2000.

Wayne Stancill. U.S. Fish and Wildlife Service. July 2009. Personal communication during meeting.

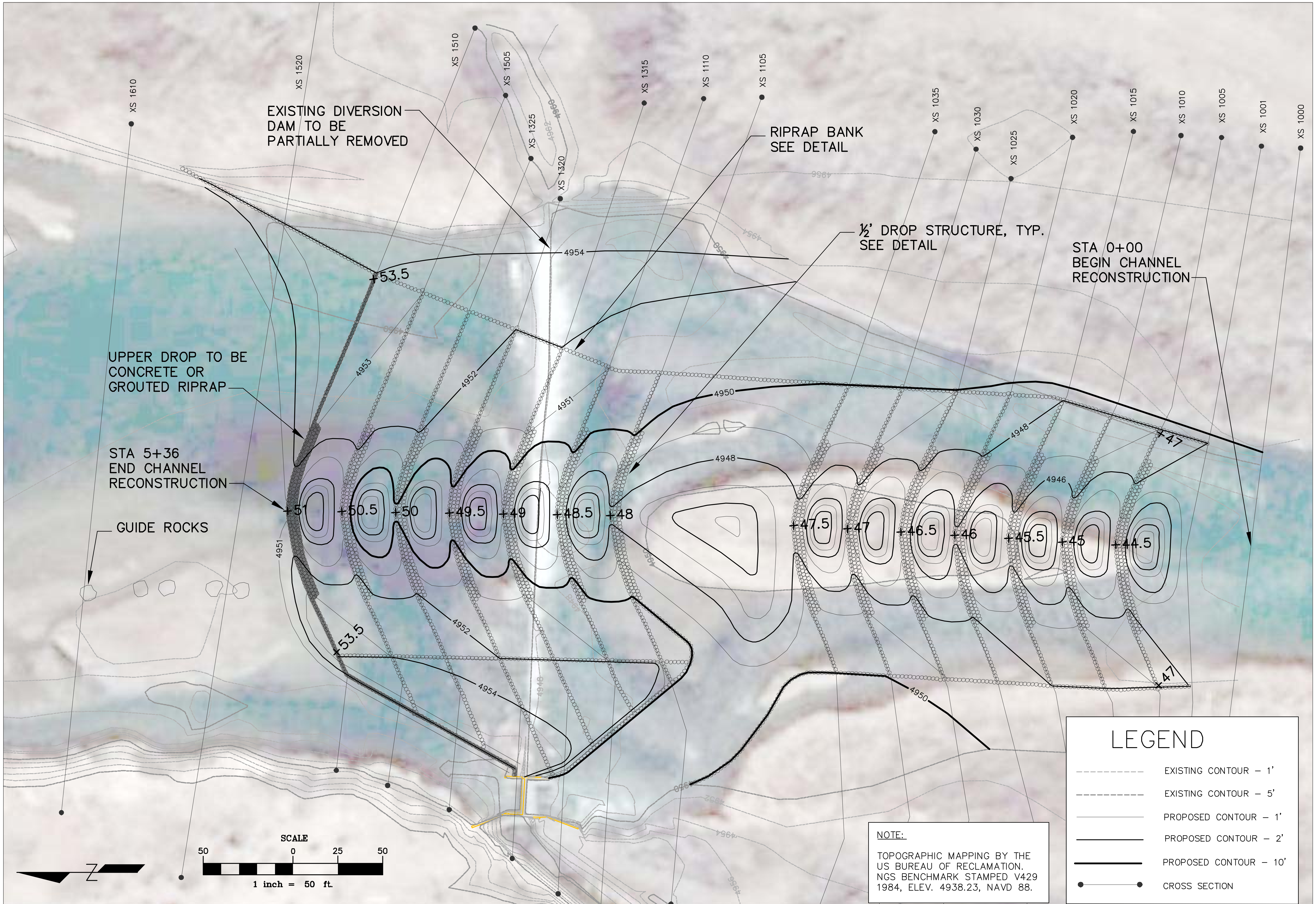
Urban Drainage and Flood Control District (UDFCD). 2008. *Drainage Criteria Manual V.2. Hydraulic Structures*.

U.S Bureau of Reclamation (USBR). January 2009. Draft Environmental Statement, Aspinall Unit Operations, Aspinall Unit-Colorado River Storage Project Gunnison River, Colorado. Volume II Technical Appendices, Appendix A, Aspinall EIS Hydrology Report.

U.S. Army Corps of Engineers (USACE). 2005. HECRAS River Analysis System Version 3.1.3. Hydrologic Engineering Center, Davis, CA.

APPENDIX A

DRAWINGS



NOTE:

TOPOGRAPHIC MAPPING BY THE US BUREAU OF RECLAMATION. NGS BENCHMARK STAMPED V429 1984, ELEV. 4938.23, NAVD 88.

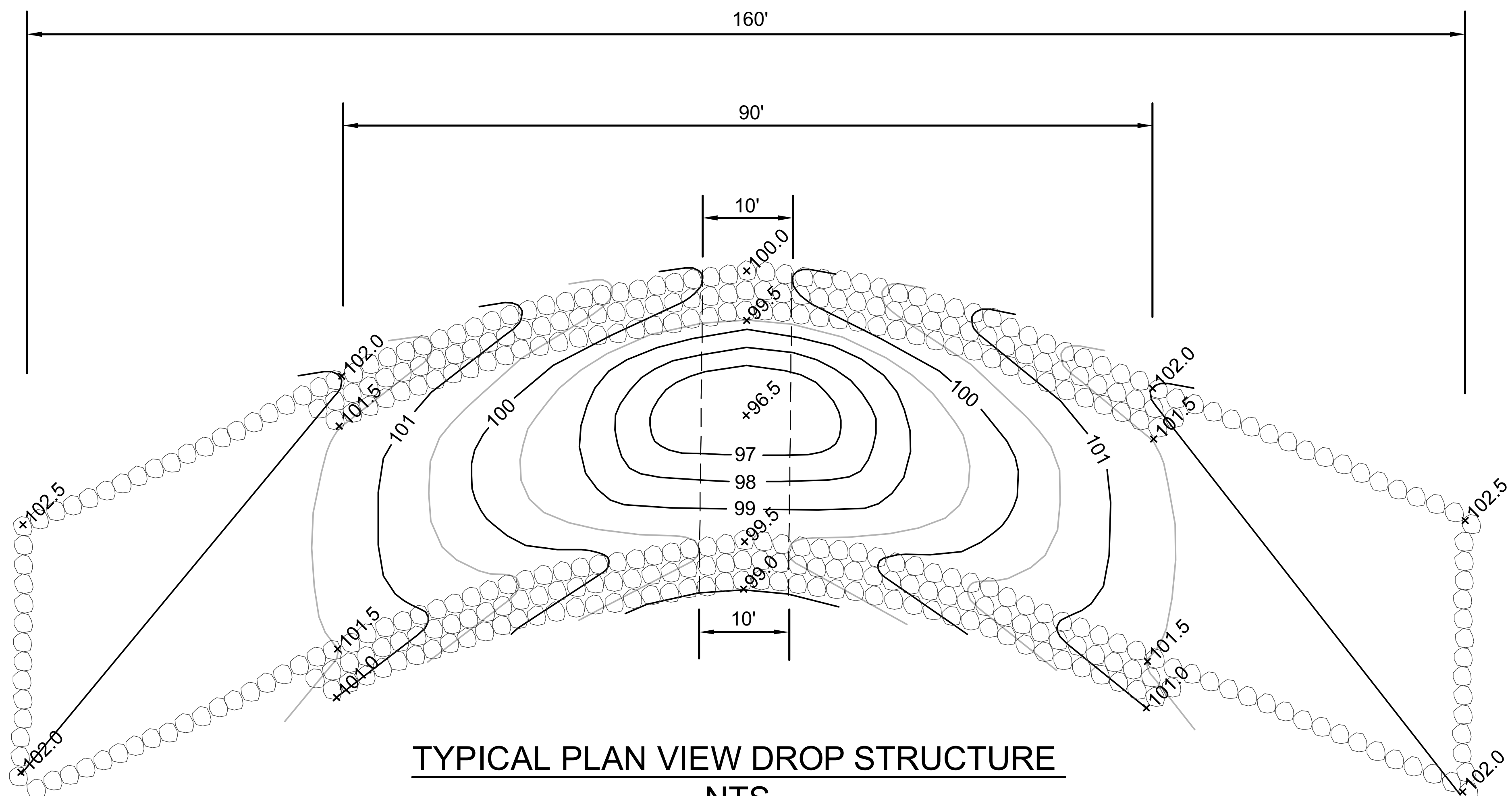
REVISIONS

HARTLAND DIVERSION ALTERNATIVE 4

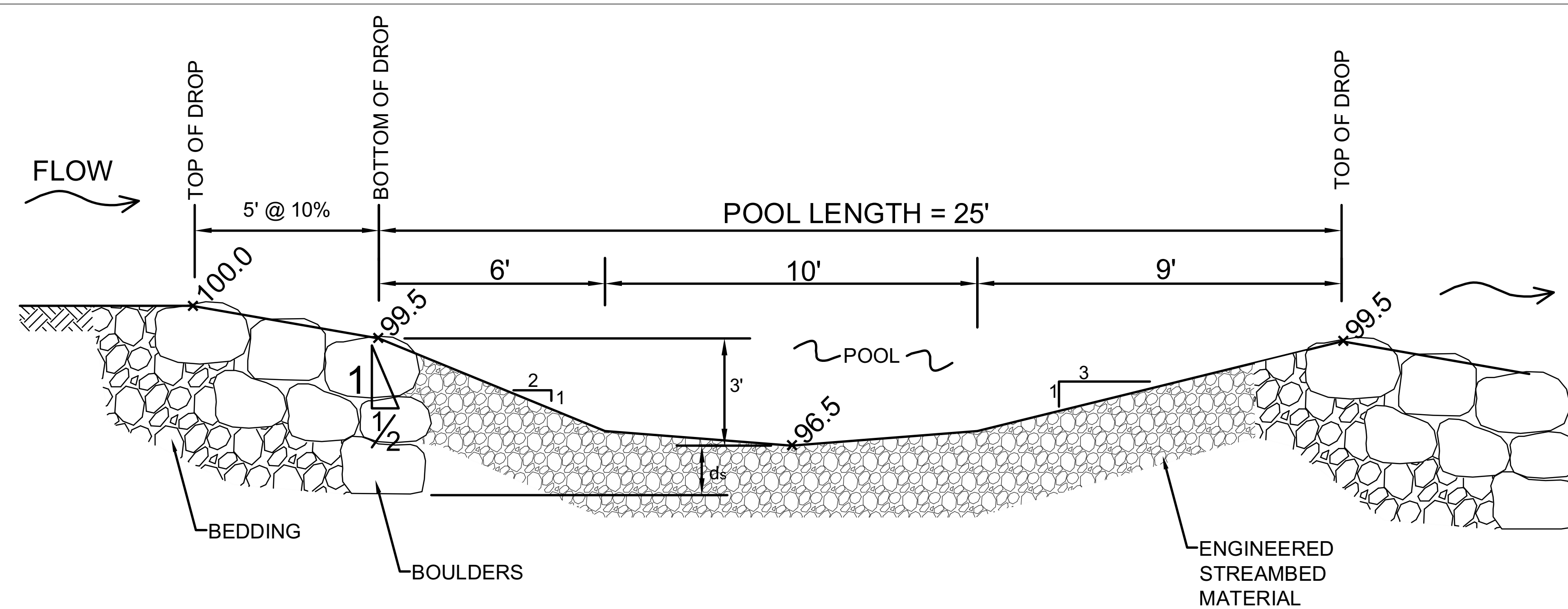
DESIGNED BY: PMB
DATE: DECEMBER 18, 2009
CHECKED BY: PMB
SCALE:
DRAWN BY: PGS
PROJECT #: 133-39802-09001
CADD FILE: HART_ALT4.DWG

TETRA TECH, INC.
130 SKI HILL ROAD, SUITE 130, PO BOX 1659
BRECKENRIDGE, CO 80424
(970) 453-6394 Fax (970) 453-4579

DRAWING NUMBER: 1



TYPICAL PLAN VIEW DROP STRUCTURE
NTS



TYPICAL DROP & POOL PROFILE
NTS

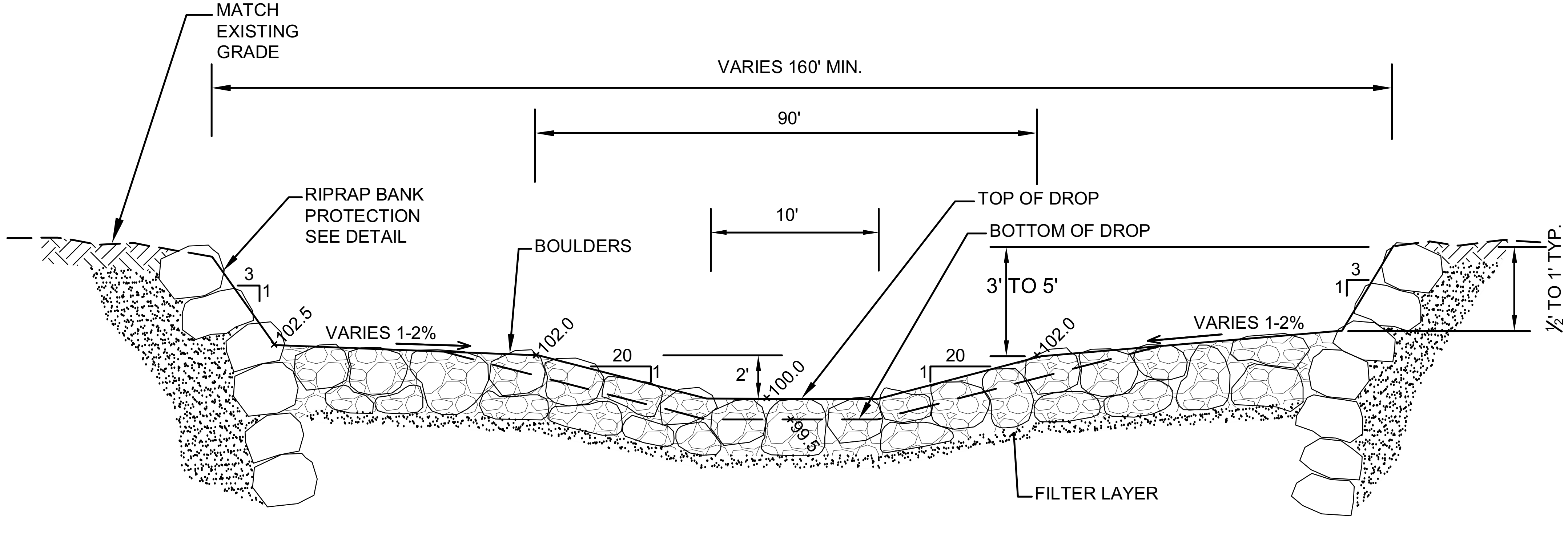
REVISIONS

HARTLAND DIVERSION
ALTERNATIVE 4 DETAILS

DESIGNED BY: PMB
CHECKED BY: PMB
DRAWN BY: PGS
DATE: DECEMBER 18, 2009
SCALE:
PROJECT #: 133-39802-09001
CADD FILE: HART_ALT4.DWG

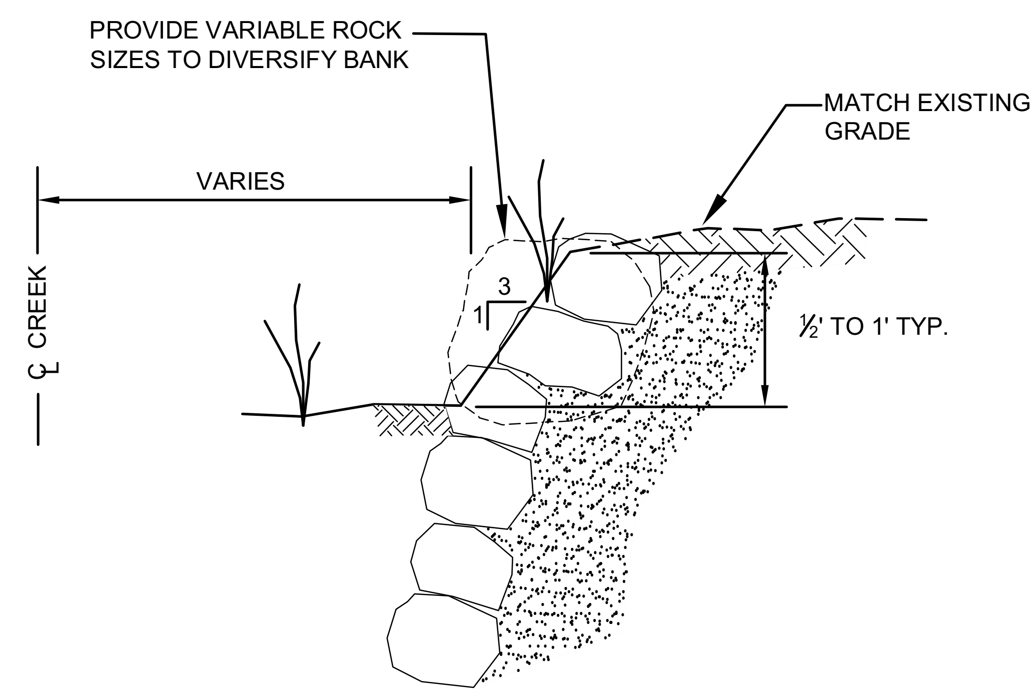
TETRA TECH, INC.
130 SKI HILL ROAD, SUITE 130, PO BOX 1659
BRECKENRIDGE, CO 80424
(970) 453-6394 Fax (970) 453-4579

DRAWING NUMBER:
2



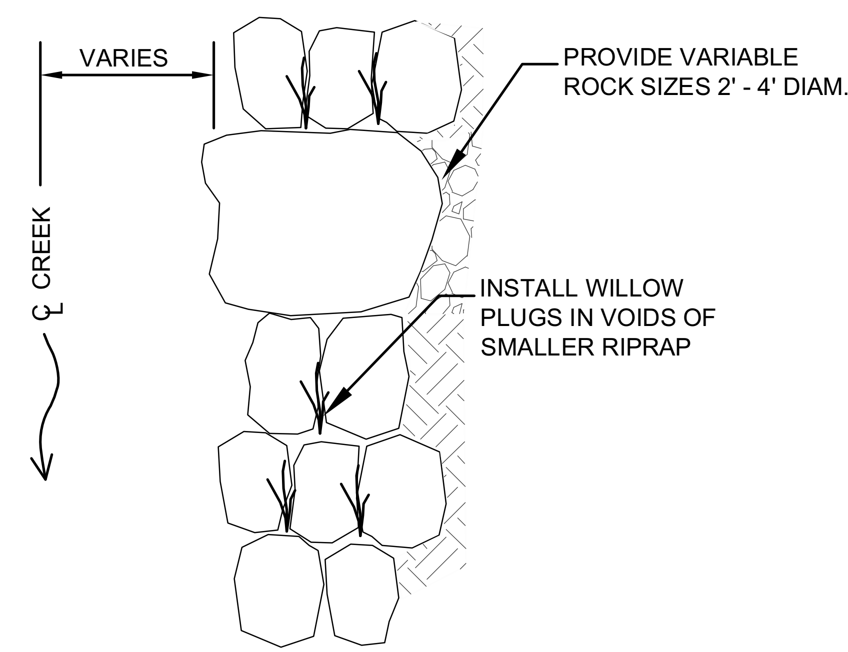
TYPICAL DROP STRUCTURE SECTION

NTS



BANK PROTECTION SECTION DETAIL

NTS



BANK PROTECTION PLAN VIEW

NTS

REVISIONS

HARTLAND DIVERSION
ALTERNATIVE 4 DETAILS

DESIGNED BY: PMB | CHECKED BY: PMB | DRAWN BY: PGS
DATE: DECEMBER 18, 2009 | SCALE: | PROJECT #: 133-39802-09001
CADD FILE: HART_ALT4.DWG

TETRA TECH, INC.
130 SKI HILL ROAD, SUITE 130, PO BOX 1659
BRECKENRIDGE, CO 80424
(970) 453-6394 Fax (970) 453-4579

DRAWING NUMBER: 3

APPENDIX B

CONCEPTUAL REPORT

CONCEPT DEVELOPMENT REPORT
HARTLAND DIVERSION DAM
FISH PASSAGE STRUCTURE
DELTA, COLORADO

Prepared for:

United States Bureau of Reclamation
Grand Junction Area Office
P.O. Box 60340
Grand Junction, Colorado 81506

Contract No. 1425-6-CA-40-1730A
Delivery Order No. 20

Prepared by:

Tetra Tech, Inc.
P.O. Box 1659
410 South French Street
Breckenridge, CO 80424

June 12, 2000
Revised December 20, 2000

CONCEPT DEVELOPMENT REPORT
HARTLAND DIVERSION DAM
FISH PASSAGE STRUCTURE
DELTA, COLORADO

Prepared for:

United States Bureau of Reclamation
Grand Junction Area Office
P.O. Box 60340
Grand Junction, Colorado 81506

Contract No. 1425-6-CA-40-1730A
Delivery Order No. 20

Prepared by:

Tetra Tech, Inc.
P.O. Box 1659
410 South French Street
Breckenridge, CO 80424

June 12, 2000
Revised December 20, 2000

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

As part of the Upper Colorado River Endangered Fish Recovery Program, fish passage is proposed at the Hartland diversion dam to provide fish access to historic habitat further upstream on the Gunnison River. The target species for this project include the Colorado pikeminnow and the razorback sucker. Selective passage for the screening of non-native predators is not considered necessary at the Hartland Diversion Dam since selective passage is provided on the Gunnison River at the Redlands fish passageway downstream at Grand Junction, Colorado.

Three alternatives are developed and presented in this report. These alternatives include a concrete fish ladder on the east bank, an open channel boulder drop-pool fish ladder on the east bank and the reconstruction of the dam for fish and boater passage in an open channel drop-pool sequence through the center of the river.

Both Alternatives I and II (concrete or boulder drop-pool on east bank) accomplish the goal of providing fish passage and both alternatives are relatively inexpensive. However, the City of Delta has expressed an interest in the third alternative, which provides fish passage and accommodates boater passage. Alternative III is more expensive than either Alternative I and II since it requires regrading 250 feet of river, installation of concrete cutoff walls and over 20,000 tons of boulders. The primary advantage of Alternative III is that it opens this reach of the Gunnison River to boater passage, which is currently not possible due to the height of the Hartland dam. Hartland Irrigation Company was not opposed to Alternative III.

The three alternatives are evaluated for a range of hydraulic conditions ranging from low flows of 350 cfs up to and including the 100-year flood of 21,200 cfs. Bank overtopping for existing conditions and all three alternatives occurs when flows exceed 11,600 cfs, the 5-year event. For events that exceed 11,600 cfs the dam becomes submerged and the difference in water surface elevations upstream and downstream of the dam become small enough that fish passage may be possible directly along the riverbanks.

All three alternatives require some maintenance for debris removal. Alternatives II and III require additional maintenance for the replacement and upkeep of boulder drop-pools.

Easements across private property are required for all three alternatives for the placement of the structures, for construction and for maintenance.

Supporting design and cost analyses are presented in the report. A short summary of the alternatives is presented in Table E.1.

TABLE E.1 SUMMARY OF ALTERNATIVES

Feature	Alternative I	Alternative II	Alternative III
Type	Concrete with option of roughened bottom	Open channel with rock baffles, pools & riffles	Fish and boat passage with chutes and pools
Fish Passage	Ladder available for all flows	Ladder available for all flows	Center of river for low flow conditions, banks of river for flood events
Access	East side, easements required	East side, easements required	East side, easements required
Property issues	Easements required for ladder and access	Easements required for ladder and access	Easements required for ladder and access
Maintenance	Trash and debris	Trash and debris, rock replacement	Trash and debris, boulder replacement
Costs	$493,700	$353,000	$2,011,000
Maintenance Costs: yearly Present value, 8%, 50-yr, 3 % inflation)	$2,000 $37,000	$4,000 $75,000	$6,500 $121,000
Construction cost & maintenance (pres. value)	$530,700	$428,000	$2,132,000
Disadvantages	Not available for boat passage Least natural appearance	Not available for boater passage Rock baffles require maintenance to insure proper placement	Five times the cost of Alternative II Rock chutes require maintenance to insure proper placement May disturb existing wetlands Safety and social issues with increased public use
Advantages	Cost within 20% of Alternative II Easy to maintain Could be converted for selective passage	Least expensive Could be converted for selective passage	Available for boat passage Most natural appearance

The Hartland Irrigation Company reports a long history of fish capture in the ditch. Thus, in addition to the fish passageway alternatives, several options are evaluated for the installation of a fish screen and bypass return channel along the ditch.

I. INTRODUCTION

The Hartland diversion dam, serving the Hartland Ditch, is located on the Gunnison River near Delta, CO. The Hartland diversion dam consists of a low head dam that is currently a barrier to fish passage. As part of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program), passage is proposed at the dam to provide fish access to historic habitat further upstream on the Gunnison River. The target species for this project include the Colorado pikeminnow (Ptychocheilus lucius) and the razorback sucker (Xyrauchen texanus).

The purpose of this document is to present conceptual alternatives for establishing fish passage at the Hartland diversion dam and to generate input by key project participants prior to developing final plans. This document includes general criteria for conceptual layout and grading of three alternatives; development of basic design information to support the final design process including hydraulics, hydrology, and mapping; cost estimates to assist in alternative selection; evaluation of pros and cons of each alternative; and recommendations to assist in the development of the final design. This document also presents general criteria for layout and design of a fish screen and bypass return channel to be installed along the Hartland Ditch downstream of the diversion structure.

II. SITE DESCRIPTION AND OPERATIONS

2.1 Site Description

The Hartland diversion dam is located in Delta County on the Gunnison River (River Mile 59.9) approximately 2 ½ miles (measured along the Gunnison River) upstream of U.S. Highway 50 bridge at Delta Colorado (Figure 2.1). The diversion dam was constructed in 1881 and delivers an average of 40 cfs of water into the Hartland Ditch. The structure includes a 5 foot high by 300 foot wide dam spanning the entire river and a headgate and ditch on the north bank. The structure, headgate and ditch are owned and operated by the Hartland Irrigation Company (HIC).

The diversion dam is approximately 1½ miles north of Highway 50 and ¾ miles northeast of the City of Delta Golf Course. Access to the headgate on the northeast bank of the river is obtained by following County Roads H40, 1600 Road, H75, 1675 Road and 1825 Drive, off of Highway 50. The diversion dam is located within a 30-foot wide easement on private property.

2.2 Spill Channel Site Description

Approximately ¾ of a mile downstream of the Hartland diversion dam on the Hartland Ditch, there is an existing spill channel for returning excess flows from the Hartland Ditch back to the Gunnison River (Figure 2.1). This analysis evaluates the feasibility of utilizing the existing spill channel as a bypass channel to return fish from the Hartland Ditch back to the Gunnison River. While other locations along the ditch may be suitable for a fish screen and bypass channel, the intent is to utilize the spill channel and facilities that already exist.

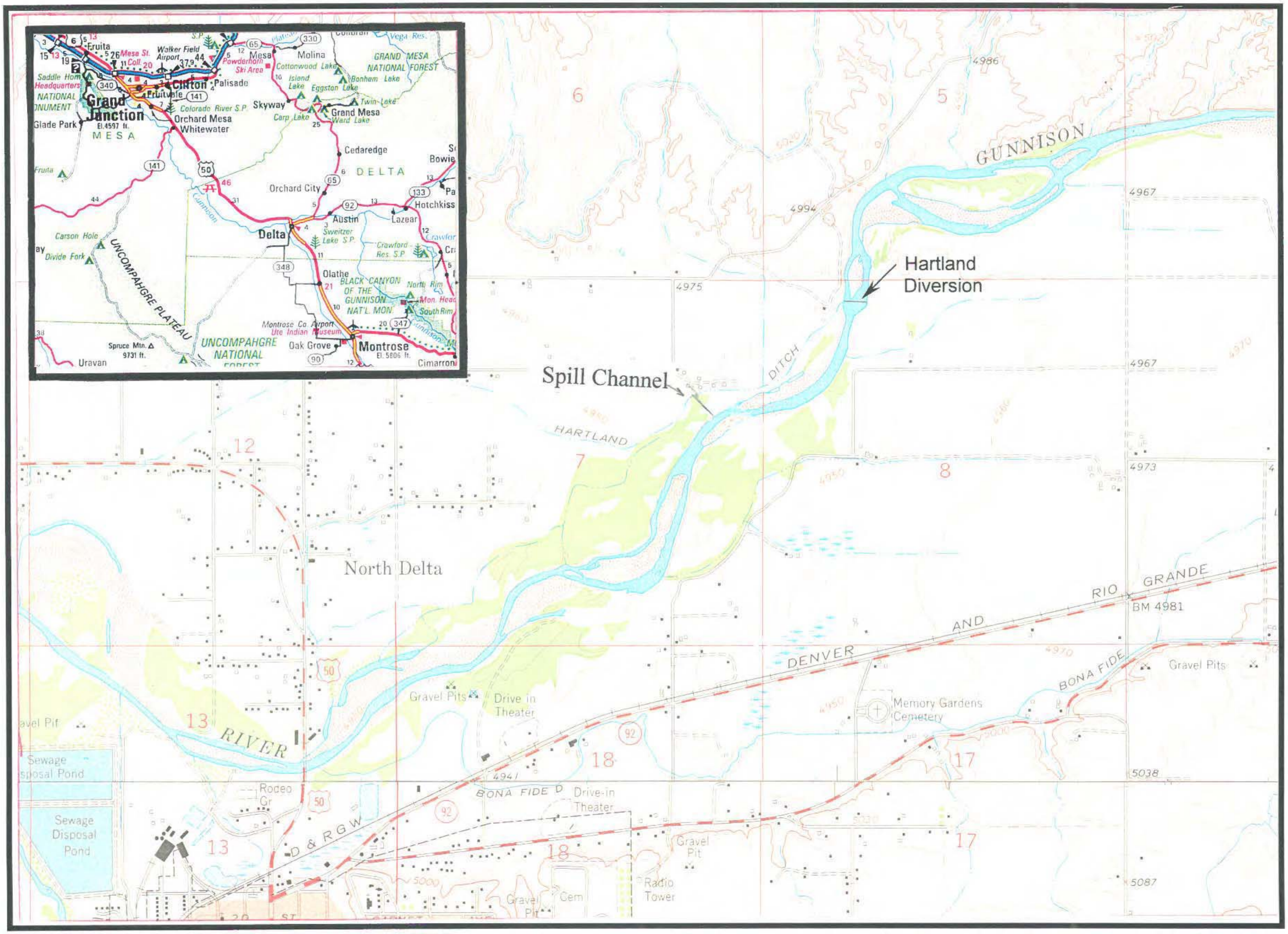


Figure 2.1 Project Site Location Map

2.3 Diversion Operations

Flows in the Hartland Ditch are monitored at a gaging station located approximately 245 feet downstream of the spill channel. The gaging station consists of a concrete flume and staff gage. A rating table of stage versus flow was provided to Tetra Tech, Inc. by the State Engineers Office and is found in Appendix F. Gage records for the Hartland Ditch are available from 1970 to present.

Based on conversations with HIC, the spill channel flows, upstream of the gage, are typically 10 cfs (HIC 2000). Flows through the gage average 40 cfs with peak days of 60 to 70 cfs. The highest peak on record is 90 cfs, diverted on October 31, 1979. Since the gage is downstream of the spill channel, the flows diverted out of the Gunnison River at the headgate are typically 10 cfs higher than those recorded at the gage. The period of operation of the diversion is typically from early April through October, although the records indicate that in some years the diversion has been operated all year long (CDSS 2000). The diversion supplies water for irrigation of approximately 2385 acres of crops, including alfalfa, corn grain, grass pasture and spring grain. The diversion also supplies water for stock watering (CDSS 2000).

HIC indicated that there has been one instance, approximately ten years ago, that they were unable to divert sufficient flows due to low flow conditions in the Gunnison. This was resolved by minor earthwork in the main river. Otherwise, in general, the ditch headgates are used to restrict the inflow to the rates noted above (HIC 2000).

HIC has also indicated that under current operation conditions, fish (native and non-native) and trash are entrained in the Hartland Ditch. Trash, especially large debris, is often removed by the ditch rider near the headgate area. Fish, however are typically removed manually near and around the individual points of diversion and disposed of (HIC 2000).

2.4 Spill Channel Operations

Two gates on the Hartland Ditch divert flows into the spill channel by backing water up and forcing excess flows to spill into the channel. Diversion to the spill channel is through a 4.5-foot opening with flashboards to create a weir spill. A second opening adjacent to the flashboards is gated and typically stays closed during normal operations. Water passes over the flashboards into an open concrete box and then into an open channel leading immediately to a 36-inch culvert. From the culvert, flows enter a 350-foot long open channel that slopes back into the Gunnison River (Drawing 5, Appendix A).

2.5 Dam Structure

The dam structure is approximately 300 feet wide and spans the entire Gunnison River. The elevation at the crest of the dam varies between 4952.4 and 4953.0. The channel bed elevations also vary along the toe of the dam and at an approximate elevation of 4948. Scour holes exist along the east bank toe at elevation 4946. The water surface over the top of the dam drops a total of 4.5 feet in low flow conditions and is less than 1 foot when flows in the river reach or exceed the 5-year event. The east bank elevation ranges from 4957 to 4962, where a small berm has been constructed to redirect overtopping flows back into the river when elevations exceed 4957. The west bank rises steeply and is at least 20 feet above the main river channel.

The dam consists of railroad iron driven vertically into the riverbed and horizontally placed steel cribbing (HIC 2000). The cribbing is filled with river cobbles and boulders. The structure was repaired in 1942 (HIC 2000). HIC reports that the dam functions very well and they have no immediate or future needs for repair or reinforcing. The only feature of the dam that causes some problems is that the dam snags debris and trees that are floating in the river (HIC 2000). This is a typical maintenance requirement at any low head diversion dam where there is a significant debris load in the river.

2.6 Site Survey

2.6.1 Diversion Dam

In order to provide the information necessary to analyze the conditions at the Hartland diversion dam and to produce design drawings, a survey was conducted. The survey was performed using 1988 N.A.V.D. vertical datum, and 1983 N.A.D. State Plane coordinates. The following information was obtained: 1) a topographic survey in the immediate area of the diversion structure, 2) cross sections of the Gunnison River upstream and downstream of the structure, and 3) detailed measurements and spot surveys of the headgate. The U.S. Bureau of Reclamation conducted the topographic and cross section surveys in October of 1999.

Tetra Tech, Inc. measured water surface elevations at the surveyed cross sections in 1999 and 2000 for use in the hydraulic calibration model.

2.6.2 Spill Channel

In May of 2000 Tetra Tech, Inc. conducted a survey of the spill channel and the Hartland Ditch in the vicinity of the spill channel in order to evaluate the feasibility of a fish screen at this location. The survey was performed using the same datum as the survey prepared for the diversion dam by utilizing the right end point for cross section 700 as a benchmark.

Cross sections were surveyed upstream and downstream of the spill channel diversion as well as in the spill channel itself. In addition, water surface measurements were made at the Gunnison River, in the spill channel and at the Hartland Ditch to aid in the development of a calibration analysis for the ditch and spill channel.

III. FISH PASSAGE CRITERIA

The target species for fish ladder design at the Hartland diversion dam are the Colorado pikeminnow and the razorback sucker (Burdick 1996). Three primary types of information pertinent to the design of the fish passage structure include the timing of migration patterns, swimming ability and behavior. In terms of swimming ability, standards for the fish ladder have been based on the swimming abilities of the razorback sucker, as the sucker is believed to be a weaker swimmer than the Colorado pikeminnow (Mefford 2000; Pfeifer 2000). The fish passage is designed and constructed to allow for non-selective passage (i.e. no trapping facilities).

3.1 Migration

Both the Colorado pikeminnow and the razorback sucker undertake riverine migrations for feeding and spawning during different periods of the year. Various studies on the reproductive ecology of these two species suggest that the Colorado pikeminnow tend to make more extensive and longer migrations to spawning areas than the razorback sucker (Burdick 2000c). Based on studies in the Upper Colorado River Basin both species migrate upstream and downstream to reach spawning sites (Tyus and McAda 1984; Tyus et al. 1987; Tyus 1990; McAda and Kaeding 1991; Irving and Modde 2000). Mature razorback sucker spawn on the ascending limb of the hydrograph, whereas Colorado pikeminnow begin migrating to spawning areas as peak runoff subsides and water temperatures are increasing (Tyus 1990, 1991: McAda and Kaeding 1991). Following spawning, both species may make return migrations to former areas to rest and feed (Wick 2000).

In addition, data collected from fish capture in the fish trap at the Redlands facility on the Gunnison River in Grand Junction, Colorado, indicate that a significant number of sub-adult and adult Colorado pikeminnow move up through the fish ladder during July and August (Burdick 2000c). This movement is associated with the post-spawning period for this species in the Upper Colorado and Gunnison Rivers (McAda 2000; Anderson 1999). The upstream movement may be in response to fish searching for suitable spawning habitat to be used the following year or fish seeking new upstream feeding areas following spawning for the current year (Burdick 2000c). During the first five years of operation of the Redlands fish passageway, the months of highest usage for all fishes were June and July, with fish passage continuing into August (Burdick 2000c; Pfeifer 2000b).

Analyses of flow records indicate that the peak spring runoff occurs on the Gunnison River during mid-May to mid-June. Thus, the period when both endangered fish are migrating is typically April to August.

The razorback sucker and the Colorado pikeminnow are believed to have a life span of at least 30 and 20 years respectively (Pfeifer 2000b). Given the long life span of these fish it has been theorized that migration and spawning every year may not be necessary for the survival of these species. To date it is not known if the fish must migrate to spawn nor is it known if the fish must spawn every year to survive. Under natural conditions, with a wide range of flows, it is possible that there were years when these fish species were not able to migrate to their spawn sites due to low flow conditions (Pfeifer 2000b). Similarly there will be years when the flows in the Gunnison River will be too low to operate the fish ladder simultaneously with the Hartland diversions.

3.2 Swimming Ability

Razorback suckers have been tested for swimming performance. Earlier tests indicated that the razorback sucker are capable of short bursts at speeds of 2 fps and sustained swimming at velocities of 0.66 to 1 fps (Bestgen 1990). However, recent flume tests performed by the Bureau of Reclamation indicate that the razorback sucker is capable of swimming through higher velocities than previously thought, especially in ladders with cobbles and boulders on the bottom similar to natural conditions (Mefford 2000b). Flume tests on juveniles indicate the razorbacks can swim through flows with an average velocity of 4 feet per second (fps) if the bottom velocities are 2 fps or less on a roughened surface. In video records of the flume tests the fish can be seen resting behind some of the larger boulders as they proceed upstream through the higher velocity sections (Mefford 2000b). Velocities in the Redlands fish passageway have been measured in the baffles and range from 2.3 to 3.5 fps. Since 1996, the Redlands fish passageway has been successfully negotiated by 49 endangered Colorado pikeminnow as well as over 42,000 other fish, of which 93% were the non-listed native species such as the flannelmouth sucker, bluehead sucker, and roundtail chub (Burdick 2000c).

3.3 Behavior

Razorback suckers tend to follow the riverbanks, swimming along the channel bottom (Burdick 2000b). Because the rivers tend to be quite turbid during spring runoff and the visibility is poor, it is believed the fish rely almost exclusively on flow direction for orientation. Similarly, the Colorado pikeminnow is believed to orientate itself using flow direction, however, it is unknown whether or not the Colorado pikeminnow swim along the bottom of the channel or follow the riverbanks in a similar fashion to the razorback sucker.

The fish passage entrance at the downstream end of the ladder is believed to be most easily accessible for the fish if the entrance is within 45 degrees of being parallel to the river flow (Mefford 2000a). Ideally, the ladder entrance is placed approximately 20 to 30 ft downstream of the whitewater from the diversion dam. Fish are drawn to the dam and then search for passage. Once the fish have reached the dam face they generally do not go back downstream to search for passage. Instead the fish continue to search at the most upstream accessible point. The ideal average velocity near the ladder entrance is approximately 4 fps. The target for attractive flow, plus flows in the fish ladder, is approximately 10 % of the river flow (SJRIP 2000). During spring runoff and higher flow events, 10 % can be impractical.

Thus an upper limit for ladder design has typically been 50 cfs of attractive flow and 50 cfs in the fish ladder (Mefford 2000a). Under some flood conditions this upper limit may require flow restriction with the ladder forebay gates, or in the case with Alternative III, this limit is not applicable since Alternative III does not include a separate ladder. Details are presented in Section VII.

The exit at the upstream end of the ladder is located along the river banks to provide protection for the exiting fish at a point upstream of the dam and attractive flow pipe. The distance between the fish ladder exit is placed at a distance that is far enough to reduce the possibility of fish floating back downstream and either into the attractive flow pipe or over the dam. At the Redlands facility the fish return pipe is located approximately 20 feet upstream of the upstream end of the ladder and is angled slightly downstream. Some of the fish released after sorting have floated back into the ladder or back over the dam (Burdick 2000b). It may be that the sorting operations stress and disorientate the fish such that they float back downstream for some distance or time period (Burdick 2000b). In California, fish passage design for the Cui-ui, a weaker swimmer than either the razorback sucker or the Colorado pikeminnow, use 50-foot spacing between the ladder and dams (Mefford 2000b).

At the Hartland fish passageway, where selective sorting is not proposed, it is reasonable to assume that the fish are “flow” orientated as they exit the ladder and horizontal clearances are not as critical. For the purpose of developing the fish passageway alternatives, a minimum distance of 50 feet is maintained between the fish ladder exit and the dam, or attractive flow pipe.

3.4 Hartland Diversion Operations

The operation and flow requirements for the fish passage structure cannot interfere with the operation of the Hartland diversion dam. This is an absolute design criteria for the fish passage and is of primary concern during low flow conditions. Two aspects of design are being incorporated to the development of the alternatives that reflect concerns for diversion operations. First, intakes for diverting flows into the fish ladder and attractive flow facility include shut off gates or stop logs to terminate fish passage operations in the event diversion operations are adversely impacted. The second consideration for design and operations is that the fish passageway structure be located on the opposite bank as the ditch and headgate. The purpose of this is two-fold; maintenance of either the ditch headgate or the fish ladder is easier to implement if facilities are on opposite banks and having lateral separation between the two facilities reduces the potential for accidental drift of fish from the ladder back into the facilities.

3.5 Miscellaneous Facility Requirements

There are several additional issues and design constraints for this facility that are used to develop the alternatives for the Hartland fish passage design. These are listed below.

1. Use metal baffles as opposed to concrete. They are easier to replace and/or alter (Mefford 2000b).
2. Install grates on the top of the fish ladder to prevent trash and debris from entering the ladder under flood or high water conditions.
3. Include a log boom and trash rack on the upstream of the fish ladder.

3.6 Fish Screen Criteria

With the introduction of a fish ladder on the main stem of the Gunnison, an increase in fish above the Hartland diversion is anticipated, including the endangered razorback sucker and Colorado pikeminnow. This may, in turn, increase the numbers of fish that accidentally enter the Hartland Ditch. The Upper Colorado Endangered Fish Recovery Implementation Program (UCRIP) fish screen design criteria was developed from the National Marine Fisheries Service (NFMS 1997) fish screening criteria for anadromous salmonids, and the Washington Department of Fish and Wildlife (WDFW 2000). Using this information, the U.S. Bureau of Reclamation, in the Pre-design Memorandum for fish screen alternatives at the Grand Valley

Irrigation Company on the Colorado River in Grand Junction, Colorado (USBR 2000) has developed the UCRIP screening guidelines. The primary design criteria for the fish screens include screen size, approach velocity, sweeping velocity, and design flows. Design guidelines are summarized as follows:

1. Size of screen: 3/32 inch for perforated vertical plate, 1 inch for louvers.
2. Approach velocity, perpendicular to the screen: 0.5 fps.
3. Sweeping velocity, parallel to the screen: 2.0 fps.
4. Screen angle: angle screen to facilitate sweeping and minimizing approach velocities.
5. Trash rack: install close to the screen to remove leaves, trash and twigs that enter the ditch between the diversion and the screen.
6. Log boom: if significant debris is anticipated, install a log boom at the headgate on the Gunnison River.
7. Bypass channel outfall: locate in an area that is relatively free from predation and from eddies and reverse flow.
8. Bypass flow is approximately 3 to 10 % of screened flows.

IV. HYDROLOGY

The purpose of the hydrologic analysis is to determine low flows, typical flows and high flows for which the fish passage will operate during the appropriate times of the year. As part of the design criteria stated in Section III, the operation and flow requirements for the fish passage structure cannot interfere with the operation of the Hartland diversion dam. This is of primary concern during low flow conditions. The hydrologic analysis provides the information necessary to determine the flow conditions for which passage is possible from both a physical and operational standpoint. Typical flows are used to evaluate the hydraulics of the ladder design while peak high flows (flood events) are evaluated in order to design a stable structure.

An analysis of historical flows is conducted to assess conditions throughout the course of an average year. Data used in the analysis came from the United States Geological Survey (USGS) stream gaging station “Gunnison River at Delta, CO” (number 09144250), which is approximately 2 ¼ miles downstream from the diversion dam. The gage is located on the left bank of the Gunnison River near the upstream side of the bridge at U.S. Highway 50 north of Delta. Records are available from June 1, 1976 through 1999. Since water year 2000 is considered “provisional data” it is not used in this analysis.

4.1 Flood Events

Major flood events utilized in this report are based on the flows developed and presented in the Flood Insurance Study (FIS) for Delta County, Colorado, conducted by the Federal Emergency Management Agency (FEMA 1991). These flows are summarized in Table 4.1.

TABLE 4.1 PEAK FLOWS FOR RETURN PERIODS ON THE GUNNISON RIVER AT DELTA, CO

Return Periods (years)	FIS Delta, CO Aug. 19, 1991
10	13,500
50	18,700
100	21,200
500	26,700

4.2 Diversions and Returns

There are no significant diversions between the Delta gage and the Hartland diversion. However, there are two ditches, which return to the Gunnison River immediately upstream of the gage. These ditches are the Relief canal and Bona Fide ditch. The returns are not monitored but are believed to return up to 20 to 30 cfs (Boyd 2000). For the purpose of this analysis these returns are considered negligible.

4.3 Average Monthly Flows

Using gage information from 1976 through the end of 1999, the daily minimum, mean, and maximum flows are calculated for each month. Exceedences for mean daily flows are also determined. As previously discussed, April through August is the critical time for fish passage. Results of the gage analysis are presented in Table 4.2.

Based on the analysis, the average spring runoff since 1976 occurs in late May or early June. 30 days prior to the peak, average flows are approximately 3000 cfs. Average daily flows in August are approximately 1200 cfs with a 50% exceedence of 1100 cfs. The 90% exceedence for August is 350 cfs.

Flood flow-frequency curves for the Gunnison River are based on gage information using log-Pearson Type III distribution for events that are not available from the FIS (USWRC 1981). These return periods and flows are presented in Table 4.3.

TABLE 4.2 MEAN, MINIMUM, AND MAXIMUM AVERAGE DAILY FLOWS BY MONTH ON THE GUNNISON RIVER AT DELTA, CO FOR 1976-1999.

Month	Daily Flow (cfs)	Daily Flow (cfs)	Daily Flow (cfs)	Exceedence for Mean Daily Flows (cfs)				
	Minimum	Mean	Maximum	0.1	0.2	0.5	0.8	0.9
January	299	1630	3700	2991	2385	1481	749	565
February	421	1673	3740	3285	2444	1578	778	617
March	315	1957	5350	3689	3084	1818	809	613
April	282	2532	9120	4806	3913	2085	1091	675
May	299	4776	19,200	9071	7164	4313	1591	896
June	210	4284	20,300	9125	7042	3136	1284	710
July	244	2263	14,100	5175	3341	1310	491	366
August	208	1213	5,100	2296	1708	1097	496	357
September	289	1248	4,390	2125	1788	1123	700	550
October	333	1421	5,030	2612	1987	1272	722	574
November	395	1544	3,730	2698	2393	1446	700	563
December	355	1621	3,280	2598	2393	1446	700	563

TABLE 4.3 FREQUENCY ANALYSIS FOR WATER YEARS 1977-1998 ON THE GUNNISON RIVER AT DELTA, CO

Return Periods (Years)	Peak Flow, cfs
1.25	3,460
2	6,470
5	11,600

4.4 Summary of Design Flows

Several critical design flows are considered to develop a range of flows for conducting the hydraulic analysis. One low flow scenario analyzed is 350 cfs, which represents the flows exceeded 90% of the time in August. By coincidence 350 cfs is also equal to the 90% exceedence value in July. All other months have a 90% exceedence that is greater than 350 cfs, including September and October. The lowest flow of all the years analyzed (1974 to 1998) is approximately 210 cfs which occurred in August of 1977. Calculations indicate that at 210 cfs the headwater over the dam is at elevation 4953.1, which is sufficient to divert at least 80 cfs into the canal as long as the Gunnison River flows are at or above 80 cfs. This low flow scenario may not be physically practical given that the river could be concentrated on the opposite bank or is naturally channelized in the center. This analysis assumes that, given these conditions, which may be similar to the one year noted where HIC bermed the river to direct flows into the canal, the ladder forebay gates are closed.

The average low flow over the record period is 650 cfs. This is determined by averaging the lowest flow from each year from 1976 to 1999. The average August flows of 1200 cfs are also analyzed to insure depths and velocities remain within the design criteria previously addressed. Results are presented in Section VII.

For pre-runoff conditions during fish migration, the average flows in late April and early May are analyzed. The gage data indicates that the average daily flows vary from 2400 to 3500 cfs averaging approximately 3000 cfs. Flows in excess of 3000 cfs are also analyzed to evaluate flood conditions for the 1.25-, 2-, 5-, 10-, 50- and 100-year events of which are typically snowmelt runoff. The higher runoff events are also necessary to evaluate for stability of the structure. These flows are summarized in Table 4.4.

4.5 Ditch Flows for Fish Screen Design

Flows for the screen analysis and by-pass channel are based on diversion records for the Hartland Ditch, measured just downstream of the spill channel. Maximum daily flow records are available from 1970. The average daily diversion is 40 cfs. The maximum daily diversion is 90 cfs. For the purposes of this analysis the 90 cfs is not included since this flow occurred only once since 1970. There is also one year with a maximum day of 70 cfs, however all the other years have peak days that are less than 60 cfs. Thus for the fish screen design a range of flows used to represent the daily flows is 40 cfs and the maximum daily flows is 60 cfs.

TABLE 4.4 DESCRIPTIONS OF DESIGN FLOW, GUNNISON RIVER AT HARTLAND DIVERSION DAM

Flow	Description
210 cfs	Lowest flow in period of record.
350 cfs	90% exceedence of low flow in August. Lowest flow analyzed for ladder design
650 cfs	Average low flow used to establish ladder inverts.
1,200 cfs	Average flows in August
3,000 cfs	Average flows last week of April (anticipated pre-runoff migration period)
3,460 cfs	1.25-year flood event
6,470 cfs	2-year flood event
11,600 cfs	5-year flood event
13,500 cfs	10-year flood event (FIS)
18,700 cfs	50-year flood event (FIS)
21,200 cfs	Regulatory 100-year flood event (FIS)

HIC reports that they typically spill approximately 10 cfs (HIC 2000) at the spill channel, which indicates that the amount of water diverted out of the Gunnison River at the headgates is 50 to 70 cfs. To provide sufficient depth and velocities for the fish in the by-pass channel, an additional 10 cfs is added to the spilled amount of flow. This requires an additional 10 cfs at the headgate to the ditch. Thus the screen is designed for 40 to 60 cfs with 20 cfs being diverted into the spill/by-pass channel.

V. HYDRAULICS

To develop design parameters and evaluate the impacts of a fish passage structure on the hydraulic conditions at the Hartland diversion, a hydraulic model was developed using the Army Corp of Engineers HEC-RAS program, version 2.2 (USACE 1997). A total of 19 river cross sections were surveyed upstream and downstream of the diversion structure by Reclamation. Figure 5.1 shows the location of the cross sections. Tetra Tech, Inc. measured water surface elevations at each cross section at various flows to provide information for

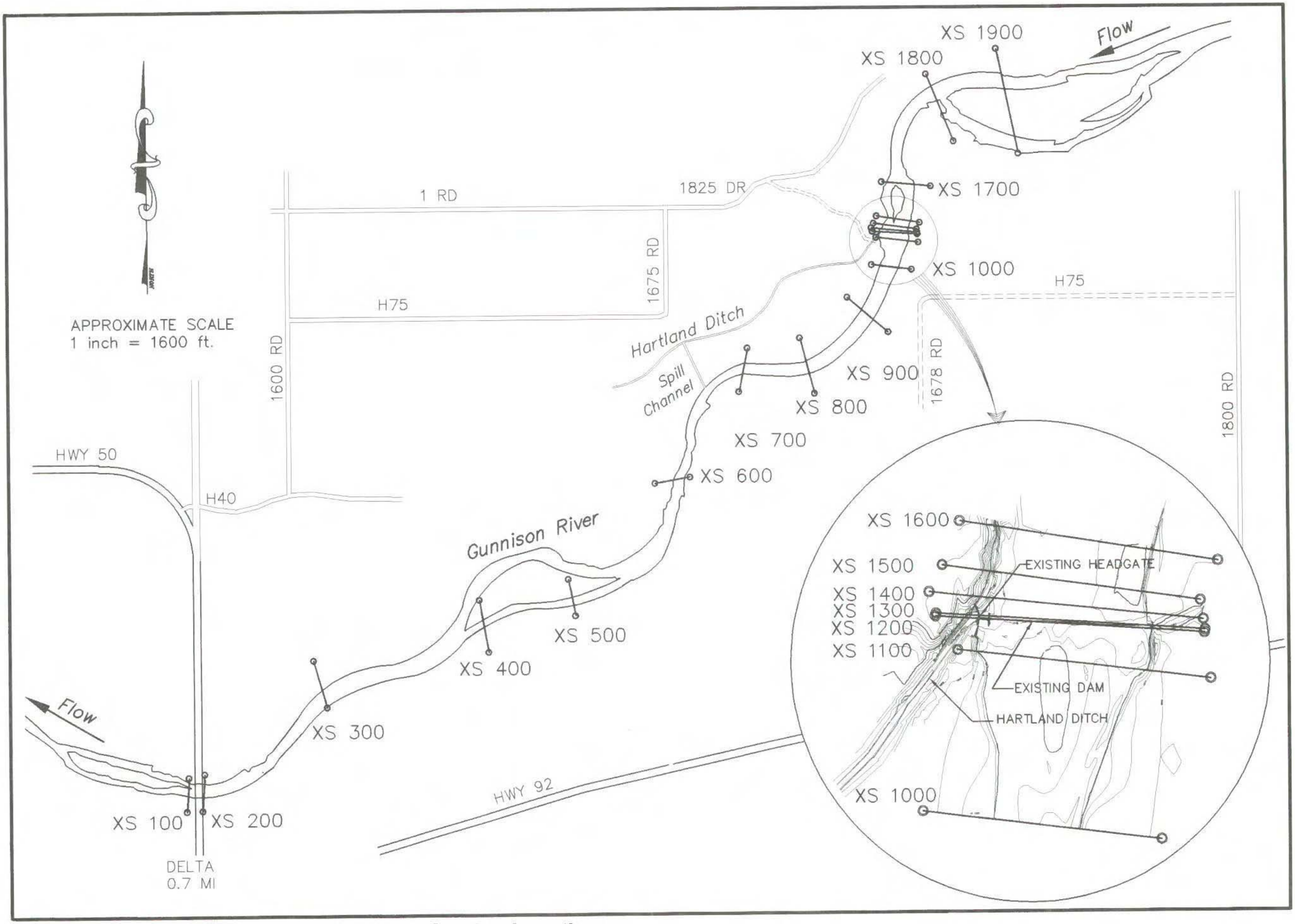


Figure 5.1 - Project Plan View with Cross Section Locations
Hartland Diversion on the Gunnison River

calibration of the model. Cross section 1900 is the most upstream section located approximately ½ miles upstream of the diversion structure. The most downstream cross section is 100 and is located 2 ½ miles below the diversion structure. In addition to the cross section surveys, Reclamation prepared a detailed topographic survey at the Hartland headgate and dam structure.

The hydraulic analysis for the development of the alternatives is based on the assumption that the water levels are controlled by the top of the dam and the rock cribbing along the dam does not have a permeability that results in a significant flow capacity.

5.1 Model Calibration, hydraulic parameters

Manning's n values (roughness coefficient) are estimated from inspection of the channel. The n values within the channel banks are further refined by calibration of the HEC-RAS model based on surveyed water surface elevations. Surveyed water surface elevations are utilized as the downstream boundary conditions and for comparison with the calibration model. Flows utilized in the calibration run are from the USGS gage information at Delta recorded at the time of the water surface elevation surveys. For n-values above the banks, where surveys and calibration runs are not possible, values from the Delta County FIS are used. The flow change option within the HEC-RAS steady flow data editor is used to model a flow intake of 60 cfs at the Hartland headgate. The inline weir editor within HEC-RAS is used to model the diversion as a weir using a weir coefficient of 2.64.

Manning's n values in the model are shown in Table 5.1. These selected n values are within the range of values used by FEMA for the hydraulic analysis of the Gunnison River for preparation of the Delta County FIS. The FEMA values are included in Table 5.1 for comparison purposes. A typical coefficient of contraction of 0.1 and coefficient of expansion of 0.3 is also used in the HEC-RAS model. The calibration run and results are presented in Appendix C.

TABLE 5.1 SUMMARY OF MANNING'S n VALUES USED IN THE GUNNISON RIVER HYDRAULIC MODEL

Location	Manning's n	Manning's n Delta County FIS
Channel	0.039	0.032-0.05
River banks	0.045	0.040-0.10
Overbanks	0.070	0.040-0.10
Dam and diversion structure	0.055	na

5.2 Model Results

Calculations indicate that when flows in the Gunnison River are 350 cfs, the head on the diversions dam is approximately 5 to 6 inches deep at the dam crest and drops a total of 3.1 feet to the toe. At 3000 cfs the head increases to 2 feet and drops a total of 2.4 feet. When flows in the Gunnison River reach 11,600 cfs (the 5-year event) the head on the dam is 4.8 feet and drops a total of 0.9 feet, essentially submerging the drop. Flows in excess of 11,600 cfs results in submerged conditions as well as overbank flooding in many of the river sections within the study reach including, the sections upstream of the diversion structure. Table 5.2 summarizes these water surface elevations at cross sections just upstream and downstream of the Hartland diversion for the modeled flows. Appendix D has a listing of water surface elevations at all cross sections.

TABLE 5.2 WATER SURFACE ELEVATIONS (FT) FOR RANGE OF FLOWS UNDER EXISTING CONDITIONS

Flow rate (cfs)	XS 1500	XS 1400	XS 1300* us of dam	XS 1200** ds of dam	XS 1100	XS 1000
350	4953.39	4953.38	4953.28	4950.12	4950.10	4947.78
650	4953.70	4953.69	4953.54	4950.61	4950.58	4948.50
1200	4954.13	4954.11	4953.91	4951.19	4951.14	4949.40
3000	4955.15	4955.12	4954.81	4952.52	4952.41	4951.27
3460	4955.37	4955.33	4955.01	4952.84	4952.73	4951.65
6470	4956.55	4956.51	4956.12	4954.67	4954.54	4953.66
11600	4958.13	4958.10	4957.63	4956.87	4956.72	4955.90
13500	4958.61	4958.59	4958.10	4957.46	4957.31	4956.48
18700	4959.84	4959.83	4959.30	4958.82	4958.65	4957.75
21200	4960.37	4960.36	4959.83	4959.37	4959.20	4958.27

* Cross Section 1300 is located immediately upstream of the diversion dam

** Cross Section 1200 is located immediately downstream of the diversion structure at the toe of the dam

5.3 Ditch Hydraulics for Fish Screen Design

The survey of the Hartland Ditch was conducted on May 12, 2000. At the time of the survey the staff gage in the ditch reading was 1.78 ft corresponding to 31.2 cfs on the gage rating table (Appendix F). Flow entering the spill channel is estimated to be 12.7 cfs based on weir flow over the existing flashboards. Thus flow in the upstream portion of Hartland Ditch is estimated to be 43.9 cfs. These flows and water surface elevations are used to calibrate the hydraulic parameters for modeling proposed conditions. The results of the calibration analysis are presented in Appendix F. Based on the calibration model, a Manning's n value for the channel is set at 0.038 for the channel and 0.04 along the banks. Depths of water for the range of flows analyzed (60 to 80 cfs) vary between 4 and 5 feet with velocities ranging between 1 to 1.5 fps.

VI. FISH PASSAGE ALTERNATIVES

The following section presents and evaluates three fish passage alternatives. The three include: a concrete fish ladder with baffles on the left bank, a fish ladder with boulder drops on the left bank, and an in-channel boulder drop structure which provides passage for both fish and boats. These alternatives are formulated to provide a set of options, which span the potential range of costs and functionality. Since the HIC headgate and ditch are located on the right bank, to avoid interference with the HIC operations all three alternatives utilize either the left floodplain (Alternatives I and II) or the center of the channel (Alternative III).

6.1 Alternative I

Fish passage for Alternative I is depicted on Drawing 2 in Appendix A. This alternative includes a concrete fish ladder located opposite the Hartland Ditch headgate on the east (left) bank of the river. The fish entrance is located approximately 35 feet downstream of the dam, below the white water being created at the dam toe. The fish ladder is a concrete structure open on top to allow for natural lighting. The top of the fish ladder is set flush with the ground elevations along the left bank and is therefore inundated for flows equal to or greater than 11,600 cfs or the 5-year event. To prevent the entrainment of trash and debris in the ladder during a flood event, the top of the concrete structure includes a horizontal grate. The maximum slope for the concrete fish ladder is 1.3% based on velocity and flow limitations in the ladder.

One optional feature for Alternative I being considered is constructing the fish ladder bottom with grouted river rock to create a roughened bed as shown on the typical details. The purpose of the roughened bottom is to provide diversity in flow velocities, including pockets of low velocities to serve as resting areas. To date there are no known roughened bottom concrete fish ladders in use for the species of concern, so it is experimental. However, flume tests have demonstrated the potential for success (Mefford 2000b).

Calculations indicate that this alternative lowers the water surface elevations at the Hartland headgate by less than 0.1 feet when the river flows are 350 cfs. For flows that equal or exceed 3,000 cfs, the change in water surface elevations, at the headgate, are negligible (0.03 feet or less).

6.1.1 Baffles

Two different baffle designs are being considered; the chevron baffle and the Redlands style baffle. The Redlands style baffle is based on the baffle design in use at the Redlands fish passageway (Burdick 2000a). The baffle includes an orifice opening on the bottom plus one slotted opening from bottom to top. Redlands has documented success in fish passage, however, it is not known which fish are using which opening. Chevron ladders have two slots extending from bottom to top and have a slight bend in the center of the baffle to form a v-shape in plan view. Chevron ladders are being used for Cui-ui sucker fish passage structures in Nevada. The Cui-ui are believed to be weak swimmers (weaker than the razorback suckers) because they are ordinarily lake dwellers that swim in rivers only for spawning. The chevron style baffles appear to be working well for the Cui-ui, providing streamlined flows and less eddies on the upstream side of the baffle than the Redlands style baffle. Eddies may cause fish disorientation in the ladders, especially when turbidity is high and the fish rely on flow for swimming direction. (Mefford 2000a) The chevron slots allow for fish passage anywhere in the water column between the floor and the surface.

6.1.2 Alignment

The upstream end of the fish ladder is approximately 60 feet upstream of the dam and 50 feet from the attractive flow pipe intake. This distance is set to maintain a minimum of 50 feet between the ladder exit and the intake for the attractive flow pipe to reduce the possibility of fish floating downstream into the inlet. The downstream end of the fish ladder is 30 feet from the face of the dam.

The ladder alignment is also shown 20 feet east of the existing dam with the intent of providing sufficient clearance between the fish ladder and the existing dam to avoid disturbance to the existing dam structure and foundation during construction of the fish ladder.

6.1.3 Elevations

The upstream ladder invert elevations, set at 4950, take advantage of a low spot located on the east (left) bank of the Gunnison River. This low spot is approximately 3 feet lower than the top of the dam. Although the dam has been in place for over 100 years, it appears that sediment accumulation is not occurring on the upstream side of the dam. This may be due to the high permeability of the dam material (rock cribbing), which allows for the passage of fine materials. This portion of the Gunnison River is also below several dams, which may result in flows with little sediment.

The invert of the downstream ladder inlet (fish entrance) is set at elevation 4948 which, based on the October 1999 survey data, appears to be the dominant channel elevation at the toe of the dam. The entrance is located near a small, 2 feet deep scour hole. Because the scour hole could create unusual localized flow patterns, this alternative includes filling the scour with riprap to the elevation of the surrounding river bed. The placement of the riprap also elevates the hole to match the elevation of the ladder entrance, which helps the target species locate the fish ladder if the fish are swimming along the channel bottom.

The floor elevations of the ladder also maintain 2 feet minimum depth of water in the fish ladder during the time period when it is anticipated that the passageway is in use, in particular late April through August, which is represented by flows ranging from 3000 cfs to 350 cfs, respectively. Based on the channel surveys in October of 1999 and the hydraulic calculations performed for this analysis, the elevation difference between the channel bed upstream of the dam, where the fish ladder inlet is proposed, and the calculated water surface elevation for 350 cfs is approximately 3.4 feet, while downstream the water depth in the ladder is 2.1 feet. At 3000 cfs these depths are 5.2 and 4.4 feet respectively. When the Gunnison River reaches flows at or above 11,600 cfs, the ladder becomes submerged. Under these conditions, velocities in the ladder remain within the acceptable range for the swimming capabilities of the target species. However, these fish may also be able to pass directly over the dam along the riverbanks.

Flow characteristics in the ladder for the range of design river flows are calculated in conjunction with the hydraulic analysis of the alternative presented in Section VII. Table 7.2 summarizes the results.

5.1.1 6.1.4 Attractive Flow

The inlet for the attractive flow pipe is located between the ladder exit and the dam as shown on the drawings. To minimize the length of the pipeline, the inlet is located as close to the dam as can reasonably be constructed. The distance from the pipe inlet to the ladder exit is also a function of maintaining a 50-foot separation between the pipe inlet and fish exit. The intake design includes a screen for trash and debris.

6.1.5 Access

Access to the fish ladder would be from the east side. Existing roads from the east are available up to approximately 1000 feet from the bank of the diversion dam by following Highway 92 for 3 miles east of Delta to 1800 Road, north on 1800 Road for ½ mile to H75 Road, and east on H75 for ½ mile to 1678 Road. At this point, a new road is required to the diversion structure. For the purposes of this analysis it is assumed that the road is a 10-foot wide gravel road, approximately 1000 feet long. This access road requires at least one culvert to cross an existing ditch. This road also requires an easement as it is on private property.

6.2 Alternative II

Fish passage for Alternative II is depicted on Drawing 3 in Appendix A. This alternative includes the construction of a ladder that utilizes boulders to create a riffle and pool sequence in an artificial side channel. This alternative is located opposite the diversion channel on the east bank of the river. The ladder is a series of rock drops and stilling pools and includes a gate for closure at the fish exit. No grating is proposed over the top of the ladder except at the fish entrance and exit. Thus the ladder is exposed to periodic flood inundation when flows in the Gunnison exceed 11,600 cfs. Consequently, some maintenance may be required after floods occur to remove debris accumulated in the ladder. The grating at the entrance and exit provides access to gates, which are proposed for controlling flows through the ladder and for isolating the ladder from the river.

The rock drops serve as the baffle sections between each pool. A typical rock baffle includes several large boulders, approximately 4 feet in diameter to be placed in the center of the channel section with approximately 12 inch spacing in between. Smaller rocks are placed to the sides of the center boulders. Typical details are found in Appendix B. Upstream of each rock baffle is a pool that is 2 to 4 feet deep. The vertical drop between each pool is 0.25 feet. Maximum velocity is approximately 3 fps.

Calculations indicate that this alternative lowers the water surface elevations at the Hartland headgate by less than 0.1 feet when the river flows are 350 cfs. For flows that equal or exceed 3,000 cfs, the change in water surface elevations at the headgate is negligible (0.03 feet or less).

6.2.1 Alignment

The upstream end of the fish ladder is approximately 100 feet upstream of the dam and 60 feet from the attractive flow pipe intake. The fish entrance is located approximately 40 feet from the white water area at the toe of the dam. These distances are due primarily to the length required to grade this open channel fish ladder and are only several feet longer than Alternative I.

6.2.2 Elevations

The invert elevations of the ladder are set as described in Alternative I. Flow characteristics in the ladder for the range of design river flows are calculated in conjunction with the hydraulic analysis of the alternative presented in Section VII. Table 7.2 summarizes the results.

6.2.3 Attractive Flow

The intake for the attractive flow pipe is located downstream from the fish ladder exit by 60 feet primarily as a function of alignment as discussed above. Distance between the intake and the fish ladder are maintained at 50 feet as discussed in Alternative I. The intake design includes a screen for trash and debris.

6.2.4 Access

Access to the fish ladder is needed from the east side as described in Alternative I.

6.3 Alternative III

Fish passage for Alternative III is depicted on Drawing 4 in Appendix A. This alternative includes dam reconstruction and channel regrading to accommodate both fish and boat passage. In this alternative, boulders and concrete cutoff walls are utilized in conjunction with alterations to the existing dam to create two sequences of chutes and plunge pools.

The upstream cutoff wall is created by utilizing the existing dam. A low flow notch is cut into the structure 1.5 feet deep by 50 feet wide. This notch is designed for boaters and fish by insuring surface flow through the chutes during low flows. The top of the existing dam is capped to create a gentle slope from the low flow notch up to the channel banks. Both the upstream and downstream faces of the dam are backfilled with riprap. The upstream backfill is to protect the structure from debris and to protect boaters from the structure. Downstream riprap serves to provide a continuous bed from the top of the dam, into the plunge pool. The second chute consists of a concrete cutoff wall with the same general shape and dimensions as the reconfigured dam.

Each chute includes grouted boulders 2 to 3 feet in diameter. Smaller boulders and stones line the remaining channel bottom as shown in Drawing 4. A boulder sill, stretching across the width of the channel downstream of the second plunge pool, provides grade control on the downstream end of the structure. Both banks are lined with riprap as shown in Drawing 4 to prevent bank erosion.

This alternative results in higher water surface elevations for the 100-year flood between stations 1500 and 1000 when compared to the water surface elevations under existing conditions. This is due primarily to the drop of 5 feet being distributed over a 320-foot length, as proposed, versus a vertical drop occurring at the existing dam face. To protect the adjacent properties to the east, a berm is recommended along the left bank. The existing right bank (west) is sufficiently high to contain floods up to and including the 100-year event. Upstream and downstream of the proposed structure the water surface elevation changes are negligible from existing conditions. Thus the left bank berm extends only the length of the proposed structure.

This berm is not designed to meet standards set by the Federal Emergency Management Agency (FEMA) for levee protection. The Delta County FIS FIRM map (panel number 080041 0393C, August 19,1991) shows the Gunnison River overtopping much of its banks during the 100-year flood, between the Highway 50 bridge and cross section 1900 at the upstream limit of the study area. In the vicinity of the Hartland diversion dam the 100-year floodplain width is approximately 1400 feet wide over the left bank, extending 3600 feet upstream. Thus a berm or levee at the fish passage structure, as proposed, serves as flood protection from flows that overtop the river bank immediately adjacent to the berm, but not from flood flows that have reached the overbank areas from upstream flooding.

6.3.1 Alignment

The alignment of the fish and boat passage runs through the center of the river, including the boater entrance to the plunge pools. Large boulders are proposed to mark the boater passage. The installation of the fish and boater passage requires the removal of the small island located immediately downstream of the existing dam.

The construction of this alternative may disturb existing wetlands located downstream of the existing dam on the island as well as both banks.

6.3.2 Elevations

The elevations for this alternative must maintain the water levels at the Hartland Ditch headgate and connect to the downstream channel bed. The alternative is shown as a series of two drops, each dropping in 6-inch sequences. The upstream drop includes three 6-inch drops, and the downstream drop includes four 6-inch sequences. Flow characteristics in the chutes and pools for the range of river flows being evaluated are calculated in conjunction with the hydraulic analysis of the alternative presented in Section VII. Table 7.2 summarizes the results.

6.3.3 Access

Access to the fish and boat passage structure could be from either side of the river. Access from the east side would be as described in Alternative I and is preferred since access from river right requires descending very steep river banks.

VII. PRELIMINARY EVALUATION OF ALTERNATIVES

Evaluation of the three alternatives are based on the criteria developed in Section III. These include hydraulic impacts on the functioning of the Hartland diversion and floodplain; fish passageway operations over a range of flows; fish swimming ability; and fish behavior. In addition, the associated construction costs and maintenance requirements are also addressed for each alternative.

7.1 Hydraulics

The potential hydraulic impact on the floodplain and the ability for the Hartland diversion to operate without impact from the proposed alternatives is evaluated in this section. To perform this evaluation, the alterations to the system represented by each alternative are input into the HEC-RAS model. For Alternatives I and II, the model changes include reduction of the flow in the main channel due to the flows being diverted into the ladders and attractive flow. For Alternative III, the model changes take the form of altered cross sections to represent the cutoff walls and passage chutes constructed in the main channel. All three alternatives are analyzed for flows ranging from 350 cfs to 21,200 cfs, representing the August low flow (90% exceedence) to 100-year peak. All three alternatives are also analyzed with an additional 10 cfs being diverted at the Hartland headgates to accommodate the fish screen by-pass channel. Table 7.1 summarizes the results of the hydraulic analysis for each alternative and compares the water surface elevations with existing conditions. In Table 7.1 the column with elevation changes represents the new elevations subtracted from water surface elevations under existing conditions. Flow characteristics in the ladders for each alternative are presented in Table 7.2. Detailed HEC-RAS information is provided in Appendix E.

TABLE 7.1 SUMMARY OF WATER SURFACE ELEVATIONS FOR EXISTING AND WITH LADDER

XS	Flow Rate (cfs)	Alt I			Alt II			Alt III		
		Exist'g WSEL	WSEL w/ ladder	Elev change	Exist'g WSEL	WSEL w/ ladder	Elev change	Exist'g WSEL	WSEL w/ boat chute	Elev change
1500	350	4953.39	4953.31	-0.08	4953.39	4953.30	-0.09	4953.39	4953.62	0.23
	650	4953.70	4953.64	-0.06	4953.70	4953.63	-0.07	4953.70	4954.07	0.37
	1200	4954.13	4954.08	-0.05	4954.13	4954.08	-0.05	4954.13	4954.55	0.42
	3000	4955.15	4955.12	-0.03	4955.15	4955.12	-0.03	4955.15	4955.53	0.38
	3460	4955.37	4955.33	-0.04	4955.37	4955.33	-0.04	4955.37	4955.73	0.36
	6470	4956.55	4956.52	-0.03	4956.55	4956.53	-0.02	4956.55	4956.84	0.29
	11600	4958.13	4958.10	-0.03	4958.13	4958.11	-0.02	4958.13	4958.27	0.14
1300 (Hartland headgate)	350	4953.28	4953.21	-0.07	4953.28	4953.21	-0.07	4953.28	4953.23	-0.05
	650	4953.54	4953.48	-0.06	4953.54	4953.48	-0.06	4953.54	4953.64	0.10
	1200	4953.91	4953.86	-0.05	4953.91	4953.86	-0.05	4953.91	4954.09	0.18
	3000	4954.81	4954.78	-0.03	4954.81	4954.78	-0.03	4954.81	4954.71	-0.10
	3460	4955.01	4954.98	-0.03	4955.01	4954.98	-0.03	4955.01	4954.84	-0.17
	6470	4956.12	4956.10	-0.02	4956.12	4956.10	-0.02	4956.12	4955.6	-0.52
	11600	4957.63	4957.61	-0.02	4957.63	4957.61	-0.02	4957.63	4956.63	-1.00
1100 (Fish entrance)	350	4950.10	4950.10	0	4950.10	4950.10	0	4950.10	4951.04	0.94
	650	4950.58	4950.58	0	4950.58	4950.58	0	4950.58	4951.58	1.00
	1200	4951.14	4951.14	0	4951.14	4951.14	0	4951.14	4952.16	1.02
	3000	4952.41	4952.41	0	4952.41	4952.41	0	4952.41	4953.29	0.88
	3460	4952.73	4952.73	0	4952.73	4952.73	0	4952.73	4953.52	0.79
	6470	4954.54	4954.54	0	4954.54	4954.54	0	4954.54	4954.82	0.28
	11600	4956.72	4956.72	0	4956.72	4956.72	0	4956.72	4956.94	0.22

TABLE 7.2 SUMMARY OF HYDRAULIC PARAMETERS FOR FISH PASSAGE ALTERNATIVES

River Flow (cfs)		350	650	1200	3000	3460	6470	11600
Description		exceeded 90% in Aug & July	average low flow over period of record	exceeded 50% in August	average yearly pre-runoff flow	1.25-yr event	2-yr event	5-yr event
Alt I	Flow in Ladder (cfs)	20	21	23	28	29	29	29
	Aux. Flow(cfs)	43	42	41	40	39	34	28
	Total Flow(cfs)	63	63	64	68	68	63	57
	Ladder Depth (ft)	3.3	3.6	4.1	5.1	5.3	6.5	8.1
	Ladder Velocity (ft/s)	3.0	2.9	2.8	2.8	2.7	2.3	1.8
Alt II	Flow in Ladder (cfs)	49	50	63	75	75*	75*	75*
	Aux. Flow(cfs)	43	42	41	40	39	34	28
	Aux. Flow(cfs)	92	92	104	115	114	109	104
	Ladder Depth (ft)	3.3	3.6	4.1	5.0	5.0*	5.0*	5.0*
	Ladder Velocity (ft/s)	3.0	2.8	2.7	2.7	2.7	2.7	2.7
Alt III	Flow in River (cfs)	350	650	1200	3000	3460	6470	11600
	Depth (ft)	1.7 – 4.5	2.1 – 5.0	2.6 – 5.5	***	***	***	***
	Velocity (ft/s)	4.6 – 0.4	4.7 – 0.7	4.8 – 1.1	***	***	***	***

* River flows entering ladder are limited with forebay gates.

** FLOWS OVERTOP BANKS AND INUNDATE LADDER. FISH PASSAGE POSSIBLE ALONG RIVER BANKS.

*** FISH PASSAGE POSSIBLE ALONG RIVER BANKS.

7.1.1 Alternatives I and II

The HEC-RAS results indicate that under proposed conditions for Alternatives I and II the water level is lower than under existing conditions by less than 0.1 foot for all flows analyzed. When flows in the Gunnison River drop to 350 cfs, the lowest flow analyzed, the drop in water surface elevation due to the ladder and attractive flows, is 0.07 feet. At 3000 cfs the ladder drops the water surface elevations by 0.03 feet. At 11,600-cfs, flows overtop the banks and inundate the ladders for both alternatives.

7.1.2 Alternative III

Under Alternative III, water surface elevations at the intake to the Hartland Ditch are lower than existing conditions by 0.05 feet at low flows (350 cfs) to 0.52 feet during the 2-year event (6470 cfs) and 1.2 feet during the 100-year event (21,200 cfs). Hydraulic calculations indicate that the lower water elevation during the flood stages do not impact the ability to divert flows of 80 cfs or less into the ditch.

Above the headgate water surface elevations are slightly above water elevations under existing conditions for most low flow and flood events. The 100-year flood is 0.14 feet greater than existing conditions at cross section 1500, but by cross section 1600 is equal to or less than existing conditions.

The chutes and plunge pools located between cross sections 1500 and 1000 create an extended high water elevation since the 5 foot vertical drop is now occurring over 320 horizontal feet versus the current vertical drop. As a result of the increased water surface elevations, the existing berm located on the east bank must be extended along the length of the improvements to contain flood flows. To provide additional hydraulic information, intermediate cross sections are included in the HEC-RAS model for Alternative III as shown in Drawing 4 in Appendix A.

7.1.3 Summary of Hydraulic Analysis

The hydraulic evaluation for the headgate operations indicate that as long as flows are at, or above, elevation 4952.5, and as long as there is sufficient flow in the Gunnison River, HIC will be able to divert up to 80 cfs. The water surface elevations estimated for the three alternatives, for the lowest flow analyzed (350 cfs), are all above elevation 4953.2, which is 0.7 feet higher than the minimum required for diversion operations at the headgate. The net effect of the fish passage structures, under low flow conditions of 350 cfs, is to lower the water surface elevation by .07 feet for Alternatives I and II and .05 feet for Alternative III. The net effect of the fish passage structures on water surface elevations, for flows above 350 cfs, decrease as flows increase for Alternatives I and II. The net effect of the fish and boat passage on water surface elevations for Alternative III increase as flows increase above 350 cfs. However the water surface elevations for Alternatives III all remain well above the minimum operating levels.

7.2 Fish Passageway Operations and Swimming Ability

All three alternatives are developed using the same criteria for fish swimming ability. For flows that are less than 11,600 cfs, velocities and depths for Alternatives I and II are in the acceptable range. The fish ladders in Alternatives I and II become inundated when river flows exceed 11,600 cfs, at which time fish passage may be possible directly over the dam along the riverbanks.

Flow characteristics for Alternative III vary not only as a function of river flows but also as a function of location in the passageway. When the Gunnison River is at 350 cfs, depths range from 1.7 to 4.5 feet and velocities vary from 4.6 to 0.4 fps in the chutes and pools, respectively. As flows increase so do depths and velocities. At 1200 cfs, depths range from 2.6 to 5.5 feet and velocities range from 4.8 to 1.1 fps in the chutes and pools, respectively. Above 1200 cfs velocities in the center of the river start to exceed the limits established for fish passage at which time it is anticipated that the fish are able to pass over the structure along the riverbanks. Thus during the critical pre-runoff spawning period in late April, modeled at 3000 cfs, the river banks are accessible for fish passage.

Alternative III design is very similar to the water diversion/fish passageway structure built on the Yampa River for the City of Craig. Flow characteristics and river dimensions of the Yampa River are very similar to the Gunnison River at the Hartland diversion structure.

Follow-up studies by BIO/WEST, for the City of Craig, indicate that native fish are crossing the structure in both the upstream and downstream directions, although there were no endangered fish captured during the study period. The study was conducted between March 24, 1992 and December 15, 1992 and included 5 field trips to document fish passage. The study documents the passage of many fish. Eight surrogate species crossed the structure including the flannelmouth sucker and northern pike. Of the eight documented passages, four were moving upstream and four downstream (BIO/WEST 1993). The study also concludes that "no evidence of fish aggregations was found below the diversion structure during the study, indicating that the structure did not impede upstream movement" (BIO/WEST 1993).

7.3 Fish Behavior versus Design

In general all three alternatives use the general fish behavior criteria presented in Section III of this report, including consideration for locating the fish entrances and exits. The exception to this is that Alternative III fish passage sections are located in the center of the channel with the boater passage under low flow conditions. As previously discussed the riverbanks become accessible for the fish as flows reach 3000 cfs, which represents the average flows in late April during which migration occurs. Calculations indicate that under low flow conditions (less than 3000 cfs) the velocities in the chutes tend to be higher than the design limits based on swimming ability. These velocities are averages for the low flow section, which have a wide range of diversity in velocities due to the large boulders proposed for the chutes. One of the purposes of using boulders in the chutes is to provide resting areas needed for fish passage of the target species.

7.4 Opinion of Probable Cost

Preliminary cost estimates are developed for the construction of each alternative and are presented in the following sections. The costs for each alternative are based on current (year 2000) unit prices and assume the project is competitively bid and built by a private contractor.

7.4.1 Alternative I

Costs for Alternative I include excavation for installation of the concrete fish ladder with a grouted rock (roughened) bottom, two gates, a log boom and a 30-inch attractive flow pipe. The cost for baffles assume that the Redlands style and chevron style are both similar and are therefore not differentiated here. Costs assume that access and staging are available from the east side of the river. Costs for the access road are for construction of a 10-foot gravel road. Costs do not include easement or property acquisition.

The total estimated construction cost for Alternative I is $493,700. Maintenance costs are calculated for both annual and present worth over a 50-year life span at 8% and 3% inflation per year. The total construction cost plus maintenance costs (present value) are estimated to be $530,700.

TABLE 7.3 CONCEPTUAL DESIGN ALTERNATIVE I – OPINION OF PROBABLE COSTS

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ESTIMATED COST
1 Mobilization/demobilization	LS	1	$12,000	$12,000
2 Concrete Fish Ladder				
Excavation	CY	2500	$8	$20,000
Shoring	SF	1200	$20	$24,000
Structural Backfill	CY	2000	$8	$16,000
Concrete	CY	200	$600	$120,000
Grate	SF	1350	$40	$54,000
Guard Rail	LF	160	$20	$3,200
Grouted Riprap	CY	35	$400	$14,000
Baffles (Chevron)	EA	10	$750	$7,500
5' x 5' Gates	EA	2	$7,500	$15,000
3 Attractive Flow				
30" DIP	LF	110	$100	$11,000
30" Gate	EA	1	$8,000	$8,000
Screen	EA	1	$2,500	$2,500
4 Riprap	TN	300	$60	$18,000
5 Water Control/Dewatering	LS	1	$25,000	$25,000
6 Native Seeding	AC	1	$4,500	$4,500
7 Log Boom	LS	1	$5,000	$5,000
8 Access Road	LS	1	$20,000	$20,000
			SUBTOTAL	**$379,700**
			DESIGN/ SURVEYING/ INSPECTION (10%)	**$38,000**
			CONTINGENCY (20%)	**$76,000**
			TOTAL ESTIMATED COST	**$493,700**
Maintenance costs for trash and debris removal - yearly				
Annual clean-up				$2,000
Present value (8%, 50 years, 3% inflation)				$37,000
TOTAL CONSTRUCTION AND MAINTENANCE COST				**$ 518,100**

7.4.2 Alternative II

The total estimated construction cost for Alternative II is $353,000. The lower material costs is the primary reason this alternative is less expensive to construct than Alternative I. The cost for this alternative is influenced by the price of riprap and the haul distance. This alternative also requires additional follow-up construction and maintenance efforts to adjust and position the rock baffles. Costs assume that access and staging are available on the east side of the river. Costs for the access road are for construction of a 10-foot gravel road. Costs do not include easement or property acquisition.

Maintenance costs are calculated for both annual and present worth over a 50-year life span at 8% and 3% inflation per year. The total construction cost plus maintenance costs (present value) are estimated to be $428,000.

TABLE 7.4 CONCEPTUAL DESIGN ALTERNATIVE II – OPINION OF PROBABLE COSTS

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ESTIMATED COST
1 Mobilization	LS	1	$12,000	$12,000
2 Rock Fish Ladder				
Excavation	CY	3000	$10	$30,000
Backfill	CY	120	$10	$1,200
Concrete	CY	80	$600	$48,000
Grate	SF	50	$40	$2,000
Guard Rail	LF	130	$20	$2,600
Dredge Rock	TON	450	$25	$11,250
Boulders (4' dia.)	TON	150	$80	$12,000
Boulders (2' dia.)	TON	20	$60	$1,200
5' x 5' Gates	EA	2	$7,500	$15,000
3 Attractive Flow				
30" DIP	LF	150	$100	$15,000
30" Gate	EA	1	$8,000	$8,000
Screen	EA	1	$2,500	$2,500
4 Riprap	TON	900	$60	$54,000
5 Water Control/Dewatering	LS	1	$25,000	$25,000
6 Native Seeding	AC	1.5	$4,500	$6,750
7 Log Boom	LS	1	$5,000	$5,000
8 Access Road	LS	1	$20,000	$20,000
			SUBTOTAL	**$271,500**
			DESIGN/ SURVEYING/ INSPECTION (10%)	**$27,200**
			CONTINGENCY (20%)	**$54,300**
			TOTAL ESTIMATED COST	**$353,000**
Maintenance costs for trash and debris removal - yearly				
Annual maintenance			$2,000	
Clean-up			$2,000	
Subtotal, yearly costs				$4,000
Present value (8%, 50 years, 3% inflation)				$75,000
TOTAL CONSTRUCTION AND MAINTENANCE COST				**$ 428,000**

7.4.3 Alternative III

Substantial amounts of riprap and boulders are required to line, mark, and stabilize the channel in Alternative III. Costs associated with water control and dewatering during construction also amplify the total cost of this alternative. At an estimated construction cost of $2,011,000, Alternative III is significantly the most expensive of the three. This alternative also requires additional follow-up construction and maintenance efforts to adjust and position the boulder chutes and pools.

Costs assume that access and staging are available on the east side of the river. Costs for the access road are for construction of a 10-foot gravel road. Costs do not include easement or property acquisition, and cost of wetland mitigation.

The total estimated construction cost for Alternative III is $2,011,000. Maintenance costs are calculated for both annual and present worth over a 50-year life span at 8% and 3% inflation per year. The total construction cost plus maintenance costs (present value) are estimated to be $2,132,000.

TABLE 7.5 CONCEPTUAL DESIGN ALTERNATIVE III – OPINION OF PROBABLE COSTS

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ESTIMATED COST
1 Mobilization	LS	1	$40,000	$40,000
2 Notch existing dam, install concrete cap	LS	1	$35,000	$35,000
3 Boat/Fish Passageway				
Excavation	CY	15000	$8	$120,000
Backfill	CY	3000	$8	$24,000
Concrete	CY	170	$600	$102,000
Boulders - channel markers	TON	100	$80	$8,000
Grouted Boulder Chutes	TON	2400	$85	$204,000
4 Riprap banks and bottom	TON	20000	$45	$900,000
5 Berm embankment	CY	3000	$8	$24,000
6 Water Control/Dewatering	LS	1	$80,000	$80,000
7 Native Seeding	AC	2	$4,500	$9,000
8 Log Boom	LS	1	$5,000	$5,000
9 Access Road	LS	1	$20,000	$20,000
			SUBTOTAL	**$1,571,000**
			DESIGN/ SURVEYING/ INSPECTION (8%)	**$126,000**
			CONTINGENCY (20%)	**$314,000**
			TOTAL ESTIMATED COST	**$2,011,000**
Maintenance costs for trash and debris removal - yearly				
Annual maintenance			$4,500	
Clean-up			$2,000	
Subtotal, yearly costs				$6,500
Present value (8%, 50 years, 3% inflation)				$121,000
TOTAL CONSTRUCTION AND MAINTENANCE COST				**$2,132,000**

7.5 Maintenance

Based on field observations it appears that excessive sedimentation is not a current problem at the Hartland diversion structure and is not a problem for the proposed fish ladders. Both Alternatives II and III require periodic maintenance for adjusting, relocating or replacing boulders. In addition debris removal and clean up may be required following seasonal high waters and flood events for all three alternatives.

All three alternatives include the recommendation for installation of a log boom at the Hartland Ditch headgate for collecting large sized trash and debris. This requires ongoing maintenance as part of the ditch maintenance program, which already includes a yearly cleanup effort. The use of the log boom helps in localizing the debris and preventing the debris from entering the ditch.

6.1 7.6 Summary of Alternatives

Alternatives I and II are similar in function and cost. Each provides a fish passageway structure with minimal impact to diversion operations and each is relatively inexpensive. Both alternatives are aligned to go around the existing diversion avoiding impacts to the structure itself and both can be easily shut off using the gates at the exit and entrances. Both alternatives could also be converted to selective sorting facilities if the need arose. Alternative II has a more natural appearance since it is a rock constructed riffle-pool ladder, however, the boulder baffles may require follow-up maintenance especially after high flood events. Alternative I is relatively low maintenance except for occasional cleaning. The disadvantage with these two alternatives is that neither accommodates boater passage.

Alternative III has the advantage of accommodating boater passage. In addition, this structure brings a more natural appearance to the river by creating chutes and pools. Alternative III also has the disadvantage of being very expensive. With this alternative, there are also impacts and issues inherent to creating a boatable structure, including safety and the social issues of increased river use in this reach, and identifying who is responsible for maintenance, since the chutes and pools are intended for public use.

Table 7.6 presents a summary of the three alternatives, main features, costs and advantages and disadvantages of each.

TABLE 7.6 SUMMARY OF ALTERNATIVES

Feature	Alternative I	Alternative II	Alternative III
Type	Concrete with option of roughened bottom	Open channel with rock baffles, pools & riffles	Fish and boat passage with chutes and pools
Fish Passage	Ladder available for all flow	Ladder available for all flow	Center of river for low flow conditions, banks of river for flood events
Baffles	Chevron or Redlands-style	Rock drops with one (1) foot spacing	Low flow notch
Drop between baffles	0.4 ft	0.25 ft	15:1 slope into pools
Alignment at Entrance	30 feet below dam	40 feet below dam	Center of river
Slope	1.3%	1%	15:1 and pools
Exit	60 feet upstream of dam	100 feet upstream of dam	Center of river
Ladder Hydraulics			
River flow 350 cfs			
Ladder flow	20 cfs	49 cfs	na
Aux. Flow	43 cfs	43 cfs	na
Total flow	63 cfs	92 cfs	na
Depth	3.3 ft	3.3 ft	1.7-4.5 ft
Velocity	3.0 fps	3.0 fps	4.6-0.4 fps
River flow 11600 cfs			
Ladder flow	29 cfs	75 cfs(gated, controlled)	Passage along banks
Aux. Flow	34 cfs	28 cfs	na
Total Flow	63 cfs	104 cfs	na
Depth	8.1 ft	5.0 ft	na
Velocity	1.8 fps	2.7 ft	na
Access	East side, easements required	East side, easements required	East side, easements required
Effect on W.S. elevation at Hartland Diversion			
River at 350 cfs	(0.07) ft	(0.07) ft	(0.05) ft
River at 21260 cfs	(0.01) ft	(0.01) ft	(1.20) ft
Maintenance	Trash and debris	Trash and debris, rock replacement	Trash and debris, boulder replacement
Costs	$493,700	$353,000	$2,011,000
Maintenance Costs: yearly present value, 8%, 50-yr, 3% inflation)	$2,000 $37,000	$4,000 $75,000	$6,500 $121,000
Construction cost & maintenance (pres. value)	$530,700	$428,000	$2,132,000
Disadvantages	Not available for boat passage Least natural appearance	Not available for boater passage Rock baffles require maintenance to insure proper placement	Five times the cost of Alternative II Rock chutes require maintenance to insure proper placement May disturb existing wetlands Safety and social issues with increased public use
Advantages	Cost within 20% of Alternative II Easy to maintain Could be converted for selective passage	Least expensive Could be converted for selective passage	Available for boat passage More natural appearance

VIII. Fish Screen Options

Three options are evaluated in this section based on the criteria developed in Section III. These include screen sizes, sweeping velocities, and approach velocities. In addition, the associated construction costs and maintenance requirements are also addressed for each option.

Fish screen design for the Hartland Ditch is based on guidelines developed by the U.S. Bureau of Reclamation. The Bureau prepared a Pre-design Memorandum for fish screen alternatives at the Grand Valley Irrigation Company irrigation ditch on the Colorado River in Grand Junction Colorado (USBR 2000). The GVIC fish screen design initially was based on using a 300-mm opening to screen for adult fish. This is considered reasonable since spawning is minimal above the irrigation ditch diversion (USBR 2000). However, the memorandum points out that a 3/32-inch size opening screens most of the life stages of the targeted species (razorback sucker and Colorado pikeminnow) and is only approximately 17% more in cost than a 300-mm screen. Furthermore, the Bureau of Reclamation's experience is that the larger holes actually wedged more debris in the openings than the smaller holes and that the wedged debris in the larger holes is difficult to clean (Norman 2000). Thus Reclamation recommended the GVIC screen use a 3/32-inch vertical plate screen.

Following the same rational, the Hartland Ditch is evaluated for the feasibility of installing a vertical plate fish screen using 3/32-inch openings. In addition, a louvered screen is also considered which has one-inch openings. Although the louvered screen does not screen for all life stages, it does screen for fish larger than 300 mm and is small enough to prevent the screened fish from being "gilled" (USBR 2000). Rotary drum screens are also presented as an option. Each of these alternatives is reviewed in the following sections.

8.1 Option A: Vertical Flat Plate Screen

This option includes a vertical plate screen installed at approximately 20 degrees from the bank. The screen is 44 feet long, 5 feet high and includes an access platform over the top of the entire screen. This alignment is shown on Figure 5 in Appendix A. The depth of water at the screen is 4 feet when the ditch is flowing at 40 cfs and 4.6 feet at 60 cfs, leaving 0.4 to 1.0 feet of freeboard. This configuration has an approach velocity of 0.5 fps and a sweeping velocity of 1.2 fps. HIC has indicated that trash and debris are significant problems in the ditch. Therefore a trash rack is recommended immediately upstream of the fish screen and a log boom at the headgates to the Hartland Ditch on the Gunnison River.

Cleaning of the vertical plate screen is typically done with a motor driven brush (USBR 2000), which requires the installation of power to the site.

8.2 Option B: Louvered Screen

Louvered screens consist of vertical slats with one (1) inch spacing assembled similar to a Venetian blind (USBR 2000). The layout is the same as the vertical plate shown on Figure 5 in Appendix A and include an access platform over the entire top of the screen. Louvers do not require a mechanical cleaning system but requires periodic manual cleaning (USBR 2000).

8.3 Option C: Rotary Drum Screens

There are two possibilities for rotary drum screens. The first is a cylindrical rotary drum that rotates with a small electric motor. The drums lift debris and carry it over to the downstream side where it is carried off by the ditch flow. The second option is a self-rotating paddlewheel using water to turn the wheels. The WDFW has used paddlewheel drums for low flow channels up to 40 cfs, although 60 cfs could easily be accommodated in a paddlewheel driven drum. Based on 75 % submergence and 60 cfs, three 6-foot diameter drums would be required.

HIC has indicated that trash and debris are significant problems in the ditch. Therefore a trash rack is recommended immediately upstream of the drums and a log boom at the headgates to the Hartland Ditch on the Gunnison River.

Based on cost data from the WDFW, rotating drums are almost twice as expensive as vertical plates. Furthermore the paddlewheel driven drums are more expensive to construct and install then the motor driven wheels. However, the self-rotating paddlewheel has the advantage of not requiring electricity. Therefore this option is included in the Opinion of Probable Costs for comparison purposes.

8.4 Bypass Channel

One of the main reasons for installing the fish screen at the location of the existing spill channel is to utilize the spill channel as a bypass to return the fish to the Gunnison River. This includes the use of approximately 10 cfs that HIC historically has over diverted and spilled back into the Gunnison River, thereby reducing the additional flows needed to sweep fish out of the ditch and back into the river. Design considerations include minimum depths of 0.75 feet and minimum velocities of 2 fps in the return channel (NMFS 1997). These design standards have been developed for salmon but are used here since the fish in the by-pass channel are being swept out to the main river, with the flow direction as opposed to an upstream orientation.

Hydraulic calculations for the spill channel indicate that the spill channel is under the influence of backwater from the Gunnison River for most flow conditions except low flows below 650 cfs, which represents the average low flow over the record period. Velocities drop below the recommended 2 fps when the Gunnison River flows exceed 2000 cfs. 2000 cfs is less than the average annual flow but it is exceeded at least 50% of the time in April, May, June and July. When flows in the Gunnison are in excess of 11,600 cfs (5-year event) in the river, backwater is high enough to submerge the spill channel reducing velocities to negligible rates. Thus, when flows in the river are at or above 2000 cfs the velocities in the spill channel are less than the minimum recommended 2 fps for carrying fish back to the river. Under these conditions, fish are swept into the entrainment area but may linger in the spill channel. The following table summarizes hydraulic conditions for this range of river flows with 20 cfs in the spill channel.

TABLE 8.1 SUMMARY OF HYDRAULIC CONDITIONS FOR 20 CFS IN THE SPILL CHANNEL

Gunnison River Flow	Spill Channel Depth	Spill Channel Velocity
650 cfs	0.8 to 1.4 ft	4.2 to 2.3 fps
1200 cfs	1.0 to 1.3 ft	3.0 to 2.6 fps
2000 cfs	1.7 to 1.3 ft	1.4 to 2.4 fps
3000 cfs	2.3 to 1.8 ft	0.9 to 1.4 fps
6460 cfs	4.2 to 3.7 ft	0.4 to 0.5 fps
11600 cfs	6.4 to 5.9 ft	0.2 fps

In order to utilize the spill channel some modifications are required to the headgate structure. The scenario, presented in Drawing 5 in Appendix A, includes replacing the flashboards with a 5 foot square gate and constructing a concrete weir at the downstream end of the existing apron to create an entrainment area. A small concrete channel is included to connect the weir outlet to the 36-inch culvert inlet.

8.5 Estimated Costs

Approximate costs have been developed utilizing price information available from the Yakima Screen Shop at the Washington Department of Fish and Wildlife (WDFW 1999) along with information from the GVIC report (USBR 2000). Option A is for a vertical plate and Option B is for a paddlewheel driven drum screen. Louvers or profile bar screen are not detailed in the cost estimate, however, both are approximately 15% of the cost for vertical plates (USBR 2000).

Costs for the bypass channel are presented based on utilizing the existing spill channel. Maintenance costs for cleaning varies depending on the type of screen. This estimate includes cleaning two hours per day, 3 days per week for 26 weeks a year. Maintenance costs are calculated for both annual and present worth over a 50-year life span at 8% and 3% inflation. Repair costs to the screening facilities have not been included since they vary depending on the type of screen, and type of repairs needed.

TABLE 8.2 OPINION OF PROBABLE COSTS: OPTION A: VERTICAL PLATES

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ESTIMATED COST
1 Mobilization/demobilization	LS	1	$15,000	$15,000
2 Concrete Weir and Apron				
Concrete	CY	20	$600	$12,000
Structural Backfill	CY	20	$50	$1,000
Guard Rail	LF	200	$20	$4,000
5' x 5' Gate	EA	1	$7,500	$7,500
3 Screen and Deck				
Screen-Vertical Plate	SF	240	$500	$120,000
Decking	SF	1200	$40	$48,000
Site work& misc concrete	LS	1	$20,000	$20,000
Cleaner	SF	240	$40	$9,600
4 Trash Rack and Deck				
Trash Rack	SF	100	$50	$5,000
Decking	SF	80	$40	$3,200
Site work& misc concrete	LS	1	$1,000	$1,000
Cleaner	SF	100	$40	$4,000
5 Water Control/Dewatering	LS	1	$5,000	$5,000
6 Electric				
Power	LF	3000	$10	$30,000
Transformer	EA	1	$10,000	$10,000
Panel, lights, misc	LS	1	$5,000	$5,000
7 Native Seeding	AC	0.25	$6,000	$1,500
			SUBTOTAL	**$301,800**
			DESIGN/SURVEYING/INSPECTION (10%)	**$30,000**
			CONTINGENCY (20%)	**$60,000**
			TOTAL ESTIMATED COST	**$391,800**

Operation and Maintenance costs for trash and debris removal - yearly	
Annual clean-up and electric costs	$6,000
Present value (8%, 50 years, 3% inflation)	$111,000
TOTAL CONSTRUCTION AND MAINTENANCE COST	**$ 502,800**

TABLE 8.3 OPINION OF PROBABLE COSTS: OPTION B: PADDLEWHEEL DRUMS

	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	ESTIMATED COST
1	Mobilization/demobilization	LS	1	$15,000	$15,000
2	Concrete Weir and Apron				
	Concrete	CY	20	$600	$12,000
	Structural Backfill	CY	20	$50	$1,000
	Guard Rail	LF	200	$20	$4,000
	5' x 5' Gate	EA	1	$7,500	$7,500
3	Screen and Deck				
	Drum & paddlewheels	SF	260	$1,000	$260,000
	Decking	SF	1200	$40	$48,000
	Site work& misc concrete	LS	1	$20,000	$20,000
4	Trash Rack and Deck				
	Trash Rack	SF	100	$50	$5,000
	Decking	SF	80	$40	$3,200
	Site work& misc concrete	LS	1	$1,000	$1,000
	Cleaner	SF	100	$40	$4,000
5	Water Control/Dewatering	LS	1	$5,000	$5,000
				SUBTOTAL	**$385,700**
				DESIGN/SURVEYING/INSPECTION 10%)	**$38,000**
				CONTINGENCY (20%)	**$77,000**
				TOTAL ESTIMATED COST	**$500,700**

Operation and Maintenance costs for trash and debris removal - yearly

Annual clean-up	$4,000
Present value (8%, 50 years, 3% inflation)	$75,000

TOTAL CONSTRUCTION AND MAINTENANCE COST **$ 575,700**

IX. PERMITTING

The two primary regulatory requirements for the project are NEPA compliance and the Corp of Engineers 404 permit. In addition, approval may be required from the Federal Emergency Management Agency if floodplain elevations are altered, which is the case if Alternative III is selected. The calculations indicate that floodplain modifications are minimal, however, an evaluation and permitting is recommended to ensure regulatory compliance with the National Flood Insurance Program.

A construction dewatering permit is required from the State, which is obtained by the contractor at the time of construction.

Construction of all alternatives require the appropriate approvals and easements from adjacent and affected property owners.

X. RECOMMENDATIONS PRIOR TO FINAL DESIGN

Prior to proceeding with final design on any of these alternatives there are several additional evaluations that are recommended. These are listed as follows:

1. Consideration of Alternative III should include a survey of the existing dam and surveys of the river channel for the entire length of disturbance and reconstruction.
2. Consideration of Alternative III should include a wetland evaluation to assess the extent of disturbance to existing wetlands.
3. Consideration of Alternative III should include a floodplain evaluation to ensure regulatory compliance with the National Flood Insurance Program.
4. Boulder and riprap sizing as well as scour analysis should be performed on all rock placement for whichever alternative is selected.
5. Contact property owners to secure access easement.
6. Coordinate with City and County of Delta on Alternative III.
7. Consideration of Alternatives I or II should include surveys of water levels at the dam crest during low flow conditions. Several readings with flows under 500 cfs are recommended.
8. Consideration of Alternatives I or II should include a geotechnical investigation, including exploratory pits to investigate foundation conditions and soils conditions along the dam's foundation on the east bank.

XI. REFERENCES

Berry, C.R. and R. Pimentel. 1985. "Swimming Performances of three Rare Colorado River Fishes." Transactions of the American Fisheries Society, 114:397-402.

Bestgen, K.R. 1990. "Status Review of the Razorback Sucker, Xyrauchen Texanus." U.S. Dept. of the Interior, Bureau of Reclamation, Upper Colorado Regional Office. Salt Lake City, UT. Contribution 44, Colorado State University Larval Fish Laboratory.

BIO/WEST, 1993, "City of Craig, Colorado, Yampa River Diversion Fish Passage Study, Final Report," Prepared for the City of Craig, Colorado, 38 pp + appendices.

Boyd, Jimmy. Water Commissioner, District 41, State of Colorado Engineers Office, Division of Water Resources. May 9,2000. Telephone Conversation.

Burdick, Bob. U.S. Fish and Wildlife Service. February 4, 2000a, Meeting.

Burdick, Bob. U.S. Fish and Wildlife Service. March 21, 2000b, Telephone conversation.

Burdick, Bob. U.S. Fish and Wildlife Service. August, 2000c, Personal Communication.

Burdick, B.D. and F.K. Pfeifer, 1996. "Discussion of the Merits for Fish Passage at Hartland Diversion Dam on the Gunnison River near Delta, Colorado." U.S. Fish and Wildlife Service, Grand Junction, Colorado. 8pp.

Colorado's Decision Support System (CDSS) October 26, 1999. At http://cdss.state.co.us/

Federal Emergency Management Agency (FEMA). 1991. "Flood Insurance Study, for Delta County, Unincorporated Areas, Colorado.

Hartland Irrigation Company (HIC). April 7, 2000. Personal communication during informal meeting.

Irving, D.B. and T. Modde. 2000. Home-range fidelity and use of historic habitat by adult Colorado pikeminnow, *Ptychocheilus lucius,* in the White River, Colorado and Utah. Western North American Naturalist 60 (1): 16-25.

Mefford, Brent, U.S. Bureau of Reclamation. February 17, 2000a, Telephone conversation.

Mefford, Brent, U.S. Bureau of Reclamation. February 22, 2000b, Meeting.

National Marine Fisheries Service (NMFS) Southwest Region, January 1997. *Fish Screening Criteria for Anadromous Salmonids*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 10pp.

Norman, Bob. U.S. Bureau of Reclamation. May 2000, Telephone conversation.

Osmundson, D.B., and L.F. Kaeding. 1991. Recommendations for flows in the 15-mile reach during October-June for maintenance and enhancement of the endangered fish populations in the Upper Colorado River. Final Report to the Recovery Implementation Program for Endangered Fishes of the Upper Colorado River. U.S. Fish and wildlife Service, Grand Junction, Colorado.

Pfeifer, Frank, U.S. Fish and Wildlife Service. February 24, 2000a, Telephone conversation.

Pfeifer, Frank, U.S. Fish and Wildlife Service. March 16, 2000b, Meeting.

Pfeifer, Frank, U.S. Fish and Wildlife Service. May 30, 2000c, Telephone conversation.

San Juan Recovery Implementation Program (SJRIP). April 11,2000, Personal communication with committee at committee meeting.

Tyus, H.M. and C. W. McAda. 1984. Migration, movements and habitat preferences of Colorado squawfish (pikeminnow), *Ptychocheilus lucius*, in the Green, White and Yampa rivers, Colorado and Utah. Southwestern naturalist 29:289-299.

Tyus, H.M. 1990. Potamodromy and reproduction of Colorado Squawfish (pikeminnow) in the Green River basin, Colorado and Utah. Transactions of the American Fisheries Society 119:1035-1047.

Tyus, H.M. 1991. Ecology and management of Colorado Squawfish (pikeminnow). Pages 379-402 in W.L. Minckley and J.E. Deacon editors. Battle against extinction: native fish management in the American west. University of Arizona Press, Tucson.

Tyus, H.M. and C.A. Karp. 1990. Spawning and movements of razorback sucker, *Xyrauchen texanus*, in the Green River Basin of Colorado and Utah. Southwestern Naturalist 35:427-433.

U.S. Army Corps of Engineers (USACE). 1997. *HEC-RAS River Analysis System User's Manual*. Hydrologic Engineering Center, Davis, CA.

U.S. Bureau of Reclamation (USBR), January 2000. *Predesign Memorandum, Grand Valley Irrigation Company Fish Screens*, U.S. Bureau of Reclamation, PN Region Design Group, Boise Idaho. 33pp (and appendices).

U.S. Water Resources Council (USWRC). 1981. Guildelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Committee. Washington, D.C.

Washington Department of Fish and Wildlife (WDFW). 5/26/1999. Yakima Screen Shop. At: www.wa.gov/wdfw/hab/engineer/scrunit.htm.

Washington Department of Fish and Wildlife (WDFW). 5/11/2000. Screening Requirements for Water Diversions. At: www.wa.gov/wdfw/hab/engineer/fishcrn.htm.

APPENDIX A – DRAWINGS

NOTE:

TOPOGRAPHIC MAPPING BY THE US BUREAU OF RECLAMATION. NGS BENCHMARK STAMPED V429 1984, ELEV. 4938.23, NAVD 88.

LEGEND

EXISTING CONTOUR – 1
EXISTING CONTOUR – 5
CROSS SECTION
EDGE OF WATER 05/03/99

20 0 20 40 60

SCALE OF FEET
1 inch = 40 ft.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
FISH PASSAGE PROJECT – COLORADO

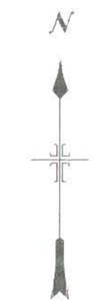
BASE MAP – HARTLAND DIVERSION
GUNNISON RIVER
WORK DRAWING

DESIGNED P. BAILEY FIELD APPROVAL
DRAWN N. MLADENOV TECHNICAL APPROVAL
CHECKED APPROVED

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
410 S French Street, P.O. Box 1659
Breckenridge Co 80424
(970) 453-6394 Fax (970) 453-4579

DATE PLOTTED
12/20/00

DRAWING 1



NOTE:

TOPOGRAPHIC MAPPING BY THE US BUREAU OF RECLAMATION. NGS BENCHMARK STAMPED V429 1984, ELEV. 4938.23, NAVD 88.

LEGEND

- EXISTING CONTOUR – 1
- EXISTING CONTOUR – 5
- PROPOSED CONTOUR – 1
- PROPOSED CONTOUR – 5
- CROSS SECTION
- GRATE
- GUARD RAIL
- CONCRETE
- GRAVEL ROAD
- EDGE OF WATER 05/03/99

20 0 20 40 60

SCALE OF FEET
1 inch = 40 ft.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
FISH PASSAGE PROJECT – COLORADO

ALTERNATIVE I – HARTLAND DIVERSION
GUNNISON RIVER

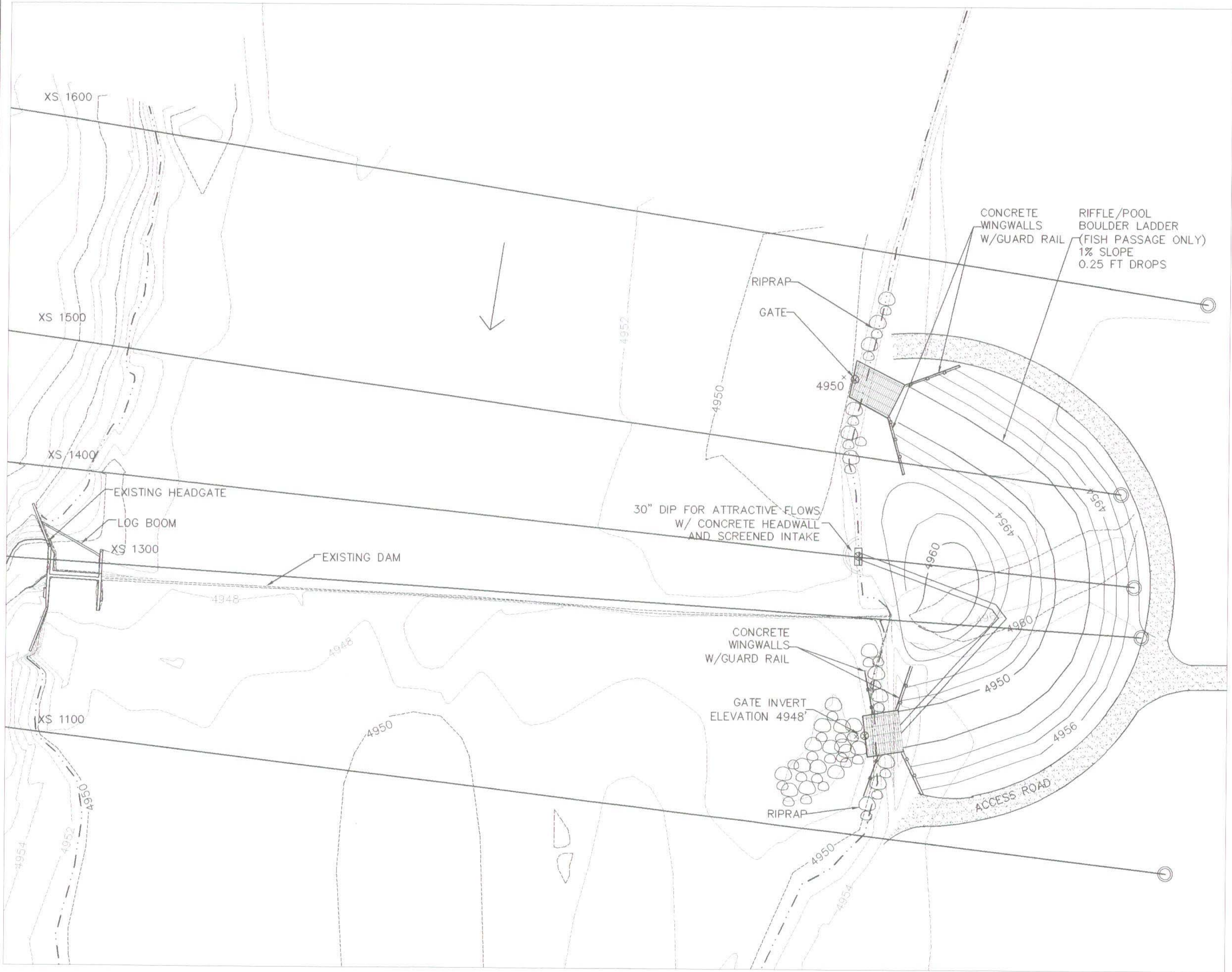
WORK DRAWING

DESIGNED P. BAILEY FIELD APPROVAL
DRAWN N. MLADENOV TECHNICAL APPROVAL
CHECKED APPROVED

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
410 S French Street, P.O. Box 1659
Breckenridge Co 80424
(970) 453-6394 Fax (970) 453-4579

DATE PLOTTED 12/20/00

DRAWING 2



NOTE:

TOPOGRAPHIC MAPPING BY THE US BUREAU OF RECLAMATION. NGS BENCHMARK STAMPED V429 1984, ELEV. 4938.23, NAVD 88.

LEGEND

- EXISTING CONTOUR – 1
- EXISTING CONTOUR – 5
- PROPOSED CONTOUR – 1
- PROPOSED CONTOUR – 5
- CROSS SECTION
- GRATE
- GUARD RAIL
- GRAVEL ROAD
- EDGE OF WATER 05/03/99

20 0 20 40 60

SCALE OF FEET
1 inch = 40 ft.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
FISH PASSAGE PROJECT – COLORADO

ALTERNATIVE II – HARTLAND DIVERSION
GUNNISON RIVER

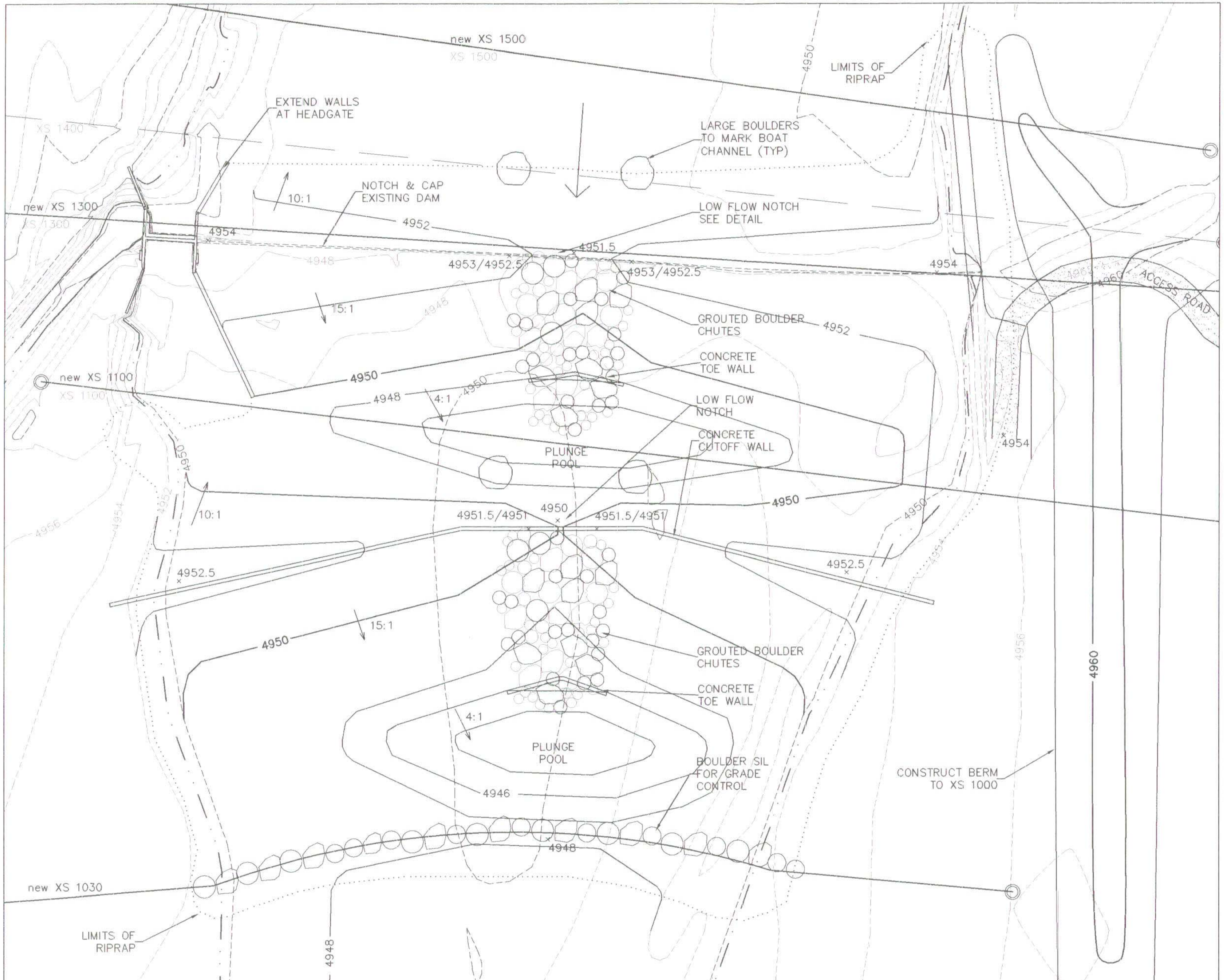
WORK DRAWING

DESIGNED P. BAILEY FIELD APPROVAL
DRAWN N. MLADENOV TECHNICAL APPROVAL
CHECKED APPROVED

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
410 S French Street, P.O. Box 1658
Breckenridge Co 80424
(970) 453-6394 Fax (970) 453-4579

DATE PLOTTED 12/20/00

DRAWING 3



N

NOTE:

TOPOGRAPHIC MAPPING BY THE US BUREAU OF RECLAMATION. NGS BENCHMARK STAMPED V429 1984, ELEV. 4938.23, NAVD 88.

LEGEND

----------	EXISTING CONTOUR - 1
----------	EXISTING CONTOUR - 5
————	PROPOSED CONTOUR-5
————	PROPOSED CONTOUR-1
o———o	NEW MODEL CROSS SECTION
o— —o	EXISTING SURVEYED CROSS SECTION
═══	CONCRETE CUTOFF WALL
▒▒▒	GRAVEL ACCESS ROAD
—·—·—	EDGE OF WATER 05/03/99

20 0 20 40 60

SCALE OF FEET
1 inch = 40 ft.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
FISH PASSAGE PROJECT - COLORADO

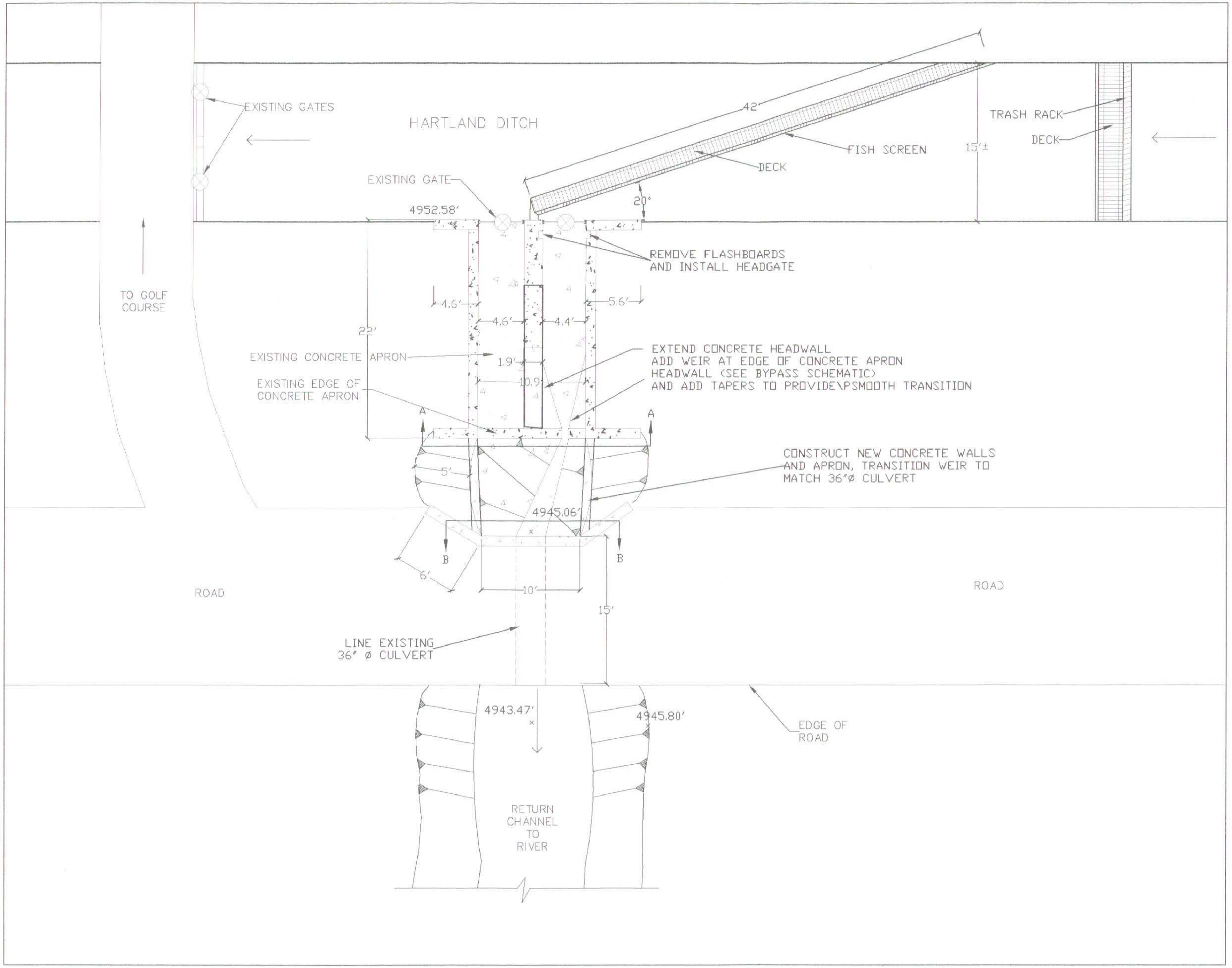
ALTERNATIVE III -- HARTLAND DIVERSION
GUNNISON RIVER
WORK DRAWING

DESIGNED P. BAILEY FIELD APPROVAL
DRAWN N. MLADENOV TECHNICAL APPROVAL
CHECKED APPROVED

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
410 S French Street, P.O. Box 1659
Breckenridge Co 80424
(970) 453-6394 Fax (970) 453-4579

DATE PLOTTED
12/20/00

DRAWING 4



LEGEND

- FISH SCREEN
- GRATE
- TRASH RACK
- CONCRETE

10 0 10 20 30

SCALE OF FEET
1 inch = 20 ft.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
FISH PASSAGE PROJECT – COLORADO

CONCEPTUAL SCREEN DESIGN – HARTLAND DITCH GUNNISON RIVER

WORK DRAWING

DESIGNED P. BAILEY FIELD APPROVAL
DRAWN N. MLADENOV TECHNICAL APPROVAL
CHECKED APPROVED

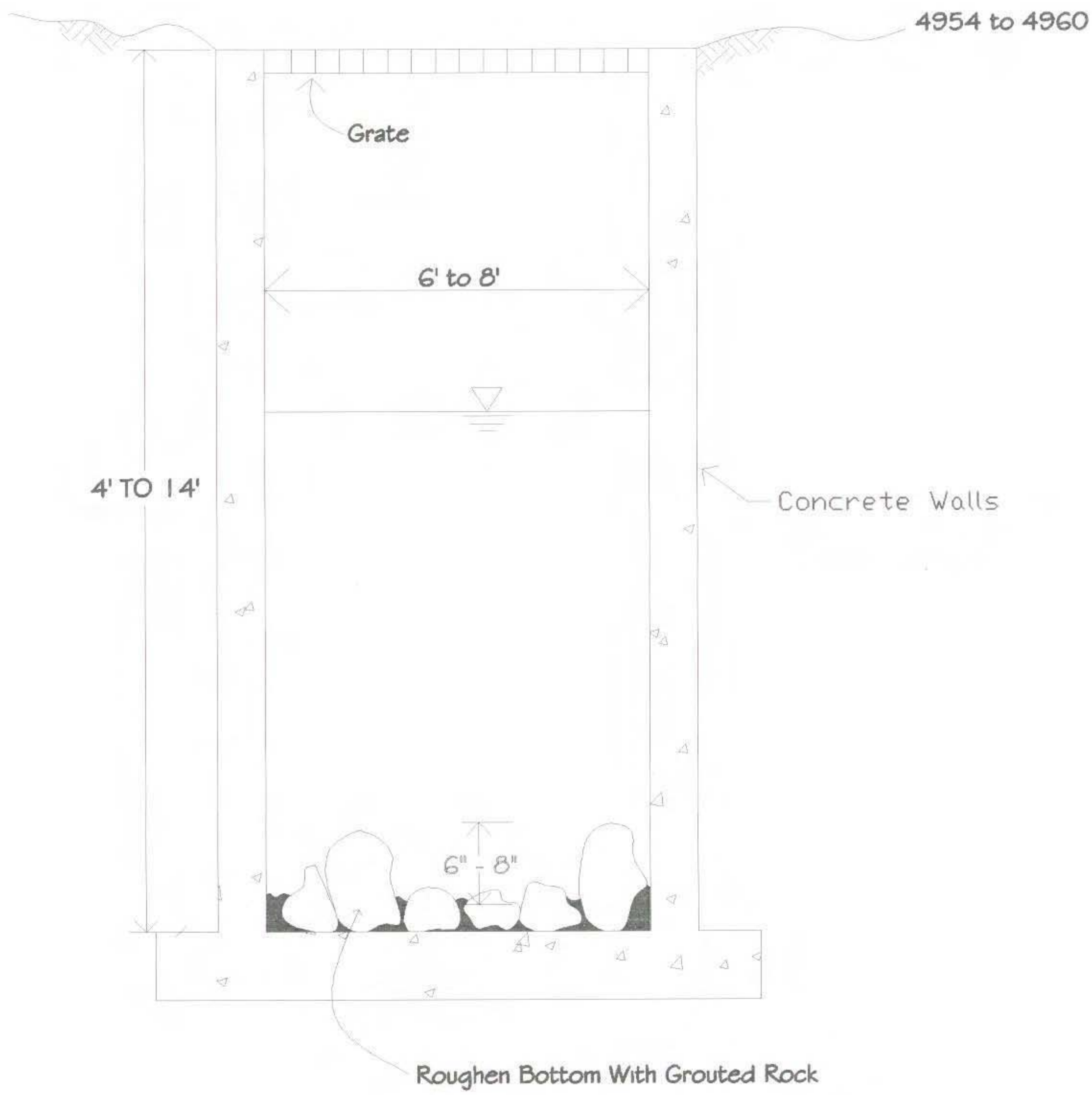
TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
410 S French Street, P.O. Box 1659
Breckenridge Co 80424
(970) 453-6394 Fax (970) 453-4579

DATE PLOTTED
12/20/00

DRAWING 5

APPENDIX B – DETAILS

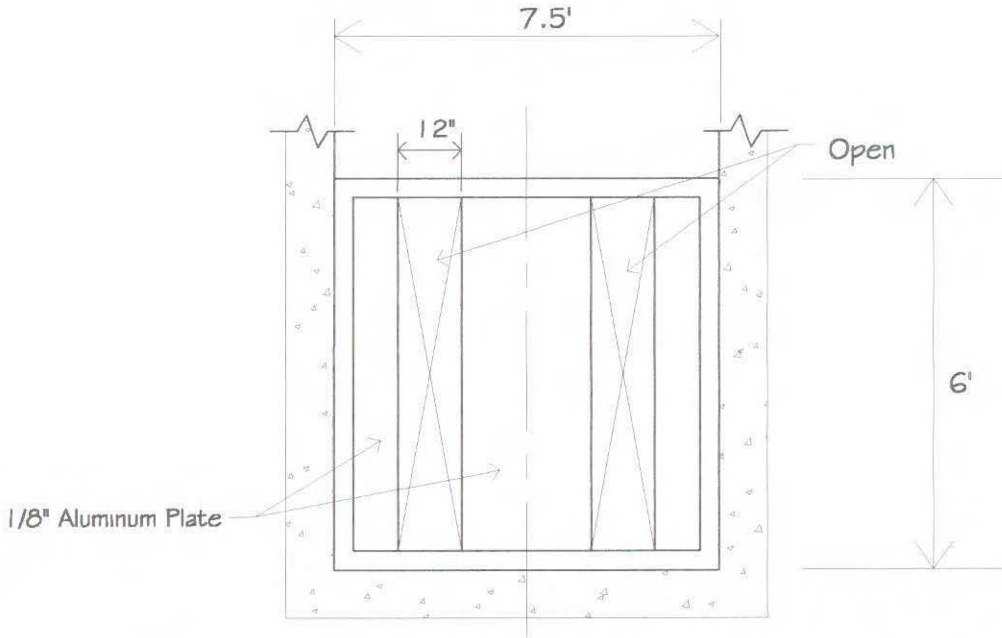
HARTLAND DIVERSION STRUCTURE
GUNNISON RIVER



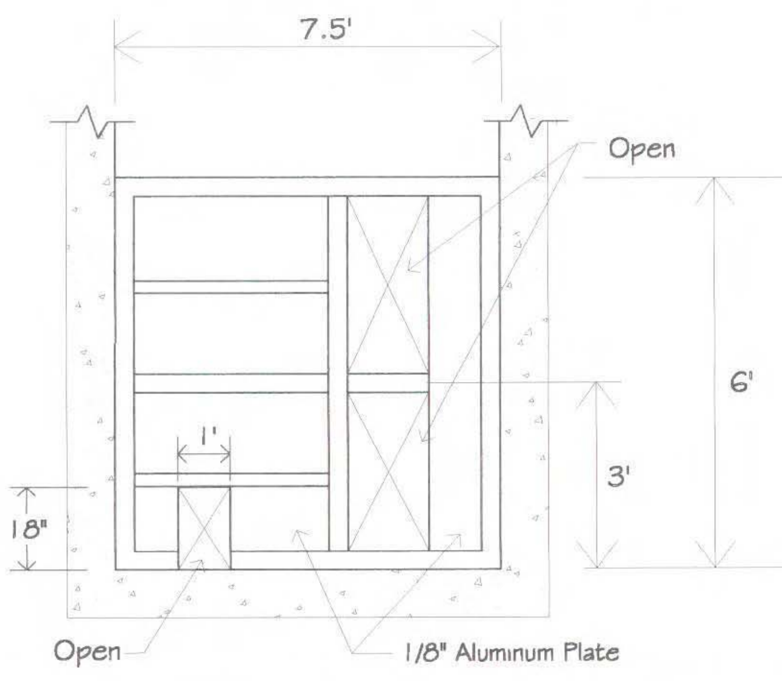
Concrete Fish Ladder Typical Section

NTS

HARTLAND DIVERSION STRUCTURE
GUNNISON RIVER

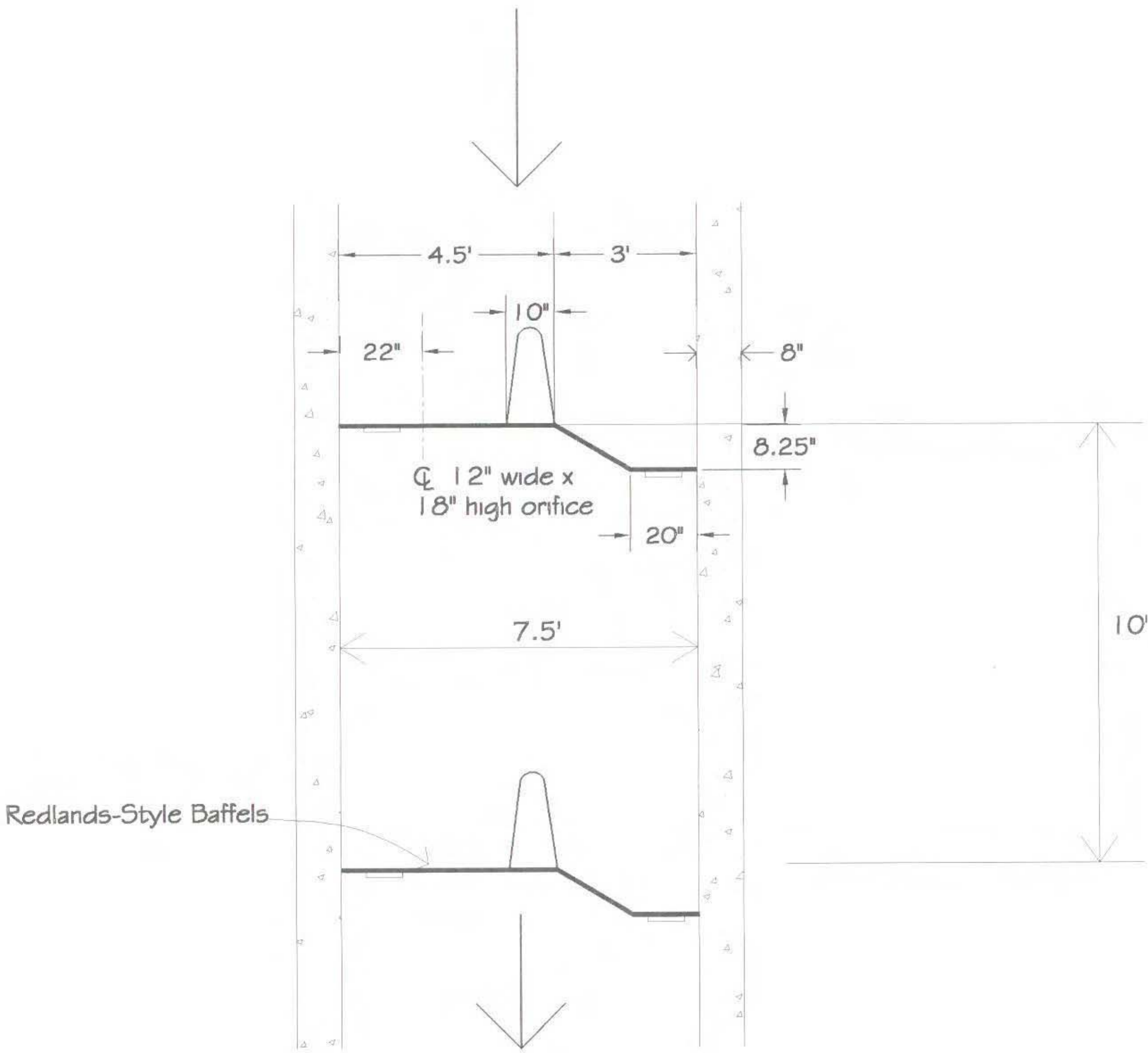


Concrete Fish Ladder Elevation w/ Chevron Baffles
Typical Section - Alternative I



Concrete Fish Ladder Elevation w/ Redlands-Style Baffles
Typical Section - Alternative I
NTS

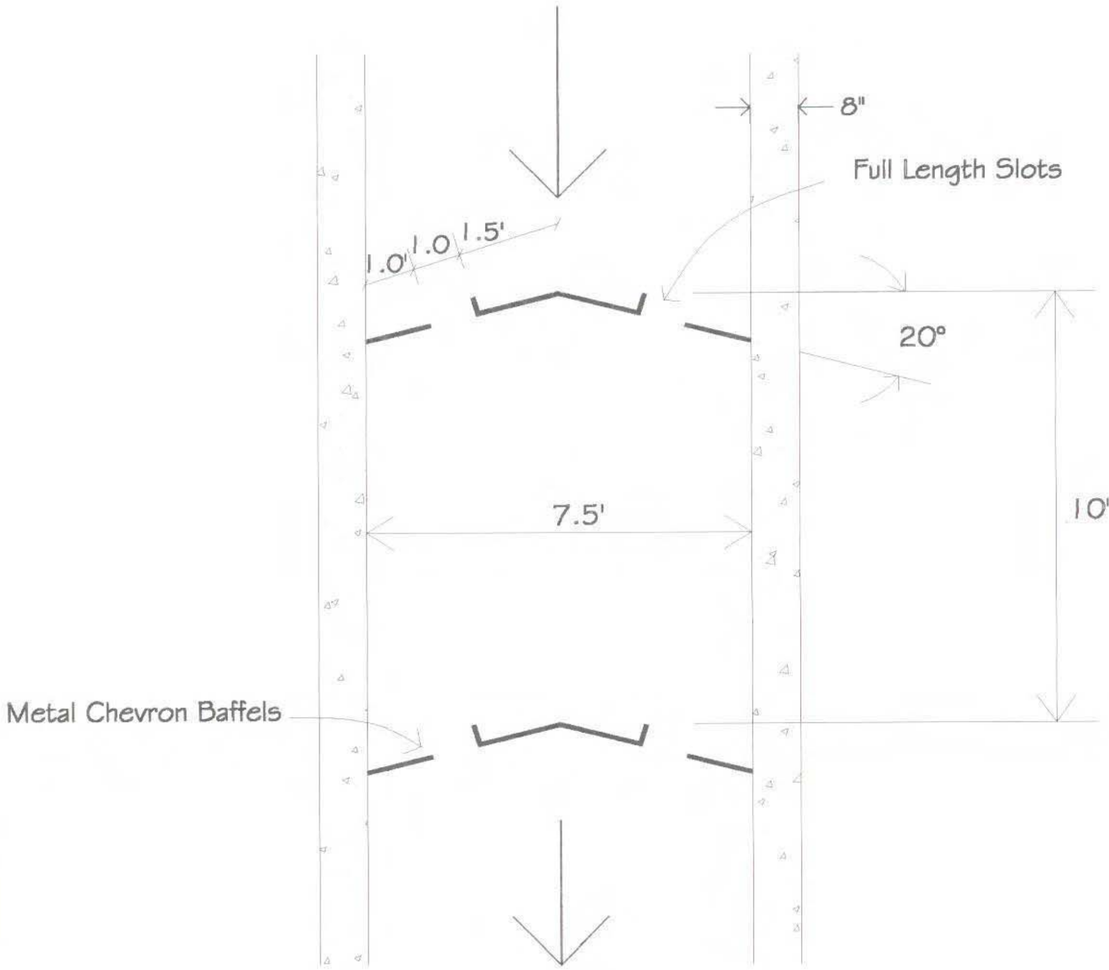
HARTLAND DIVERSION STRUCTURE
GUNNISON RIVER



Concrete Fish Ladder w/ Redlands-Style Baffles
Typical Plan - Alternative 1

NTS

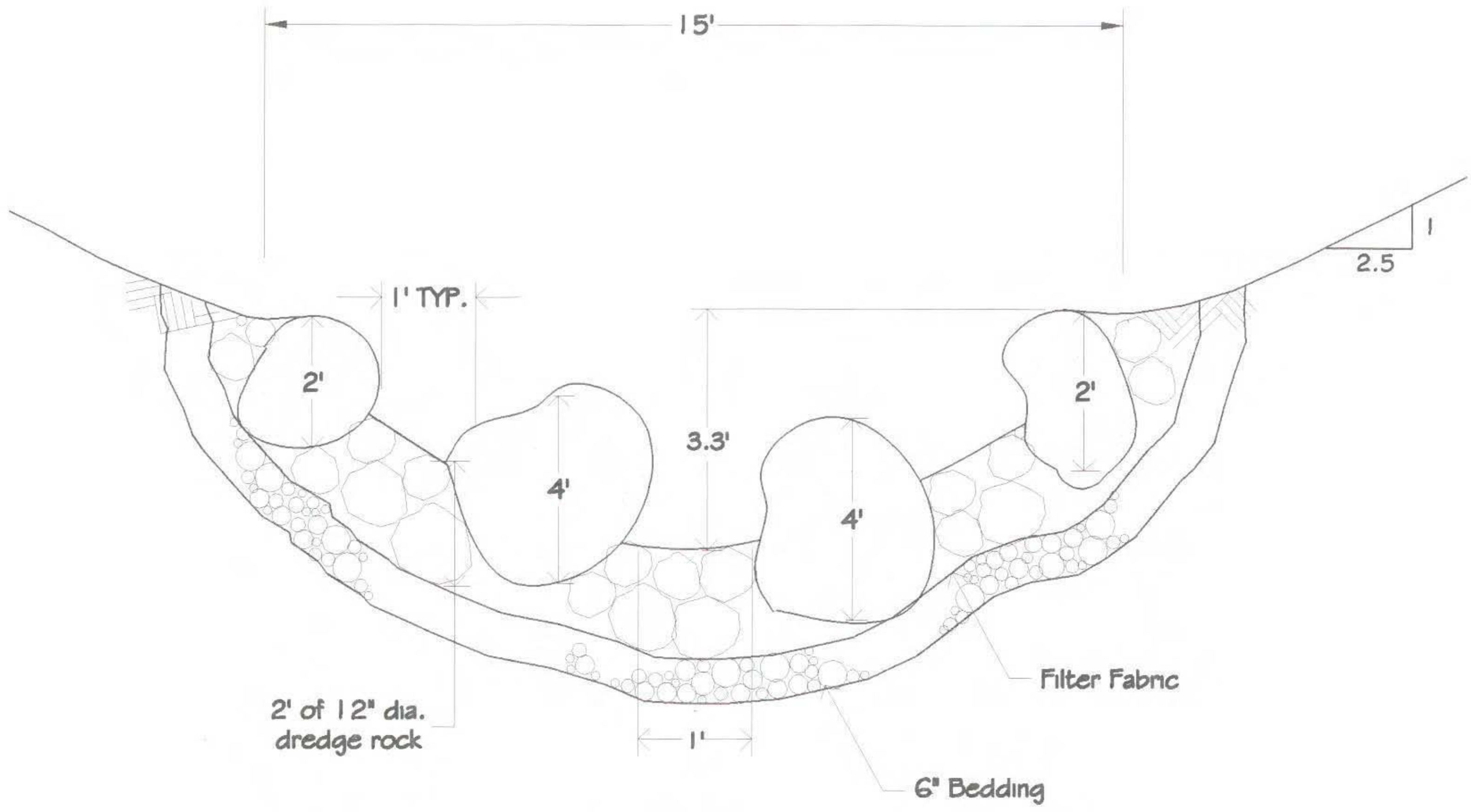
HARTLAND DIVERSION STRUCTURE
GUNNISON RIVER



Concrete Fish Ladder Plan w/ Chevron Baffles
Typical Section - Alternative I

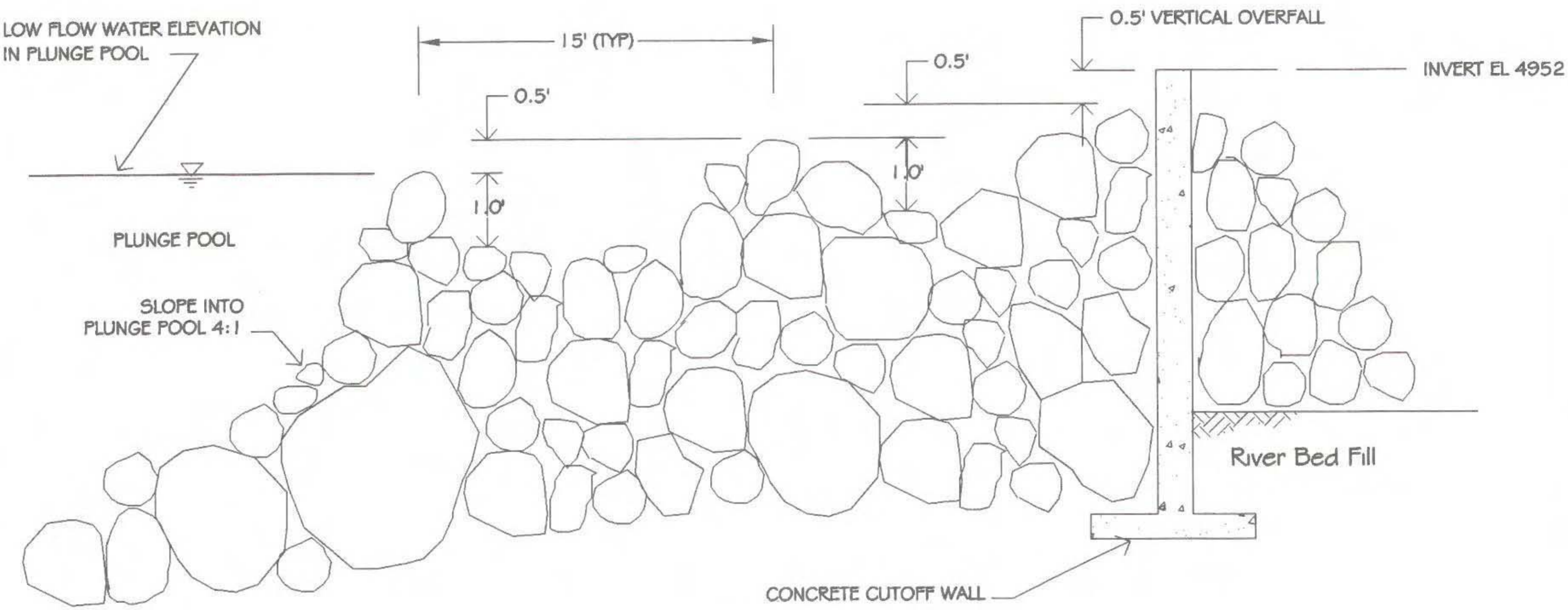
NTS

HARTLAND DIVERSION STRUCTURE
GUNNISON RIVER



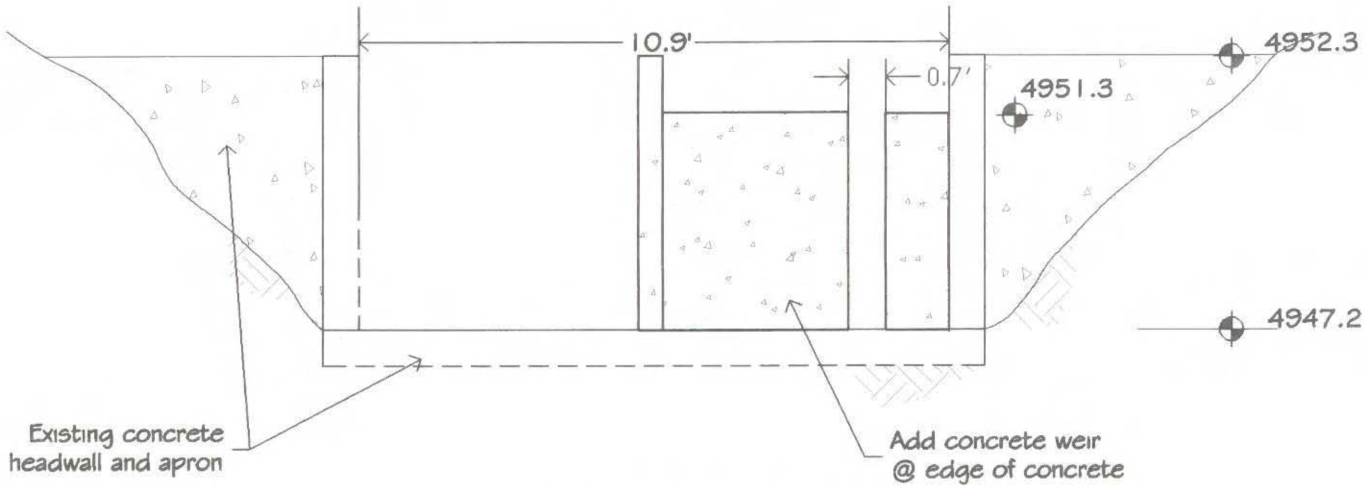
Rock Fish Ladder
Typical Section - Alternative II
NTS

HARTLAND DIVERSION STRUCTURE
GUNNISON RIVER



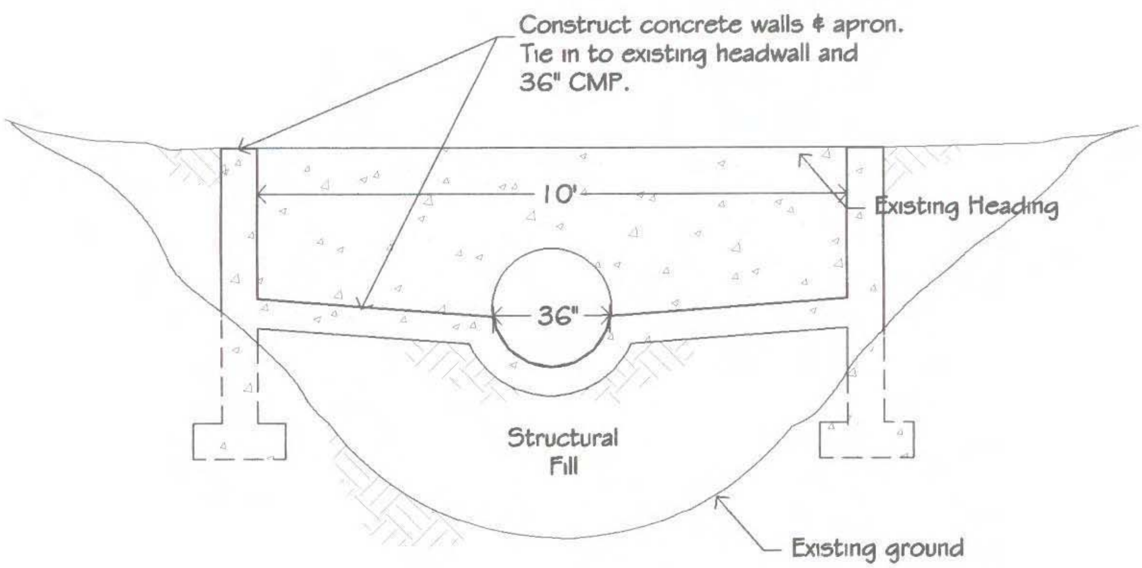
DETAIL OF LOW FLOW PASSAGE FROM
INVERT OF CUTOFF WALL TO PLUNGE POOL - ALTERNATIVE III
NTS

HARTLAND DIVERSION STRUCTURE
FISH SCREEN BY-PASS DETAILS
GUNNISON RIVER



Section A - A
Spill Channel

NTS



Section B - B
Spill Channel

NTS

APPENDIX C – MODEL CALIBRATION RESULTS

APPENDIX C – MODEL CALIBRATION RESULTS

Results of the model calibration are compared with measured water surface elevations in Tables C.1 to C.5.

TABLE C.1 RESULTS OF MODEL CALIBRATION FOR 479 CFS (4/17/99)

Cross section	Actual W.S. elev on 04/17/99 (ft)	Model W.S. elev (ft)	Change in W.S. elev Model – Actual (ft)
1900	not taken	4954.52	
1800	4953.93	4954.15	0.22
1700	4953.98	4953.73	-0.25
1600	4953.82	4953.58	-0.24
1500	4953.82	4953.55	-0.27
1400	4953.77	4953.54	-0.23
1300	4953.76	4953.41	-0.35
1200	not taken	4949.15	
1100	4949.74	4948.78	-0.96
1000	4947.92	4948.17	0.25
900	4947.48	4947.61	0.13
800	4945.93	4945.67	-0.26
700	4944.19	4943.88	-0.31
600	4939.66	4939.71	0.05
500	4936.25	4936.25	0.00
400	4935.03	4934.19	-0.84
300	4929.44	4929.86	0.42
200	4925.72	4924.5	-1.22
100	4924.48	4924.48	0.00

TABLE C.2 RESULTS OF MODEL CALIBRATION FOR 2050 CFS (5/03/99)

Cross section	Actual W.S. elev on 05/03/99 (ft)	Model W.S. elev (ft)	Change in W.S. elev Model – Actual (ft)
1900	not taken	4956.73	
1800	4955.10	4956.18	1.08
1700	4955.04	4955.26	0.22
1600	4954.71	4954.79	0.08
1500	4954.69	4954.67	-0.02
1400	4954.72	4954.64	-0.08
1300	4954.71	4954.38	-0.33
1200	not taken	4951.23	
1100	4950.95	4951.07	0.12
1000	4949.49	4950.42	0.93
900	4948.88	4949.57	0.69
800	4947.21	4947.84	0.63
700	4945.85	4945.84	-0.01
600	4941.81	4941.86	0.05
500	4937.92	4938.46	0.54
400	4936.40	4936.25	-0.15
300	4930.96	4931.58	0.62
200	4927.00	4926.76	-0.24
100	4926.54	4926.54	0.00

TABLE C.3 RESULTS OF MODEL CALIBRATION FOR 1790 CFS (5/06/99)

Cross section	Actual W.S. elev on 05/06/99 (ft)	Model W.S. elev (ft)	Change in W.S. elev Model – Actual (ft)
1900	not taken	4956.46	
1800	4955.02	4955.92	0.90
1700	4954.91	4955.07	0.16
1600	4954.65	4954.63	-0.02
1500	4954.64	4954.53	-0.11
1400	4954.63	4954.50	-0.13
1300	4954.62	4954.25	-0.37
1200	not taken	4950.98	
1100	4950.83	4950.81	-0.02
1000	4949.33	4950.15	0.82
900	4948.75	4949.31	0.56
800	4947.18	4947.61	0.43
700	4945.73	4945.66	-0.07
600	4941.65	4941.63	-0.02
500	4937.80	4938.22	0.42
400	4936.18	4936.05	-0.13
300	4930.77	4931.32	0.55
200	4926.90	4926.59	-0.31
100	4926.41	4926.41	0.00

TABLE C.4 RESULTS OF MODEL CALIBRATION FOR 2560 CFS (5/14/99)

Cross section	Actual W.S. elev on 05/14/99 (ft)	Model W.S. elev (ft)	Change in W.S. elev Model – Actual (ft)
1900	not taken	4957.22	
1800	4955.54	4956.63	1.09
1700	4955.44	4955.6	0.16
1600	4955.05	4955.08	0.03
1500	4954.98	4954.95	-0.03
1400	4955.03	4954.91	-0.12
1300	4954.94	4954.63	-0.31
1200	not taken	4951.69	
1100	4951.43	4951.53	0.10
1000	4950.10	4950.91	0.81
900	4949.37	4950.03	0.66
800	4947.64	4948.25	0.61
700	4946.24	4946.17	-0.07
600	4942.33	4942.29	-0.04
500	4938.51	4938.89	0.38
400	4936.50	4936.69	0.19
300	4931.34	4931.92	0.58
200	4927.45	4927.34	-0.11
100	4927.10	4927.10	0.00

TABLE C.5 RESULTS OF MODEL CALIBRATION FOR 2880 CFS (6/04/99)

Cross section	Actual W.S. elev on 06/04/99 (ft)	Model W.S. elev (ft)	Change in W.S. elev Model – Actual (ft)
1900	not taken	4957.5	
1800	4955.75	4956.9	1.15
1700	4955.29	4955.8	0.51
1600	4955.19	4955.25	0.06
1500	4955.12	4955.1	-0.02
1400	4955.08	4955.07	-0.01
1300	4954.98	4954.77	-0.21
1200	not taken	4951.96	
1100	4951.77	4951.8	0.03
1000	4950.35	4951.18	0.83
900	4949.62	4950.3	0.68
800	4947.94	4948.49	0.55
700	4946.45	4946.36	-0.09
600	4942.69	4942.54	-0.15
500	4938.70	4939.13	0.43
400	4936.76	4936.96	0.20
300	4931.36	4932.1	0.74
200	4927.88	4927.77	-0.11
100	4927.54	4927.54	0.00

APPENDIX D – MODEL RESULTS FOR EXISTING CONDITIONS

APPENDIX D – MODEL RESULTS FOR EXISTING CONDITIONS

TABLE D.1 WATER SURFACE ELEVATIONS (FT) AT RANGE OF FLOWS FOR EXISTING CONDITIONS

Cross section	350	650	1200	3000	3460	6470	11600	13500	18700	21200
	LOW FLOW IN AUG	LOW FLOW AVG	AUG FLOW AVG	APRIL FLOW AVG	1.25 YR	2 YR	5 YR	10 YR	50 YR	100 YR
1900	4954.15	4954.87	4955.74	4957.61	4958.00	4960.04	4962.22	4962.86	4964.25	4964.84
1800	4953.87	4954.45	4955.26	4957.00	4957.35	4959.24	4961.30	4961.90	4963.29	4963.89
1700	4953.53	4953.95	4954.58	4955.87	4956.14	4957.62	4959.39	4959.92	4961.25	4961.82
1600	4953.41	4953.74	4954.22	4955.30	4955.53	4956.77	4958.44	4958.97	4960.27	4960.83
1500	4953.39	4953.70	4954.13	4955.15	4955.37	4956.55	4958.13	4958.61	4959.84	4960.37
1400	4953.38	4953.69	4954.11	4955.12	4955.33	4956.51	4958.10	4958.59	4959.83	4960.36
1300	4953.28	4953.54	4953.91	4954.81	4955.01	4956.12	4957.63	4958.10	4959.30	4959.83
1200	4950.12	4950.61	4951.19	4952.52	4952.84	4954.67	4956.87	4957.46	4958.82	4959.37
1100	4950.10	4950.58	4951.14	4952.41	4952.73	4954.54	4956.72	4957.31	4958.65	4959.20
1000	4947.78	4948.50	4949.40	4951.27	4951.65	4953.66	4955.90	4956.48	4957.75	4958.27
900	4947.30	4947.89	4948.62	4950.38	4950.76	4952.69	4954.81	4955.36	4956.54	4957.02
800	4945.33	4945.96	4946.97	4948.56	4948.90	4950.52	4952.44	4952.98	4954.28	4954.87
700	4943.47	4944.27	4945.24	4946.42	4946.68	4948.19	4950.30	4950.92	4952.35	4952.96
600	4939.28	4940.31	4940.99	4942.63	4942.97	4944.78	4946.99	4947.61	4949.05	4949.65
500	4935.91	4936.59	4937.49	4939.24	4939.56	4941.23	4943.07	4943.58	4944.82	4945.38
400	4934.06	4934.55	4935.26	4936.87	4937.19	4938.91	4940.91	4941.47	4942.87	4943.53
300	4929.53	4930.12	4930.89	4932.54	4932.85	4934.42	4936.46	4937.05	4938.51	4939.20
200	4924.49	4924.90	4925.52	4926.87	4927.17	4928.99	4931.17	4931.91	4933.89	4934.54
100	4920.71	4921.29	4922.05	4923.59	4923.90	4925.67	4928.11	4928.76	4930.26	4931.54

APPENDIX E – MODEL RESULTS FOR ALTERNATIVES

APPENDIX E – MODEL RESULTS FOR ALTERNATIVES

TABLE E.1 WATER SURFACE ELEVATIONS (FT) AT RANGE OF FLOWS FOR ALTERNATIVE I

Cross section	350	650	1200	3000	3460	6470	11600	13500	18700	21200
	LOW FLOW IN AUG	LOW FLOW AVG	AUG FLOW AVG	APRIL FLOW AVG	1.25 YR	2 YR	5 YR	10 YR	50 YR	100 YR
1900	4954.13	4954.85	4955.73	4957.60	4957.99	4960.04	4962.22	4962.86	4964.25	4964.84
1800	4953.83	4954.43	4955.25	4956.99	4957.35	4959.24	4961.30	4961.90	4963.29	4963.89
1700	4953.45	4953.90	4954.55	4955.85	4956.12	4957.60	4959.37	4959.91	4961.24	4961.81
1600	4953.33	4953.68	4954.16	4955.26	4955.49	4956.75	4958.42	4958.95	4960.25	4960.81
1500	4953.31	4953.64	4954.08	4955.12	4955.33	4956.52	4958.10	4958.59	4959.82	4960.35
1400	4953.30	4953.62	4954.06	4955.08	4955.29	4956.48	4958.08	4958.57	4959.81	4960.34
1300	4953.21	4953.48	4953.86	4954.78	4954.98	4956.10	4957.61	4958.08	4959.29	4959.82
1200	4950.12	4950.61	4951.19	4952.52	4952.84	4954.67	4956.87	4957.47	4958.82	4959.37
1100	4950.10	4950.58	4951.14	4952.41	4952.73	4954.54	4956.72	4957.31	4958.65	4959.20
1000	4947.78	4948.50	4949.40	4951.27	4951.65	4953.66	4955.90	4956.48	4957.75	4958.27
900	4947.30	4947.89	4948.62	4950.38	4950.76	4952.69	4954.81	4955.36	4956.54	4957.02
800	4945.33	4945.96	4946.97	4948.56	4948.90	4950.52	4952.44	4952.98	4954.28	4954.87
700	4943.47	4944.27	4945.24	4946.42	4946.68	4948.19	4950.30	4950.92	4952.35	4952.96
600	4939.28	4940.31	4940.99	4942.63	4942.97	4944.78	4946.99	4947.61	4949.05	4949.65
500	4935.91	4936.59	4937.49	4939.24	4939.56	4941.23	4943.07	4943.58	4944.82	4945.38
400	4934.06	4934.54	4935.26	4936.87	4937.19	4938.91	4940.91	4941.47	4942.87	4943.53
300	4929.53	4930.12	4930.89	4932.54	4932.85	4934.42	4936.46	4937.05	4938.51	4939.20
200	4924.49	4924.89	4925.52	4926.87	4927.17	4928.99	4931.17	4931.91	4933.89	4934.54
100	4920.71	4921.29	4922.04	4923.59	4923.90	4925.67	4928.11	4928.76	4930.26	4931.54

TABLE E.2 WATER SURFACE ELEVATIONS (FT) AT RANGE OF FLOWS FOR ALTERNATIVE II

Cross section	350	650	1200	3000	3460	6470	11600	13500	18700	21200
	LOW FLOW IN AUG	LOW FLOW AVG	AUG FLOW AVG	APRIL FLOW AVG	1.25 YR	2 YR	5 YR	10 YR	50 YR	100 YR
1900	4954.12	4954.85	4955.73	4957.60	4957.99	4960.03	4962.22	4962.86	4964.25	4964.84
1800	4953.82	4954.42	4955.24	4956.99	4957.34	4959.23	4961.30	4961.90	4963.29	4963.89
1700	4953.44	4953.88	4954.53	4955.84	4956.11	4957.60	4959.37	4959.91	4961.23	4961.81
1600	4953.32	4953.67	4954.16	4955.26	4955.49	4956.75	4958.42	4958.95	4960.25	4960.81
1500	4953.30	4953.63	4954.08	4955.12	4955.33	4956.53	4958.11	4958.60	4959.82	4960.36
1400	4953.30	4953.62	4954.06	4955.08	4955.30	4956.49	4958.08	4958.58	4959.81	4960.35
1300	4953.21	4953.48	4953.86	4954.78	4954.98	4956.10	4957.61	4958.08	4959.29	4959.82
1200	4950.12	4950.61	4951.19	4952.52	4952.84	4954.67	4956.87	4957.47	4958.82	4959.37
1100	4950.10	4950.58	4951.14	4952.41	4952.73	4954.54	4956.72	4957.31	4958.65	4959.20
1000	4947.78	4948.50	4949.40	4951.27	4951.65	4953.66	4955.90	4956.48	4957.75	4958.27
900	4947.30	4947.89	4948.62	4950.38	4950.76	4952.69	4954.81	4955.36	4956.54	4957.02
800	4945.33	4945.96	4946.97	4948.56	4948.90	4950.52	4952.44	4952.98	4954.28	4954.87
700	4943.47	4944.27	4945.24	4946.42	4946.68	4948.19	4950.30	4950.92	4952.35	4952.96
600	4939.28	4940.31	4940.99	4942.63	4942.97	4944.78	4946.99	4947.61	4949.05	4949.65
500	4935.91	4936.59	4937.49	4939.24	4939.56	4941.23	4943.07	4943.58	4944.82	4945.38
400	4934.06	4934.54	4935.26	4936.87	4937.19	4938.91	4940.91	4941.47	4942.87	4943.53
300	4929.53	4930.12	4930.89	4932.54	4932.85	4934.42	4936.46	4937.05	4938.51	4939.20
200	4924.49	4924.89	4925.52	4926.87	4927.17	4928.99	4931.17	4931.91	4933.89	4934.54
100	4920.71	4921.30	4922.05	4923.59	4923.90	4925.67	4928.11	4928.76	4930.26	4931.54

TABLE E.3 WATER SURFACE ELEVATIONS (FT) AT RANGE OF FLOWS FOR ALTERNATIVE III

Cross section	350	650	1200	3000	3460	6470	11600	13500	18700	21200
	LOW FLOW IN AUG	LOW FLOW AVG	AUG FLOW AVG	APRIL FLOW AVG	1.25 YR	2 YR	5 YR	10 YR	50 YR	100 YR
1900	4954.23	4954.96	4955.82	4957.66	4958.05	4960.05	4962.22	4962.85	4964.23	4964.81
1800	4953.99	4954.62	4955.39	4957.07	4957.42	4959.26	4961.30	4961.89	4963.26	4963.85
1700	4953.72	4954.24	4954.82	4956.05	4956.30	4957.70	4959.38	4959.89	4961.14	4961.69
1600	4953.63	4954.09	4954.58	4955.59	4955.80	4956.94	4958.43	4958.90	4960.08	4960.59
1500	4953.62	4954.07	4954.55	4955.53	4955.73	4956.84	4958.27	4958.72	4959.79	4960.24
1300	4953.23	4953.64	4954.09	4954.71	4954.84	4955.60	4956.63	4956.99	4958.03	4958.66
1100	4951.04	4951.58	4952.16	4953.29	4953.52	4954.82	4956.94	4957.53	4958.87	4959.43
1080	4950.57	4951.09	4951.59	4952.46	4952.63	4954.11	4956.51	4957.12	4958.49	4959.05
1060	4949.50	4949.95	4950.50	4952.10	4952.46	4954.40	4956.64	4957.24	4958.59	4959.15
1030	4949.16	4949.51	4949.94	4951.74	4952.11	4954.08	4956.38	4956.99	4958.35	4958.91
1000	4947.78	4948.50	4949.40	4951.27	4951.65	4953.66	4955.90	4956.48	4957.75	4958.27
900	4947.30	4947.89	4948.62	4950.38	4950.76	4952.69	4954.81	4955.36	4956.54	4957.02
800	4945.33	4945.96	4946.97	4948.56	4948.90	4950.52	4952.44	4952.98	4954.28	4954.87
700	4943.47	4944.27	4945.24	4946.42	4946.68	4948.19	4950.30	4950.92	4952.35	4952.96
600	4939.28	4940.31	4940.99	4942.63	4942.97	4944.78	4946.99	4947.61	4949.05	4949.65
500	4935.91	4936.59	4937.49	4939.24	4939.56	4941.23	4943.07	4943.58	4944.82	4945.38
400	4934.06	4934.54	4935.26	4936.87	4937.19	4938.91	4940.91	4941.47	4942.87	4943.53
300	4929.53	4930.12	4930.89	4932.54	4932.85	4934.42	4936.46	4937.05	4938.51	4939.20
200	4924.49	4924.89	4925.52	4926.87	4927.17	4928.99	4931.17	4931.91	4933.89	4934.54
100	4920.71	4921.29	4922.05	4923.59	4923.91	4925.67	4928.10	4928.76	4930.26	4931.54

APPENDIX F – FISH SCREEN AND DITCH HYDRAULICS

APPENDIX F – FISH SCREEN

Results of the calibration model are shown in Table F.1. Given the surveyed water surface elevations and gage data, shown in the rating table (Table F.3) provided by HIC, Manning's n is calculated to be 0.038 in the channel and 0.04 at the banks. The cross section located upstream of the spill channel is also the location of the proposed fish screen. Table F.2 shows the water surface elevations under proposed conditions for fish screen operation.

TABLE F.1 RESULTS OF MODEL CALIBRATION FOR 5/12/00

Cross Section Location	Existing Conditions on 05/12/00		
	Flow Rate (cfs)	Surveyed WSEL (ft)	Model WSEL (ft)
At gage	31.2	4949.41	4949.41
Upstream of spill channel	12.7	4950.98	4950.98
In spill channel	43.9	4945.78	4945.78

TABLE F.2 SUMMARY OF WATER SURFACE ELEVATIONS FOR FISH SCREEN OPTION

Cross Section Location	Flow Rate (cfs)	Model WSEL (ft)
At gage	60	4951.49
Upstream of spill channel	80	4951.72
In spill channel	20	*

* Varies with water surface elevation in the Gunnison River.

Table F.3 Rating Table for Gage at Hartland Ditch downstream of Spill Channel

June 15, 93

ADD .28 Gage Readings

HARTLAND RATING TABLE
DISCHARGE IN cfs

FEET	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
2	30.4	30.5	30.6	30.8	30.9	31.0	31.2	31.3	31.5	31.6
2.1	31.7	31.9	32.0	32.2	32.3	32.4	32.6	32.7	32.8	33.0
2.2	33.1	33.3	33.4	33.5	33.7	33.8	34.0	34.1	34.2	34.4
2.3	34.5	34.7	34.8	34.9	35.1	35.2	35.3	35.5	35.6	35.8
2.4	35.9	36.0	36.2	36.3	36.5	36.6	36.7	36.9	37.0	37.1
2.5	37.3	37.4	37.6	37.7	37.8	38.0	38.1	38.3	38.4	38.5
2.6	38.7	38.8	39.0	39.1	39.2	39.4	39.5	39.6	39.8	39.9
2.7	40.1	40.2	40.3	40.5	40.6	40.8	40.9	41.0	41.2	41.3
2.8	41.4	41.6	41.7	41.9	42.0	42.1	42.3	42.4	42.6	42.7
2.9	42.8	43.0	43.1	43.3	43.4	43.5	43.7	43.8	43.9	44.1
3	44.2	44.4	44.5	44.6	44.8	44.9	45.1	45.2	45.3	45.5
3.1	45.6	45.7	45.9	46.0	46.2	46.3	46.4	46.6	46.7	46.9
3.2	47.0	47.1	47.3	47.4	47.5	47.7	47.8	48.0	48.1	48.2
3.3	48.4	48.5	48.7	48.8	48.9	49.1	49.2	49.4	49.5	49.6
3.4	49.8	49.9	50.0	50.2	50.3	50.5	50.6	50.7	50.9	51.0
3.5	51.2	51.3	51.4	51.6	51.7	51.8	52.0	52.1	52.3	52.4
3.6	52.5	52.7	52.8	53.0	53.1	53.2	53.4	53.5	53.7	53.8
3.7	53.9	54.1	54.2	54.3	54.5	54.6	54.8	54.9	55.0	55.2
3.8	55.3	55.5	55.6	55.7	55.9	56.0	56.1	56.3	56.4	56.6
3.9	56.7	56.9	57.0	57.1	57.3	57.4	57.5	57.7	57.8	58.0
4	58.1	58.2	58.4	58.5	58.6	58.8	58.9	59.1	59.2	59.3
4.1	59.5	59.6	59.8	59.9	60.0	60.2	60.3	60.4	60.6	60.7
4.2	60.9	61.0	61.1	61.3	61.4	61.6	61.7	61.8	62.0	62.1
4.3	62.3	62.4	62.5	62.7	62.8	62.9	63.1	63.2	63.4	63.5
4.4	63.6	63.8	63.9	64.1	64.2	64.3	64.5	64.6	64.7	64.9

Most accurate

APPENDIX C

HYDROLOGY & HYDRAULICS

Hydrology

Aspinall summary of changes to Peak Flow (cfs) Alternative B at Delta Gage

	May peak flows			June-July peak flows		
year	no action	alt B	change	no action	alt B	change
1975	7019	10308	47%	6055	7388	22%
1976	3889	6649	71%	2377	2598	9%
1977	900	895	-1%	689	876	27%
1978	8964	9677	8%	5784	7752	34%
1979	11153	12144	9%	7759	10433	34%
1980	12722	15047	18%	8521	10817	27%
1981	2651	2651	0%	1775	1775	0%
1982	6807	9374	38%	5768	6950	20%
1983	13364	12712	-5%	18507	18413	-1%
1984	16421	16421	0%	17922	17923	0%
1985	9655	13047	35%	17209	13956	-19%
1986	8744	11878	36%	8343	12406	49%
1987	7503	7596	1%	8194	9015	10%
1988	2133	4536	113%	1951	1951	0%
1989	1988	4879	145%	1622	1484	-9%
1990	1456	1456	0%	1602	1602	0%
1991	6939	7119	3%	5589	5182	-7%
1992	4101	6647	62%	2476	4180	69%
1993	15696	16146	3%	10824	11997	11%
1994	3294	6582	100%	3177	2153	-32%
1995	10805	12919	20%	16522	16471	0%
1996	7291	11931	64%	3331	6834	105%
1997	9475	12145	28%	10224	12754	25%
1998	8281	7396	-11%	5567	5541	0%
1999	3284	7100	116%	5350	6970	30%
2000	2872	7122	148%	1946	5087	161%
2001	2950	6910	134%	2807	2649	-6%
2002	842	842	0%	690	816	18%
2003	4499	6144	37%	3894	3894	0%
2004	2390	4451	86%	1599	1599	0%
2005	10278	7603	-26%	4305	4840	12%
average	6721	8398	25%	6206	6978	12%
median	6939	7396	7%	5350	5541	4%

Adjusted Flow recommendations for Hartland Feasibility Study

Delta Gage Flows (downstream of Hartland)

Dec-Jan-Feb

Assume average flows 25% lower than previous record
was 1600 cfs, use 1200 cfs

May

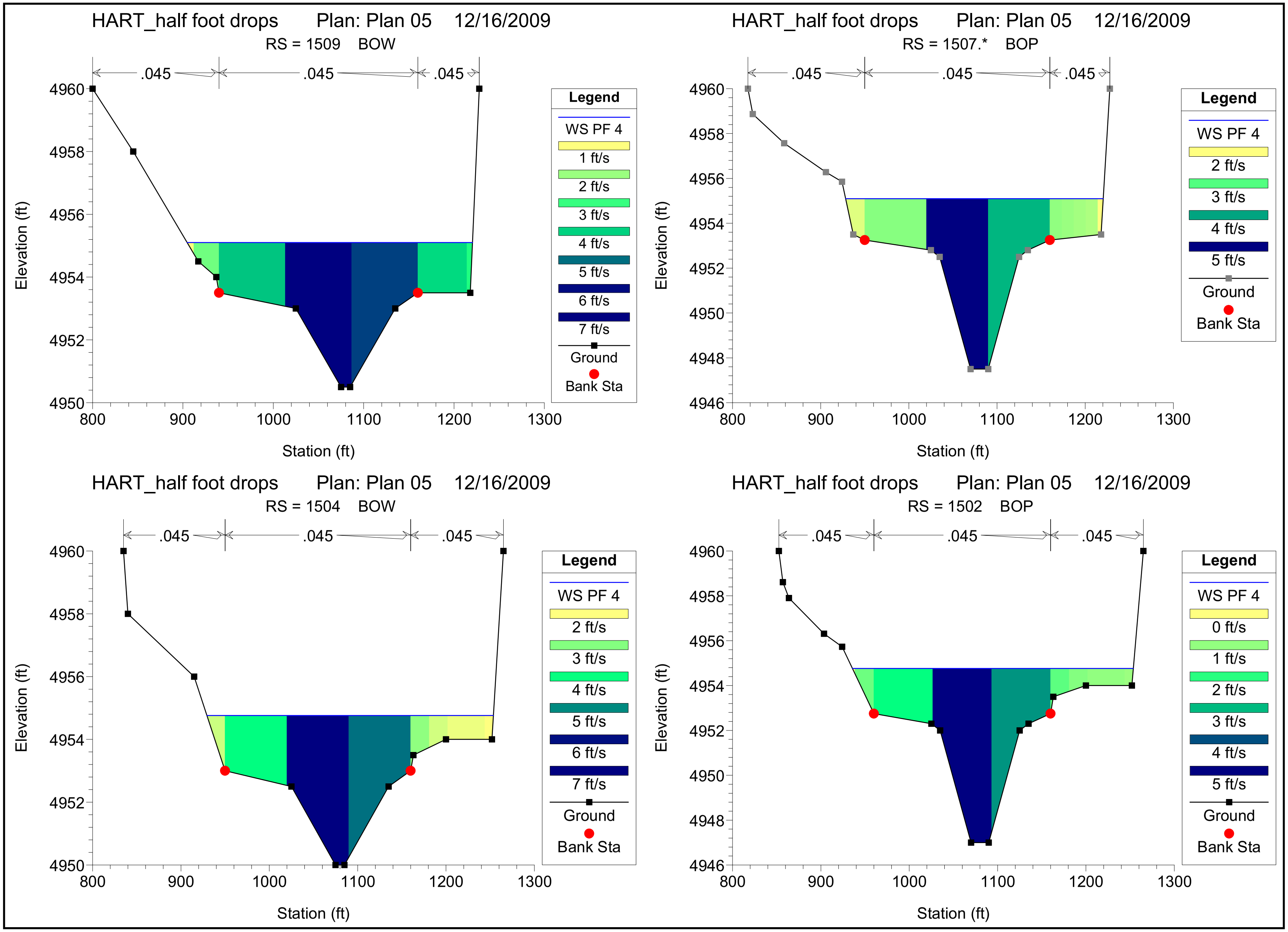
Average peak flows adjusted for reops
median peak flow was 6700 cfs, use 7400 cfs

Summary of flows

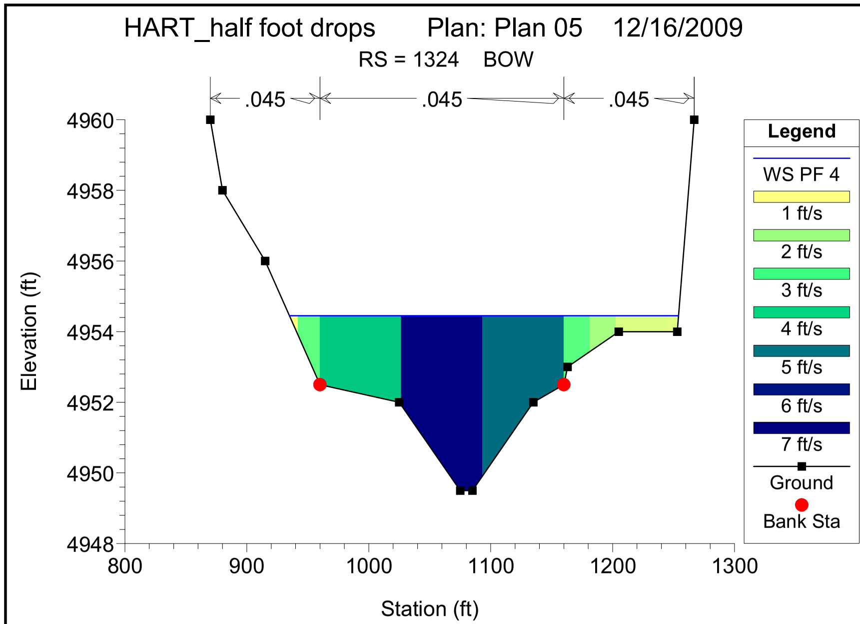
Description	Delta Gage Q cfs	DS return Q cfs	DS diver Q cfs	US diver Q cfs
August low flow (90% exceed)	350	350	340	420
Average low flow	650	650	640	720
August mean daily flow	1200	1200	1190	1270
Bankfull, use estimated 1.25-yr	3460	3460	3450	3530
May average (gage analysis)	4800	4800	4790	4870
May peak (adj for aspinall)	7400	7400	7390	7470
5-yr (initial overtopping)	11600	11600	11590	11670
100-yr	21200	21200	21190	21270

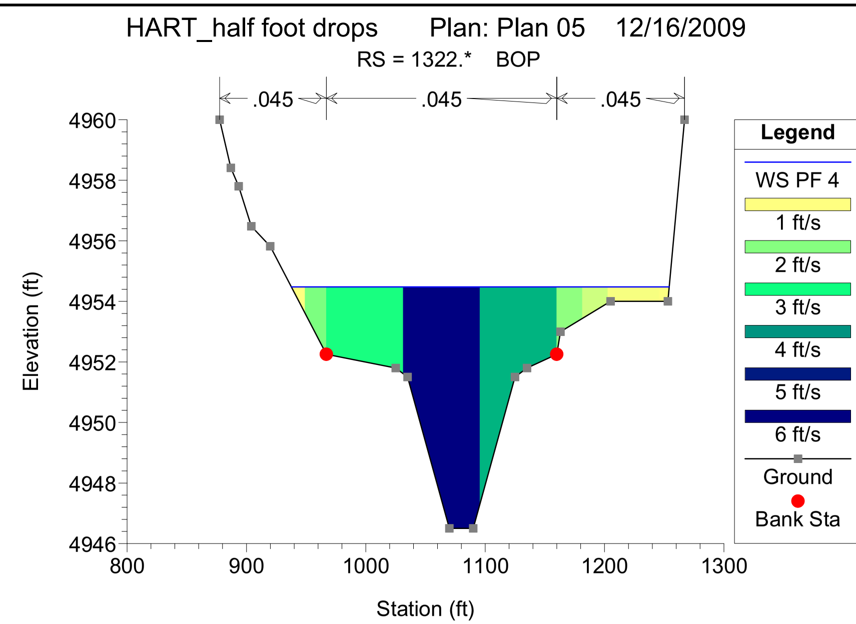
Proposed Cross Section Velocity Distribution Plots

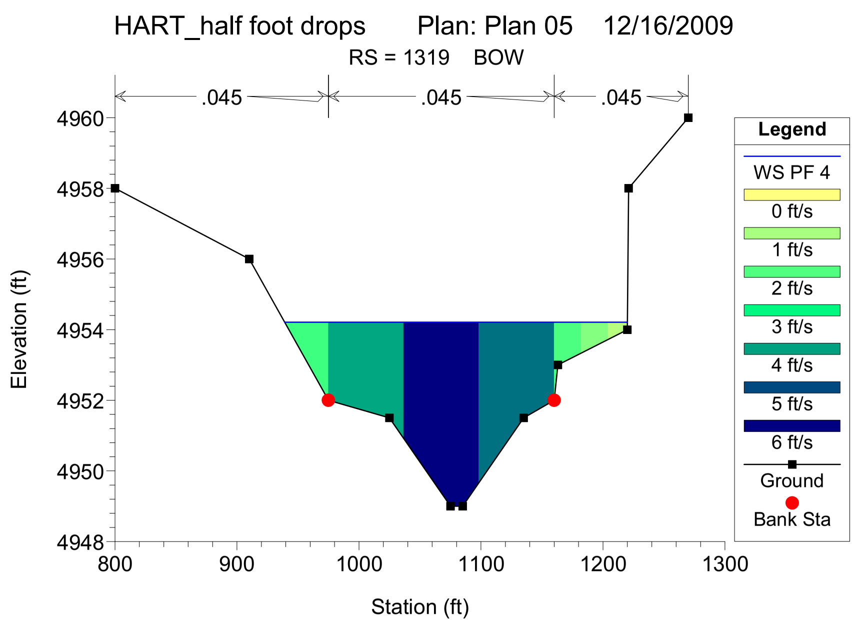
Velocity distribution, bankfull discharge
Proposed conditions

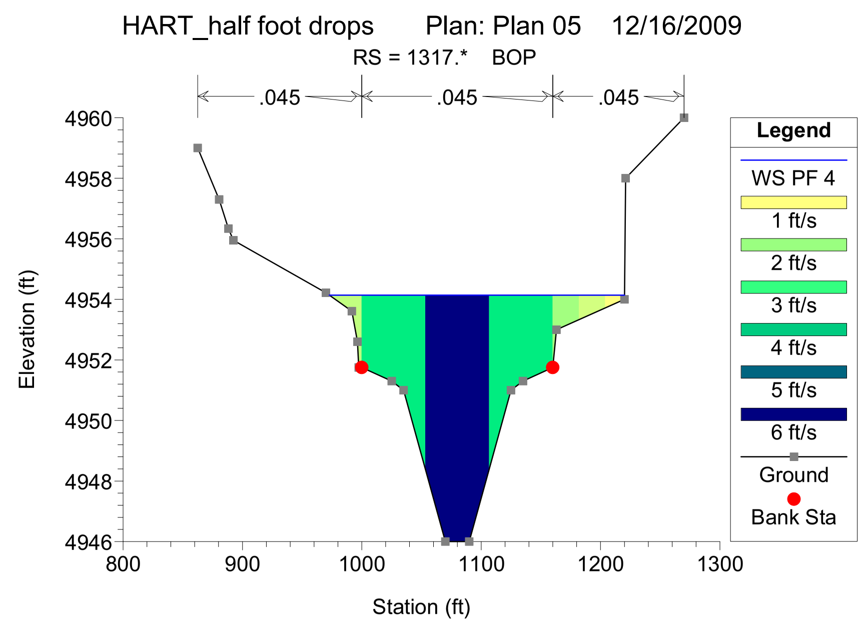


Velocity distribution, bankfull discharge
Proposed conditions

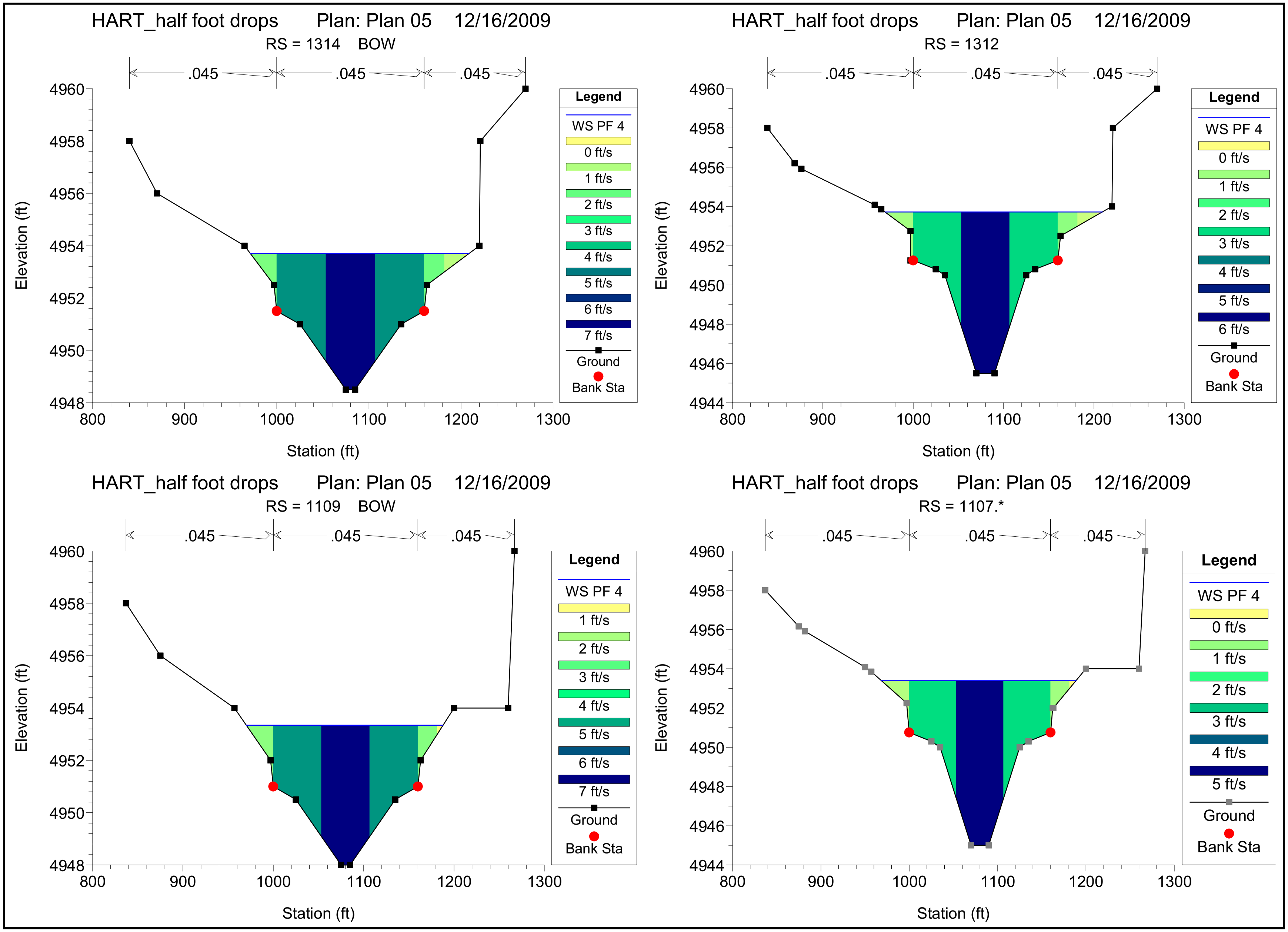




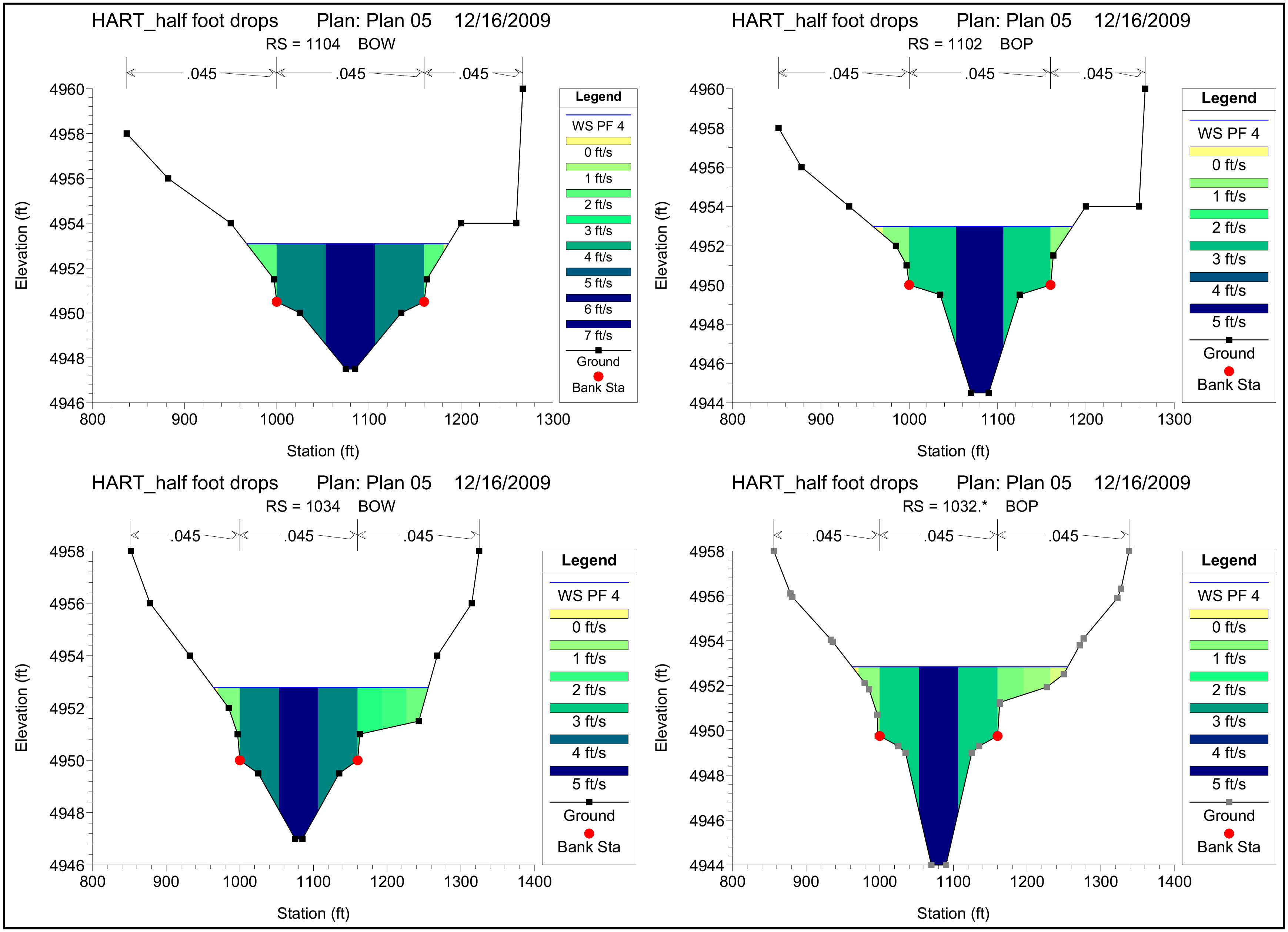




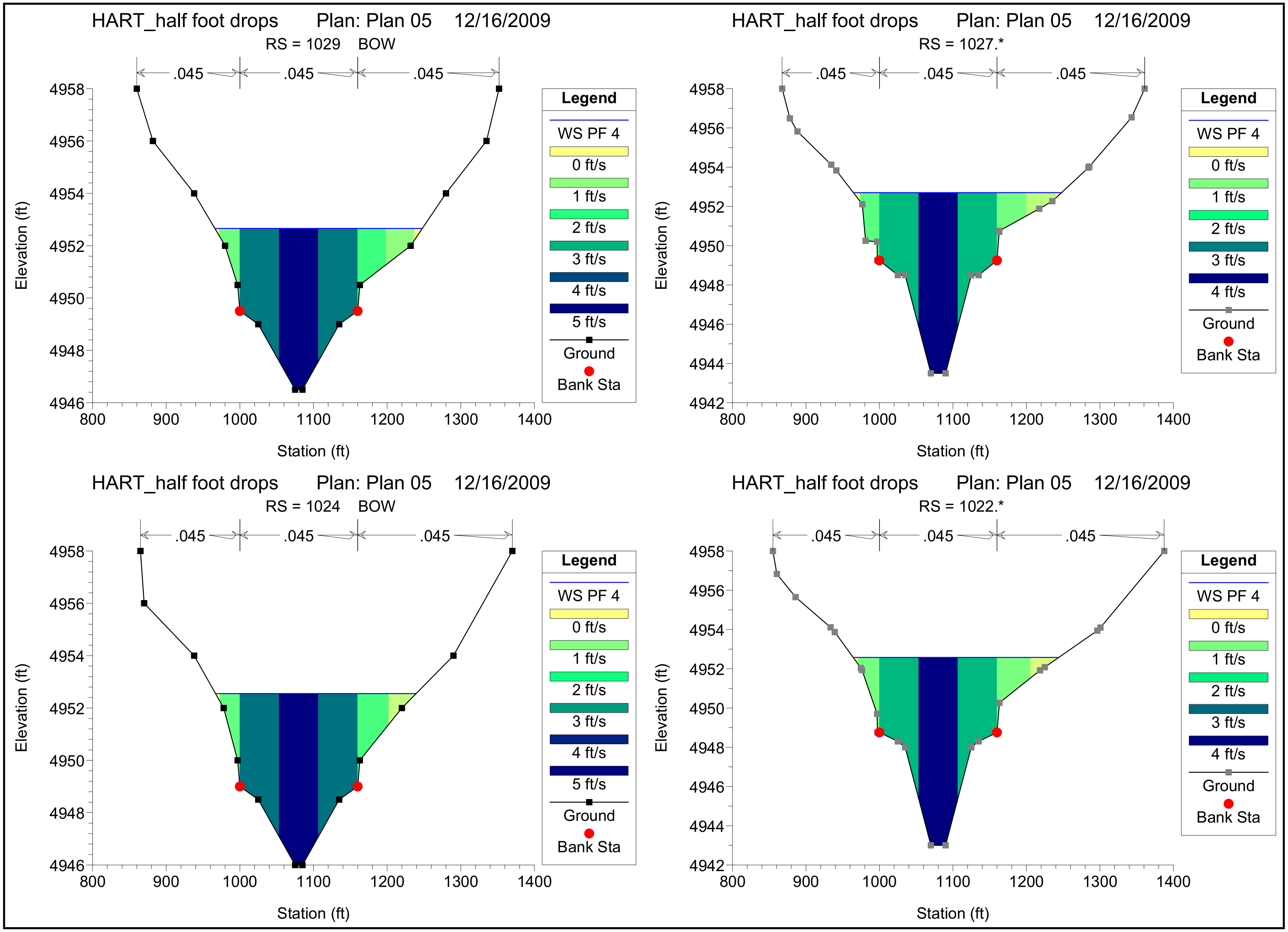
Velocity distribution, bankfull discharge
Proposed conditions



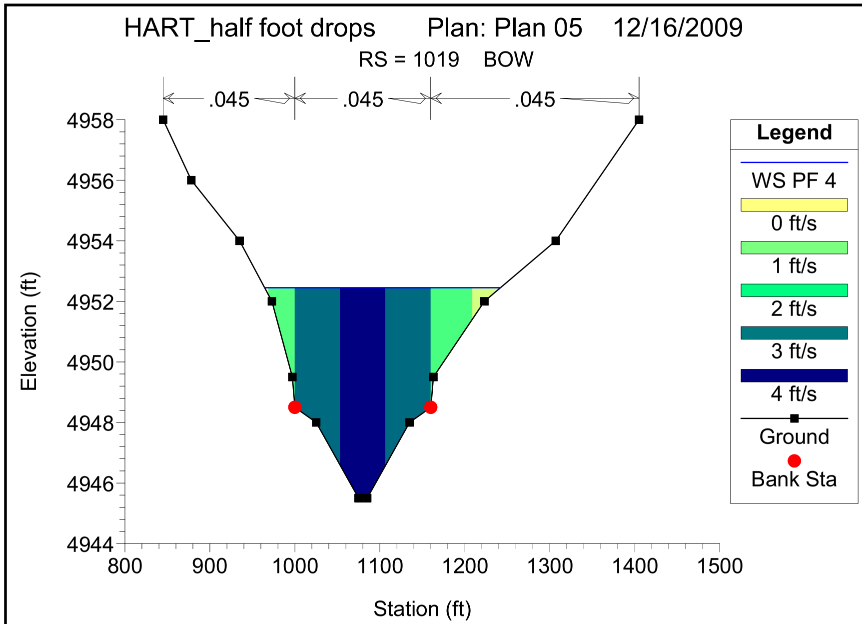
Velocity distribution, bankfull discharge
Proposed conditions

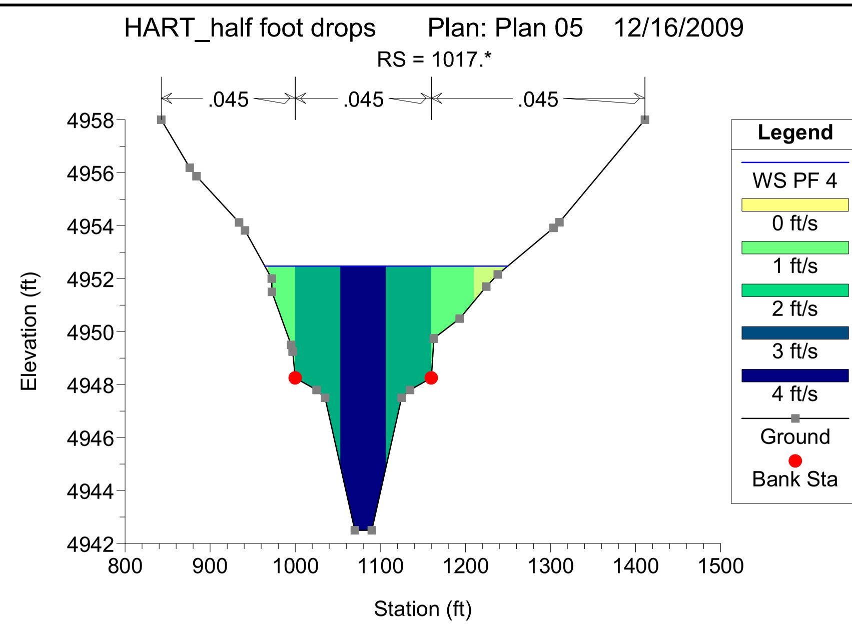


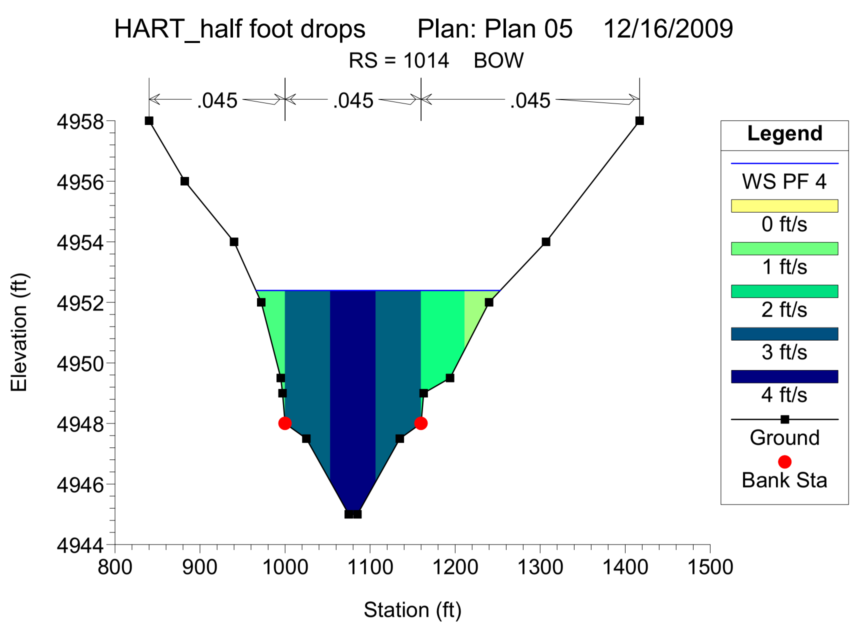
Velocity distribution, bankfull discharge
Proposed conditions

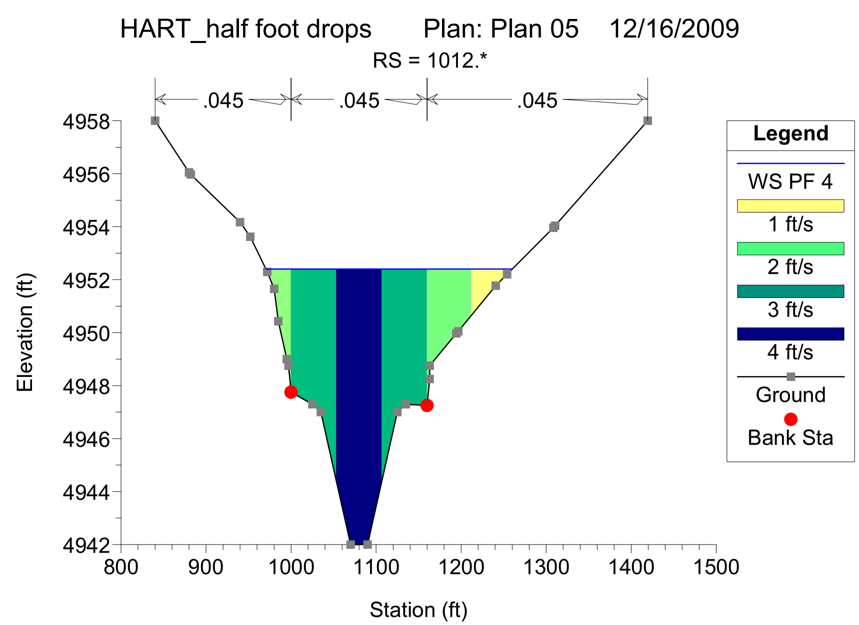


Velocity distribution, bankfull discharge
Proposed conditions

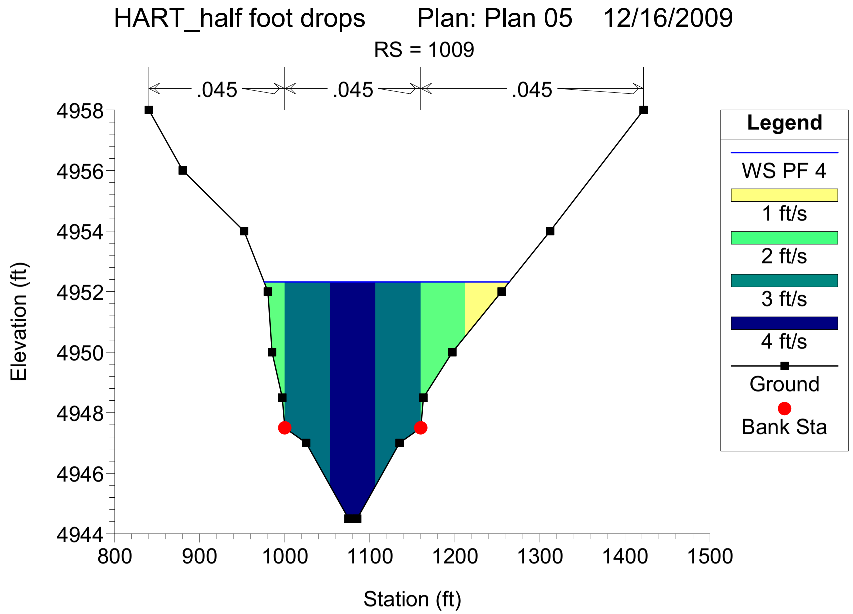


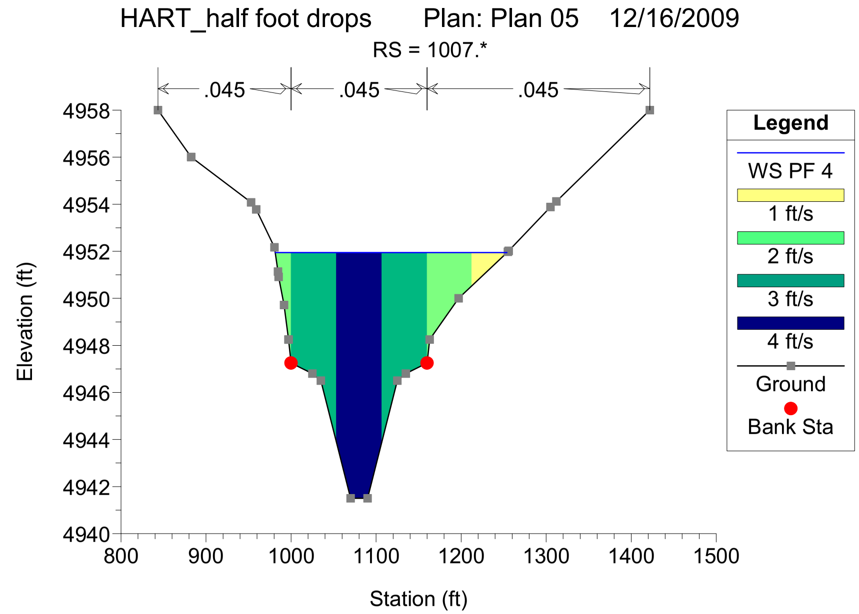


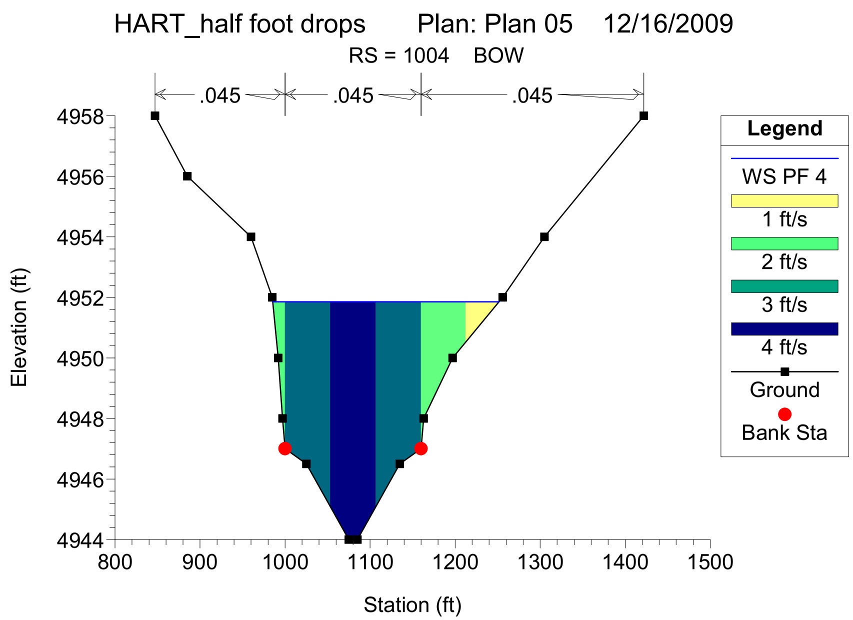




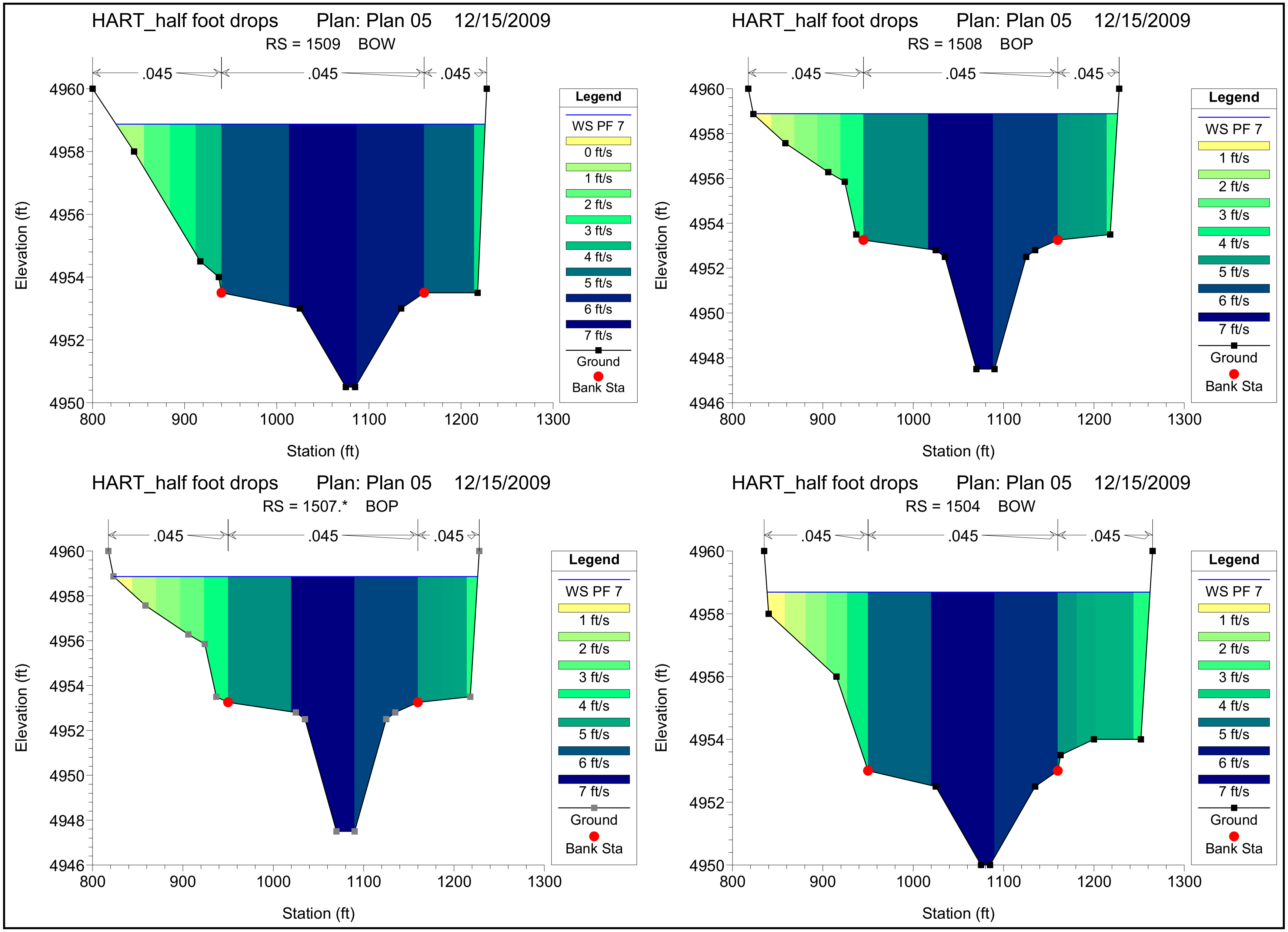
Velocity distribution, bankfull discharge
Proposed conditions



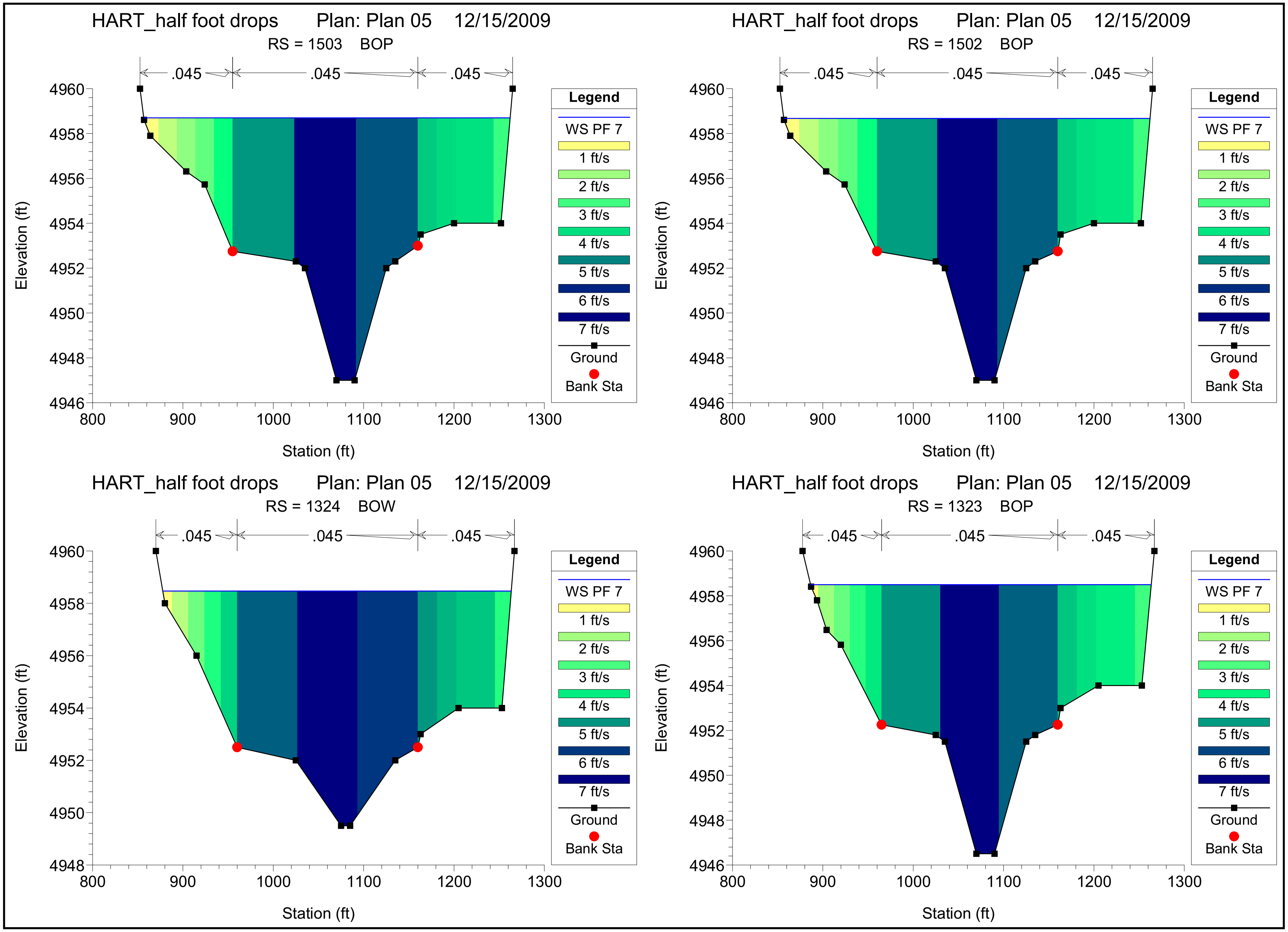




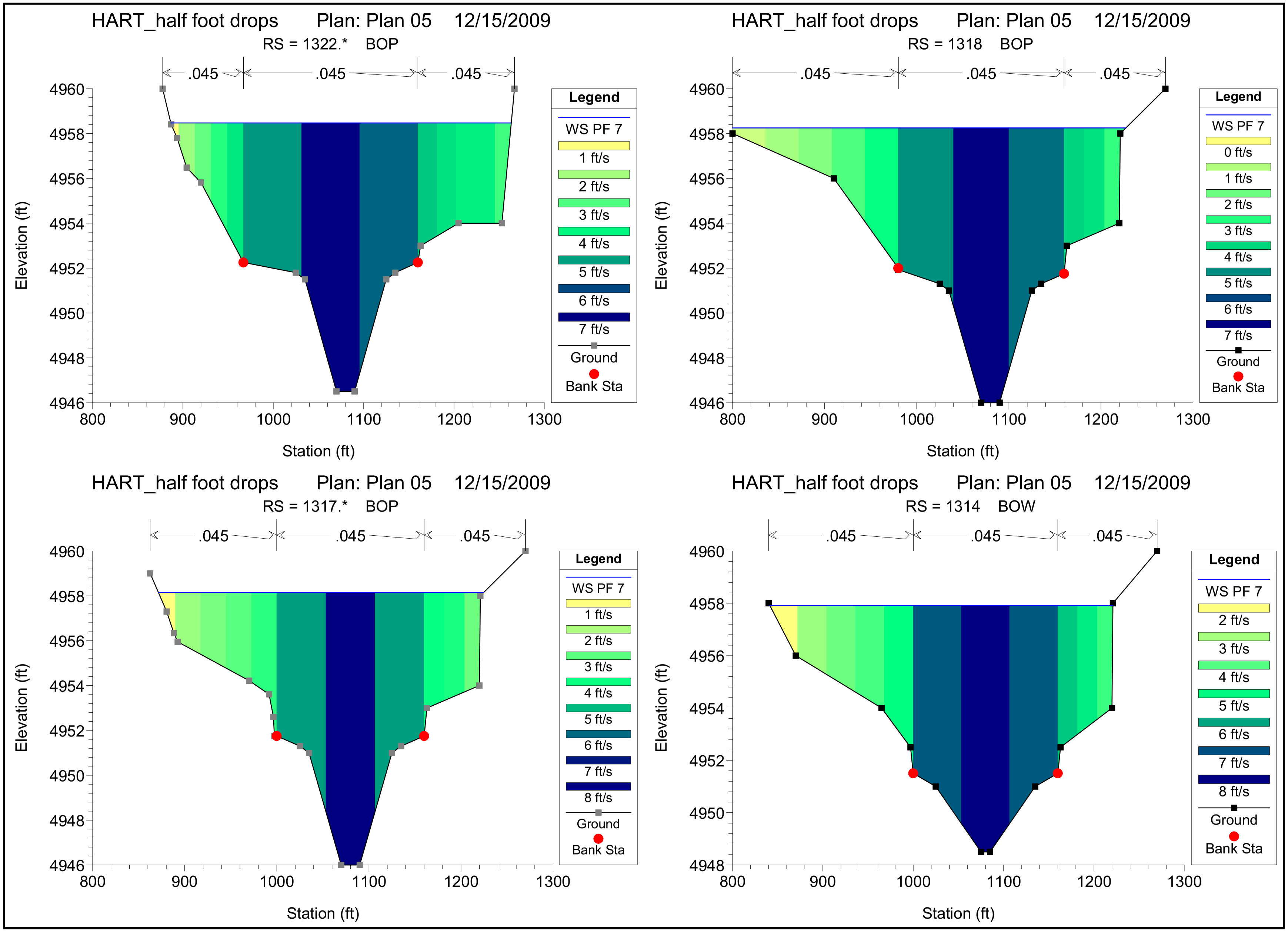
Velocity distribution, 5-year flood event
Proposed conditions



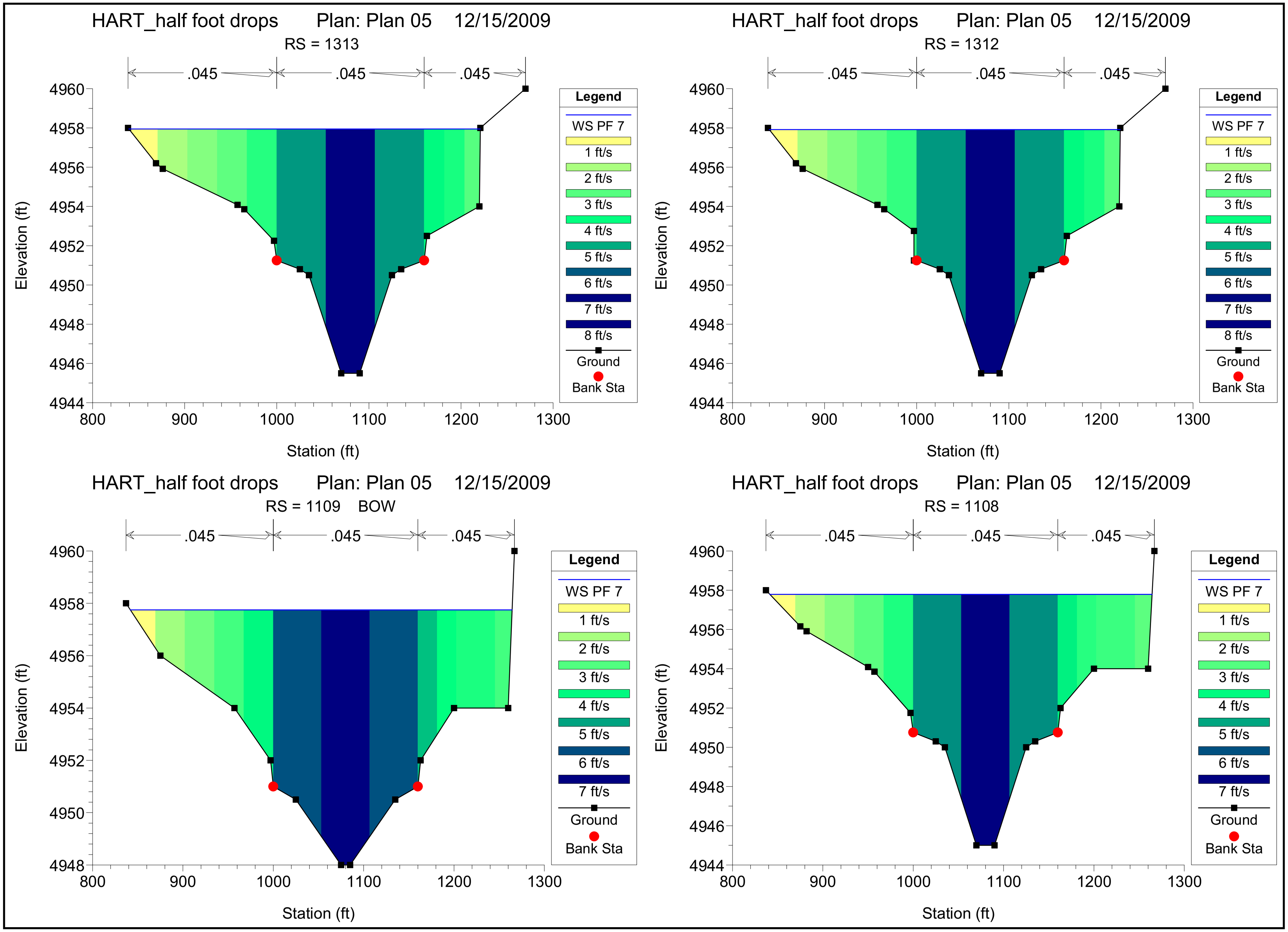
Velocity distribution, 5-year flood event
Proposed conditions



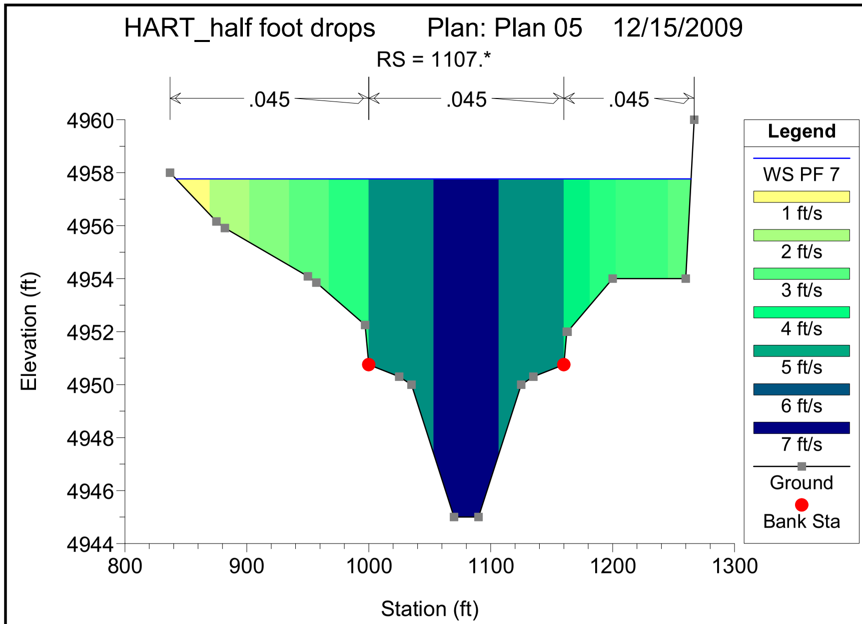
Velocity distribution, 5-year flood event
Proposed conditions

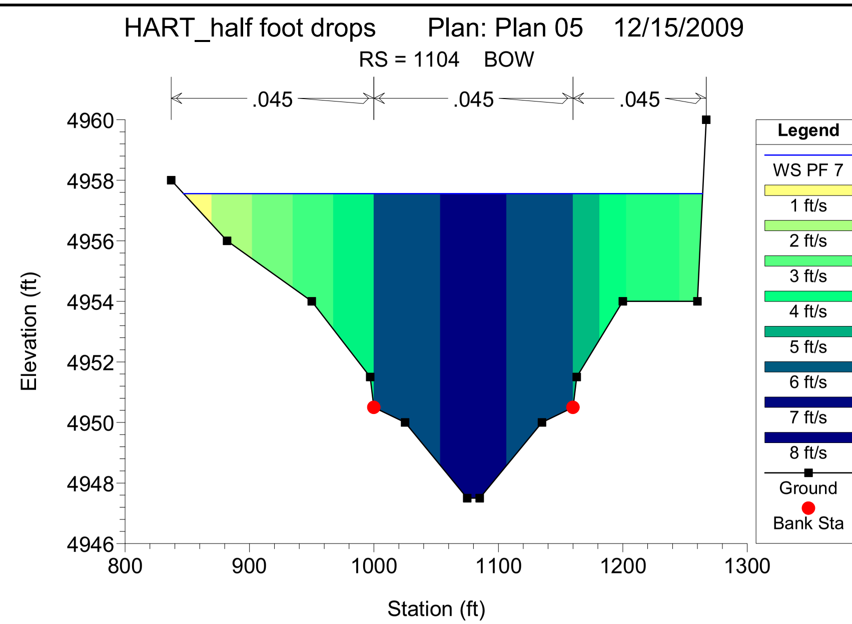


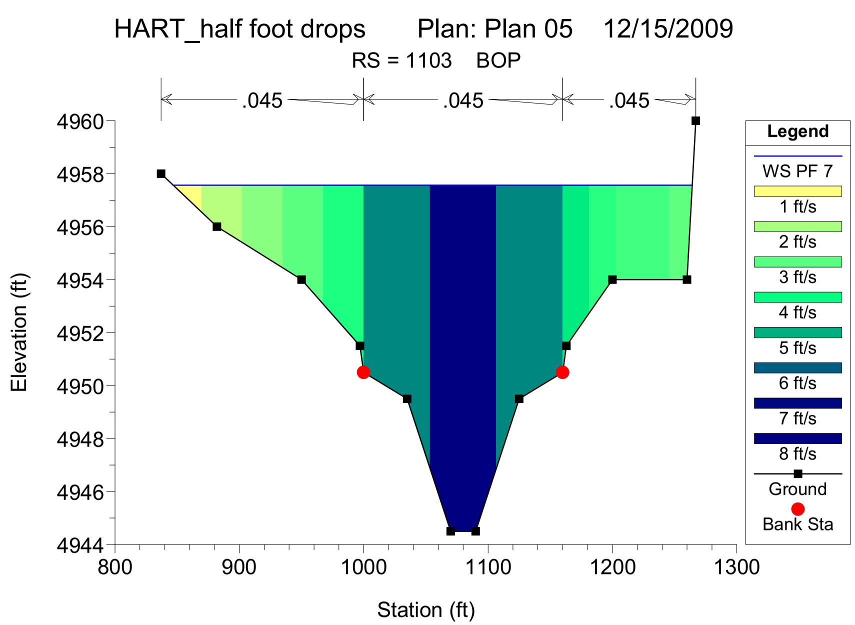
Velocity distribution, 5-year flood event
Proposed conditions

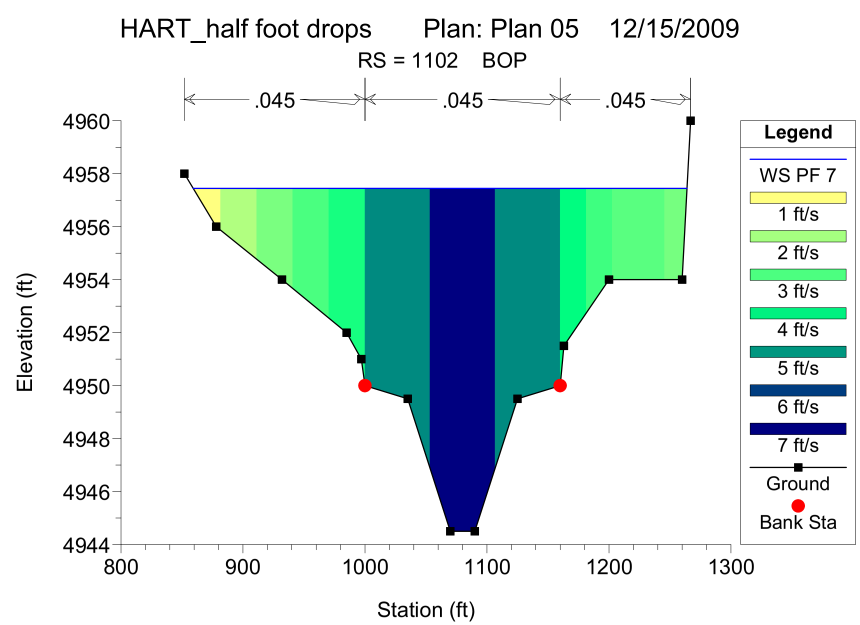


Velocity distribution, 5-year flood event
Proposed conditions

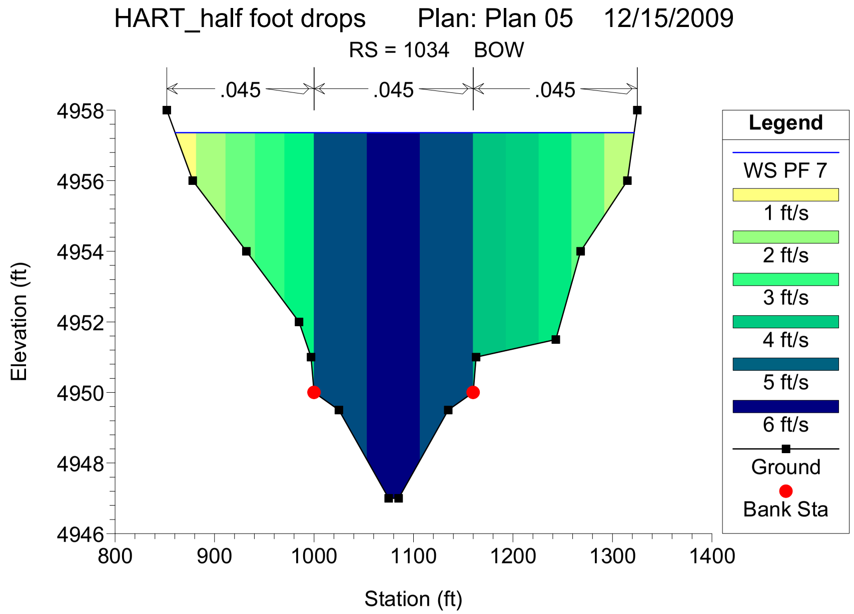


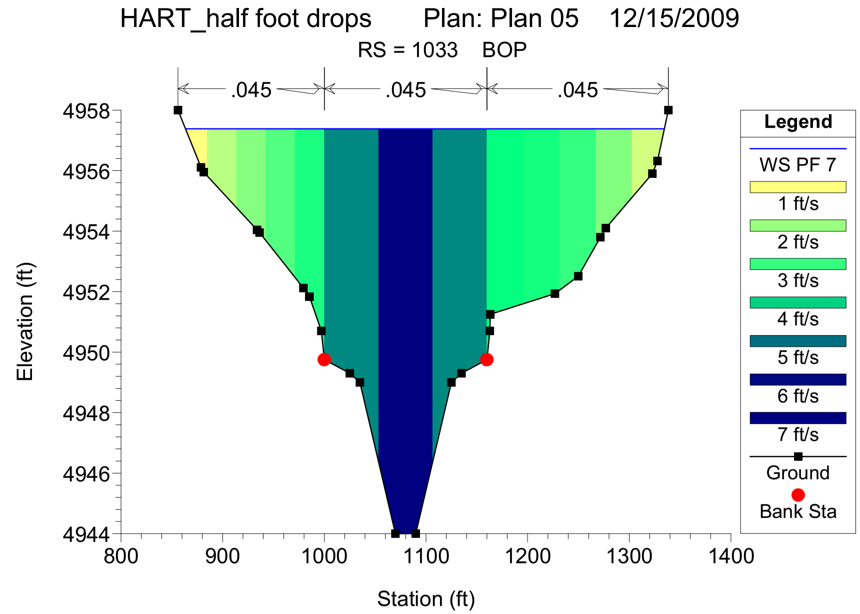


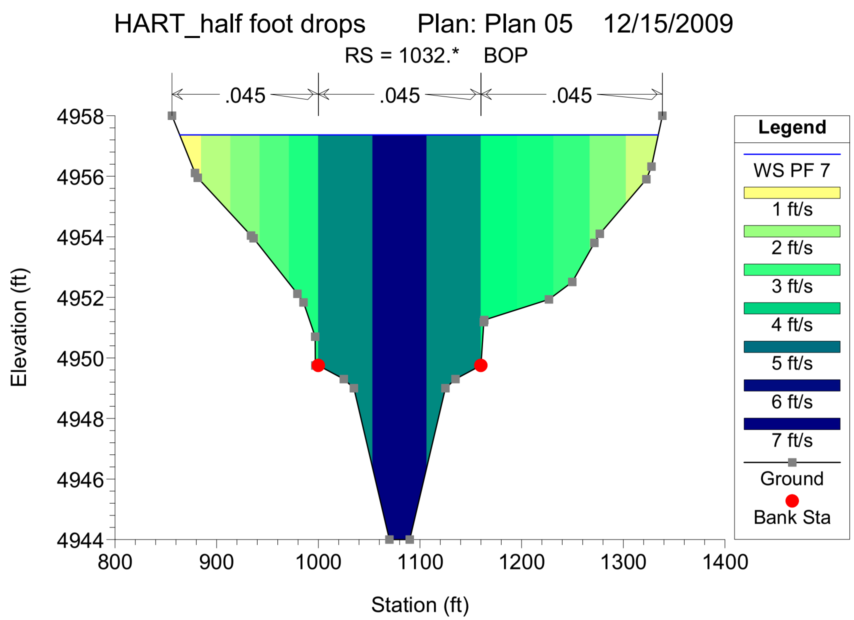


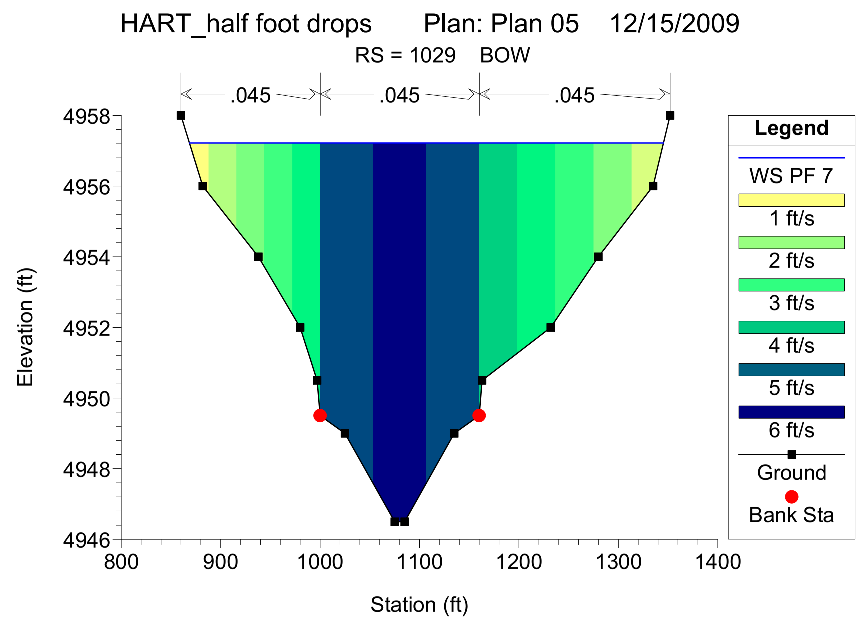


Velocity distribution, 5-year flood event
Proposed conditions

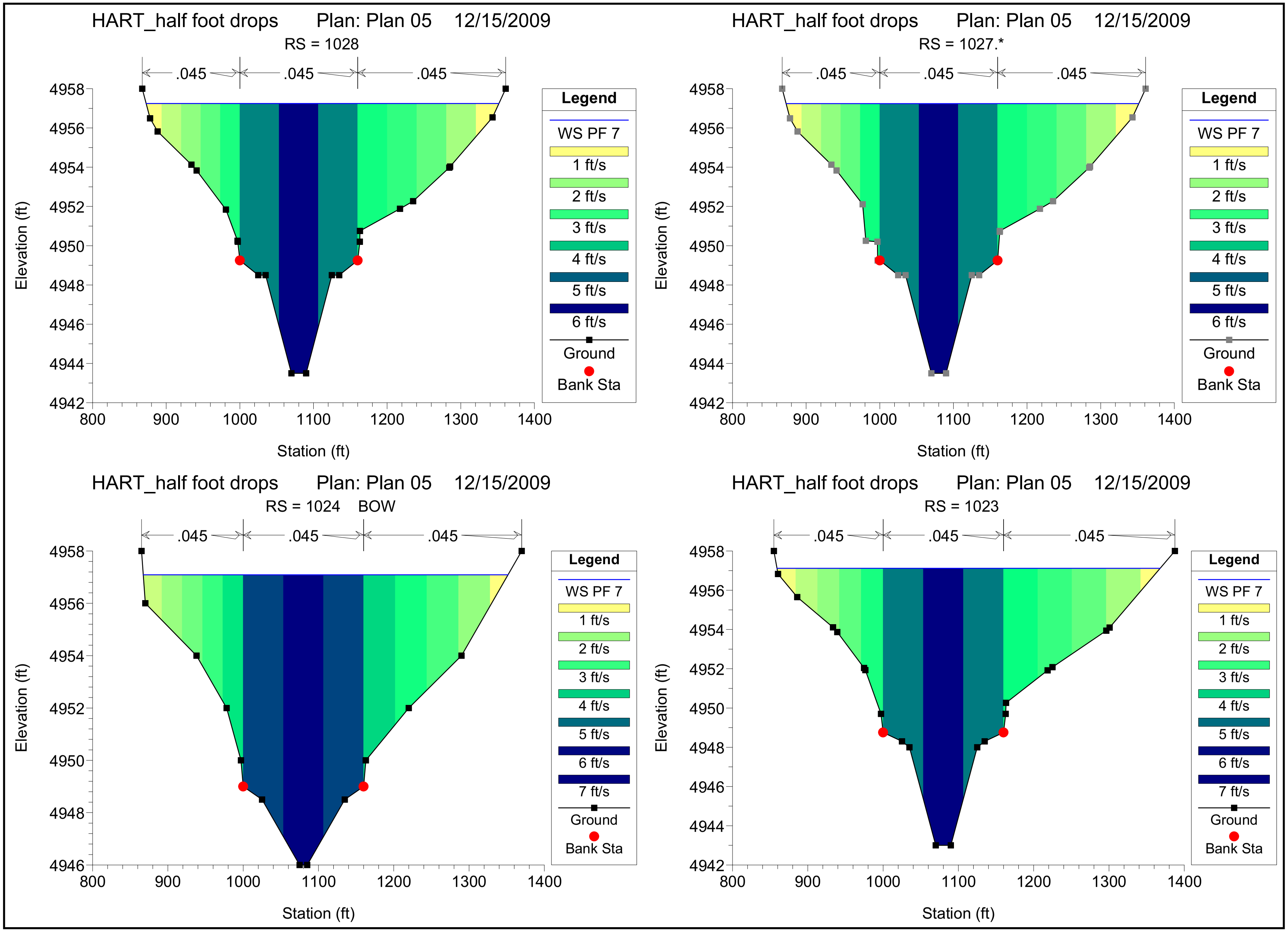




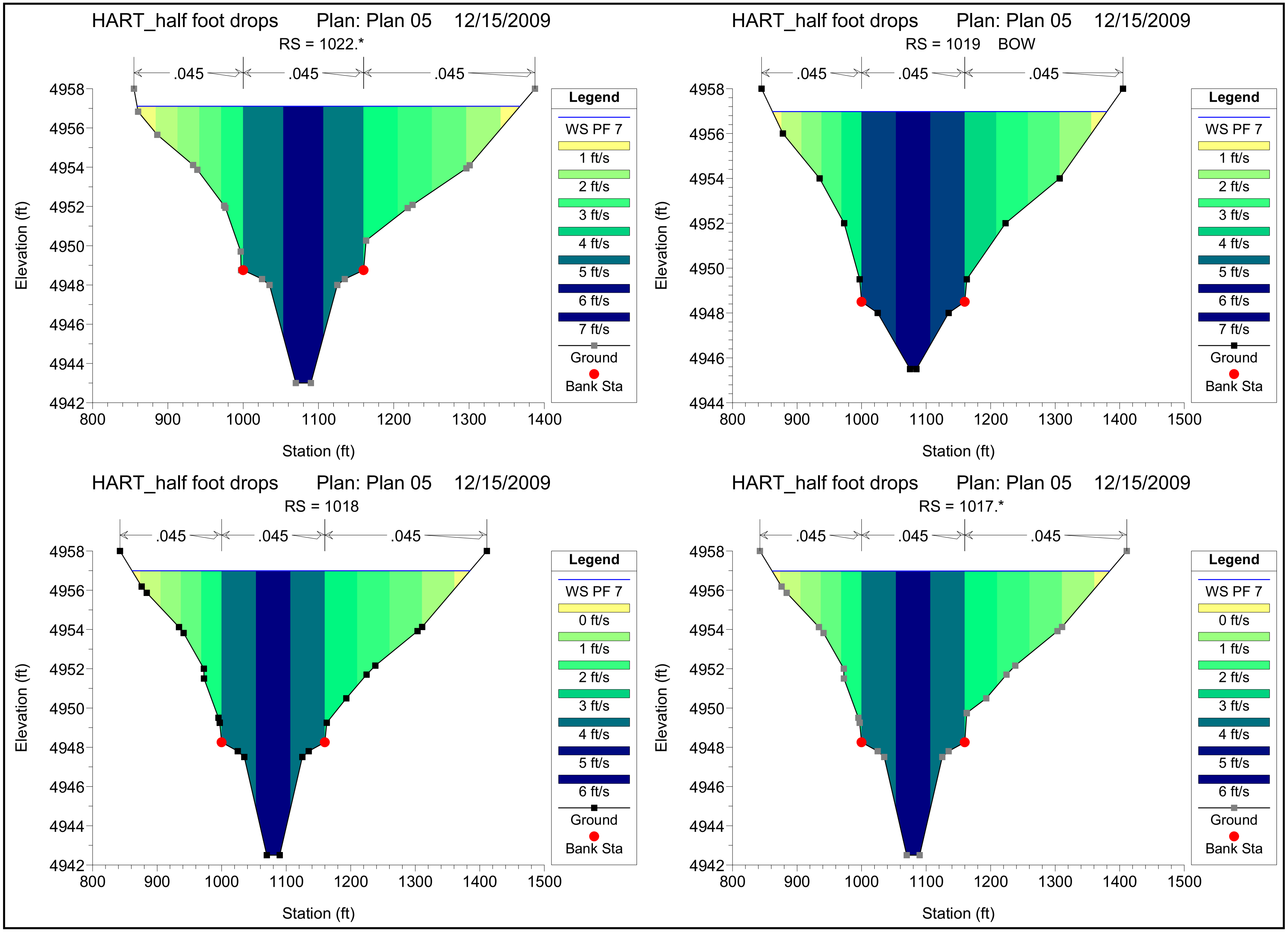




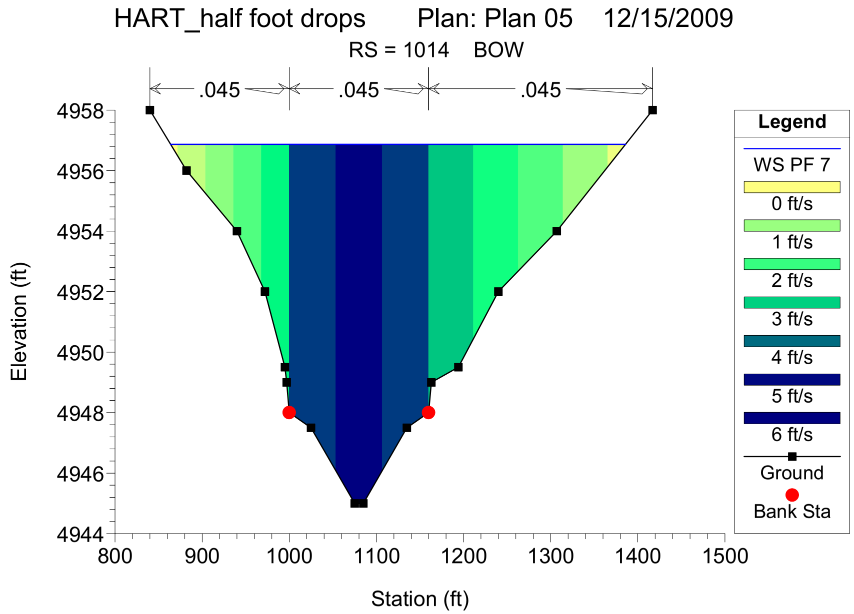
Velocity distribution, 5-year flood event
Proposed conditions

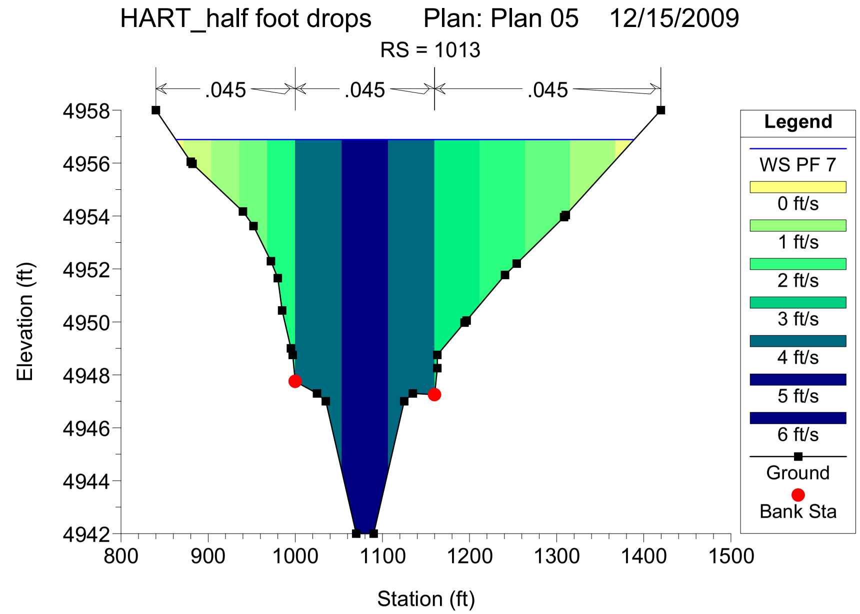


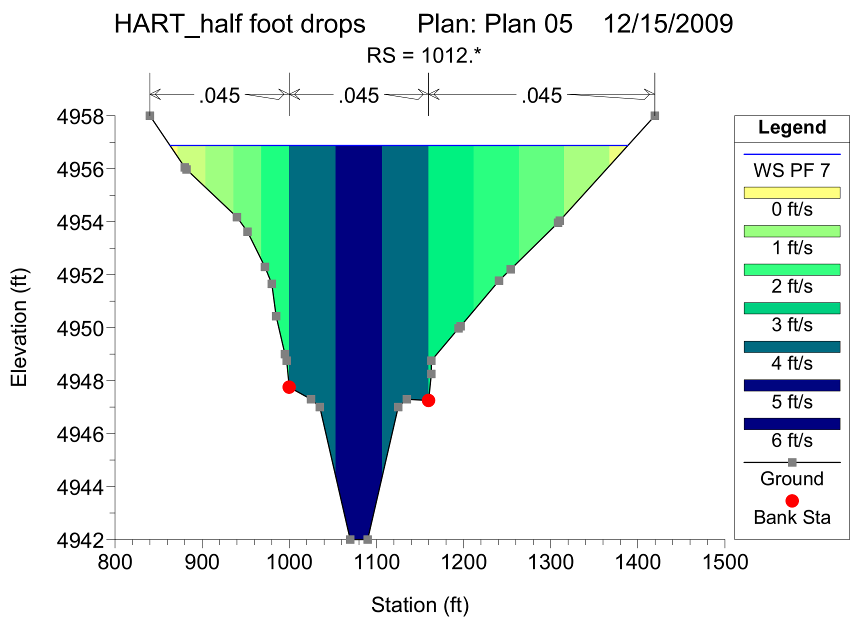
Velocity distribution, 5-year flood event
Proposed conditions

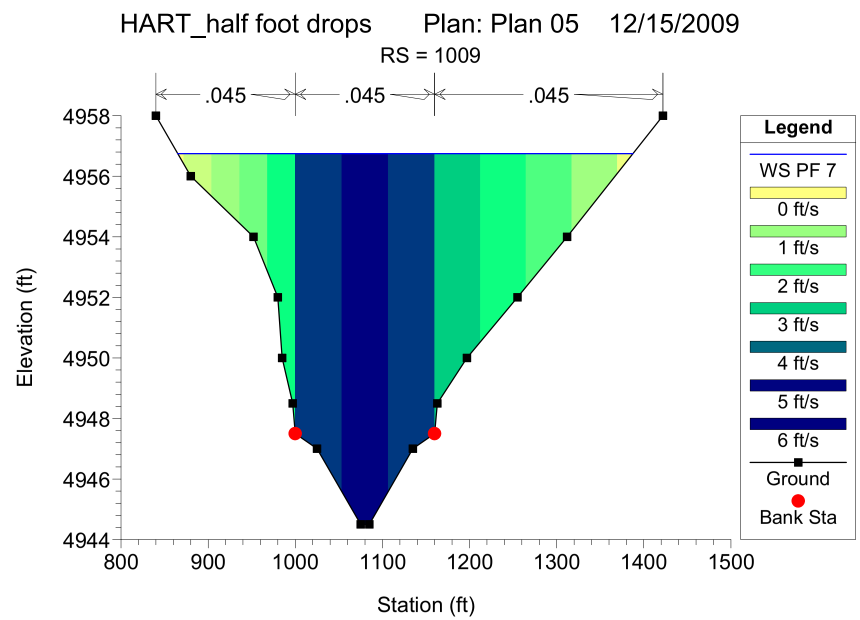


Velocity distribution, 5-year flood event
Proposed conditions

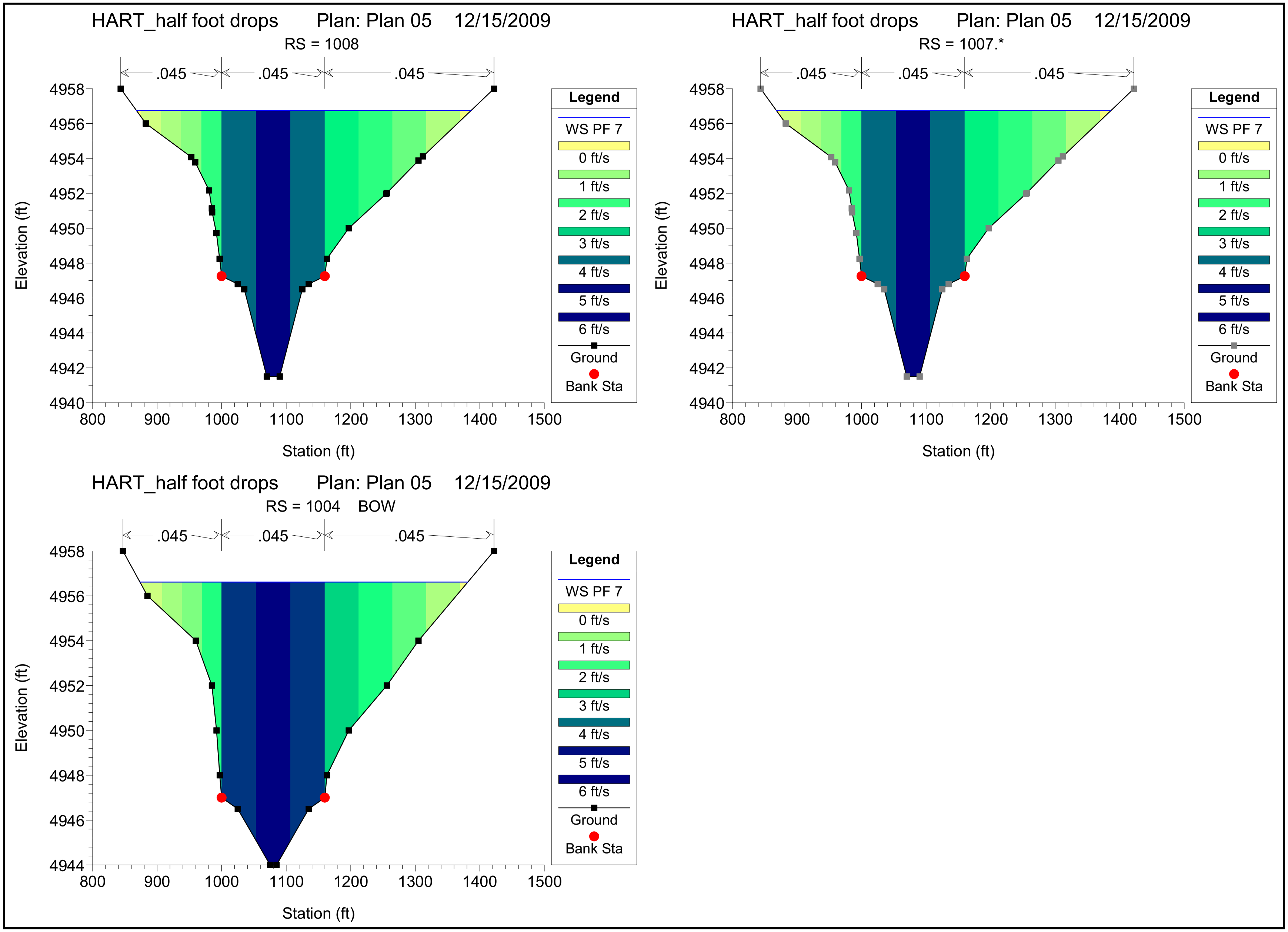








Velocity distribution, 5-year flood event
Proposed conditions



Proposed Hydraulics

HEC-RAS Plan: Plan 04 River: Gunnison R. Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	1900	PF 1	420.00	4951.85	4953.96		4954.05	0.002705	2.40	174.79	130.78	0.37
1	1900	PF 2	720.00	4951.85	4954.70		4954.78	0.002934	2.30	313.17	266.74	0.37
1	1900	PF 3	1270.00	4951.85	4955.50		4955.58	0.001770	2.31	552.26	325.65	0.31
1	1900	PF 4	3530.00	4951.85	4957.57		4957.67	0.001034	2.59	1382.75	463.98	0.26
1	1900	PF 5	4870.00	4951.85	4958.49		4958.60	0.000946	2.66	1862.46	559.99	0.25
1	1900	PF 6	7470.00	4951.85	4960.02		4960.12	0.000851	2.57	2954.32	851.17	0.24
1	1900	PF 7	11670.00	4951.85	4961.82		4961.92	0.000542	2.62	4536.79	908.27	0.20
1	1900	PF 8	21270.00	4951.85	4964.83		4964.95	0.000417	2.80	7747.05	1155.39	0.19
1	1800	PF 1	420.00	4949.79	4953.37		4953.39	0.000348	1.12	375.60	189.70	0.14
1	1800	PF 2	720.00	4949.79	4953.97		4954.00	0.000430	1.47	491.07	193.28	0.16
1	1800	PF 3	1270.00	4949.79	4954.73		4954.79	0.000572	1.99	638.89	196.75	0.19
1	1800	PF 4	3530.00	4949.79	4956.63		4956.81	0.000977	3.45	1036.48	223.01	0.27
1	1800	PF 5	4870.00	4949.79	4957.46		4957.71	0.001130	4.06	1227.51	246.17	0.30
1	1800	PF 6	7470.00	4949.79	4958.84		4959.21	0.001286	4.91	1619.46	318.32	0.33
1	1800	PF 7	11670.00	4949.79	4960.72		4961.19	0.001340	5.74	2306.33	414.95	0.35
1	1800	PF 8	21270.00	4949.79	4963.88		4964.37	0.001077	6.25	4517.28	729.12	0.32
1	1700	PF 1	420.00	4949.50	4953.21		4953.22	0.000065	0.55	760.27	316.02	0.06
1	1700	PF 2	720.00	4949.50	4953.74		4953.75	0.000104	0.77	934.36	334.72	0.08
1	1700	PF 3	1270.00	4949.50	4954.40		4954.41	0.000163	1.10	1154.78	339.22	0.11
1	1700	PF 4	3530.00	4949.50	4955.99		4956.05	0.000357	2.08	1700.10	345.73	0.17
1	1700	PF 5	4870.00	4949.50	4956.70		4956.80	0.000438	2.50	1947.43	348.64	0.19
1	1700	PF 6	7470.00	4949.50	4957.98		4958.13	0.000525	3.12	2397.73	360.71	0.21
1	1700	PF 7	11670.00	4949.50	4959.79		4960.01	0.000586	3.83	3097.47	483.73	0.23
1	1700	PF 8	21270.00	4949.50	4962.90		4963.26	0.000643	4.89	4650.84	501.06	0.25
1	1610	PF 1	420.00	4949.30	4953.15		4953.17	0.000361	1.13	372.42	189.90	0.14
1	1610	PF 2	720.00	4949.30	4953.63		4953.67	0.000588	1.52	472.98	221.58	0.18
1	1610	PF 3	1270.00	4949.30	4954.22		4954.28	0.001080	2.02	627.61	303.05	0.25
1	1610	PF 4	3530.00	4949.30	4955.63		4955.80	0.001499	3.34	1056.42	306.38	0.32
1	1610	PF 5	4870.00	4949.30	4956.26		4956.49	0.001638	3.89	1250.93	307.88	0.34
1	1610	PF 6	7470.00	4949.30	4957.46		4957.79	0.001635	4.59	1645.73	357.57	0.35
1	1610	PF 7	11670.00	4949.30	4959.27		4959.67	0.001391	5.14	2421.90	442.04	0.34
1	1610	PF 8	21270.00	4949.30	4962.38		4962.92	0.001206	6.07	3801.90	444.76	0.34
1	1520	PF 1	420.00	4948.00	4953.15	4948.97	4953.15	0.000042	0.48	785.74	275.48	0.04
1	1520	PF 2	720.00	4948.00	4953.64	4949.41	4953.65	0.000079	0.77	921.71	278.67	0.07
1	1520	PF 3	1270.00	4948.00	4954.23	4950.03	4954.25	0.000150	1.22	1085.59	285.27	0.10
1	1520	PF 4	3530.00	4948.00	4955.63	4951.63	4955.72	0.000433	2.57	1504.78	311.94	0.18
1	1520	PF 5	4870.00	4948.00	4956.26	4952.43	4956.40	0.000570	3.17	1706.77	333.68	0.22
1	1520	PF 6	7470.00	4948.00	4957.46	4953.26	4957.67	0.000718	4.00	2147.75	401.46	0.25
1	1520	PF 7	11670.00	4948.00	4959.27	4954.29	4959.56	0.000767	4.76	2922.22	433.90	0.27
1	1520	PF 8	21270.00	4948.00	4962.37	4956.21	4962.82	0.000834	5.99	4271.21	435.00	0.29
1	1510		Inl Struct									
1	1509	PF 1	340.00	4950.50	4952.64		4952.78	0.006653	3.01	113.01	95.61	0.49
1	1509	PF 2	640.00	4950.50	4953.20		4953.40	0.010082	3.63	176.43	154.04	0.60
1	1509	PF 3	1190.00	4950.50	4953.75		4954.00	0.010644	4.07	302.24	279.88	0.63
1	1509	PF 4	3450.00	4950.50	4955.10		4955.50	0.006794	5.22	704.05	315.81	0.56
1	1509	PF 5	4790.00	4950.50	4955.75		4956.20	0.005871	5.61	913.97	330.18	0.54
1	1509	PF 6	7390.00	4950.50	4957.02		4957.52	0.004236	5.92	1351.13	358.26	0.49
1	1509	PF 7	11590.00	4950.50	4958.87		4959.41	0.002975	6.22	2052.50	400.84	0.43
1	1509	PF 8	21190.00	4950.50	4961.97		4962.63	0.002209	6.97	3364.00	428.00	0.40
1	1508	PF 1	340.00	4947.50	4952.63		4952.65	0.000312	1.18	287.54	98.86	0.12
1	1508	PF 2	640.00	4947.50	4953.20		4953.25	0.001268	1.74	367.32	202.93	0.23
1	1508	PF 3	1190.00	4947.50	4953.74		4953.83	0.001829	2.42	508.81	282.70	0.28
1	1508	PF 4	3450.00	4947.50	4955.13		4955.37	0.002677	4.03	907.38	292.34	0.37
1	1508	PF 5	4790.00	4947.50	4955.78		4956.10	0.002825	4.62	1100.00	296.89	0.39
1	1508	PF 6	7390.00	4947.50	4957.07		4957.47	0.002602	5.29	1513.75	346.59	0.39
1	1508	PF 7	11590.00	4947.50	4958.89		4959.37	0.002207	5.87	2197.50	403.33	0.38
1	1508	PF 8	21190.00	4947.50	4961.98		4962.61	0.001865	6.82	3463.08	410.50	0.37
1	1507.*	PF 1	340.00	4947.50	4952.63	4949.19	4952.65	0.000312	1.18	287.25	98.66	0.12
1	1507.*	PF 2	640.00	4947.50	4953.19	4949.88	4953.23	0.001247	1.76	363.75	195.47	0.23
1	1507.*	PF 3	1190.00	4947.50	4953.72	4950.79	4953.82	0.001876	2.46	500.99	282.55	0.29
1	1507.*	PF 4	3450.00	4947.50	4955.10	4953.56	4955.34	0.002772	4.11	895.64	292.11	0.38
1	1507.*	PF 5	4790.00	4947.50	4955.75	4954.07	4956.07	0.002919	4.70	1087.38	296.64	0.40
1	1507.*	PF 6	7390.00	4947.50	4957.04	4954.78	4957.45	0.002683	5.37	1499.50	345.21	0.40
1	1507.*	PF 7	11590.00	4947.50	4958.86	4955.77	4959.35	0.002257	5.94	2183.94	402.82	0.39
1	1507.*	PF 8	21190.00	4947.50	4961.96	4957.77	4962.59	0.001888	6.86	3451.91	410.50	0.37
1	1505		Inl Struct									
1	1504	PF 1	340.00	4950.00	4952.13		4952.27	0.006810	3.03	112.03	95.20	0.49
1	1504	PF 2	640.00	4950.00	4952.70		4952.91	0.009809	3.64	176.03	150.04	0.59
1	1504	PF 3	1190.00	4950.00	4953.31		4953.56	0.009469	4.03	295.96	215.48	0.60

HEC-RAS Plan: Plan 04 River: Gunnison R. Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	1504	PF 4	3450.00	4950.00	4954.76		4955.18	0.006483	5.35	699.64	324.18	0.56
1	1504	PF 5	4790.00	4950.00	4955.44		4955.90	0.005501	5.68	923.34	333.59	0.53
1	1504	PF 6	7390.00	4950.00	4956.81		4957.29	0.003766	5.85	1401.85	373.47	0.47
1	1504	PF 7	11590.00	4950.00	4958.69		4959.18	0.002604	6.04	2165.68	423.89	0.41
1	1504	PF 8	21190.00	4950.00	4961.75		4962.36	0.002001	6.78	3477.50	430.00	0.38
1	1503	PF 1	340.00	4947.00	4952.13		4952.15	0.000312	1.18	287.44	98.79	0.12
1	1503	PF 2	640.00	4947.00	4952.70		4952.75	0.001165	1.76	364.26	186.46	0.22
1	1503	PF 3	1190.00	4947.00	4953.31		4953.41	0.001716	2.43	490.32	212.75	0.28
1	1503	PF 4	3450.00	4947.00	4954.80		4955.05	0.002598	4.14	899.81	320.01	0.37
1	1503	PF 5	4790.00	4947.00	4955.50		4955.82	0.002625	4.65	1128.72	328.88	0.38
1	1503	PF 6	7390.00	4947.00	4956.87		4957.24	0.002273	5.15	1604.11	368.61	0.37
1	1503	PF 7	11590.00	4947.00	4958.70		4959.14	0.001919	5.66	2320.63	405.51	0.36
1	1503	PF 8	21190.00	4947.00	4961.78		4962.36	0.001690	6.64	3584.21	412.50	0.36
1	1502	PF 1	340.00	4947.00	4952.13	4948.69	4952.15	0.000312	1.18	287.16	98.60	0.12
1	1502	PF 2	640.00	4947.00	4952.69	4949.38	4952.74	0.001191	1.76	362.65	187.51	0.22
1	1502	PF 3	1190.00	4947.00	4953.30	4950.31	4953.39	0.001714	2.46	486.13	208.76	0.28
1	1502	PF 4	3450.00	4947.00	4954.76	4952.95	4955.03	0.002689	4.22	883.65	317.92	0.38
1	1502	PF 5	4790.00	4947.00	4955.46	4953.47	4955.79	0.002720	4.74	1110.87	327.94	0.39
1	1502	PF 6	7390.00	4947.00	4956.84	4954.56	4957.22	0.002337	5.23	1586.63	367.69	0.38
1	1502	PF 7	11590.00	4947.00	4958.68	4955.55	4959.12	0.001958	5.73	2304.67	405.37	0.36
1	1502	PF 8	21190.00	4947.00	4961.75	4957.42	4962.34	0.001712	6.69	3569.67	412.50	0.36
1	1325		Inl Struct									
1	1324	PF 1	340.00	4949.50	4951.64		4951.78	0.006653	3.01	113.01	95.61	0.49
1	1324	PF 2	640.00	4949.50	4952.21		4952.41	0.009428	3.61	177.06	147.79	0.58
1	1324	PF 3	1190.00	4949.50	4952.83		4953.08	0.009032	4.05	294.54	206.22	0.59
1	1324	PF 4	3450.00	4949.50	4954.45		4954.86	0.005682	5.28	708.84	319.12	0.53
1	1324	PF 5	4790.00	4949.50	4955.20		4955.64	0.004711	5.55	952.46	330.52	0.50
1	1324	PF 6	7390.00	4949.50	4956.63		4957.08	0.003276	5.72	1441.44	355.16	0.44
1	1324	PF 7	11590.00	4949.50	4958.47		4958.97	0.002513	6.12	2127.26	385.78	0.40
1	1324	PF 8	21190.00	4949.50	4961.47		4962.15	0.002125	7.11	3309.68	397.00	0.39
1	1323	PF 1	340.00	4946.50	4951.63		4951.65	0.000312	1.18	287.40	98.76	0.12
1	1323	PF 2	640.00	4946.50	4952.21		4952.25	0.001157	1.75	365.16	186.61	0.22
1	1323	PF 3	1190.00	4946.50	4952.83		4952.93	0.001615	2.44	490.25	204.71	0.27
1	1323	PF 4	3450.00	4946.50	4954.51		4954.75	0.002257	4.06	918.30	317.69	0.35
1	1323	PF 5	4790.00	4946.50	4955.26		4955.56	0.002287	4.56	1160.77	328.91	0.36
1	1323	PF 6	7390.00	4946.50	4956.67		4957.03	0.002013	5.06	1644.80	356.64	0.35
1	1323	PF 7	11590.00	4946.50	4958.50		4958.93	0.001804	5.67	2314.07	377.09	0.35
1	1323	PF 8	21190.00	4946.50	4961.50		4962.12	0.001738	6.86	3473.05	389.50	0.36
1	1322.*	PF 1	340.00	4946.50	4951.63	4948.19	4951.65	0.000312	1.18	287.11	98.57	0.12
1	1322.*	PF 2	640.00	4946.50	4952.19	4948.89	4952.24	0.001151	1.77	362.55	182.56	0.22
1	1322.*	PF 3	1190.00	4946.50	4952.82	4949.79	4952.91	0.001650	2.46	485.06	202.72	0.27
1	1322.*	PF 4	3450.00	4946.50	4954.48	4952.45	4954.73	0.002332	4.11	905.33	316.49	0.36
1	1322.*	PF 5	4790.00	4946.50	4955.23	4952.99	4955.53	0.002358	4.62	1146.74	328.12	0.37
1	1322.*	PF 6	7390.00	4946.50	4956.64	4954.09	4957.01	0.002060	5.11	1631.03	356.36	0.36
1	1322.*	PF 7	11590.00	4946.50	4958.47	4955.24	4958.91	0.001835	5.72	2301.03	376.89	0.35
1	1322.*	PF 8	21190.00	4946.50	4961.47	4957.10	4962.10	0.001758	6.90	3460.09	389.50	0.36
1	1320		Inl Struct									
1	1319	PF 1	340.00	4949.00	4951.13		4951.27	0.006810	3.03	112.03	95.20	0.49
1	1319	PF 2	640.00	4949.00	4951.72		4951.92	0.008891	3.60	177.86	143.03	0.57
1	1319	PF 3	1190.00	4949.00	4952.41		4952.65	0.007592	3.97	301.25	192.90	0.55
1	1319	PF 4	3450.00	4949.00	4954.21		4954.61	0.004754	5.17	717.88	280.96	0.49
1	1319	PF 5	4790.00	4949.00	4954.96		4955.42	0.004318	5.62	933.24	293.34	0.48
1	1319	PF 6	7390.00	4949.00	4956.38		4956.89	0.003386	6.05	1369.19	331.49	0.45
1	1319	PF 7	11590.00	4949.00	4958.19		4958.77	0.002794	6.62	2059.16	425.65	0.43
1	1319	PF 8	21190.00	4949.00	4961.21		4961.89	0.002193	7.37	3438.43	470.00	0.40
1	1318	PF 1	340.00	4946.00	4951.14		4951.16	0.000312	1.18	287.88	99.09	0.12
1	1318	PF 2	640.00	4946.00	4951.72		4951.77	0.000993	1.76	362.76	163.61	0.21
1	1318	PF 3	1190.00	4946.00	4952.40		4952.50	0.001495	2.46	485.37	188.59	0.26
1	1318	PF 4	3450.00	4946.00	4954.23		4954.48	0.002070	4.09	902.34	279.02	0.34
1	1318	PF 5	4790.00	4946.00	4955.03		4955.35	0.002133	4.63	1132.90	293.32	0.35
1	1318	PF 6	7390.00	4946.00	4956.45		4956.85	0.002044	5.31	1571.45	335.54	0.36
1	1318	PF 7	11590.00	4946.00	4958.25		4958.75	0.001960	6.09	2262.39	427.11	0.37
1	1318	PF 8	21190.00	4946.00	4961.24		4961.87	0.001771	7.07	3632.33	470.00	0.37
1	1317.*	PF 1	340.00	4946.00	4951.13	4947.69	4951.16	0.000312	1.18	287.59	98.89	0.12
1	1317.*	PF 2	640.00	4946.00	4951.71	4948.39	4951.76	0.000957	1.78	359.67	155.72	0.21
1	1317.*	PF 3	1190.00	4946.00	4952.38	4949.29	4952.48	0.001437	2.55	468.88	164.84	0.26
1	1317.*	PF 4	3450.00	4946.00	4954.14	4951.89	4954.45	0.002401	4.51	808.06	247.27	0.37
1	1317.*	PF 5	4790.00	4946.00	4954.92	4952.48	4955.31	0.002584	5.18	1012.93	281.49	0.39
1	1317.*	PF 6	7390.00	4946.00	4956.34	4953.52	4956.82	0.002400	5.83	1458.11	332.34	0.39

HEC-RAS Plan: Plan 04 River: Gunnison R. Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	1317.*	PF 7	11590.00	4946.00	4958.15	4955.18	4958.72	0.002231	6.57	2071.34	353.02	0.39
1	1317.*	PF 8	21190.00	4946.00	4961.04	4957.33	4961.83	0.002237	7.97	3203.04	407.50	0.41
1	1315		Inl Struct									
1	1314	PF 1	340.00	4948.50	4950.63		4950.77	0.006810	3.03	112.03	95.20	0.49
1	1314	PF 2	640.00	4948.50	4951.22		4951.42	0.008176	3.62	176.65	132.02	0.55
1	1314	PF 3	1190.00	4948.50	4951.90		4952.18	0.007721	4.23	281.96	162.40	0.56
1	1314	PF 4	3450.00	4948.50	4953.70		4954.22	0.005833	5.88	622.47	237.21	0.55
1	1314	PF 5	4790.00	4948.50	4954.55		4955.13	0.005012	6.28	843.67	281.25	0.53
1	1314	PF 6	7390.00	4948.50	4956.08		4956.65	0.003587	6.48	1329.87	351.72	0.47
1	1314	PF 7	11590.00	4948.50	4957.92		4958.53	0.002800	6.86	2002.79	379.78	0.43
1	1314	PF 8	21190.00	4948.50	4960.81		4961.59	0.002500	8.00	3192.58	430.00	0.43
1	1313	PF 1	340.00	4945.50	4950.63		4950.65	0.000312	1.18	287.54	98.86	0.12
1	1313	PF 2	640.00	4945.50	4951.22		4951.27	0.000954	1.77	360.73	156.48	0.21
1	1313	PF 3	1190.00	4945.50	4951.90		4952.00	0.001412	2.53	470.40	163.47	0.26
1	1313	PF 4	3450.00	4945.50	4953.75		4954.04	0.002213	4.40	829.50	243.59	0.35
1	1313	PF 5	4790.00	4945.50	4954.65		4955.01	0.002220	4.94	1070.53	287.97	0.37
1	1313	PF 6	7390.00	4945.50	4956.14		4956.56	0.002063	5.56	1546.50	350.05	0.37
1	1313	PF 7	11590.00	4945.50	4957.95		4958.46	0.001934	6.26	2209.17	381.57	0.37
1	1313	PF 8	21190.00	4945.50	4960.84		4961.55	0.001956	7.58	3405.19	431.50	0.39
1	1312	PF 1	340.00	4945.50	4950.63	4947.19	4950.65	0.000312	1.18	287.25	98.66	0.12
1	1312	PF 2	640.00	4945.50	4951.21	4947.89	4951.26	0.000959	1.78	359.14	155.34	0.21
1	1312	PF 3	1190.00	4945.50	4951.88	4948.81	4951.98	0.001434	2.55	469.21	164.51	0.26
1	1312	PF 4	3450.00	4945.50	4953.72	4951.39	4954.02	0.002282	4.45	815.84	240.60	0.36
1	1312	PF 5	4790.00	4945.50	4954.62	4951.98	4954.99	0.002288	5.00	1054.75	286.54	0.37
1	1312	PF 6	7390.00	4945.50	4956.10	4953.07	4956.54	0.002116	5.62	1529.22	349.23	0.37
1	1312	PF 7	11590.00	4945.50	4957.92	4954.73	4958.44	0.001975	6.31	2191.47	381.07	0.37
1	1312	PF 8	21190.00	4945.50	4960.81	4956.96	4961.53	0.001993	7.64	3385.39	431.50	0.39
1	1110		Inl Struct									
1	1109	PF 1	340.00	4948.00	4950.14		4950.28	0.006653	3.01	113.01	95.61	0.49
1	1109	PF 2	640.00	4948.00	4950.71		4950.92	0.008301	3.65	175.30	131.00	0.56
1	1109	PF 3	1190.00	4948.00	4951.40		4951.68	0.007721	4.23	281.96	162.40	0.56
1	1109	PF 4	3450.00	4948.00	4953.34		4953.83	0.005165	5.67	637.47	217.58	0.52
1	1109	PF 5	4790.00	4948.00	4954.29		4954.83	0.004358	6.07	879.16	315.23	0.50
1	1109	PF 6	7390.00	4948.00	4955.88		4956.39	0.003024	6.15	1433.61	382.27	0.43
1	1109	PF 7	11590.00	4948.00	4957.75		4958.27	0.002334	6.44	2188.55	422.63	0.40
1	1109	PF 8	21190.00	4948.00	4960.64		4961.30	0.002027	7.35	3427.76	430.00	0.39
1	1108	PF 1	340.00	4945.00	4950.13		4950.16	0.000312	1.18	287.64	98.93	0.12
1	1108	PF 2	640.00	4945.00	4950.72		4950.76	0.000955	1.78	360.20	156.10	0.21
1	1108	PF 3	1190.00	4945.00	4951.41		4951.51	0.001392	2.52	472.40	163.56	0.26
1	1108	PF 4	3450.00	4945.00	4953.42		4953.70	0.001971	4.25	851.23	224.15	0.34
1	1108	PF 5	4790.00	4945.00	4954.38		4954.73	0.001988	4.80	1107.77	321.43	0.35
1	1108	PF 6	7390.00	4945.00	4955.94		4956.33	0.001774	5.30	1655.90	381.20	0.34
1	1108	PF 7	11590.00	4945.00	4957.79		4958.24	0.001635	5.90	2399.82	423.09	0.34
1	1108	PF 8	21190.00	4945.00	4960.67		4961.27	0.001619	7.02	3634.45	430.00	0.35
1	1107.*	PF 1	340.00	4945.00	4950.13	4946.69	4950.15	0.000312	1.18	287.30	98.70	0.12
1	1107.*	PF 2	640.00	4945.00	4950.71	4947.39	4950.75	0.000960	1.78	358.68	155.01	0.21
1	1107.*	PF 3	1190.00	4945.00	4951.39	4948.31	4951.49	0.001417	2.54	469.61	162.51	0.26
1	1107.*	PF 4	3450.00	4945.00	4953.39	4950.89	4953.68	0.002036	4.30	834.49	220.39	0.34
1	1107.*	PF 5	4790.00	4945.00	4954.35	4951.49	4954.71	0.002058	4.87	1086.29	320.19	0.35
1	1107.*	PF 6	7390.00	4945.00	4955.92	4952.55	4956.31	0.001823	5.36	1633.79	380.36	0.35
1	1107.*	PF 7	11590.00	4945.00	4957.77	4954.00	4958.22	0.001670	5.95	2378.16	422.54	0.34
1	1107.*	PF 8	21190.00	4945.00	4960.64	4956.61	4961.26	0.001647	7.07	3612.60	430.00	0.36
1	1105		Inl Struct									
1	1104	PF 1	340.00	4947.50	4949.66		4949.80	0.006360	2.96	114.93	96.41	0.48
1	1104	PF 2	640.00	4947.50	4950.24		4950.44	0.007935	3.57	179.31	134.02	0.54
1	1104	PF 3	1190.00	4947.50	4950.94		4951.21	0.007161	4.13	288.47	162.64	0.54
1	1104	PF 4	3450.00	4947.50	4953.09		4953.51	0.004109	5.29	686.88	219.42	0.47
1	1104	PF 5	4790.00	4947.50	4954.08		4954.56	0.003577	5.72	925.44	312.82	0.45
1	1104	PF 6	7390.00	4947.50	4955.69		4956.17	0.002645	5.94	1474.60	369.43	0.41
1	1104	PF 7	11590.00	4947.50	4957.56		4958.08	0.002171	6.36	2212.98	417.25	0.39
1	1104	PF 8	21190.00	4947.50	4960.40		4961.07	0.001991	7.40	3428.46	430.00	0.39
1	1103	PF 1	340.00	4944.50	4949.66		4949.68	0.000312	1.17	289.97	100.97	0.12
1	1103	PF 2	640.00	4944.50	4950.24		4950.29	0.000837	1.77	360.59	141.71	0.20
1	1103	PF 3	1190.00	4944.50	4950.95		4951.05	0.001390	2.52	472.16	162.68	0.26
1	1103	PF 4	3450.00	4944.50	4953.13		4953.38	0.001766	4.11	877.54	220.67	0.32
1	1103	PF 5	4790.00	4944.50	4954.10		4954.43	0.001838	4.71	1113.29	313.42	0.34
1	1103	PF 6	7390.00	4944.50	4955.71		4956.09	0.001657	5.23	1665.22	370.20	0.33
1	1103	PF 7	11590.00	4944.50	4957.57		4958.02	0.001575	5.89	2398.74	417.44	0.34

HEC-RAS Plan: Plan 04 River: Gunnison R. Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	1103	PF 8	21190.00	4944.50	4960.41		4961.03	0.001614	7.09	3616.84	430.00	0.35
1	1102	PF 1	340.00	4944.50	4949.63	4946.19	4949.65	0.000350	1.18	287.87	108.18	0.13
1	1102	PF 2	640.00	4944.50	4950.17	4946.88	4950.22	0.000949	1.76	364.52	160.84	0.21
1	1102	PF 3	1190.00	4944.50	4950.84	4947.79	4950.94	0.001391	2.52	473.00	164.18	0.26
1	1102	PF 4	3450.00	4944.50	4952.98	4950.31	4953.24	0.001804	4.14	875.23	225.89	0.32
1	1102	PF 5	4790.00	4944.50	4953.96	4950.92	4954.28	0.001826	4.68	1115.00	266.14	0.33
1	1102	PF 6	7390.00	4944.50	4955.58	4951.95	4955.96	0.001642	5.20	1681.52	372.59	0.33
1	1102	PF 7	11590.00	4944.50	4957.45	4953.53	4957.89	0.001545	5.83	2410.60	404.84	0.33
1	1102	PF 8	21190.00	4944.50	4960.27	4956.13	4960.90	0.001625	7.10	3577.07	415.00	0.36
1	1035		Inl Struct									
1	1034	PF 1	340.00	4947.00	4949.13		4949.27	0.006810	3.03	112.03	95.20	0.49
1	1034	PF 2	640.00	4947.00	4949.71		4949.92	0.008301	3.65	175.30	131.00	0.56
1	1034	PF 3	1190.00	4947.00	4950.42		4950.69	0.007434	4.18	285.22	162.52	0.55
1	1034	PF 4	3450.00	4947.00	4952.79		4953.10	0.002970	4.64	832.92	291.84	0.40
1	1034	PF 5	4790.00	4947.00	4953.82		4954.13	0.002345	4.78	1152.80	329.42	0.37
1	1034	PF 6	7390.00	4947.00	4955.48		4955.81	0.001810	5.06	1765.33	410.74	0.34
1	1034	PF 7	11590.00	4947.00	4957.36		4957.73	0.001533	5.47	2596.65	461.48	0.33
1	1034	PF 8	21190.00	4947.00	4960.17		4960.67	0.001475	6.47	3922.12	473.00	0.34
1	1033	PF 1	340.00	4944.00	4949.14		4949.16	0.000312	1.18	287.88	99.09	0.12
1	1033	PF 2	640.00	4944.00	4949.72		4949.77	0.000955	1.78	360.35	156.20	0.21
1	1033	PF 3	1190.00	4944.00	4950.44		4950.53	0.001350	2.50	477.02	164.13	0.26
1	1033	PF 4	3450.00	4944.00	4952.85		4953.06	0.001406	3.79	1003.27	293.33	0.29
1	1033	PF 5	4790.00	4944.00	4953.85		4954.10	0.001362	4.18	1317.50	333.93	0.29
1	1033	PF 6	7390.00	4944.00	4955.51		4955.80	0.001234	4.64	1940.33	419.37	0.29
1	1033	PF 7	11590.00	4944.00	4957.38		4957.71	0.001171	5.20	2784.19	471.08	0.29
1	1033	PF 8	21190.00	4944.00	4960.18		4960.65	0.001230	6.29	4131.55	482.50	0.31
1	1032.*	PF 1	340.00	4944.00	4949.13	4945.69	4949.15	0.000312	1.18	287.54	98.86	0.12
1	1032.*	PF 2	640.00	4944.00	4949.71	4946.39	4949.76	0.000960	1.78	358.83	155.12	0.21
1	1032.*	PF 3	1190.00	4944.00	4950.42	4947.31	4950.52	0.001369	2.51	475.78	164.35	0.26
1	1032.*	PF 4	3450.00	4944.00	4952.84	4949.89	4953.05	0.001420	3.81	999.62	292.72	0.29
1	1032.*	PF 5	4790.00	4944.00	4953.84	4950.49	4954.09	0.001375	4.20	1313.23	333.31	0.29
1	1032.*	PF 6	7390.00	4944.00	4955.50	4951.56	4955.78	0.001243	4.65	1935.38	418.65	0.29
1	1032.*	PF 7	11590.00	4944.00	4957.37	4953.23	4957.70	0.001178	5.21	2778.76	470.84	0.29
1	1032.*	PF 8	21190.00	4944.00	4960.17	4955.38	4960.64	0.001237	6.30	4125.50	482.50	0.31
1	1030		Inl Struct									
1	1029	PF 1	340.00	4946.50	4948.64		4948.78	0.006653	3.01	113.01	95.61	0.49
1	1029	PF 2	640.00	4946.50	4949.20		4949.41	0.008421	3.68	174.03	130.02	0.56
1	1029	PF 3	1190.00	4946.50	4950.13		4950.35	0.005119	3.73	319.47	163.78	0.47
1	1029	PF 4	3450.00	4946.50	4952.66		4952.94	0.002378	4.40	870.17	281.71	0.36
1	1029	PF 5	4790.00	4946.50	4953.69		4953.99	0.002035	4.67	1184.12	328.05	0.35
1	1029	PF 6	7390.00	4946.50	4955.35		4955.68	0.001650	5.00	1800.32	416.93	0.33
1	1029	PF 7	11590.00	4946.50	4957.22		4957.58	0.001443	5.46	2650.27	476.79	0.32
1	1029	PF 8	21190.00	4946.50	4959.98		4960.47	0.001422	6.47	4002.15	492.00	0.33
1	1028	PF 1	340.00	4943.50	4948.63		4948.66	0.000386	1.17	290.26	118.89	0.13
1	1028	PF 2	640.00	4943.50	4949.21		4949.26	0.000884	1.73	369.82	157.30	0.20
1	1028	PF 3	1190.00	4943.50	4950.19		4950.27	0.000962	2.26	528.89	165.63	0.22
1	1028	PF 4	3450.00	4943.50	4952.71		4952.90	0.001097	3.53	1072.73	284.43	0.26
1	1028	PF 5	4790.00	4943.50	4953.74		4953.96	0.001114	3.96	1388.97	334.18	0.27
1	1028	PF 6	7390.00	4943.50	4955.39		4955.65	0.001069	4.48	2008.12	416.55	0.27
1	1028	PF 7	11590.00	4943.50	4957.25		4957.57	0.001070	5.11	2852.42	478.99	0.28
1	1028	PF 8	21190.00	4943.50	4960.02		4960.48	0.001163	6.24	4213.94	493.50	0.30
1	1027.*	PF 1	340.00	4943.50	4948.63	4945.19	4948.65	0.000387	1.17	289.79	118.63	0.13
1	1027.*	PF 2	640.00	4943.50	4949.20	4945.88	4949.25	0.000891	1.74	368.36	156.68	0.20
1	1027.*	PF 3	1190.00	4943.50	4950.18	4946.79	4950.26	0.000970	2.26	528.32	165.00	0.22
1	1027.*	PF 4	3450.00	4943.50	4952.71	4949.33	4952.88	0.001079	3.49	1087.00	283.39	0.26
1	1027.*	PF 5	4790.00	4943.50	4953.73	4949.93	4953.95	0.001100	3.93	1402.33	333.71	0.27
1	1027.*	PF 6	7390.00	4943.50	4955.38	4951.02	4955.64	0.001059	4.46	2020.79	416.13	0.27
1	1027.*	PF 7	11590.00	4943.50	4957.24	4952.56	4957.56	0.001063	5.09	2864.56	478.83	0.28
1	1027.*	PF 8	21190.00	4943.50	4960.01	4955.01	4960.46	0.001157	6.22	4225.48	493.50	0.30
1	1025		Inl Struct									
1	1024	PF 1	340.00	4946.00	4948.19		4948.32	0.005951	2.89	117.82	97.60	0.46
1	1024	PF 2	640.00	4946.00	4948.98		4949.12	0.005453	2.99	214.32	158.00	0.45
1	1024	PF 3	1190.00	4946.00	4950.03		4950.18	0.002771	3.10	385.46	167.13	0.35
1	1024	PF 4	3450.00	4946.00	4952.55		4952.79	0.001837	4.09	929.87	272.24	0.32
1	1024	PF 5	4790.00	4946.00	4953.58		4953.86	0.001690	4.45	1239.54	328.90	0.32
1	1024	PF 6	7390.00	4946.00	4955.23		4955.54	0.001450	4.85	1856.30	418.42	0.31
1	1024	PF 7	11590.00	4946.00	4957.09		4957.45	0.001332	5.38	2709.19	484.52	0.31
1	1024	PF 8	21190.00	4946.00	4959.82		4960.31	0.001358	6.44	4078.51	505.00	0.33

HEC-RAS Plan: Plan 04 River: Gunnison R. Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	1023	PF 1	340.00	4943.00	4948.21		4948.23	0.000305	1.15	295.27	103.94	0.12
1	1023	PF 2	640.00	4943.00	4949.02		4949.05	0.000651	1.57	408.31	161.56	0.17
1	1023	PF 3	1190.00	4943.00	4950.06		4950.13	0.000713	2.06	580.70	169.26	0.19
1	1023	PF 4	3450.00	4943.00	4952.58		4952.75	0.000921	3.34	1131.11	280.20	0.24
1	1023	PF 5	4790.00	4943.00	4953.62		4953.82	0.000964	3.79	1451.50	339.99	0.25
1	1023	PF 6	7390.00	4943.00	4955.26		4955.51	0.000958	4.34	2083.00	428.59	0.26
1	1023	PF 7	11590.00	4943.00	4957.12		4957.43	0.000984	5.00	2961.26	508.84	0.27
1	1023	PF 8	21190.00	4943.00	4959.84		4960.27	0.001086	6.11	4399.60	532.50	0.29
1	1022.*	PF 1	340.00	4943.00	4948.21	4944.69	4948.23	0.000305	1.15	294.96	103.75	0.12
1	1022.*	PF 2	640.00	4943.00	4949.01	4945.38	4949.05	0.000656	1.57	407.82	163.48	0.17
1	1022.*	PF 3	1190.00	4943.00	4950.05	4946.31	4950.12	0.000716	2.07	580.59	169.25	0.19
1	1022.*	PF 4	3450.00	4943.00	4952.58	4948.89	4952.74	0.000924	3.35	1129.93	279.66	0.24
1	1022.*	PF 5	4790.00	4943.00	4953.61	4949.49	4953.81	0.000968	3.80	1449.44	339.40	0.25
1	1022.*	PF 6	7390.00	4943.00	4955.25	4950.54	4955.50	0.000962	4.35	2080.04	428.04	0.26
1	1022.*	PF 7	11590.00	4943.00	4957.11	4952.08	4957.42	0.000989	5.01	2957.22	508.55	0.27
1	1022.*	PF 8	21190.00	4943.00	4959.83	4954.75	4960.26	0.001090	6.12	4394.78	532.50	0.30
1	1020		Inl Struct									
1	1019	PF 1	340.00	4945.50	4948.08		4948.15	0.002814	2.14	159.13	118.01	0.32
1	1019	PF 2	640.00	4945.50	4948.91		4948.99	0.002190	2.26	283.63	162.46	0.30
1	1019	PF 3	1190.00	4945.50	4949.95		4950.06	0.001604	2.63	458.64	181.13	0.28
1	1019	PF 4	3450.00	4945.50	4952.45		4952.65	0.001392	3.75	1019.23	277.46	0.29
1	1019	PF 5	4790.00	4945.50	4953.48		4953.72	0.001350	4.15	1337.30	340.28	0.29
1	1019	PF 6	7390.00	4945.50	4955.14		4955.42	0.001209	4.59	1981.08	432.43	0.29
1	1019	PF 7	11590.00	4945.50	4956.98		4957.31	0.001173	5.19	2860.62	518.18	0.29
1	1019	PF 8	21190.00	4945.50	4959.68		4960.12	0.001216	6.21	4351.40	560.00	0.31
1	1018	PF 1	340.00	4942.50	4948.10		4948.12	0.000283	0.99	343.23	143.51	0.11
1	1018	PF 2	640.00	4942.50	4948.93		4948.96	0.000395	1.35	475.38	163.98	0.14
1	1018	PF 3	1190.00	4942.50	4949.98		4950.03	0.000491	1.84	658.05	190.94	0.16
1	1018	PF 4	3450.00	4942.50	4952.48		4952.62	0.000713	3.07	1249.07	285.89	0.21
1	1018	PF 5	4790.00	4942.50	4953.51		4953.68	0.000776	3.53	1571.87	341.93	0.23
1	1018	PF 6	7390.00	4942.50	4955.17		4955.39	0.000803	4.10	2215.84	433.58	0.24
1	1018	PF 7	11590.00	4942.50	4956.99		4957.28	0.000875	4.82	3091.51	523.56	0.26
1	1018	PF 8	21190.00	4942.50	4959.69		4960.10	0.000993	5.95	4604.14	568.50	0.28
1	1017.*	PF 1	340.00	4942.50	4948.10	4944.19	4948.11	0.000284	0.99	342.81	143.19	0.11
1	1017.*	PF 2	640.00	4942.50	4948.92	4944.88	4948.95	0.000397	1.35	474.53	163.32	0.14
1	1017.*	PF 3	1190.00	4942.50	4949.97	4945.81	4950.02	0.000496	1.85	651.00	182.28	0.16
1	1017.*	PF 4	3450.00	4942.50	4952.47	4948.39	4952.61	0.000724	3.09	1238.20	285.39	0.21
1	1017.*	PF 5	4790.00	4942.50	4953.50	4948.99	4953.68	0.000787	3.55	1560.15	341.37	0.23
1	1017.*	PF 6	7390.00	4942.50	4955.16	4950.05	4955.38	0.000813	4.12	2202.96	433.00	0.24
1	1017.*	PF 7	11590.00	4942.50	4956.98	4951.65	4957.27	0.000884	4.85	3077.16	523.03	0.26
1	1017.*	PF 8	21190.00	4942.50	4959.68	4954.23	4960.09	0.001002	5.97	4588.15	568.50	0.28
1	1015		Inl Struct									
1	1014	PF 1	340.00	4945.00	4948.05		4948.09	0.001322	1.51	225.48	160.30	0.22
1	1014	PF 2	640.00	4945.00	4948.86		4948.91	0.001026	1.80	357.30	165.16	0.21
1	1014	PF 3	1190.00	4945.00	4949.90		4949.98	0.000950	2.24	553.54	210.04	0.22
1	1014	PF 4	3450.00	4945.00	4952.39		4952.55	0.000986	3.33	1163.82	287.31	0.24
1	1014	PF 5	4790.00	4945.00	4953.41		4953.60	0.001012	3.76	1482.64	337.80	0.25
1	1014	PF 6	7390.00	4945.00	4955.05		4955.29	0.000992	4.30	2106.91	426.31	0.26
1	1014	PF 7	11590.00	4945.00	4956.87		4957.17	0.001032	5.00	2973.52	522.20	0.28
1	1014	PF 8	21190.00	4945.00	4959.53		4959.95	0.001129	6.10	4477.19	577.00	0.30
1	1013	PF 1	340.00	4942.00	4948.05		4948.06	0.000167	0.81	421.14	163.28	0.09
1	1013	PF 2	640.00	4942.00	4948.87		4948.89	0.000238	1.16	556.43	170.02	0.11
1	1013	PF 3	1190.00	4942.00	4949.90		4949.94	0.000335	1.64	749.85	203.91	0.14
1	1013	PF 4	3450.00	4942.00	4952.41		4952.52	0.000554	2.83	1361.84	290.31	0.19
1	1013	PF 5	4790.00	4942.00	4953.44		4953.59	0.000624	3.29	1683.83	337.42	0.21
1	1013	PF 6	7390.00	4942.00	4955.07		4955.27	0.000692	3.92	2304.07	427.58	0.22
1	1013	PF 7	11590.00	4942.00	4956.89		4957.16	0.000786	4.69	3177.04	525.99	0.24
1	1013	PF 8	21190.00	4942.00	4959.53		4959.94	0.000940	5.89	4682.00	579.50	0.28
1	1012.*	PF 1	340.00	4942.00	4948.05	4943.69	4948.06	0.000167	0.81	420.90	163.27	0.09
1	1012.*	PF 2	640.00	4942.00	4948.87	4944.38	4948.89	0.000239	1.16	556.01	169.94	0.11
1	1012.*	PF 3	1190.00	4942.00	4949.90	4945.31	4949.94	0.000336	1.64	749.15	203.80	0.14
1	1012.*	PF 4	3450.00	4942.00	4952.40	4947.85	4952.52	0.000556	2.83	1360.14	290.04	0.19
1	1012.*	PF 5	4790.00	4942.00	4953.43	4948.44	4953.58	0.000626	3.30	1681.52	337.10	0.21
1	1012.*	PF 6	7390.00	4942.00	4955.06	4949.53	4955.26	0.000694	3.93	2300.94	427.15	0.22
1	1012.*	PF 7	11590.00	4942.00	4956.88	4951.06	4957.15	0.000789	4.70	3172.42	525.57	0.24
1	1012.*	PF 8	21190.00	4942.00	4959.52	4953.61	4959.93	0.000944	5.90	4675.78	579.50	0.28
1	1010		Inl Struct									

HEC-RAS Plan: Plan 04 River: Gunnison R. Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	1009	PF 1	340.00	4944.50	4948.02		4948.04	0.000505	1.13	301.51	163.12	0.15
1	1009	PF 2	640.00	4944.50	4948.84		4948.87	0.000532	1.48	438.69	176.42	0.16
1	1009	PF 3	1190.00	4944.50	4949.86		4949.92	0.000607	1.95	634.59	207.70	0.18
1	1009	PF 4	3450.00	4944.50	4952.32		4952.46	0.000788	3.12	1241.13	288.59	0.22
1	1009	PF 5	4790.00	4944.50	4953.34		4953.52	0.000839	3.56	1557.61	331.94	0.23
1	1009	PF 6	7390.00	4944.50	4954.95		4955.18	0.000882	4.18	2156.74	420.34	0.25
1	1009	PF 7	11590.00	4944.50	4956.75		4957.05	0.000959	4.93	3011.61	522.63	0.27
1	1009	PF 8	21190.00	4944.50	4959.36		4959.79	0.001100	6.12	4493.44	582.00	0.30
1	1008	PF 1	340.00	4941.50	4947.87		4947.88	0.000119	0.73	466.28	163.68	0.08
1	1008	PF 2	640.00	4941.50	4948.64		4948.66	0.000192	1.09	594.83	174.95	0.10
1	1008	PF 3	1190.00	4941.50	4949.58		4949.62	0.000302	1.59	770.54	196.61	0.13
1	1008	PF 4	3450.00	4941.50	4951.95		4952.07	0.000570	2.87	1322.57	272.77	0.19
1	1008	PF 5	4790.00	4941.50	4952.95		4953.11	0.000656	3.37	1613.99	310.48	0.21
1	1008	PF 6	7390.00	4941.50	4954.56		4954.78	0.000750	4.07	2168.21	388.87	0.23
1	1008	PF 7	11590.00	4941.50	4956.34		4956.65	0.000884	4.95	2962.85	498.94	0.26
1	1008	PF 8	21190.00	4941.50	4958.91		4959.38	0.001104	6.34	4381.42	578.50	0.30
1	1007.*	PF 1	340.00	4941.50	4947.87	4943.19	4947.88	0.000119	0.73	466.12	163.68	0.08
1	1007.*	PF 2	640.00	4941.50	4948.64	4943.88	4948.65	0.000192	1.09	594.49	174.91	0.10
1	1007.*	PF 3	1190.00	4941.50	4949.58	4944.80	4949.62	0.000303	1.59	769.96	196.55	0.13
1	1007.*	PF 4	3450.00	4941.50	4951.94	4947.38	4952.06	0.000572	2.88	1320.84	272.56	0.19
1	1007.*	PF 5	4790.00	4941.50	4952.94	4947.99	4953.11	0.000658	3.37	1611.72	310.19	0.21
1	1007.*	PF 6	7390.00	4941.50	4954.55	4949.06	4954.78	0.000753	4.08	2164.98	388.33	0.23
1	1007.*	PF 7	11590.00	4941.50	4956.33	4950.56	4956.64	0.000888	4.96	2957.74	498.45	0.26
1	1007.*	PF 8	21190.00	4941.50	4958.89	4953.21	4959.37	0.001110	6.35	4373.51	578.50	0.30
1	1005		Inl Struct									
1	1004	PF 1	340.00	4944.00	4947.86		4947.87	0.000290	0.96	357.30	165.16	0.11
1	1004	PF 2	640.00	4944.00	4948.61		4948.64	0.000385	1.34	485.10	177.86	0.14
1	1004	PF 3	1190.00	4944.00	4949.54		4949.59	0.000521	1.87	659.08	196.01	0.17
1	1004	PF 4	3450.00	4944.00	4951.85		4952.00	0.000821	3.20	1188.16	266.17	0.23
1	1004	PF 5	4790.00	4944.00	4952.84		4953.03	0.000903	3.70	1467.85	302.04	0.24
1	1004	PF 6	7390.00	4944.00	4954.42		4954.68	0.000978	4.39	1995.17	373.19	0.26
1	1004	PF 7	11590.00	4944.00	4956.18		4956.54	0.001113	5.29	2754.71	487.26	0.29
1	1004	PF 8	21190.00	4944.00	4958.69		4959.22	0.001355	6.73	4114.97	575.00	0.33
1	1000	PF 1	340.00	4944.50	4947.81		4947.85	0.000730	1.60	212.46	109.25	0.20
1	1000	PF 2	640.00	4944.50	4948.52		4948.60	0.001020	2.16	296.96	125.41	0.25
1	1000	PF 3	1190.00	4944.50	4949.41		4949.54	0.001393	2.82	428.50	163.66	0.30
1	1000	PF 4	3450.00	4944.50	4951.66		4951.92	0.001592	4.22	869.46	234.57	0.34
1	1000	PF 5	4790.00	4944.50	4952.62		4952.95	0.001569	4.72	1107.60	258.56	0.35
1	1000	PF 6	7390.00	4944.50	4954.18		4954.60	0.001537	5.40	1539.15	294.81	0.36
1	1000	PF 7	11590.00	4944.50	4955.90		4956.44	0.001606	6.31	2175.47	434.84	0.38
1	1000	PF 8	21190.00	4944.50	4958.27		4959.10	0.001880	8.05	3249.49	458.70	0.43
1	900	PF 1	340.00	4944.94	4947.32		4947.35	0.000784	1.35	251.96	176.78	0.20
1	900	PF 2	640.00	4944.94	4947.91		4947.95	0.000947	1.78	358.74	190.73	0.23
1	900	PF 3	1190.00	4944.94	4948.63		4948.72	0.001126	2.38	499.78	196.01	0.26
1	900	PF 4	3450.00	4944.94	4950.77		4950.98	0.001292	3.70	932.00	208.36	0.31
1	900	PF 5	4790.00	4944.94	4951.71		4951.99	0.001377	4.24	1129.72	215.80	0.33
1	900	PF 6	7390.00	4944.94	4953.18		4953.57	0.001603	5.01	1498.27	303.61	0.36
1	900	PF 7	11590.00	4944.94	4954.82		4955.35	0.001775	5.93	2103.01	414.18	0.39
1	900	PF 8	21190.00	4944.94	4957.03		4957.83	0.002031	7.57	3319.27	625.60	0.44
1	800	PF 1	340.00	4944.12	4945.37	4945.12	4945.53	0.009426	3.17	107.32	135.32	0.63
1	800	PF 2	640.00	4944.12	4945.98		4946.14	0.005545	3.23	197.93	162.56	0.52
1	800	PF 3	1190.00	4944.12	4946.99		4947.14	0.002628	3.18	373.66	179.11	0.39
1	800	PF 4	3450.00	4944.12	4948.90		4949.24	0.002717	4.69	744.27	214.73	0.43
1	800	PF 5	4790.00	4944.12	4949.71		4950.13	0.002877	5.25	929.26	238.52	0.45
1	800	PF 6	7390.00	4944.12	4950.93		4951.51	0.002981	6.16	1247.02	289.17	0.48
1	800	PF 7	11590.00	4944.12	4952.44		4953.18	0.002899	7.12	1846.41	455.55	0.49
1	800	PF 8	21190.00	4944.12	4954.87		4955.71	0.002419	8.03	3346.13	665.70	0.47
1	700	PF 1	340.00	4941.11	4943.49		4943.54	0.001130	1.81	188.16	111.94	0.25
1	700	PF 2	640.00	4941.11	4944.28		4944.36	0.001206	2.27	282.31	125.38	0.27
1	700	PF 3	1190.00	4941.11	4945.25		4945.37	0.001980	2.77	429.16	204.40	0.34
1	700	PF 4	3450.00	4941.11	4946.68		4947.02	0.002976	4.68	753.05	249.04	0.45
1	700	PF 5	4790.00	4941.11	4947.39		4947.82	0.003062	5.31	931.88	258.24	0.47
1	700	PF 6	7390.00	4941.11	4948.61		4949.18	0.002985	6.13	1257.91	274.22	0.48
1	700	PF 7	11590.00	4941.11	4950.30		4951.01	0.002647	6.94	1874.81	438.88	0.47
1	700	PF 8	21190.00	4941.11	4952.96		4953.86	0.002331	8.14	3061.06	453.47	0.47
1	600	PF 1	350.00	4936.55	4939.26	4938.75	4939.52	0.008943	4.08	85.82	70.90	0.65
1	600	PF 2	650.00	4936.55	4940.31	4939.47	4940.45	0.007198	2.95	220.50	252.56	0.56
1	600	PF 3	1200.00	4936.55	4940.99	4940.31	4941.13	0.003686	3.06	392.28	257.07	0.44
1	600	PF 4	3460.00	4936.55	4942.97		4943.19	0.001944	3.79	912.49	267.33	0.36
1	600	PF 5	4800.00	4936.55	4943.85		4944.12	0.001770	4.18	1149.24	271.12	0.36

HEC-RAS Plan: Plan 04 River: Gunnison R. Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	600	PF 6	7400.00	4936.55	4945.24		4945.60	0.001683	4.83	1531.76	279.15	0.36
1	600	PF 7	11600.00	4936.55	4946.99		4947.49	0.001794	5.69	2039.01	305.05	0.39
1	600	PF 8	21200.00	4936.55	4949.65		4950.45	0.001906	7.22	3079.77	416.90	0.42
1	500	PF 1	350.00	4931.84	4935.92		4935.95	0.000726	1.45	241.57	143.53	0.20
1	500	PF 2	650.00	4931.84	4936.59		4936.65	0.000859	1.91	340.45	151.67	0.22
1	500	PF 3	1200.00	4931.84	4937.49		4937.58	0.001042	2.49	482.34	166.68	0.26
1	500	PF 4	3460.00	4931.84	4939.56		4939.80	0.001505	3.96	874.59	198.06	0.33
1	500	PF 5	4800.00	4931.84	4940.37		4940.70	0.001668	4.63	1040.76	223.68	0.36
1	500	PF 6	7400.00	4931.84	4941.66		4942.14	0.001796	5.58	1440.92	403.85	0.39
1	500	PF 7	11600.00	4931.84	4943.07		4943.71	0.001998	6.70	2030.52	433.70	0.42
1	500	PF 8	21200.00	4931.84	4945.38		4946.32	0.002245	8.43	3033.67	433.70	0.47
1	400	PF 1	350.00	4932.46	4934.05	4933.68	4934.17	0.005998	2.76	126.93	140.45	0.51
1	400	PF 2	650.00	4932.46	4934.55	4934.02	4934.71	0.005240	3.23	201.03	158.28	0.51
1	400	PF 3	1200.00	4932.46	4935.26	4934.48	4935.48	0.004501	3.72	322.82	183.94	0.49
1	400	PF 4	3460.00	4932.46	4937.19		4937.49	0.003083	4.47	796.76	278.26	0.45
1	400	PF 5	4800.00	4932.46	4938.02		4938.37	0.002767	4.78	1037.09	300.46	0.44
1	400	PF 6	7400.00	4932.46	4939.42		4939.83	0.002426	5.25	1511.78	419.87	0.43
1	400	PF 7	11600.00	4932.46	4940.91		4941.40	0.002108	5.84	2277.06	533.58	0.42
1	400	PF 8	21200.00	4932.46	4943.53		4944.10	0.001655	6.56	3840.37	618.00	0.39
1	300	PF 1	350.00	4926.28	4929.53	4927.90	4929.56	0.000970	1.41	248.50	191.03	0.22
1	300	PF 2	650.00	4926.28	4930.11	4928.47	4930.16	0.001008	1.80	361.65	198.37	0.23
1	300	PF 3	1200.00	4926.28	4930.89	4929.26	4930.97	0.001060	2.32	519.99	212.94	0.25
1	300	PF 4	3460.00	4926.28	4932.85		4933.05	0.001291	3.66	999.44	277.79	0.31
1	300	PF 5	4800.00	4926.28	4933.62		4933.88	0.001411	4.22	1223.98	299.73	0.33
1	300	PF 6	7400.00	4926.28	4934.90		4935.26	0.001616	4.99	1628.92	340.48	0.36
1	300	PF 7	11600.00	4926.28	4936.46		4936.95	0.001753	5.88	2199.27	380.70	0.39
1	300	PF 8	21200.00	4926.28	4939.20		4939.97	0.001898	7.54	3400.02	551.51	0.42
1	200	PF 1	350.00	4923.26	4924.49	4924.33	4924.71	0.013423	3.82	91.69	113.87	0.75
1	200	PF 2	650.00	4923.26	4924.90	4924.69	4925.23	0.012667	4.55	142.88	130.52	0.77
1	200	PF 3	1200.00	4923.26	4925.52	4925.22	4925.93	0.011749	5.16	232.76	166.50	0.77
1	200	PF 4	3460.00	4923.26	4927.17		4927.78	0.007838	6.24	554.29	219.04	0.69
1	200	PF 5	4800.00	4923.26	4928.00		4928.65	0.006255	6.49	739.50	232.52	0.64
1	200	PF 6	7400.00	4923.26	4929.40		4930.13	0.004607	6.84	1083.44	258.45	0.58
1	200	PF 7	11600.00	4923.26	4931.17		4932.04	0.003595	7.53	1579.68	302.88	0.54
1	200	PF 8	21200.00	4923.26	4934.54		4935.59	0.002517	8.43	2709.77	374.95	0.49
1	100	PF 1	350.00	4918.85	4920.72	4920.72	4921.25	0.022639	5.85	59.88	58.02	1.01
1	100	PF 2	650.00	4918.85	4921.29	4921.29	4922.00	0.020630	6.75	96.30	70.11	1.01
1	100	PF 3	1200.00	4918.85	4922.05	4922.05	4922.97	0.018617	7.69	156.00	86.36	1.01
1	100	PF 4	3460.00	4918.85	4923.90	4923.90	4925.54	0.015410	10.27	336.82	104.42	1.01
1	100	PF 5	4800.00	4918.85	4924.74	4924.74	4926.71	0.014267	11.26	426.49	109.86	1.00
1	100	PF 6	7400.00	4918.85	4926.34	4926.34	4928.61	0.011193	12.13	629.33	175.46	0.93
1	100	PF 7	11600.00	4918.85	4928.11	4928.11	4930.77	0.009334	13.44	952.39	186.67	0.89
1	100	PF 8	21200.00	4918.85	4931.54	4931.54	4934.61	0.006890	15.04	1757.90	303.48	0.82

```
                         HEC-RAS Version 3.1.3 May 2005
                          U.S. Army Corp of Engineers
                         Hydrologic Engineering Center
                               609 Second Street
                               Davis, California

            X     X  XXXXXX    XXXX        XXXX      XX      XXXX
            X     X  X        X    X       X   X    X  X    X
            X     X  X        X            X   X   X    X   X
            XXXXXXX  XXXX     X      XXX   XXXX    XXXXXX    XXXX
            X     X  X        X            X  X    X    X        X
            X     X  X        X    X       X   X   X    X        X
            X     X  XXXXXX    XXXX        X    X  X    X   XXXXX
```

PROJECT DATA
Project Title: HART_half foot drops
Project File : hart.prj
Run Date and Time: 12/16/2009 8:16:56 AM

Project in English units

Project Description:
half foot drops, 25 ft pools

PLAN DATA

Plan Title: Plan 05
Plan File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\final 0.5' drops\final\hart\hart.p05

Geometry Title: hart half lower drops final
Geometry File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\final 0.5' drops\final\hart\hart.g03

Flow Title : Hartland flow data
Flow File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\final 0.5' drops\final\hart\hart.f01

Plan Summary Information:

```
Number of:  Cross Sections =   55    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =   14
            Bridges        =    0    Lateral Structures =    0
```

hart.rep

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 40
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Hartland flow data
Flow File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\final 0.5' drops\final\hart\hart.f01

Flow Data (cfs)

River	Reach	RS	PF 1	PF 2	PF 3	PF 4	PF 5	PF 6	PF 7	PF 8
Gunnison R.	1	1900	420	720	1270	3530	4870	7470	11670	21270
Gunnison R.	1	1510	340	640	1190	3450	4790	7390	11590	21190
Gunnison R.	1	600	350	650	1200	3460	4800	7400	11600	21200

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Gunnison R.	1	PF 1		Critical
Gunnison R.	1	PF 2		Critical
Gunnison R.	1	PF 3		Critical
Gunnison R.	1	PF 4		Critical

```
  Gunnison R.     1              PF 5                                                   Critical

  Gunnison R.     1              PF 6                                                   Critical

  Gunnison R.     1              PF 7                                                   Critical



GEOMETRY DATA

Geometry Title: hart half lower drops final
Geometry File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\final 0.5'
drops\final\hart\hart.g03

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1900

INPUT
Description: XS 14435 - most upstream XS
Station Elevation Data    num=      35
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000 4964.71   1009.1 4964.62    10104964.256   1028.7 4956.69   1037.7 4955.22
  1049.9 4954.67   1050.6 4954.51   1129.3 4954.31   1148.5 4954.28   1161.3 4954.61
  1183.2 4955.71   1227.8 4956.72   1280.3 4959.21   1391.3 4959.44   1510.2 4958.78
  1542.1 4962.73   1627.1 4962.81   1734.9 4963.19     1736 4958.19   1750.1 4954.66
  1764.4 4952.79     1778 4952.24   1794.5 4951.85     1817 4952.07   1852.7 4952.85
  1880.2 4953.68   1900.4 4954.61   1942.4  4956.5   1950.2 4958.25   2003.8 4957.51
    20604962.948   2062.5 4963.19   2143.8 4954.64   2173.9  4981.1   2248.7 4983.83

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    1000    .045     1010    .039     2060    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1010    2060              861     848    1120               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1800

INPUT
Description: XS 13585 - th XS
Station Elevation Data    num=      24
```

```
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000 4960.49   1011.5 4956.34   1022.9 4954.95   1028.2 4956.43   1032.9 4957.14
  1217.1 4961.21   1391.3 4960.75   1504.7 4961.43     15054961.341   1528.9 4954.22
  1539.5 4952.26   1552.4 4951.02   1581.7 4951.55   1610.9  4951.8   1637.1 4951.38
  1657.1 4950.26   1665.9 4949.79   1681.7 4951.21   1700.9 4951.42   1722.9 4952.75
  1723.7 4954.27     17304965.439   1730.7 4966.68   1844.5 4973.41

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    1000    .045     1505    .039     1730    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1505    1730             1350    1300    1300              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1700

INPUT
Description: XS 12405 - th XS
Station Elevation Data    num=      23
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000  4959.5   1053.1 4959.83   1108.4 4959.34   1139.7 4957.53     11404957.418
  1149.1 4954.04   1161.7 4952.33   1176.1  4951.8     1250  4949.5     1300  4949.5
  1390.1 4950.72   1422.5 4952.22   1453.9 4952.56   1474.1 4953.56   1484.4 4953.01
  1487.2 4954.28   1490.9 4956.93   1512.7 4969.75     15154972.015   1519.9 4976.84
    15204976.814   1529.9 4974.32   1574.8 4989.64

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    1000    .045     1140    .039     1515    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1140    1515              389     381     374              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1610

INPUT
Description: upstream of ex section 1600
Station Elevation Data    num=      24
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000 4957.87   1050.5 4957.79     1090 4956.38   1106.9 4957.74   1129.8 4957.41
    11304957.276   1134.7 4954.13   1137.7 4951.98   1149.8  4949.3   1190.6 4950.07
  1212.1  4951.3   1239.6    4952   1277.3 4953.01   1326.1 4953.86   1353.4 4954.06
  1392.4 4953.79   1405.8 4950.61   1431.9 4950.85   1437.3 4953.85     14454962.657
```

```
  1449.2 4967.46  1456.8 4967.66  1477.3 4976.91    1510 4979.04

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1130    .039    1445    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1130    1445                  66      74      81               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1520

INPUT
Description: TOP
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     800    4958     910    4956     945    4954     955    4952    1035    4948
    1070    4948    1090    4948    1125    4952    1180    4952    1200    4952
    1220    4950    1235    4960

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     800    .045     945    .039    1125    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           945    1125                  89      40      57               .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1510

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     937    4954     940  4953.5    1035    4953    1075    4951    1085    4951
    1125    4953    1160  4953.5    1163    4954    1227    4954

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested
```

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1509

INPUT
Description: BOW
Station Elevation Data num= 12

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
800	4960	845	4958	917	4954.5	937	4954	940	4953.5
1025	4953	1075	4950.5	1085	4950.5	1135	4953	1160	4953.5
1218	4953.5	1228	4960						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
800	.045	940	.045	1160	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
940	1160	6	6	6	.1	.3

Internal Rating Curve

Flow (cfs)	Elev (ft)
340	4952.64
640	4953.2
1190	4953.75
3450	4955.1
4790	4955.75
7390	4957.02
11590	4958.87
21190	4961.97

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1508

INPUT
Description: BOP
Station Elevation Data num= 16

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
817.5	4960	823.03	4958.87	858.56	4957.57	905.98	4956.28	924.26	4955.85
937	4953.5	945	4953.25	1025	4952.8	1035	4952.5	1070	4947.5
1090	4947.5	1125	4952.5	1135	4952.8	1160	4953.25	1218	4953.5

```
    1228    4960

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   817.5    .045     945    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
            945    1160                 10       10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1507.*

INPUT
Description: BOP
Station Elevation Data    num=      16
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   817.5    4960  823.03 4958.87  858.56 4957.57  905.98 4956.28  924.26 4955.85
     937  4953.5     950 4953.25    1025  4952.8    1035  4952.5    1070  4947.5
    1090  4947.5    1125  4952.5    1135  4952.8    1160 4953.25    1218  4953.5
    1228    4960

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   817.5    .045     950    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
            950    1160                 14       14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1505

INPUT
Description:
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000    4953    1035  4952.5    1075  4950.5    1085  4950.5    1125  4952.5
    1160    4953

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
Downstream Embankment side slope           =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins        =
```

Weir crest shape = Broad Crested

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1504

INPUT
Description: BOW
Station Elevation Data num= 13

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
835	4960	840	4958	915	4956	950	4953	1025	4952.5
1075	4950	1085	4950	1135	4952.5	1160	4953	1163	4953.5
1200	4954	1252	4954	1265	4960				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
835	.045	950	.045	1160	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
950	1160	6	6	6	.1	.3

Internal Rating Curve

Flow (cfs)	Elev (ft)
340	4952.13
640	4952.7
1190	4953.31
3450	4954.76
4790	4955.44
7390	4956.81
11590	4958.69
21190	4961.75

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1503

INPUT
Description: BOP
Station Elevation Data num= 17

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
852.5	4960	856.97	4958.61	863.85	4957.9	903.56	4956.31	924.02	4955.73
955	4952.75	1025	4952.3	1035	4952	1070	4947	1090	4947

```
    1125    4952    1135  4952.3    1160    4953    1163  4953.5    1200    4954
    1252    4954    1265    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   852.5    .045     955    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           955    1160               10      10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1502

INPUT
Description: BOP
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   852.5    4960  856.97 4958.61  863.85  4957.9  903.56 4956.31  924.02 4955.73
     960 4952.75    1025  4952.3    1035    4952    1070    4947    1090    4947
    1125    4952    1135  4952.3    1160 4952.75    1163  4953.5    1200    4954
    1252    4954    1265    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   852.5    .045     960    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           960    1160               14      14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1325

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000  4952.5    1035    4952    1075    4950    1085    4950    1125    4952
    1160  4952.5

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
Downstream Embankment side slope           =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
```

Elevation at which weir flow begins =
Weir crest shape = Broad Crested

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1324

INPUT
Description: BOW
Station Elevation Data num= 13

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
870	4960	880	4958	915	4956	960	4952.5	1025	4952
1075	4949.5	1085	4949.5	1135	4952	1160	4952.5	1163	4953
1205	4954	1253	4954	1267	4960				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
870	.045	960	.045	1160	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
960	1160	6	6	6	.1	.3

Internal Rating Curve

Flow (cfs)	Elev (ft)
340	4951.64
640	4952.21
1190	4952.83
3450	4954.45
4790	4955.2
7390	4956.63
11590	4958.47
21190	4961.47

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1323

INPUT
Description: BOP
Station Elevation Data num= 17

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
877.5	4960	886.92	4958.41	893.48	4957.8	904.13	4956.48	919.9	4955.82

```
     965 4952.25    1025  4951.8    1035  4951.5    1070  4946.5    1090  4946.5
    1125  4951.5    1135  4951.8    1160 4952.25    1163    4953    1205    4954
    1253    4954    1267    4960

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   877.5    .045     965    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           965    1160               10      10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1322.*

INPUT
Description: BOP
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   877.5    4960  886.92 4958.41  893.48  4957.8  904.13 4956.48   919.9 4955.82
     967 4952.25    1025  4951.8    1035  4951.5    1070  4946.5    1090  4946.5
    1125  4951.5    1135  4951.8    1160 4952.25    1163    4953    1205    4954
    1253    4954    1267    4960

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   877.5    .045     967    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           967    1160               14      14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1320

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000    4952    1035  4951.5    1075  4949.5    1085  4949.5    1125  4951.5
    1160    4952

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
Downstream Embankment side slope           =       0 horiz. to 1.0 vertical
```

```
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1319

INPUT
Description: BOW
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     800    4958     910    4956     975    4952    1025  4951.5    1075    4949
    1085    4949    1135  4951.5    1160    4952    1163    4953    1220    4954
    1221    4958    1270    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     800    .045     975    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
           975    1160               6       6       6               .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4951.13
      640   4951.72
     1190   4952.41
     3450   4954.21
     4790   4954.96
     7390   4956.38
    11590   4958.19
    21190   4961.21


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1318

INPUT
Description: BOP
Station Elevation Data    num=      15
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
```

```
     800    4958     910    4956     980    4952     980 4951.93    1025  4951.3
    1035    4951    1070    4946    1090    4946    1125    4951    1135  4951.3
    1160 4951.75    1163    4953    1220    4954    1221    4958    1270    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     800    .045     980    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           980    1160               10      10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1317.*

INPUT
Description: BOP
Station Elevation Data    num=      20
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   862.5    4959  880.43  4957.3  888.28 4956.34  892.39 4955.95  969.92 4954.22
  991.63 4953.61  996.41  4952.6  997.42 4951.75    1000 4951.75    1025  4951.3
    1035    4951    1070    4946    1090    4946    1125    4951    1135  4951.3
    1160 4951.75    1163    4953    1220    4954    1221    4958    1270    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   862.5    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               14      14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1315

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000  4951.5    1035    4951    1075    4949    1085    4949    1125    4951
    1160  4951.5

Upstream Embankment side slope            =       0 horiz. to 1.0 vertical
Downstream Embankment side slope          =       0 horiz. to 1.0 vertical
```

```
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1314

INPUT
Description: BOW
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     840    4958     870    4956     965    4954     997  4952.5    1000  4951.5
    1025    4951    1075  4948.5    1085  4948.5    1135    4951    1160  4951.5
    1163  4952.5    1220    4954    1221    4958    1270    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     840    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160                6       6       6               .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4950.63
      640   4951.22
     1190    4951.9
     3450    4953.7
     4790   4954.55
     7390   4956.08
    11590   4957.92
    21190   4960.81


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1313

INPUT
Description:
Station Elevation Data    num=      18
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
```

```
   838.5     4958  868.78  4956.2  876.15 4955.92   957.4 4954.08  964.67 4953.86
  997.03  4952.25    1000 4951.25    1025  4950.8    1035  4950.5    1070  4945.5
    1090   4945.5    1125  4950.5    1135  4950.8    1160 4951.25    1163  4952.5
    1220     4954    1221    4958    1270    4960

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   838.5    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               10       10      10                .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1312

INPUT
Description:
Station Elevation Data    num=      19
     Sta     Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   838.5     4958  868.78  4956.2  876.15 4955.92   957.4 4954.08  964.67 4953.86
  996.97  4952.75  997.03 4951.25    1000 4951.25    1025  4950.8    1035  4950.5
    1070   4945.5    1090  4945.5    1125  4950.5    1135  4950.8    1160 4951.25
    1163   4952.5    1220    4954    1221    4958    1270    4960

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   838.5    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               14       14      14                .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1110

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta     Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000     4951    1035  4950.5    1075  4948.5    1085  4948.5    1125  4950.5
    1160     4951

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
```

```
Downstream Embankment side slope          =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins       =
Weir crest shape                          = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1109

INPUT
Description: BOW
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     837    4958     875    4956     957    4954     997    4952    1000    4951
    1025  4950.5    1075    4948    1085    4948    1135  4950.5    1160    4951
    1163    4952    1200    4954    1260    4954    1267    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     837    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
          1000    1160                6       6       6              .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4950.14
      640   4950.71
     1190    4951.4
     3450   4953.34
     4790   4954.29
     7390   4955.88
    11590   4957.75
    21190   4960.64


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1108

INPUT
Description:
Station Elevation Data    num=      18
```

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
837	4958	875	4956.16	882	4955.91	950	4954.09	957	4953.85
997	4951.75	1000	4950.75	1025	4950.3	1035	4950	1070	4945
1090	4945	1125	4950	1135	4950.3	1160	4950.75	1163	4952
1200	4954	1260	4954	1267	4960				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
837	.045	1000	.045	1160	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
1000	1160	10	10	10	.1	.3

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1107.*

INPUT
Description:
Station Elevation Data num= 19

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
837	4958	875	4956.16	882	4955.91	950	4954.09	957	4953.85
997	4952.25	1000	4950.75	1025	4950.3	1035	4950	1070	4945
1090	4945	1125	4950	1135	4950.3	1160	4950.75	1162.38	4952
1163	4952	1200	4954	1260	4954	1267	4960		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
837	.045	1000	.045	1160	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
1000	1160	14	14	14	.1	.3

INLINE STRUCTURE

RIVER: Gunnison R.
REACH: 1 RS: 1105

INPUT
Description: WEIR
Distance from Upstream XS = 9
Deck/Roadway Width = 3
Weir Coefficient = 2.6
Weir Embankment Coordinates num = 6

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
1000	4950.5	1035	4950	1075	4948	1085	4948	1125	4950
1160	4950.5								

```
Upstream Embankment side slope              =      0 horiz. to 1.0 vertical
Downstream Embankment side slope            =      0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =    .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1104

INPUT
Description: BOW
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     837    4958     882    4956     950    4954     997  4951.5    1000  4950.5
    1025    4950    1075  4947.5    1085  4947.5    1135    4950    1160  4950.5
    1163  4951.5    1200    4954    1260    4954    1267    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     837    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
          1000    1160                6       6       6                .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4949.66
      640   4950.24
     1190   4950.94
     3450   4953.09
     4790   4954.08
     7390   4955.69
    11590   4957.56
    21190    4960.4


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1103

INPUT
Description: BOP
```

```
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     837    4958     882    4956     950    4954     997  4951.5    1000  4950.5
    1035  4949.5    1070  4944.5    1090  4944.5    1125  4949.5    1160  4950.5
    1163  4951.5    1200    4954    1260    4954    1267    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     837    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
          1000    1160               86       80      96              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1102

INPUT
Description: BOP
Station Elevation Data    num=      15
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     852    4958     878    4956     932    4954     985    4952     997    4951
    1000    4950    1035  4949.5    1070  4944.5    1090  4944.5    1125  4949.5
    1160    4950    1163  4951.5    1200    4954    1260    4954    1267    4960

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     852    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
          1000    1160               14       14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1035

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000    4950    1035  4949.5    1075  4947.5    1085  4947.5    1125  4949.5
    1160    4950

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
```

```
Downstream Embankment side slope           =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins        =
Weir crest shape                           = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1034

INPUT
Description: BOW
Station Elevation Data    num=      16
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     852    4958     878    4956     932    4954     985    4952     997    4951
    1000    4950    1025  4949.5    1075    4947    1085    4947    1135  4949.5
    1160    4950    1163    4951    1243  4951.5    1268    4954    1315    4956
    1325    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     852    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
          1000    1160                6       6       6                .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4949.13
      640   4949.71
     1190   4950.42
     3450   4952.79
     4790   4953.82
     7390   4955.48
    11590   4957.36
    21190   4960.17


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1033

INPUT
Description: BOP
```

```
Station Elevation Data    num=      25
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     856    4958  878.63 4956.11   881.3 4955.95  933.84 4954.04  936.23 4953.95
  979.43 4952.12  985.41 4951.83  997.08  4950.7    1000 4949.75    1025  4949.3
    1035    4949    1070    4944    1090    4944    1125    4949    1135  4949.3
    1160 4949.75 1162.79  4950.7 1163.25 4951.25 1226.94 4951.93 1249.79 4952.51
 1271.56  4953.8 1276.84  4954.1  1322.7  4955.9 1327.68 4956.32  1338.5    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     856    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               10       10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1032.*

INPUT
Description: BOP
Station Elevation Data    num=      26
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     856    4958  878.63 4956.11   881.3 4955.95  933.84 4954.04  936.23 4953.95
  979.43 4952.12  985.41 4951.83  996.91  4950.7  997.08 4949.75    1000 4949.75
    1025  4949.3    1035    4949    1070    4944    1090    4944    1125    4949
    1135  4949.3    1160 4949.75 1162.79 4951.18 1163.25 4951.25 1226.94 4951.93
 1249.79 4952.51 1271.56  4953.8 1276.84  4954.1  1322.7  4955.9 1327.68 4956.32
  1338.5    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     856    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               14       14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1030

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
```

```
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000  4949.5    1035    4949    1075    4947    1085    4947    1125    4949
    1160  4949.5

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1029

INPUT
Description: BOW
Station Elevation Data    num=      16
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     860    4958     882    4956     938    4954     980    4952     997  4950.5
    1000  4949.5    1025    4949    1075  4946.5    1085  4946.5    1135    4949
    1160  4949.5    1163  4950.5    1232    4952    1280    4954    1335    4956
    1352    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     860    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
          1000    1160                6       6       6              .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4948.64
      640    4949.2
     1190   4950.13
     3450   4952.66
     4790   4953.69
     7390   4955.35
    11590   4957.22
    21190   4959.98


CROSS SECTION
```

RIVER: Gunnison R.
REACH: 1 RS: 1028

INPUT
Description:
Station Elevation Data num= 24

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
867.5	4958	878.1	4956.49	888.32	4955.82	934.28	4954.13	941.32	4953.83
981.07	4951.84	996.82	4950.25	997.16	4950.2	1000	4949.25	1025	4948.5
1035	4948.5	1070	4943.5	1090	4943.5	1125	4948.5	1135	4948.5
1160	4949.25	1162.87	4950.2	1163.14	4950.75	1217.43	4951.88	1235.38	4952.27
1284.43	4953.98	1285.62	4954.03	1343.2	4956.54	1361	4958		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
867.5	.045	1000	.045	1160	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
1000	1160	10	10	10	.1	.3

CROSS SECTION

RIVER: Gunnison R.
REACH: 1 RS: 1027.*

INPUT
Description:
Station Elevation Data num= 25

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
867.5	4958	878.1	4956.49	888.32	4955.82	934.28	4954.13	941.32	4953.83
976.68	4952.11	981.07	4950.25	996.82	4950.2	997.16	4949.25	1000	4949.25
1025	4948.5	1035	4948.5	1070	4943.5	1090	4943.5	1125	4948.5
1135	4948.5	1160	4949.25	1162.87	4950.71	1163.14	4950.75	1217.43	4951.88
1235.38	4952.27	1284.43	4953.98	1285.62	4954.03	1343.2	4956.54	1361	4958

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
867.5	.045	1000	.045	1160	.045

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
1000	1160	14	14	14	.1	.3

INLINE STRUCTURE

RIVER: Gunnison R.
REACH: 1 RS: 1025

INPUT
Description: WEIR

```
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000    4949    1035  4948.5    1075  4946.5    1085  4946.5    1125  4948.5
    1160    4949

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1024

INPUT
Description: BOW
Station Elevation Data    num=      15
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     865    4958     870    4956     938    4954     978    4952     997    4950
    1000    4949    1025  4948.5    1075    4946    1085    4946    1135  4948.5
    1160    4949    1163    4950    1220    4952    1290    4954    1370    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     865    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         1000    1160                  6       6       6              .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4948.19
      640   4948.98
     1190   4950.03
     3450   4952.55
     4790   4953.58
     7390   4955.23
    11590   4957.09
    21190   4959.82
```

```
CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1023

INPUT
Description:
Station Elevation Data    num=      23
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     855    4958  860.37 4956.83  885.87 4955.65  933.41 4954.11  939.19 4953.87
  974.74 4952.04  976.37 4951.93  997.19  4949.7    1000 4948.75    1025  4948.3
    1035    4948    1070    4943    1090    4943    1125    4948    1135  4948.3
    1160 4948.75 1162.79  4949.7 1163.25 4950.26  1218.5 4951.92    1225 4952.08
  1296.5 4953.94 1300.83  4954.1  1387.5    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     855    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               10      10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1022.*

INPUT
Description:
Station Elevation Data    num=      23
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     855    4958  860.37 4956.83  885.87 4955.65  933.41 4954.11  939.19 4953.87
  974.74 4952.04  976.37 4951.93  996.78  4949.7  997.19 4948.75    1000 4948.75
    1025  4948.3    1035    4948    1070    4943    1090    4943    1125    4948
    1135  4948.3    1160 4948.75 1163.25 4950.26  1218.5 4951.92    1225 4952.08
  1296.5 4953.94 1300.83  4954.1  1387.5    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     855    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               14      14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                   RS: 1020
```

```
INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000  4948.5    1035    4948    1075    4946    1085    4946    1125    4948
    1160  4948.5

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1019

INPUT
Description: BOW
Station Elevation Data    num=      15
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     845    4958     878    4956     935    4954     973    4952     997  4949.5
    1000  4948.5    1025    4948    1075  4945.5    1085  4945.5    1135    4948
    1160  4948.5    1163  4949.5    1223    4952    1307    4954    1405    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     845    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160                6       6       6              .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4948.08
      640   4948.91
     1190   4949.95
     3450   4952.45
     4790   4953.48
     7390   4955.14
    11590   4956.98
```

```
    21190   4959.68


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1018

INPUT
Description:
Station Elevation Data    num=      25
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   842.5    4958  876.03 4956.19  883.84 4955.87  933.95 4954.12  940.94 4953.82
  972.44    4952  972.56  4951.5  995.08  4949.5  996.95 4949.25  997.05 4949.25
    1000 4948.25    1025  4947.8    1035  4947.5    1070  4942.5    1090  4942.5
    1125  4947.5    1135  4947.8    1160 4948.25 1162.93 4949.25 1193.21 4950.49
 1224.54  4951.7 1238.13 4952.16 1303.57 4953.92  1310.6 4954.13    1411    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   842.5    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160                10      10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1017.*

INPUT
Description:
Station Elevation Data    num=      26
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   842.5    4958  876.03 4956.19  883.84 4955.87  933.95 4954.12  940.94 4953.82
  972.44    4952  972.56  4951.5  995.08  4949.5  996.95 4949.25  997.05 4949.25
    1000 4948.25    1025  4947.8    1035  4947.5    1070  4942.5    1090  4942.5
    1125  4947.5    1135  4947.8    1160 4948.25 1162.93 4949.73 1163.07 4949.75
 1193.21 4950.49 1224.54  4951.7 1238.13 4952.16 1303.57 4953.92  1310.6 4954.13
    1411    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   842.5    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160                14      14      14              .1       .3

INLINE STRUCTURE
```

```
RIVER: Gunnison R.
REACH: 1                  RS: 1015

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000    4948    1035  4947.5    1075  4945.5    1085  4945.5    1125  4947.5
    1160    4948

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1014

INPUT
Description: BOW
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     840    4958     882    4956     940    4954     972    4952     995  4949.5
     997    4949    1000    4948    1025  4947.5    1075    4945    1085    4945
    1135  4947.5    1160    4948    1163    4949    1194  4949.5    1240    4952
    1307    4954    1417    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     840    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160                6       6       6              .1       .3

Internal Rating Curve

    Flow      Elev
     (cfs)      (ft)

      340   4948.05
      640   4948.86
```

```
     1190    4949.9
     3450   4952.39
     4790   4953.41
     7390   4955.05
    11590   4956.87
    21190   4959.53


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1013

INPUT
Description:
Station Elevation Data    num=      27
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     840    4958     880 4956.05     882 4955.97     940 4954.17     952 4953.62
     972 4952.29     980 4951.65     985 4950.43     995    4949     997 4948.75
    1000 4947.75    1025  4947.3    1035    4947    1070    4942    1090    4942
    1125    4947    1135  4947.3    1160 4947.25 1162.97 4948.25 1163.03 4948.75
 1194.33 4949.97 1196.65 4950.05 1240.78 4951.77 1254.09  4952.2 1308.43 4953.96
 1310.55 4954.04  1419.5    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     840    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.   Expan.
          1000    1160               10       10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1012.*

INPUT
Description:
Station Elevation Data    num=      27
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     840    4958     880 4956.05     882 4955.97     940 4954.17     952 4953.62
     972 4952.29     980 4951.65     985 4950.43     995    4949     997 4948.75
    1000 4947.75    1025  4947.3    1035    4947    1070    4942    1090    4942
    1125    4947    1135  4947.3    1160 4947.25 1162.97 4948.25 1163.03 4948.75
 1194.33 4949.97 1196.65 4950.05 1240.78 4951.77 1254.09  4952.2 1308.43 4953.96
 1310.55 4954.04  1419.5    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
     840    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160                 14      14      14              .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                  RS: 1010

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000  4947.5    1035    4947    1075    4945    1085    4945    1125    4947
    1160  4947.5

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1009

INPUT
Description:
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     840    4958     880    4956     952    4954     980    4952     985    4950
     997  4948.5    1000  4947.5    1025    4947    1075  4944.5    1085  4944.5
    1135    4947    1160  4947.5    1163  4948.5    1197    4950    1255    4952
    1312    4954    1422    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
     840    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160                  6       6       6              .1       .3

Internal Rating Curve
```

```
  Flow      Elev
   (cfs)      (ft)

     340   4948.02
     640   4948.84
    1190   4949.86
    3450   4952.32
    4790   4953.34
    7390   4954.95
   11590   4956.75
   21190   4959.36


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1008

INPUT
Description:
Station Elevation Data    num=      26
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   843.5    4958  882.37 4956.01  882.62    4956  953.05 4954.08  959.08 4953.78
  980.44 4952.17  984.66 4951.14  985.33 4950.91  991.82 4949.72  996.93 4948.25
  997.07 4948.25    1000 4947.25    1025  4946.8    1035  4946.5    1070  4941.5
    1090  4941.5    1125  4946.5    1135  4946.8    1160 4947.25    1163 4948.25
    1197    4950    1255 4951.98    1256 4952.02    1305 4953.88    1312 4954.12
    1422    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   843.5    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               10       10      10              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1007.*

INPUT
Description:
Station Elevation Data    num=      26
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
   843.5    4958  882.37 4956.01  882.62    4956  953.05 4954.08  959.08 4953.78
  980.44 4952.17  984.66 4951.14  985.33 4950.91  991.82 4949.72  996.93 4948.25
  997.07 4948.25    1000 4947.25    1025  4946.8    1035  4946.5    1070  4941.5
```

```
    1090  4941.5    1125  4946.5    1135  4946.8    1160 4947.25    1163 4948.25
    1197    4950    1255 4951.98    1256 4952.02    1305 4953.88    1312 4954.12
    1422    4958

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
   843.5    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               14       14      14               .1       .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                   RS: 1005

INPUT
Description: WEIR
Distance from Upstream XS =       9
Deck/Roadway Width        =       3
Weir Coefficient          =     2.6
 Weir Embankment Coordinates    num =        6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000    4947    1035  4946.5    1075  4944.5    1085  4944.5    1125  4946.5
    1160    4947

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Weir crest shape                            = Broad Crested


CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 1004

INPUT
Description: BOW
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     847    4958     885    4956     960    4954     985    4952     992    4950
     997    4948    1000    4947    1025  4946.5    1075    4944    1085    4944
    1135  4946.5    1160    4947    1163    4948    1197    4950    1256    4952
    1305    4954    1422    4958

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
     847    .045    1000    .045    1160    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1000    1160               39      61      55               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1000

INPUT
Description: XS 10, sta 11380
Station Elevation Data    num=      25
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4957.02  1050.9 4954.63  1088.3 4954.93  1143.9 4955.26    11454955.031
  1152.5 4953.47  1160.9 4948.43  1167.5 4946.67  1179.5 4945.87  1183.6 4945.67
  1204.4  4944.5  1229.5 4944.72  1235.4 4945.21    1243 4946.76  1255.8 4947.18
  1275.3 4947.91  1284.8 4948.47    13254950.051  1329.8 4950.24    1339 4948.56
  1347.2 4948.65  1350.5 4950.68  1387.9 4951.56  1420.8 4952.98  1458.7 4954.95

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1145    .039    1325    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1145    1325              547     645     677               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 900

INPUT
Description: XS 11, sta 10730
Station Elevation Data    num=      21
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4956.16  1100.3 4955.35  1209.6 4955.59    12104955.419  1227.7 4947.89
  1239.7 4945.02  1267.4 4944.94  1297.1  4945.4  1335.3 4945.89    1362 4946.58
  1388.6 4946.99    1402 4947.08  1419.7 4947.97    1432 4951.56    14754954.041
  1476.2 4954.11    1524  4953.3  1563.5  4952.8  1583.1 4951.88  1597.4 4954.01
  1625.6 4954.66

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1210    .039    1475    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1210    1475              860     956     994               .1       .3
```

```
CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 800

INPUT
Description: XS 12, sta 9770
Station Elevation Data    num=      20
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4952.92  1099.3 4953.13  1208.8 4952.83    12104952.485  1231.6 4946.28
  1246.8 4944.39  1279.3 4944.12  1318.6 4944.51  1368.4 4945.21  1405.5 4946.22
  1414.4 4948.69  1435.1  4949.2    14454950.914  1449.6 4951.71  1511.6 4951.39
  1525.2 4947.21  1526.9 4947.26  1538.8 4950.08  1588.6 4951.34  1665.7 4951.57

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1210    .039    1445    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1210    1445              698     781     803             .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 700

INPUT
Description: XS 13, sta 8990
Station Elevation Data    num=      20
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4949.63  1074.5 4949.24  1132.9 4949.22    11354948.208  1142.2 4944.74
  1150.8 4941.68  1165.1 4941.11  1211.8 4941.45  1234.4 4942.32  1255.4 4943.33
  1276.3 4944.81  1344.9 4945.12    13654949.107  1369.7 4950.04  1383.7 4949.16
  1391.8 4946.67  1422.6 4945.35    1433 4949.23  1457.2 4953.64  1515.1 4953.12

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1135    .039    1365    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1135    1365             1730    1600    1600             .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 600

INPUT
```

```
Description: XS 14, sta 7390
Station Elevation Data    num=      21
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
999.9999 4947.89  1033.6 4947.12    10354946.981  1054.9     4945  1062.3 4940.47
  1071.3 4938.01  1087.2 4936.55  1109.1   4938.2  1133.2 4940.23    1150 4940.02
    1163 4938.83  1182.2 4939.57  1222.4   4940.3  1271.6 4940.19    1303 4939.64
  1315.1 4940.24  1322.7   4941.9  1334.8 4946.43    13504948.055  1350.8 4948.14
  1416.9 4947.27

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
999.9999    .045    1035    .039    1350    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1035    1350             1990    1990    1990               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 500

INPUT
Description: XS 15, sta 5390
Station Elevation Data    num=      20
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
    1000 4942.72  1022.5   4942.2  1031.2 4939.98  1041.6 4941.22  1093.8 4939.99
    10954939.604  1101.9 4937.38  1118.4 4938.04  1132.8 4936.75    1145   4935.4
  1190.3 4935.24  1210.5 4934.51  1234.4 4933.33  1260.1 4931.84    1278 4934.04
  1286.5 4936.77    12954940.298  1295.1 4940.34  1381.5   4941.7  1433.7 4941.03

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    1000    .045    1095    .039    1295    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1095    1295             1075    1104    1098               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 400

INPUT
Description: XS 16, sta 4290
Station Elevation Data    num=      21
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
    1000 4941.85  1034.3 4941.38  1082.3 4941.63    10854940.719  1099.5 4935.83
  1125.9 4935.26  1148.6 4933.49  1181.4 4932.99  1205.3 4932.46  1227.2 4933.18
  1250.9 4933.05  1271.8 4933.62  1310.4 4935.29    13754939.383    1377 4939.51
```

```
  1425.8 4938.23  1436.9 4935.61  1457.3 4935.52  1470.6 4939.07  1550.7 4940.01
    1618 4939.26

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1085    .039    1375    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1085    1375             2320    2320    2320               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 300

INPUT
Description: XS 17, sta 2090
Station Elevation Data    num=      25
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4940.04  1033.3  4939.1    10354937.884  1045.8 4930.16  1055.3 4929.24
  1090.3 4928.51  1117.2 4928.89  1150.5 4929.37  1173.9 4927.15  1183.2 4927.06
  1195.2 4929.08  1207.7 4926.58  1231.8 4926.28  1235.8 4926.52  1244.5 4929.99
  1251.6  4934.5    12754935.197  1278.8 4935.31  1287.5 4933.26  1333.2  4930.5
    1365 4932.83  1424.1  4936.9    1492 4938.89  1580.4 4938.45  1581.3 4938.51

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1035    .039    1275    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1035    1275             2000    2000    2000               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 200

INPUT
Description: XS 18, sta 200
Station Elevation Data    num=      19
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4935.66    1037 4934.04    10404932.355  1052.1 4925.56  1075.2 4924.05
  1086.1 4925.09  1105.9 4925.61  1125.7 4927.05  1131.1 4925.46  1138.9 4924.06
  1145.4 4923.41  1162.2 4923.58  1187.7 4923.26  1235.7 4924.07  1253.1 4926.14
    12954928.998  1296.2 4929.08    1352 4931.47  1431.3 4936.48

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1040    .039    1295    .045
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1040    1295                200     200     200                .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 100

INPUT
Description: XS 19, sta 0 - most downstream
Station Elevation Data    num=      22
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000 4937.86     1033 4933.22  1059.1 4930.56  1062.2 4927.11  1072.4 4925.16
    10754924.258  1082.2 4921.76  1095.7 4920.94  1104.4 4920.22    1127 4918.85
  1153.3 4920.23  1162.6 4921.68  1175.8 4922.62  1184.5 4925.02    11904925.821
  1190.2 4925.85  1241.3 4926.22  1252.1 4929.28  1309.1 4930.97  1324.5 4929.16
    1341    4930  1400.2 4937.59

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    1000    .045     1075    .039     1190    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1075    1190                  0       0       0                .1       .3
```

SUMMARY OF MANNING'S N VALUES

River:Gunnison R.

Reach	River Sta.	n1	n2	n3
1	1900	.045	.039	.045
1	1800	.045	.039	.045
1	1700	.045	.039	.045
1	1610	.045	.039	.045
1	1520	.045	.039	.045
1	1510	Inl Struct		
1	1509	.045	.045	.045
1	1508	.045	.045	.045
1	1507.*	.045	.045	.045
1	1505	Inl Struct		
1	1504	.045	.045	.045
1	1503	.045	.045	.045
1	1502	.045	.045	.045
1	1325	Inl Struct		
1	1324	.045	.045	.045
1	1323	.045	.045	.045

1	1322.*	.045	.045	.045
1	1320	Inl Struct		
1	1319	.045	.045	.045
1	1318	.045	.045	.045
1	1317.*	.045	.045	.045
1	1315	Inl Struct		
1	1314	.045	.045	.045
1	1313	.045	.045	.045
1	1312	.045	.045	.045
1	1110	Inl Struct		
1	1109	.045	.045	.045
1	1108	.045	.045	.045
1	1107.*	.045	.045	.045
1	1105	Inl Struct		
1	1104	.045	.045	.045
1	1103	.045	.045	.045
1	1102	.045	.045	.045
1	1035	Inl Struct		
1	1034	.045	.045	.045
1	1033	.045	.045	.045
1	1032.*	.045	.045	.045
1	1030	Inl Struct		
1	1029	.045	.045	.045
1	1028	.045	.045	.045
1	1027.*	.045	.045	.045
1	1025	Inl Struct		
1	1024	.045	.045	.045
1	1023	.045	.045	.045
1	1022.*	.045	.045	.045
1	1020	Inl Struct		
1	1019	.045	.045	.045
1	1018	.045	.045	.045
1	1017.*	.045	.045	.045
1	1015	Inl Struct		
1	1014	.045	.045	.045
1	1013	.045	.045	.045
1	1012.*	.045	.045	.045
1	1010	Inl Struct		
1	1009	.045	.045	.045
1	1008	.045	.045	.045
1	1007.*	.045	.045	.045
1	1005	Inl Struct		
1	1004	.045	.045	.045
1	1000	.045	.039	.045
1	900	.045	.039	.045
1	800	.045	.039	.045
1	700	.045	.039	.045
1	600	.045	.039	.045
1	500	.045	.039	.045
1	400	.045	.039	.045
1	300	.045	.039	.045

1	200	.045	.039	.045
1	100	.045	.039	.045

SUMMARY OF REACH LENGTHS

River: Gunnison R.

Reach	River Sta.	Left	Channel	Right
1	1900	861	848	1120
1	1800	1350	1300	1300
1	1700	389	381	374
1	1610	66	74	81
1	1520	89	40	57
1	1510	Inl Struct		
1	1509	6	6	6
1	1508	10	10	10
1	1507.*	14	14	14
1	1505	Inl Struct		
1	1504	6	6	6
1	1503	10	10	10
1	1502	14	14	14
1	1325	Inl Struct		
1	1324	6	6	6
1	1323	10	10	10
1	1322.*	14	14	14
1	1320	Inl Struct		
1	1319	6	6	6
1	1318	10	10	10
1	1317.*	14	14	14
1	1315	Inl Struct		
1	1314	6	6	6
1	1313	10	10	10
1	1312	14	14	14
1	1110	Inl Struct		
1	1109	6	6	6
1	1108	10	10	10
1	1107.*	14	14	14
1	1105	Inl Struct		
1	1104	6	6	6
1	1103	86	80	96
1	1102	14	14	14
1	1035	Inl Struct		
1	1034	6	6	6
1	1033	10	10	10
1	1032.*	14	14	14
1	1030	Inl Struct		
1	1029	6	6	6

1	1028	10	10	10
1	1027.*	14	14	14
1	1025	Inl Struct		
1	1024	6	6	6
1	1023	10	10	10
1	1022.*	14	14	14
1	1020	Inl Struct		
1	1019	6	6	6
1	1018	10	10	10
1	1017.*	14	14	14
1	1015	Inl Struct		
1	1014	6	6	6
1	1013	10	10	10
1	1012.*	14	14	14
1	1010	Inl Struct		
1	1009	6	6	6
1	1008	10	10	10
1	1007.*	14	14	14
1	1005	Inl Struct		
1	1004	39	61	55
1	1000	547	645	677
1	900	860	956	994
1	800	698	781	803
1	700	1730	1600	1600
1	600	1990	1990	1990
1	500	1075	1104	1098
1	400	2320	2320	2320
1	300	2000	2000	2000
1	200	200	200	200
1	100	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Gunnison R.

Reach	River Sta.	Contr.	Expan.
1	1900	.1	.3
1	1800	.1	.3
1	1700	.1	.3
1	1610	.1	.3
1	1520	.1	.3
1	1510	Inl Struct	
1	1509	.1	.3
1	1508	.1	.3
1	1507.*	.1	.3
1	1505	Inl Struct	
1	1504	.1	.3

1	1503	.1	.3
1	1502	.1	.3
1	1325	Inl Struct	
1	1324	.1	.3
1	1323	.1	.3
1	1322.*	.1	.3
1	1320	Inl Struct	
1	1319	.1	.3
1	1318	.1	.3
1	1317.*	.1	.3
1	1315	Inl Struct	
1	1314	.1	.3
1	1313	.1	.3
1	1312	.1	.3
1	1110	Inl Struct	
1	1109	.1	.3
1	1108	.1	.3
1	1107.*	.1	.3
1	1105	Inl Struct	
1	1104	.1	.3
1	1103	.1	.3
1	1102	.1	.3
1	1035	Inl Struct	
1	1034	.1	.3
1	1033	.1	.3
1	1032.*	.1	.3
1	1030	Inl Struct	
1	1029	.1	.3
1	1028	.1	.3
1	1027.*	.1	.3
1	1025	Inl Struct	
1	1024	.1	.3
1	1023	.1	.3
1	1022.*	.1	.3
1	1020	Inl Struct	
1	1019	.1	.3
1	1018	.1	.3
1	1017.*	.1	.3
1	1015	Inl Struct	
1	1014	.1	.3
1	1013	.1	.3
1	1012.*	.1	.3
1	1010	Inl Struct	
1	1009	.1	.3
1	1008	.1	.3
1	1007.*	.1	.3
1	1005	Inl Struct	
1	1004	.1	.3
1	1000	.1	.3
1	900	.1	.3
1	800	.1	.3

1	700	.1	.3
1	600	.1	.3
1	500	.1	.3
1	400	.1	.3
1	300	.1	.3
1	200	.1	.3
1	100	.1	.3

Existing Hydraulics

HEC-RAS Plan: Hartland River: Gunnison R. Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	1900	PF 1	3520.00	4951.85	4958.00		4958.08	0.000745	2.25	1594.20	517.99	0.22
1	1900	PF 2	4870.00	4951.85	4958.98		4959.06	0.000680	2.31	2145.96	620.14	0.22
1	1900	PF 3	7470.00	4951.85	4960.48		4960.56	0.000571	2.27	3351.72	865.86	0.20
1	1900	PF 4	11670.00	4951.85	4962.22		4962.31	0.000425	2.43	4906.14	921.09	0.18
1	1900	PF 5	21270.00	4951.85	4964.84		4964.96	0.000415	2.79	7758.89	1155.41	0.19
1	1800	PF 1	3520.00	4949.79	4957.35		4957.49	0.000625	2.99	1203.01	240.95	0.22
1	1800	PF 2	4870.00	4949.79	4958.26		4958.45	0.000731	3.52	1443.55	288.18	0.24
1	1800	PF 3	7470.00	4949.79	4959.67		4959.95	0.000870	4.30	1900.17	361.24	0.27
1	1800	PF 4	11670.00	4949.79	4961.31		4961.73	0.001096	5.38	2642.82	706.66	0.31
1	1800	PF 5	21270.00	4949.79	4963.90		4964.38	0.001070	6.24	4528.67	729.13	0.32
1	1700	PF 1	3520.00	4950.72	4956.14		4956.32	0.001400	3.41	1032.78	275.76	0.31
1	1700	PF 2	4870.00	4950.72	4956.84		4957.08	0.001630	3.95	1233.57	295.79	0.34
1	1700	PF 3	7470.00	4950.72	4957.98		4958.31	0.001951	4.61	1622.35	360.82	0.38
1	1700	PF 4	11670.00	4950.72	4959.39		4959.86	0.001957	5.49	2149.03	392.30	0.40
1	1700	PF 5	21270.00	4950.72	4961.83		4962.52	0.001938	6.81	3334.54	499.22	0.42
1	1600	PF 1	3520.00	4947.67	4955.53		4955.69	0.001352	3.23	1089.78	306.15	0.30
1	1600	PF 2	4870.00	4947.67	4956.13		4956.35	0.001548	3.82	1274.53	307.58	0.33
1	1600	PF 3	7470.00	4947.67	4957.11		4957.46	0.001808	4.73	1588.45	339.40	0.37
1	1600	PF 4	11670.00	4947.67	4958.45		4958.96	0.001977	5.76	2123.31	441.32	0.40
1	1600	PF 5	21270.00	4947.67	4960.83		4961.60	0.002072	7.23	3177.16	443.40	0.43
1	1500	PF 1	3520.00	4948.83	4955.37		4955.56	0.001696	3.50	1006.03	297.02	0.34
1	1500	PF 2	4870.00	4948.83	4955.94		4956.20	0.001950	4.14	1176.19	299.19	0.37
1	1500	PF 3	7470.00	4948.83	4956.87		4957.28	0.002280	5.13	1457.03	302.74	0.41
1	1500	PF 4	11670.00	4948.83	4958.13		4958.75	0.002574	6.34	1861.16	375.25	0.45
1	1500	PF 5	21270.00	4948.83	4960.38		4961.37	0.002826	8.14	2766.03	411.11	0.50
1	1400	PF 1	3440.00	4948.68	4955.34		4955.48	0.001186	3.04	1132.74	316.68	0.28
1	1400	PF 2	4790.00	4948.68	4955.90		4956.11	0.001414	3.65	1313.10	317.42	0.32
1	1400	PF 3	7390.00	4948.68	4956.84		4957.17	0.001736	4.59	1610.47	321.08	0.36
1	1400	PF 4	11590.00	4948.68	4958.11		4958.61	0.002256	5.65	2049.84	364.26	0.42
1	1400	PF 5	21190.00	4948.68	4960.37		4961.20	0.002544	7.31	2911.82	394.63	0.47
1	1300	PF 1	3440.00	4952.43	4955.01	4954.38	4955.39	0.012394	4.94	696.29	329.25	0.60
1	1300	PF 2	4790.00	4952.43	4955.54	4954.75	4956.01	0.011483	5.49	872.01	331.66	0.60
1	1300	PF 3	7390.00	4952.43	4956.43	4955.38	4957.05	0.010518	6.33	1168.05	335.69	0.60
1	1300	PF 4	11590.00	4952.43	4957.63	4956.27	4958.47	0.009789	7.36	1576.25	352.08	0.60
1	1300	PF 5	21190.00	4952.43	4959.83	4957.99	4961.05	0.008873	8.93	2425.05	401.05	0.61
1	1299		Inl Struct									
1	1200	PF 1	3440.00	4945.60	4952.84		4952.89	0.000519	1.90	1810.24	330.72	0.14
1	1200	PF 2	4790.00	4945.60	4953.71		4953.79	0.000622	2.28	2100.47	333.79	0.16
1	1200	PF 3	7390.00	4945.60	4955.16		4955.28	0.000758	2.86	2587.40	338.88	0.18
1	1200	PF 4	11590.00	4945.60	4956.87		4957.08	0.000972	3.65	3174.20	344.91	0.21
1	1200	PF 5	21190.00	4945.60	4959.37		4959.79	0.001491	5.21	4112.89	398.96	0.27
1	1100	PF 1	3440.00	4946.81	4952.73		4952.83	0.000832	2.64	1303.76	348.39	0.24
1	1100	PF 2	4790.00	4946.81	4953.59		4953.73	0.000819	2.98	1606.05	352.74	0.25
1	1100	PF 3	7390.00	4946.81	4955.03		4955.21	0.000795	3.49	2117.12	358.30	0.25
1	1100	PF 4	11590.00	4946.81	4956.72		4957.00	0.000906	4.22	2745.97	400.93	0.28
1	1100	PF 5	21190.00	4946.81	4959.21		4959.69	0.001076	5.61	3927.83	498.50	0.32
1	1030	PF 1	3440.00	4948.00	4951.98		4952.52	0.007473	5.88	584.59	243.81	0.67
1	1030	PF 2	4790.00	4948.00	4952.93		4953.45	0.004723	5.83	841.25	300.94	0.56
1	1030	PF 3	7390.00	4948.00	4954.47		4954.98	0.002881	5.87	1378.94	390.96	0.47
1	1030	PF 4	11590.00	4948.00	4956.22		4956.77	0.002208	6.30	2137.12	473.19	0.43
1	1030	PF 5	21190.00	4948.00	4958.71		4959.45	0.002040	7.49	3379.00	512.00	0.44
1	1000	PF 1	3440.00	4944.50	4951.65		4951.92	0.001592	4.21	867.63	234.38	0.34
1	1000	PF 2	4790.00	4944.50	4952.62		4952.95	0.001569	4.72	1107.60	258.56	0.35
1	1000	PF 3	7390.00	4944.50	4954.18		4954.60	0.001537	5.40	1539.15	294.81	0.36
1	1000	PF 4	11590.00	4944.50	4955.90		4956.44	0.001606	6.31	2175.47	434.84	0.38
1	1000	PF 5	21190.00	4944.50	4958.27		4959.10	0.001880	8.05	3249.49	458.70	0.43
1	900	PF 1	3440.00	4944.94	4950.76		4950.97	0.001292	3.70	930.27	208.32	0.31
1	900	PF 2	4790.00	4944.94	4951.71		4951.99	0.001377	4.24	1129.72	215.80	0.33
1	900	PF 3	7390.00	4944.94	4953.18		4953.57	0.001603	5.01	1498.27	303.61	0.36
1	900	PF 4	11590.00	4944.94	4954.82		4955.35	0.001775	5.93	2103.01	414.18	0.39
1	900	PF 5	21190.00	4944.94	4957.03		4957.83	0.002031	7.57	3319.27	625.60	0.44
1	800	PF 1	3440.00	4944.12	4948.90		4949.24	0.002715	4.69	742.59	214.33	0.43
1	800	PF 2	4790.00	4944.12	4949.71		4950.13	0.002877	5.25	929.26	238.52	0.45
1	800	PF 3	7390.00	4944.12	4950.93		4951.51	0.002981	6.16	1247.02	289.17	0.48
1	800	PF 4	11590.00	4944.12	4952.44		4953.18	0.002899	7.12	1846.41	455.55	0.49
1	800	PF 5	21190.00	4944.12	4954.87		4955.71	0.002419	8.03	3346.13	665.70	0.47

HEC-RAS Plan: Hartland River: Gunnison R. Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	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)	
1	700	PF 1	3440.00	4941.11	4946.68		4947.02	0.002970	4.68	752.08	248.99	0.45
1	700	PF 2	4790.00	4941.11	4947.39		4947.82	0.003062	5.31	931.88	258.24	0.47
1	700	PF 3	7390.00	4941.11	4948.61		4949.18	0.002985	6.13	1257.91	274.22	0.48
1	700	PF 4	11590.00	4941.11	4950.30		4951.01	0.002647	6.94	1874.81	438.88	0.47
1	700	PF 5	21190.00	4941.11	4952.96		4953.86	0.002331	8.14	3061.06	453.47	0.47
1	600	PF 1	3460.00	4936.55	4942.97		4943.19	0.001944	3.79	912.49	267.33	0.36
1	600	PF 2	4800.00	4936.55	4943.85		4944.12	0.001770	4.18	1149.24	271.12	0.36
1	600	PF 3	7400.00	4936.55	4945.24		4945.60	0.001683	4.83	1531.76	279.15	0.36
1	600	PF 4	11600.00	4936.55	4946.99		4947.49	0.001794	5.69	2039.01	305.05	0.39
1	600	PF 5	21200.00	4936.55	4949.65		4950.45	0.001906	7.22	3079.77	416.90	0.42
1	500	PF 1	3460.00	4931.84	4939.56		4939.80	0.001505	3.96	874.59	198.06	0.33
1	500	PF 2	4800.00	4931.84	4940.37		4940.70	0.001668	4.63	1040.76	223.68	0.36
1	500	PF 3	7400.00	4931.84	4941.66		4942.14	0.001796	5.58	1440.92	403.85	0.39
1	500	PF 4	11600.00	4931.84	4943.07		4943.71	0.001998	6.70	2030.52	433.70	0.42
1	500	PF 5	21200.00	4931.84	4945.38		4946.32	0.002245	8.43	3033.67	433.70	0.47
1	400	PF 1	3460.00	4932.46	4937.19		4937.49	0.003083	4.47	796.76	278.26	0.45
1	400	PF 2	4800.00	4932.46	4938.02		4938.37	0.002767	4.78	1037.09	300.46	0.44
1	400	PF 3	7400.00	4932.46	4939.41		4939.83	0.002427	5.25	1511.58	419.75	0.43
1	400	PF 4	11600.00	4932.46	4940.91		4941.40	0.002109	5.84	2276.80	533.57	0.42
1	400	PF 5	21200.00	4932.46	4943.53		4944.10	0.001655	6.56	3840.37	618.00	0.39
1	300	PF 1	3460.00	4926.28	4932.85		4933.05	0.001291	3.66	999.44	277.79	0.31
1	300	PF 2	4800.00	4926.28	4933.62		4933.88	0.001411	4.22	1224.12	299.74	0.33
1	300	PF 3	7400.00	4926.28	4934.90		4935.26	0.001615	4.98	1629.25	340.53	0.36
1	300	PF 4	11600.00	4926.28	4936.46		4936.95	0.001754	5.88	2198.90	380.69	0.39
1	300	PF 5	21200.00	4926.28	4939.20		4939.97	0.001898	7.54	3400.02	551.51	0.42
1	200	PF 1	3460.00	4923.26	4927.17		4927.78	0.007838	6.24	554.29	219.04	0.69
1	200	PF 2	4800.00	4923.26	4927.99		4928.65	0.006263	6.49	739.16	232.50	0.64
1	200	PF 3	7400.00	4923.26	4929.40		4930.13	0.004614	6.84	1082.94	258.40	0.58
1	200	PF 4	11600.00	4923.26	4931.17		4932.04	0.003590	7.52	1580.57	302.95	0.54
1	200	PF 5	21200.00	4923.26	4934.54		4935.59	0.002517	8.43	2709.77	374.95	0.49
1	100	PF 1	3460.00	4918.85	4923.90	4923.90	4925.54	0.015410	10.27	336.82	104.42	1.01
1	100	PF 2	4800.00	4918.85	4924.74	4924.74	4926.71	0.014222	11.25	426.92	109.89	1.00
1	100	PF 3	7400.00	4918.85	4926.34	4926.34	4928.61	0.011149	12.12	630.36	175.51	0.93
1	100	PF 4	11600.00	4918.85	4928.10	4928.10	4930.77	0.009381	13.46	950.65	186.63	0.89
1	100	PF 5	21200.00	4918.85	4931.54	4931.54	4934.61	0.006889	15.04	1758.04	303.48	0.82

```
                    HEC-RAS Version 3.1.3 May 2005
                     U.S. Army Corp of Engineers
                    Hydrologic Engineering Center
                          609 Second Street
                          Davis, California

            X     X  XXXXXX    XXXX        XXXX      XX      XXXX
            X     X  X        X    X       X   X    X  X    X
            X     X  X        X            X   X   X    X   X
            XXXXXXX  XXXX     X      XXX   XXXX    XXXXXX    XXXX
            X     X  X        X            X  X    X    X        X
            X     X  X        X    X       X   X   X    X        X
            X     X  XXXXXX    XXXX        X    X  X    X   XXXXX
```

PROJECT DATA
Project Title: HART_existing revPGS
Project File : hartex.prj
Run Date and Time: 12/16/2009 11:47:24 AM

Project in English units

Project Description:
existing conditions for hi flow check

PLAN DATA

Plan Title: Hartland Plan Data
Plan File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\existing\hartex.p01

Geometry Title: hart1
Geometry File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\existing\hartex.g01

Flow Title : Hartland flow data
Flow File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\existing\hartex.f01

Plan Summary Information:

Number of:	Cross Sections =	20	Multiple Openings =	0
	Culverts =	0	Inline Structures =	1
	Bridges =	0	Lateral Structures =	0

Computational Information

```
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001
```

Computation Options

```
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow
```

FLOW DATA

Flow Title: Hartland flow data
Flow File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\existing\hartex.f01

Flow Data (cfs)

River	Reach	RS	PF 1	PF 2	PF 3	PF 4	PF 5
Gunnison R.	1	1900	3520	4870	7470	11670	21270
Gunnison R.	1	1400	3440	4790	7390	11590	21190
Gunnison R.	1	600	3460	4800	7400	11600	21200

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Gunnison R.	1	PF 1		Critical
Gunnison R.	1	PF 2		Critical
Gunnison R.	1	PF 3		Critical
Gunnison R.	1	PF 4		Critical

```
GEOMETRY DATA

Geometry Title: hart1
Geometry File : f:\Projects\133_39802-09001 Hartland\SupportDocs\Calcs\HEC RAS\existing\hartex.g01

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                RS: 1900

INPUT
Description: XS1, sta 1900 - most upstream XS
Station Elevation Data    num=      35
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4964.71  1009.1 4964.62    10104964.256  1028.7 4956.69  1037.7 4955.22
  1049.9 4954.67  1050.6 4954.51  1129.3 4954.31  1148.5 4954.28  1161.3 4954.61
  1183.2 4955.71  1227.8 4956.72  1280.3 4959.21  1391.3 4959.44  1510.2 4958.78
  1542.1 4962.73  1627.1 4962.81  1734.9 4963.19    1736 4958.19  1750.1 4954.66
  1764.4 4952.79    1778 4952.24  1794.5 4951.85    1817 4952.07  1852.7 4952.85
  1880.2 4953.68  1900.4 4954.61  1942.4  4956.5  1950.2 4958.25  2003.8 4957.51
    20604962.948  2062.5 4963.19  2143.8 4954.64  2173.9  4981.1  2248.7 4983.83

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1010    .039    2060    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1010    2060              861     848    1120              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                RS: 1800

INPUT
Description: XS2, sta 1800
Station Elevation Data    num=      24
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4960.49  1011.5 4956.34  1022.9 4954.95  1028.2 4956.43  1032.9 4957.14
  1217.1 4961.21  1391.3 4960.75  1504.7 4961.43    15054961.341  1528.9 4954.22
  1539.5 4952.26  1552.4 4951.02  1581.7 4951.55  1610.9  4951.8  1637.1 4951.38
  1657.1 4950.26  1665.9 4949.79  1681.7 4951.21  1700.9 4951.42  1722.9 4952.75
  1723.7 4954.27    17304965.439  1730.7 4966.68  1844.5 4973.41

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
    1000    .045    1505    .039    1730    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1505    1730             1350    1300    1300              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1700

INPUT
Description: XS 3, sta 1700
Station Elevation Data    num=      31
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000  4959.5  1053.1 4959.83  1108.4 4959.34  1139.7 4957.53    11404957.418
  1149.1 4954.04  1161.7 4952.33  1176.1  4951.8  1187.9 4952.46  1189.7 4954.03
    1191 4955.59  1227.8 4957.17  1273.3 4957.08  1276.5 4954.23  1279.9 4953.47
  1302.4 4952.41  1334.6  4951.4  1361.2 4950.95  1390.1 4950.72  1422.5 4952.22
  1453.9 4952.56  1474.1 4953.56  1484.4 4953.01  1487.2 4954.28  1490.9 4956.93
  1512.7 4969.75    15154972.015  1519.9 4976.84    15204976.814  1529.9 4974.32
  1574.8 4989.64

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1140    .039    1515    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1140    1515              455     455     455              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1600

INPUT
Description: XS 4 sta 1600
Station Elevation Data    num=      26
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4957.87  1050.5 4957.79    1090 4956.38  1106.9 4957.74  1129.8 4957.41
    11304957.276  1134.7 4954.13  1137.7 4951.98  1149.8  4949.3  1190.6 4950.07
  1212.1  4951.3  1239.6    4952  1277.3 4953.01  1326.1 4953.86  1353.4 4954.06
  1392.4 4953.79  1405.8 4950.61    1411 4947.85  1427.8 4947.67  1431.9 4950.85
  1437.3 4953.85    14454962.657  1449.2 4967.46  1456.8 4967.66  1477.3 4976.91
    1510 4979.04

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1130    .039    1445    .045
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1130    1445                  85      85      85              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1500

INPUT
Description: XS 5, sta 1500 - pts 643-662
Station Elevation Data    num=      22
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4959.02  1034.4  4958.1  1083.4  4957.8    1103 4957.34    11054956.579
  1111.2 4954.22  1113.6 4949.99  1116.1 4948.83  1165.7 4949.88  1175.2 4951.86
  1205.5 4952.04  1230.4 4952.51  1271.4 4952.81  1313.5 4953.55  1362.5 4952.42
  1388.6 4951.72  1402.4 4951.68  1403.3 4953.75  1414.5 4963.25    1430 4973.48
  1431.5 4974.47  1508.5    4976

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1105    .039    1430    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1105    1430                  45      45      45              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1400

INPUT
Description: XS 6, sta 1400 - pts 696-663
Station Elevation Data    num=      36
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000  4958.7  1005.4 4958.23  1021.5 4963.12    10454962.488  1045.3 4962.48
  1074.6 4958.04  1100.8 4957.09  1111.5 4957.05  1114.9 4954.05  1119.8 4951.17
  1133.6 4950.51  1152.4 4950.57    1182 4950.37  1197.2 4951.05  1204.7 4951.88
  1239.7 4952.14  1281.4 4952.24  1306.9 4952.82  1337.1 4953.05  1360.1 4952.58
  1384.6 4952.42  1405.1 4951.09  1411.9  4950.4  1417.7 4948.68  1420.8  4948.8
    1429 4951.47  1429.9 4953.89  1430.3 4956.45  1437.7 4957.59  1451.9 4968.35
  1457.7 4969.63    14654972.583  1468.6 4974.04  1486.2 4971.14  1499.9 4974.48
  1538.8 4974.71

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1045    .039    1465    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1045    1465                  25      25      25              .1       .3
```

```
CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1300

INPUT
Description: XS 7, sta 1300 top of weir
Station Elevation Data    num=      24
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
999.9999 4957.93  1034.6  4957.5  1042.5 4959.63  1069.5 4962.54  1090.6 4960.23
    1098 4958.39  1098.9 4953.52  1110.6  4953.5  1139.7 4952.82  1166.3 4952.43
  1192.7 4952.49  1223.9 4952.89  1256.6 4953.01  1281.1 4952.95  1313.9 4952.77
  1339.4 4952.94  1367.4 4952.79  1390.6 4952.87  1418.7  4952.9    14654963.534
  1465.2 4963.58  1479.4  4964.7  1502.2 4974.37  1525.9 4974.27

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
999.9999    .055    1098    .055    1465    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1098    1465                5       5       5              .1      .3

INLINE STRUCTURE


RIVER: Gunnison R.
REACH: 1                 RS: 1299

INPUT
Description: XS 1199 - U/S side of weir
Distance from Upstream XS =       0
Deck/Roadway Width        =       5
Weir Coefficient          =    2.64
 Weir Embankment Coordinates    num =       23
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
999.9999 4957.93  1034.6  4957.5  1042.5 4959.63  1069.5 4962.54  1090.6 4960.23
    1098 4958.39  1098.9 4953.52  1110.6  4953.5  1139.7 4952.82  1166.3 4952.43
  1192.7 4952.49  1223.9 4952.89  1256.6 4953.01  1281.1 4952.95  1313.9 4952.77
  1339.4 4952.94  1367.4 4952.79  1390.6 4952.87  1418.7  4952.9  1465.2 4963.58
  1479.4  4964.7  1502.2 4974.37  1525.9 4974.27

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
Downstream Embankment side slope           =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins        =
Weir crest shape                           = Broad Crested


CROSS SECTION
```

```
RIVER: Gunnison R.
REACH: 1                 RS: 1200

INPUT
Description: XS 8, sta 1200 - at toe of weir
No wsel taken at this cross
             section
Station Elevation Data    num=      24
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4957.93  1034.6  4957.5  1042.4 4959.63  1069.5 4962.54  1090.6 4960.23
    1098 4958.39    1099 4950.64  1109.9 4949.56    1140 4947.14  1167.1 4946.17
  1194.1 4946.55  1223.9 4946.08  1256.6 4945.76  1281.5  4945.6  1312.2 4947.46
  1339.3 4948.05  1367.9 4948.29  1390.8 4948.13  1416.7 4949.07    14654963.344
  1465.8 4963.58    1480  4964.7  1502.8 4974.37  1526.5 4974.27

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .055    1098    .055    1465    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1098    1465               80      80      80               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 1100

INPUT
Description: XS 9, sta 1100 - pts 757-733
Station Elevation Data    num=      27
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4957.17  1043.7 4956.84    10904956.663  1090.6 4956.66  1115.4 4955.28
  1129.7 4950.23  1143.4 4948.55  1160.2 4947.13  1176.6 4946.81  1195.4 4948.26
  1230.4 4947.99  1262.2 4949.08    1272 4948.51    1303 4950.57  1320.4 4950.86
  1346.3 4949.63  1374.4 4949.17  1395.8 4948.79  1422.4  4949.5    1440 4949.29
  1454.3 4947.88  1460.9 4947.62  1466.9 4950.87  1473.4  4953.8    1475 4955.72
  1477.4  4958.6  1498.5 4958.69

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1090    .039    1475    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1090    1475              155     145     190               .1       .3

CROSS SECTION
```

```
RIVER: Gunnison R.
REACH: 1                  RS: 1030

INPUT
Description: new 1030 - pulled off topo
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000    4956    1058    4954    1097    4952    1101    4950    1109    4949
    1120    4949    1128    4950    1164    4950    1184    4948    1198    4950
    1235    4950    1255    4949    1304    4949    1324    4950    1341    4952
    1425    4954    1512    4958

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1097    .039    1341    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1097    1341              183     176     155              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 1000

INPUT
Description: XS 10, sta 1000
Station Elevation Data    num=      25
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4957.02  1050.9 4954.63  1088.3 4954.93  1143.9 4955.26    11454955.031
  1152.5 4953.47  1160.9 4948.43  1167.5 4946.67  1179.5 4945.87  1183.6 4945.67
  1204.4  4944.5  1229.5 4944.72  1235.4 4945.21    1243 4946.76  1255.8 4947.18
  1275.3 4947.91  1284.8 4948.47    13254950.051  1329.8 4950.24    1339 4948.56
  1347.2 4948.65  1350.5 4950.68  1387.9 4951.56  1420.8 4952.98  1458.7 4954.95

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1145    .039    1325    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1145    1325              547     645     677              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 900

INPUT
Description: XS 11, sta 900
Station Elevation Data    num=      21
```

```
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000 4956.16   1100.3 4955.35   1209.6 4955.59    12104955.419   1227.7 4947.89
  1239.7 4945.02   1267.4 4944.94   1297.1  4945.4   1335.3 4945.89     1362 4946.58
  1388.6 4946.99     1402 4947.08   1419.7 4947.97     1432 4951.56    14754954.041
  1476.2 4954.11     1524  4953.3   1563.5  4952.8   1583.1 4951.88   1597.4 4954.01
  1625.6 4954.66

Manning's n Values         num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    1000    .045     1210    .039     1475    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1210    1475              860     956     994               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 800

INPUT
Description: XS 12, sta 800
Station Elevation Data    num=      20
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000 4952.92   1099.3 4953.13   1208.8 4952.83    12104952.485   1231.6 4946.28
  1246.8 4944.39   1279.3 4944.12   1318.6 4944.51   1368.4 4945.21   1405.5 4946.22
  1414.4 4948.69   1435.1  4949.2     14454950.914   1449.6 4951.71   1511.6 4951.39
  1525.2 4947.21   1526.9 4947.26   1538.8 4950.08   1588.6 4951.34   1665.7 4951.57

Manning's n Values         num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    1000    .045     1210    .039     1445    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1210    1445              698     781     803               .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                 RS: 700

INPUT
Description: XS 13, sta 700
Station Elevation Data    num=      20
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    1000 4949.63   1074.5 4949.24   1132.9 4949.22    11354948.208   1142.2 4944.74
  1150.8 4941.68   1165.1 4941.11   1211.8 4941.45   1234.4 4942.32   1255.4 4943.33
  1276.3 4944.81   1344.9 4945.12     13654949.107   1369.7 4950.04   1383.7 4949.16
  1391.8 4946.67   1422.6 4945.35     1433 4949.23   1457.2 4953.64   1515.1 4953.12
```

```
Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1135    .039    1365    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1135    1365             1730    1600    1600             .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 600

INPUT
Description: XS 14, sta 600
Station Elevation Data    num=      21
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
999.9999 4947.89  1033.6 4947.12    10354946.981  1054.9    4945  1062.3 4940.47
  1071.3 4938.01  1087.2 4936.55  1109.1  4938.2  1133.2 4940.23    1150 4940.02
    1163 4938.83  1182.2 4939.57  1222.4  4940.3  1271.6 4940.19    1303 4939.64
  1315.1 4940.24  1322.7  4941.9  1334.8 4946.43    13504948.055  1350.8 4948.14
  1416.9 4947.27

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
999.9999    .045    1035    .039    1350    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1035    1350             1990    1990    1990             .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                   RS: 500

INPUT
Description: XS 15, sta 500
Station Elevation Data    num=      20
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4942.72  1022.5  4942.2  1031.2 4939.98  1041.6 4941.22  1093.8 4939.99
    10954939.604  1101.9 4937.38  1118.4 4938.04  1132.8 4936.75    1145  4935.4
  1190.3 4935.24  1210.5 4934.51  1234.4 4933.33  1260.1 4931.84    1278 4934.04
  1286.5 4936.77    12954940.298  1295.1 4940.34  1381.5  4941.7  1433.7 4941.03

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1095    .039    1295    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1095    1295             1075    1104    1098             .1       .3
```

```
CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 400

INPUT
Description: XS 16, sta 400
Station Elevation Data    num=      21
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4941.85  1034.3 4941.38  1082.3 4941.63    10854940.719  1099.5 4935.83
  1125.9 4935.26  1148.6 4933.49  1181.4 4932.99  1205.3 4932.46  1227.2 4933.18
  1250.9 4933.05  1271.8 4933.62  1310.4 4935.29    13754939.383    1377 4939.51
  1425.8 4938.23  1436.9 4935.61  1457.3 4935.52  1470.6 4939.07  1550.7 4940.01
    1618 4939.26

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1085    .039    1375    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1085    1375             2320    2320    2320              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 300

INPUT
Description: XS 17, sta 300
Station Elevation Data    num=      25
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4940.04  1033.3  4939.1    10354937.884  1045.8 4930.16  1055.3 4929.24
  1090.3 4928.51  1117.2 4928.89  1150.5 4929.37  1173.9 4927.15  1183.2 4927.06
  1195.2 4929.08  1207.7 4926.58  1231.8 4926.28  1235.8 4926.52  1244.5 4929.99
  1251.6  4934.5    12754935.197  1278.8 4935.31  1287.5 4933.26  1333.2  4930.5
    1365 4932.83  1424.1  4936.9    1492 4938.89  1580.4 4938.45  1581.3 4938.51

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1035    .039    1275    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1035    1275             2000    2000    2000              .1       .3

CROSS SECTION


RIVER: Gunnison R.
```

```
REACH: 1                  RS: 200

INPUT
Description: XS 18, sta 200
Station Elevation Data    num=      19
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4935.66    1037 4934.04    10404932.355  1052.1 4925.56  1075.2 4924.05
  1086.1 4925.09  1105.9 4925.61  1125.7 4927.05  1131.1 4925.46  1138.9 4924.06
  1145.4 4923.41  1162.2 4923.58  1187.7 4923.26  1235.7 4924.07  1253.1 4926.14
    12954928.998  1296.2 4929.08    1352 4931.47  1431.3 4936.48

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1040    .039    1295    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1040    1295              200      200     200              .1       .3

CROSS SECTION


RIVER: Gunnison R.
REACH: 1                  RS: 100

INPUT
Description: XS 19, sta 100 - most downstream
Station Elevation Data    num=      22
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1000 4937.86    1033 4933.22  1059.1 4930.56  1062.2 4927.11  1072.4 4925.16
    10754924.258  1082.2 4921.76  1095.7 4920.94  1104.4 4920.22    1127 4918.85
  1153.3 4920.23  1162.6 4921.68  1175.8 4922.62  1184.5 4925.02    11904925.821
  1190.2 4925.85  1241.3 4926.22  1252.1 4929.28  1309.1 4930.97  1324.5 4929.16
    1341    4930  1400.2 4937.59

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1000    .045    1075    .039    1190    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          1075    1190                0        0       0              .1       .3


SUMMARY OF MANNING'S N VALUES

River:Gunnison R.

      Reach          River Sta.       n1        n2        n3

 1                    1900              .045      .039      .045
 1                    1800              .045      .039      .045
```

1	1700	.045	.039	.045
1	1600	.045	.039	.045
1	1500	.045	.039	.045
1	1400	.045	.039	.045
1	1300	.055	.055	.055
1	1299	Inl Struct		
1	1200	.055	.055	.055
1	1100	.045	.039	.045
1	1030	.045	.039	.045
1	1000	.045	.039	.045
1	900	.045	.039	.045
1	800	.045	.039	.045
1	700	.045	.039	.045
1	600	.045	.039	.045
1	500	.045	.039	.045
1	400	.045	.039	.045
1	300	.045	.039	.045
1	200	.045	.039	.045
1	100	.045	.039	.045

SUMMARY OF REACH LENGTHS

River: Gunnison R.

Reach	River Sta.	Left	Channel	Right
1	1900	861	848	1120
1	1800	1350	1300	1300
1	1700	455	455	455
1	1600	85	85	85
1	1500	45	45	45
1	1400	25	25	25
1	1300	5	5	5
1	1299	Inl Struct		
1	1200	80	80	80
1	1100	155	145	190
1	1030	183	176	155
1	1000	547	645	677
1	900	860	956	994
1	800	698	781	803
1	700	1730	1600	1600
1	600	1990	1990	1990
1	500	1075	1104	1098
1	400	2320	2320	2320
1	300	2000	2000	2000
1	200	200	200	200
1	100	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Gunnison R.

Reach	River Sta.	Contr.	Expan.
1	1900	.1	.3
1	1800	.1	.3
1	1700	.1	.3
1	1600	.1	.3
1	1500	.1	.3
1	1400	.1	.3
1	1300	.1	.3
1	1299	Inl Struct	
1	1200	.1	.3
1	1100	.1	.3
1	1030	.1	.3
1	1000	.1	.3
1	900	.1	.3
1	800	.1	.3
1	700	.1	.3
1	600	.1	.3
1	500	.1	.3
1	400	.1	.3
1	300	.1	.3
1	200	.1	.3
1	100	.1	.3

APPENDIX D

OPINION OF PROBABLE COSTS

Opinion of Probable Costs

ITEM DESCRIPTION	UNIT	UNIT PRICE	TWELVE CELLS (1/2 FT DROPS) QUANTITY	SUBTOTAL
Mobilization/demobilization	LS	$26,000	1	$26,000
Site preparation	LS	$14,000	1	$14,000
Water Control/Dewatering	LS	$32,000	1	$32,000
Headwall				
Remove existing dam	LS	$16,000	1	$16,000
Concrete headwall	CY	$1,000	200	$200,000
Riprap wall protection, d_{50}=24 in	CY	$45	4000	$180,000
Earthwork				
Excavation	CY	$10	10500	$105,000
Use excess-grade on site	CY	$5	2600	$13,000
Boat/Fish Passageway				
Subgrade grading and bed compaction	EA	$4,000	14	$56,000
Boulders - guide rocks, 6 ft diam	CY	$60	40	$2,400
Boulder Weirs, d_{50}=36 in	CY	$50	3700	$185,000
Engineered stream bed	CY	$40	4100	$164,000
Riprap bank protection, d_{50}=24 in	CY	$45	1200	$54,000
Native Seeding	AC	$5,000	6	$30,000
Ditch crossing-temporay access road	LS	$5,000	1	$5,000
SUBTOTAL				**$1,082,400**
DESIGN/ SURVEYING/ INSPECTION (8%)				**$87,500**
CONTINGENCY (20%)				**$218,800**
TOTAL ESTIMATED COST				**$1,388,700**

see backup tabs for assumptions

Description	labor			equipment*			misc material		totals	use
	crew size	hours	rate	number	hours	rate	cost	quantity		
Mob/demob										
mob and demob	2	40	$ 50	$ 2	$ 20	$ 150	2500	1	$ 12,500	
include bonds, trailers, port-a-potty, licenses	1	80	50				9000	1	$ 13,000	
									$ 25,500	$ 26,000
	labor			equipment*			misc material			
	crew size	hours	rate	number	hours	rate	cost	quantity		
Temporary controls and staging										
include temporary road work, set up staging,	4	24	$ 50	2	24	150	1000	1	$ 13,000	
reinforce ditch crossing	2	16	$ 50	1	4	150	2500	1	$ 4,700	
									$ 17,700	$ 14,000
	labor			equipment*			misc material			
	crew size	hours	rate	number	hours	rate	cost	quantity		
Water Control and dewatering										
coffer dam-install	2	12	25	1	12	150	50	300	$ 17,400	
coffer dam-maintain	2	60	25	1	10	150			$ 4,500	
pumps for footings	1	24	25	1	150	50	1	1500	$ 9,600	
									$ 31,500	$ 32,000

* equipment may inlcude a dump truck, excavator or backhoe

Description		labor			equipment*		misc material		totals	use
	crew size	labor hours	rate	number	equipment* hours	rate	misc material cost	quantity		
Dam removal										
assume some welder cuts, remove cribbing to crossing	1	20	100	1	12	250	1	3000	$ 8,000	
remove some steel to sell or haul-off	1	20	100	1	12	250	1	3000	$ 8,000	
empty cribs, stockpile material onsite									$ 16,000	$16,000
do in two phases										
	footing cy/ft	**wall cy**	**area cy**	**length ft**	**volume cy**					
Concrete headwall										
assume length and volume are the same for all scenarios										
assume 5 ft wide footer, 10 feet tall, 1 ft thick										
costs include rebar, forms, finish	0.185185	0.3704	0.555556	350	194.4444					200 cy
	height ft	bottom ft	length ft	volume CY						
Headwall protection										
assume 24 inch d50 riprap set at 3 to 1 to top of wall	10	30	360	4000						4000 cy
assume bottom of riprap at footing										
assume riprap on both sides of wall										

* equipment may inlcude a dump truck, excavator or backhoe

Description Earthwork was calculated to finish grade for the 1/2 ft drops

updated:

		to final grade	to subgrade				
CADD	cut	4759	3700	for 1/2 riprap plus esb	8459	inc by 20%	10150.8
	fill	4629		use fill for embankment (not shown)			5521.8

assume riprap installation requires cut and will generate fill material
assume esb requires 1/2 of its volume to be cut
assume 1/2 the cut is generated by esb

riprap		3700		
engineered streambed		4100		
				total, cy
cut	4759	3700	2050	10509
fill	4629	2050		2579

Description	labor			equipment*			
	crew siz	hours	rate	number	hours	rate	
Subgrade prep							
assume for each chute and pool							
subgrade	2	8	50	1	8	150	$ 2,000
compaction	2	4	50	1	4	150	$ 1,000
final grade	2	4	50	1	4	150	$ 1,000
							$ 4,000

weir rocks assume d50 of 36 inches buried 6 ft and two rows of boulders per chute @1/2 to 1
add 12 in for bedding

drops	low fl ch	total width	overbank width
1	90	160	70
2	90	160	70
3	90	160	70
4	90	160	70
5	90	160	70
6	90	160	70
7	90	160	70
8	90	175	85
9	90	205	115
10	90	235	145
11	90	255	165
12	90	250	160
13	90	250	160
14	90	225	135
totals, ft	1260	2715	1455

low flow	6	6.7	7	1260	2189	
overbanks	4	4.5	5	1455	1213	
					3401	say 3700

engineered stream be assume ESB is 3.5 ft thick comprised of 24 inch and smaller river cobble

volume=	0.13 cy/sf	length	1260	ft
		area	31500	sf

area	31500	sf
volume	4095	cy
	say 4100 cy	

Description	riprap delivered 20 cy truck 600/truck banks	weirs	guide rk	ESB*
delivered cost, cy	D_{50} 24	D_{50} 36	D_{50} 72	river cobble
loaded volume, cy	16	14	12	17
delivered cost, cy	$ 37.50	$ 42.86	$ 50.00	$ 35.29
installation				
rate of installation, cy/hr	40	40	30	60
costs per hour (2 laborers, 1bh)	300	300	300	300
installation costs, cy	$ 7.50	$ 7.50	$ 10.00	5
total riprap unit cost, cy	$ 45.00	$ 50.36	$ 60.00	$ 40.29

Guide rocks, 6 ft diam, 4 cy each, 6 rocks total
ESB assume is a well graded river cobble with a D50 of 24 inches