DRAFT
CONDITIONAL LETTER OF MAP REVISION (CLOMR) FOR HAPPY CANYON CREEK AT BELFORD AVENUE TOWN OF PARKER, COLORADO

A Part of the NE ¼ of Section 7, SE ¼ of Section 6 and SW ¼ of Section 5 of Township 5 South and Range 66 West of the 6th P.M., Douglas County, Colorado

Prepared for:

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FHU Project No. 115360-01

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I. GENERAL LOCATION AND DESCRIPTION

A. Location

Compark South plans to develop the land surrounded by E-470 on the north, Grandview Estates on the south, Chambers Road on the east, and Peoria Street on the west. Compark South is planning on a single family residential subdivision with a regional trail. Belford Avenue is a proposed local roadway connection that will cross over Happy Canyon Creek. The project limits for Belford Avenue are from Chambers Road on the east to Peoria Street on the west. The project limits for the proposed channel work are from approximately 1500 feet upstream of Belford Avenue to approximately 500 feet downstream including a new bridge structure. The bridge, channel and associated trail improvements are located within the Town of Parker boundary, with part of the roadway located in unincorporated Douglas County. The total length of the new roadway is approximately 1.90 miles (10,000 feet).

The surrounding area consists of the following:

- Arapahoe County Water and Wastewater Authority (ACWWA) facility to the southeast.
- Grandview Estates on the south, single family residential subdivision.
- Happy Canyon and Cherokee/470 regional trails.
- Undeveloped land on both sides of Happy Canyon Creek owned by Compark.

The Happy Canyon Creek project is in the northeast ¼ of Section 7, southeast ¼ of Section 6, and southwest ¼ of Section 5 of Township 5 South, Range 66 West of the 6th P.M. in Douglas County, Colorado (see **Figure 1**).

B. Description of Property

The project will include the following proposed roadway improvements that will improve traffic conveyance and increase safety in the area:

- Belford Avenue connection from Chambers Road on the east to Peoria Street on the west.
- Future development of residential and commercial properties.
- Improvements at Happy Canyon Creek include a new bridge crossing, new trail crossing, a trail connection under Belford Avenue, drop structures, and associated channel improvements.

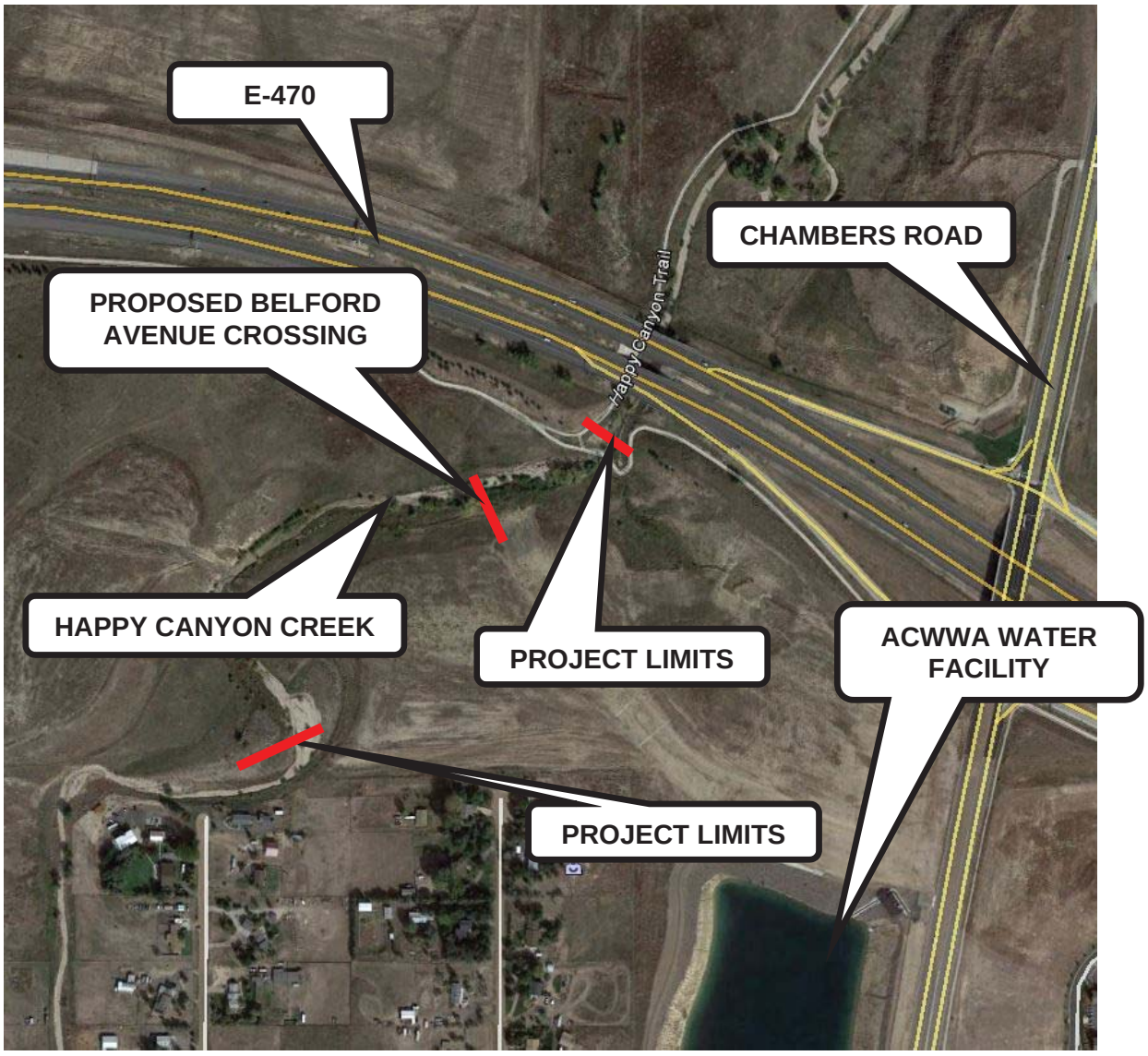

Figure 1. Vicinity Map

The National Resource Conservation Service has mapped the area as having the soil types shown on **Figure 2** and listed in **Table 1** (**Reference 3**). Ground cover currently consists of weeds, native grasses, and non-vegetated ground.

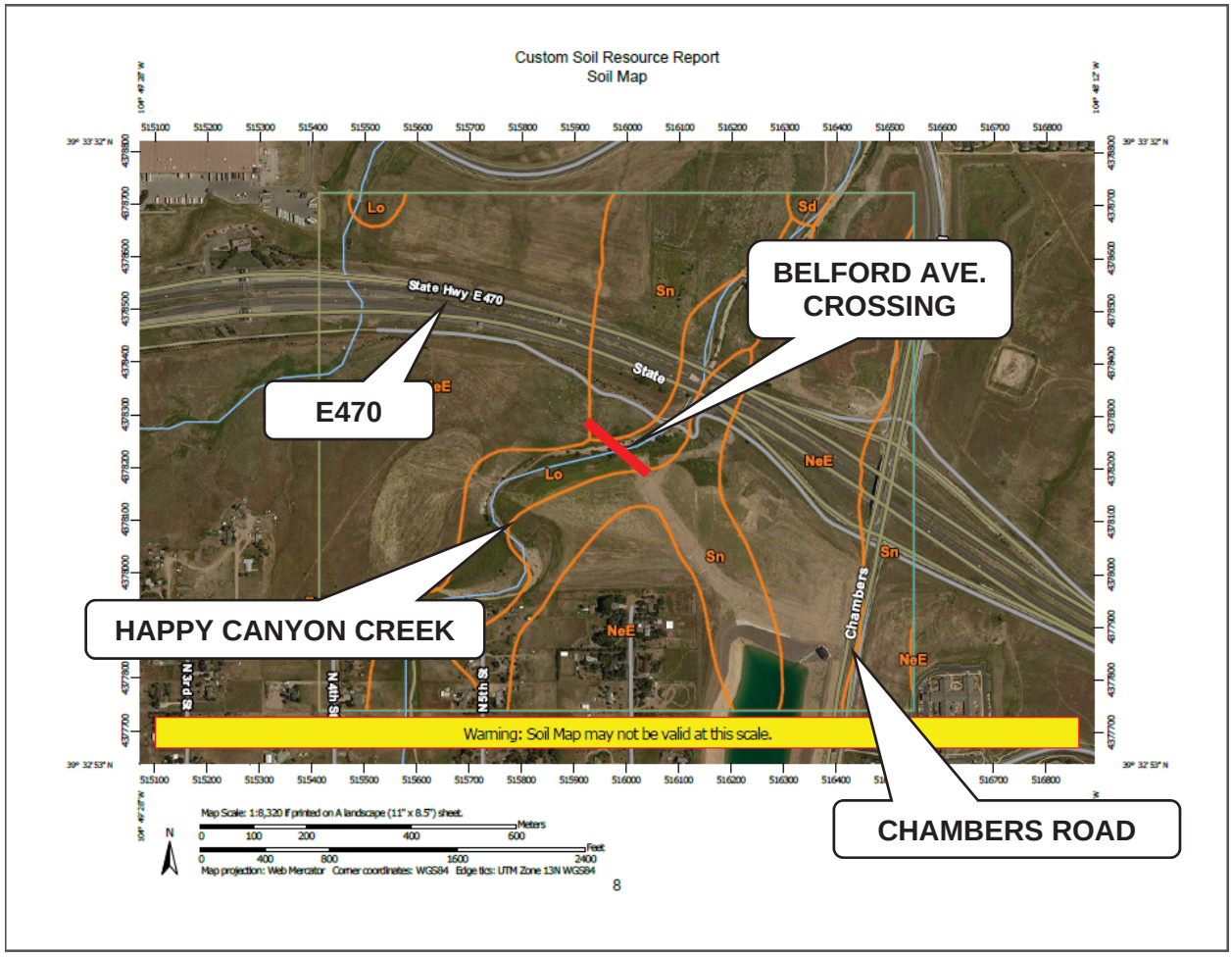

Figure 2. National Resource Conservation Service Map

Table 1. Area Soil Types

Soil Name	Map Symbol	HSG	Runoff Potential	Soil and Water Erosion Hazard
Fondis clay loam, 1 to 3 percent slopes	FoB	C	Medium	Moderately low to moderately high
Loamy alluvial land	*Lo*	*C*	*Very Low*	*Moderately high to high*
Newlin gravelly sandy loam, 8 to 30 percent slopes	NeE	B	Medium	Moderately high to high
Sandy alluvial land	Sd	A	Negligible	High to very high
Satanta loam	*Sn*	*B*	*Low*	*Moderately high to high*

Notes:

HSG = Hydraulic Soils Group as defined by the National Resource Conservation Service

Soils identified in the immediate project area are *italicized*

Soils in the immediate area include Loamy alluvial land and Satanta loam. The surrounding areas slope primarily from the southeast to the northwest with varying grades.

II. DRAINAGE BASINS

A. Major Basin Description

Happy Canyon Creek Major Basin

The Happy Canyon Creek watershed has a drainage area of 17.5 square miles from its headwaters in the City of Castle Pines to its confluence with Cherry Creek. Happy Canyon Creek flows primarily from southwest to the northeast throughout parts of Douglas County, Arapahoe County, Town of Parker, and the City of Lone Tree. Happy Canyon Creek is approximately 12.8 miles in total length.

Muller Engineering completed a Flood Hazard Area Delineation (FHAD) (July 2014) for the Urban Drainage and Flood Control District (UDFCD) and the Southeast Metro Stormwater Authority (SEMSWA) (**Reference 5**). The FHAD determined potential flood hazards along Happy Canyon Creek from its headwaters down to its confluence. The floodplain delineation was completed for the 100-year and 500-year floodplain (**Figure 3** and **Figure 4**) as well as 0.5-foot and 1.0-foot floodway encroachments. A Major Drainageway Plan (MDP) was also completed in March 2014 by Muller Engineering (**Reference 6**) addressing the same flood hazards as the FHAD.

There are currently two effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) for Happy Canyon Creek near the project vicinity (both revised March 16, 2016). Map number 08035C0062G defines the upstream drainage and map number 08035C0066G defines the downstream drainage (see **Figure 5**, **Figure 6,** and **Reference 1**). The effective FIRMs define a floodplain, floodway, and base flood elevations for Happy Canyon Creek. The effective Flood Insurance Study (FIS), revised March 16, 2016, for the site (**Reference 8**) includes a flow rate approximately 5,000 feet upstream of this project. Both the FIRM and the FIS were based on a FHAD that was released in November 1977 by Howard, Needles, Tammen, & Bergendoff (**Reference 4**).

A preliminary FIS (**Reference 9**) that includes Happy Canyon Creek and a preliminary revised FIRM (**Figure 6** and **Reference 2**) were both completed on June 30, 2016. At the time this document was prepared, both preliminary documents have been submitted but not yet accepted by FEMA. It was determined that the preliminary documents would be used for this project in anticipation of acceptance for the floodplain and floodway delineation of Happy Canyon Creek.

Table 2. Happy Canyon Creek Peak Flows near Project Area

Drainageway	Reference	10-Year	50-Year	100-Year	500-Year
Happy Canyon Creek	FEMA (Effective FIS) *	2,350	4,450	5,610	8,660
	FEMA (Preliminary FIS) **	2,656	6,249	8,355	12,107

Notes:

* Approx. 5,000 ft. upstream of project site.

** Flow rates used for design from Preliminary FIS. Flows at Stonegate Tributary Confluence.

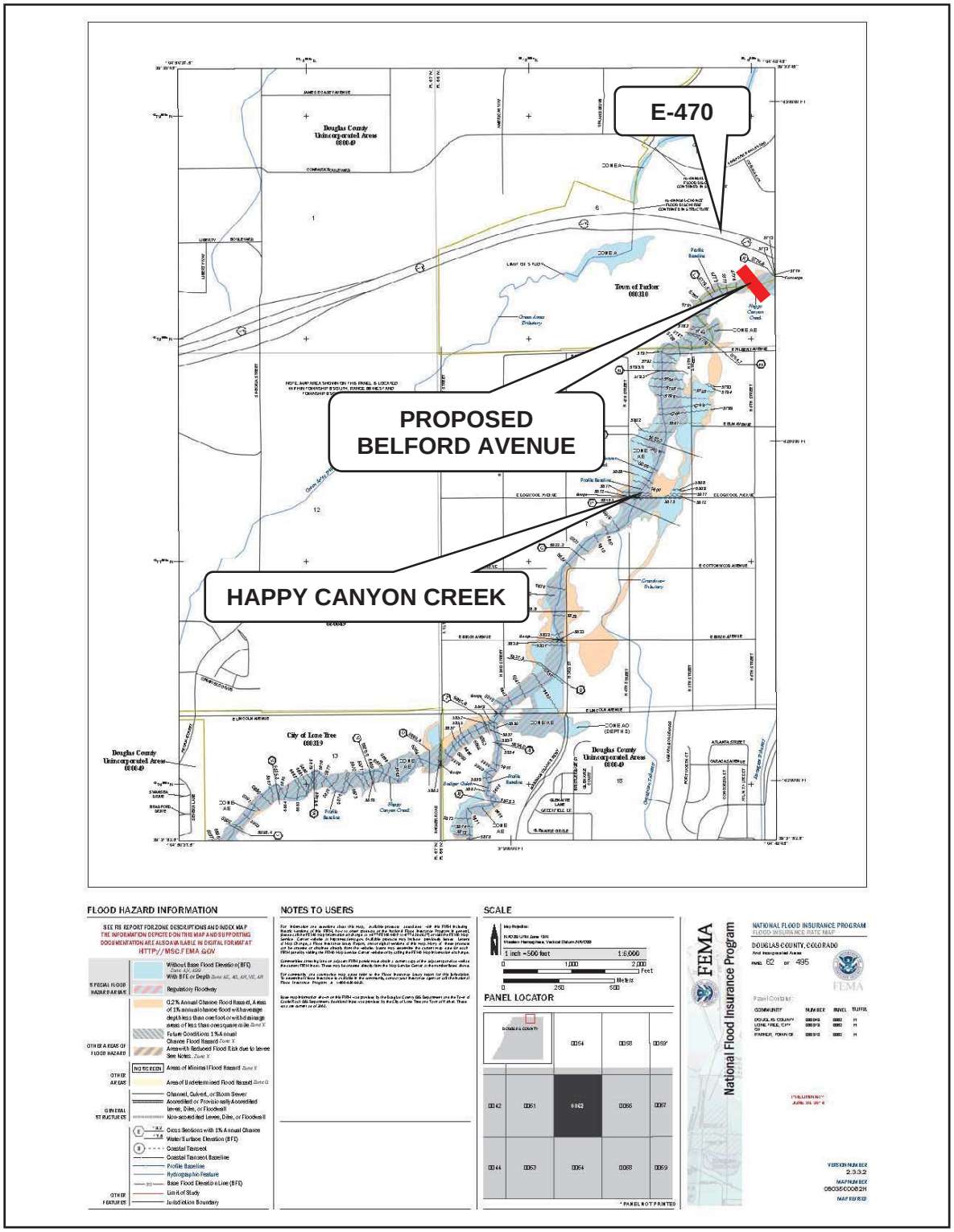

Figure 3. Preliminary Flood Insurance Rate Map 08035C0062H

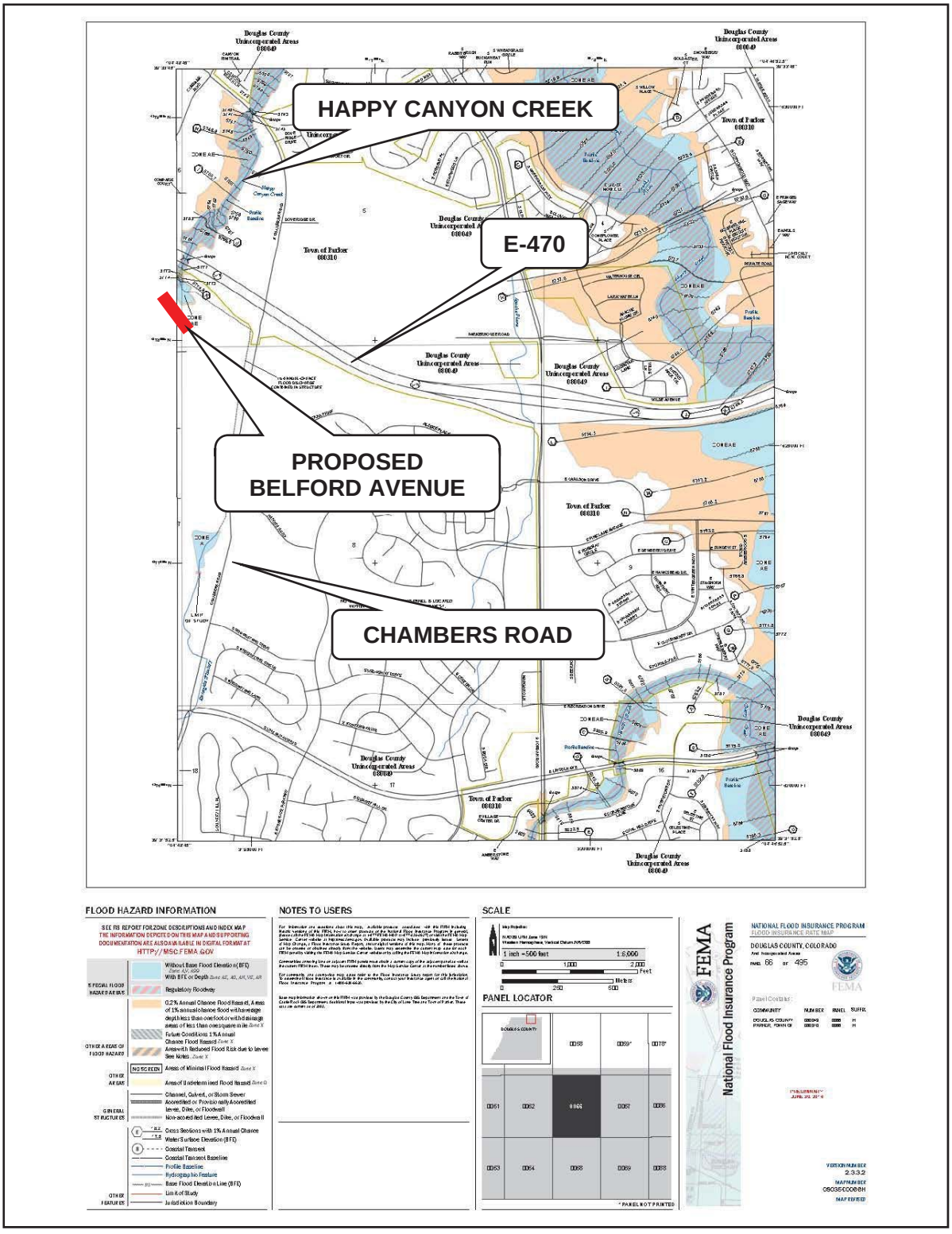

Figure 4. Preliminary Flood Insurance Rate Map 08035C0066H

Note:
Refer to **Appendix B** for full size preliminary FIRM Panels 08035C0062H and 08035C0066H.

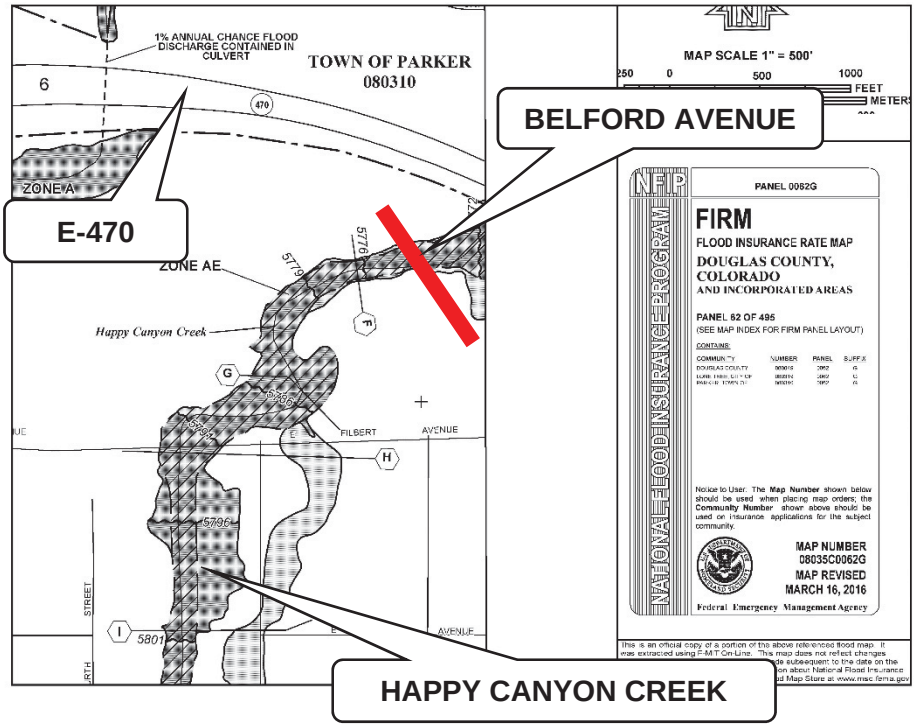

Figure 5. Effective Flood Insurance Rate Map 08035C0062G

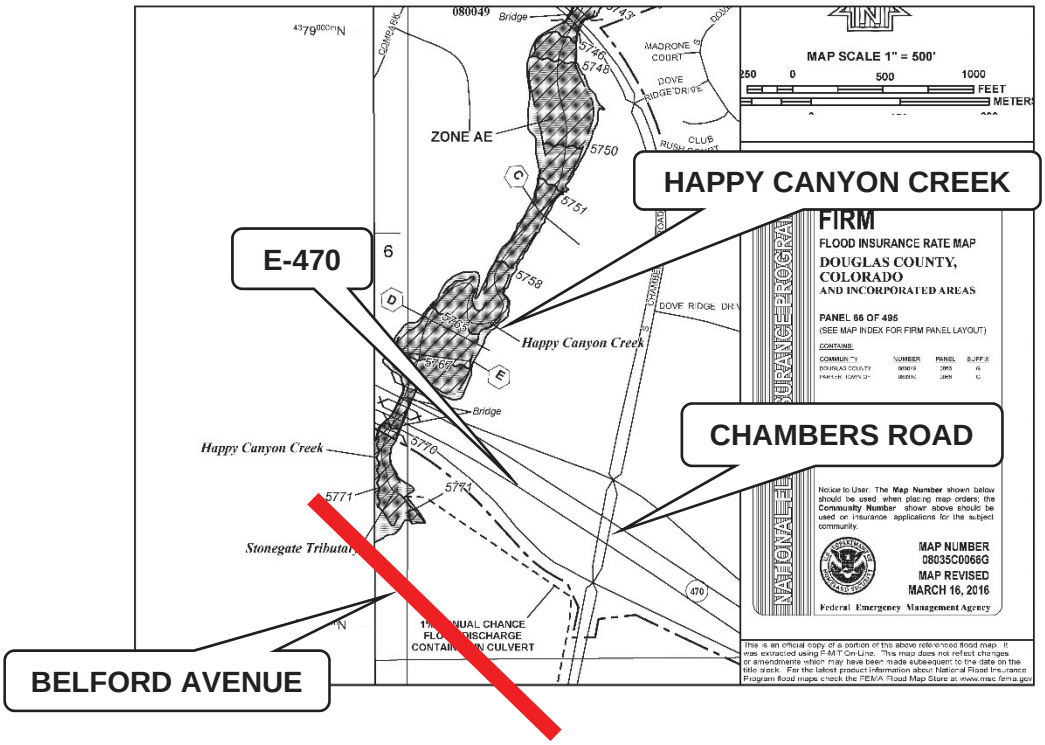

Figure 6. Effective Flood Insurance Rate Map 08035C0066G

III. DRAINAGE FACILITIES DESIGN

A. General Concept

Compark plans to develop the area south of E-470 and will add a connection between Chambers Road and Peoria Street via Belford Avenue. Belford Avenue will cross over Happy Canyon Creek via a new bridge structure. The Belford Avenue crossing over Happy Canyon Creek will be approximately 560 feet south of E-470 and 2,000 feet west of Chambers Road. As part of the development, the Cherokee/E-470 Trail (parallel to E-470) will also be reconstructed with a new multi-cell reinforced concrete box culvert (RCBC) crossing. There will also be four drop structures installed as well as a realigned low-flow segment of Happy Canyon Creek through the proposed bridge section. Both the 2014 FHAD and MDP include recommendations for Happy Canyon Creek throughout the project limits. Those recommendations are listed below.

B. Specific Details

The Happy Canyon Creek channel will be modified upstream and downstream within the project limits of Belford Avenue. Below is a summary of the existing and proposed conditions related to the improvements associated with this project. Both the FHAD and MDP recommendations were accounted for during the design.

Happy Canyon Creek at Belford Avenue is located in Reach 8 as defined by the FHAD and the MDP. Per the FHAD, the reach has a dry, sandy bottom with some wetland vegetation. There are some cottonwood trees, native grasses, and shrubs. The stream is well defined upstream of E-470 with a couple of steep banks evident of head cutting. The existing channel slope through the project limits is approximately 0.8 percent. The 100-year flow velocities in the existing channel range from about 4 feet per second to 15 feet per second within the project limits. The Froude numbers in the existing channel range from about 0.18 (on the upstream side of the existing trail crossing) to 0.96. The existing channel alignment for Happy Canyon Creek was developed based on aerial survey performed and provided by Manhard Consulting.

There is currently aggradation in this reach with specific grade control structures suggested by the MDP. Erosion concerns will be addressed while keeping the channel in its most natural form.

Happy Canyon Creek is conveyed under the existing E-470 trail via two 24-inch corrugated metal pipe culverts that pass very minor base flows. Sediment deposition has been a major maintenance issue at the crossing. Per the MDP, a 20-foot by 3-foot CBC is suggested to assist with maintenance and convey more frequent runoff flows as the surrounding area develops. Downstream of the existing trail, there is riprap protection on both sides of the main low-flow channel banks.

Recommendations are made for the confluence of Happy Canyon Creek and Stonegate Tributary. Currently, Stonegate outlets via 42-inch concrete pipe culvert into Happy Canyon Creek on the east side. The swale in between the active Happy Canyon Creek channel and the pipe outlet is unstable and actively degrading. The MDP recommends filling in the ineffective floodplain fringe area near the outlet pipe to assist with conveyance of the 100-year and 500-year storm events more efficiently upstream of the existing E-470 bridges. The proposed fill area has been coordinated with the Town of Parker.

The channel improvements include four grouted sloping boulder (GSB) drop structures, a small section of realigned low-flow channel and existing channel toe protection along the active low-flow channel to preserve existing embankment beyond the toe as identified in the MDP and verified based on site conditions. Toe protection was provided based on recommendations provided in the MDP per the future 2-year flow and water surface elevation of approximately 3 feet. There will be three GSBs upstream of Belford Avenue and one directly upstream of the proposed trail multi-cell RCBC crossing.

All four crest elevations of the GSBs were based on the assumed future equilibrium channel slope of 0.3 percent as described in the MDP. All four GSB drop structures will have an 8-foot approach soil riprap section and steel sheet piles extending out to 1 foot above the 100-year water surface elevation. The main objective for the drop structure design, minor channel improvements and associated revetment is to provide grade control and stabilization per the MDP as well as minimize the disturbance to the existing channel and associated vegetation.

The two most upstream GSBs will primarily be contained to the existing active low-flow channel section and remain buried until the anticipated future equilibrium slope is achieved as the surrounding area develops and runoff rates increase. The low-flow channel realignment section associated with the GSB upstream of Belford Avenue is being proposed to direct the low-flow channel section away from the proposed piers for the new bridge structure. The low-flow channel will be 16 feet wide and connect into the existing low-flow channel section just north of the proposed bridge. This section of low-flow channel will be soil riprap lined to protect from degradation and have a 0.3 percent longitudinal slope. The proposed GSB upstream of the re-aligned E-470 trail will include a 1-foot drop section to transition the existing channel into the invert of the proposed RCBC crossing.

The proposed Belford Avenue bridge crossing will be a two span, singe pier crossing that spans 150 feet total, with each span measuring 75 feet. The proposed roadway and bridge crossing is aligned perpendicular to the channel. The bridge will be built in two phases, with the south half being built first, then the north half in the future as the area develops. The total length of the bridge is 93 feet. The proposed concrete piers are 48 inch drilled caissons extending into bedrock. There will be a pedestrian trail on the west side of the bridge crossing and a maintenance access path on the east side. The pedestrian trail and the maintenance access path are both 10 feet wide. The pedestrian trail has a vertical clearance at the west abutment of 10 feet and the maintenance access has a vertical clearance at the east abutment of 8 feet. The proposed elevation of both paths were designed to keep inundation minimized recognizing the FHAD and MDP future 2-year storm event. The pier, both abutments, and both path embankment areas where applicable will be protected by riprap revetment. The adjacent fill slopes from Belford Avenue near the bridge section are 4:1. The 100-year and 500-year storm events will be conveyed within the proposed bridge section and not overtop Belford Avenue.

The alignment of Belford Avenue is adjacent to ACWWA's emergency overflow section for the reservoir along the west side of Chambers Road. It is anticipated that Belford Avenue will provide a conveyance of the emergency overflow in the event the spillway is utilized. The proposed Belford Avenue vertical alignment continues west down grade towards Happy Canyon Creek with a proposed sump condition for the roadway west of the western abutment for the new bridge. Overtopping protection will be added to the abutments on both the north and south sides of the road to accommodate emergency overflows from the spillway.

The existing E-470 trail crossing culverts will be replaced by a new multi-cell 20-foot by 3-foot RCBC. To achieve clearance for the RCBC, the existing trail will be replaced with a new trail.

The new trail will be straight-lined across the channel and will be raised slightly higher than the existing trail elevation at Happy Canyon Creek. The new trail will have overtopping protection on both the upstream and downstream sides.

The improvements will stabilize this reach of Happy Canyon Creek. The proposed drop structures and channel revetment will help stabilize the channel and are in general design conformance per the suggested improvements outlined in the MDP.

IV. HYDRAULIC ANALYSIS

A. HEC-RAS

Effective Model

The effective model was derived from the hydraulic model produced for the April 24, 2003 Letter of Map Revision (LOMR), provided by UDFCD. The LOMR was based on the 1977 FHAD WSPRO data. It included the 1977 FHAD sections 53, 52, 51, 50, 61, 49, and 48. Section 48 corresponds to the effective FIS section F, with LOMR section 9700 corresponding to the effective FIS section E. Section E was used as the downstream tie-in section. To tie into effective FIS section G, section 47A from the 1977 FHAD was utilized. With no cross section data for 47A in the 1977 FHAD (WSPRO) tables, 47A was included using 2 foot contours on the plan view in the 1977 FHAD. Reach lengths were calculated and Manning's n's were used accordingly based on field observations. Section G from the FIS is the upper tie-in section just north of Grandview Estates within the Compark right-of-way.

The Effective Model water surface elevations are on the North American Vertical Datum, 1988 (NAVD 88) datum. The Belford Avenue connection project is also on the NAVD 88 datum and survey was provided by Manhard Consultants. The Effective Model is included in **Appendix B** for information. (Note: The 500-year floodplain has been included with this study and analysis.) The Effective, Duplicate Effective, Corrected Effective, Pre-project, and Post-project conditions were modeled using HEC-RAS (4.1.0).

Duplicate Effective Model

The Duplicate Effective Model consisted of input of the Effective Model data. The Duplicate Effective Model is included in **Appendix C** for information.

Corrected Effective Model

The Corrected Effective Model does not reflect any man-made physical changes since the date of the Effective Model. In anticipation of the 2014 FHAD becoming effective within the next year, the FHAD hydraulic model was obtained from UDFCD and used as the base of the corrected effective model. Elevations were taken from 2-foot interval topography obtained from the Denver Democratic National Convention (DNC) LIDAR survey by Sanborn Geospatial. Manning's n's were based off aerials and photos. Cross sections outside of the project limits were taken out of the model, with a new boundary condition set to the most downstream section.

In addition to the existing sections, 13 new sections were added and one existing section was deleted. The existing section was deleted so that the existing E-470 trail crossing could be accurately modeled. The FHAD had previously modeled the trail as completely blocked, so the channel bottom elevation was set at the trail crossing elevation. The inclusion of the existing trail was done to provide a comparison between the pre- and post-project trail crossing water surface elevations. The sections were added to provide a comparison between pre- and post-project conditions around the proposed Belford Avenue crossing and the proposed channel improvements.

Topography was then updated with the most up-to-date survey for the project. Elevations were based off of 1-foot interval contours taken from a flown survey. All of the sections within the project limits, with the exception of a portion of the two most upstream sections, 12694 and 13012, were within the flown survey limits. All Manning's n's were kept consistent with the values in the effective model.

Within the project limits, the reach lengths differ slightly between the effective model and the corrected effective model. The reach length for the effective model was based off of the effective FIS and was 2988.26 feet through the project limits. The corrected effective model reach was based off of flown survey and was found to be 2964.51 feet through the project limits. The corrected effective reach was 23.75 feet longer than the effective model, due to updated project survey and natural occurring low-flow channel geometry changes. The corrected effective model is included in **Appendix D** for information.

Pre-project Conditions Model

The Pre-project Conditions Model is a revision of the Corrected Effective Model that has been modified to reflect changes that have occurred within the floodplain since the date of the Effective Model but prior to construction of the project for which the revision is being requested. Because no changes have occurred since the date of the Corrected Effective Model, the Corrected Effective Model is also the Pre-project Conditions Model.

Post-project Conditions Model

The Post-Project Conditions Model consists of the Pre-project Conditions Model with the proposed Belford Avenue crossing, the realigned low-flow section of Happy Canyon Creek, the new bridge crossing, and the proposed trail connection and RCBC. Seven sections were added to this model and two existing sections were removed. These new sections were added to the locations of the proposed drop structure, although no change in the topography will occur. There is a difference in reach length of approximately 18 feet between the corrected effective model and the post-project conditions model that can be attributed to the realigned section of Happy Canyon Creek near the upstream face of the Belford Avenue crossing. The post-project conditions model is included in **Appendix E** for information.

The results of the hydraulic analysis are presented in a preliminary floodplain comparison table for the various models and have been included in **Appendix F** for information.

V. SUMMARY

If the proposed improvements are built per plan, the floodplain and floodway as shown on the hydraulic analysis and drawings will not cause overtopping of Belford Avenue, show no rise when compared to the existing conditions (pre-project) water surface elevations for the 100-year floodplain/floodway, do not impact any habitable structures and the flooding limits of the 100-year floodplain/floodway will be contained entirely within Compark right-of-way. The results of the improvements to the crossing by providing a new crossing, channelization, and drop structures will benefit the traveling public and adjacent property owners as well as reduce future maintenance efforts on Happy Canyon Creek at Belford Avenue and the E-470 Trail.

Sediment transport was not considered part of this floodplain modification study. The proposed drop structures, channel toe protection and revetment will aid against the potential for erosion within the project limits. Additional sediment transport and mitigation measures for Happy Canyon Creek are addressed in the MDP and included in the appendices for reference.

It is anticipated that a LOMR will be required once project construction is complete. The LOMR will be coordinated with the Town of Parker and will be submitted to FEMA for approval.

VI. REFERENCES

1) Federal Emergency Management Agency Flood Insurance Rate Map Community Panel Numbers 08035C0062G and 08035C0066G, Effective Date March 16, 2016.

2) Preliminary Federal Emergency Management Agency Flood Insurance Rate Map Community Panel Numbers 08035C0062H and 08035C0066H Preliminary June 30, 2016.

3) Custom Soil Resource Report for Castle Rock Area, Colorado, U.S. Department of Agriculture, Natural Resources Conservation Service, October 2016.

4) Flood Hazard Area Delineation, Happy Canyon Creek, November 1977, Howard, Needles, Tammen & Bergendoff.

5) Flood Hazard Area Delineation, Happy Canyon Creek, July 2014, Muller Engineering.

6) Major Drainageway Plan Conceptual Design Report, Happy Canyon Creek, March 2014, Muller Engineering.

7) Urban Storm Drainage Criteria Manual, Urban Drainage and Flood Control District, Volumes I, II, and III.

8) Federal Emergency Management Agency Flood Insurance Study, Douglas County, Colorado, 08035CV001B and 08035CV002B, March 16, 2016.

9) Preliminary Federal Emergency Management Agency Flood Insurance Study, Douglas County, Colorado, 08035CV001C, June 30, 2016.

APPENDIX A. FLOODPLAIN WORK MAP

LEGEND

- FIRM FLOODWAY LIMITS
- FHAD FLOODWAY LIMITS
- 100 YR FIRM FLOODPLAIN LIMITS
- 100 YR FHAD FLOODPLAIN LIMITS
- 100 YR PP FLOODPLAIN LIMITS
- 500 YR FHAD FLOODPLAIN LIMITS
- 500 YR PP FLOODPLAIN LIMITS
- 100 YR FHAD BFE
- FHAD CROSS-SECTION
- FHU ADDED CROSS-SECTION
- SURVEYED 1 FT CONTOURS
- WETLANDS

NOTE:

POST-PROJECT FLOODWAY = POST-PROJECT FLOODPLAIN

PROPERTY OF
E470 PUBLIC HIGHWAY AUTHORITY
22470 E 6TH PKWY SUITE 100
AURORA, CO 80018-2425

PROPERTY OF
COTTONWOOD WATER & SANITATION DISTRICT
2 INVERNESS DR E SUITE 200
CENTENNIAL, CO 80112-5509

E-470

HAPPY CANYON TRAIL

PROPERTY OF
PLATTE VALLEY COMMERCIAL GROUP
4900 MAIN STREET
KANSAS CITY, MO 64112-2630

CHEROKEE/470 TRAIL

PROPERTY OF
COMPARK BUSINESS CAMPUS METRO DISTRICT
FKA E-470 BUSINESS METRO DISTRICT
8480 E ORCHARD RD SUITE 6200
GREENWOOD VILLAGE, CO 80111

N

HORIZONTAL SCALE: 1"=100'
0' 50' 100' 200'

PROPOSED DROP STRUCTURE NO. 2

PROPOSED BELFORD OVER HAPPY CANYON CREEK CROSSING

HAPPY CANYON CREEK HCL

PROPERTY OF
470 COMPARK LLC
C/O MPV COMPARK MANAGEMENT LLC
DENVER, CO 80206

PROPOSED DROP STRUCTURE NO. 3

PROPOSED DROP STRUCTURE NO. 1

PROPOSED DROP STRUCTURE NO. 4

PROPERTY OF
COMPARK 190 LLC
4600 S ULSTER ST SUITE 1400
DENVER, CO 80237-2850

PROPOSED BELFORD AVE.

CHAMBERS ROAD

PROPERTY OF
470 COMPARK LLC
C/O MPV COMPARK MANAGEMENT LLC
DENVER, CO 80206

PROPERTY OF
COMPARK 190 LLC
4600 S ULSTER ST SUITE 1400
DENVER, CO 80237-2850

EXISTING TOPOGRAPHY SHOWN ON THE WORKMAP REPRESENTS SURVEYED 1 FOOT CONTOURS (NAVD 88). FLOODPLAIN LIMITS ARE SHOWN ON NAVD 88 DATUM.

I HEREBY CERTIFY TO THE BEST OF MY KNOWLEDGE, THAT THIS PROJECT, IF BUILT, WILL AFFECT THE HAPPY CANYON CREEK FLOODPLAIN AS SHOWN ON THIS PLAN.

KENDRA M. GABBERT, P.E. NO. 45344

J:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\, Chad.Twiss

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R-X

Sheet Revisions

Date	Comments	Initials

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Civil Engineers • Surveyors • Water Resource Engineers • Water & Wastewater Engineers
Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed
No Revisions:
Revised:
Void:

BELFORD-HAPPY CANYON CREEK FLOODPLAIN WORK MAP

Designer: CDT
Detailer: ZJG
Subset:
Structure Numbers:
Sheets: 1 of 1

Project No./Code

Sheet Number

APPENDIX B. EFFECTIVE MODEL, SUPPORTING INFORMATION FROM FHAD AND MDP

Happy Canyon Creek
Flood Hazard Area Delineation (FHAD)

July 2014

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

DOUGLAS COUNTY COLORADO

CITY OF LONE TREE

Town of Parker COLORADO

Southeast Metro Stormwater Authority

MULLER

1.5 Data Collection

Existing floodplain studies were compiled at the beginning of the project. The 1977 FHAD included floodplain mapping based on predicted future peak flow rates on Happy Canyon Creek from the confluence with Cherry Creek to I-25, and along Badger Gulch from the confluence with Happy Canyon Creek to a point north of present day RidgeGate Parkway. The current Flood Insurance Study (FIS) for Arapahoe County is dated December 17, 2010; the current Douglas County FIS is dated September 30, 2005. The most recent FIRM panels depicting the Happy Canyon Creek flood hazard area are identified by study reach in Table 1-2. The regulatory FIRM was initially based on the same mapping and cross sections as the FHAD, but reflected existing condition flow rates rather than future. Several Letter of Map Revision (LOMR) studies have altered the regulatory floodplain within the study reach. Map revisions were conducted in Grandview Estates in 2006 (06-08-B443P) and 2009 (09-08-0969P). A 2011 LOMR associated with the construction of the RidgeGate Parkway crossings studied 0.3-miles each of Badger Gulch and the Happy Canyon mainstem (11-08-0846P). The current mainstem regulatory floodplain limit extends approximately 2500 feet upstream of I-25 to the Oak Hills Tributary; no detailed studies above this location have been identified.

Wherever possible, hydraulic cross-sections have been oriented to match the existing LOMR and FHAD studies for the purpose of comparison. Comparison tables have been included in Appendix C.

Numerous additional reports, studies, and design plans were reviewed and utilized in the preparation of this report. A full listing is included in the References section at the end of this report.

Table 1-2
Happy Canyon Creek FIRM Panels

Panel I.D.	Community	Study Reach	Effective Date
08035C0160F	Douglas County	Reach 1 & 2	09/30/2005
08035C0044F	Douglas County	Reach 2	09/30/2005
08035C0063F	Douglas County	Reach 3 & 4	09/30/2005
08035C0064F	Douglas County	Reach 5	09/30/2005
08035C0062F	Douglas County	Reach 6, 7 & 8	09/30/2005
08035C0066F	Douglas County	Reach 8	09/30/2005
08035C0058F	Douglas County	Reach 8	09/30/2005
08005C0483K	Arapahoe County	Reach 9	12/17/2010

1.6 Acknowledgements

This report could not have been prepared without the participation and support of the following project sponsors and stakeholders. We are grateful for their contributions.

Table 1-3
Project Participants

Project Sponsors	Agency
Shea Thomas	Urban Drainage and Flood Control District
Bill DeGroot	Urban Drainage and Flood Control District
Terri Fead	Urban Drainage and Flood Control District
Brad Robenstein	Douglas County
Greg Weeks	City of Lone Tree
Tom Williams	Town of Parker
Jacob James	Town of Parker
Monica Bortolini	Southeast Metro Stormwater Authority
Stacey Thompson	Southeast Metro Stormwater Authority
Project Stakeholders	**Agency**
Chuck Haskins	Arapahoe County
Bryan Ruth	representing Rampart Range Metro District
Ken Linhardt	representing Rampart Range Metro District
Denise Denslow	representing Rampart Range Metro District
Brad Meyering	City of Castle Pines
Lisa Schwien	representing Castle Pines North Metro District
Bill Ruzzo	Cherry Creek Basin Water Quality Authority

Upper Watershed: West of I-25
The upper watershed includes approximately one third of the total area and is essentially fully developed. The City of Castle Pines is primarily small lot residential, with some medium lot residential and a small commercial area along Castle Pines Parkway near I-25. Small lot residential developments were grouped by density based on visual assessment, and an average % impervious was assigned to each group ranging from 40% to 60%. Undeveloped commercial parcels, golf courses, and other open space areas were assigned 2%, school sites were assigned 50%, and commercial areas were assigned 80%. Outside of Castle Pines, unincorporated Douglas County is dominated by large lot residential. Areas were separated into two groups based on lot size and average imperviousness values of 10% and 15% were calculated for the two groups. For future conditions, undeveloped areas were assumed to develop according to the surrounding areas.

The weighted impervious values for the upper watershed are 21.6 % for existing development and 22.5 % for future development.

Middle Watershed: I-25 to Lincoln Avenue
The middle watershed, which represents nearly half of the total watershed area, is largely undeveloped. This area will see significant growth, however, within the planned RidgeGate development in the City of Lone Tree's jurisdiction. RidgeGate is a 3500 acre planned development that extends from the eastern edge of Lone Tree west across I-25 to Yosemite Street. Land use within RidgeGate will run the gamut from an ultra-dense city center just east of I-25 to rural residential and dedicated open space. Within the Happy Canyon Creek watershed, future land use is based on the PDD document and is largely residential mixed use. Impervious values for the various mixed use/residential planning areas were calculated based on maximum allowable ratios of commercial and multi-family residential development indicated in the PDD, with 85% applied to commercial areas, 80% for multi-family residential, and 50% for single family residential in the remaining area. Other land uses and their associated % impervious values within RidgeGate include city center (95%), commercial mixed use (85%), institutional (50%), rural residential (15%), central community park (10%), and open space (2%). RidgeGate Parkway, which has been constructed at half of its ultimate design width, is reflected as 50% impervious in the existing condition and 100% in the future.

South of RidgeGate, unincorporated Douglas County is zoned for agricultural use. This area is slated for another planned development, Freshfields, under the same landowner/developer as RidgeGate; however, planning for Freshfields has not yet begun and development is not expected to begin until RidgeGate is built out. Because that timeline exceeds the expected life of this plan, no future development is reflected.

Several other planned developments are located within the middle watershed. Surrounded on three sides by RidgeGate, Meridian Commons is a mixed-use/residential filing of the Meridian International Business Center (Meridian). East of Lone Tree, Meridian Filing No. 7 is under active development. Sierra Ridge is located along the west side of Chambers Road and is currently undeveloped. Future land use for each of these planned developments is based on master drainage plans.

Overall weighted impervious values for the middle watershed are 9.8 % for existing development and 36.8 % for future development.

Lower Watershed: Lincoln Avenue to Cherry Creek
North of Lincoln Avenue, Happy Canyon Creek bisects Grandview Estates, an established large lot residential area in unincorporated Douglas County. Impervious values are set at 15% for both existing and future conditions. East of Grandview Estates, Chambers Reservoir is currently under construction. For the purpose of this study, the reservoir is assumed complete and is reflected as 100% impervious. West of Peoria Street lies additional Meridian planned development. Undeveloped industrial/business parks are located between Meridian and Grandview Estates. North of Grandview Estates, the Compark planned development spans both sides of E-470 to the Douglas-Arapahoe County line. Portions of Compark north of E-470 are within the Town of Parker; the area south of E-470 is a proposed annexation to the Town. Future impervious values for Meridian and Compark planned development areas are based on master drainage plans. Industrial/business parks are assumed to develop to 80% impervious.

North of Compark, the Happy Canyon Creek watershed crosses into Arapahoe County. The Dove Valley Business Park stretches from the county line to Jordan Road and is largely undeveloped. Future development is reflected as 80% impervious. East of Jordan Road, the creek is flanked by residential development in the Southcreek subdivision.

Weighted impervious values for the lower watershed are 19.6% for existing development and 54.2% for future development.

2.3 Reach Description

The Happy Canyon Creek channel character varies widely along its length. The character of each segment is heavily influenced by the surrounding land use; because land use varies by jurisdiction, the creek is easily divided into nine distinct reaches at the jurisdictional boundaries. A description of each reach follows; reach limits are shown in Figures B-1 and B-2.

Happy Canyon Creek Reach 1 – Castle Pines
Within the City of Castle Pines, Happy Canyon Creek lies within a dedicated open space corridor adjacent to Monarch Boulevard. The channel is generally stable and well-vegetated, with significant wetland growth supported by a base flow. Five online regional detention ponds are located within Castle Pines on Happy Canyon Creek and its tributaries; the ponds are maintained by the Castle Pines North Metro District (CPNMD). The two mainstem ponds are located at Castle Pines Parkway

Happy Canyon Creek Reach 8 – Town of Parker

Happy Canyon Creek takes a sharp turn to the east as it exits Grandview Estates, and meanders widely before crossing under dual bridges at E-470. The dry, sandy bottom continues through this reach, and the channel takes a sharp turn to the west before crossing under a bridge at Chambers Road. This bend was stabilized with soil riprap toe protection during the Chambers Road bridge construction. There is very little if any wetland vegetation in this reach, as there is no base flow to support it. Reach 8 is primarily undeveloped at this point, but lies within several planned developments. A future bridge crossing for Belford Avenue, just south of E-470, will connect two proposed Town of Parker annexations: Compark Village South and Chambers Highpoint, located on the west and east sides of the creek, respectively. North of E-470, various filings of Compark are located within current Town of Parker boundaries. Drainage tracts and/or easements have been, or will be, dedicated throughout the planned developments. The channel invert through Compark has been stabilized with drop structures at each crossing and several check structures.

Happy Canyon Creek Reach 8

Happy Canyon Creek Reach 9 – Arapahoe County

The final reach of Happy Canyon Creek extends from the Douglas-Arapahoe County line to its confluence with Cherry Creek. West of Jordan Road, it passes through the Dove Valley Business Park, which is largely undeveloped. Channel stabilization measures and an access trail have been implemented along one developed parcel that is adjacent to the creek, and there is a sloping grouted boulder drop structure upstream of the bridge at Jordan Road. East of Jordan Road, the creek is located in a wide Arapahoe County open space tract between two built out residential developments that are part of the Southcreek subdivision. Three sloping grouted boulder drop structures and a concrete box culvert pedestrian crossing were constructed with the development.

Happy Canyon joins Cherry Creek just upstream of the Broncos Parkway bridge, within the Cherry Creek Valley Ecological Park. Historically, the creek paralleled the east side of Jordan Road for a distance before turning to the east toward Cherry Creek. In 1975, the channel was realigned and the confluence moved approximately 2000' upstream to its current location. The channel character in reach 9 is unappealing, with its wide sandy bottom, straight alignment, and dry, upland plains vegetation.

Happy Canyon Creek Reach 9

Figure 4-1 - Reach 2 – Douglas County South
Meandering with slight incision. Dense, healthy vegetation with some vertical banks.
Manning's 'n': 0.1 (overbank) / 0.05 (channel)

Figure 4-2 - Reach 4 – Lone Tree South
Overgrazed area with sparse short vegetation
Mid-Range Manning's 'n': 0.035 (overbank) / 0.03 (channel)
High-Range Manning's 'n': 0.045 (overbank) / 0.035 (channel)

Figure 4-3 - Reach 8 – Town of Parker
Sparse, bunchy vegetation with sandy, aggraded low-flow
Mid-Range Manning's 'n': 0.03 (overbank) / 0.03 (channel)
High-Range Manning's 'n': 0.04 (overbank) / 0.035 (channel)

Bridges and culvert crossings were modeled in HEC-RAS using the bridge routine. A total of fourteen major roadway crossings and three minor crossings were identified and surveyed within the study reach. Two of the major crossings are on Badger Gulch, and the remainder are at various locations along the mainstem. Of the seventeen identified crossings, sixteen were modeled using HEC-RAS bridge or culvert routines. The exception is the E-470 trail crossing, which is a low-flow crossing consisting of (2) 24" CMP culverts beneath a concrete trail. These culverts tend be largely blocked due to accumulated debris; the channel cross section at 10749 was set based on the concrete trail elevation, and no conveyance through the culverts was considered. Bridge and culvert modeling routines are based on ground survey points and measurements, and supplemented by measurements and observations during a field visit in October 2012. Major structure capacities are summarized in Table 4-1. Additional information regarding spill flow analysis at overtopping structures can be found in Section 4.3, below.

Floodplain delineation was accomplished with the aid of terrain modeling software. The hydraulic cross-sections were exported to a HEC-RAS GIS file (.sdf), with each of the cross-sections at the appropriate WSEL (either 100-year or 500-year). The terrain modeling software was used to interpolate water surface elevations between the hydraulic sections, and this information was then translated into a floodplain boundary. The delineation was reviewed and adjusted by hand where necessary.

The floodway locations were discussed with the project sponsors prior to the preliminary submittal. Since the majority of Happy Canyon Creek is contained in a well-defined channel, floodways have generally been set coincident to the floodplain with no additional analysis performed. In certain areas of overbank flooding (particularly within the Grandview Estates development), separate floodways have been computed. In these areas, the floodway was delineated for a 0.5-foot rise for both hydraulic grade line and energy grade line.

Floodway analysis on Badger Gulch was conducted in one area: downstream of Bristleridge Drive in the vicinity of a detention pond adjacent to the channel. No separate floodway analysis was conducted for the Green Acres Tributary.

Table B-4
Peak Flows

SWMM Node	Station (ft)	Channel Reach	Landmark	Design Storm	EXISTING DEVELOPMENT 500-YR (cfs)	100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)	FUTURE DEVELOPMENT 500-YR (cfs)	100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)
HAPPY CANYON CREEK																		
HC999	0	9	Cherry Creek	3-hr	12101	8161	5910	4237	2095	1166	322	13367	9234	6970	5236	3049	1994	836
HC037	2500	9	Jordan Road (D/S)	3-hr	12097	8168	5915	4241	2100	1173	326	13353	9233	6969	5236	3049	1994	832
HC036	2700	9	Jordan Rd (U/S) / Green Acres Trib (D/S)	3-hr	12093	8166	5914	4240	2100	1173	326	13344	9228	6964	5231	3046	1991	828
HC035	2700	9	Green Acres Tributary (U/S)	3-hr	11269	7621	5502	3923	1915	1047	283	12230	8449	6324	4704	2669	1705	656
HC034	7300	8	Chambers Road	3-hr	11363	7693	5558	3979	1963	1093	301	12287	8489	6355	4740	2691	1724	664
HC033	10500	8	E-470 / Stonegate Tributary (D/S)	3-hr	11364	7702	5569	3997	1982	1114	309	12259	8474	6344	4740	2691	1728	652
HC032	10500	8	Stonegate Tributary (U/S)	3-hr	11223	7593	5488	3937	1954	1100	304	12106	8354	6249	4670	2656	1708	633
HC031	12700	8	Grandview Estates / Compark South Boundary	3-hr	11154	7552	5460	3922	1953	1106	308	12023	8302	6211	4648	2647	1705	625
HC030	14600	7	Elm Avenue (extended)	3-hr	11105	7523	5440	3914	1955	1114	312	11971	8269	6189	4639	2646	1710	625
HC029	16200	7	Grandview Tributary (D/S)	3-hr	11069	7502	5425	3905	1953	1115	313	11932	8245	6172	4630	2643	1710	624
HC028	16200	7	Grandview Tributary (U/S)	3-hr	10541	7161	5190	3745	1904	1093	306	11308	7776	5803	4339	2461	1592	578
HC027	17400	7	Cottonwood Avenue (extended)	3-hr	10442	7097	5144	3714	1891	1088	305	11180	7689	5734	4288	2431	1573	569
HC026	20100	7	Lincoln Ave / Badger Gulch (D/S)	3-hr	10408	7079	5132	3715	1899	1102	311	11139	7663	5717	4287	2434	1580	572
HC025	20100	6	Badger Gulch (U/S)	2-hr	8538	5897	4340	3166	1734	1088	316	8984	6247	4689	3511	2073	1394	465
HC024	22600	6	1100' W of West Parker Road	2-hr	8517	5884	4331	3162	1739	1100	325	8950	6223	4670	3502	2069	1396	469
HC023	25600	6	East boundary of Meridian Commons	2-hr	8385	5801	4273	3130	1738	1117	339	8725	6066	4540	3410	2006	1361	462
HC022	28800	5	West boundary of Meridian Commons	2-hr	8178	5668	4174	3068	1712	1119	356	8439	5871	4382	3299	1929	1314	454
HC021	32000	4	Ridgegate Parkway	2-hr	7994	5555	4094	3020	1698	1125	370	8217	5726	4263	3216	1870	1280	452
HC020	32800	4		2-hr	7867	5476	4040	2981	1683	1120	370	8067	5627	4183	3149	1826	1251	444
HC019	36800	4		2-hr	7697	5369	3962	2932	1662	1117	376	7848	5481	4066	3062	1767	1214	434
HC018	40000	4		2-hr	7390	5169	3817	2846	1630	1117	396	7448	5212	3858	2918	1684	1169	432
HC017	42000	4		2-hr	7319	5124	3783	2831	1623	1120	406	7365	5158	3815	2896	1671	1166	438
HC016	43500	3	I-25	2-hr	6959	4899	3628	2708	1570	1099	407	6988	4920	3647	2757	1603	1133	433
HC015	44600	3		2-hr	6924	4879	3614	2697	1566	1098	408	6952	4899	3633	2747	1598	1132	435
HC014	46100	3	Oak Hills Tributary (D/S)	2-hr	6648	4700	3488	2598	1520	1078	407	6659	4708	3497	2636	1543	1105	430
HC013	46100	3	Oak Hills Tributary (U/S)	2-hr	4255	3012	2254	1698	1045	773	308	4260	3017	2260	1730	1064	796	332
HC012	49300	2		2-hr	4161	2948	2203	1676	1032	775	329	4163	2950	2205	1705	1053	797	352
HC011	51200	2		2-hr	4013	2858	2143	1624	1010	767	335	4012	2857	2144	1648	1030	788	358
HC010	52200	2		2-hr	3736	2676	2022	1519	965	744	332	3733	2674	2021	1539	983	763	355
HC009	54300	2	500' N of Oak Hills Drive / Beverly Hills Tributary (D/S)	2-hr	3617	2598	1969	1475	954	746	352	3609	2591	1964	1497	971	763	372
HC008	54500	2	Beverly Hills Tributary (U/S)	2-hr	2493	1832	1415	1028	693	560	273	2496	1834	1416	1029	694	561	274
HC007	56700	2		2-hr	2344	1733	1350	985	668	548	281	2345	1734	1351	986	669	549	281
HC006	58700	2		2-hr	2127	1591	1258	928	633	527	281	2128	1592	1258	929	633	528	282
HC005	59600	1	Castle Pines City Limit / CPNMD Pond #12 Outflow	2-hr	1855	1408	1132	853	587	495	270	1856	1409	1133	853	587	495	270
HC320	59600	1	CPNMD Pond #12 Inflow	2-hr	1965	1517	1269	1056	700	554	277	1967	1518	1270	1057	701	554	277
HC004	61000	1	Tenby Way	2-hr	1605	1259	1067	898	614	492	251	1605	1259	1067	898	614	492	251
HC003	62500	1	Castle Pines Parkway / CPNMD Pond #11 Outflow	2-hr	551	491	449	408	321	273	153	551	491	449	408	321	273	153
HC310	62500	1	CPNMD Pond #11 Inflow	2-hr	1362	1001	808	644	409	310	154	1362	1001	808	644	409	310	154
HC002	64000	1		2-hr	859	635	513	410	264	201	103	859	635	513	410	264	201	103
HC001	64700	1	Monarch Blvd.	2-hr	485	356	288	229	140	104	50	485	356	288	229	140	104	50

Happy Canyon Creek Major Drainageway Plan

March 2014

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

DOUGLAS COUNTY COLORADO

CITY OF LONE TREE

Town of Parker COLORADO

Southeast Metro Stormwater Authority

MULLER

Reach 8 – Town of Parker

North of Grandview Estates, Happy Canyon Creek passes through Town of Parker annexation areas and current boundaries. Between Grandview and E-470, the Compark Village South annexation is located to the west of the channel, and the Chambers Highpoint annexation is on the east side of the channel. Drop structures are identified through this reach to provide an assumed equilibrium slope of 0.3%, and bank protection is shown along the outside bends. Bank erosion caused by recent earthwork operations is also in need of repair. A future road crossing is planned in this reach; a 100-year bridge is recommended. (Costs for this crossing have not been included.)

An existing low flow trail crossing at the E-470 trail provides little capacity and presents a maintenance issue due to sedimentation. A new crossing that incorporates a drop structure will provide additional capacity without drastically altering the existing trail profile. Aggradation in this reach is expected to continue, so the crossing should be designed with that consideration in mind, and continued (though reduced) maintenance will be necessary until the channel invert stabilizes. While a 100-year bridge crossing would generally be preferred in an aggrading reach such as this, the grades in this location are not favorable as a bridge would need to be approximately 400' long to span the floodplain.

Extension of the recently constructed Stonegate Tributary pipeline an additional two hundred feet to the confluence with Happy Canyon Creek will address channel degradation that is occurring in the steep segment downstream of the existing pipe outfall. Channelization of Happy Canyon Creek through placement of fill in the right overbank immediately upstream of E-470 will eliminate an expansion in the floodplain that further promotes sedimentation in this reach.

Downstream of E-470, Happy Canyon Creek passes through open space tracts within the Compark Village planned development. Check structures have been installed throughout this reach; as improvements upstream reduce the sediment loading to this reach, some degradation is anticipated as the channel seeks a flatter equilibrium slope. Conversion of the existing check structures to drop structures is shown.

Maintenance access through Compark Village is provided by a maintenance / recreational trail; initial plans for Compark Village South show an open space corridor with a recreational trail for the remainder of the reach.

A full spectrum detention facility on the Green Acres Tributary at E-470 is tabulated with the costs for Reach 8.

The total capital improvement cost for Reach 8 is estimated at $1.88 million. Annual operations and maintenance costs are estimated at $30,100 per year, with a total 50-year maintenance cost of $647,000.

CLICK HERE TO VIEW REACH 8 MAP

CLICK HERE TO VIEW REACH 8 PROFILE

Green Acres Tributary

Compark Blvd.

Town of Parker

E-470

S. Chambers Rd.

E-470 POND
FULL SPECTRUM
DETENTION
EURV = 10.9 AF
V100 = 17.8 AF
Q2 = 25 CFS
Q100 = 355 CFS
CLICK HERE TO VIEW
POND DETAIL

DESIGN CONTOURS
FOR CHAMBERS
RESERVOIR PROJECT
(TYPICAL)

FUTURE ROAD ALIGNMENT

3' DROP
STRUCTURE

100-YEAR
FLOODPLAIN WITH
IMPROVEMENTS

FILL OVERBANK TO ELIMINATE
FLOODPLAIN EXPANSION

EXTEND 42" RCP

100-Year
Floodplain
(2014 FHAD)

4' DROP STRUCTURE AND NEW
LOW FLOW TRAIL CROSSING
(20' x 3' CBC)

E-470 Bike Path
Existing Double
24" CMP

E-470
Existing Single Span
Concrete Bridge

Existing Stonegate
Tributary 42" Pipeline

REACH 8

Existing Check
Structure

Existing 7' Deep
Check Structure

2' DROP
STRUCTURE

4' DROP
STRUCTURE

Existing 6' Deep
Check Structure

Existing 8' Deep
Check Structure

South Chambers Road
Existing Single Span
Concrete Bridge

Existing 5' Grouted
Boulder Drop

0' 100' 200' 400'

DATE: MAR 28, 2014 TIME: 0:15 AM

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No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-010.01

DESIGN MDC
DRAWN SAR
CHECK JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

CONCEPTUAL DESIGN PLAN
REACH 8

DATE
MARCH 2014

FIGURE NO.

REACH 8

$Q_{100,\ FHAD}$ = 8355 cfs
$Q_{100,\ MDP}$ = 5812 cfs

$Q_{100,\ FHAD}$ = 8490 cfs
$Q_{100,\ MDP}$ = 5894 cfs

DOUGLAS COUNTY

Chambers Road
Single Span Concrete Bridge

E-470
Two Single Span Concrete Bridges

CONFLUENCE WITH STONEGATE TRIBUTARY

E-470 Bike Trail
Double 24" CMP

100-YEAR WSEL (MASTER PLAN)

100-Year WSEL (2014 FHAD)

Existing Channel Invert Average Slope = 0.74%

Existing Channel Invert Average Slope = 0.64%

3' DROP STRUCTURE

2' DROP STRUCTURE

3' DROP STRUCTURE

3' DROP STRUCTURE

3' DROP STRUCTURE

4' DROP STRUCTURE WITH NEW TRAIL CROSSING (20' x 3' CBC)

Existing Check Structure

Existing 7' Deep Check Structure

Existing 5' Grouted Boulder Drop

DESIGN CHANNEL INVERT AT ASSUMED EQUILIBRIUM SLOPE

Existing 6' Deep Check Structure

Existing 8' Deep Check Structure

Existing 6' Deep Check Structure

Existing 6' Deep Check Structure

Existing 12" Sanitary Sewer (Approximate)

0.3%

5830 5820 5810 5800 5790 5780 5770 5760 5750 5740 5730 5720 5710 5700 5690 5680 5670 5660

50+00 52+00 54+00 56+00 58+00 60+00 62+00 64+00 66+00 68+00 70+00 72+00 74+00 76+00 78+00 80+00 82+00 84+00 86+00 88+00 90+00 92+00 94+00 96+00 98+00 100+00 102+00 104+00 106+00 108+00 110+00

RIVER STATION (FT)

LEGEND

- EXISTING CHANNEL THALWEG
- ASSUMED FUTURE CHANNEL THALWEG
- 100-YEAR WSEL (2014 FHAD)
- 100-YEAR WSEL (MASTER PLAN)

NOTE: ELEVATIONS SHOWN ARE BASED ON THE NAVD 88 DATUM

SCALE
HORIZONTAL: 1" = 200'
VERTICAL: 1" = 10'

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777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-010.01

DESIGN MDC
DRAWN SAR
CHECK JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

CONCEPTUAL DESIGN PROFILE
REACH 8 (1 OF 2)

DATE MARCH 2014
FIGURE NO.

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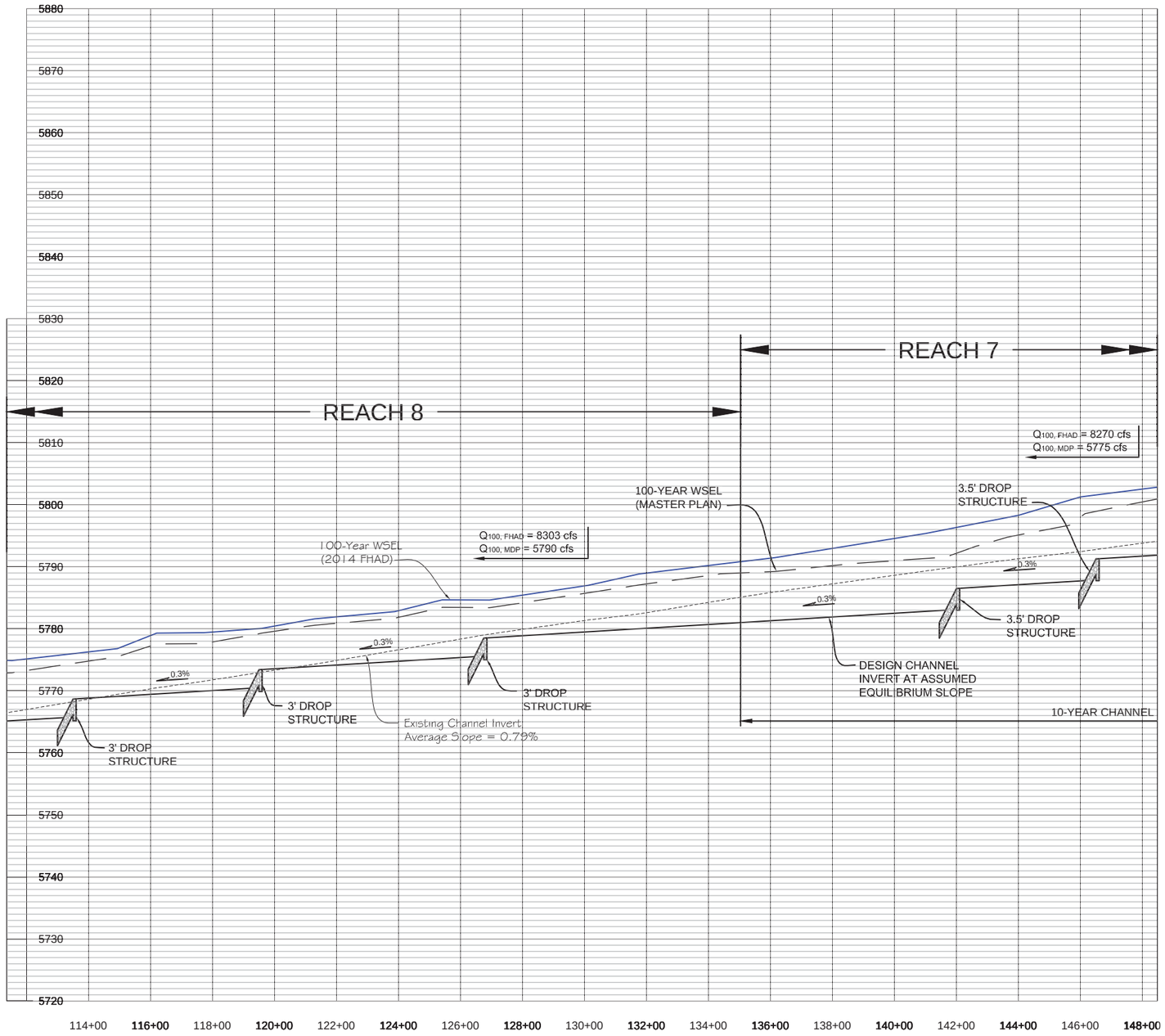

RIVER STATION (FT)

SCALE
HORIZONTAL: 1" = 200'
VERTICAL: 1" = 10'

LEGEND

- EXISTING CHANNEL THALWEG
- ASSUMED FUTURE CHANNEL THALWEG
- 100-YEAR WSEL (2014 FHAD)
- 100-YEAR WSEL (MASTER PLAN)

NOTE: ELEVATIONS SHOWN ARE BASED ON THE NAVD 88 DATUM

No.	DATE	REVISIONS	APPR.

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80226 (303) 988-4939
PROJECT NO. 12-010.01

DESIGN MDC
DRAWN SAR
CHECK JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

CONCEPTUAL DESIGN PROFILE
REACH 8 (2 OF 2); REACH 7 (1 OF 2)

DATE
MARCH 2014

FIGURE NO.

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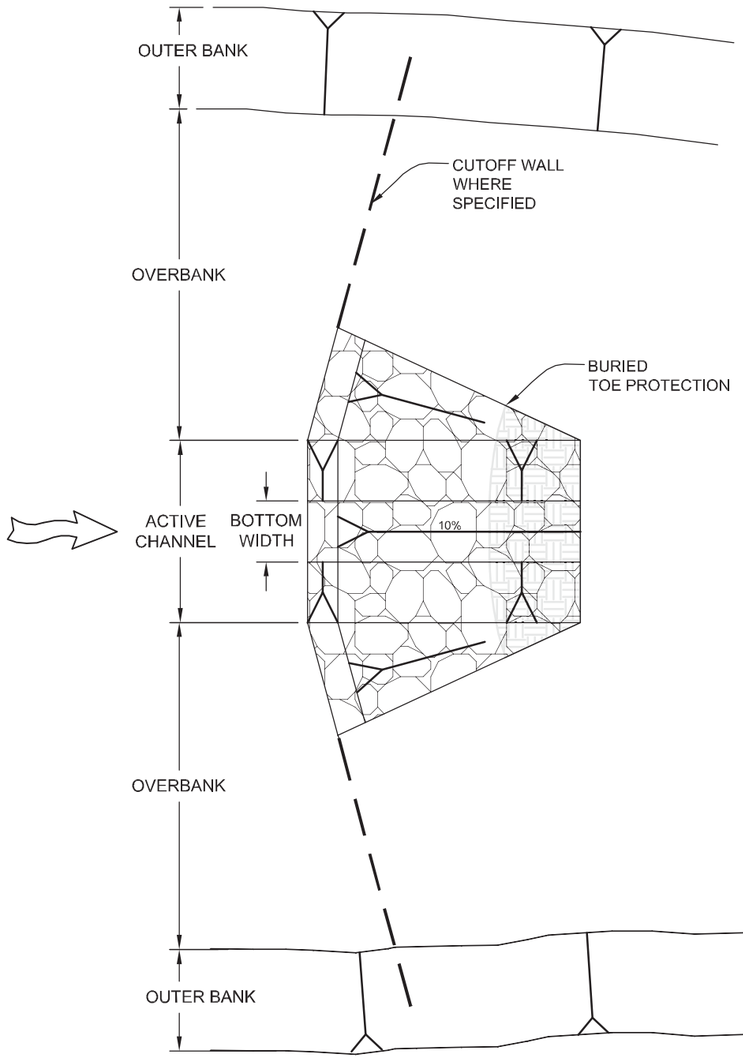
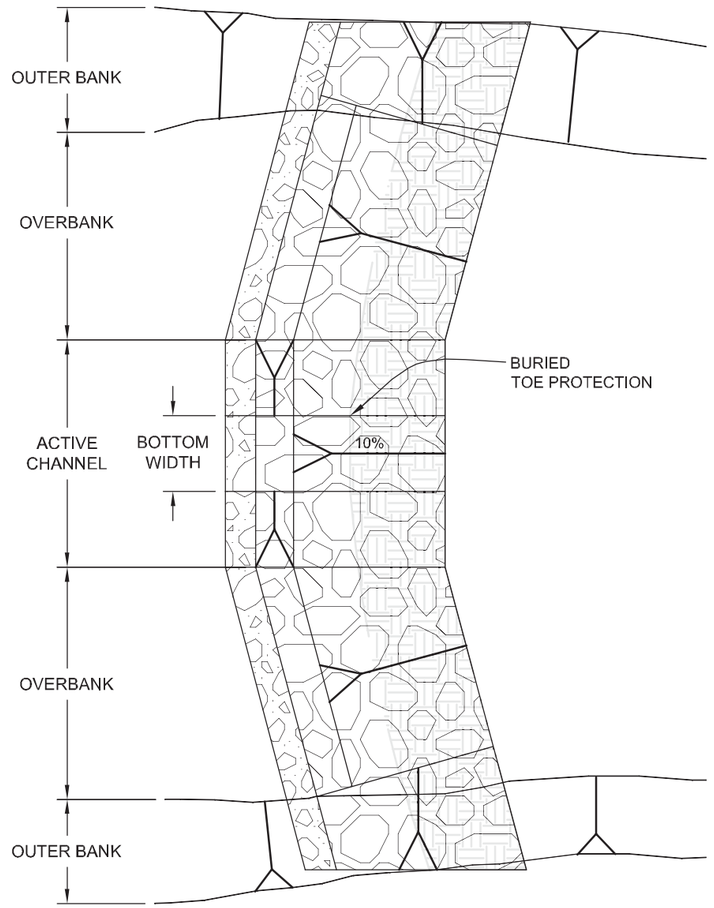
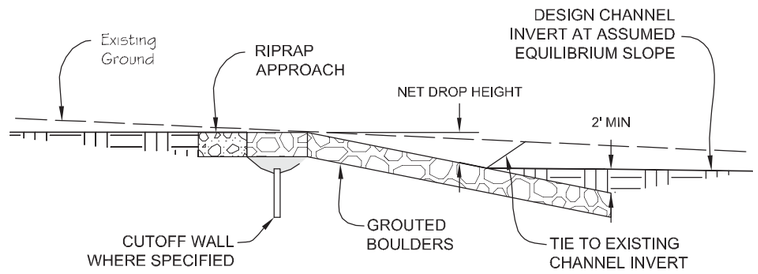


DROP STRUCTURE PLAN
LOW-FLOW



DROP STRUCTURE PLAN
FULL WIDTH



DROP STRUCTURE
PROFILE

NAME: P:\12-010.01 Happy Canyon Creek MDP & FHAD UDFCD\Happy Canyon Creek MDP Technical Appendix\7 AUTOCAD FILES\Conceptual Design\12010HCC_MDP_DROP_STRUCTURE_DET.dwg DATE: MAR 28, 2014 TIME: 2:55 AM

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777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-010.01

DESIGN MDC
DRAWN SAR
CHECK JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

CONCEPTUAL DESIGN
TYPICAL DROP STRUCTURE DETAILS

DATE MARCH 2014
FIGURE NO. G-5

UDFCD LOMC AGREEMENT TABLE

PROJECT NAME:	115360-01 Compark/Belford Avenue
COMPANY:	Felsburg Holt & Ullevig
COMPLETED BY:	ZJG

Community(ies): Town of Parker & Douglas County, CO
Flooding Source(s): Happy Canyon Creek

Page: 1 **of** 1
Date: 11/16/2016

Reference Location	Stream Station	Cross Section #	Channel Distance (ft)			Cumulative Channel Distance (ft)			Base Floodplain Width (ft)			Floodway Width (ft)			Comments
			Model	Map	% Difference	Model	Map	% Difference	Model	Map	Difference (ft)	Model	Map	Difference (ft)	
		10111	0	0	#DIV/0!	0	0	#DIV/0!	444	444	0	444	444	0	*
		10157	45	45	1%	45	45	1%	239	239	0	239	239	0	*
D/S XS - E-470 Bridge		10326	169	169	0%	214	214	0%	94	94	0	94	94	0	*
U/S XS - E-470 Bridge		10548	223	223	0%	437	437	0%	129	129	0	129	129	0	*
		10595	46	48	4%	484	485	0%	121	121	0	121	121	0	*
		10679	94	94	0%	578	580	0%	103	103	0	103	103	0	*
		10725	43	44	2%	620	623	0%	185	185	0	185	185	0	*
D/S XS - E-470 Trail Crossing		10750	29	29	0%	650	652	0%	219	219	0	219	219	0	*
U/S XS - E-470 Trail Crossing		10810	59	59	0%	708	711	0%	316	315	1	316	315	1	*
		10819	9	10	***14%***	717	721	1%	326	326	1	326	326	1	*
		10825	6	5	***11%***	723	727	0%	331	333	2	331	333	2	*
		10900	85	76	***10%***	808	803	1%	303	312	8	303	312	8	*
		10974	74	74	0%	882	877	1%	207	207	0	207	207	0	*
D/S XS - Belford Avenue		11100	54	54	0%	936	931	1%	175	169	6	175	169	6	*
U/S XS - Belford Avenue		11180	173	173	0%	1109	1104	0%	181	183	3	181	183	3	*
		11280	96	96	0%	1205	1200	0%	185	189	3	185	189	3	*
		11380	99	99	0%	1305	1300	0%	156	156	0	156	156	0	*
		11395	15	15	0%	1320	1315	0%	162	160	2	162	160	2	*
		11410	15	15	0%	1335	1330	0%	147	149	2	147	149	2	*
		11416	6	6	0%	1341	1336	0%	145	147	1	145	147	1	*
		11494	79	79	0%	1419	1414	0%	134	130	4	134	130	4	*
		11620	136	136	0%	1555	1550	0%	235	240	4	235	240	4	*
		11772	152	156	3%	1707	1706	0%	196	197	1	196	197	1	*
		11925	157	161	3%	1864	1867	0%	203	203	0	203	203	0	*
		11955	30	32	***8%***	1894	1900	0%	205	205	0	205	205	0	*
		11961	6	6	0%	1900	1906	0%	207	207	0	207	207	0	*
		12129	177	177	0%	2077	2083	0%	294	294	0	294	294	0	*
		12388	264	266	1%	2341	2348	0%	245	245	0	245	245	0	*
		12400	11	11	0%	2352	2360	0%	266	266	0	266	266	0	*
		12430	30	30	0%	2382	2390	0%	300	300	0	300	300	0	*
		12436	6	6	0%	2388	2396	0%	309	309	0	309	309	0	*
		12541	105	105	0%	2494	2501	0%	499	499	0	499	499	0	*
		12694	153	146	4%	2646	2647	0%	425	425	0	425	425	0	*
		13012	318	326	2%	2812	2827	1%	263	264	0	200	202	2	
ACCEPTABLE TOLERANCES =			**+/- 5% of Model**			**+/- 5% of Model**			**+/- 25 Feet**						

* - Floodway = Floodplain

UDFCD DLOMC Submittal - BFE Comparison Table

Project Name :	**115360-01 Compark/Belford Avenue**
Flooding Source:	**Happy Canyon Creek**
Company:	**Felsburg Holt & Ullevig**
Completed By:	**ZJG**

SOURCE DATA											COMPARISONS				
HYDRAULIC CROSS-SECTION INFO.						BASE FLOOD ELEVATIONS (NAVD)									
Effective Cross-Section ID (Letter)	Corrected Effective Cross-Section ID	Corrected Effective Stream Station	Existing Cross-Section ID	Proposed Cross-Section ID	Proposed Stream Station	EFFECTIVE	DUP. EFF.	COR. EFF.	EXISTING	PROPOSED	DUP. EFF vs. EFF.	COR. EFF. vs. EFF.	EX. vs. COR. EFF.	PP. vs. COR. EFF.	PP. vs. EFF.
						BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE
9920 (E)	10111	10111	-	10111	10111	5766.3	5766.3	5766.3	-	5766.3	0.0	0.0	-	0.0	0.0
-	10157	10157	-	10157	10157	-	-	5766.3	-	5766.3	-	-	-	0.0	-
-	10326	10326	-	10326	10326	-	-	5768.3	-	5768.2	-	-	-	-0.1	-
-	10548	10548	-	10548	10548	-	-	5770.3	-	5770.3	-	-	-	0.0	-
-	10595	10597	-	10595	10597	-	-	5770.1	-	5770.1	-	-	-	0.0	-
-	10679	10691	-	10679	10691	-	-	5771.1	-	5771.1	-	-	-	0.0	-
-	10725	10735	-	10725	10735	-	-	5772.7	-	5773.0	-	-	-	0.3	-
-	-	-	-	10750	10764	-	-	-	-	5773.3	-	-	-	-	-
-	10775	10786	-	-	-	-	-	5773.2	-	-	-	-	-	-	-
-	-	-	-	10810	10823	-	-	-	-	5773.4	-	-	-	-	-
-	-	-	-	10819	10833	-	-	-	-	5773.7	-	-	-	-	-
-	-	-	-	10825	10838	-	-	-	-	5773.6	-	-	-	-	-
-	10842	10856	-	-	-	-	-	5772.9	-	-	-	-	-	-	-
-	10900	10922	-	10900	10915	-	-	5773.2	-	5773.5	-	-	-	0.3	-
-	10974	10995	-	10974	10989	-	-	5772.9	-	5773.3	-	-	-	0.4	-
-	11100	11050	-	11100	11043	-	-	5773.1	-	5773.6	-	-	-	0.6	-
-	11153	11187	-	-	-	-	-	5774.0	-	-	-	-	-	-	-
-	11180	11230	-	11180	11215	-	-	5773.8	-	5774.2	-	-	-	0.4	-
-	11280	11321	-	11280	11312	-	-	5774.9	-	5774.9	-	-	-	0.0	-
-	11380	11424	-	11380	11411	-	-	5775.3	-	5775.2	-	-	-	-0.1	-
-	11395	11440	-	11395	11426	-	-	5775.4	-	5775.6	-	-	-	0.2	-
-	11410	11458	-	11410	11441	-	-	5775.6	-	5775.5	-	-	-	-0.1	-
-	11416	11465	-	11416	11447	-	-	5775.6	-	5775.8	-	-	-	0.2	-
11320 (F)	11494	11544	-	11494	11526	5776.7	5776.7	5776.8	-	5776.4	0.0	0.1	-	-0.4	-0.3
-	11620	11680	-	11620	11662	-	-	5777.9	-	5777.7	-	-	-	-0.1	-
-	11772	11836	-	11772	11818	-	-	5777.9	-	5777.7	-	-	-	-0.2	-
-	-	-	-	11925	11979	-	-	-	-	5779.3	-	-	-	-	-
-	-	-	-	11955	12011	-	-	-	-	5779.8	-	-	-	-	-
-	11959	12030	-	-	-	-	-	5779.8	-	-	-	-	-	-	-
-	-	-	-	11961	12017	-	-	-	-	5780.1	-	-	-	-	-
-	12129	12213	-	12129	12194	-	-	5781.6	-	5781.6	-	-	-	0.0	-
-	12388	12478	-	12388	12460	-	-	5782.2	-	5782.2	-	-	-	0.0	-
-	12400	12490	-	12400	12471	-	-	5782.4	-	5782.4	-	-	-	0.0	-
-	12430	12520	-	12430	12501	-	-	5783.6	-	5783.6	-	-	-	0.0	-
-	12436	12526	-	12436	12507	-	-	5783.7	-	5783.6	-	-	-	0.0	-
-	12541	12631	-	12541	12613	-	-	5784.1	-	5784.1	-	-	-	0.0	-
12605 (G)	12694	12777	-	12694	12759	5784.8	5784.8	5783.9	-	5783.9	0.0	-0.9	-	0.0	-0.9

-- = Not applicable or no direct comparison available

Information taken from Effective FIS and FIRM. Flows used were 100-yr from FIS (Q=5560 cfs @ E-470)

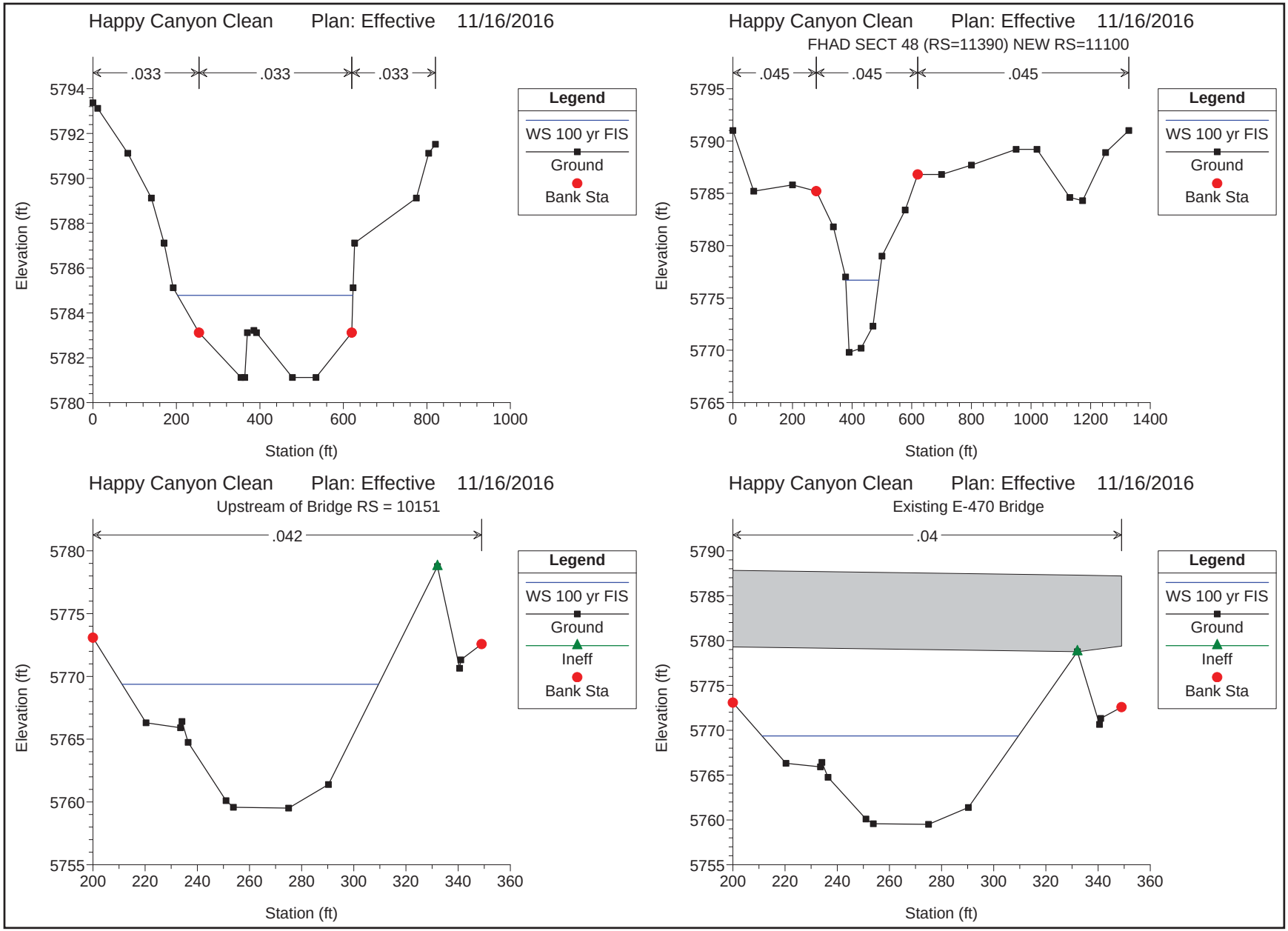
UDFCD DLOMC Submittal - BFE Comparison Table

Project Name :	**115360-01 Compark/Belford Avenue**
Flooding Source:	**Happy Canyon Creek**
Company:	**Felsburg Holt & Ullevig**
Completed By:	**ZJG**

SOURCE DATA											COMPARISONS				
HYDRAULIC CROSS-SECTION INFO.						BASE FLOOD ELEVATIONS (NAVD)									
Effective Cross-Section ID (Letter)	Corrected Effective Cross-Section ID	Corrected Effective Stream Station	Existing Cross-Section ID	Proposed Cross-Section ID	Proposed Stream Station	EFFECTIVE	DUP. EFF.	COR. EFF.	EXISTING	PROPOSED	DUP. EFF vs. EFF.	COR. EFF. vs. EFF.	EX. vs. COR. EFF.	PP. vs. COR. EFF.	PP. vs. EFF.
						BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE	BFE
10111	10111	10111	-	10111	10111	5767.4	5767.4	5767.4	-	5767.4	0.0	0.0	-	0.0	0.0
10157	10157	10157	-	10157	10157	5767.9	5767.9	5767.7	-	5767.7	0.0	-0.2	-	0.0	-0.2
10326	10326	10326	-	10326	10326	5768.5	5768.5	5769.3	-	5769.3	0.0	0.8	-	0.0	0.8
10548	10548	10548	-	10548	10548	5770.5	5770.5	5772.4	-	5772.4	0.0	2.0	-	0.0	2.0
10595	10595	10597	-	10595	10597	5771.3	5771.3	5772.1	-	5772.1	0.0	0.8	-	0.0	0.8
10679	10679	10691	-	10679	10691	5772.1	5772.1	5772.5	-	5772.5	0.0	0.4	-	0.0	0.4
-	10725	10735	-	10725	10735	-	-	5775.0	-	5775.6	-	-	-	0.6	-
10749	-	-	-	-	-	5774.9	5774.9	-	-	-	0.0	-	-	-	-
-	-	-	-	10750	10764	-	-	-	-	5775.9	-	-	-	-	-
-	10775	10786	-	-	-	-	-	5775.7	-	-	-	-	-	-	-
-	-	-	-	10810	10823	-	-	-	-	5776.1	-	-	-	-	-
-	-	-	-	10819	10833	-	-	-	-	5776.2	-	-	-	-	-
-	-	-	-	10825	10838	-	-	-	-	5776.2	-	-	-	-	-
10842	10842	10856	-	-	-	5775.0	5775.0	5775.5	-	-	0.0	0.5	-	-	-
-	10900	10922	-	10900	10915	-	-	5775.7	-	5776.1	-	-	-	0.4	-
10974	10974	10995	-	10974	10989	5774.9	5774.9	5775.5	-	5775.9	0.0	0.6	-	0.5	1.0
-	11100	11050	-	11100	11043	-	-	5775.5	-	5776.1	-	-	-	0.6	-
11153	11153	11187	-	-	-	5774.8	5774.8	5775.8	-	-	0.0	1.0	-	-	-
-	11180	11230	-	11180	11215	-	-	5775.6	-	5776.4	-	-	-	0.8	-
-	11280	11321	-	11280	11312	-	-	5776.0	-	5776.1	-	-	-	0.1	-
-	11380	11424	-	11380	11411	-	-	5776.7	-	5776.5	-	-	-	-0.2	-
-	11395	11440	-	11395	11426	-	-	5776.8	-	5777.1	-	-	-	0.4	-
-	11410	11458	-	11410	11441	-	-	5777.0	-	5776.9	-	-	-	-0.1	-
-	11416	11465	-	11416	11447	-	-	5777.1	-	5776.9	-	-	-	-0.2	-
11494	11494	11544	-	11494	11526	5776.8	5776.8	5778.1	-	5777.6	0.0	1.3	-	-0.5	0.8
11620	11620	11680	-	11620	11662	5779.4	5779.4	5779.8	-	5779.7	0.0	0.4	-	-0.1	0.3
11772	11772	11836	-	11772	11818	5779.4	5779.4	5779.8	-	5779.7	0.0	0.4	-	-0.1	0.3
-	-	-	-	11925	11979	-	-	-	-	5780.4	-	-	-	-	-
-	-	-	-	11955	12011	-	-	-	-	5780.9	-	-	-	-	-
11959	11959	12030	-	-	-	5780.1	5780.1	5781.0	-	-	0.0	0.9	-	-	-
-	-	-	-	11961	12017	-	-	-	-	5781.1	-	-	-	-	-
12129	12129	12213	-	12129	12194	5781.6	5781.6	5782.9	-	5782.9	0.0	1.3	-	0.0	1.3
12388	12388	12478	-	12388	12460	5782.8	5782.8	5783.4	-	5783.4	0.0	0.6	-	0.0	0.5
-	12400	12490	-	12400	12471	-	-	5784.0	-	5784.1	-	-	-	0.0	-
-	12430	12520	-	12430	12501	-	-	5784.8	-	5784.8	-	-	-	0.0	-
-	12436	12526	-	12436	12507	-	-	5784.8	-	5784.9	-	-	-	0.0	-
12541	12541	12631	-	12541	12613	5784.7	5784.7	5785.4	-	5785.4	0.0	0.7	-	0.0	0.7
12694	12694	12777	-	12694	12759	5784.6	5784.6	5785.3	-	5785.3	0.0	0.7	-	0.0	0.6
13012	13012	13103	-	13012	13085	5787.0	5787.0	5787.0	-	5787.0	0.0	0.0	-	0.0	0.0

-- = Not applicable or no direct comparison available

In anticipation, the FHAD Model was taken to be Effective in this comparison. Flows used were the 100-yr Future Flows (Q=8355 cfs @ E-470)


Happy Canyon Clean Plan: Effective 11/16/2016
.033
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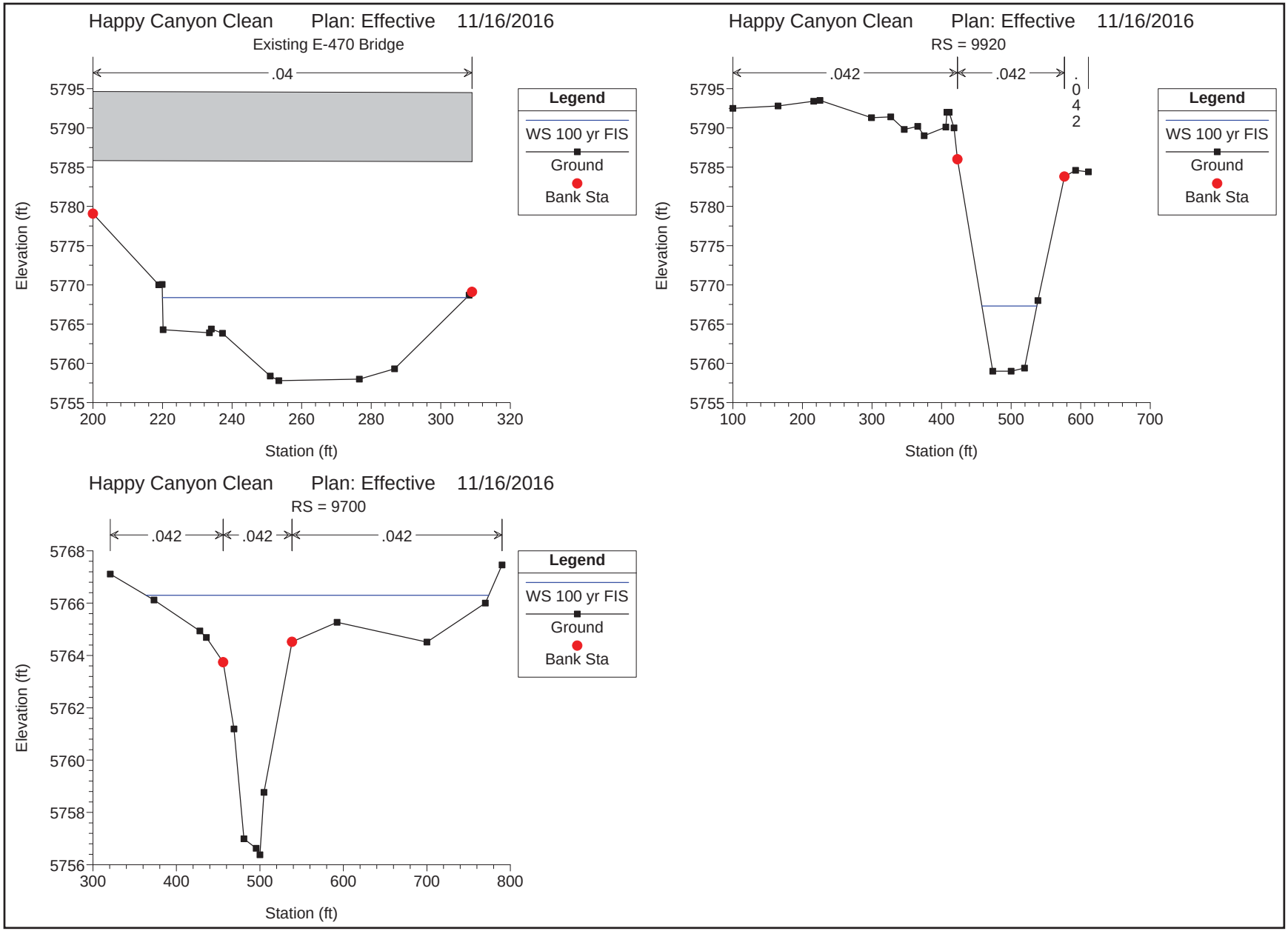
Elevation (ft)
Station (ft)
Legend
WS 100 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Effective 11/16/2016
FHAD SECT 48 (RS=11390) NEW RS=11100
.045
.045
.045
Elevation (ft)
Station (ft)
Legend
WS 100 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Effective 11/16/2016
Upstream of Bridge RS = 10151
.042
Elevation (ft)
Station (ft)
Legend
WS 100 yr FIS
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Effective 11/16/2016
Existing E-470 Bridge
.04
Elevation (ft)
Station (ft)
Legend
WS 100 yr FIS
Ground
Ineff
Bank Sta


Happy Canyon Clean Plan: Effective 11/16/2016
Existing E-470 Bridge
.04
Elevation (ft)
Station (ft)
Legend
WS 100 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Effective 11/16/2016
RS = 9920
.042
.042
.042
Elevation (ft)
Station (ft)
Legend
WS 100 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Effective 11/16/2016
RS = 9700
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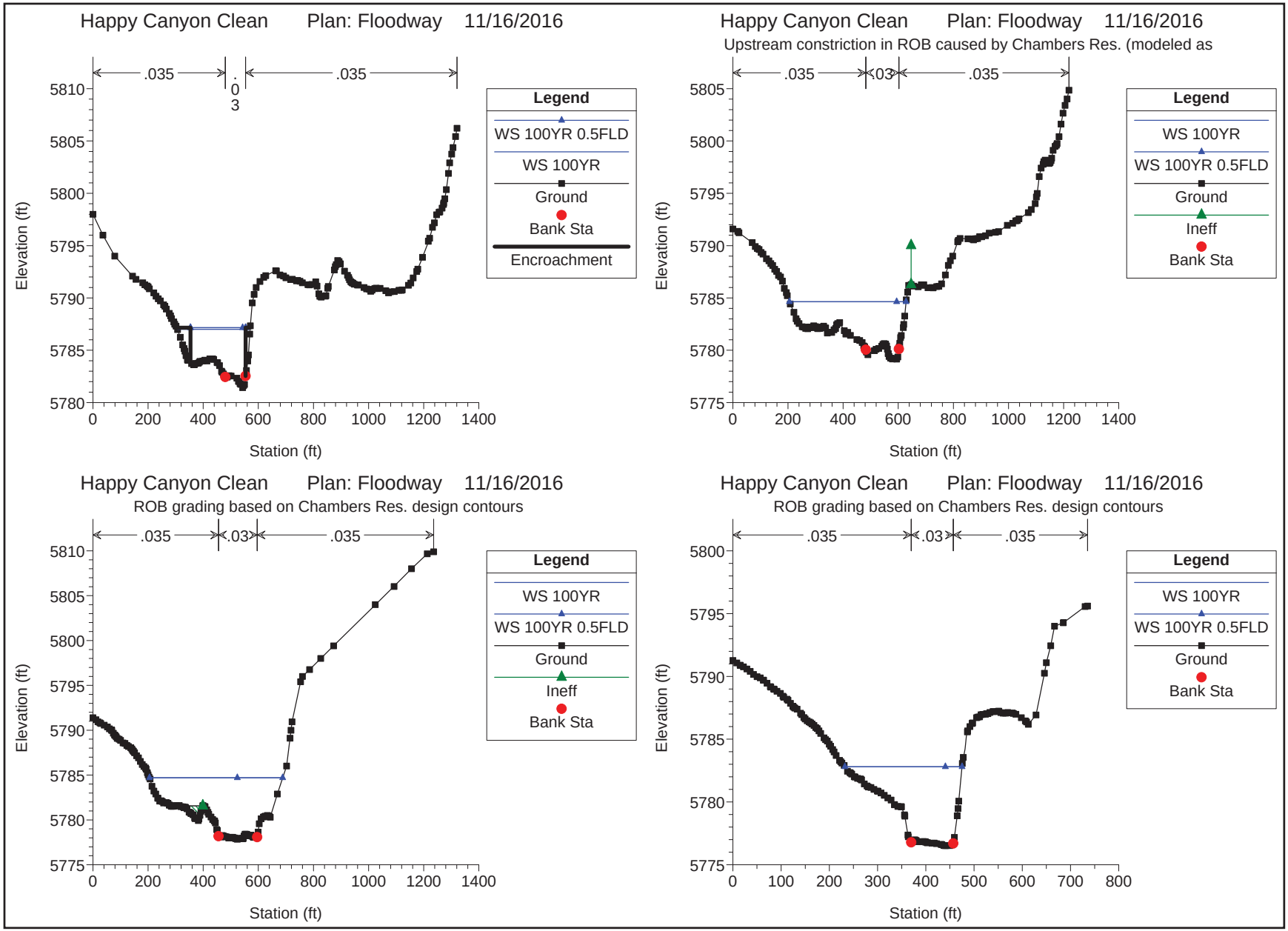
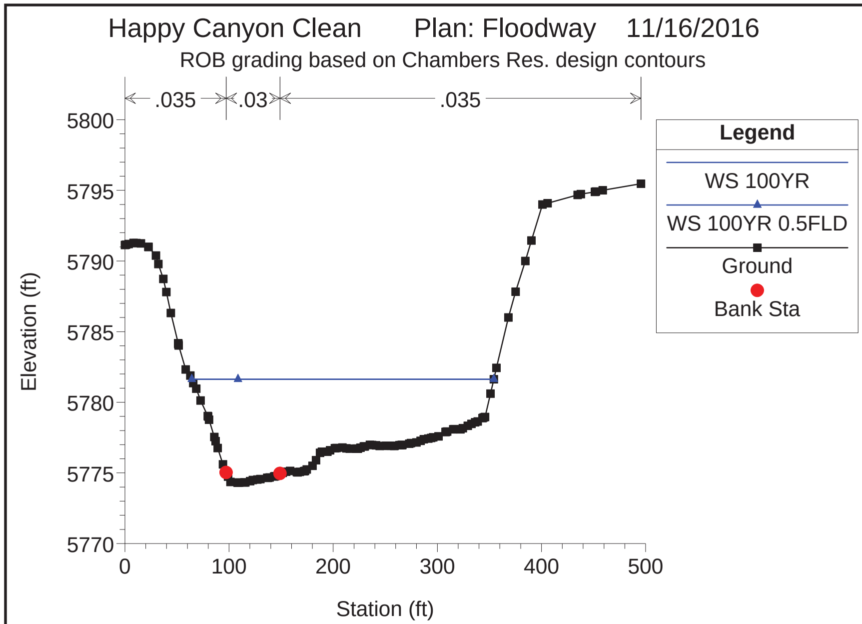
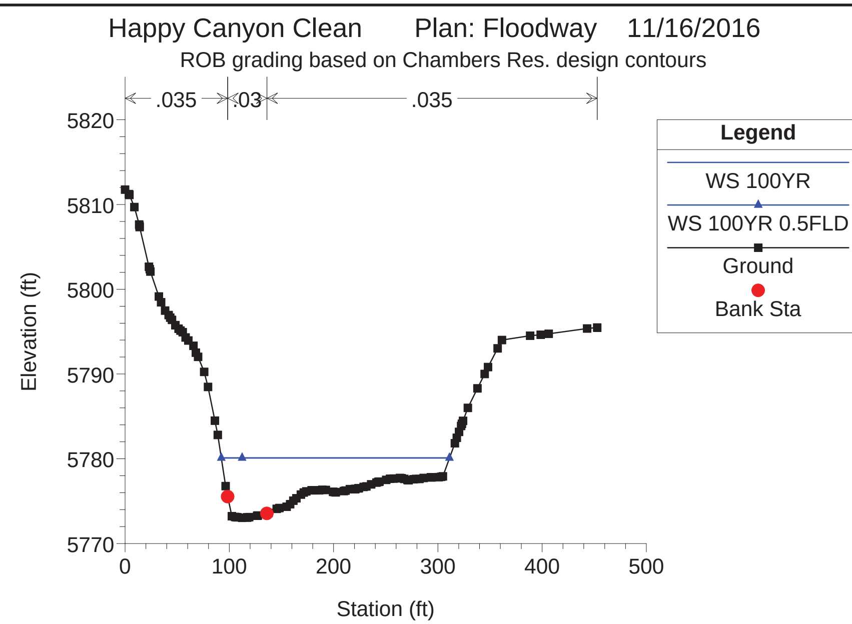
Elevation (ft)
Station (ft)
Legend
WS 100 yr FIS
Ground
Bank Sta


Happy Canyon Clean Plan: Floodway 11/16/2016
.035
.03
.035
Legend
WS 100YR 0.5FLD
WS 100YR
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
Happy Canyon Clean Plan: Floodway 11/16/2016
Upstream constriction in ROB caused by Chambers Res. (modeled as
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours


Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
.035
.03
.035
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Bank Sta
Elevation (ft)
5800
5795
5790
5785
5780
5775
5770
0
100
200
300
400
500
Station (ft)


Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
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.03
.035
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Bank Sta
Elevation (ft)
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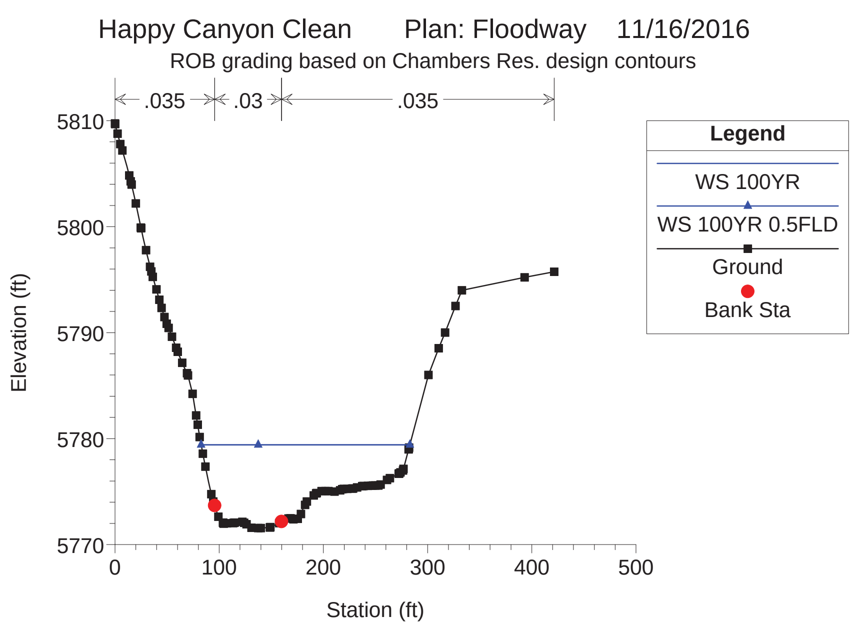
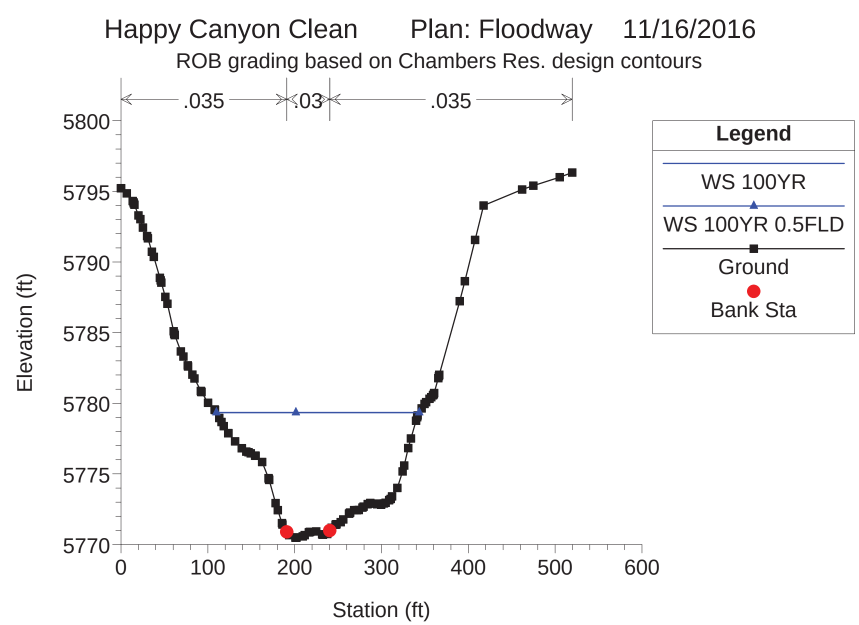
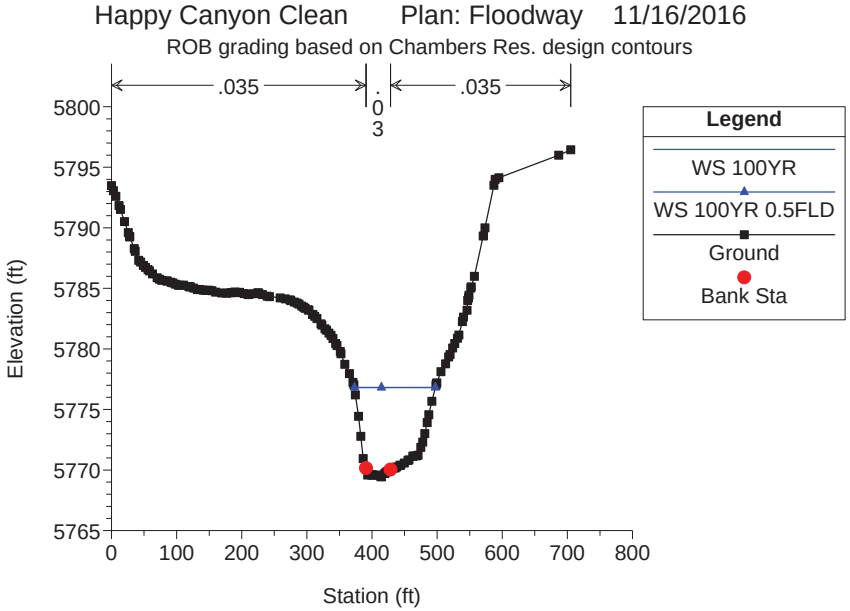
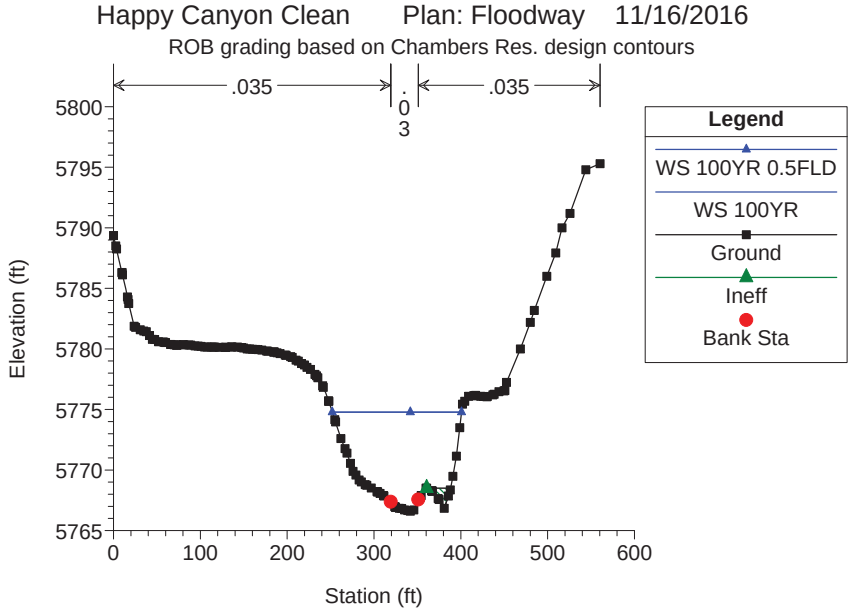
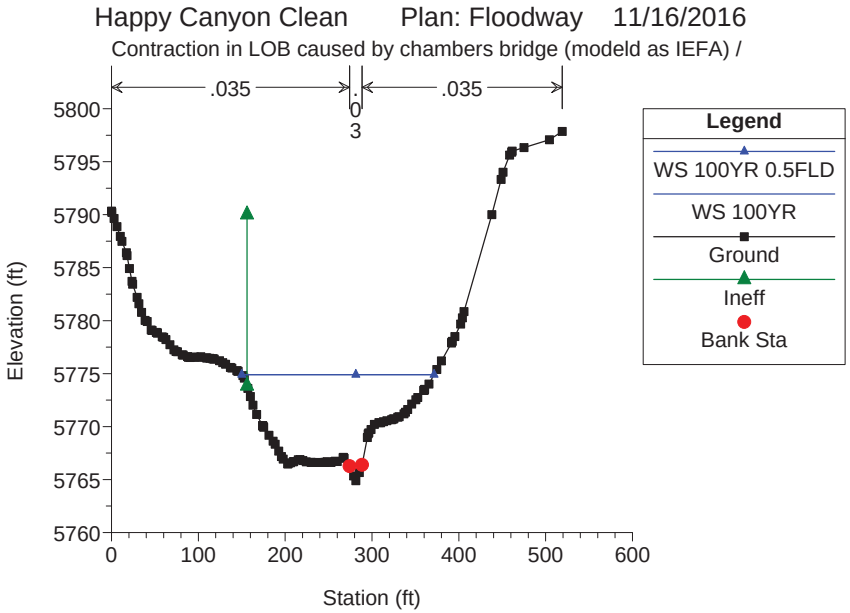
5810
5800
5790
5780
5770
0
100
200
300
400
500
Station (ft)

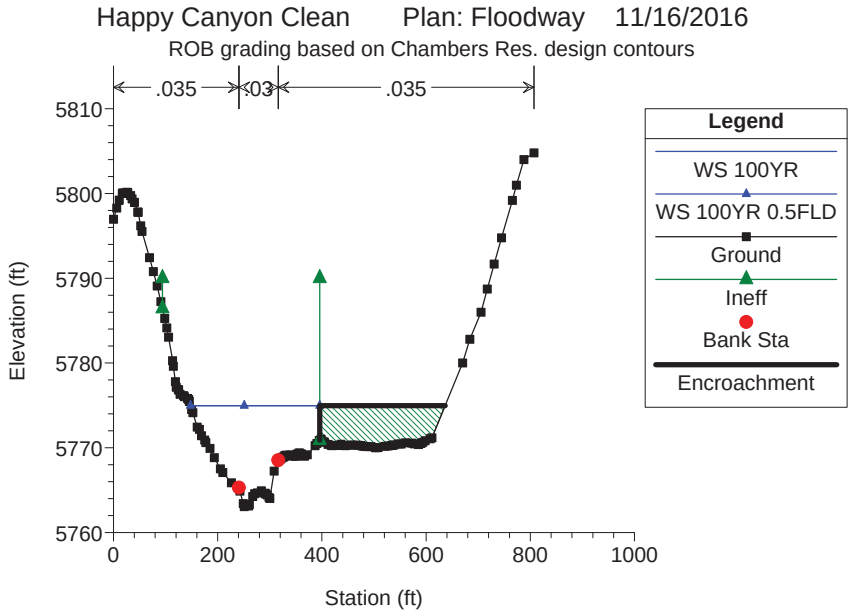

Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
.035
.03
.035
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Bank Sta
Elevation (ft)
5810
5800
5790
5780
5770
0
100
200
300
400
500
Station (ft)

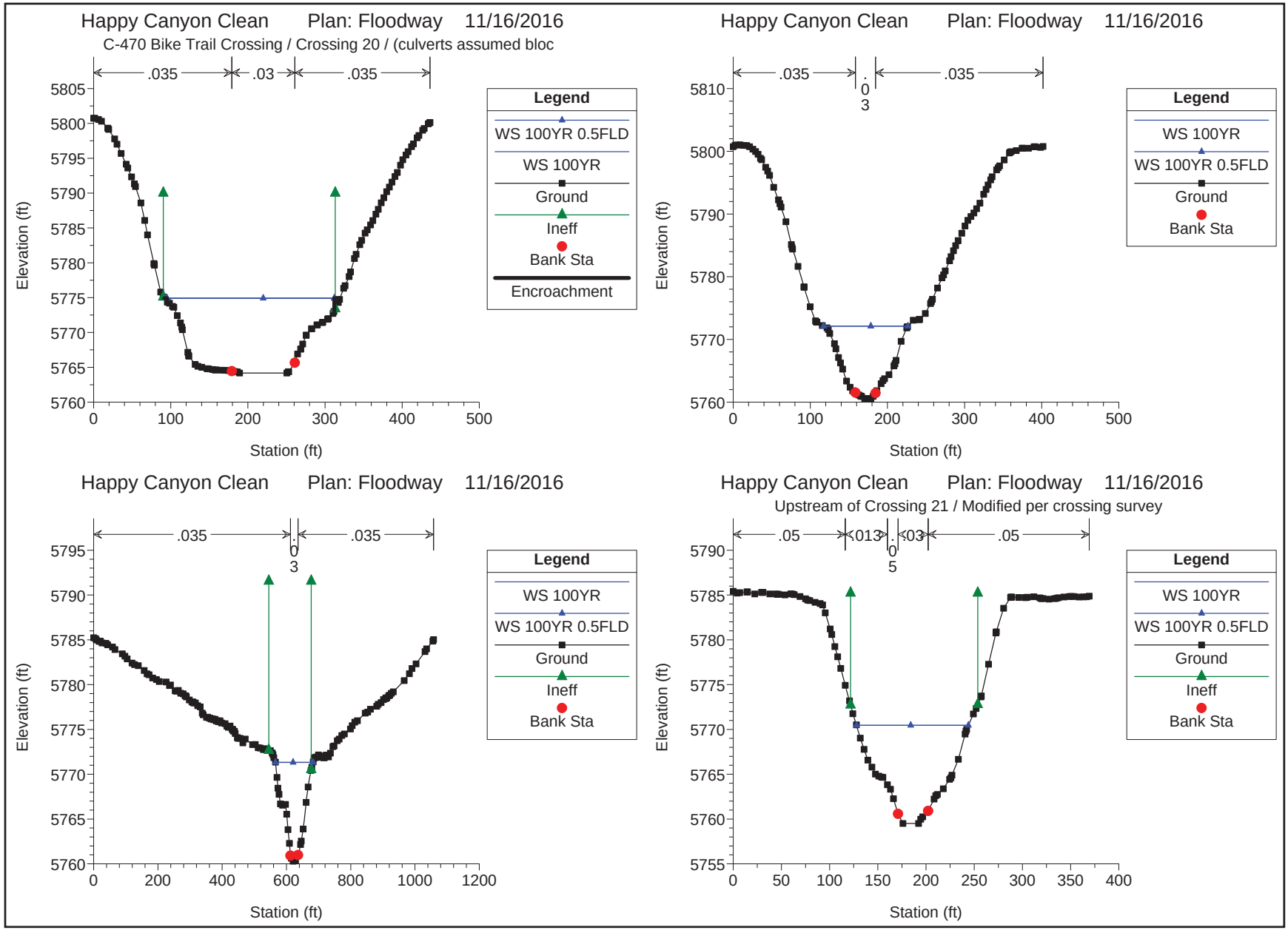

Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
.035
.03
.035
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Bank Sta
Elevation (ft)
5800
5795
5790
5785
5780
5775
5770
0
100
200
300
400
500
600
Station (ft)

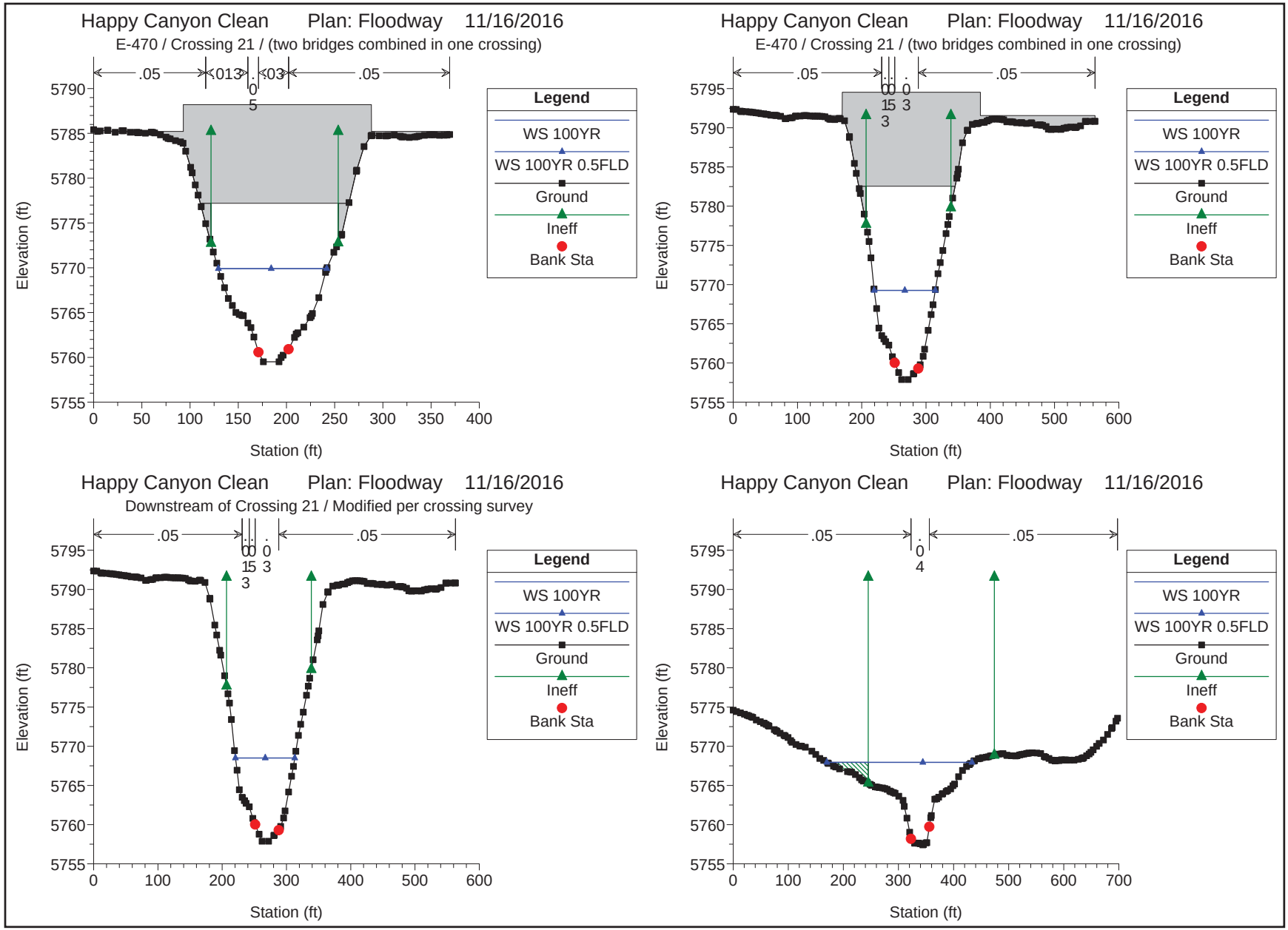

Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
.035
.03
.035
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Bank Sta
Elevation (ft)
Station (ft)


Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
.035
.03
.035
Legend
WS 100YR 0.5FLD
WS 100YR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

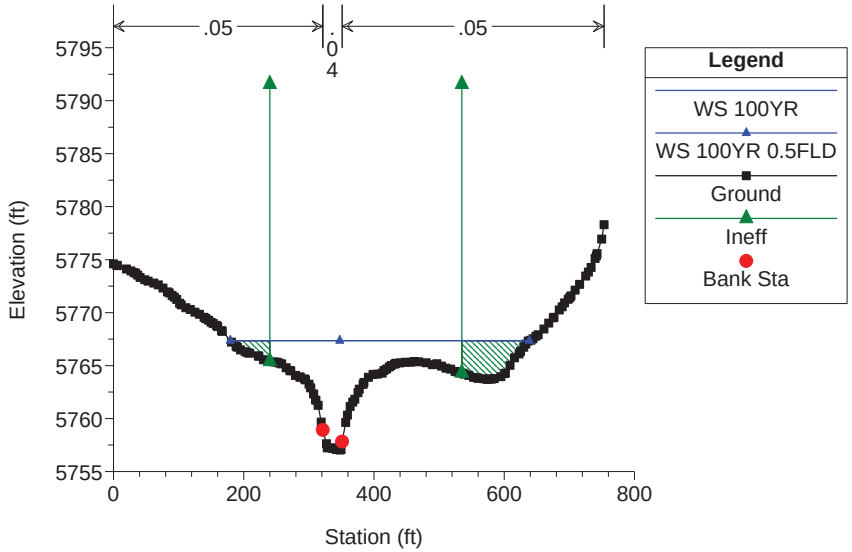

Happy Canyon Clean Plan: Floodway 11/16/2016
Contraction in LOB caused by chambers bridge (modeld as IEFA) /
.035
.03
.035
Legend
WS 100YR 0.5FLD
WS 100YR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Happy Canyon Clean Plan: Floodway 11/16/2016
ROB grading based on Chambers Res. design contours
.035
.03
.035
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)

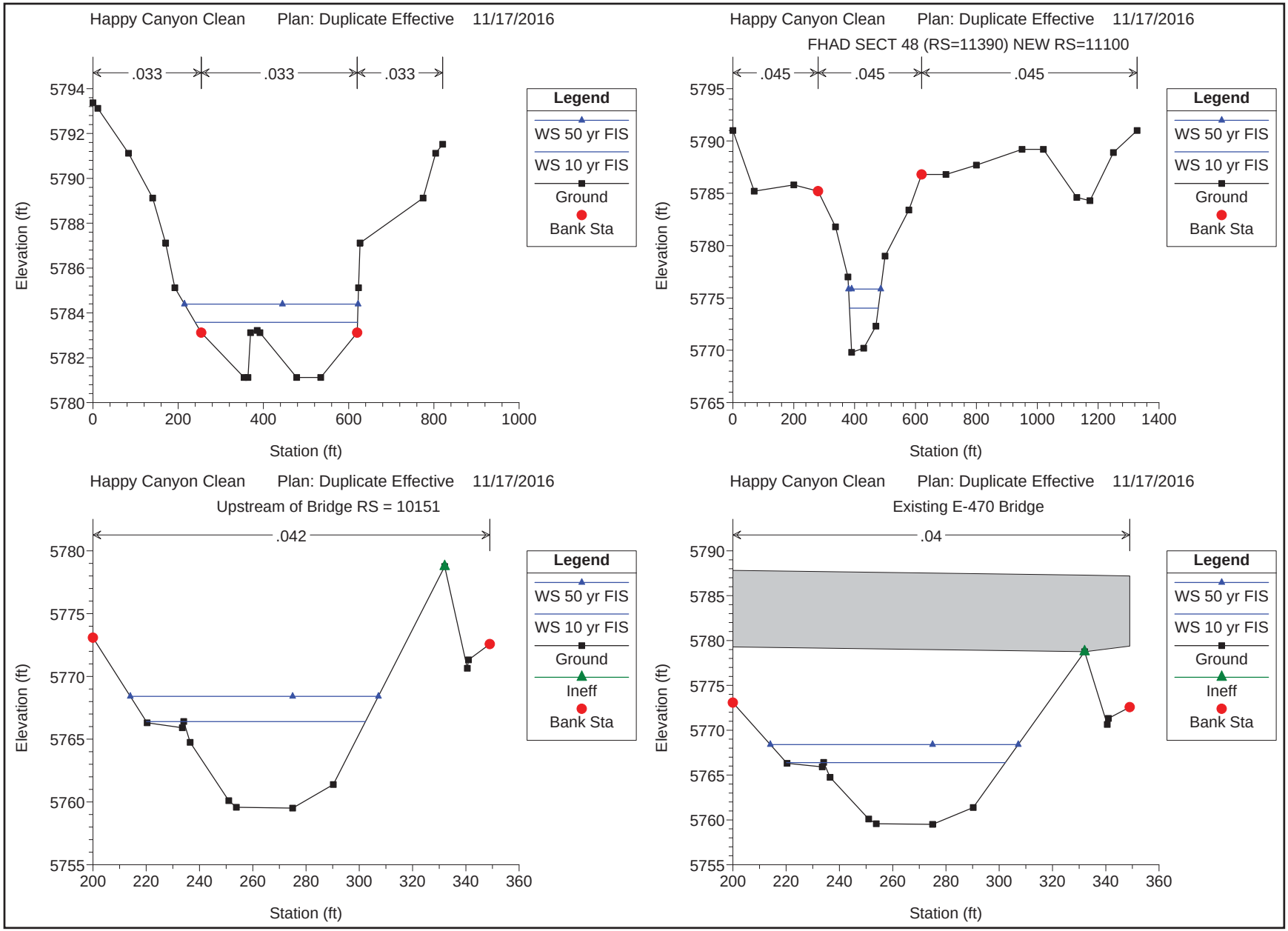

Happy Canyon Clean Plan: Floodway 11/16/2016
C-470 Bike Trail Crossing / Crossing 20 / (culverts assumed bloc
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR 0.5FLD
WS 100YR
Ground
Ineff
Bank Sta
Encroachment
Happy Canyon Clean Plan: Floodway 11/16/2016
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Bank Sta
Happy Canyon Clean Plan: Floodway 11/16/2016
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Floodway 11/16/2016
Upstream of Crossing 21 / Modified per crossing survey
.05
.013
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta

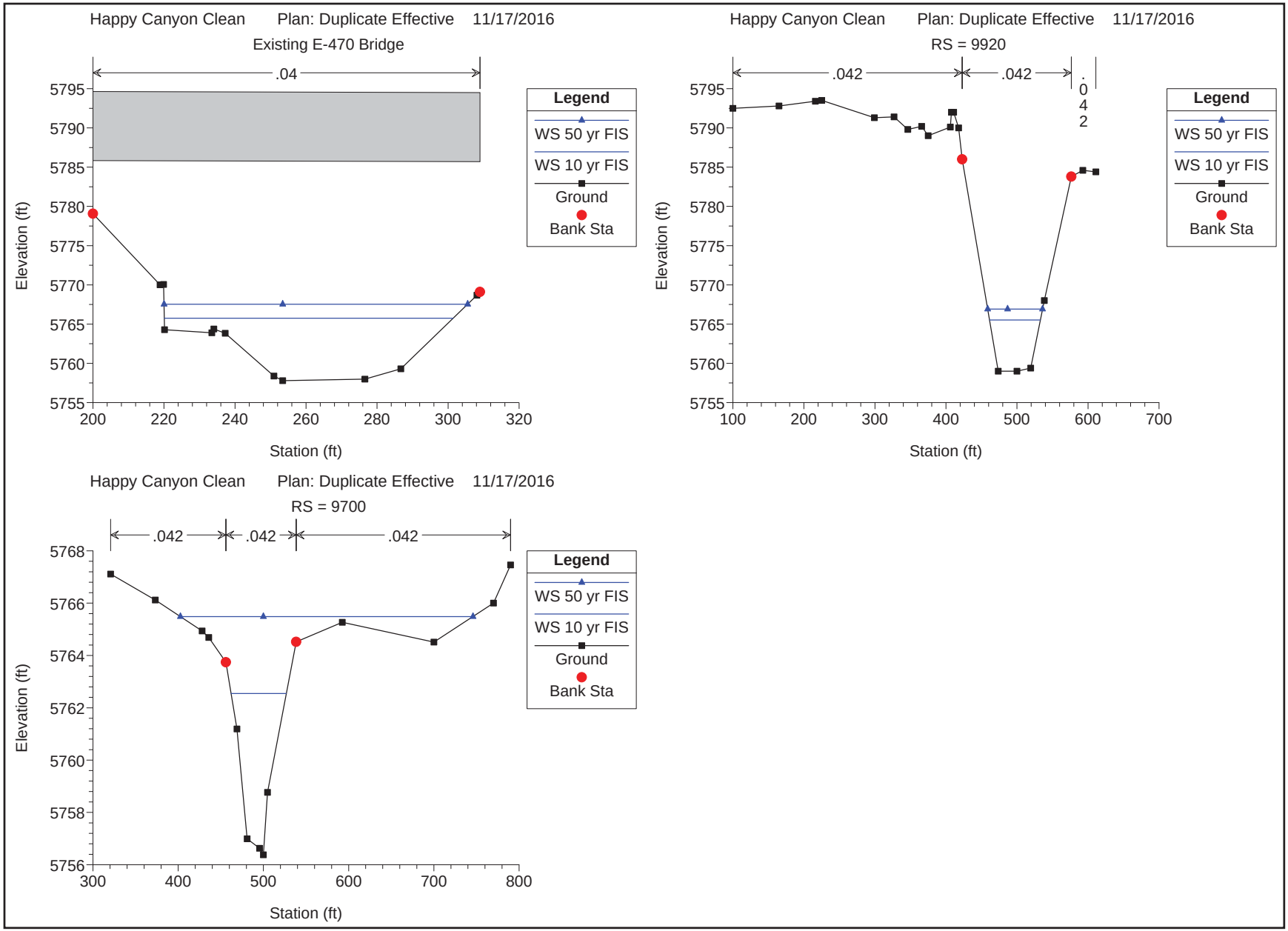

Happy Canyon Clean Plan: Floodway 11/16/2016
E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.013
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Floodway 11/16/2016
E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Floodway 11/16/2016
Downstream of Crossing 21 / Modified per crossing survey
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Floodway 11/16/2016
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
WS 100YR 0.5FLD
Ground
Ineff
Bank Sta

Happy Canyon Clean Plan: Floodway 11/16/2016

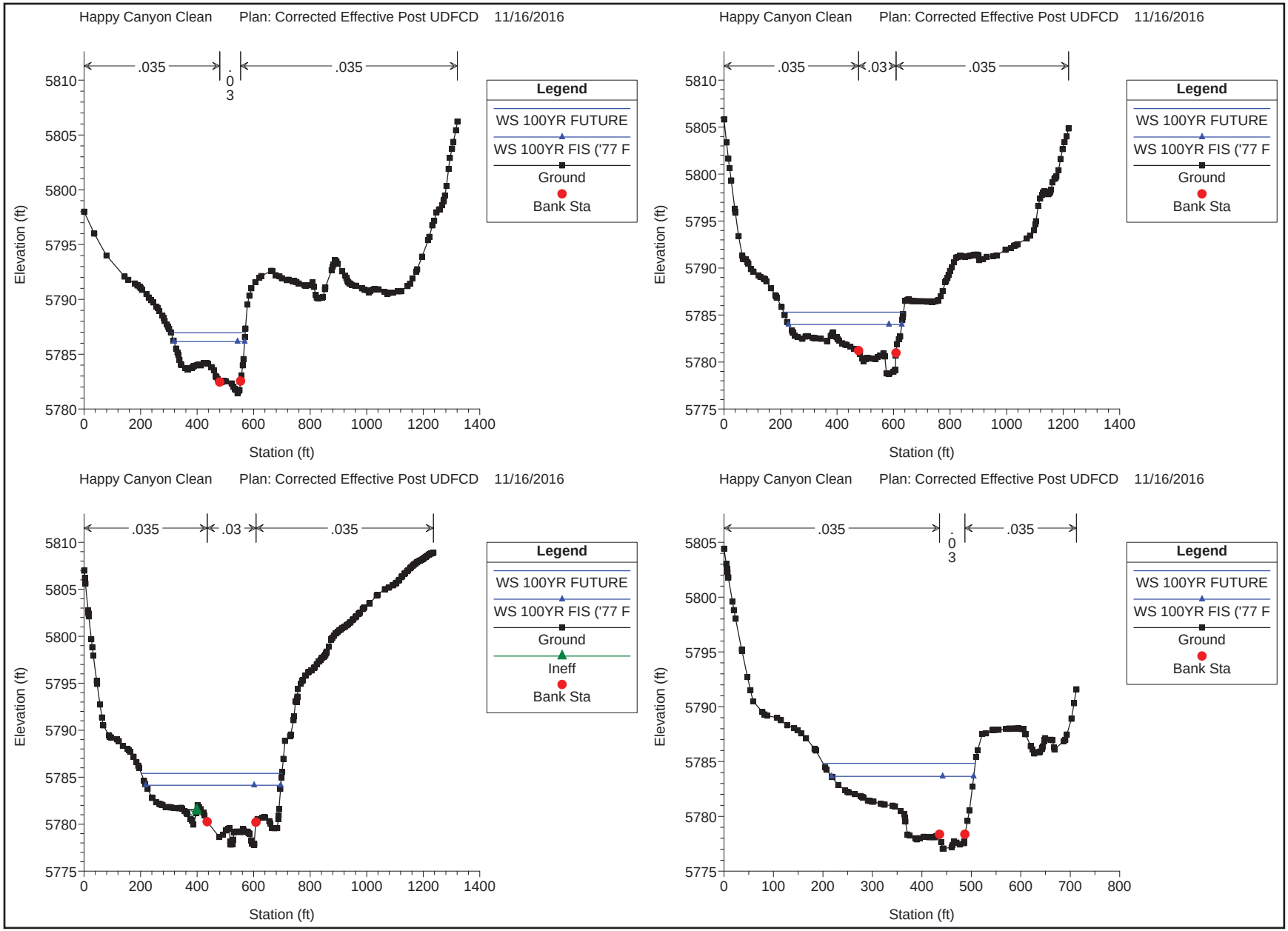


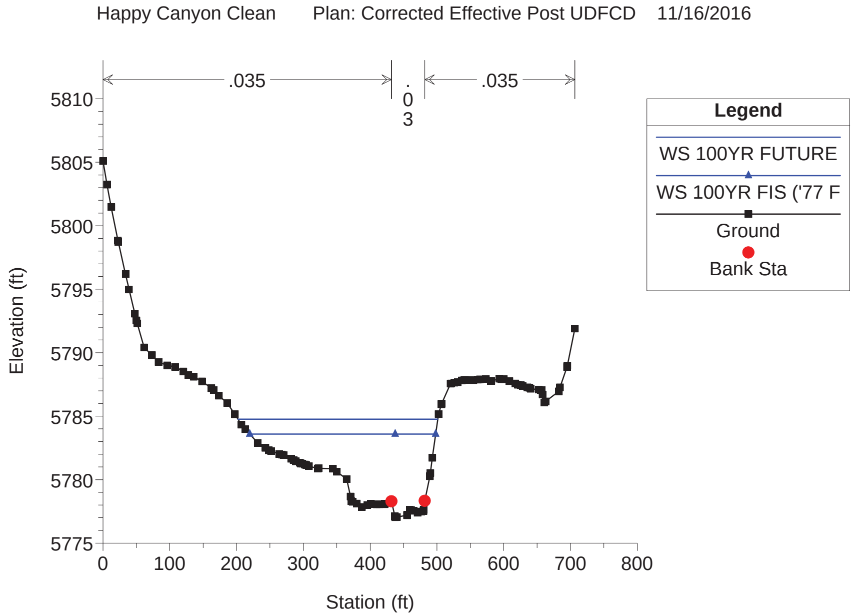
APPENDIX C. DUPLICATE EFFECTIVE MODEL (HEC-RAS MODEL)

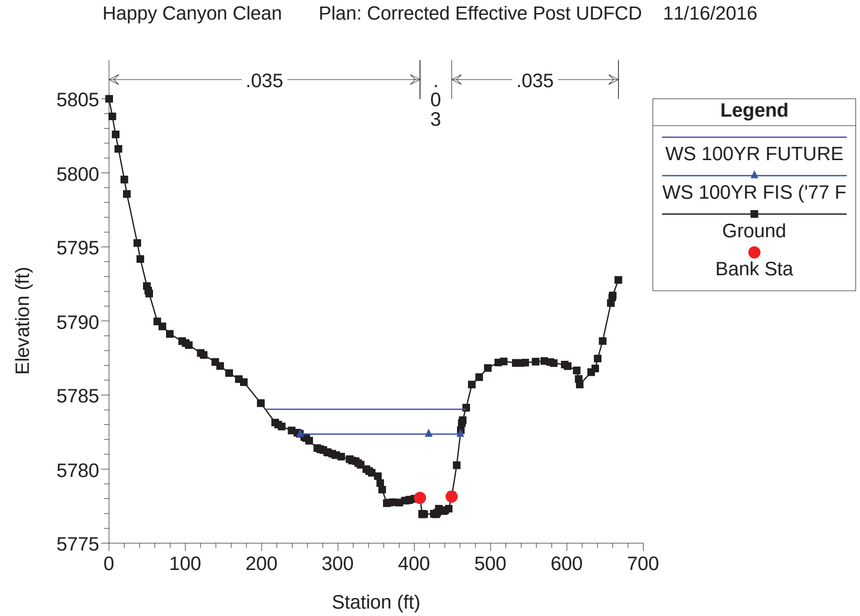

Happy Canyon Clean Plan: Duplicate Effective 11/17/2016
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 50 yr FIS
WS 10 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Duplicate Effective 11/17/2016
FHAD SECT 48 (RS=11390) NEW RS=11100
.045
.045
.045
Elevation (ft)
Station (ft)
Legend
WS 50 yr FIS
WS 10 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Duplicate Effective 11/17/2016
Upstream of Bridge RS = 10151
.042
Elevation (ft)
Station (ft)
Legend
WS 50 yr FIS
WS 10 yr FIS
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Duplicate Effective 11/17/2016
Existing E-470 Bridge
.04
Elevation (ft)
Station (ft)
Legend
WS 50 yr FIS
WS 10 yr FIS
Ground
Ineff
Bank Sta

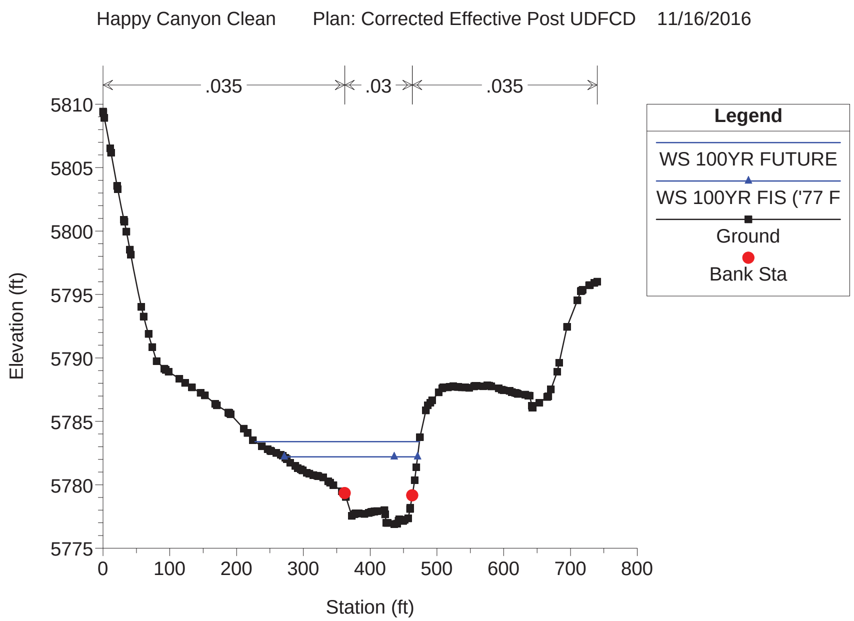

Happy Canyon Clean Plan: Duplicate Effective 11/17/2016
Existing E-470 Bridge
.04
Elevation (ft)
Station (ft)
Legend
WS 50 yr FIS
WS 10 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Duplicate Effective 11/17/2016
RS = 9920
.042
.042
.042
Elevation (ft)
Station (ft)
Legend
WS 50 yr FIS
WS 10 yr FIS
Ground
Bank Sta
Happy Canyon Clean Plan: Duplicate Effective 11/17/2016
RS = 9700
.042
.042
.042
Elevation (ft)
Station (ft)
Legend
WS 50 yr FIS
WS 10 yr FIS
Ground
Bank Sta

APPENDIX D. CORRECTED EFFECTIVE MODEL (HEC-RAS MODEL)


Happy Canyon Clean
Plan: Corrected Effective Post UDFCD
11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Ineff
Elevation (ft)
Station (ft)


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
Station (ft)
5810
5805
5800
5795
5790
5785
5780
5775
0
100
200
300
400
500
600
700
800


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
Station (ft)
5805
5800
5795
5790
5785
5780
5775
0
100
200
300
400
500
600
700


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
Station (ft)
5810
5805
5800
5795
5790
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5775
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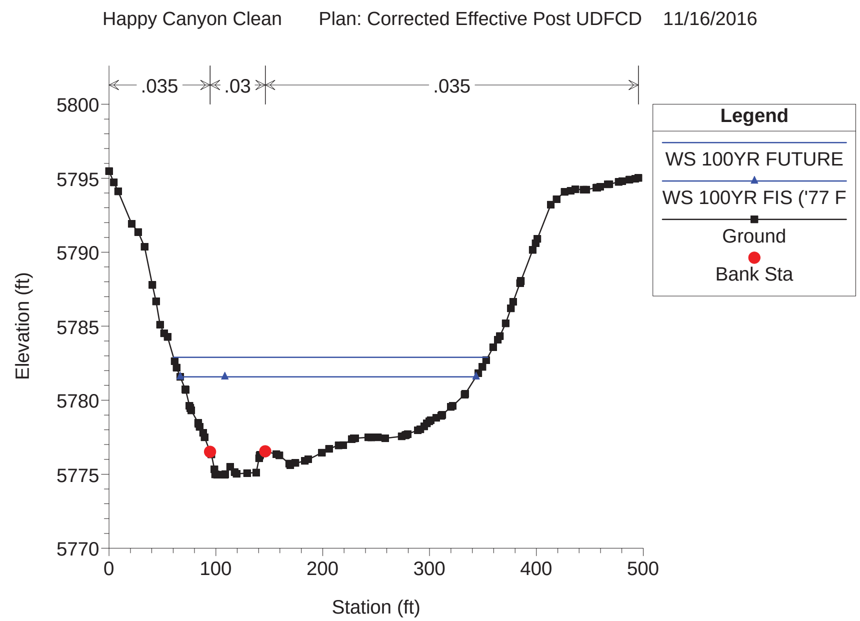
100
200
300
400
500
600
700
800


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
Station (ft)
5800
5795
5790
5785
5780
5775
5770
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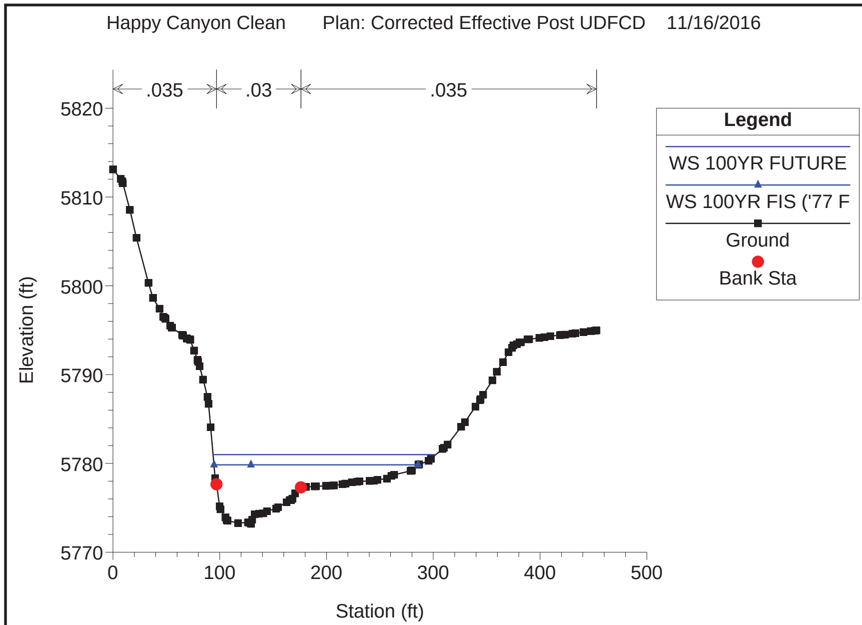
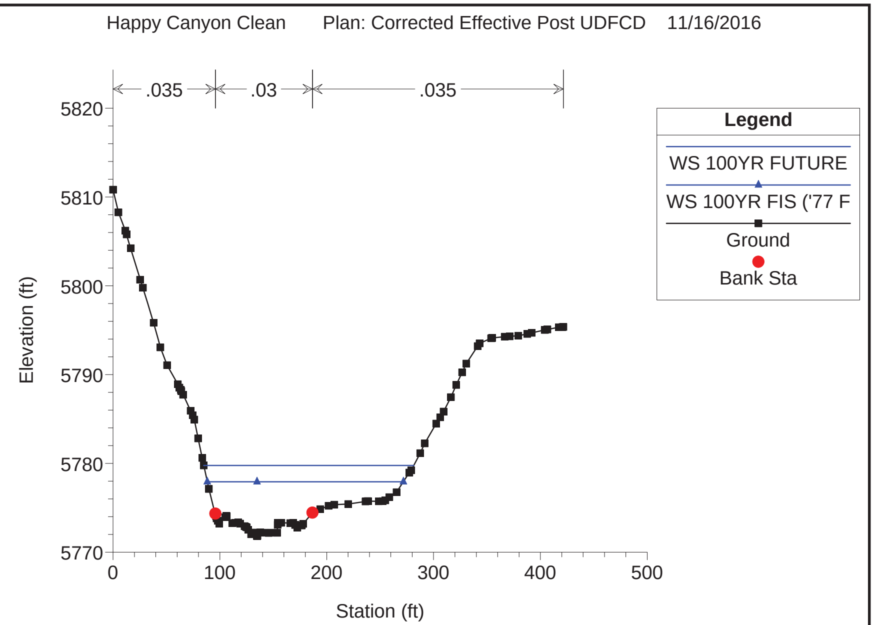
200
300
400
500


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
5770
5780
5790
5800
5810
5820
Station (ft)
0
100
200
300
400
500


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
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WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
5770
5780
5790
5800
5810
5820
Station (ft)
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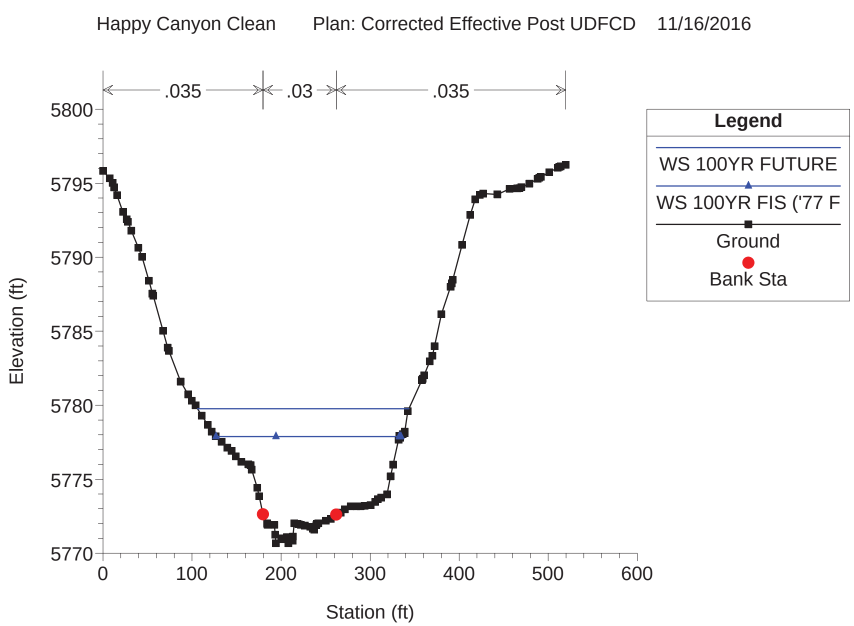
100
200
300
400
500


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
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5775
5780
5785
5790
5795
5800
Station (ft)
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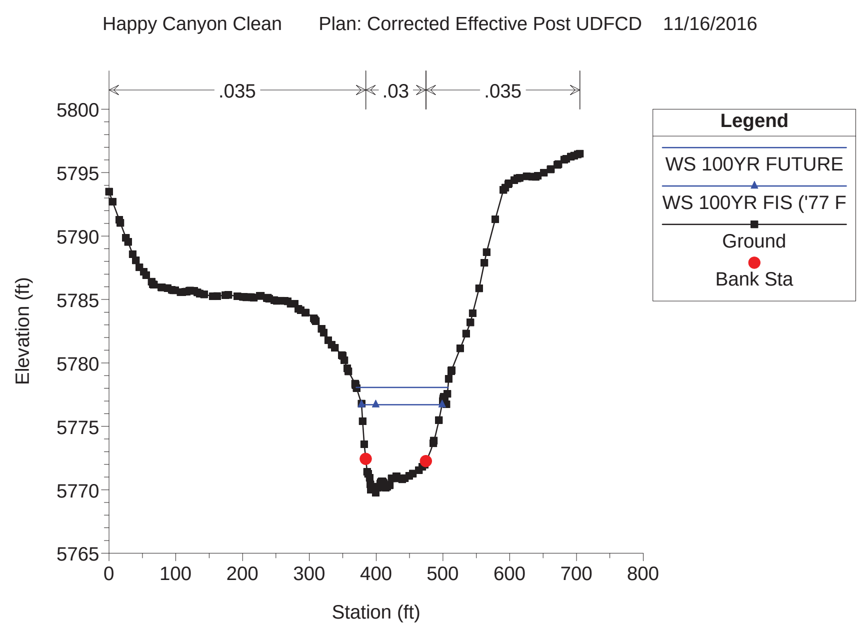
100
200
300
400
500
600


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
5765
5770
5775
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5790
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5800
Station (ft)
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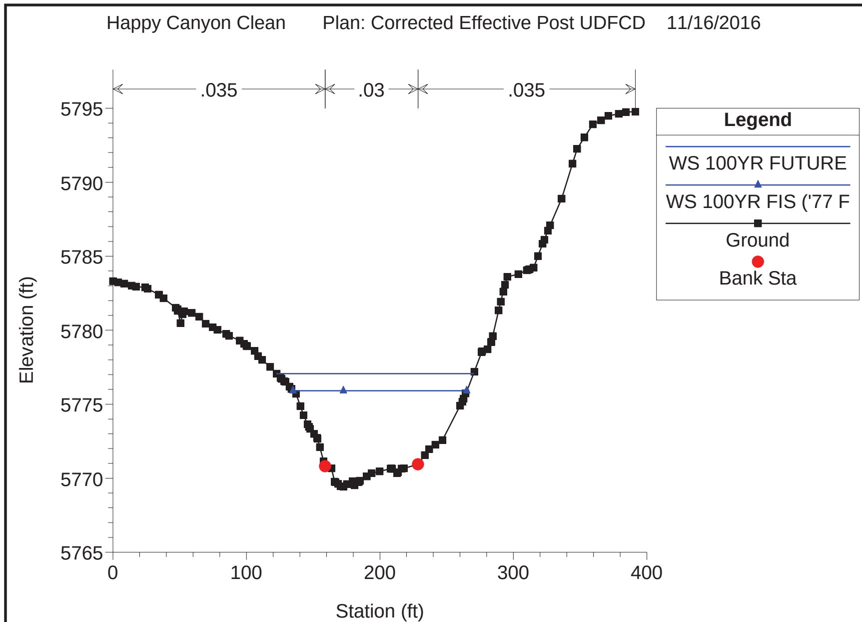
700
800


Happy Canyon Clean
Plan: Corrected Effective Post UDFCD
11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
5795
5790
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5780
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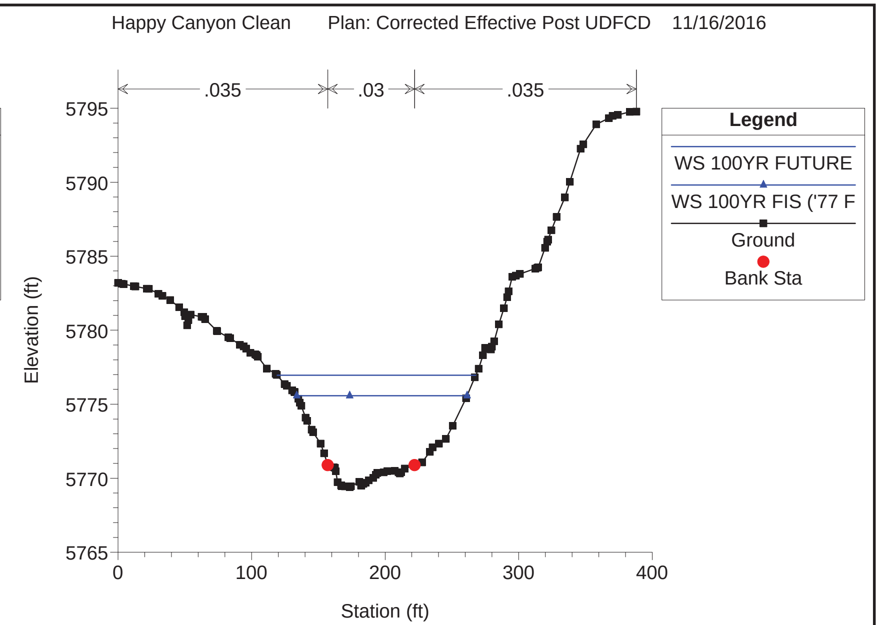
0
100
200
300
400
Station (ft)


Happy Canyon Clean
Plan: Corrected Effective Post UDFCD
11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
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5790
5785
5780
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0
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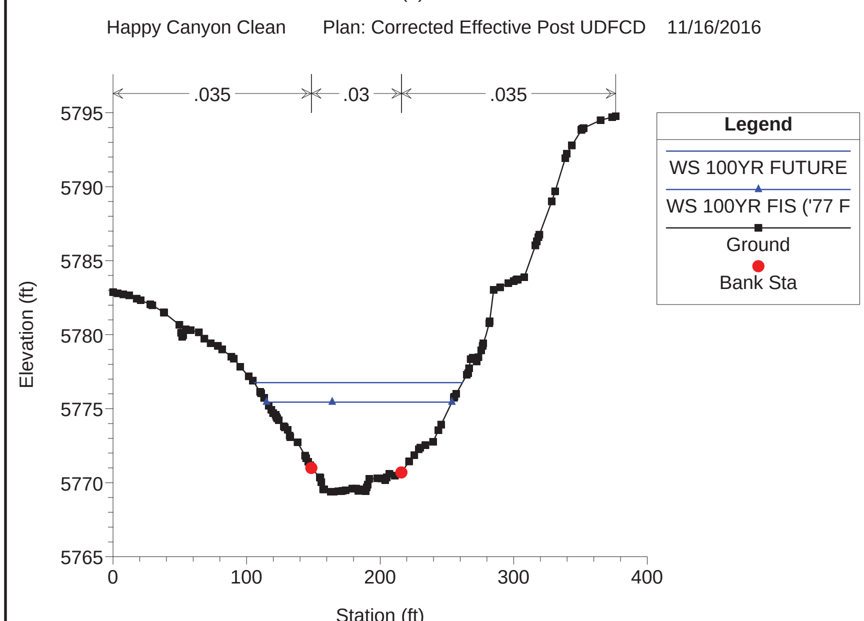
200
300
400
Station (ft)


Happy Canyon Clean
Plan: Corrected Effective Post UDFCD
11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
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5780
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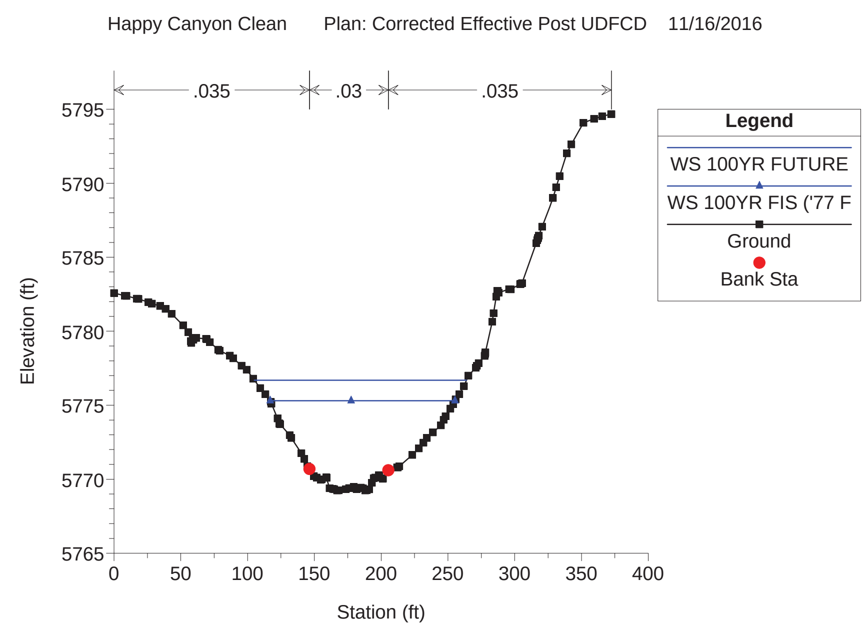
100
200
300
400
Station (ft)


Happy Canyon Clean
Plan: Corrected Effective Post UDFCD
11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
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5780
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150
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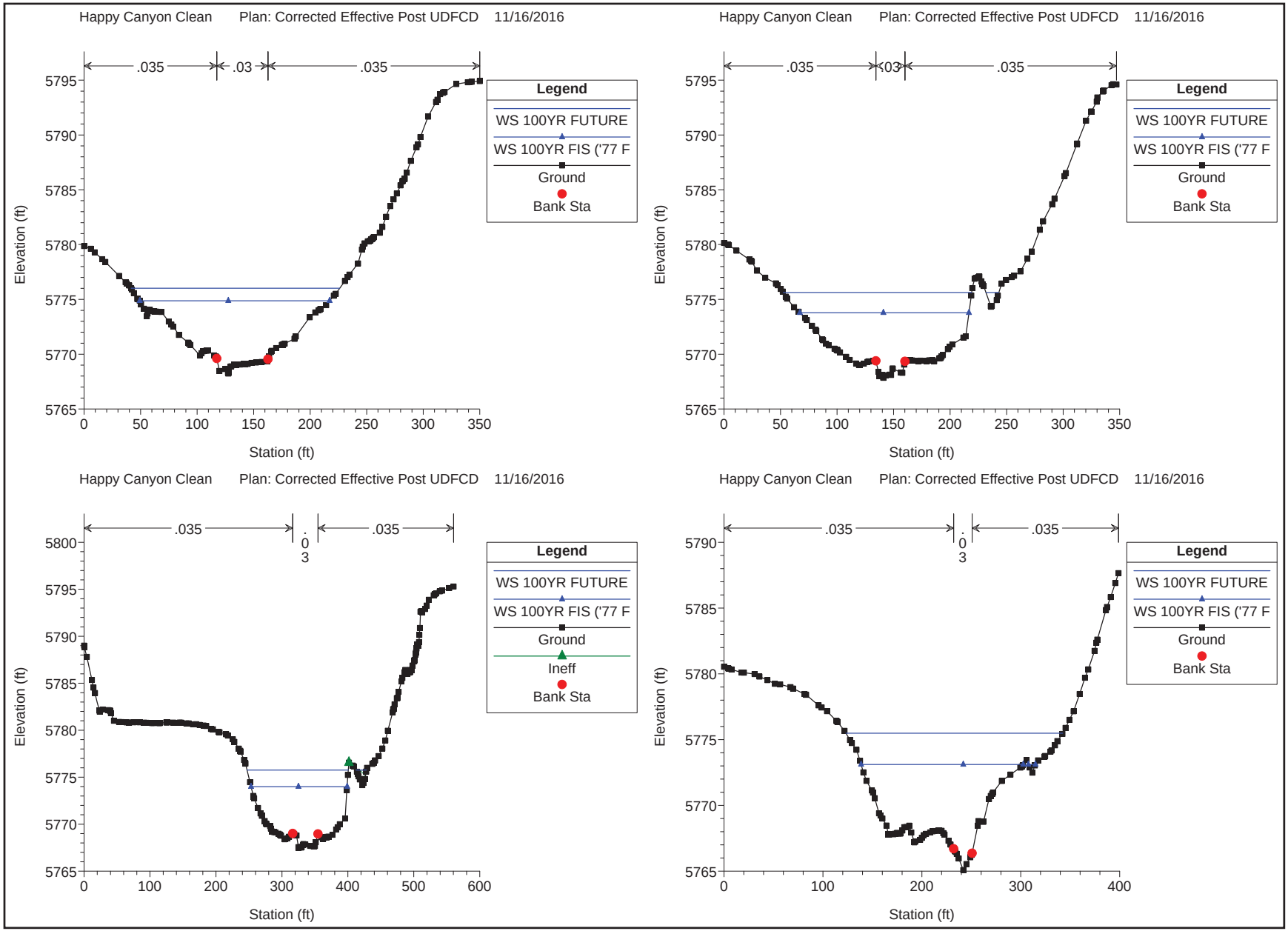
250
300
350
400
Station (ft)


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
Station (ft)
5795
5790
5785
5780
5775
5770
5765
0
50
100
150
200
250
300
350
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
Station (ft)
5795
5790
5785
5780
5775
5770
5765
0
50
100
150
200
250
300
350
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
5800
5795
5790
5785
5780
5775
5770
5765
0
100
200
300
400
500
600
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Elevation (ft)
Station (ft)
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5785
5780
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5770
5765
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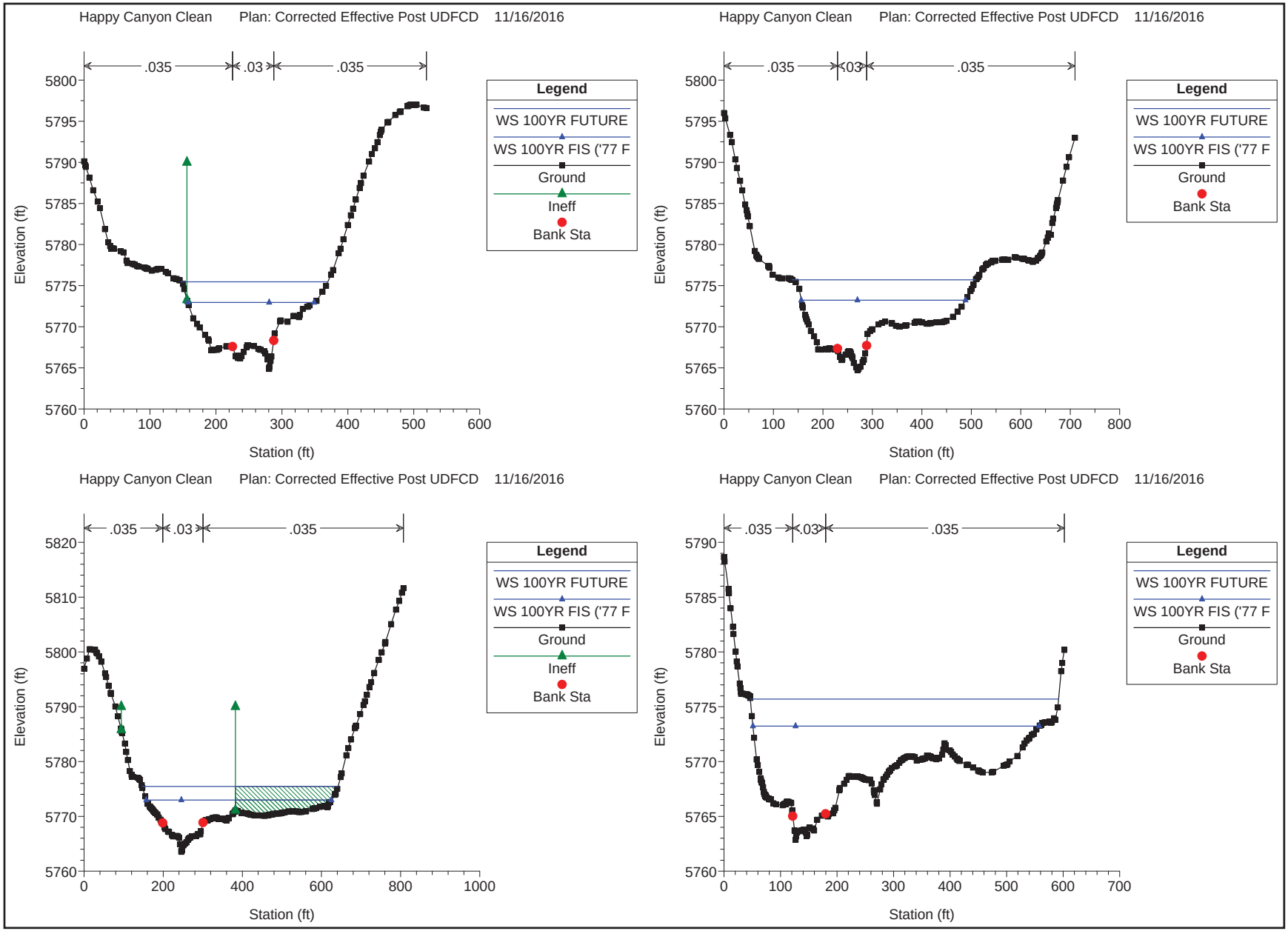
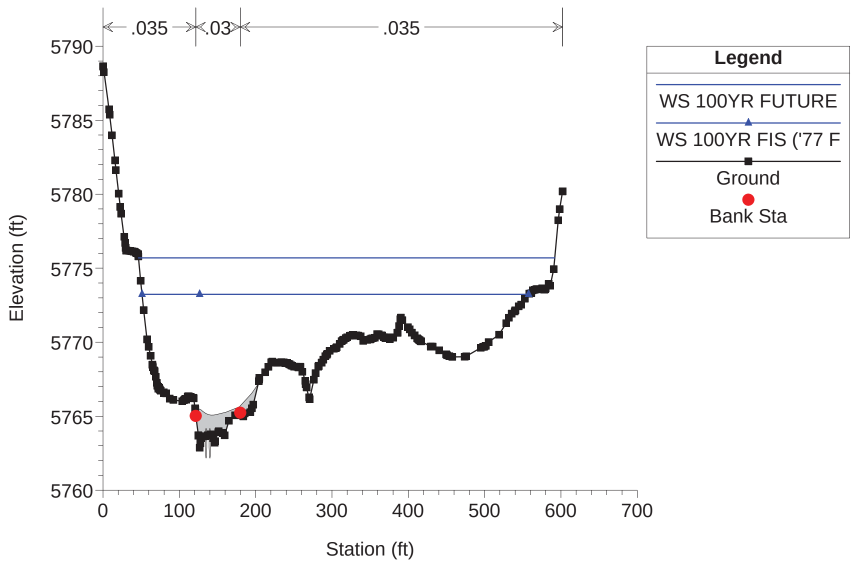
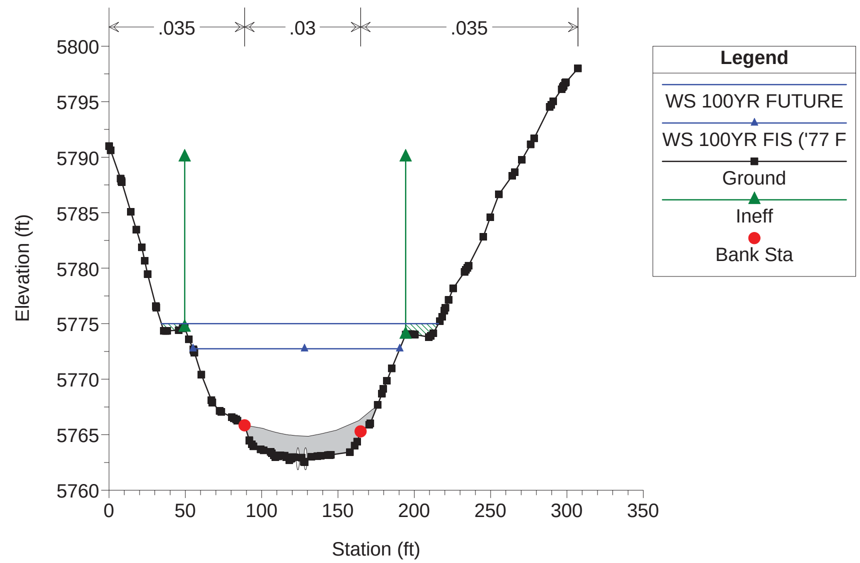
100
200
300
400


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta

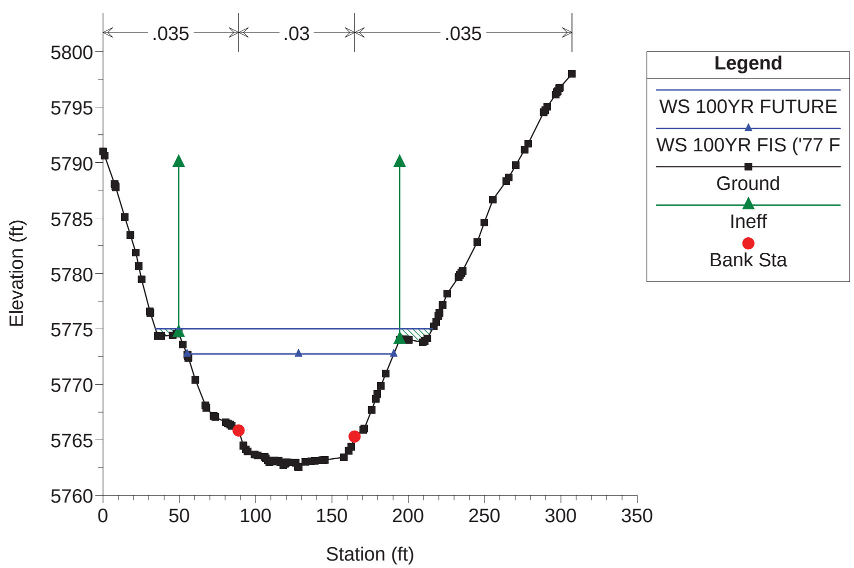
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016



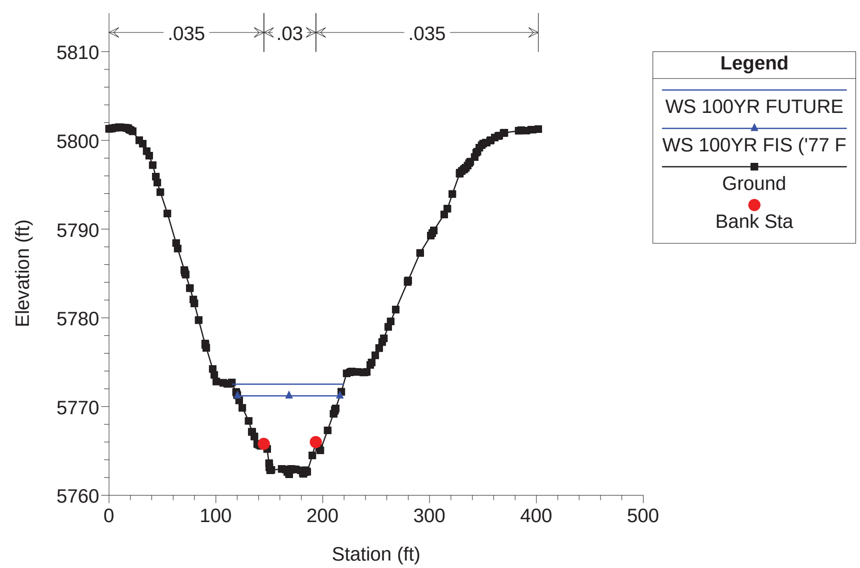
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016

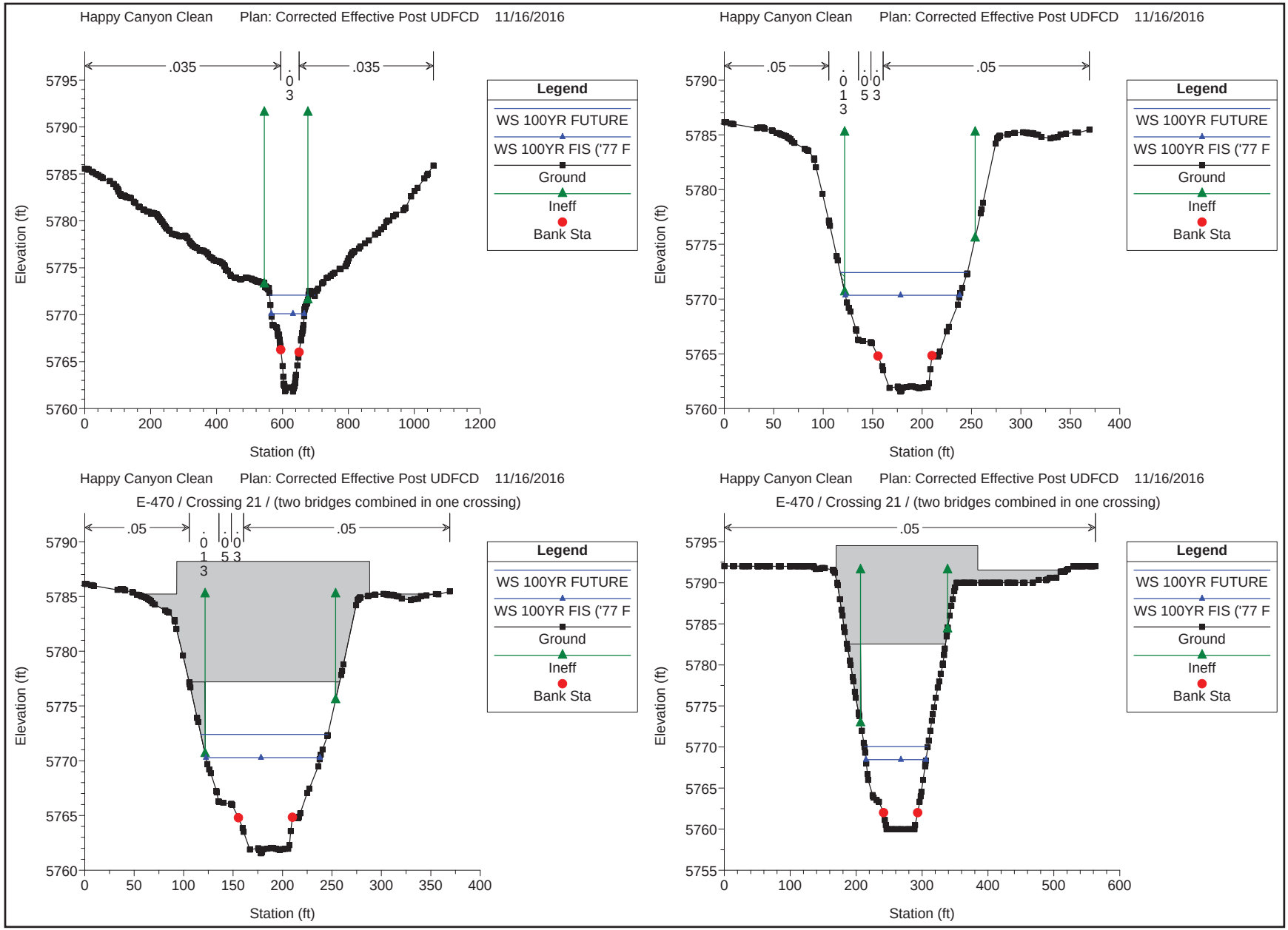


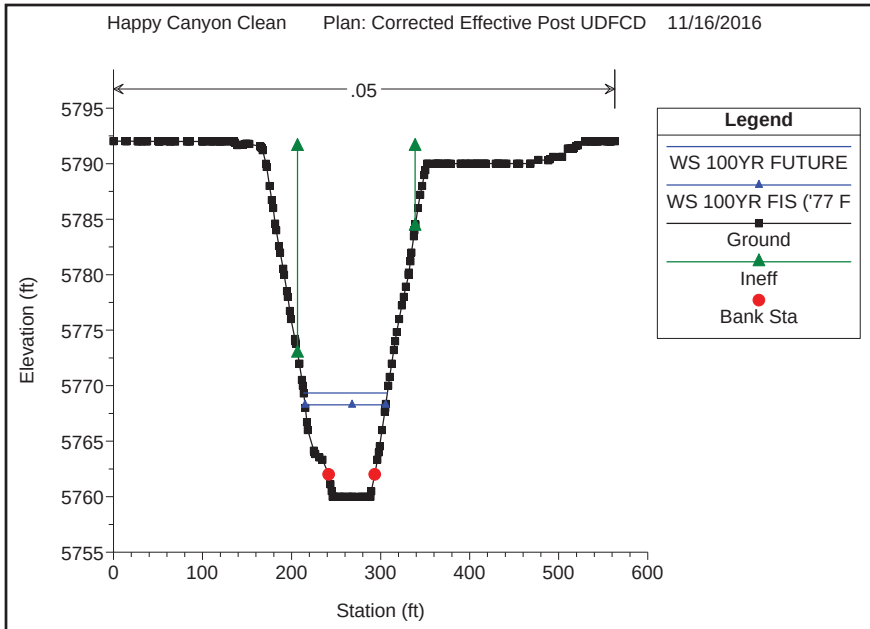
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016



Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016




Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.05
.013
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.013
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta
Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.05
Elevation (ft)
Station (ft)
Legend
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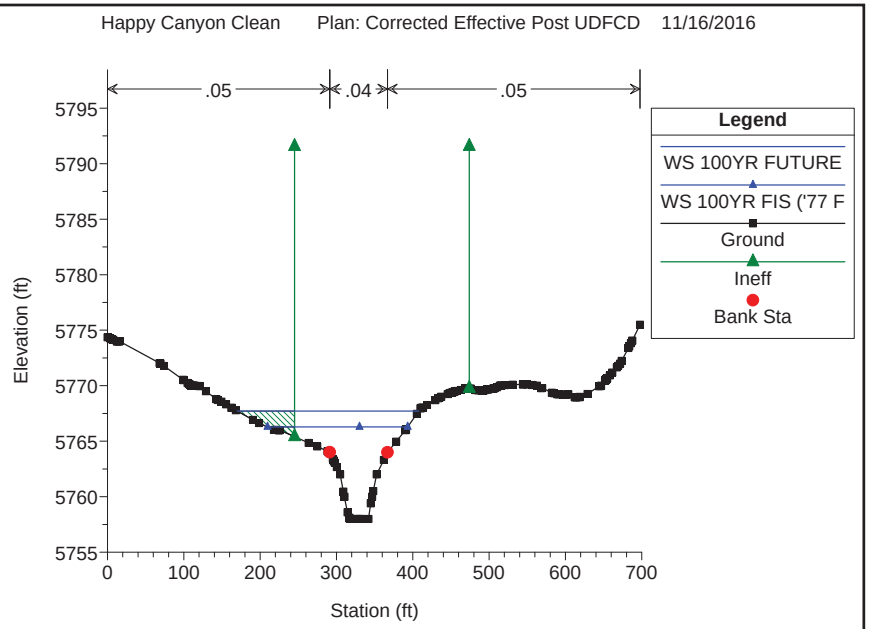
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.05
.04
.05
Elevation (ft)
Station (ft)
Legend
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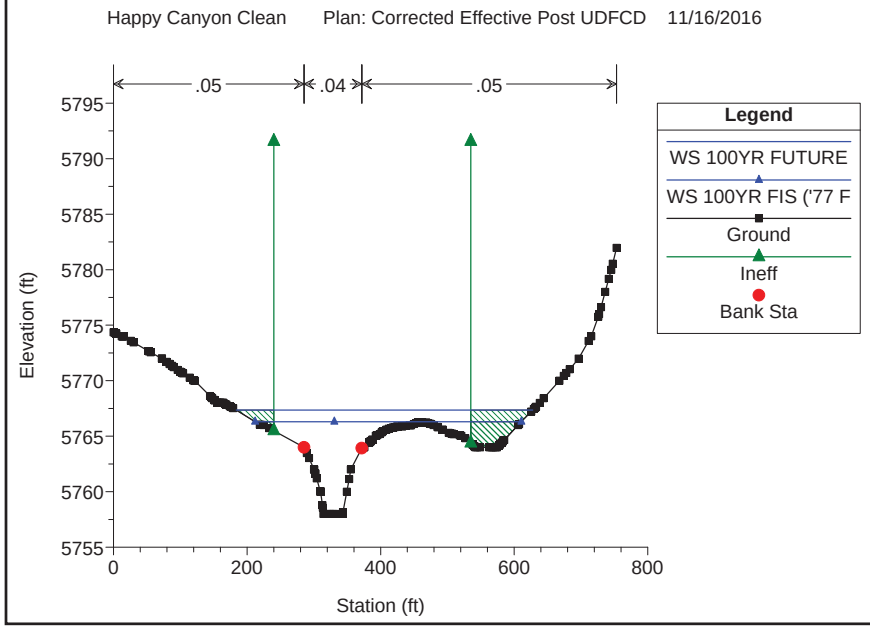
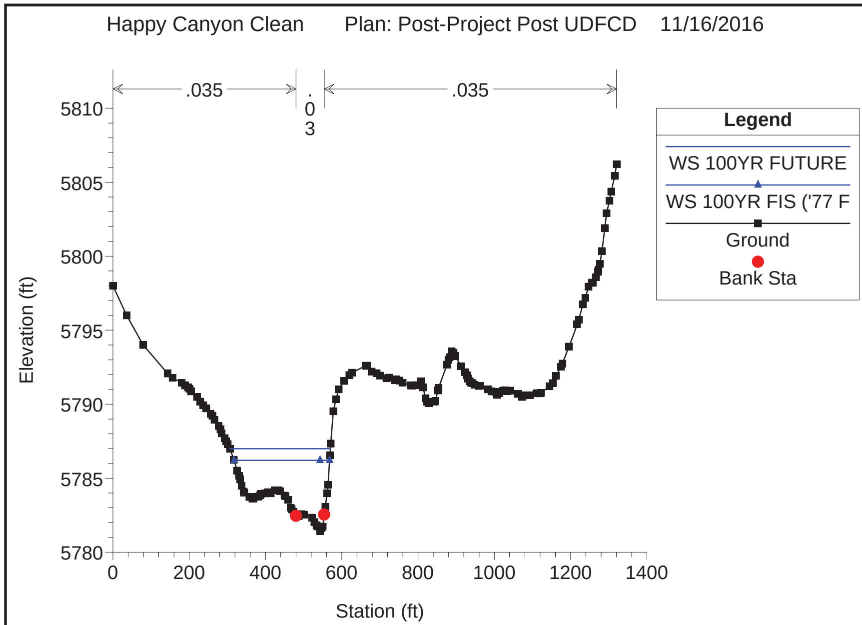
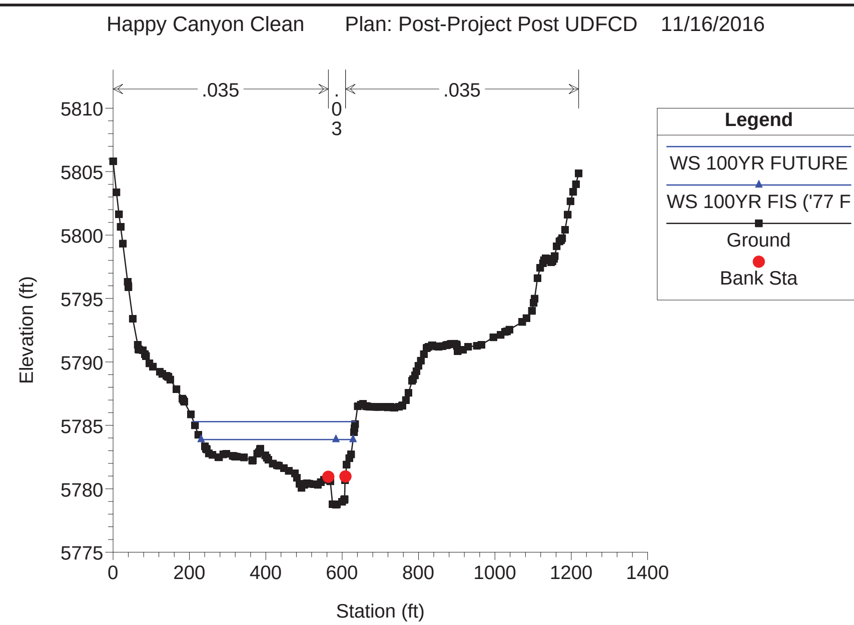
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta


Happy Canyon Clean Plan: Corrected Effective Post UDFCD 11/16/2016
.05
.04
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Ineff
Bank Sta

APPENDIX E. POST-PROJECT MODEL (HEC-RAS MODEL)


Happy Canyon Clean Plan: Post-Project Post UDFCD 11/16/2016
.035
.03
.035
Elevation (ft)
5780
5785
5790
5795
5800
5805
5810
0
200
400
600
800
1000
1200
1400
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta


Happy Canyon Clean Plan: Post-Project Post UDFCD 11/16/2016
.035
.03
.035
Elevation (ft)
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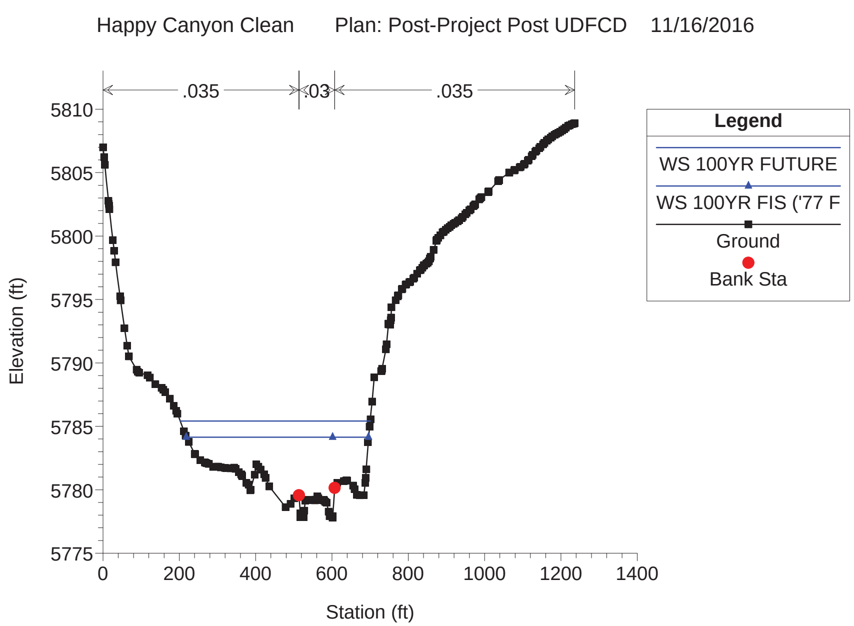
5785
5790
5795
5800
5805
5810
0
200
400
600
800
1000
1200
1400
Station (ft)
Legend
WS 100YR FUTURE
WS 100YR FIS ('77 F
Ground
Bank Sta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Station (ft)
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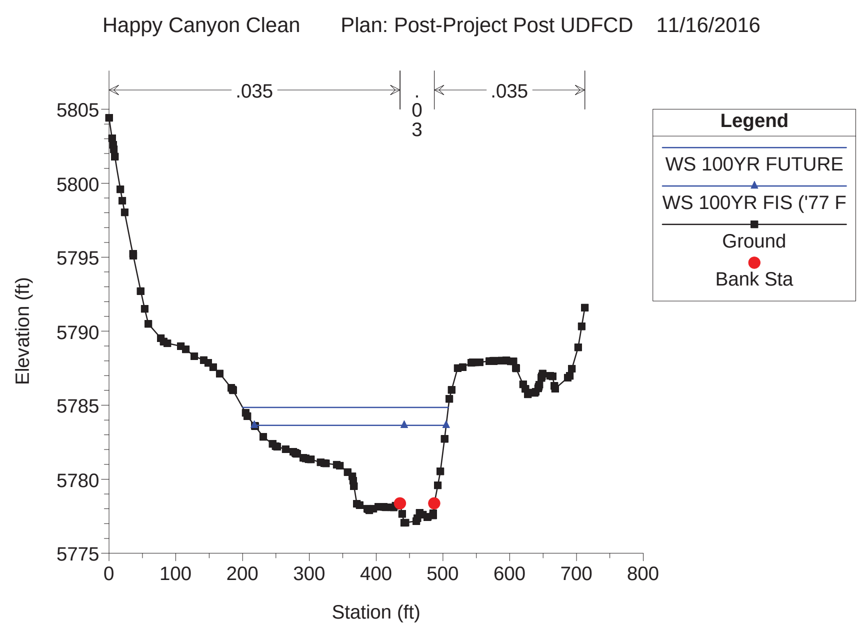
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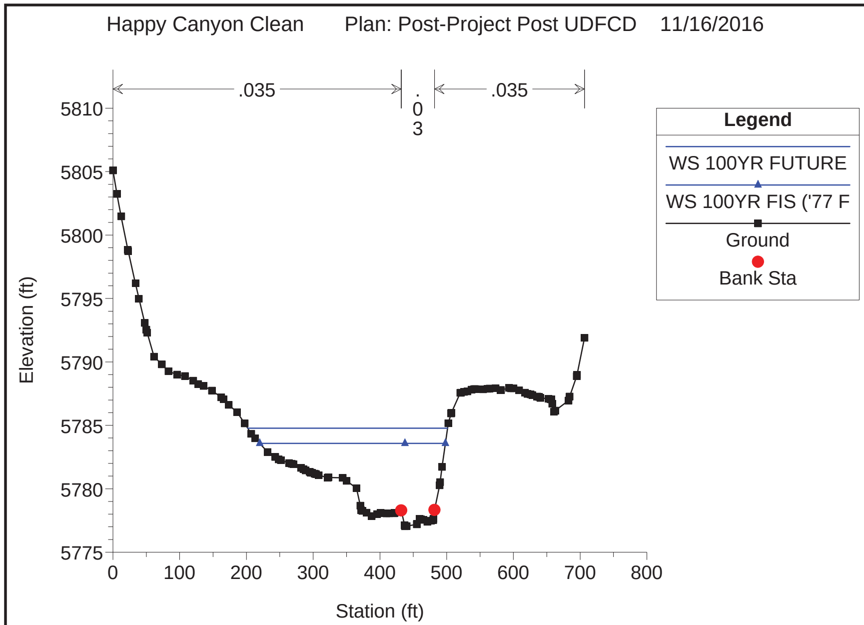
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Plan: Post-Project Post UDFCD
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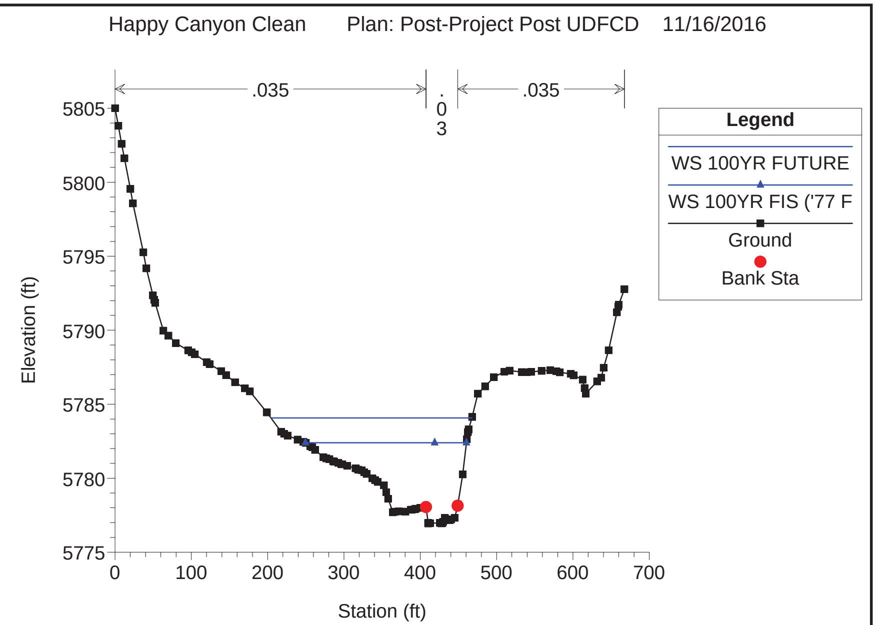
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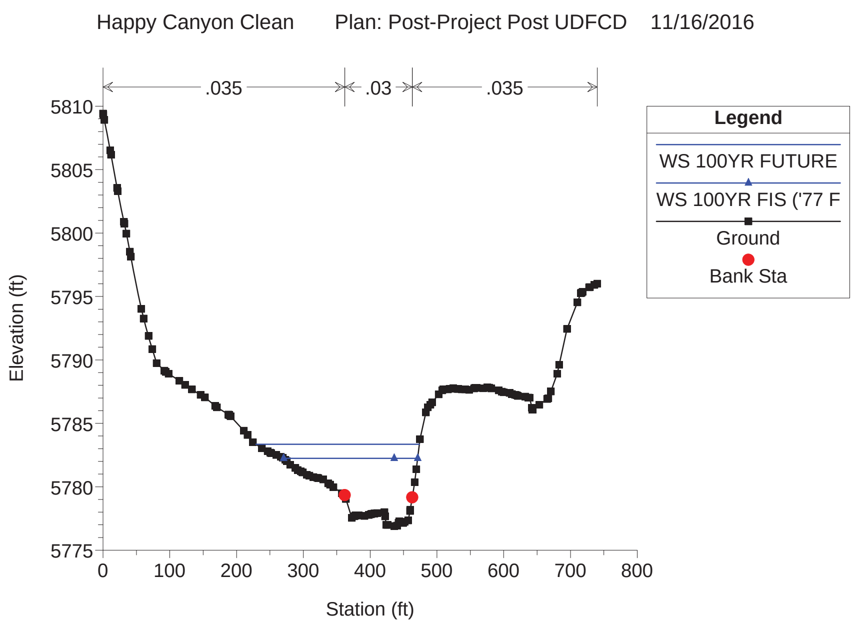
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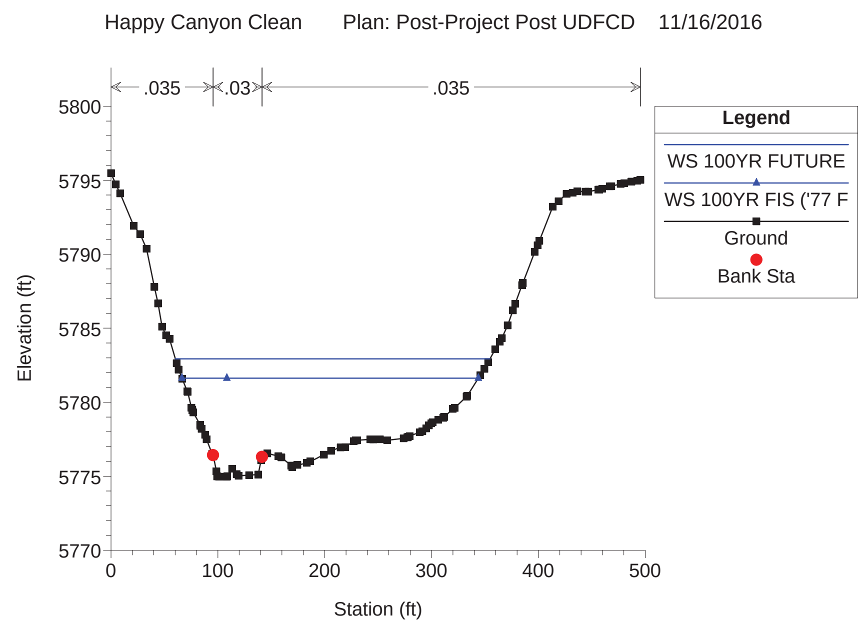
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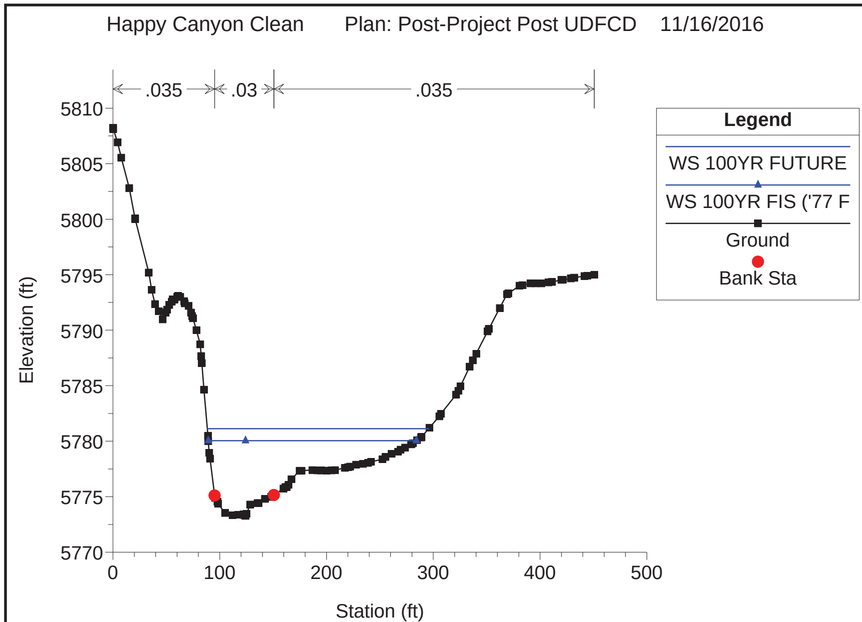
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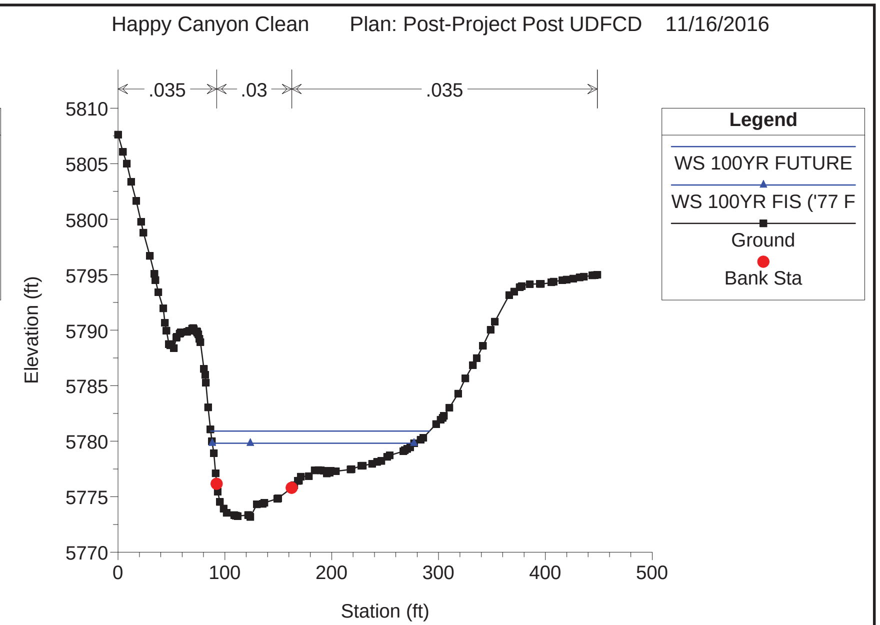
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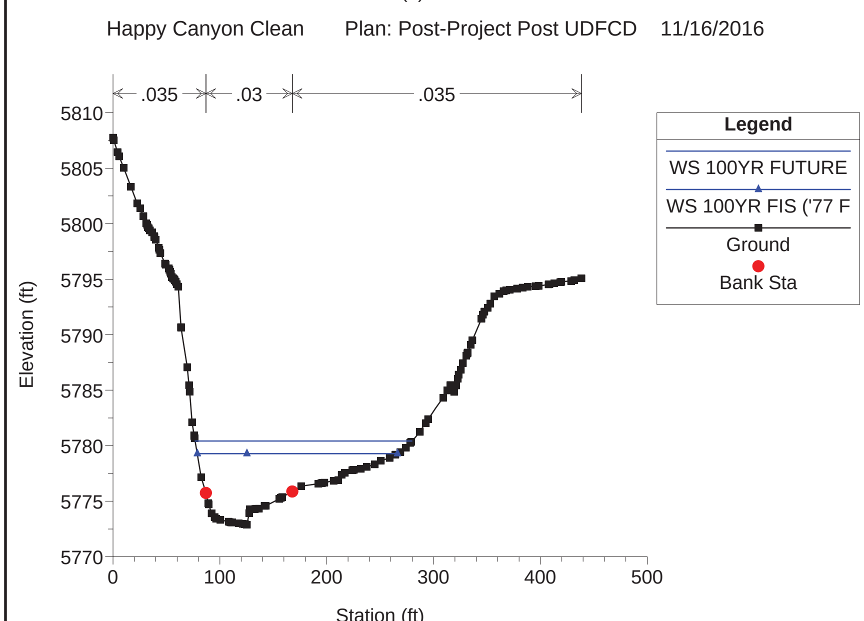
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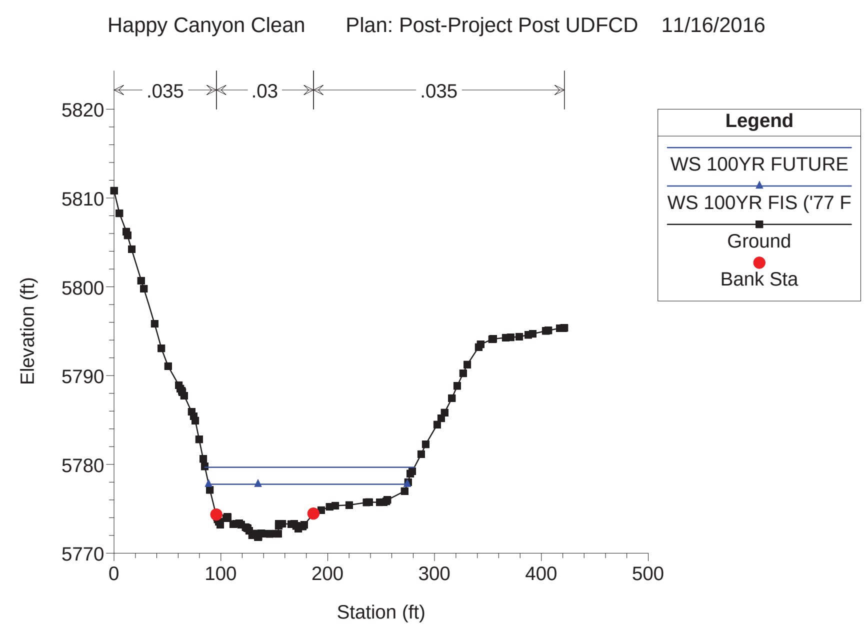
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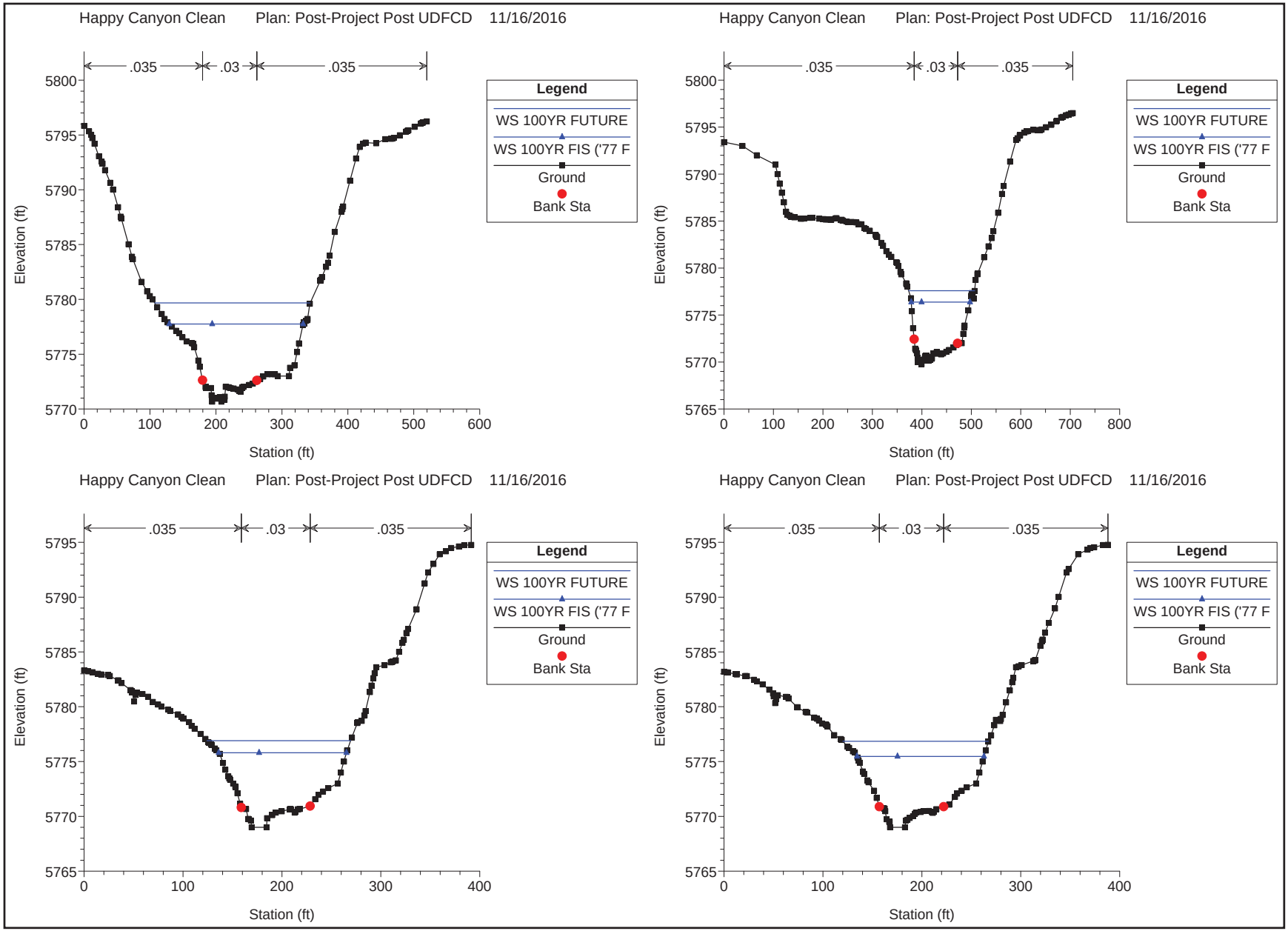
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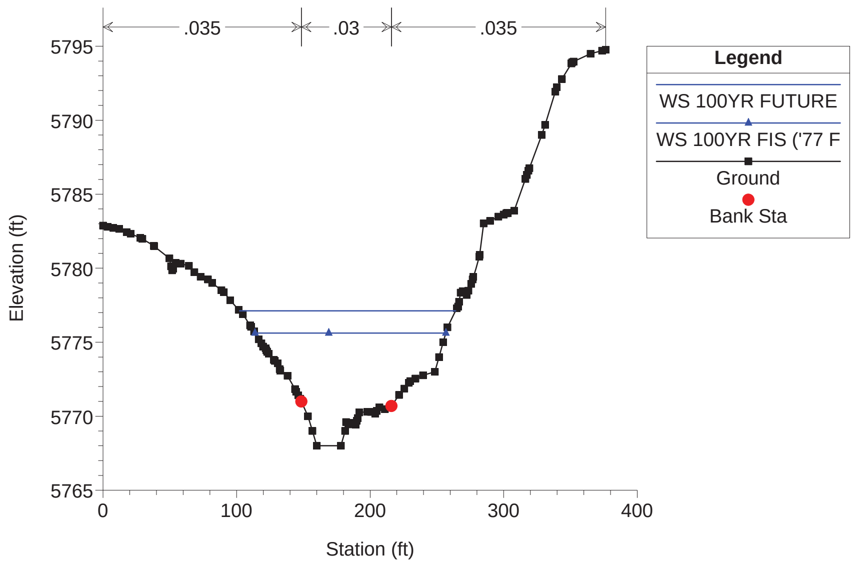
Happy Canyon Clean Plan: Post-Project Post UDFCD 11/16/2016



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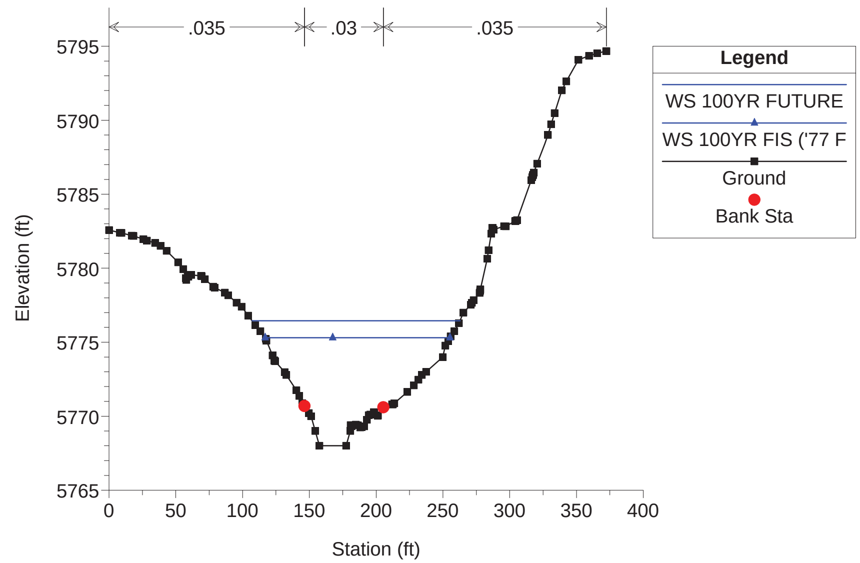

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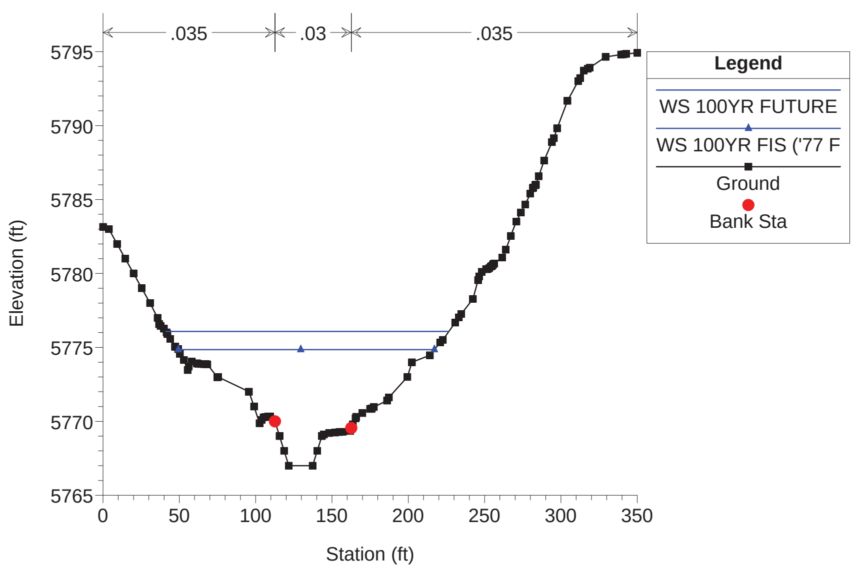

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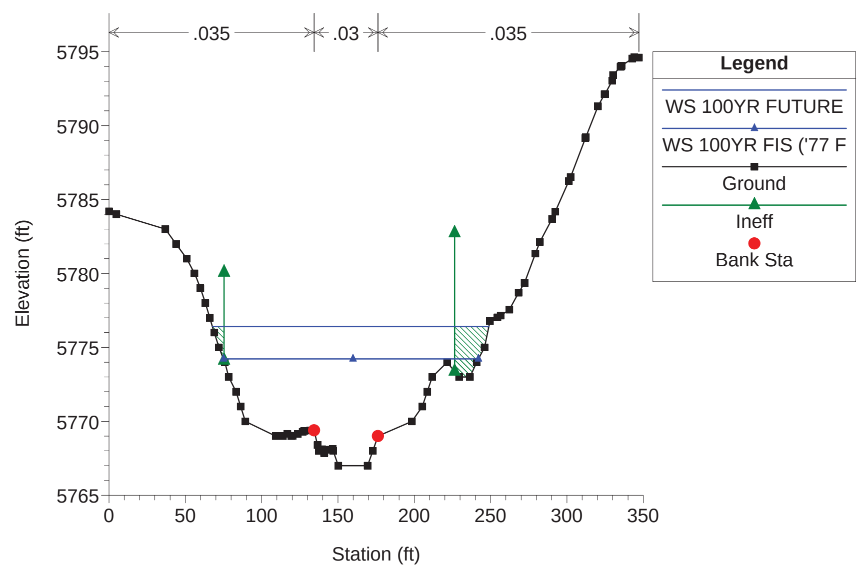

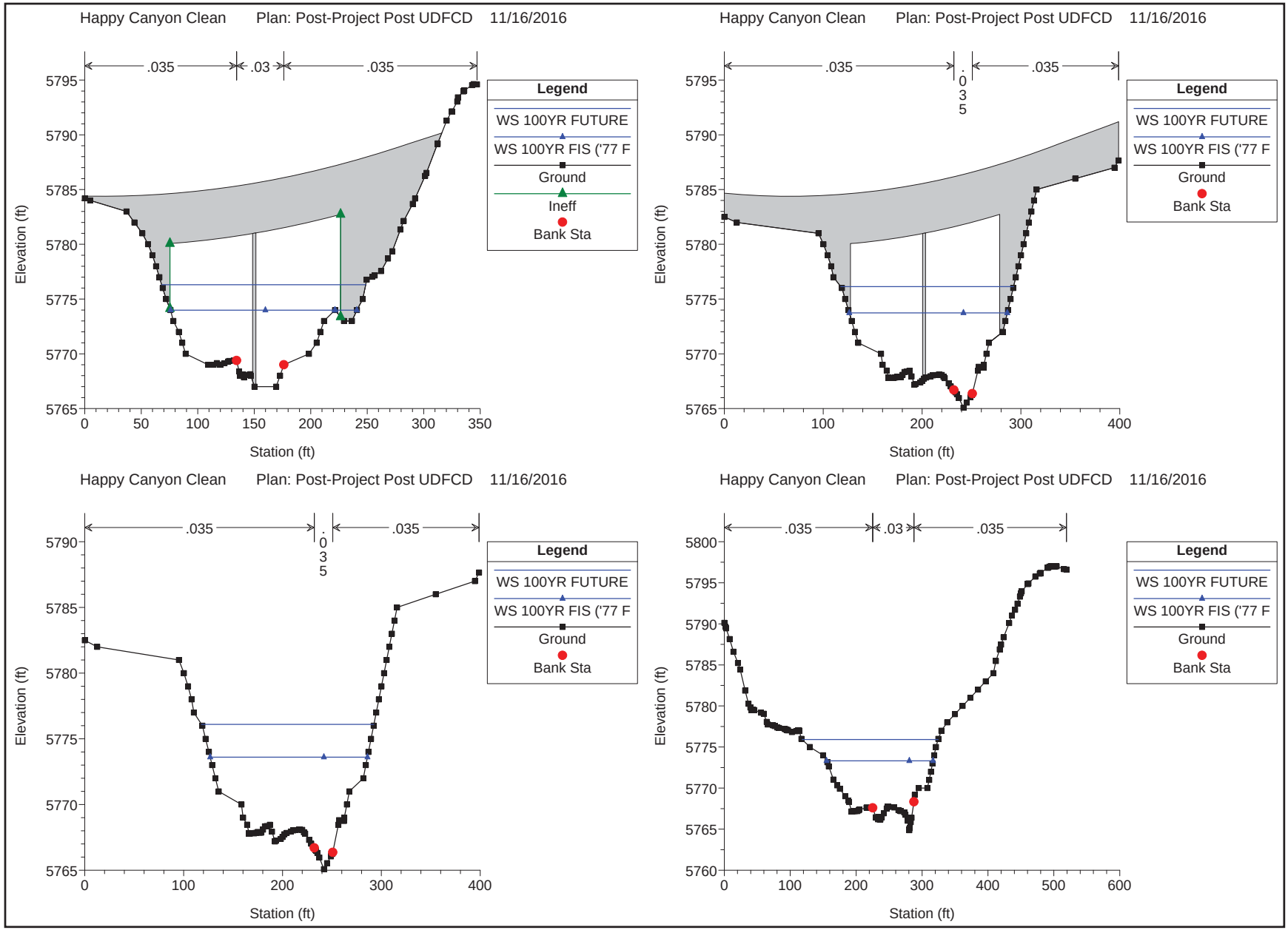
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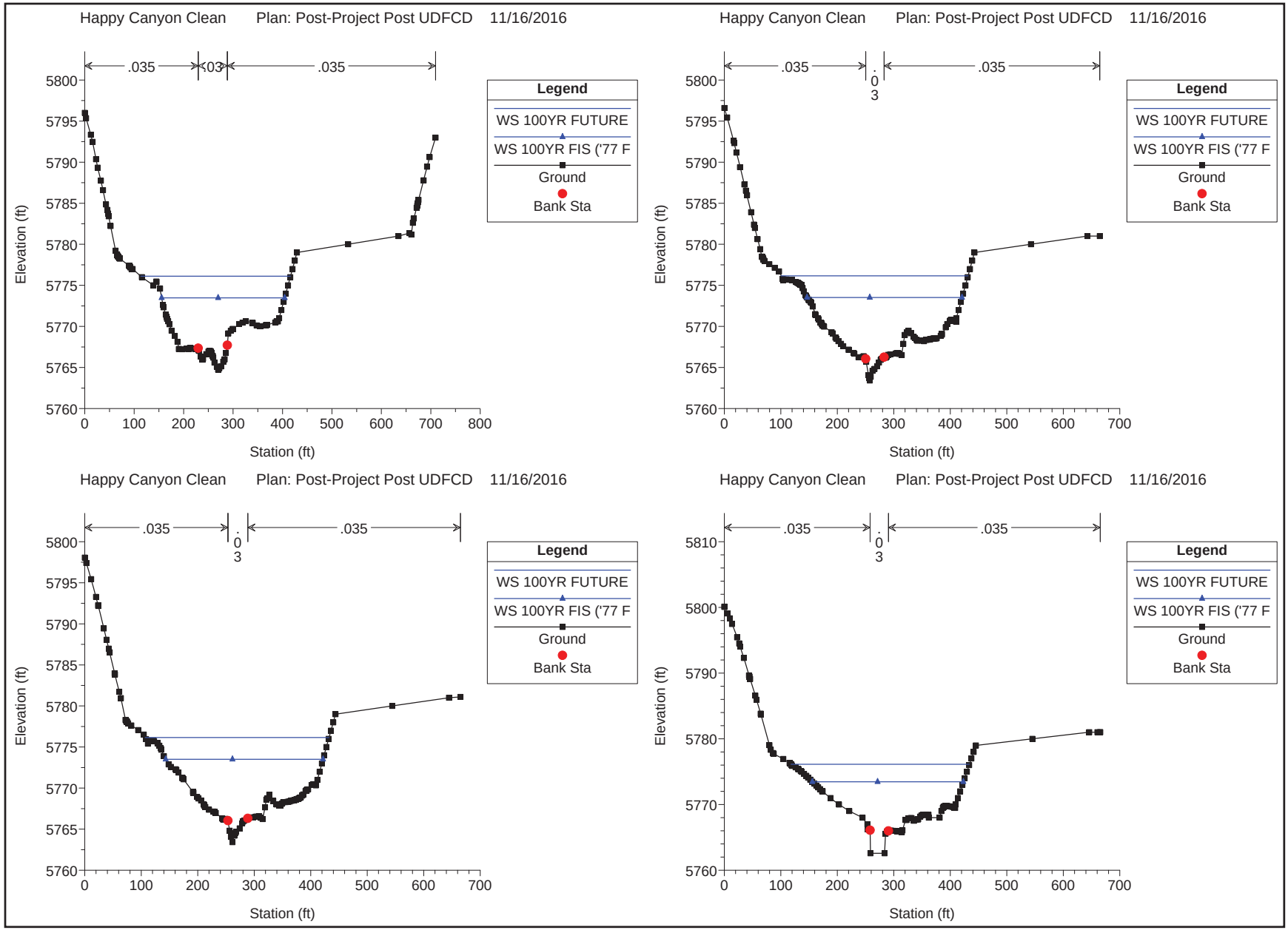
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Happy Canyon Clean
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Happy Canyon Clean
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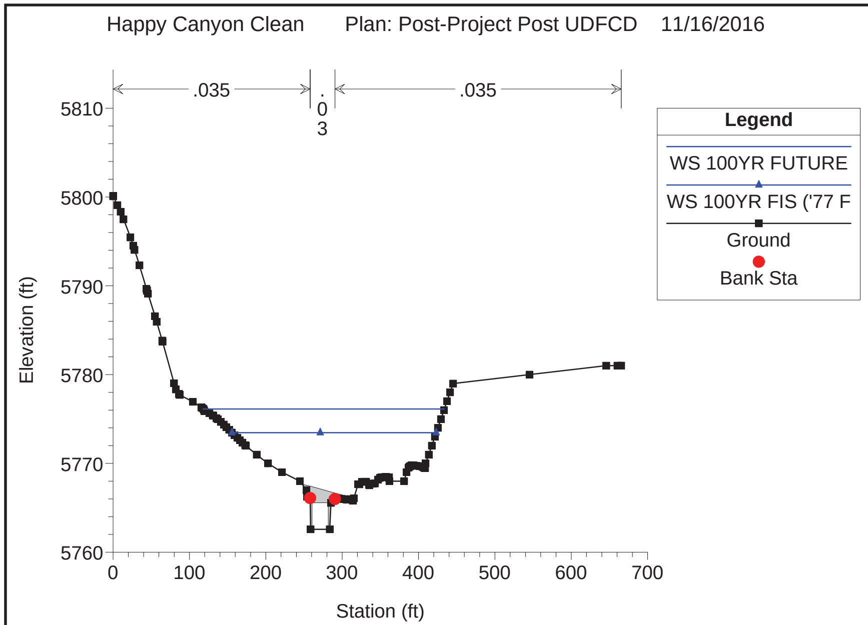
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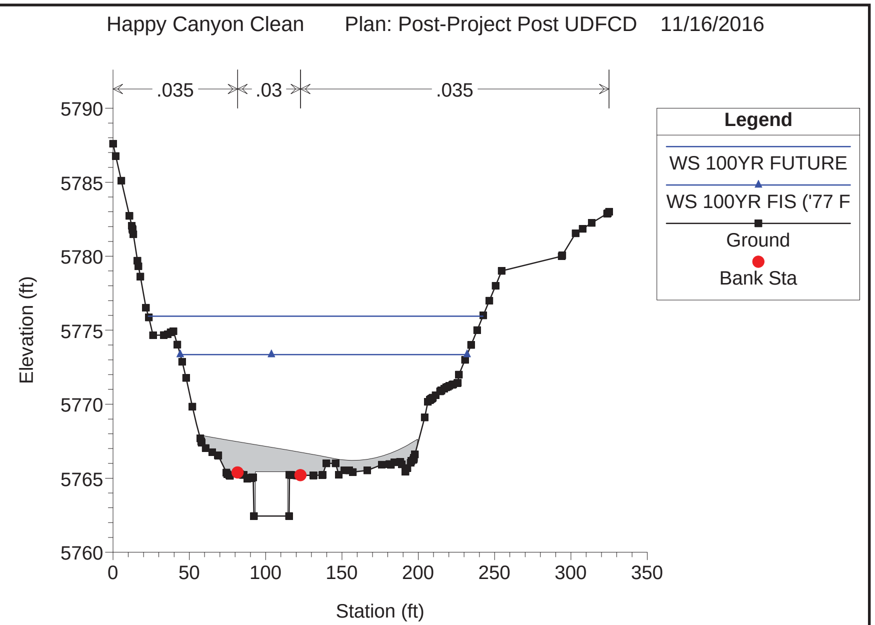
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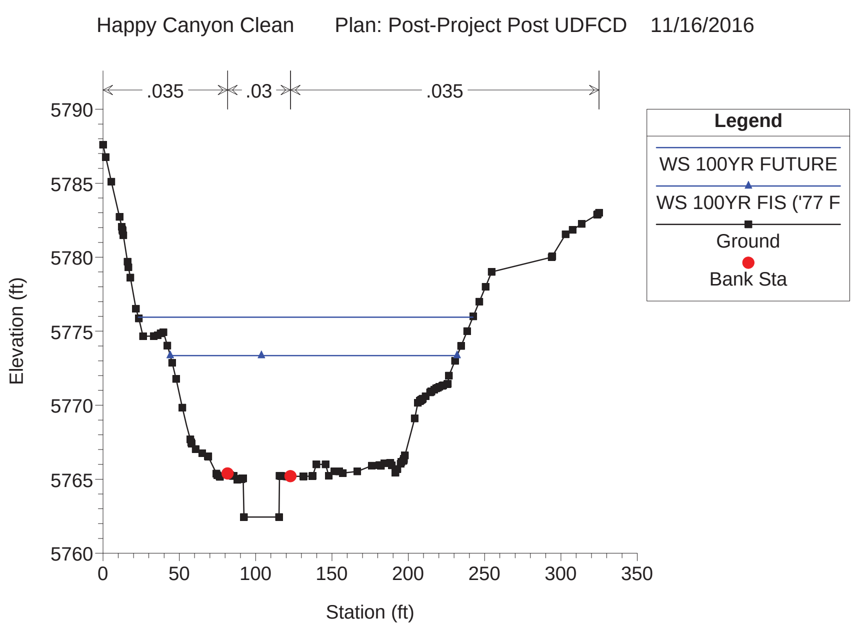
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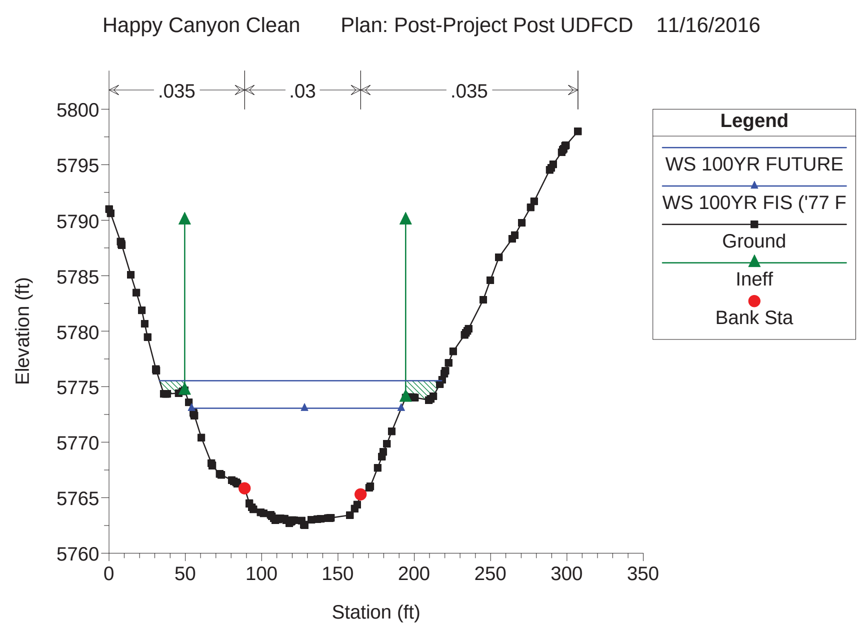
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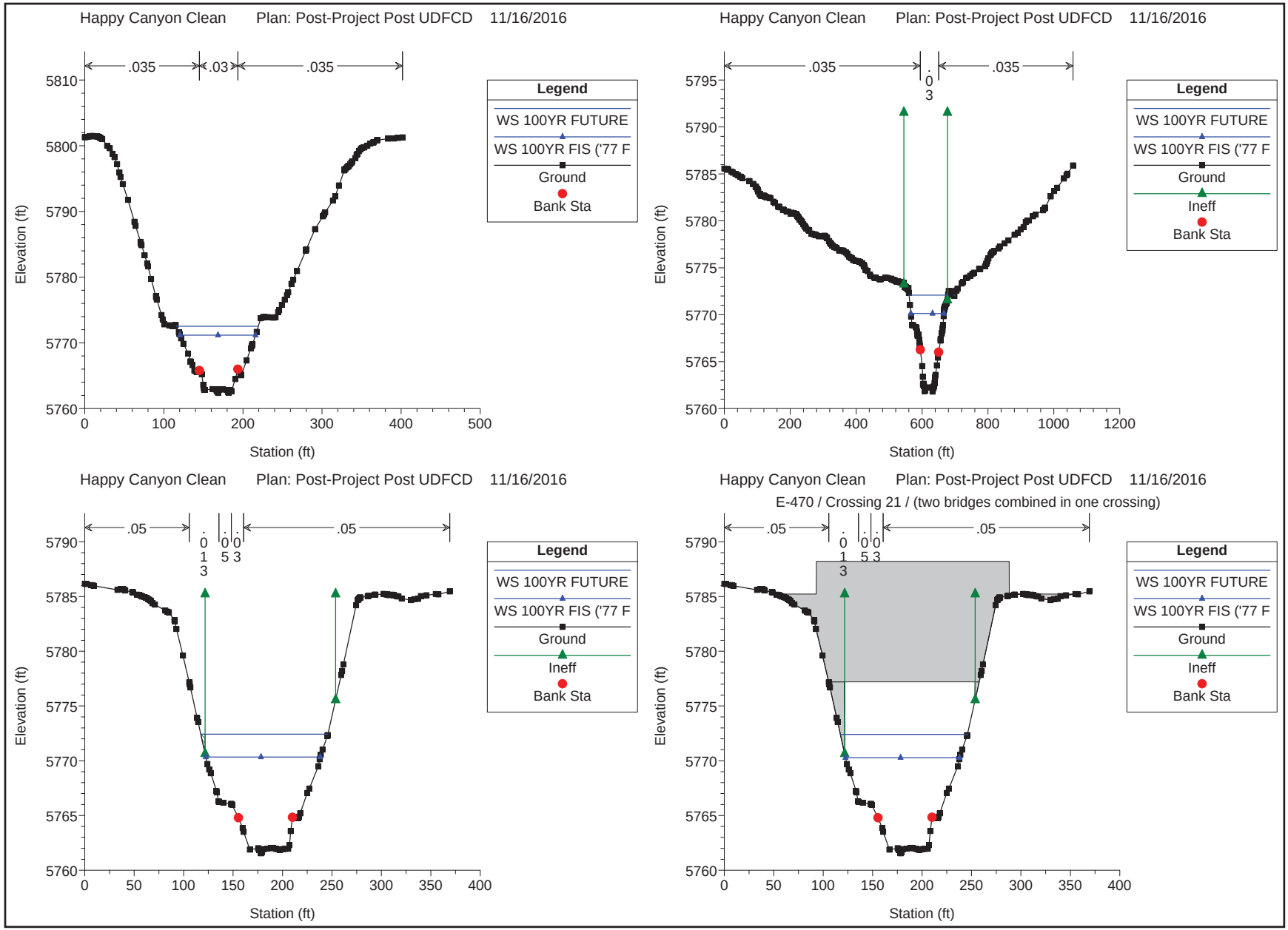
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Happy Canyon Clean Plan: Post-Project Post UDFCD 11/16/2016
E-470 / Crossing 21 / (two bridges combined in one crossing)
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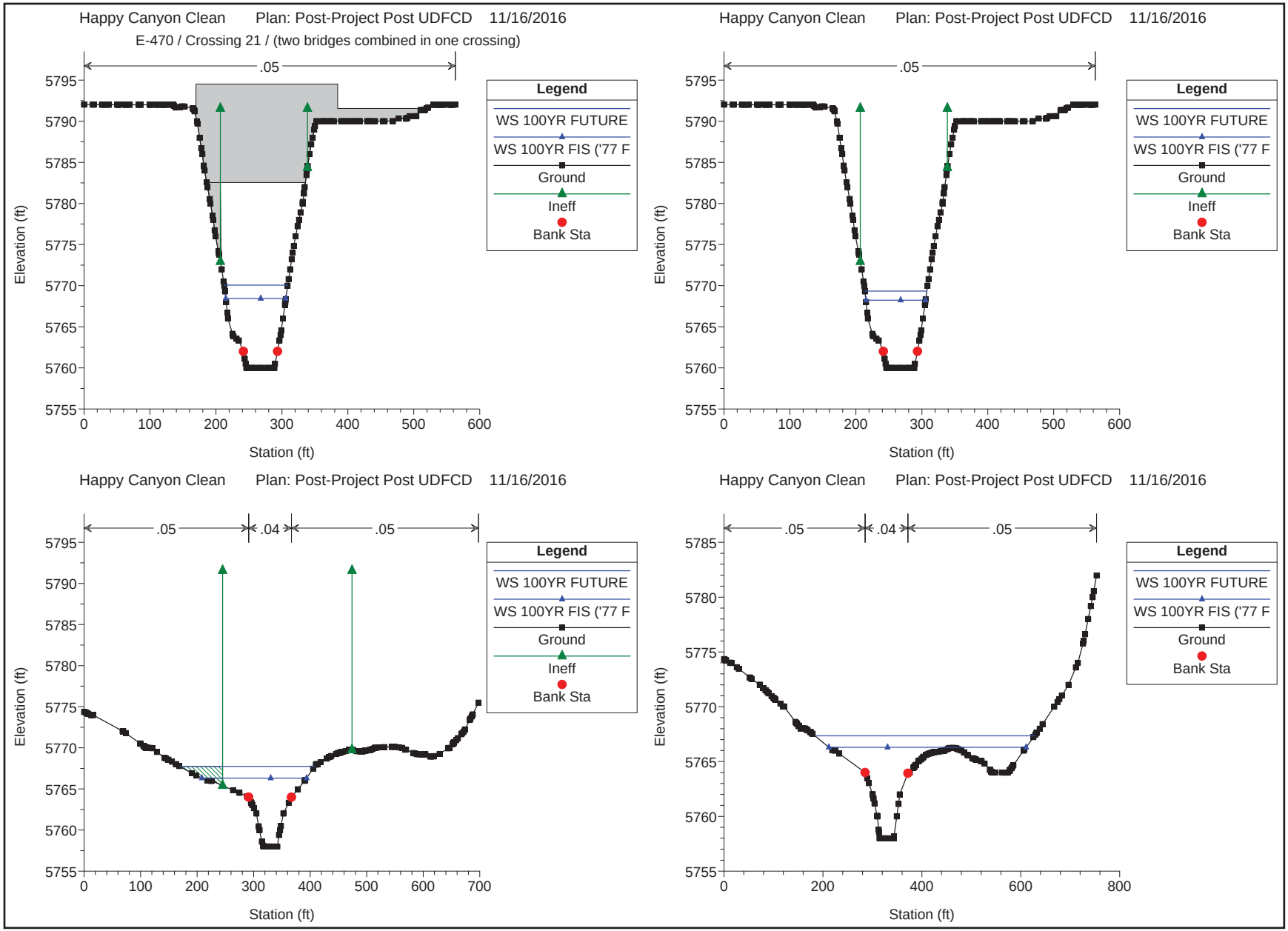
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E-470 / Crossing 21 / (two bridges combined in one crossing)
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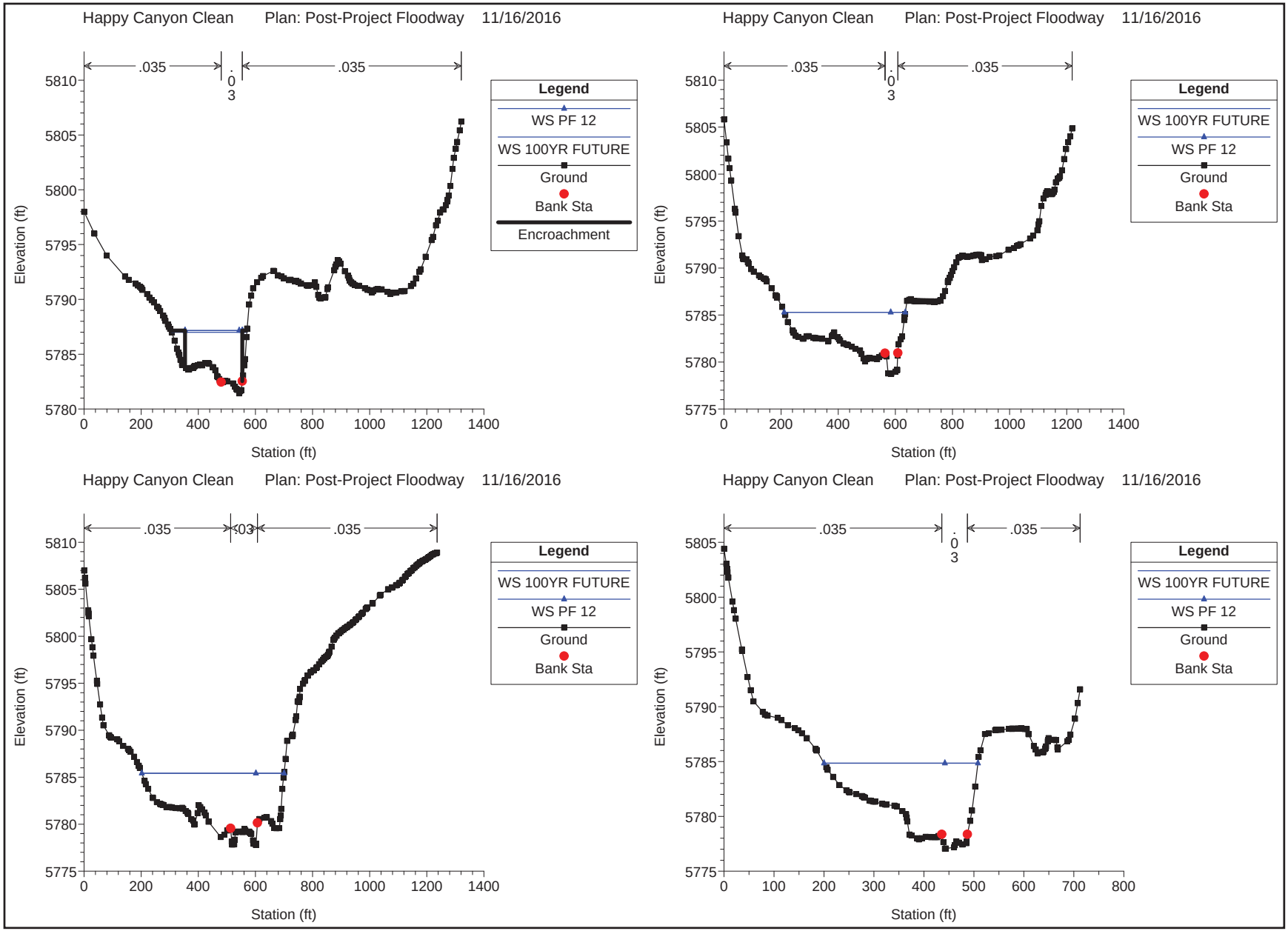
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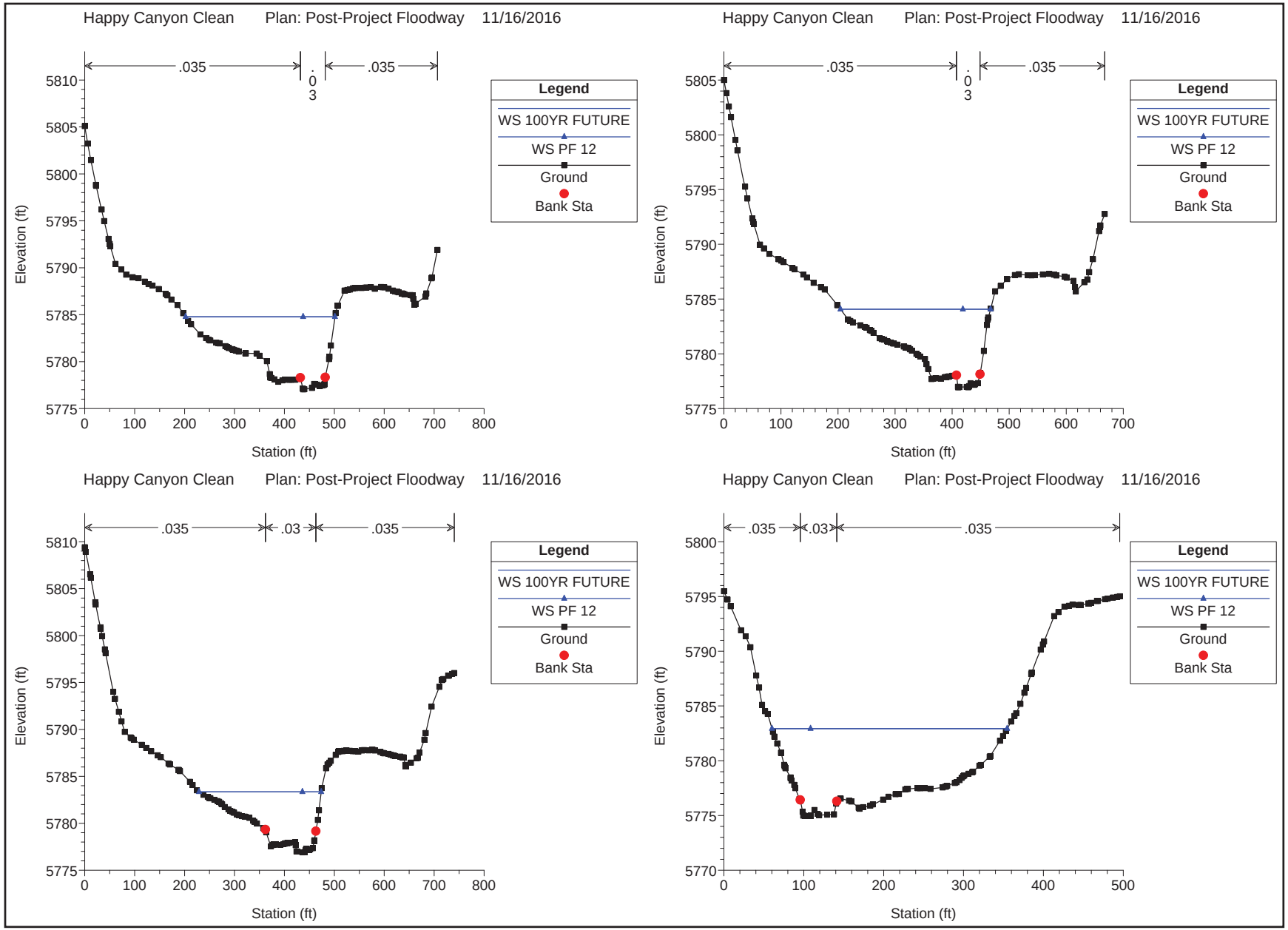
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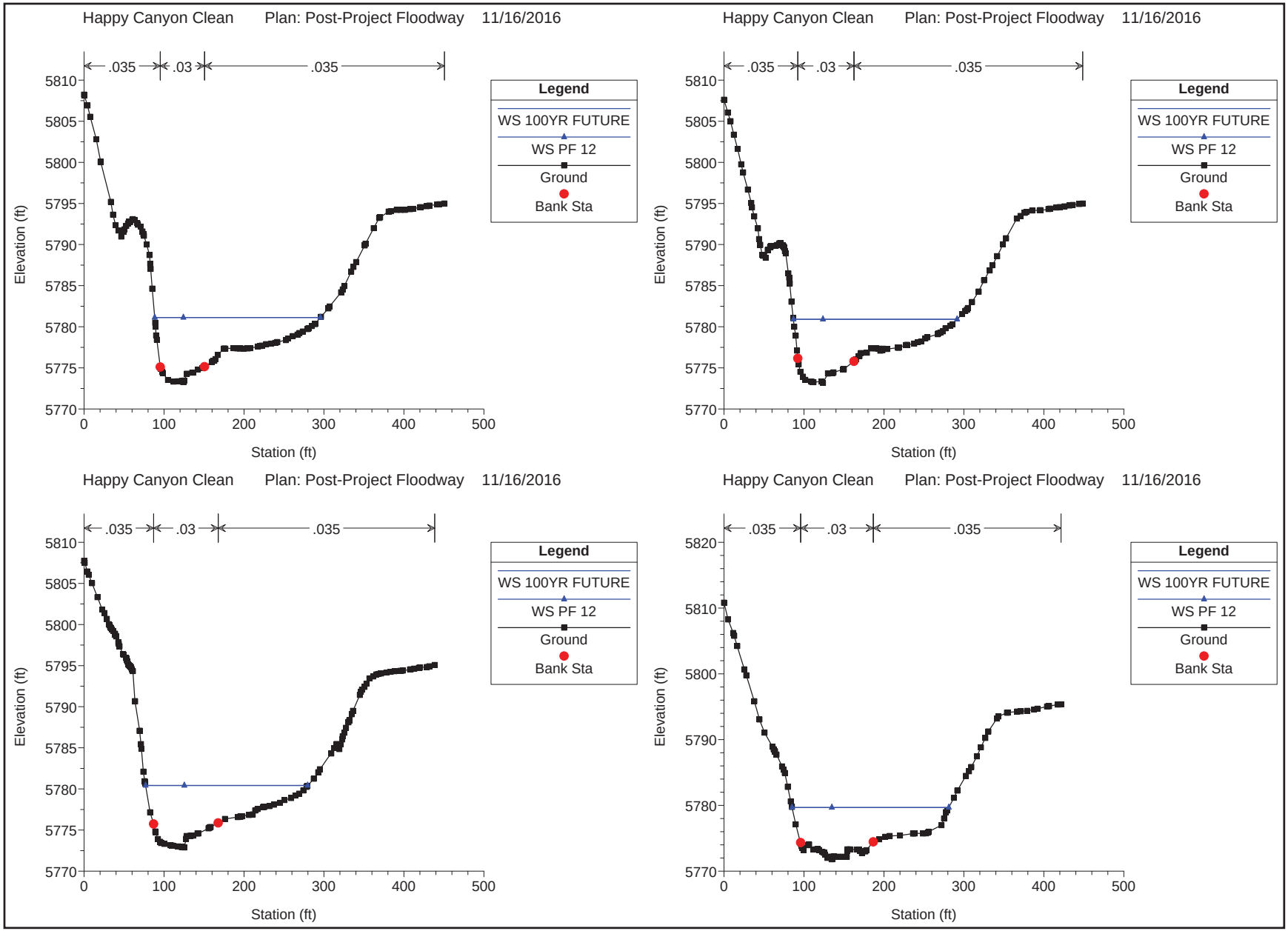
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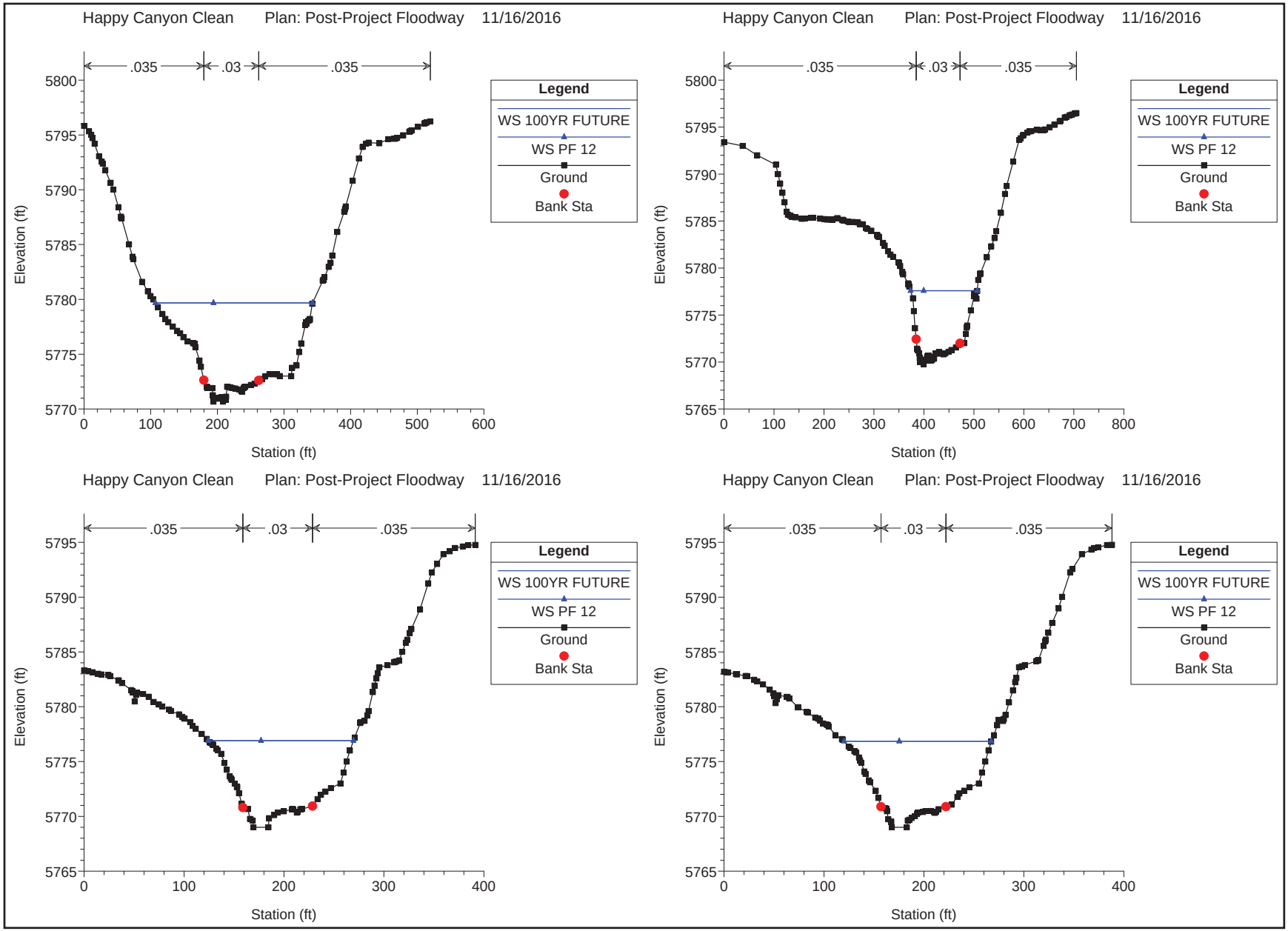
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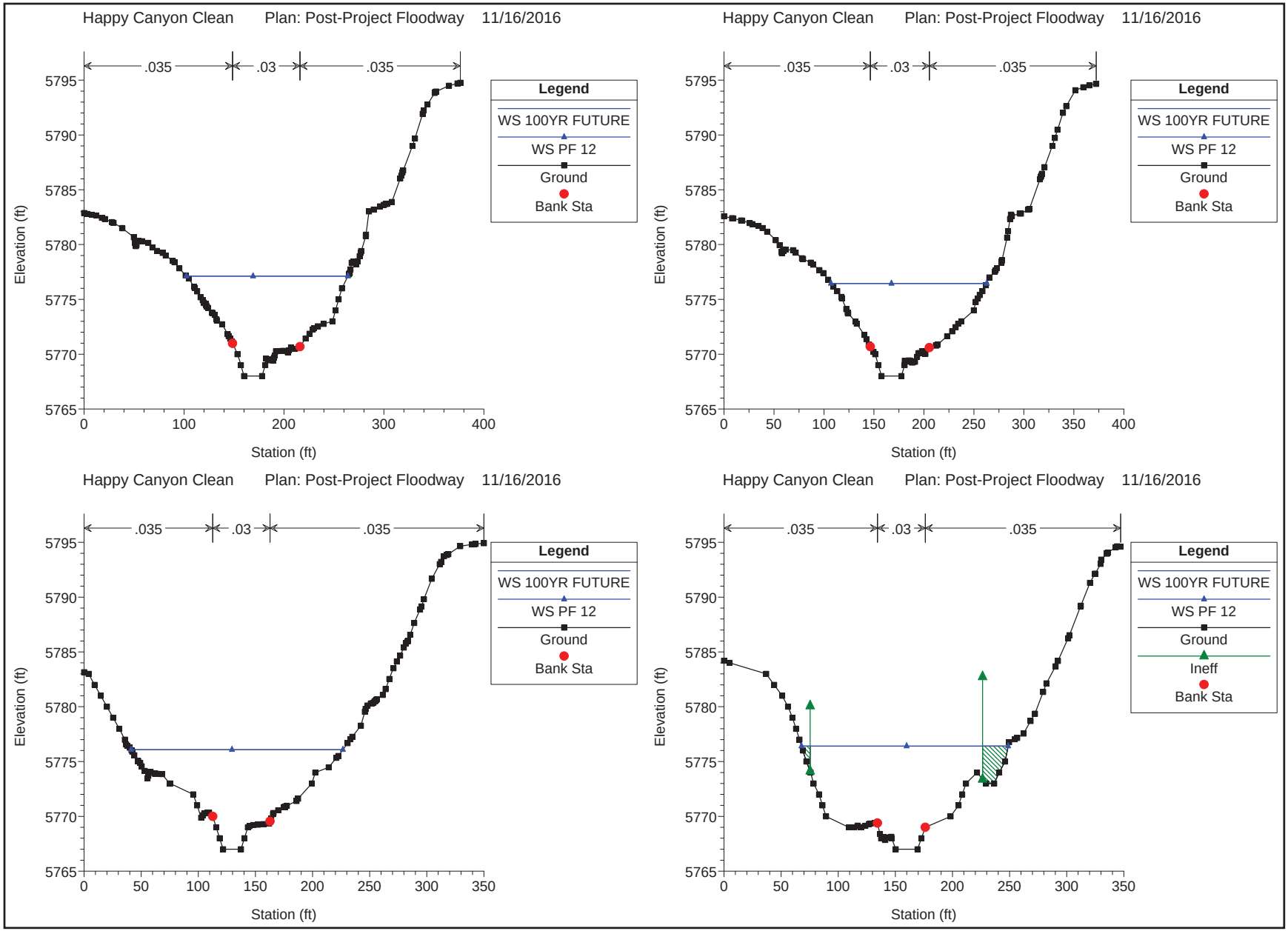
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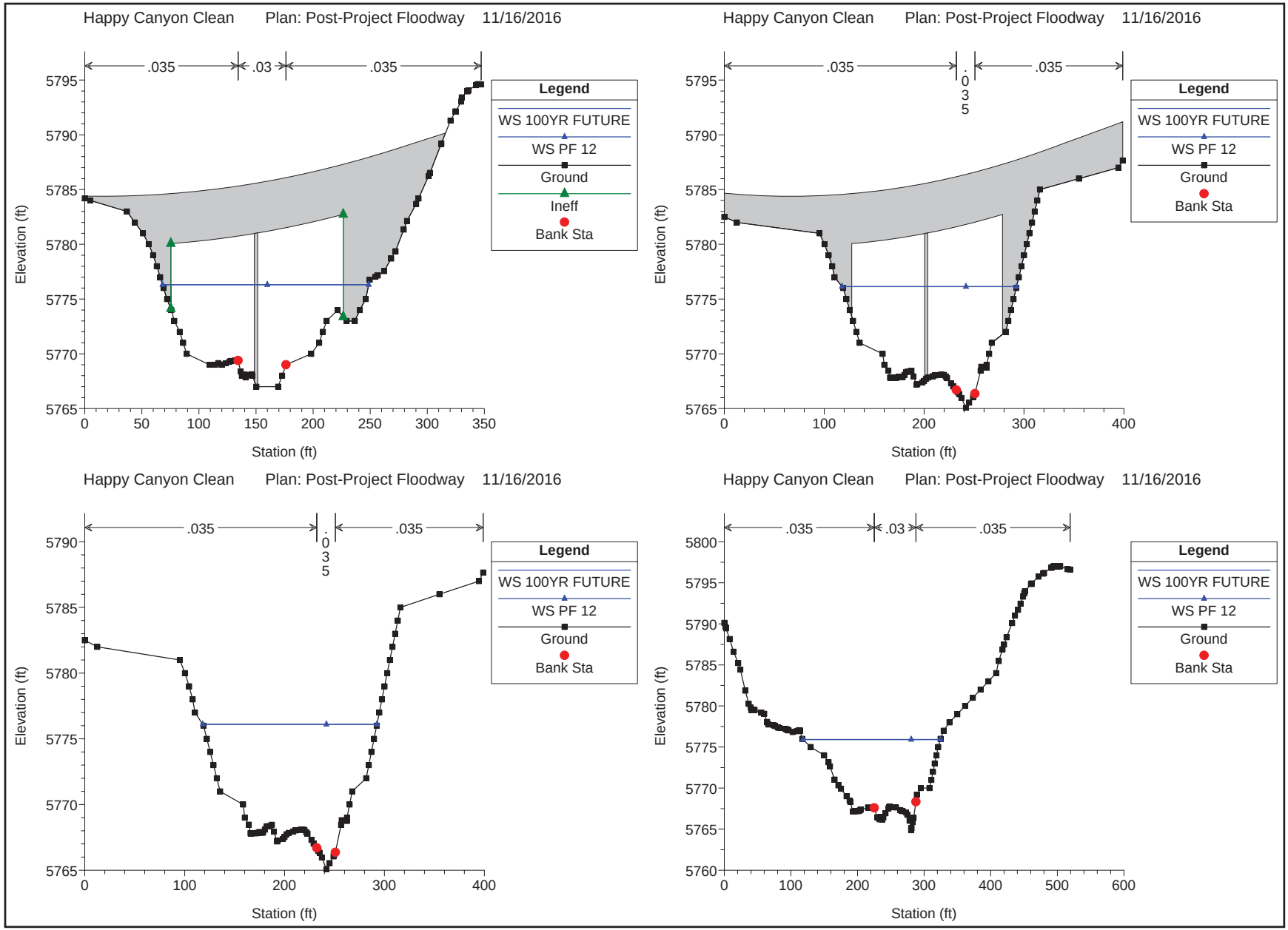
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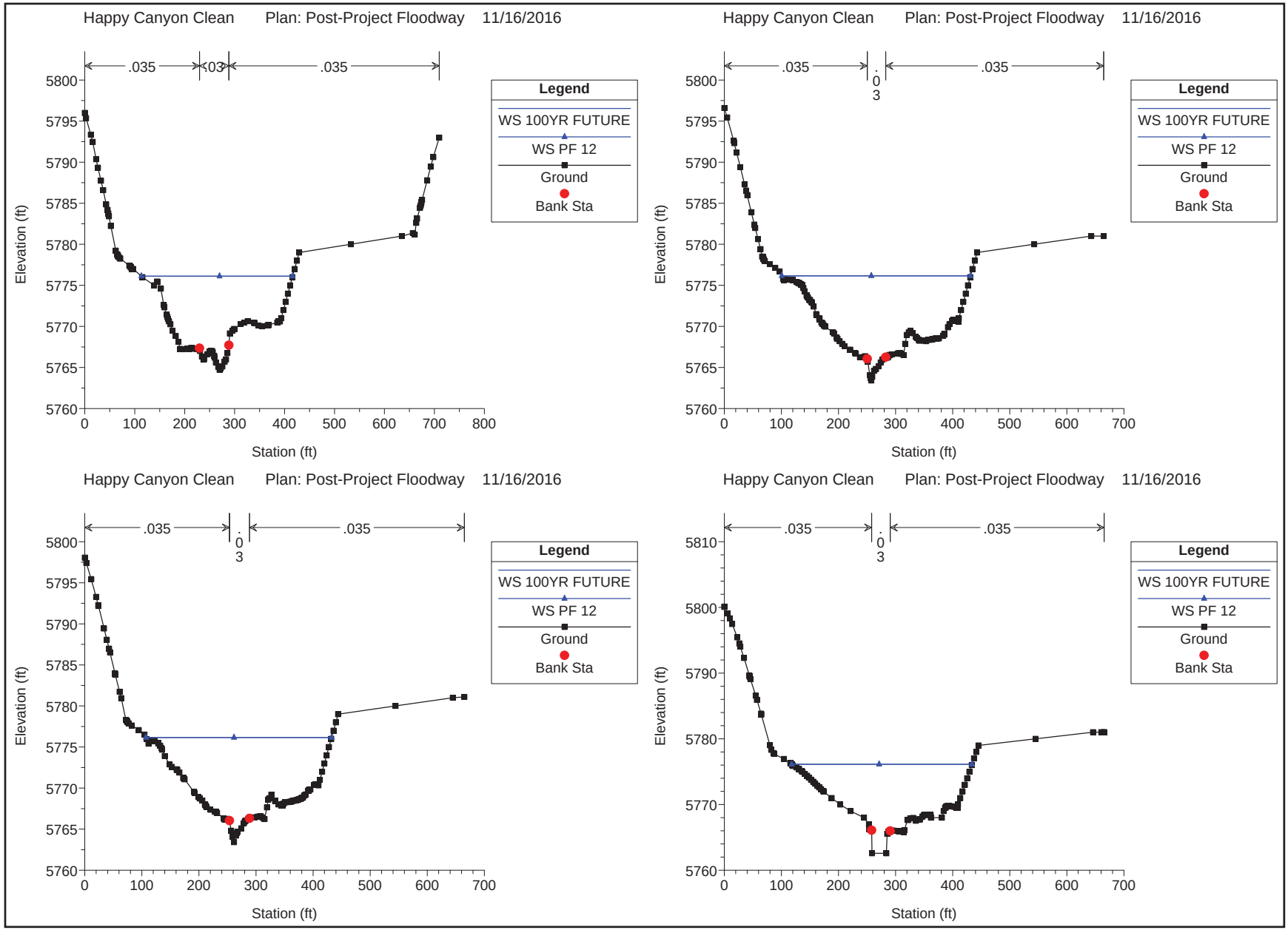
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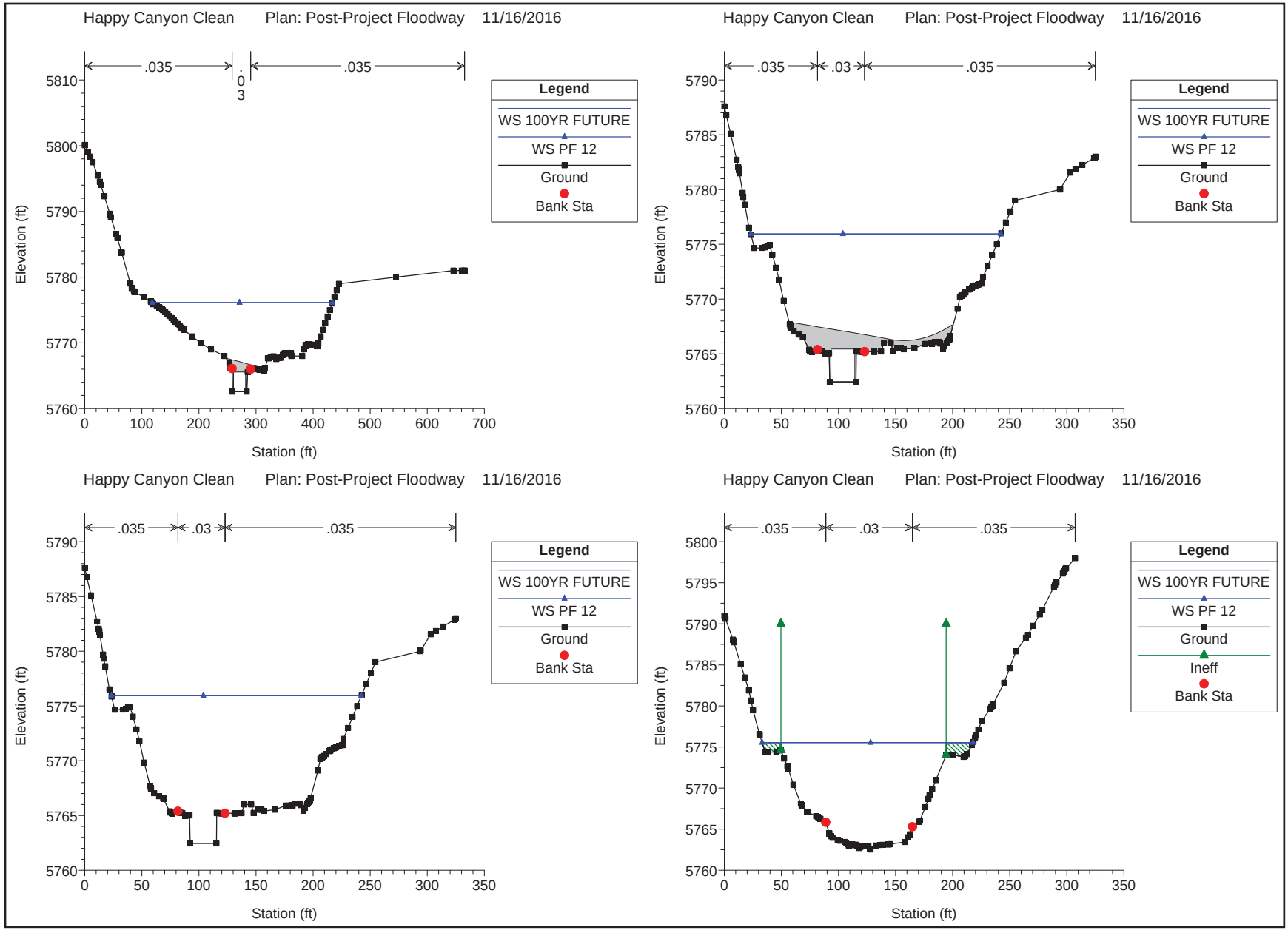
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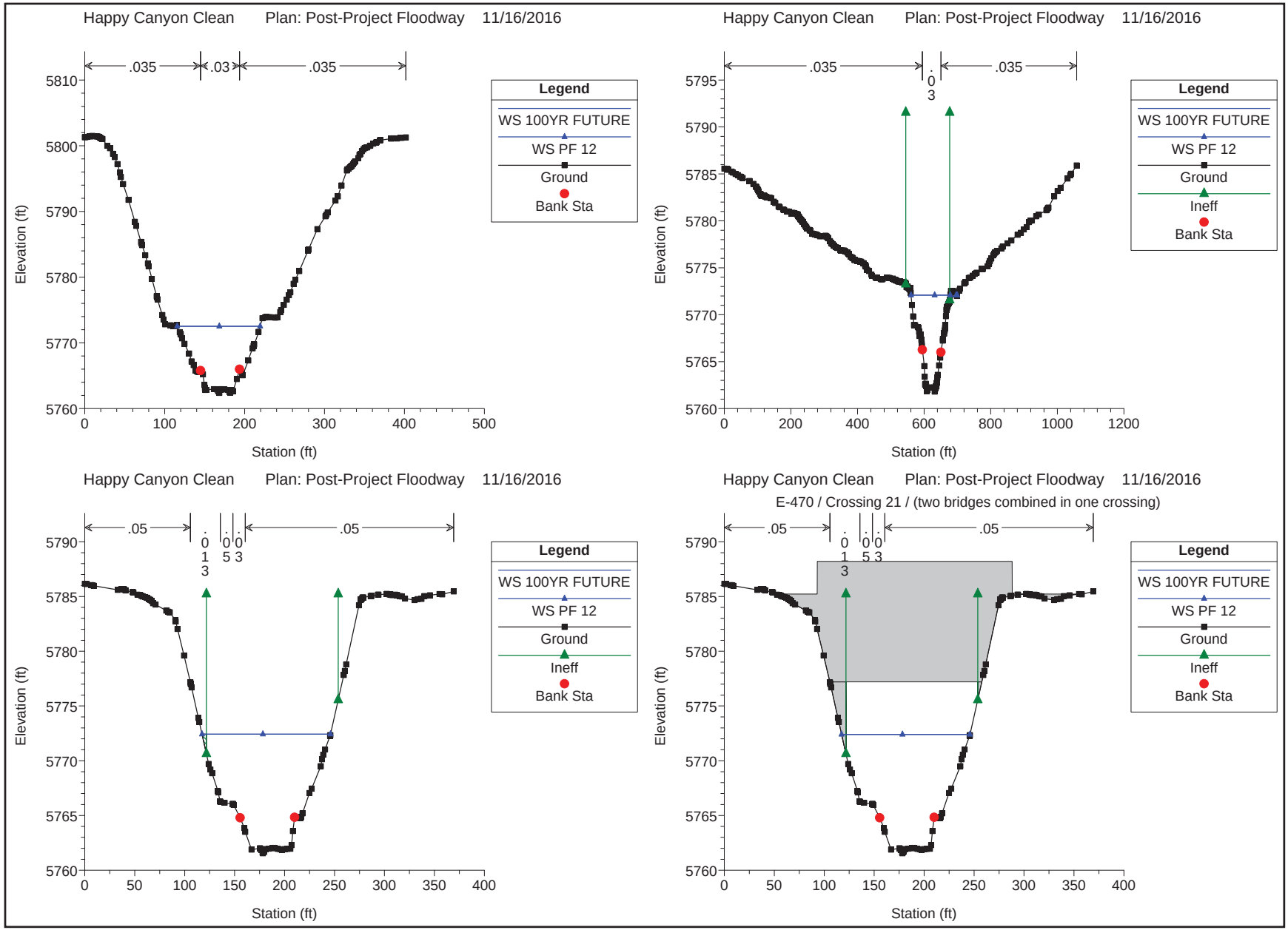
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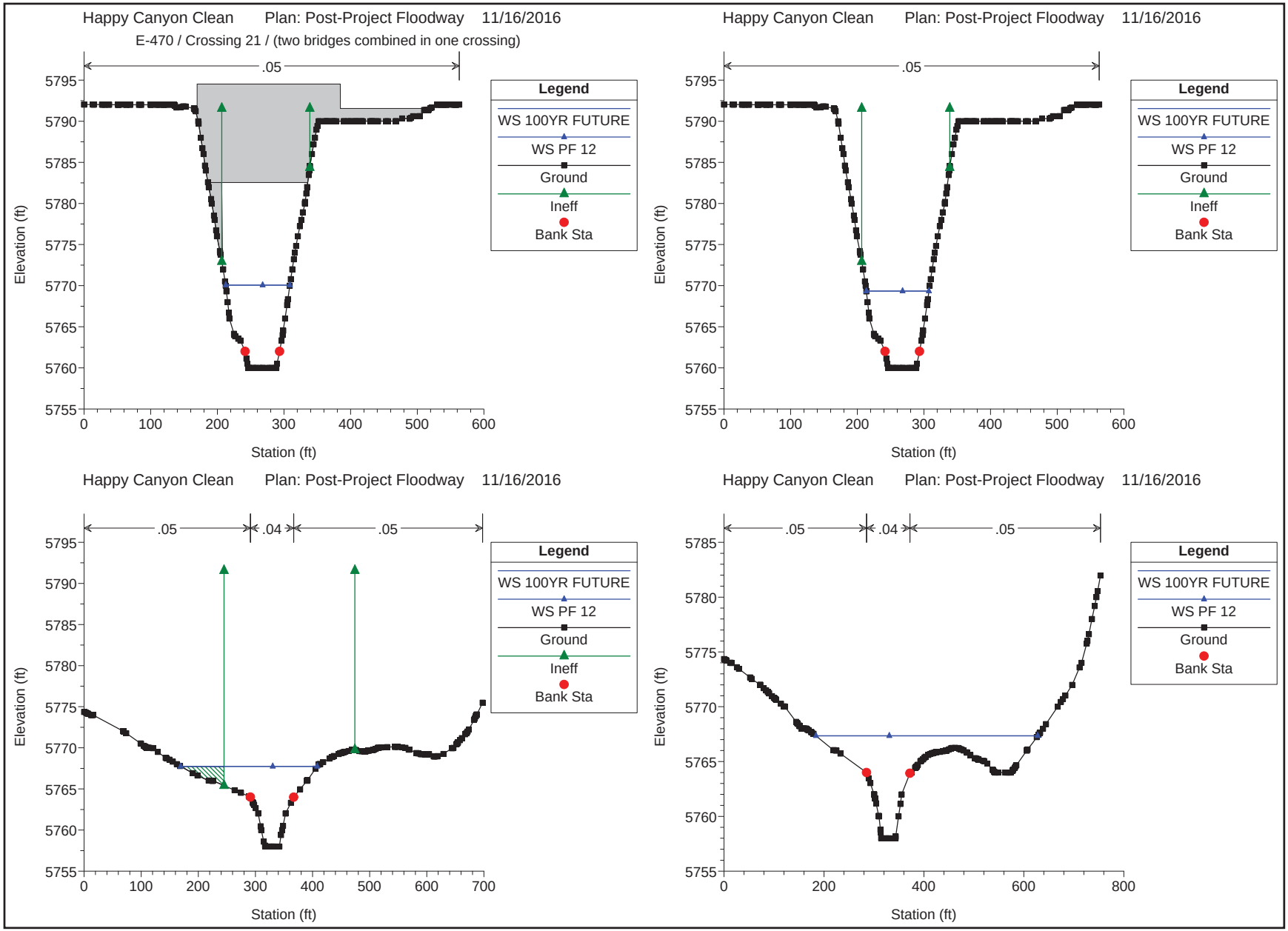
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APPENDIX F. SUPPLEMENTAL INFORMATION AND PLAN SHEETS

SMITH ENVIRONMENTAL & ENGINEERING
Delivering Sustainable Environmental Solutions

RECEIVED
APR 14 2016

U.S. FISH AND WILDLIFE SERVICE
☒ NO CONCERNS
☐ CONCUR NOT LIKELY TO ADVERSELY AFFECT
☐ NO COMMENT
5/9/16
DRUE L. DEBERRY — DATE
ACTING COLORADO FIELD SUPERVISOR

MAIL TRANSMITTAL SHEET

TO: US Fish and Wildlife Service, Colorado Field Office

ATTN: Drue DeBerry

FROM: Darrin Masters, Smith Environmental and Engineering

DATE: April 11, 2016

RE: Happy Canyon Creek Project

Attached please find one copy of the following:

- Habitat Suitability Assessment for the Happy Canyon Creek Improvement Project, Douglas County, Colorado

WWW.SMITHDELIVERS.COM
1490 W. 121st Avenue Suite 101 Westminster, CO 80234 phone: 720.887.4928 fax: 720.887.4680

SMITH ENVIRONMENTAL AND ENGINEERING
Delivering Smart Solutions for Planning, Permitting, & Design

January 5, 2016

Mr. Drue DeBerry
Colorado State Supervisor
U.S. Fish and Wildlife Service
Colorado Field Office
P.O. Box 25486, DFC (MS65412)
Denver, CO 80225-0486

Re: Habitat Suitability Assessment for Federally Threatened and Endangered Species for the Happy Canyon Creek Improvement Project.

Dear Mr. DeBerry:

This letter presents the results of a habitat suitability assessment (HSA) for federally listed threatened and endangered species (TES) completed by Smith Environmental and Engineering (SMITH) for the Compark development's proposed improvements to Happy Canyon Creek. The purpose of this HSA is to: 1) determine whether the selected species' habitat is currently in the Study Area, and 2) the likelihood of the selected species occurring in the Study Area.

STUDY AREA AND PROJECT DESCRIPTION

The Study Area consists of approximately 7.3 ac located along Happy Canyon Creek in unincorporated Douglas County, Colorado (see Figure 1). The Study Area is located south of E-470 and west of S Chambers Road. The Study Area is located in Sections 6 and 7 of Township 6 South, Range 66 West of the 6th Principal Meridian on the Parker, Colorado, U.S. Geological Survey (USGS) quadrangle. The center of the Study Area is located at 39.553 degrees north, 104.817 degrees west at an elevation of approximately 5,800 ft.

Compark proposes to construct a new bridge and roadway approaches over Happy Canyon Creek as a part of an access road that will connect S. Chambers Road with a future development area to the west. These improvements will also include permanent bank stabilization in and adjacent to Happy Canyon Creek.

EXISTING HABITAT

Happy Canyon Creek is identified on the USGS topographic map as a sand wash within the Study Area, though it is marked as an intermittent stream farther downstream. Historically, the natural course of Happy Canyon Creek led to a confluence with Cherry Creek, but development along the Front Range altered this hydrology. Happy Canyon Creek is a tributary to Cherry Creek, but the connection is now facilitated by means of pipes and culverts. Within the Study Area, the Happy Canyon Creek floodplain is broad, flat and sandy, and some water was flowing at the time of the investigation (see photos in Appendix A).

SMITH ENVIRONMENTAL AND ENGINEERING
1490 W 121st Avenue, Suite 101
Westminster, Colorado 80234
(720) 887-4928, (720) 887-4680 (fax)

HAPPY CANYON CREEK IMPROVEMENTS

0 300 600 Feet

Figure 1
Study Area

Douglas County, Colorado
January 2016

Vegetation along the creek corridor varied significantly in the Study Area. The sharpest contrast occurred between the upstream segment, located near the private residences, and the downstream segment near E-470. The downstream banks were very steep and eroded, and upland grasses were growing up to the edge of the cut. Species observed included smooth brome (*Bromus inermis)*, field brome (*Bromus arvensis)*, sideoats grama (*Bouteloua curtipendula)*, yucca (*Yucca* spp.), common mullein (*Verbascum thapsus)*, sweetclover (*Melilotus officinalis)* and horseweed (*Conyza canadensis).*

Farther upstream, the erosion was less extreme and wetland vegetation was able to establish along the edge of the banks. Species observed in these areas included plains cottonwood (*Populus deltoides)*, sandbar willow (*Salix exigua)*, redtop (*Agrostis gigantea),* common threesquare (*Schoenoplectus pungens)*, arctic rush (*Juncus arcticus)* and Torrey's rush (*Juncus torreyi)*. Species observed on the fringes included Canada thistle (*Cirsium arvense)*, Wood's rose (*Rosa woodsii)*, wild licorice (*Glycyrrhiza lepidota)* and curly dock (*Rumex crispus)*. In one area, the wetland extended inland nearly 50 ft from the edge of the bank. Portions of this area were so wet that cattails (*Typha* spp.) and Nebraska sedge (*Carex nebrascensis)* were thriving.

Soils in the Study Area have been mapped by the Natural Resource Conservation Service (NRCS). The creek drainage consists primarily of loamy alluvial land which is a well-drained soil found in floodplains. The NRCS also maps smaller areas of Newlin gravelly sandy loam and Santana loam. Newlin soils are well drained soils that occur on plateaus, terraces and mesas. Santana loams occur terraces and ridges and are also well drained (NRCS 2015).

HABITAT SUITABILITY ASSESSMENT

Ten TES were investigated for this HSA, because the U.S. Fish and Wildlife Service (USFWS) Information for Planning and Conservation (IPaC) lists them as potentially being impacted by projects occurring the Study Area (USFWS 2015). These species are listed in Table 1 with an explanation of their potential to occur in the Study Area and their potential to be affected by the Project.

Table 1. Habitat Suitability Assessment for Federally Listed Species

Species	Listing Status	Potential for Species to Occur in the Study Area
BIRDS		
Least Tern (*Sterna antillarum)*	FE	Habitat for the tern does not occur in the Study Area., and this Project does not propose to deplete water from the South Platte River or its alluvium. Therefore SMITH believes the proposed Project will have no effect on this species.
Mexican Spotted Owl (*Strix occidentalis lucida)*	FT	The owl is known to occur in Douglas County, and critical habitat has been established approximately 17 miles southwest of the Study Area. However, the Study Area does not provide suitable habitat of old growth forests and rock outcrops in steep canyon areas. SMITH believes there is no potential for the owl to occur in the Study Area, and the proposed Project will have no effect on this species.
Piping Plover (*Charadrius melodus)*	FT	Habitat for the plover does not occur in the Study Area., and this Project does not propose to deplete water from the South Platte River or its alluvium. Therefore SMITH believes the proposed Project will have no effect on this species.

Whooping Crane (*Grus americana*)	FE	Habitat for the crane does not occur in the Study Area., and this Project does not propose to deplete water from the South Platte River or its alluvium. Therefore SMITH believes the proposed Project will have no effect on this species.
FISH		
Greenback cutthroat trout (*Oncorhynchus clarki stomias*)	FT	Happy Canyon Creek is an intermittent stream with a sandy bed that was very shallow at the time of the investigation. It does not provide the necessary habitat conditions to support trout. Also, recent genetic analysis has shown that the only true population of the trout currently survives in Bear Creek west of Colorado Springs (Metcalf et al. 2012). SMITH believes there is no potential for the trout to occur in the Study Area, and the proposed Project will have no effect on this species.
Pallid sturgeon (*Scaphirhynchus albus*)	FE	Habitat for the sturgeon does not occur in the Study Area., and this Project does not propose to deplete water from the South Platte River or its alluvium. Therefore SMITH believes the proposed Project will have no effect on this species.
MAMMALS		
Preble's meadow jumping mouse (*Zapus hudsonius preblei*)	FT	Typical habitat for the Preble's meadow jumping mouse includes well-developed plains riparian vegetation with adjacent, undisturbed grasslands and a nearby water source. The Study Area occurs within the Denver Metropolitan Block Clearance Area for the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (Urban Drainage and Flood Control District 2010). Therefore SMITH believes the proposed Project will have no effect on this species.
PLANTS		
Colorado butterfly plant (*Gaura neomexicana* var. *coloradensis*)	FT	The Colorado butterfly plant is known to occur in subirrigated, alluvial soils with mesic moisture regimes in early- to mid-successional plant communities. The Study Area does provide these habitat conditions along Happy Canyon Creek; the banks are not steeply eroded in most areas and there are areas where the canopy is open. Although the plant has been historically documented in Douglas County, it is now believed that those occurrences have been extirpated (Colorado Natural Heritage Program 1997+). Although the plant could potentially thrive in the Study Area, the proposed Project will not alter the character of the existing habitat. Furthermore, SMITH believes that this species does not occur in Douglas County, and therefore the proposed Project will have no effect on this species.
Ute ladies'-tresses orchid (*Spiranthes diluvialis*)	FT	The Ute ladies'-tresses orchid (ULTO) is known to occur in seasonally moist soils and wet meadows between 4,500 and 6,500 ft. The orchid thrives in areas that do not experience high flow events, and Happy Canyon Creek is subject to seasonal flooding. Furthermore, there are currently no known current or historically documented populations in Douglas County (Colorado Natural Heritage Program 1997+). SMITH believes that there is no potential for the orchid to occur in the Study Area, and the proposed Project will have no effect on this species.
Western prairie fringed orchid	FT	Habitat for the orchid does not occur in the Study Area., and this Project does not propose to deplete water from the South Platte River or

(*Platanthera praeclara*)		its alluvium. Therefore SMITH believes the proposed Project will have no effect on this species.

FT = Federally Threatened; FE = Federally Endangered

CONCLUSIONS

SMITH concludes that the proposed Project should have no effect on any federally listed threatened or endangered species. SMITH requests concurrence on these opinions from the USFWS on behalf of the Project sponsor.

REFERENCES

Colorado Natural Heritage Program. 1997+. Colorado Rare Plant Guide. Available at: www.cnhp.colostate.edu. Latest update: June 30, 2014.

Metcalf, J. L., Love Stowell, S., Kennedy, C. M., Rogers, K. B., McDonald, D., Epp, J., Keepers, K., Cooper, A., Austin, J. J. and Martin, A. P. 2012. Historical stocking data and 19th century DNA reveal human-induced changes to native diversity and distribution of cutthroat trout. Molecular Ecology 21:21, pp. 5194-5207.

NRCS. 2015. United States Department of Agriculture, Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed November 17, 2015.

Urban Drainage and Flood Control District. 2010. Preble's Meadow Jumping Mouse, Ute-ladies' Tresses Orchid and Colorado Butterfly Plant Block Clearances for the Denver Metropolitan Area – Revised 2010. Denver, Colorado.

USFWS. 2015. IPaC - Information, Planning and Conservation System. Available online at: http://ecos.fws.gov/ipac/. Accessed November 17, 2015.

PERSONNEL

Rebecca Hannon, Environmental Scientist II of SMITH investigated this site.

SMITH requests concurrence on the opinions in this assessment from USFWS on behalf of the project sponsor. If you have any questions about this assessment, please call me at (303) 551-7980.

Sincerely,
Smith Environmental and Engineering

Darrin Masters, Certified Wildlife Biologist®
Senior Environmental Scientist

cc: Russell Burrows, Manhard Consulting, Ltd.

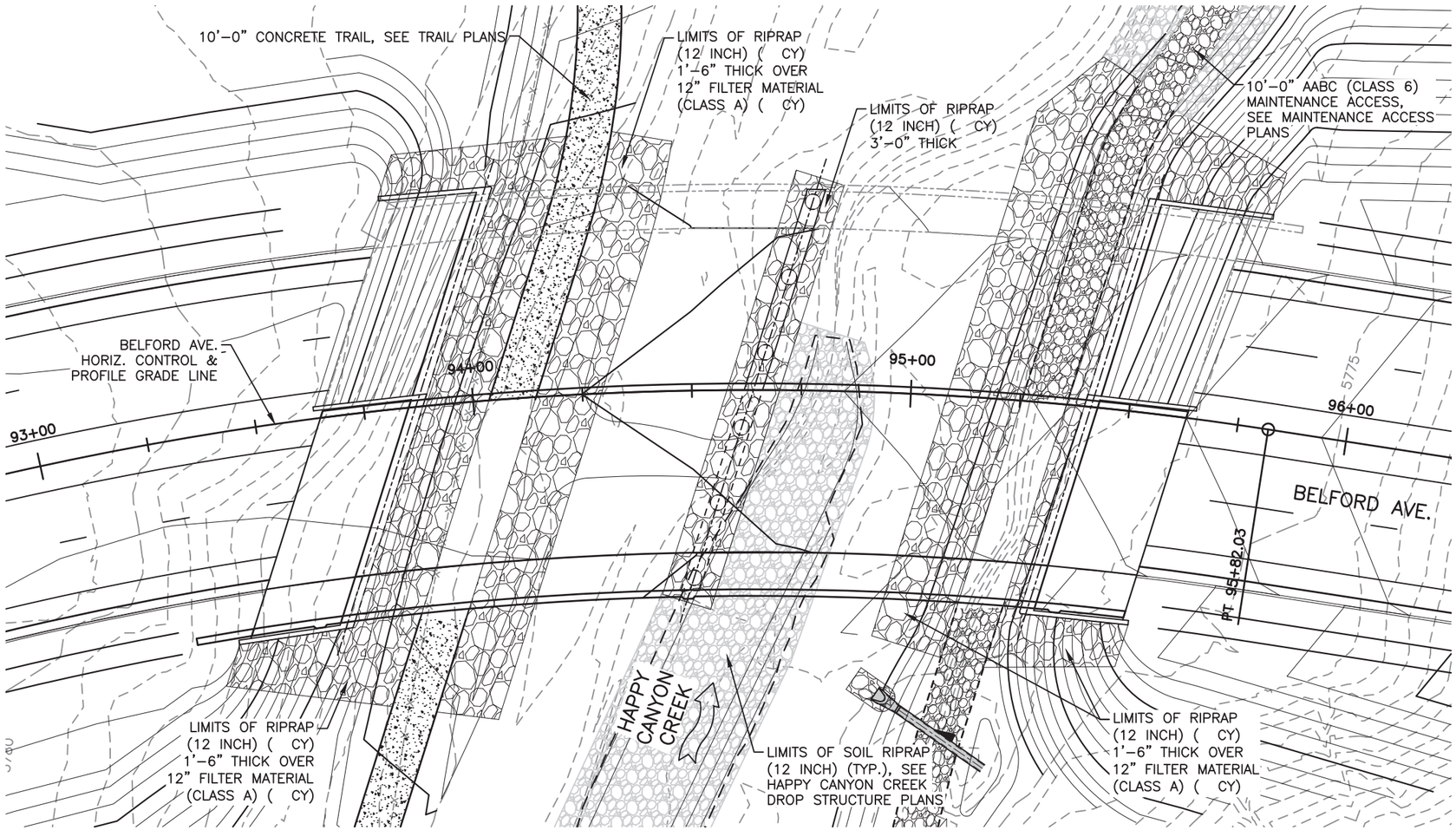
APPENDIX A - PHOTOS OF THE STUDY AREA

Photo1. A portion of Happy Canyon Creek where wetlands are supported, especially on the far bank. The shallow water that was flowing is also visible.

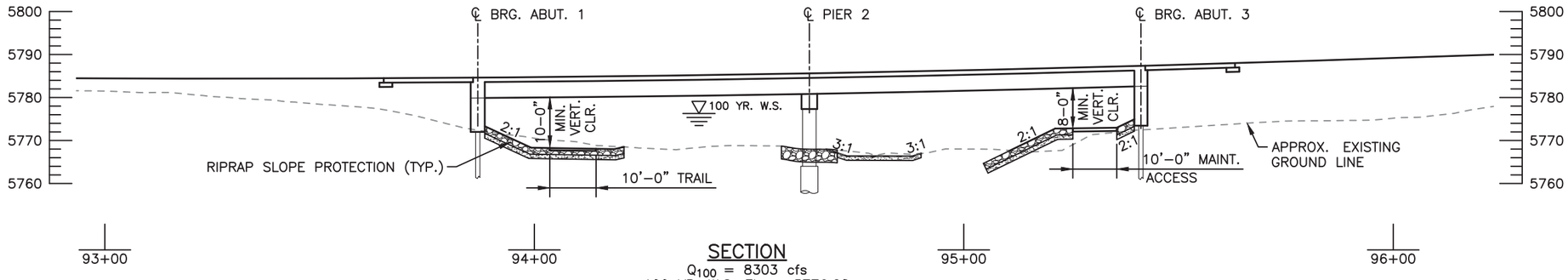
Photo 2. View of wetland vegetation that has established in the floodplain bench along Happy Canyon Creek. Willows occur above an understory of common threesquare, rushes and wetland grasses.

Photo 3. View looking south at wet area that extends inland from Happy Canyon Creek. Cattails and sedges are growing in the wettest areas.

Photo4. View of the upstream segment of Happy Canyon Creek near the private residences. The cut bank and the sandy soils are precluding the establishment of wetland vegetation.



PLAN



SECTION

Q_{100} = 8303 cfs

100 YR. W.S. EL. = 5776.28

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fax 303.721.0832

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Date	Comments	Initials

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No Revisions:
Revised:
Void:

BELFORD–HAPPY CANYON CREEK BRIDGE
BRIDGE HYDRAULIC INFORMATION
(1 OF 2)

Designer:	C. TWISS	Structure Numbers	
Detailer:	R. FILLON		
Subset:	BRIDGE	Sheets:	B6 of 32

Project No./Code

Sheet Number ————

100–YEAR RECURRENCE INTERVAL

FLOW UPSTREAM OF BRIDGE = 8303 CFS (FHAD)

DRAINAGE AREA = 17.5± SQ. MI.

CHANNEL DESCRIPTION

BOTTOM MATERIAL: COHESIVE ☐ NONCOHESIVE ☒

BOTTOM MAT. SIZE: CLAY ☐ SILT ☐ SAND ☒ GRAVEL ☐ COBBLES ☐ OTHERS ____

STREAM FORM: STRAIGHT ☐ MEANDERING ☒ BRAIDED ☐

MANNING'S "n" FOR DESIGN: CHANNEL 0.030 OVERBANK 0.035

DEBRIS -- BRUSH ☒ TREES/LOGS ☒ ICE ☐ OTHER ____

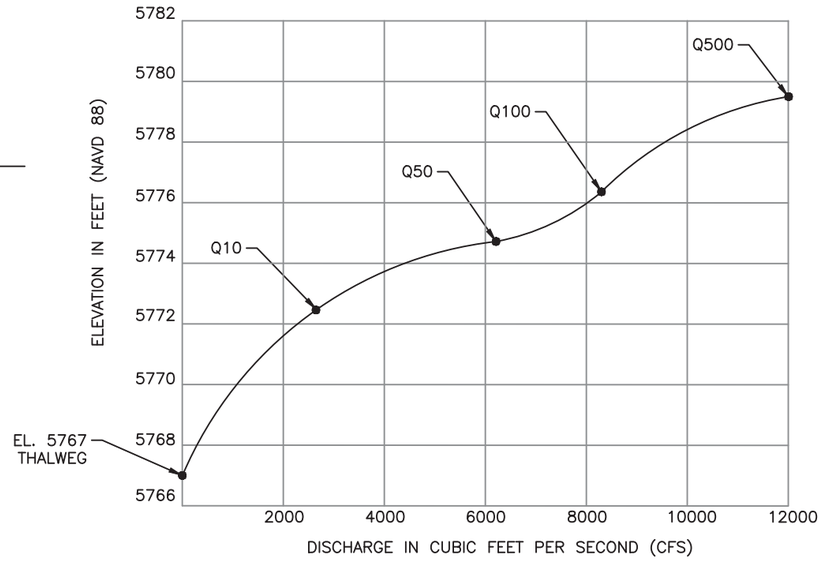
COMPARISON HYDRAULICS (100 YEAR EVENT)

(AT SECTION LOCATED 32 FEET UPSTREAM OF BRIDGE)

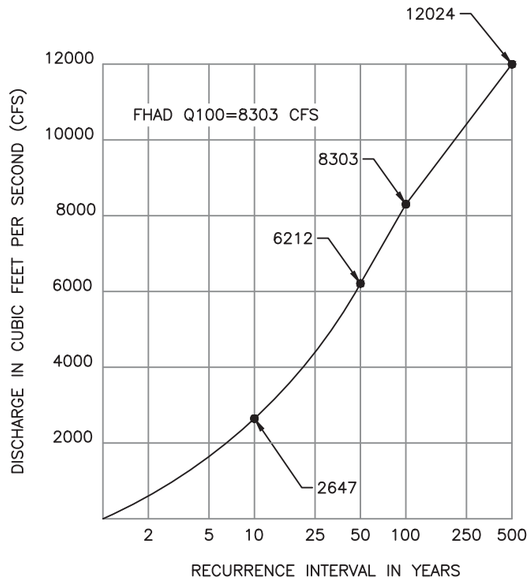
	VELOCITY (FT./SEC)		WS EL. (FT.)	MAX. BACKWATER (FT.)	FROUDE NO.
	AVERAGE	CHANNEL			
EXISTING CONDITIONS	9.81	13.59	5775.57	–	0.89
PROPOSED CONDITIONS	8.24	10.51	5776.36	–	0.62

HYDRAULIC DATA

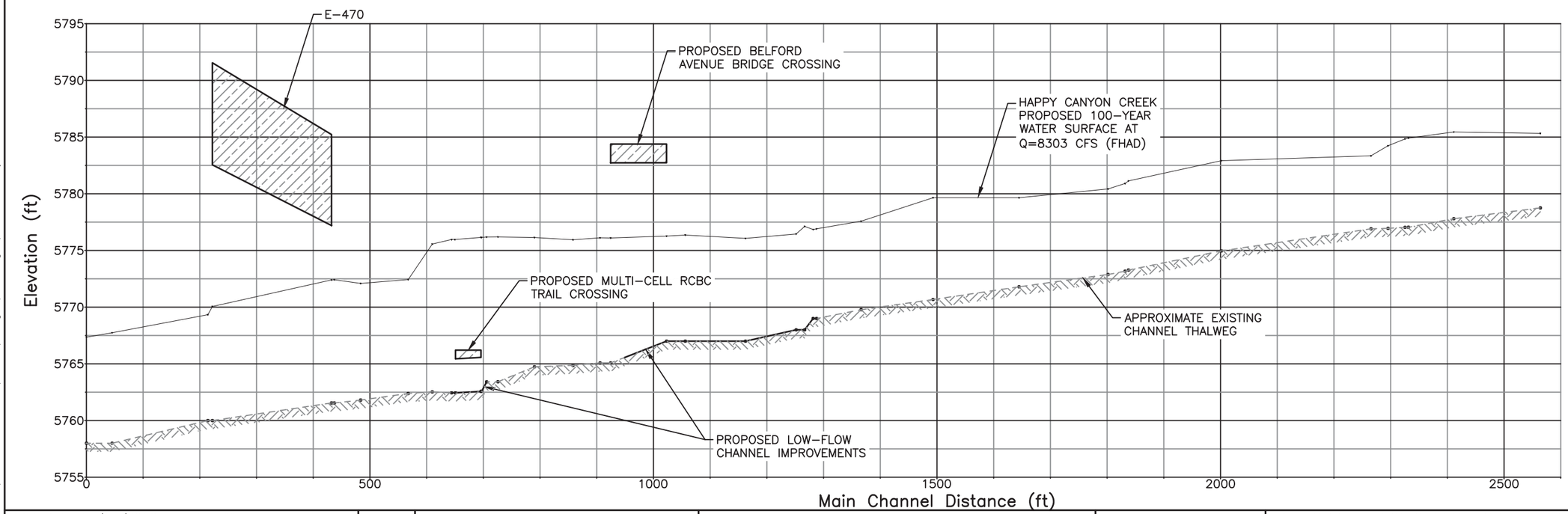
LOCATION	LOW CHORD ELEVATION AT ABUT. FRONT FACE		100–YEAR WATER SURFACE ELEVATION
	ABUT. 1	ABUT. 2	
S. SIDE (UPSTREAM)	5780.07	5782.73	5776.27
N. SIDE (DOWNSTREAM)	5780.07	5782.73	5776.10



STAGE–DISCHARGE CURVE AT UPSTREAM FACE OF BELFORD AVENUE



DISCHARGE–FREQUENCY CURVE



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VERT. SCALE: 1"=10'

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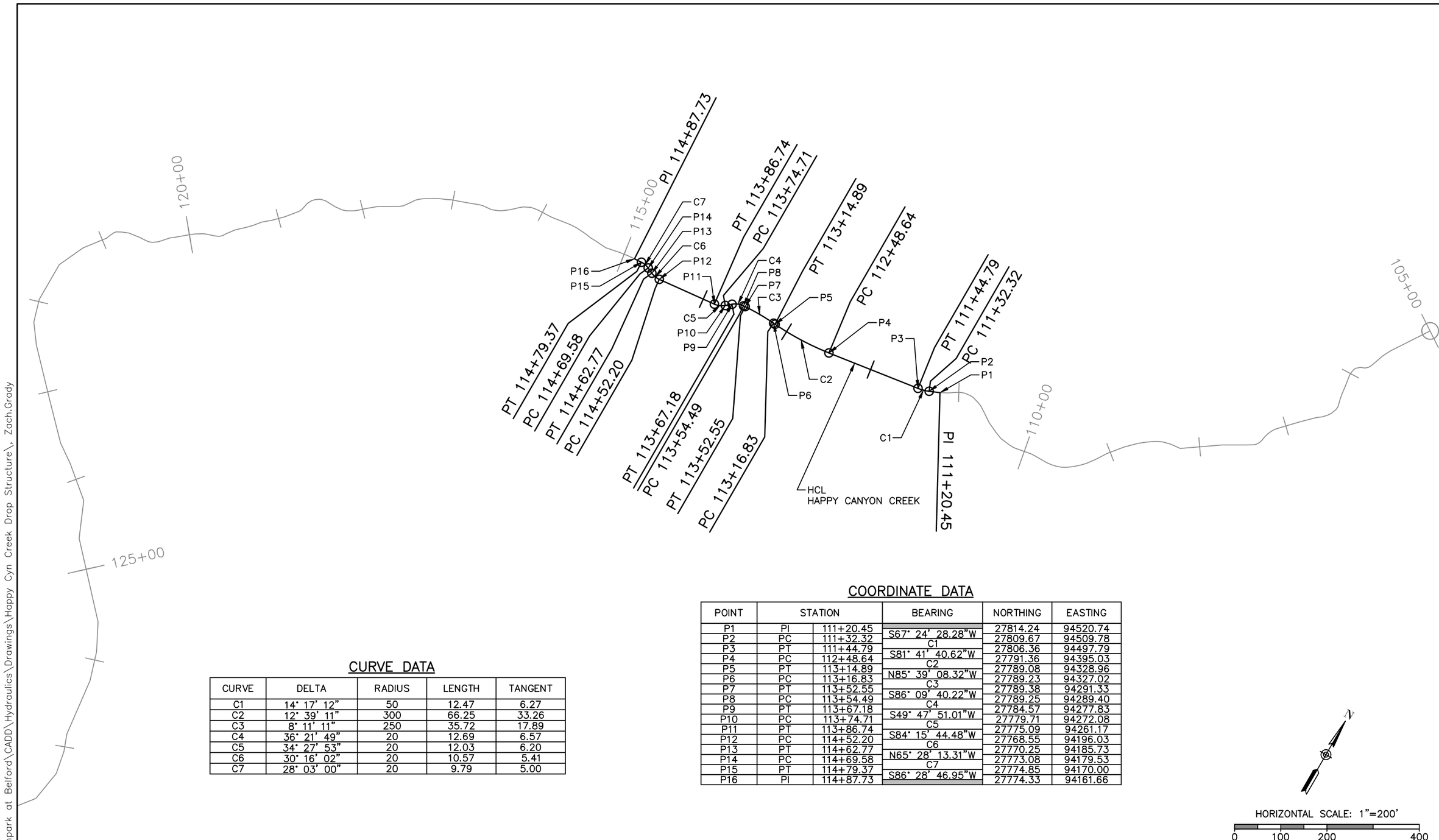
No Revisions:
Revised:
Void:

BELFORD–HAPPY CANYON CREEK BRIDGE
BRIDGE HYDRAULIC INFORMATION
(2 OF 2)

Designer:	C. TWISS	Structure Numbers	
Detailer:	K. TURNER		
Subset:	BRIDGE	Sheets:	B7 of 32

Project No./Code

Sheet Number ----



CURVE DATA

CURVE	DELTA	RADIUS	LENGTH	TANGENT
C1	14° 17' 12"	50	12.47	6.27
C2	12° 39' 11"	300	66.25	33.26
C3	8° 11' 11"	250	35.72	17.89
C4	36° 21' 49"	20	12.69	6.57
C5	34° 27' 53"	20	12.03	6.20
C6	30° 16' 02"	20	10.57	5.41
C7	28° 03' 00"	20	9.79	5.00

COORDINATE DATA

POINT	STATION		BEARING	NORTHING	EASTING
P1	PI	111+20.45		27814.24	94520.74
P2	PC	111+32.32	S67° 24' 28.28"W	27809.67	94509.78
P3	PT	111+44.79	C1	27806.36	94497.79
P4	PC	112+48.64	S81° 41' 40.62"W	27791.36	94395.03
P5	PT	113+14.89	C2	27789.08	94328.96
P6	PC	113+16.83	N85° 39' 08.32"W	27789.23	94327.02
P7	PT	113+52.55	C3	27789.38	94291.33
P8	PC	113+54.49	S86° 09' 40.22"W	27789.25	94289.40
P9	PT	113+67.18	C4	27784.57	94277.83
P10	PC	113+74.71	S49° 47' 51.01"W	27779.71	94272.08
P11	PT	113+86.74	C5	27775.09	94261.17
P12	PC	114+52.20	S84° 15' 44.48"W	27768.55	94196.03
P13	PT	114+62.77	C6	27770.25	94185.73
P14	PC	114+69.58	N65° 28' 13.31"W	27773.08	94179.53
P15	PT	114+79.37	C7	27774.85	94170.00
P16	PI	114+87.73	S86° 28' 46.95"W	27774.33	94161.66

HORIZONTAL SCALE: 1"=200'

0 100 200 400

I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\, Zach.Grady

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File Name: H115360-01DROP03Geom.dwg
Horizontal Scale: 1"=100' Vertical Scale: N.T.S.

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Revised:
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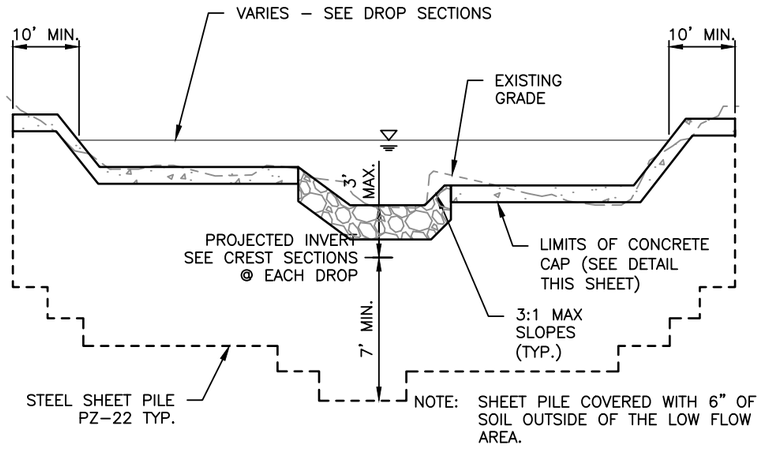
BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
HCL GEOMETRY LAYOUT

Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD-03 of 18

Project No./Code:

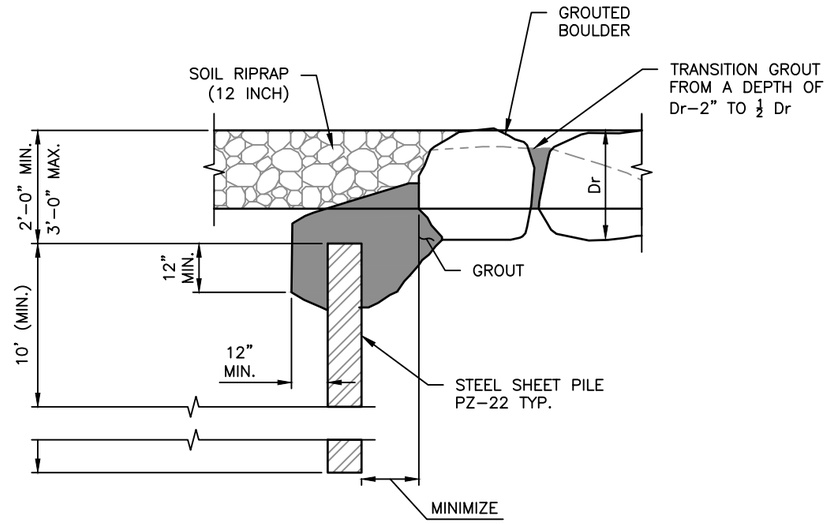
Sheet Number 45

Know what's below. Call before you dig.



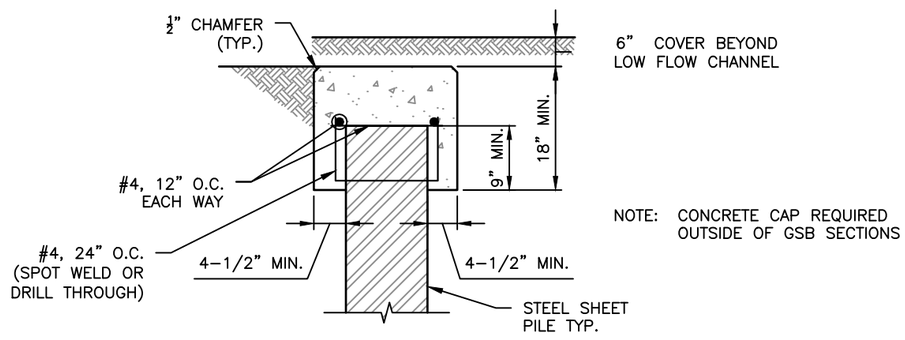
SHEET PILE SECTION

N.T.S.



SHEET PILE CUTOFF CONNECTION (GSB)

N.T.S.



CONCRETE SHEET PILE CAP DETAIL

N.T.S.

I:\115360-01 – Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\, Zach.Grady

Print Date: 11/17/2016 1:59:37 PM
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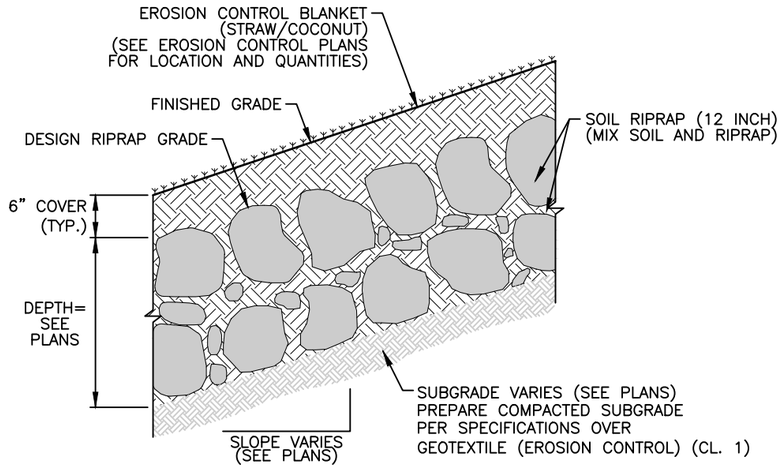
BELFORD–HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
SHEET PILE DETAILS

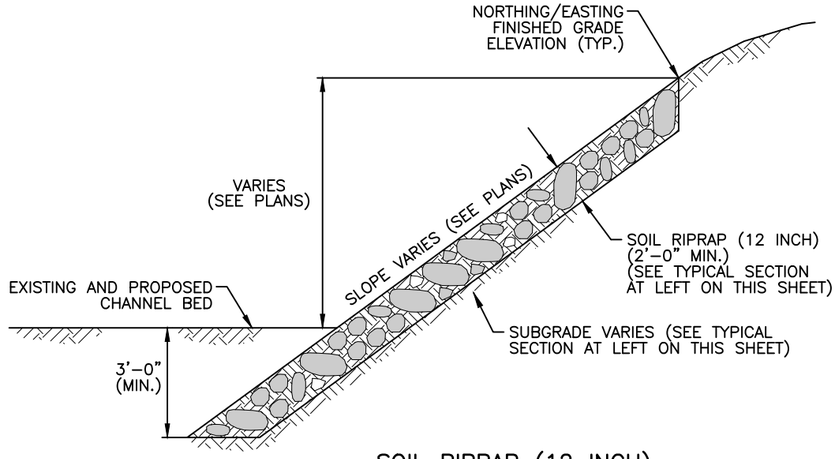
Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD–04 of 18

Project No./Code:

Sheet Number 46



SOIL RIPRAP (12 INCH)
TYPICAL SECTION
N.T.S.



SOIL RIPRAP (12 INCH)
CHANNEL BANKS
TYPICAL SECTION
N.T.S.

SOIL RIPRAP (12 INCH) NOTES:

(1) SOIL RIPRAP DETAILS ARE APPLICABLE TO SLOPED AREAS REFER TO THE SITE PLAN FOR ACTUAL LOCATION AND LIMITS.

(2) MIX UNIFORMALLY 70% RIPRAP BY VOLUME WITH 30% OF APPROVED SOIL BY VOLUME FROM THE ENGINEER PRIOR TO PLACEMENT.

(3) PLACE STONE-SOIL MIX TO RESULT IN SECURELY INTERLOCKED ROCK AT THE DESIGN THICKNESS AND GRADE COMPACT AND LEVEL TO ELIMINATE ALL VOIDS AND ROCKS PROJECTING ABOVE DESIGN RIPRAP TOP GRADE.

(4) CRIMP MULCH AS CALLED FOR IN THE PLANS AND SPECIFICATIONS.

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Print Date: 11/17/2016 11:52:02 AM
File Name: H115360-01DROP05Σoil Riprap Det.dwg
Horizontal Scale: N.T.S Vertical Scale: N.T.S

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BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
DETAILS

Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD-05 of 18

Project No./Code:

Sheet Number 47

Know what's below. Call before you dig.

GROUT NOTES

BOULDER PLACEMENT NOTES:

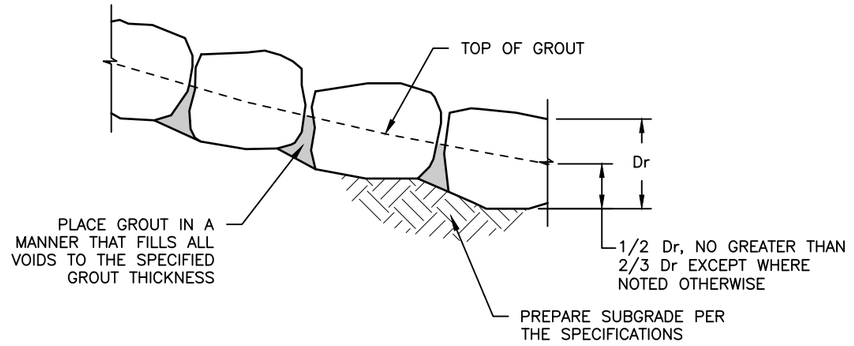
1. PLACE BOULDERS WITH THE REQUIRED BOULDER HEIGHT VERTICAL. PLACE BOULDERS AS TIGHTLY TOGETHER AS POSSIBLE (WITHOUT TOUCHING) WHILE PROVIDING ENOUGH ROOM BETWEEN THEM TO THOROUGHLY VIBRATE THE GROUT AND TO ENSURE NO GAPS IN THE GROUT. THE SMALL DIMENSION OF A 2X4 CAN BE USED AS A GUIDE TO CHECK MINIMUM SPACING.
2. BEFORE GROUTING, CLEAN ALL DIRT AND MATERIAL FROM ROCK THAT COULD PREVENT THE GROUT FROM BINDING TO THE ROCK. KEEP BOULDERS FROM TOUCHING. AVOID SLIDING BOULDERS AGAINST SUBGRADE TO PROPERLY POSITION.

MATERIAL SPECIFICATIONS:

1. ALL GROUT SHALL HAVE A MINIMUM 28–DAY COMPRESSIVE STRENGTH EQUAL TO 3200 PSI.
2. ONE CUBIC YARD OF GROUT SHALL HAVE A MINIMUM OF SIX (6) SACKS OF TYPE II PORTLAND CEMENT.
3. A MAXIMUM OF 25% TYPE F FLY ASH MAY BE SUBSTITUTED FOR THE PORTLAND CEMENT.
4. THE AGGREGATE SHALL BE COMPRISED OF 70% NATURAL SAND (FINES) AND 30% 3/8–INCH ROCK (COARSE).
5. THE GROUT SLUMP SHALL BE BETWEEN 4–INCHES TO 6–INCHES.
6. AIR ENTRAINMENT SHALL BE BETWEEN 5.5% AND 7.5%.
7. TO CONTROL SHRINKAGE AND CRACKING, 1.5 POUNDS OF FIBERMESH, OR EQUIVALENT, SHALL BE USED PER CUBIC YARD OF GROUT.
8. COLOR ADDITIVE IN REQUIRED AMOUNTS SHALL BE USED WHEN SO SPECIFIED BY CONTRACT.

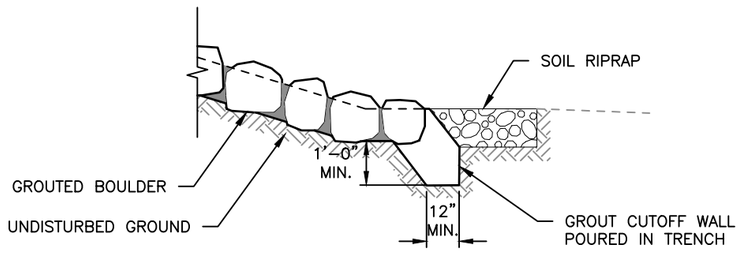
GROUT PLACEMENT SPECIFICATIONS:

1. SPECIAL PROCEDURES SHALL BE REQUIRED FOR GROUT PLACEMENT WHEN THE AIR TEMPERATURES ARE LESS THAN 40°F OR GREATER THAN 90°F. CONTRACTOR SHALL OBTAIN PRIOR APPROVAL FROM THE DESIGN ENGINEER OF THE PROCEDURES TO BE USED FOR PROTECTING THE GROUT.
2. GROUT SHALL BE DELIVERED BY MEANS OF A LOW PRESSURE (LESS THAN 10 PSI) GROUT PUMP USING A 2–INCH DIAMETER (MAXIMUM) NOZZLE.
3. FULL DEPTH PENETRATION OF THE GROUT INTO THE BOULDER VOIDS SHALL BE ACHIEVED BY INJECTING GROUT STARTING WITH THE NOZZLE NEAR THE BOTTOM AND RAISING IT AS THE GROUT FILLS, WHILE VIBRATING GROUT INTO PLACE USING A PENCIL VIBRATOR.
4. ALL GROUT BETWEEN BOULDERS SHALL BE TREATED WITH A BROOM FINISH.
5. AFTER GROUT PLACEMENT, EXPOSED BOULDER FACES SHALL BE CLEANED AND FREE OF GROUT.
6. ALL FINISHED GROUT SURFACES SHALL BE SPRAYED WITH A CLEAR LIQUID MEMBRANE CURING COMPOUND AS SPECIFIED IN ASTM C309.



GROUTED BOULDER PLACEMENT DETAIL

N.T.S.



STRUCTURE EDGE WALL DETAIL

N.T.S.

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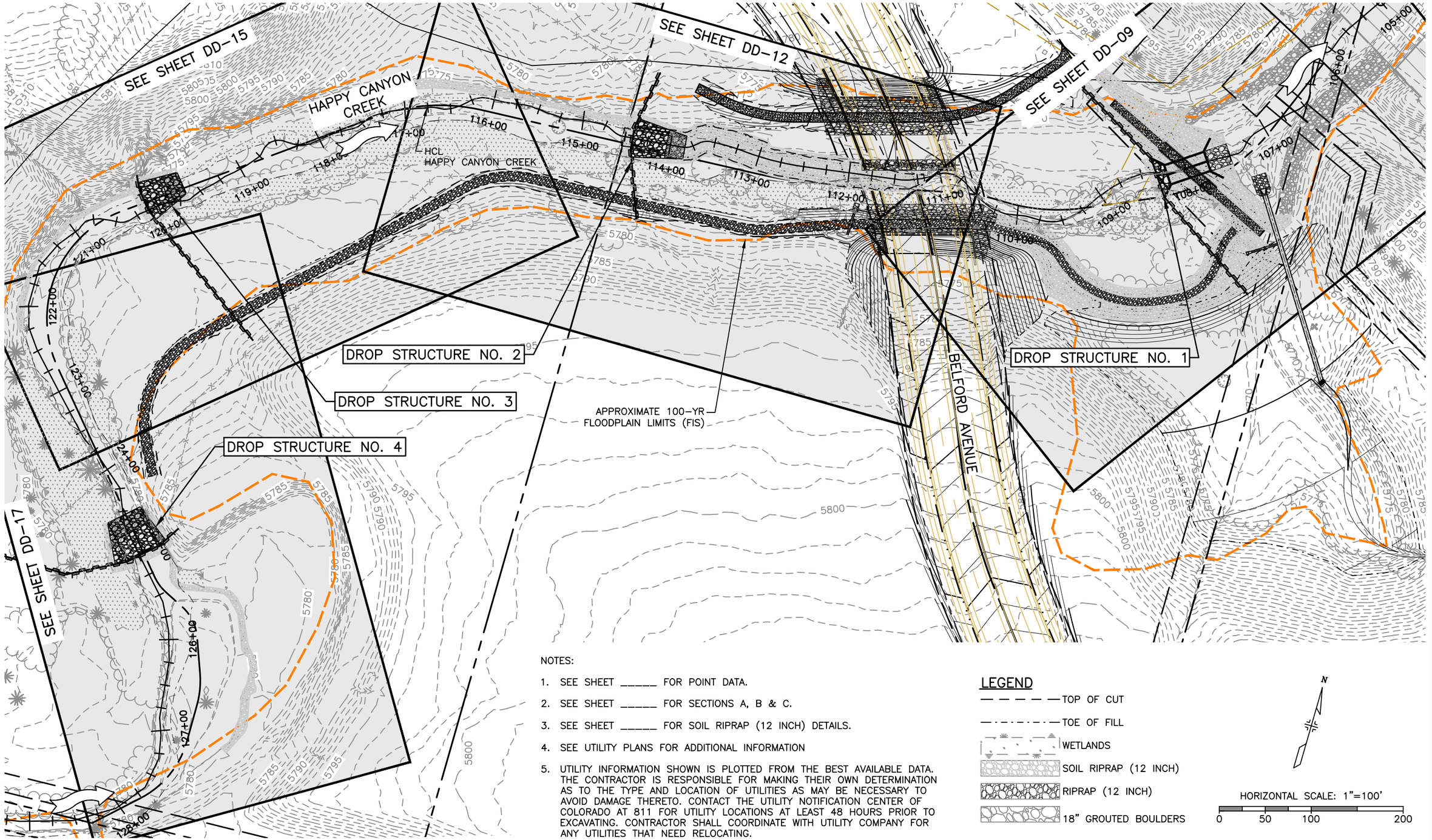
Print Date: 11/17/2016 11:52:26 AM		Sheet Revisions			Manhard CONSULTING LTD	As Constructed	BELFORD–HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DETAIL	Project No./Code
File Name: H115360-01DROP06Trouted Boulder Det.dwg	(R–X)	Date	Comments	Initials	8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph(303.708.0500 fx(303.708.0400 manhardcon	No Revisions:		
Horizontal Scale: N.T.S Vertical Scale: N.T.S					Civil Engineers • Surveyors • Water Resource Engineers • Water & Wastewater Engineers Construction Managers • Environmental Scientists • Landscape Architects • Planners	Revised:	Designer: CDT / Detailer: KLT / Subset: Drainage	Structure Numbers / Sheets: DD–06 of 18
FELSBURG HOLT & ULLEVIG 6300 South Syracuse Way, Suite 600 Centennial, CO 80111 tel 303.721.1440 fax 303.721.0832						Void:		Sheet Number 48



NOTES:

1. SEE SHEET _____ FOR POINT DATA.
2. SEE SHEET _____ FOR SECTIONS A, B & C.
3. SEE SHEET _____ FOR SOIL RIPRAP (12 INCH) DETAILS.
4. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION
5. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE CONTRACTOR IS RESPONSIBLE FOR MAKING THEIR OWN DETERMINATION AS TO THE TYPE AND LOCATION OF UTILITIES AS MAY BE NECESSARY TO AVOID DAMAGE THERETO. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AT 811 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO EXCAVATING. CONTRACTOR SHALL COORDINATE WITH UTILITY COMPANY FOR ANY UTILITIES THAT NEED RELOCATING.

LEGEND

- TOP OF CUT
- TOE OF FILL
- WETLANDS
- SOIL RIPRAP (12 INCH)
- RIPRAP (12 INCH)
- 18" GROUTED BOULDERS

N

HORIZONTAL SCALE: 1"=100'

0 50 100 200

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File Name: H115360-01DROP07?eymap.dwg
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BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
PLAN

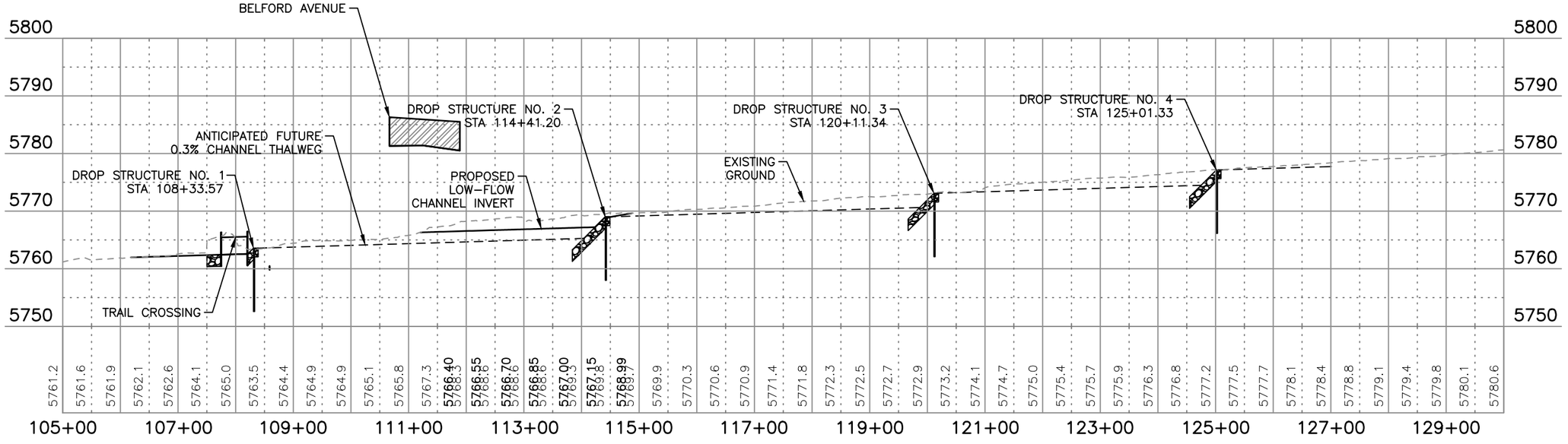
Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD-07 of 18

Project No./Code

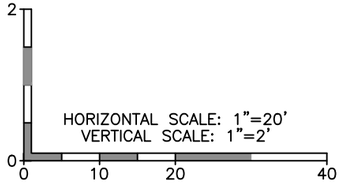
Sheet Number 49

NOTES

1. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE CONTRACTOR IS RESPONSIBLE FOR MAKING THEIR OWN DETERMINATION AS TO THE TYPE AND LOCATION OF UTILITIES AS MAY BE NECESSARY TO AVOID DAMAGE THERETO. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AT 811 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO EXCAVATING. CONTRACTOR SHALL COORDINATE WITH UTILITY COMPANY FOR ANY UTILITIES THAT NEED RELOCATING.
2. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION.



HAPPY CANYON CREEK PROFILE



I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\, Zach.Grady

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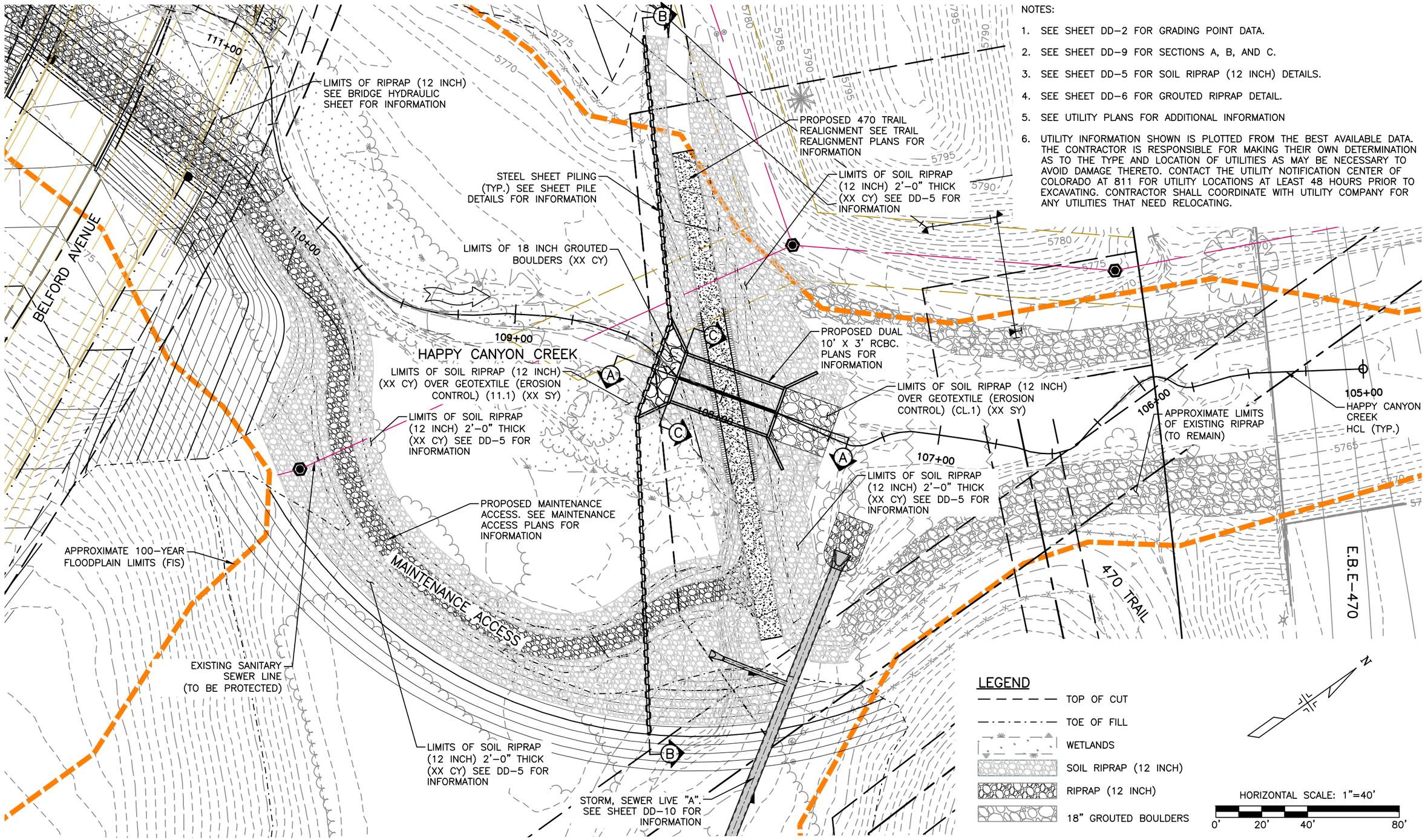
BELFORD-HAPPY CANYON CREEK			Project No./Code
PROFILE			
Designer: CDT	Structure Numbers		
Detailer: KLT			
Subset: Drainage	Sheets: DD-08 of 18		Sheet Number 50



NOTES:

1. SEE SHEET DD-2 FOR GRADING POINT DATA.
2. SEE SHEET DD-9 FOR SECTIONS A, B, AND C.
3. SEE SHEET DD-5 FOR SOIL RIPRAP (12 INCH) DETAILS.
4. SEE SHEET DD-6 FOR GROUTED RIPRAP DETAIL.
5. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION
6. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE CONTRACTOR IS RESPONSIBLE FOR MAKING THEIR OWN DETERMINATION AS TO THE TYPE AND LOCATION OF UTILITIES AS MAY BE NECESSARY TO AVOID DAMAGE THERETO. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AT 811 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO EXCAVATING. CONTRACTOR SHALL COORDINATE WITH UTILITY COMPANY FOR ANY UTILITIES THAT NEED RELOCATING.

LEGEND

- TOP OF CUT
- TOE OF FILL
- WETLANDS
- SOIL RIPRAP (12 INCH)
- RIPRAP (12 INCH)
- 18" GROUTED BOULDERS

HORIZONTAL SCALE: 1"=40'

0' 20' 40' 80'

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Print Date: 11/17/2016 2:08:13 PM
File Name: H115360-01DROP09Δrop1 Plan.dwg
Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

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BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
DROP NO. 1 PLAN

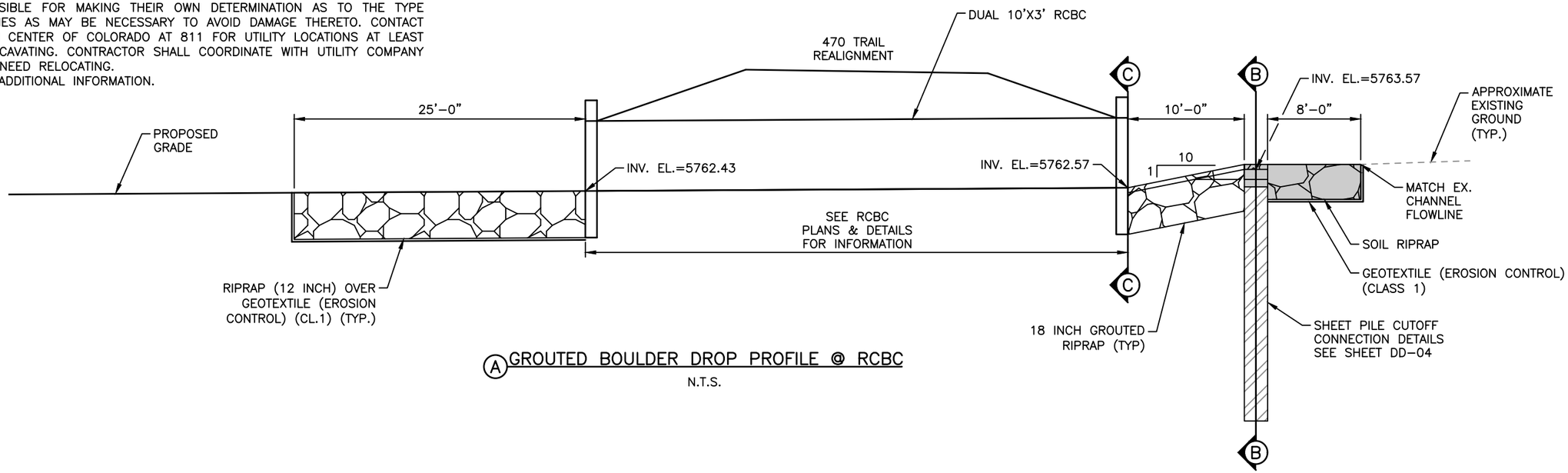
Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD-09 of 18

Project No./Code:

Sheet Number 51

NOTES

1. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE CONTRACTOR IS RESPONSIBLE FOR MAKING THEIR OWN DETERMINATION AS TO THE TYPE AND LOCATION OF UTILITIES AS MAY BE NECESSARY TO AVOID DAMAGE THERETO. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AT 811 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO EXCAVATING. CONTRACTOR SHALL COORDINATE WITH UTILITY COMPANY FOR ANY UTILITIES THAT NEED RELOCATING.
2. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION.



Ⓐ GROUTED BOULDER DROP PROFILE @ RCBC

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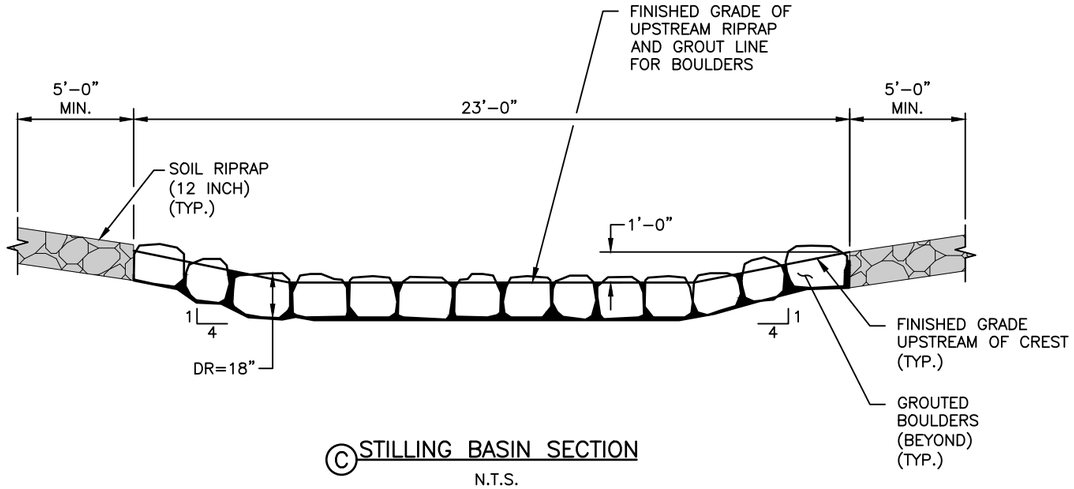

Ⓒ STILLING BASIN SECTION

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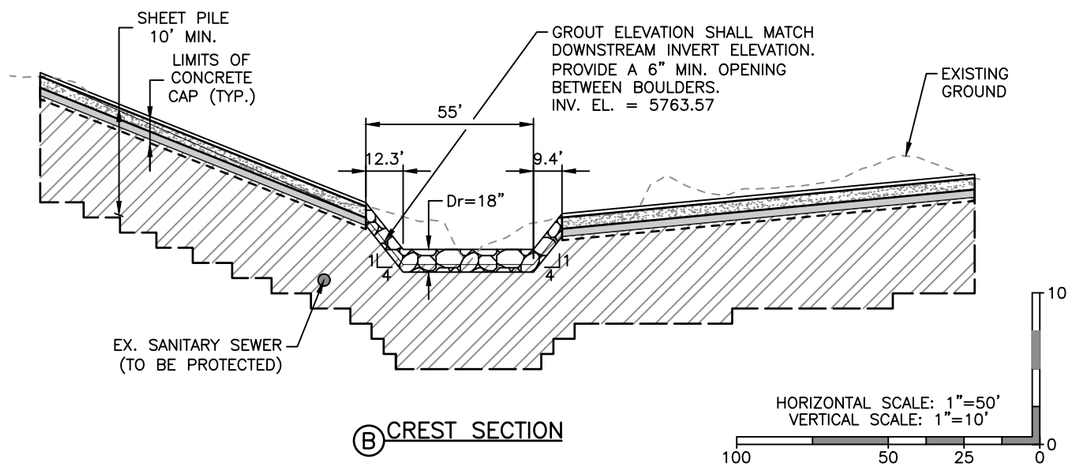

Ⓑ CREST SECTION

DROP STRUCTURE NO. 1

HAPPY CANYON CREEK HYDRAULICS
Q100= 8,303 C.F.S
Q100 VELOCITY = 5.66 F.P.S
FROUDE No.=0.30
FOR INFO ONLY

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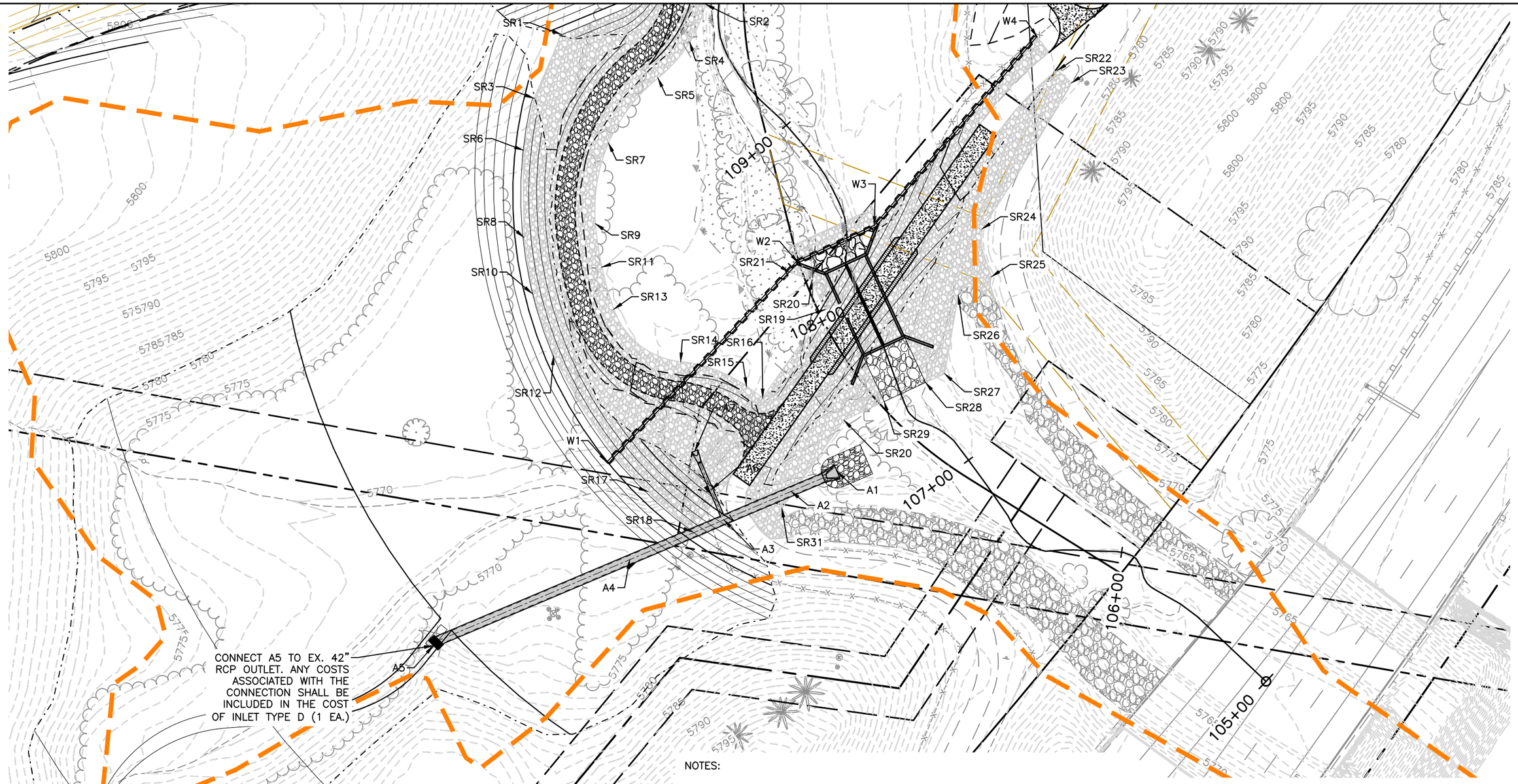
BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 1 PROFILE/DETAILS			
Designer: CDT	Structure Numbers		Project No./Code
Detailer: KLT			
Subset: Drainage	Sheets: DD-10 of 18		Sheet Number 52

I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\, Zach.Grady



I.D.	NORTHING & EASTING	ITEM	LENGTH	PAY DEPTH
A1	N: 27899.87, E: 94884.63	48" RCES		
A2		48" RCP	54'	
A3	N: 27854.05, E: 94914.30	MANHOLE SLAB BASE		10'
A4		48" RCP	157'	
A5	N: 27721.77, E: 95000.49	TYPE D INLET		10'
A6		18" RCP	30'	
A7	N: 27836.83 , E: 94887.70	18" RECS		

NOTES:

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2. SEE SHEET _____ FOR POINT DATA.

N

HORIZONTAL SCALE: 1"=50'

0 25 50 100

I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\, Zach.Grady

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File Name: H115360-01DROP11Grading Drop1.dwg
Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

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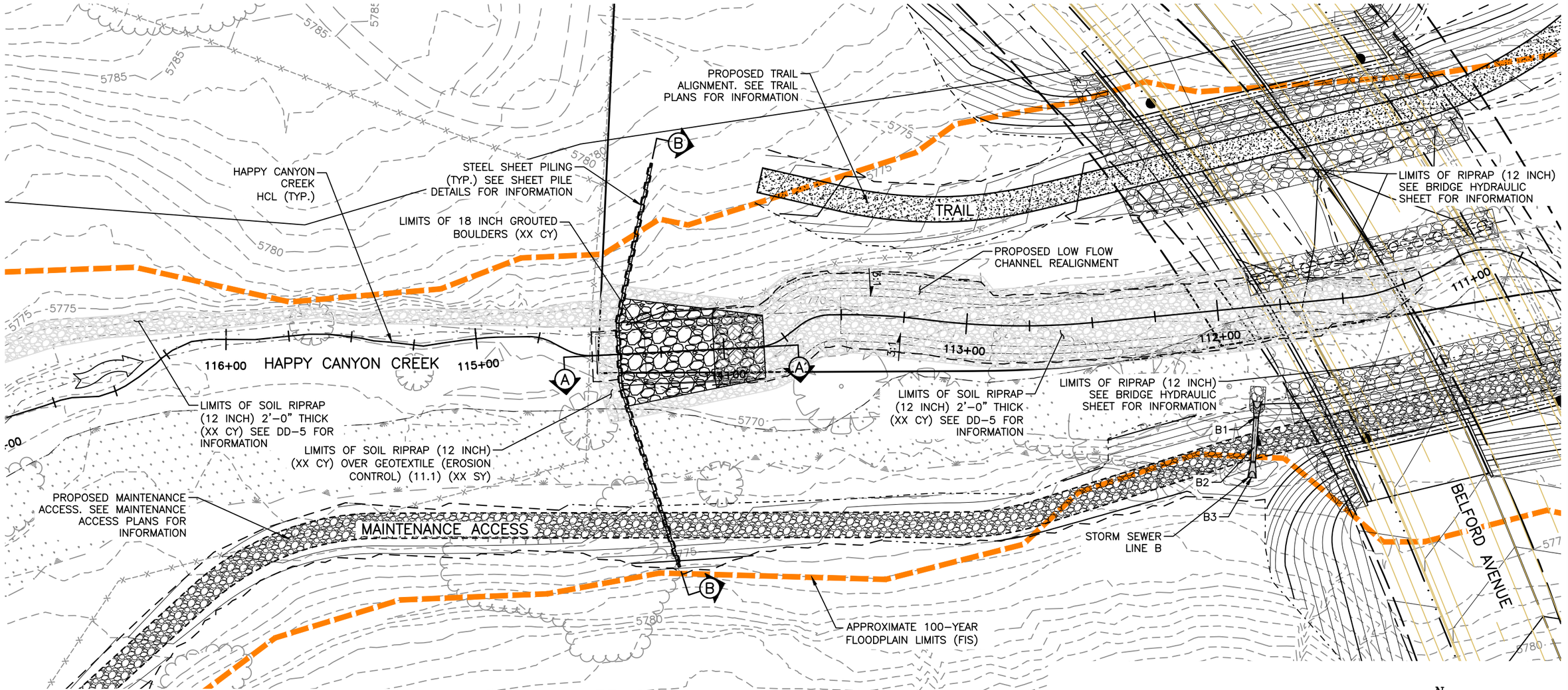
Revised:
Void:

BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
GRADING DETAIL

Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD-11 of 18

Project No./Code

Sheet Number 53



NOTES:

1. SEE SHEET DD-2 FOR GRADING POINT DATA.
2. SEE SHEET DD-4, AND DD-5 FOR SECTIONS A, AND B.
3. SEE SHEET DD-5 FOR SOIL RIPRAP (12 INCH) DETAILS.
4. SEE SHEET DD-6 FOR GROUTED RIPRAP DETAIL.
5. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION
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I.D.	NORTHING & EASTING	ITEM	LENGTH	PAY DEPTH
B1	N: 27756.42, E: 94460.52	18" RCES		
B2		18" RCP	18'	
B3	N: 27733.11, E: 94459.99	18" RCES		

LEGEND

- TOP OF CUT
- TOE OF FILL
- WETLANDS
- SOIL RIPRAP (12 INCH)
- RIPRAP (12 INCH)
- 18" GROUTED BOULDERS

N

HORIZONTAL SCALE: 1"=40'

0' 20' 40' 80'

Print Date: 11/17/2016 2:28:24 PM
File Name: H115360-01DROP12Δrop2 Plan.dwg
Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

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R-X	Sheet Revisions		
	Date	Comments	Initials

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BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
DROP NO. 2 PLAN

Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD-12 of 18

Project No./Code:
Sheet Number 54

I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\...

NOTES

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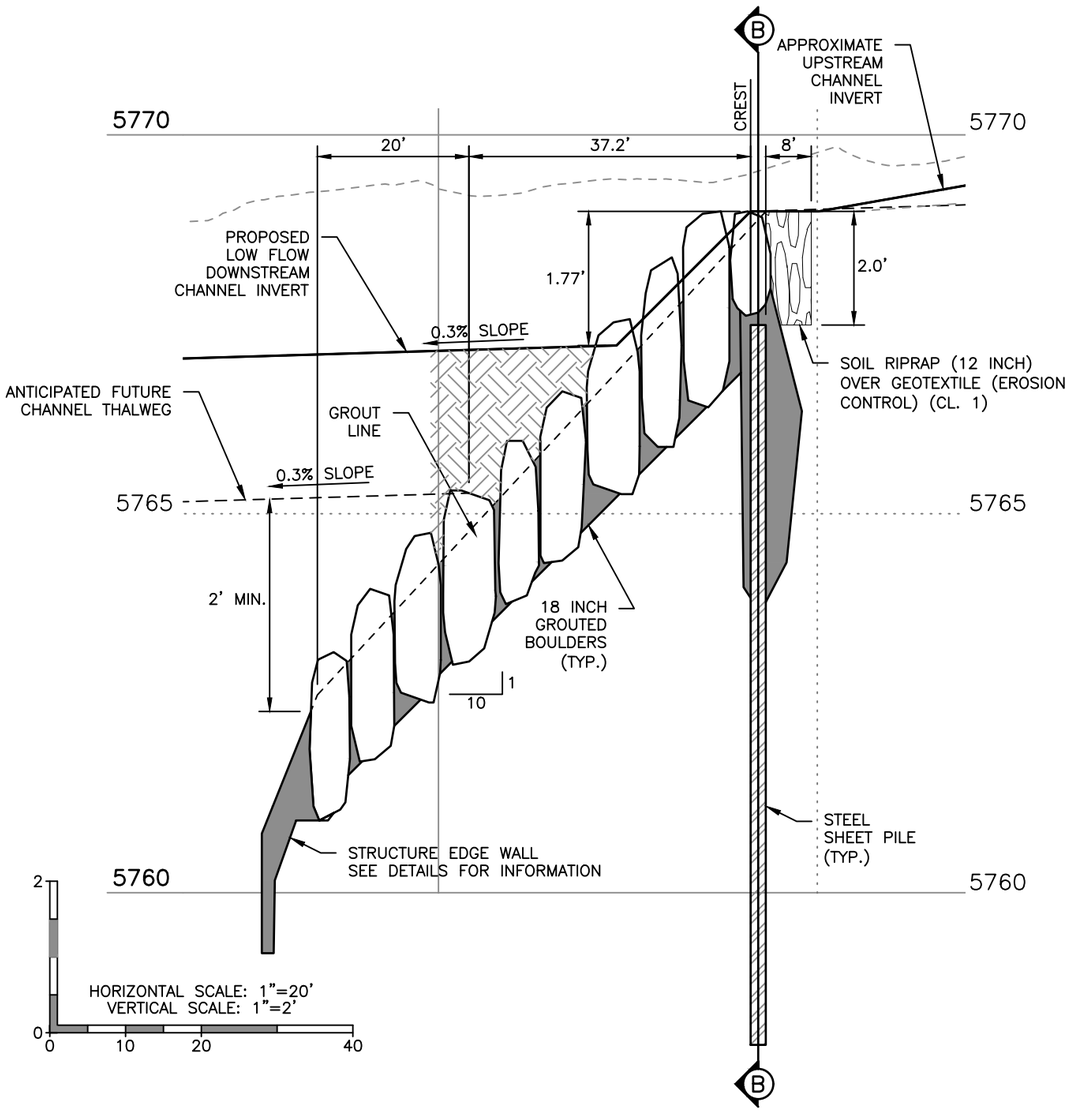
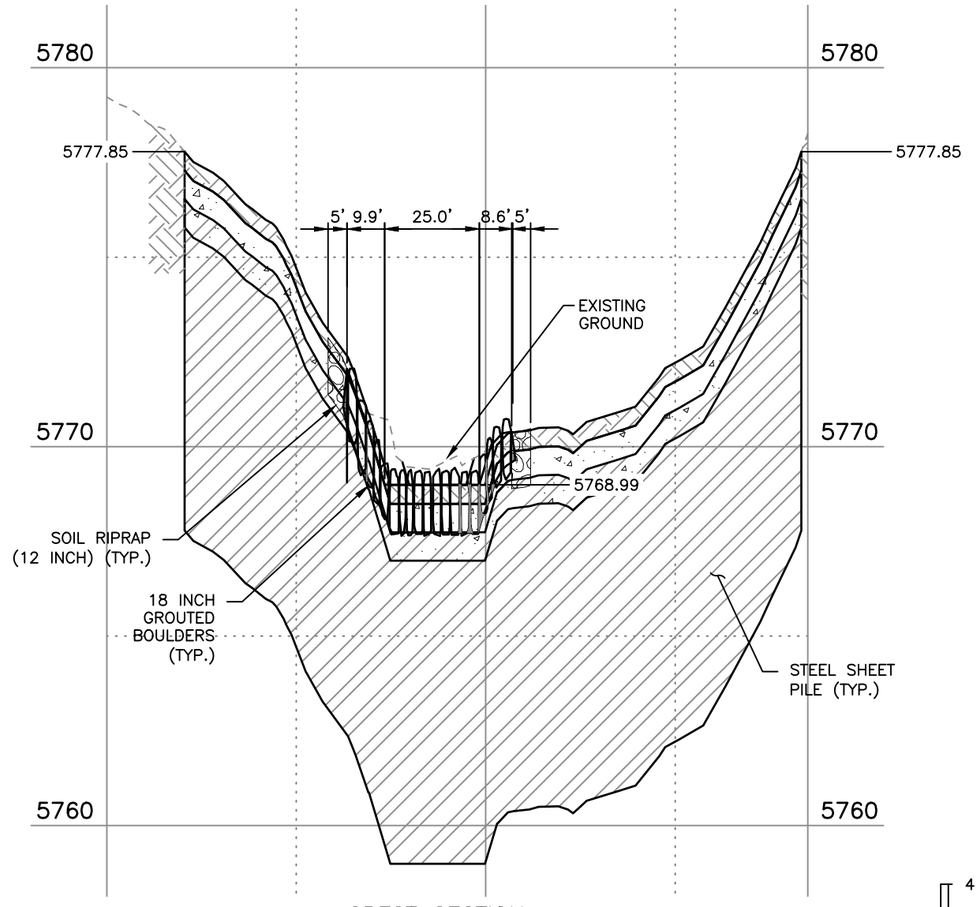
2. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION.



A GROUTED BOULDER DROP PROFILE



B CREST SECTION

DROP STRUCTURE NO. 2

HAPPY CANYON CREEK HYDRAULICS

Q100= 8,303 C.F.S
Q100 VELOCITY = 14.03 F.P.S
FROUDE No.=0.95

FOR INFO ONLY

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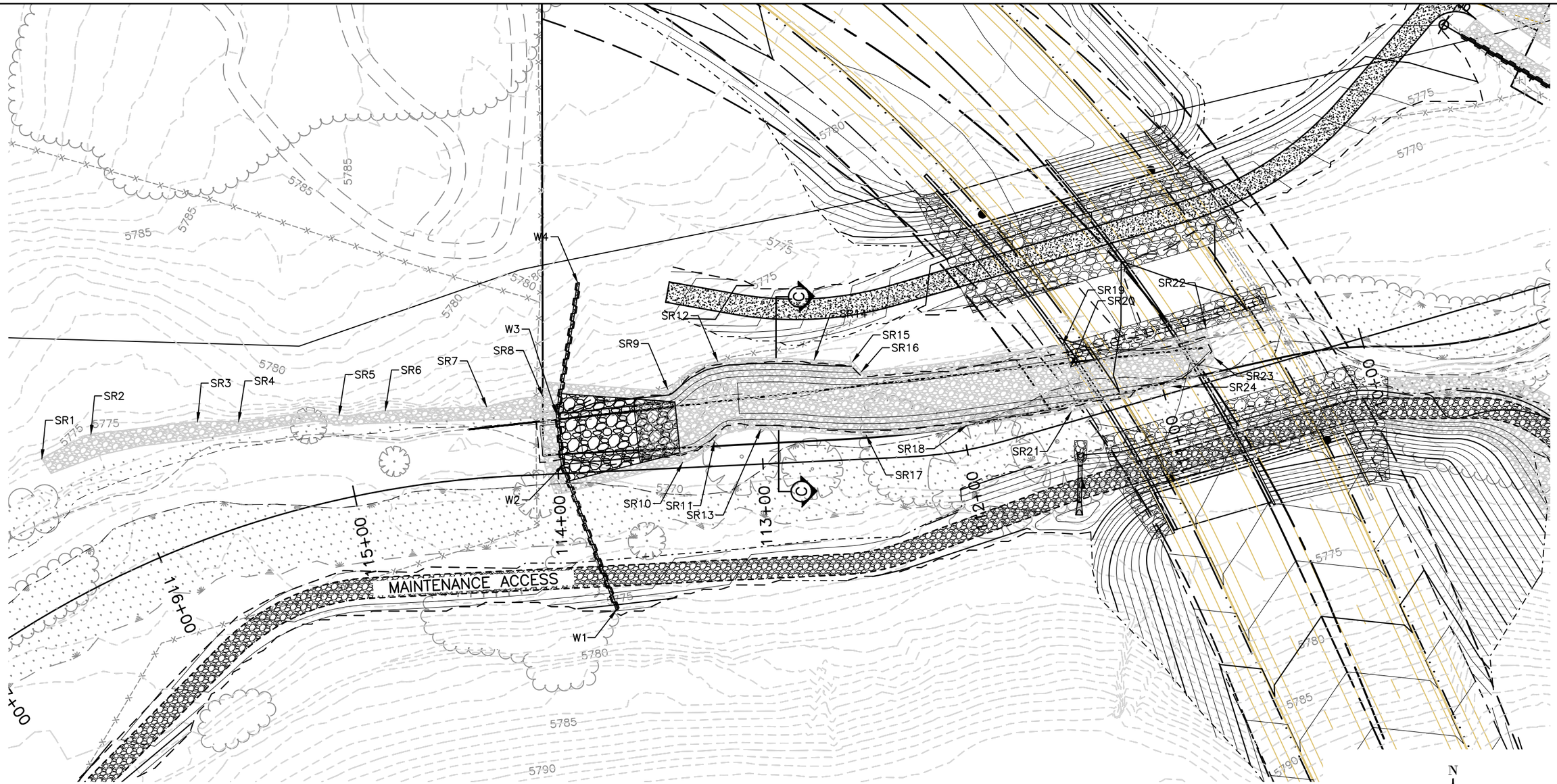
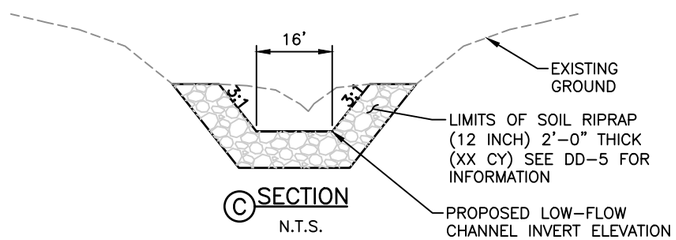
BELFORD-HAPPY CANYON CREEK DROP NO. 2 PROFILE/DETAILS				Project No./Code	
Designer:	CDT	Structure Numbers			
Detailer:	KLT				
Subset:	Drainage	Sheets:	DD-13 of 18	Sheet Number	55





Ⓒ SECTION
N.T.S.

NOTES:

1. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE CONTRACTOR IS RESPONSIBLE FOR MAKING THEIR OWN DETERMINATION AS TO THE TYPE AND LOCATION OF UTILITIES AS MAY BE NECESSARY TO AVOID DAMAGE THERETO. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AT 811 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO EXCAVATING. CONTRACTOR SHALL COORDINATE WITH UTILITY COMPANY FOR ANY UTILITIES THAT NEED RELOCATING.
2. SEE SHEET _____ FOR POINT DATA.

N

HORIZONTAL SCALE: 1"=20'
0 10 20 40

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Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

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	Date	Comments	Initials

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Void:

BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
GRADING DETAIL

Designer: CDT
Detailer: KLT
Subset: Drainage
Structure Numbers:
Sheets: DD-14 of 18

Project No./Code

Sheet Number 56

NOTES:

1. SEE SHEET DD-2 FOR GRADING POINT DATA.
2. SEE SHEET DD-4, AND DD-5 FOR SECTIONS A AND B.
3. SEE SHEET DD-5 FOR SOIL RIPRAP (12 INCH) DETAILS.
4. SEE SHEET DD-6 FOR GROUTED RIPRAP DETAIL.
5. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION
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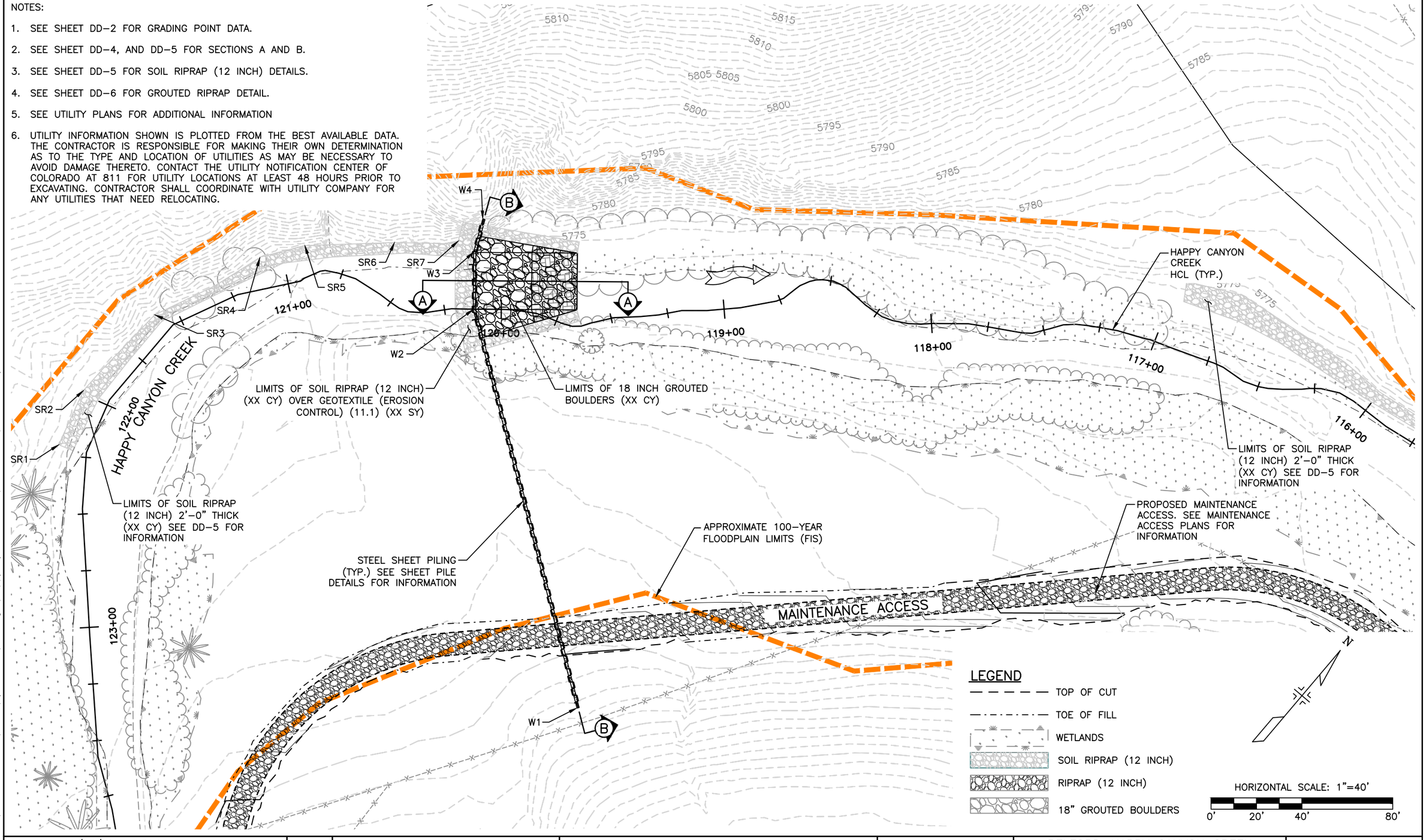

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Print Date: 11/17/2016 2:34:19 PM		Sheet Revisions	
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Void:	

BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
DROP NO. 3 PLAN

Designer:	CDT	Structure Numbers	
Detailer:	KLT		
Subset:	Drainage	Sheets:	DD-15 of 18

Project No./Code

Sheet Number 57

NOTES

1. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE CONTRACTOR IS RESPONSIBLE FOR MAKING THEIR OWN DETERMINATION AS TO THE TYPE AND LOCATION OF UTILITIES AS MAY BE NECESSARY TO AVOID DAMAGE THERETO. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AT 811 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO EXCAVATING. CONTRACTOR SHALL COORDINATE WITH UTILITY COMPANY FOR ANY UTILITIES THAT NEED RELOCATING.
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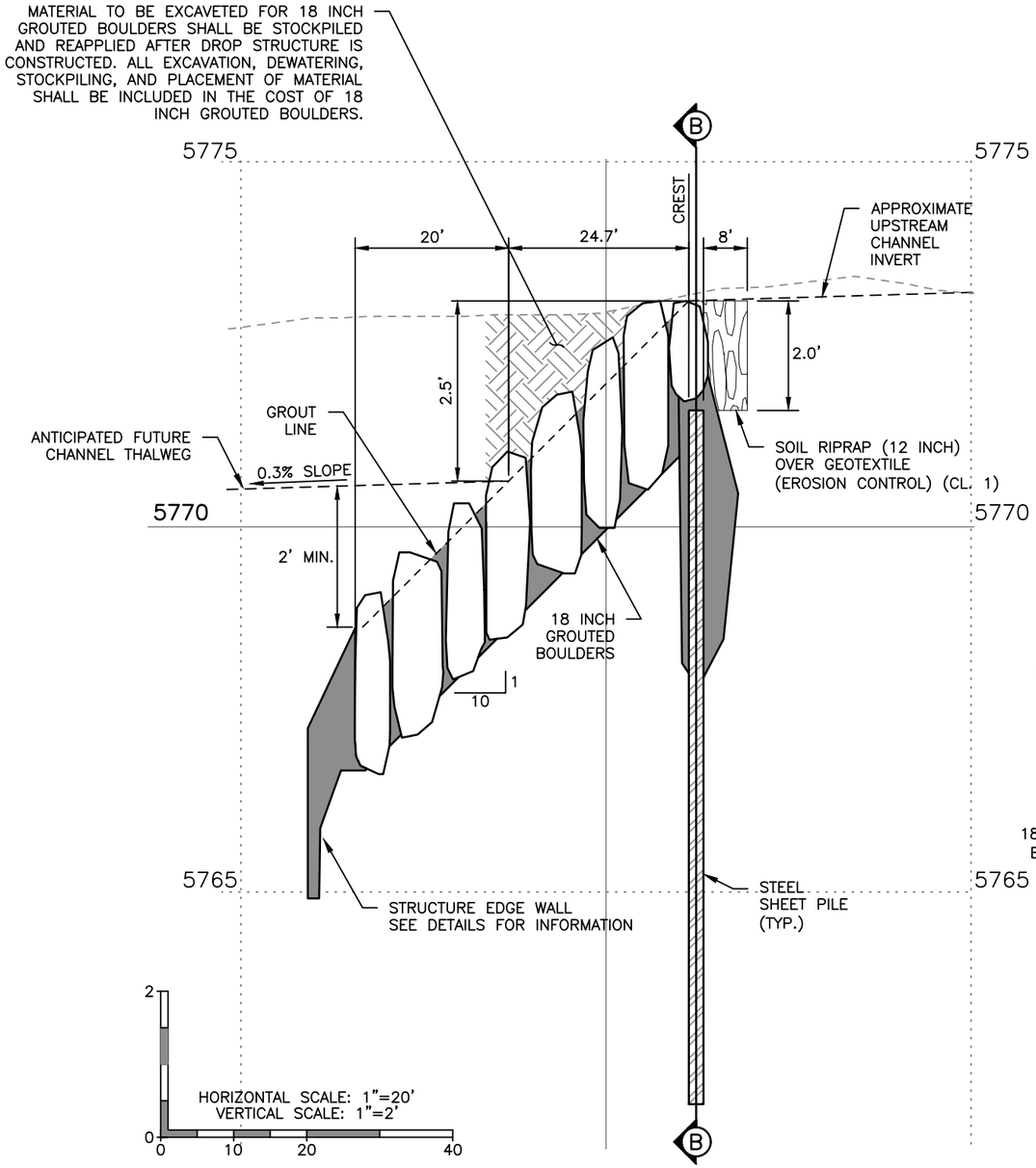
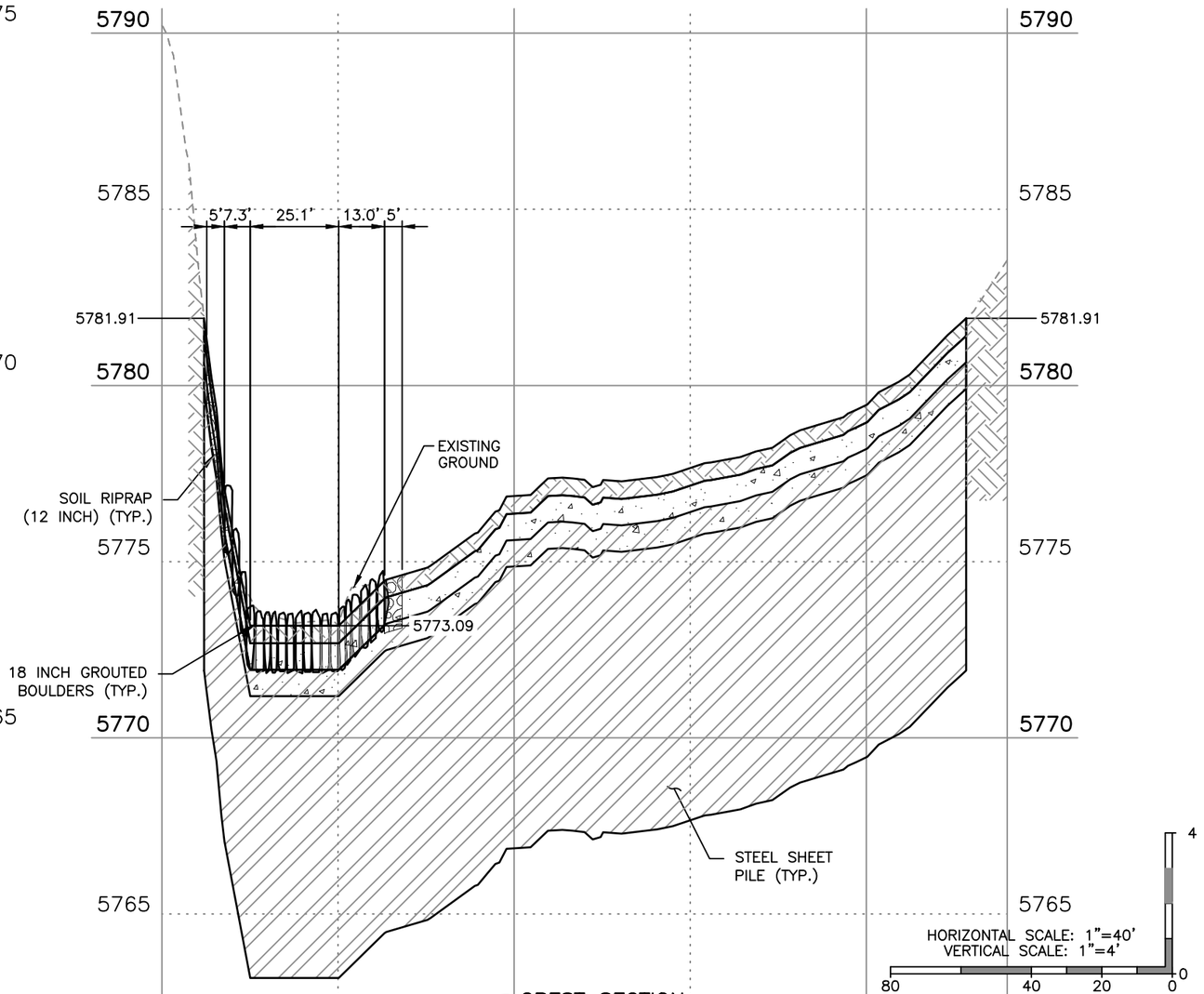


A GROUTED BOULDER DROP PROFILE



B CREST SECTION

HAPPY CANYON CREEK HYDRAULICS

Q100= 8,303 C.F.S
Q100 VELOCITY = 12.71 F.P.S
FROUDE No.=0.87
FOR INFO ONLY

DROP STRUCTURE NO. 3

Print Date: 11/17/2016 12:11:51 PM		Sheet Revisions			As Constructed
File Name: H115360-01DROP16Δrop3 Prof Sect.dwg	(R-X)	Date	Comments	Initials	No Revisions:
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BELFORD-HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
DROP NO. 3 PROFILE/DETAILS

Designer:	CDT	Structure Numbers	
Detailer:	KLT		
Subset:	Drainage	Sheets:	DD-16 of 18

Project No./Code

Sheet Number 58

I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\, Zach.Grady

NOTES:

1. SEE SHEET DD–2 FOR GRADING POINT DATA.
2. SEE SHEET DD–4, AND DD–5 FOR SECTIONS A, B & C.
3. SEE SHEET DD–5 FOR SOIL RIPRAP (12 INCH) DETAILS.
4. SEE SHEET DD–6 FOR GROUTED RIPRAP DETAIL.
5. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION
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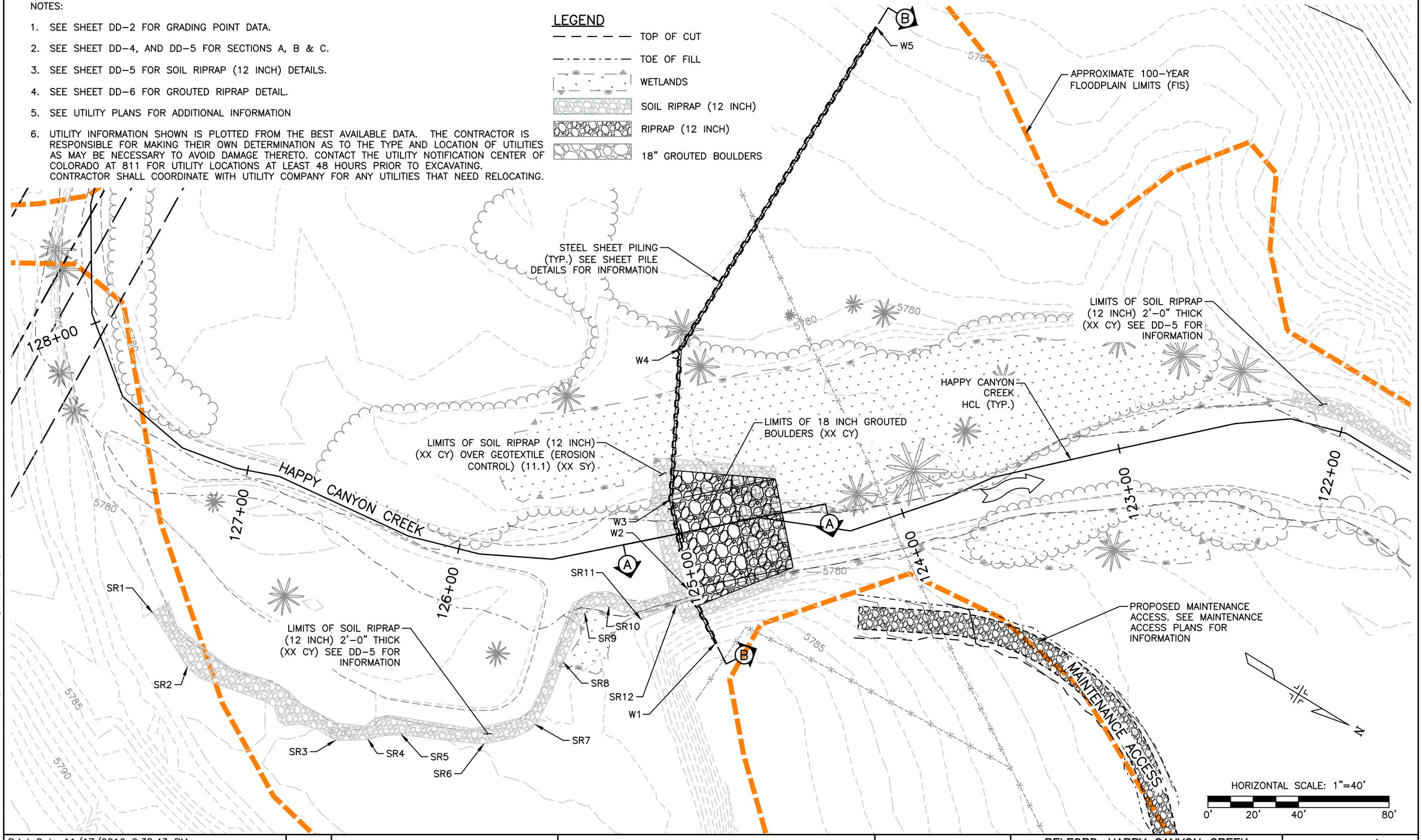
LEGEND

- TOP OF CUT
- TOE OF FILL
- WETLANDS
- SOIL RIPRAP (12 INCH)
- RIPRAP (12 INCH)
- 18" GROUTED BOULDERS



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Print Date: 11/17/2016 2:38:43 PM	R–X	Sheet Revisions			As Constructed
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BELFORD–HAPPY CANYON CREEK
HAPPY CANYON CREEK DROP STRUCTURE
DROP NO. 4 PLAN

Designer:	CDT	Structure Numbers	
Detailer:	KLT		
Subset:	Drainage	Sheets:	DD–17 of 18

Project No./Code

Sheet Number 59

NOTES

1. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE CONTRACTOR IS RESPONSIBLE FOR MAKING THEIR OWN DETERMINATION AS TO THE TYPE AND LOCATION OF UTILITIES AS MAY BE NECESSARY TO AVOID DAMAGE THERETO. CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AT 811 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO EXCAVATING. CONTRACTOR SHALL COORDINATE WITH UTILITY COMPANY FOR ANY UTILITIES THAT NEED RELOCATING.
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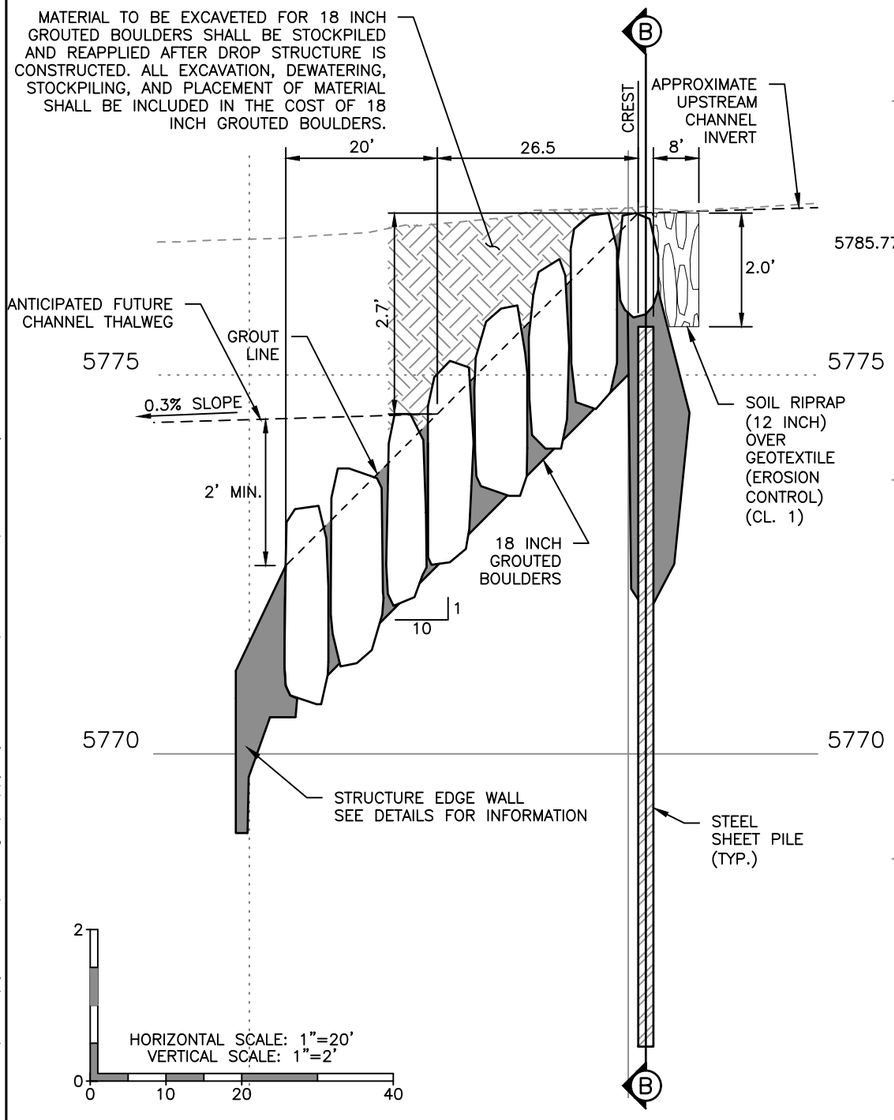
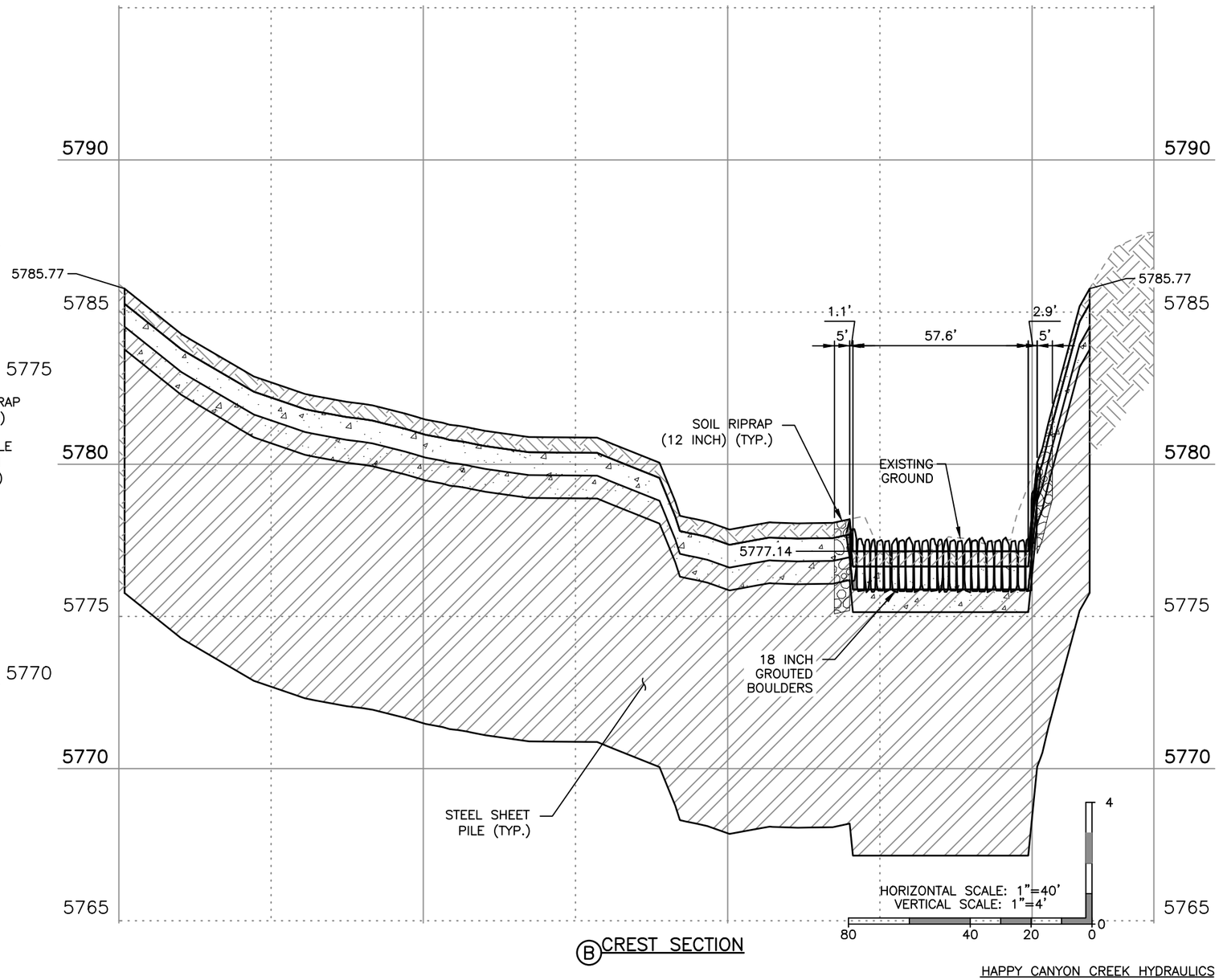


A GROUTED BOULDER DROP PROFILE



B CREST SECTION

HAPPY CANYON CREEK HYDRAULICS

Q100= 8,303 C.F.S
Q100 VELOCITY = 8.95 F.P.S
FROUDE No.=0.58
FOR INFO ONLY

DROP STRUCTURE NO. 4

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File Name: H115360-01DROP18Δrop4 Prof Sect.dwg		Date	Comments	Initials	No Revisions:
Horizontal Scale: 1"=50' Vertical Scale: 1"=10'					Revised:
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BELFORD–HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 4 PROFILE/DETAILS				Project No./Code
Designer:	CDT	Structure Numbers		
Detailer:	KLT			
Subset:	Drainage	Sheets:	DD–18 of 18	Sheet Number 60

FREEBOARD REQUIREMENTS

Project: Belford Avenue @ Happy Canyon Creek File Name: Freeboard.xlsx
Date: 16-Nov-16 FHU Project #: 115360-01

Fb = 0.1 * Q^0.3 + 0.008 * V^2 (English Units)
RE: UDFCD defers to CDOT Roadway Design Manual

REQUIRED FREEBOARD

Q_{100} =	8474	cfs	(Design Q)
V_{100} =	7.41	fps	(Average Velocity)
Fb=	1.95	ft.	(Required Freeboard)

AVAILABLE FREEBOARD

Low chord elevation =	5778.97	
Design W.S. elevation =	5776.18	
Available freeboard =	2.79	ft.

FELSBURG HOLT & ULLEVIG

Job Title Belfrard @ HCC By CBT Date 10-13-16 Job No. 115300-01

Subject Bridge Scour Checked Sheet 1 of

Vratio

$V_{shear} / V_{fall} = V_* / w$

$V_{shear} = V_* = (g\, y_1\, S_1)^{1/2}$ — 32.16; upstream depth (ft); E.G.L. slope (ft/ft) 8.382'

$V_{*100} = (32.16 * 10.79 * 0.004)^{1/2} = 1.18$

$V_{*500} = (32.16 * 13.90 * 0.008)^{1/2} = 1.89$

d_{50} size = 0.005 ft 1.5mm = 0.005 ft

$V_{fall} = w = 0.70$

$V_{ratio\,100} = V_{*100} / w = 1.18 / 0.7 = 1.69$

$V_{ratio\,500} = V_{*500} / w = 1.89 / 0.7 = 2.70$

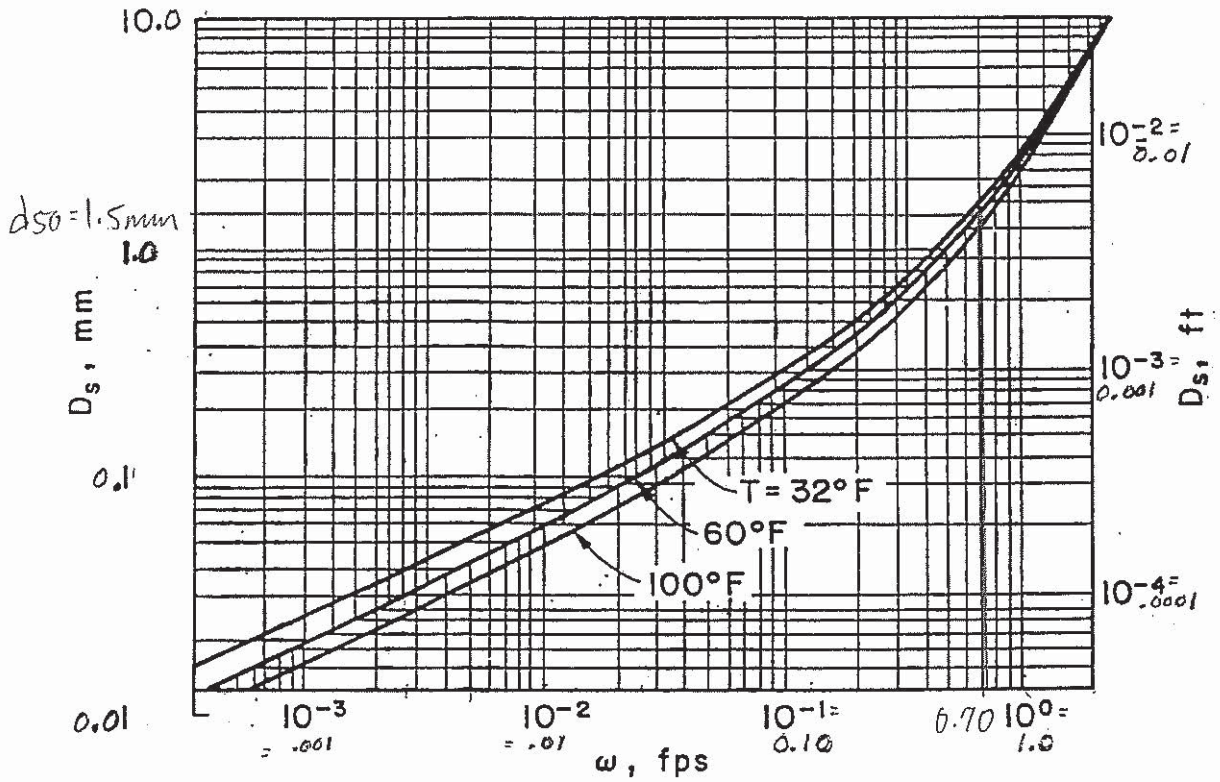


Figure 3. Fall Velocity of Sand-Sized Particles.

REV. 7-26-00

FELSBURG HOLT & ULLEVIG

Job Title Belfrid @ HCC By CDT Date 10-13-16 Job No. 115360-05

Subject Bridge Scour Checked Sheet 2 of

Determine if Contraction Scour is live bed or clear water

$V_c = 11.52\, y_1^{1/6}\, D_{50}^{1/3}$ (Critical Velocity; y_1: Upstream flow depth)

$V_{c100} = 11.52 \times \underline{10.79}^{(0.17)} \times \underline{0.005}^{(0.33)} = \underline{3.00}$

V_{100} main channel $= \underline{7.41}$ fps $\therefore$ Live Bed Scour

If $V_{c100} \leq V_{100\,mc}$ then Live Bed Scour
If $V_{c100} > V_{100mc}$ then Clear Water

$V_{c500} = 11.52 \times \underline{13.90}^{1/6} \times \underline{0.0008}^{1/3} = \underline{3.16}$

$V_{500\,mc} = \underline{7.08} \therefore$ Live Bed Scour

REV 7-26-00

FELSBURG HOLT & ULLEVIG

Job Title Belford @ HCC By CDT Date 10-13-16 Job No. 115360-01

Subject Bridge Scour Checked Sheet 3 of

CLEAR WATER SCOUR

$$Y_s = \left[\frac{Q^2}{120\, D_M^{2/3} W^2} \right]^{3/7} - Y_1$$

Y_s = Avg. Scour Depth; Q = Q bridge; Y_1 = depth of flow in channel; D_M = 1.25 D_{50}; W = bottom width of bridge less piers (low chord)

1.25 D_{50} = 1.25 * ____ = ____

DOES NOT APPLY - NOT USED

$Y_{s_{100}}$ = $\left[\frac{\quad^2}{120 * \_\_^{2/3} * \_\_^2} \right]^{3/7}$ − ____ = ____ ft.

$Y_{s_{500}}$ = $\left[\frac{\quad^2}{120 * \_\_^{2/3} * \_\_^2} \right]^{3/7}$ − ____ = ____ ft.

LIVE BED SCOUR

$$Y_2 = \left(\frac{Q_2}{Q_1} \right)^{6/7} * \left(\frac{W_1}{W_2} \right)^{K_1} * (Y_1)$$

Q_2 = Flow in cont. main channel which is often Q_{Total}; Q_1 = Flow in approach main channel that transports sediment; W_1 = Avg. bottom width of the main channel at approach cross section; W_2 = Avg. bottom width of the contracted section; Y_1 = Avg. depth in upstream main channel

100yr = 1.69
500yr = 2.70.

V* / w	K_1
< 0.5	0.59
0.5 - 2.0	0.64
> 2.0	0.69

$Y_{2(100)} = \left(\frac{8474}{6186} \right)^{0.857} * \left(\frac{125}{120} \right)^{0.64} * 10.79 = 14.39$ $\quad Y_s = Y_2 - Y_1 = 14.39 - 10.79 = 3.60'$

1.30 1.02

$Y_{2(500)} = \left(\frac{12029}{8728} \right)^{0.857} * \left(\frac{125}{120} \right)^{0.69} * 13.90 = 18.58$ $\quad Y_s = Y_2 - Y_1 = 18.58 - 13.17 = 5.41'$

1.30

Contraction Scour

100 YR = 3.60'
500 YR = 5.41'

REV 7-26-00

FELSBURG HOLT & ULLEVIG

Job Title Belfonte @ HCL By CDT Date 10-13-16 Job No. 115360-01

Subject Bridge Scour Checked Sheet 4 of

Clear Water or Live-Bed Scour at Abutments

$$\frac{y_s}{y_a} = \left[2.27 K_1 K_2 \left(\frac{a'}{y_a}\right)^{0.43} Fr^{0.61} + 1\right]$$

y_a = Avg depth in floodplain; a' = (To ineffective flow boundary) length of Abutment projected normal to flow; Fr = Approach Froude No.; K_1 = Abutment coefficient; K_2 = coefficient of abutment angle, $K_2 = (\theta/90)^{0.13}$

Vert. wall abut. $K_1 = 1.00$
" " " with wingwalls $K_1 = 0.82$
Spill through abut. $K_1 = 0.55$

$K_2 = (\theta/90)^{0.13}$

$K_2 = (90/90)^{0.13} = 1.0$

LEFT ABUTMENT

$$\frac{y_s}{y_a}_{100} = \frac{10.79}{} * \left[2.27 * \frac{0.55}{} * \frac{1.0}{} * \left(\frac{14}{10.79}\right)^{0.43} * \frac{0.45}{}^{0.61} + 1\right]$$

$= 19.9'$

$$\frac{y_s}{y_a}_{500} = \frac{13.90}{} * \left[2.27 * \frac{0.55}{} * \frac{1.0}{} * \left(\frac{14}{13.90}\right)^{0.43} * \frac{0.38}{}^{0.61} + 1\right]$$

$= 23.5'$

RIGHT ABUTMENT

$$\frac{y_s}{y_a}_{100} = \frac{10.79}{} * \left[2.27 * \frac{0.55}{} * \frac{1.0}{} * \left(\frac{12}{10.79}\right)^{0.43} * \frac{0.40}{}^{0.61} + 1\right]$$

$= 18.9'$

$$\frac{y_s}{y_a}_{500} = \frac{13.90}{} * \left[2.27 * \frac{0.55}{} * \frac{1.0}{} * \left(\frac{12}{13.90}\right)^{0.43} * \frac{0.33}{}^{0.61} + 1\right]$$

$= 22.2'$

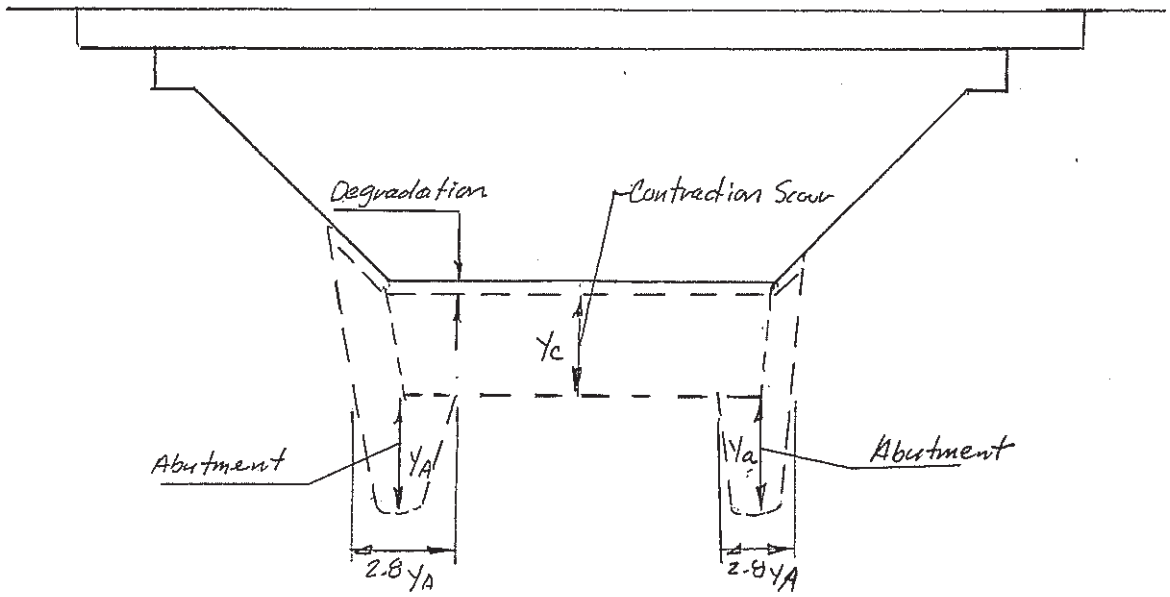
Notes:
Values above represent calculated scour w/out abutment protection. This project proposes a d50 = 12 INCH soil RIPRAP 2 foot thick layer along both sloping abutments, bridge approach and ends. Roadway embankment and channel will be seeded after final grade established.

Note:
Per HEC-18, Section 3.3.3, since abutment scour lacks field verification, riprap protection at the abutments makes it unnecessary to design abutments to resist the computed abutment scour depth. Also per HEC-18 Section 4.5.9 "Discussion of Abutment Scour Computations", it is stated that if properly vegetated in the overbanks, channel banks and areas adjacent to the abutment, scour depths as predicted with the Froehlich equation will probably not occur.

FELSBURG HOLT & ULLEVIG

Job Title Belford @ HCC By CRT Date 10-13-16 Job No. 115360-01

Subject Bridge Scour Checked Sheet 5 of



	100-YEAR			500-YEAR		
	LEFT	CHAN.	RT.	LEFT	CH.	RT.
Degradation	0	2.0	0	0	2.0	0
Contraction	3.6	3.6	3.6	5.4	5.4	5.4
*Abutment	19.9'		18.9'	23.5'		22.5'
Total	23.5'	5.6'	22.5'	28.9'	7.4'	27.9'
Pier						

* See Notes on sheet 4 @ bottom of sheet. Abutment scours not Computed due to proposed Soil Riprap along both sections of Abutment @ new bridge.

REV. 7-26-00

FELSBURG HOLT & ULLEVIG

Job Title | By | Date | Job No.

Subject Bridge Scour | Checked | Sheet 56 of

Local Scour at Pier

	100 YR	500-yr	
V =	7.96 fps	7.08 fps	= Velocity upstream of the pier
Y_1 =	7.42 ft	10.36 ft.	= Depth of flow upstream of pier

0° = Angle of attack of the flow
3.0 ft = Pier width
18.0 ft = Pier Length (TOTAL = 3' x 6 TOTAL)
1.1 = K_1 SQUARE NOSE
1.0 = K_2 ATTACK FLOW @ 0°
1.1 = K_3

F_{100} = 0.45 F_{500} = 0.38 = Froude

$$Y_S = \alpha \; 2.0 \; K_1 \; K_2 \; K_3 \left(\frac{Y_1}{\alpha}\right)^{0.35} Fr^{0.43}$$

α = Pier width; K_1 = Pier Shape; K_2 = Angle of Attack; K_3 = Bed Condition; Y_1 = Flow depth at pier; Fr = Froude No. $V_1 / (gY_1)^{0.5}$; α = Pier width

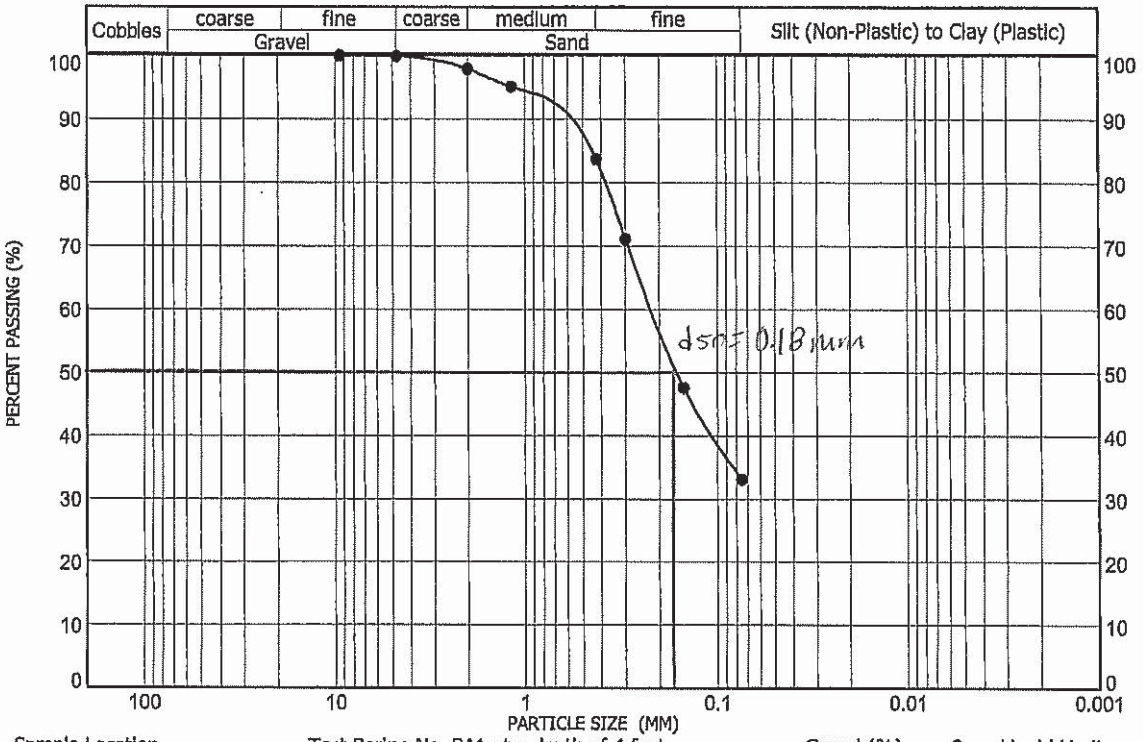
$$Y_{S_{100}} = 3.0 * 2.0 * 1.1 * 1.0 * 1.1 * \left(\frac{7.42}{3.0}\right)^{0.35} * 0.45^{0.43}$$

$$= 7.07 \text{ ft.}$$

$$Y_{S_{500}} = 3.0 * 2.0 * 1.1 * 1.0 * 1.1 * \left(\frac{10.36}{3.0}\right)^{0.35} * 0.38^{0.43}$$

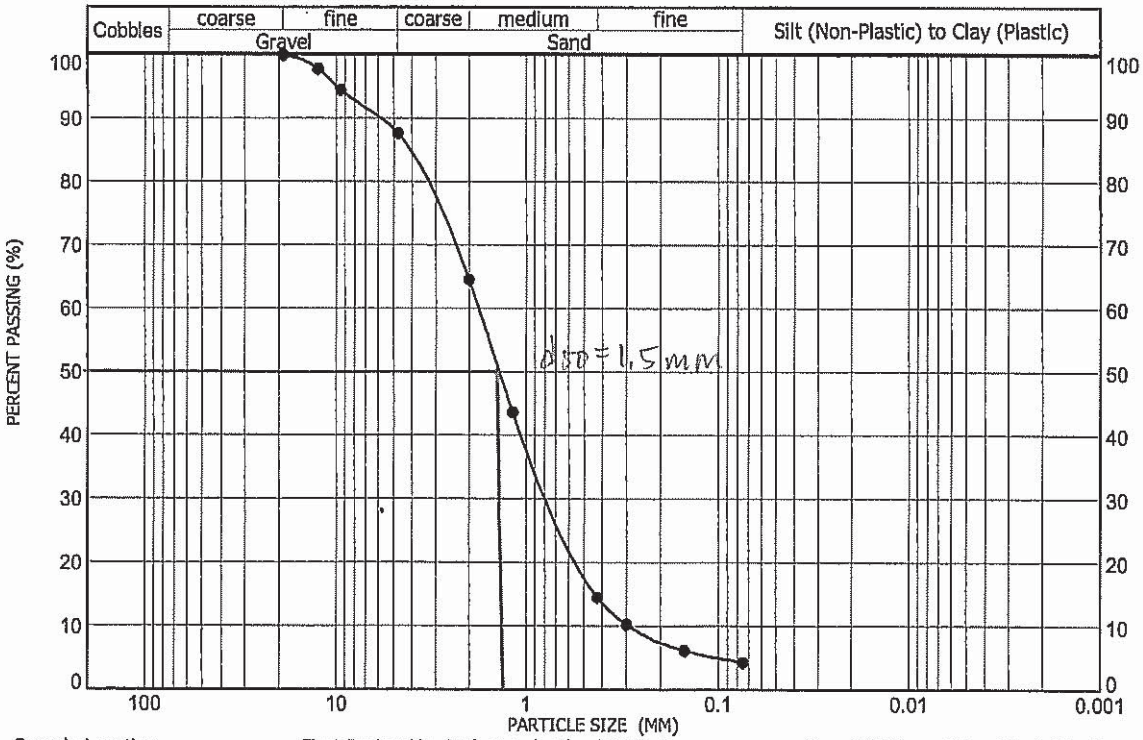
$$= 7.39 \text{ ft.}$$

A.G. Wassenaar Inc.
Geotechnical and Environmental Consultants



Sample Location: Test Boring No. BA1 at a depth of 4 feet
Sample Description: Sand, very clayey
Classification: A-2-4(0), CLAYEY SAND(SC)

Gravel (%): 0 Sand (%): 67 Clay/Silt (%): 33
Liquid Limit: 28 Plasticity Index: 9

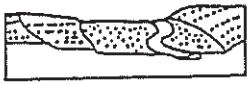
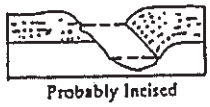
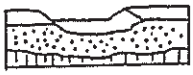
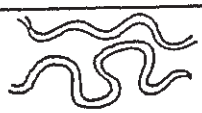
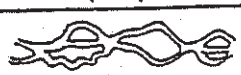


Sample Location: Test Boring No. BA2 at a depth of 14 feet
Sample Description: Sand, trace silty
Classification: A-1-b(0), WELL-GRADED SAND(SW)

Gravel (%): 12 Sand (%): 83 Clay/Silt (%): 4
Liquid Limit: NV Plasticity Index: NP

GRADATION AND ATTERBERG TEST RESULTS
FIGURE 13

PROJECT NO. 153733

STREAM SIZE (SECT. 2.2.1)	Small (< 100 ft. or 30 m wide)		Medium (100-500 ft. or 30 - 150 m)		Wide (> 500 ft. or 150 m)
FLOW HABIT (SECT. 2.2.2)	Ephemeral	(Intermittent)	Perennial but flashy		Perennial
BED MATERIAL (SECT. 2.2.3)	Silt-clay	Silt	Sand	Gravel	Cobble or boulder
VALLEY SETTING (SECT. 2.2.4)	 No valley; alluvial fan		 Low relief valley (< 100 ft. or 30 m deep)	 Moderate relief (100-1000 ft. or 30-300 m)	 High relief (> 1000 ft. or 300 m)
FLOOD PLAINS (SECT. 2.2.5)	 Little or none (< 2X channel width)		 Narrow (2-10 channel width)	 Wide (> 10X channel width)	
NATURAL LEVEES (SECT. 2.2.6)	 Little or None		 Mainly on Concave	 Well Developed on Both Banks	
APPARENT INCISION (SECT. 2.2.7)	 Not Incised			 Probably Incised	
CHANNEL BOUNDARIES (SECT.. 2.2.8)	 Alluvial		 Semi-alluvial	 Non-alluvial	
TREE COVER ON BANKS (SECT. 2.2.8)	<50 percent of bankline		50-90 percent		>90 percent
SINUOSITY (SECT. 2.2.9)	 Straight Sinuosity 1-1.05)	 Sinuous (1.06-1.25)	 Meandering (1.25-2.0)	 Highly meandering (> 2)	
BRAIDED STREAMS (SECT. 2.2.10)	 Not braided (<5 percent)		 Locally braided (5-35 percent)	 Generally braided (> 35 percent)	
ANABRANCHED STREAMS (SECT. 2.2.11)	 Not anabranched (<5 percent)		 Locally anabranched (5-35 percent)	 Generally anabranched (> 35 percent)	
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (SECT. 2.2.12)	 Equal width		 Wider at bends	 Random variation	
	 Narrow point bars		 Wide point bars	 Irregular point and lateral bars	

GEOMORPHIC FACTORS THAT AFFECT STREAM STABILITY

Job Title	Compark South	By	CDT	Date	01-Nov-16	Job No.	115360-01
	Belford Ave. @ Happy Canyon Creek						
Subject	GSB Calculations		Checked		Sheet 1 of 2		

1. Estimate Mannings n For Flows over GSB

When upper **1/2** (+/- 1") of the rock depth (height) is left ungrouted: *UDFCD Volume 2 Equation 9-1*

$$n_{18"\text{-}42"(1/2)} = \frac{0.097 * (y/D)^{0.16}}{ln(2.55\ Y/D)}$$

Upper limit: n <= 0.15 for above equation

$$n_{18"\text{-}42"(1/2)} = \frac{0.097 * \quad ^{0.16}}{ln(2.55\ \quad)} = \frac{0.000}{\#NUM!} = \#NUM!$$

When upper **1/3** (+/- 1") of the rock depth (height) is left ungrouted: *UDFCD Volume 2 Equation 9-2*

$$n_{18"\text{-}42"(2/3)} = \frac{0.086 * (y/D)^{0.16}}{ln(2.55\ y/D)}$$

Low-flow n — y= 3, d= 1.5

$$n_{18"\text{-}42"(2/3)} = \frac{0.086 * 2.0^{0.16}}{ln(2.55 * \frac{3.0}{1.5})} = \frac{0.096}{1.629} = 0.059$$

High-flow n — y= 7.76, d= 1.5

$$n_{18"\text{-}42"(2/3)} = \frac{0.086 * 5.2^{0.16}}{ln(2.55 * \frac{7.8}{1.5})} = \frac{0.114}{2.985} = 0.038$$

Upper limit: n <= 0.12 for above equation

y = depth of flow above top of rock, in feet

D = diameter of the boulder, in feet

Outside the low-flow section *UDFCD Volume 2 Equation 9-7*

$$R_p = \frac{V_c * S^{0.17}}{(S_s - 1)^{0.66}}$$

$$R_p = \frac{14.00 * 0.0075^{0.17}}{(2.55 - 1)^{0.66}} = \frac{6.09}{1.34} = 4.56$$

See Table 9-4 below
Use 18" (B18) grouted boulders for protection outside of the low-flow section.

Within the low-flow section *UDFCD Volume 2 Equation 9-7*

$$R_p = \frac{V_{mc} * S^{0.17}}{(S_s - 1)^{0.66}}$$

$$R_p = \frac{9.03 * 0.100^{0.17}}{(2.55 - 1)^{0.66}} = \frac{6.11}{1.34} = 4.57$$

See Table 9-4 below
Use 18" (B18) grouted boulders for protection within the low-flow section.

V_c = Critical Velocity
S = longitudinal slope along direction of flow in ft/ft
S_s = Specific gravity of rock - assume 2.55

(For drops of 6-feet or less in height, use UD-Channels Spreadsheet to find the 100-year critical velocities in the low-flow and the main channels to size boulders for each section)

Table 9-4. Boulder sizes for various rock sizing parameters

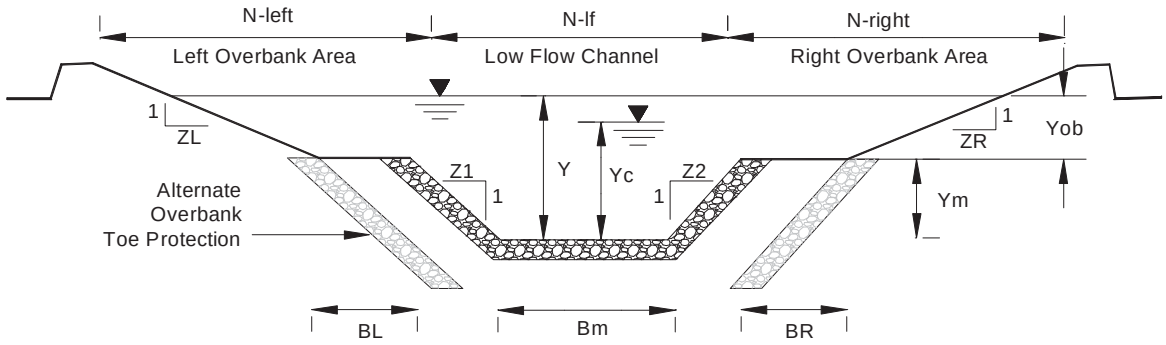
Rock Sizing Parameter, R_p	Grouted Boulders [1]
	Boulder Classification [2]
Less than 4.50	B18
4.50 to 4.99	B18
5.00 to 5.59	B24
5.60 to 6.99	B36
7.00 to 8.00	B48

[1] Grouted to no less than 1/3 the height (+1"/- 0"), no more than 1/2 (+0"/- 1") of boulder height.
[2] See *Open Channels* chapter.

Capacity Analysis of Composite Channel

Project: Happy Canyon Creek @ Belford Avenue - Drops

Channel ID: High & Low-Flow at 0.75% Slope



Design Information (Input)

Channel Invert Slope	So =	0.00750 ft/ft	Left Overbank Bottom Width	BL =	75.00 ft
			Left Overbank Side Slope	ZL =	0.03 ft/ft
Low Flow Channel Bottom Width	Bm =	15.00 ft	Left Overbank Manning's n	n-left =	0.0350
Low Flow Channel Left Side Slope	Z1 =	4.00 ft/ft	Right Overbank Bottom Width	BR =	20.00 ft
Low Flow Channel Right Side Slope	Z2 =	4.00 ft/ft	Right Overbank Side Slope	ZR =	2.50 ft/ft
Low Flow Channel Manning's Nn for Qd	n-lf =	0.0590	Right Overbank Manning's n	n-right =	0.0350
Low Flow Channel Manning's Nn for Q100	n-m-Q100 =	0.0380			
(See USDCM Vol. II, n vs. Depth Graph)					
Low Flow Channel Bank-full depth	**Ym =**	**3.00 ft**	**Overbank Flow Depth Yob (Y - Ym)**	**Yob =**	**4.85 ft**

Low Flow Channel Condition for Qd			**Low Flow Channel Flow Condition for Q100**		
Top width	Tlf =	39.0 ft	Top width	Tm =	39.0 ft
Flow area	Alf =	81.0 sq ft	Flow area	Am =	270.2 sq ft
Wetted perimeter	Plf =	39.7 ft	Wetted perimeter	Pm =	39.7 ft
Discharge (Calculated)	**Qlf =**	**284.8 cfs**	**Discharge**	**Qm =**	**3,292.1 cfs**
Velocity	**Vlf=**	**3.5 fps**	**Velocity**	**Vm =**	**12.2 fps**
Froude number	**Fr-lf =**	**0.43**	**Froude number**	**Frm =**	**0.82**
Qd Critical Velocity	Vlfc =	6.74 fps	100-Yr. Critical Velocity	Vmc =	14.0 fps
Qd Critical Depth	Ylfc =	1.88 ft	100-Yr. Critical Depth	Ymc =	7.0 ft

Left Overbank Flow Condition for Q100			**Right Overbank Flow Condition for Q100**		
Top width	TL =	75.1 ft	Top width	TR =	32.1 ft
Flow area	AL =	364.0600 sq ft	Flow area	AR =	126.4000 sq ft
Wetted perimeter	PL =	79.8500 ft	Wetted perimeter	PR =	33.0600 ft
Discharge	**QL =**	**3,690.5 cfs**	**Discharge**	**QR =**	**1,139.5 cfs**
Velocity	**VL =**	**10.1 fps**	**Velocity**	**VR =**	**9.0 fps**
Froude number	**FrL =**	**0.81**	**Froude number**	**FrR =**	**0.80**
100-Yr. Critical Velocity	VLc =	11.7 fps	100-Yr. Critical Velocity	VRc =	10.6 fps
100-Yr. Critical Depth in Overbanks	YLc =	4.2 ft	100-Yr. Critical Depth in Overbanks	YRc =	4.2 ft

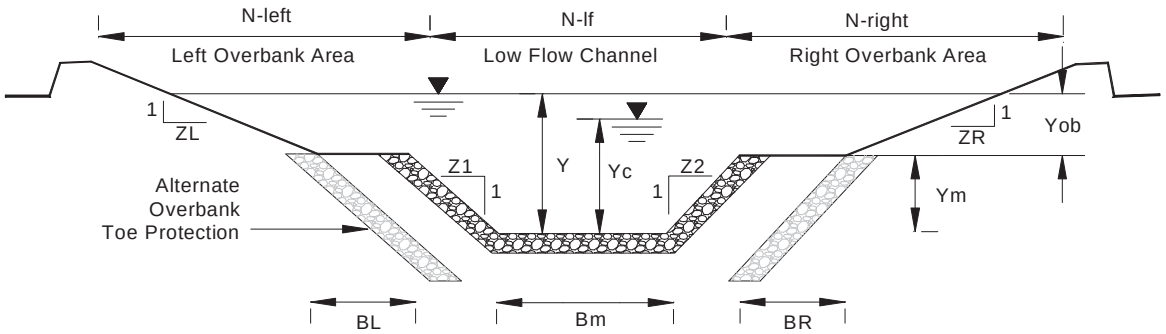
Composite Cross-Section Flow Condition for Q100

Top width	**T =**	**146.3 ft**	**Discharge**	**Q =**	**8,122.1 cfs**
Channel Depth Y	**Y =**	**7.85 ft**	**Velocity**	**V =**	**10.7 fps**
Flow area	A =	760.6 sq ft	**Froude number**	**Fr =**	**0.83**
Wetted perimeter	P =	152.7 ft	100-Yr. Critical Velocity	Vc =	12.2 fps
Cross-Sectional Manning's n (Calculated)	n =	0.0353	100-Yr. Critical Depth in Overbanks	Yc =	4.20 ft

Capacity Analysis of Composite Channel

Project: Happy Canyon Creek @ Belford Avenue Drops

Channel ID: Low-Flow at 10:1



Design Information (Input)

Channel Invert Slope	So =	0.10000 ft/ft	Left Overbank Bottom Width	BL =	75.00 ft
			Left Overbank Side Slope	ZL =	0.03 ft/ft
Low Flow Channel Bottom Width	Bm =	15.00 ft	Left Overbank Manning's n	n-left =	0.0350
Low Flow Channel Left Side Slope	Z1 =	4.00 ft/ft	Right Overbank Bottom Width	BR =	20.00 ft
Low Flow Channel Right Side Slope	Z2 =	4.00 ft/ft	Right Overbank Side Slope	ZR =	2.50 ft/ft
Low Flow Channel Manning's Nn for Qd	n-lf =	0.0590	Right Overbank Manning's n	n-right =	0.0350
Low Flow Channel Manning's Nn for Q100	n-m-Q100 =	0.0380			
(See USDCM Vol. II, n vs. Depth Graph)					
Low Flow Channel Bank-full depth	**Ym =**	**3.00 ft**	**Overbank Flow Depth Yob (Y - Ym)**	**Yob =**	**4.85 ft**

Low Flow Channel Condition for Qd			**Low Flow Channel Flow Condition for Q100**		
Top width	Tlf =	39.0 ft	Top width	Tm =	39.0 ft
Flow area	Alf =	81.0 sq ft	Flow area	Am =	270.2 sq ft
Wetted perimeter	Plf =	39.7 ft	Wetted perimeter	Pm =	39.7 ft
Discharge (Calculated)	**Qlf =**	**1,039.9 cfs**	**Discharge**	**Qm =**	**12,020.9 cfs**
Velocity	**Vlf=**	**12.8 fps**	**Velocity**	**Vm =**	**44.5 fps**
Froude number	**Fr-lf =**	**1.57**	**Froude number**	**Frm =**	**2.98**
Qd Critical Velocity	Vlfc =	9.03 fps	100-Yr. Critical Velocity	Vmc =	16.2 fps
Qd Critical Depth	Ylfc =	3.81 ft	100-Yr. Critical Depth	Ymc =	7.9 ft
Left Overbank Flow Condition for Q100			**Right Overbank Flow Condition for Q100**		
Top width	TL =	75.2 ft	Top width	TR =	32.1 ft
Flow area	AL =	364.1000 sq ft	Flow area	AR =	126.4000 sq ft
Wetted perimeter	PL =	79.8500 ft	Wetted perimeter	PR =	33.0600 ft
Discharge	**QL =**	**13,478.3 cfs**	**Discharge**	**QR =**	**4,160.9 cfs**
Velocity	**VL =**	**37.0 fps**	**Velocity**	**VR =**	**32.9 fps**
Froude number	**FrL =**	**2.96**	**Froude number**	**FrR =**	**2.92**
100-Yr. Critical Velocity	VLc =	17.9 fps	100-Yr. Critical Velocity	VRc =	14.6 fps
100-Yr. Critical Depth in Overbanks	YLc =	10.0 ft	100-Yr. Critical Depth in Overbanks	YRc =	9.1 ft

Composite Cross-Section Flow Condition for Q100

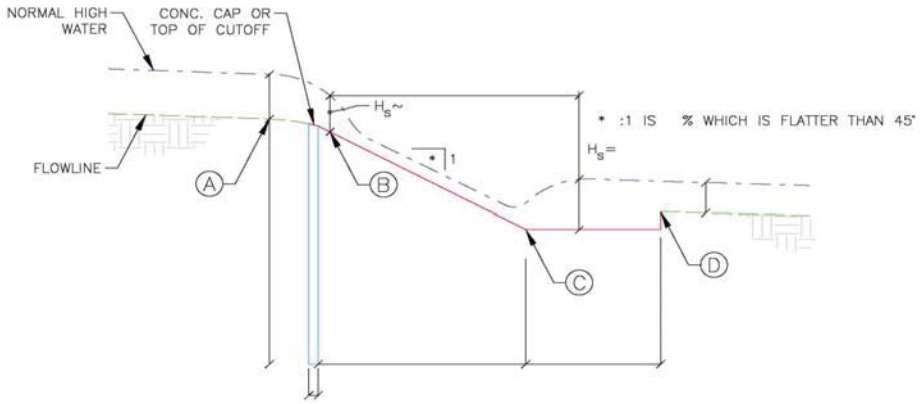
Top width	**T =**	**146.3 ft**	**Discharge**	**Q =**	**29,660.0 cfs**
Channel Depth Y	**Y =**	**7.85 ft**	**Velocity**	**V =**	**39.0 fps**
Flow area	A =	760.7 sq ft	**Froude number**	**Fr =**	**3.01**
Wetted perimeter	P =	152.7 ft	100-Yr. Critical Velocity	Vc =	18.4 fps
Cross-Sectional Manning's n (Calculated)	n =	0.0353	100-Yr. Critical Depth in Overbanks	Yc =	8.07 ft

Job Title	Compark South	By	CDT	Date	18-Oct-16	Job No.	115360-01
	Belford Ave. @ Happy Canyon Creek						
Subject	Seepage Control		Checked		Sheet	1 of	1

1. Lane's Weighed Creep Method

$$Cw = \frac{\left(\frac{L_H}{3} + L_v\right)}{Hs}$$

UDFCD Volume 2 Equation 9-5



From (A) to (B) L_H = 8.0 L_v = 0 + 0.25 = 0.25 '

Hs ~ 0.25 (Change in water surface elevation between A & B)

$$Cw = \frac{\left(\frac{8.0}{3} + 0.3\right)}{0.3} = 11.7$$ 11.7 > 6.0 OK

From (A) to (C) L_H = 38.0 L_v = 3 + 0.25 = 3.25 '

Hs = 1.06 (Change in water surface elevation between A & C)

$$Cw = \frac{\left(\frac{38.0}{3} + 3.3\right)}{1.1} = 15.0$$ 15.0 > 6.0 OK

L_H = *Horizontal creep distance*
Lv = Vertical creep distance
C_w = *Creep ratio*
H_s = *Differential head between analysis points (ft)*

Table 9-3. Lane's weighted creep: Recommended minimum ratios

Material	Ratio
Very fine sand or silt	8.5
Fine sand	7.0
Medium sand	6.0
Coarse sand	5.0
Fine gravel	4.0
Medium gravel	3.0
Coarse gravel including cobbles	3.0
Boulders with some cobbles and gravel	3.0
Soft clay	3.0
Medium clay	2.0
Hard clay	1.8
Very hard clay or hardpan	1.6

Notes: Soil samples at the site located along Happy Canyon Creek provided by A.G. Wassenaar Inc. indicates coarse to mediam lenses of clay/sand interbedded poorly graded sand with gravel, well-graded sand with silt and gravel material. Free groundwater was encountered at the time of drilling (March 2016) ranging in depths of 2 feet near the proposed ped. box culvert and 4 feet to 8 feet along the channel.

Average LWC Ratio per UDFCD Table 9-3 to the right is: 6.0

REVETMENT RIPRAP DESIGN
SIZING

Project: Belford @ HCC — By: CDT — I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
Project No. 115360-01 — Date: 11/16/2016 — Happy Canyon Creek\Bridge Hydraulics

$d_{30} = y(s_f*C_s*C_v*C_t)[(V_{des}/(K_1(S_g-1)*g*y]^{2.5}$

d_{30}=Riprap particle size for which 30% is finer by weight , ft (adapted from USACE Engineering Manual No. 1110-2-1601, 1991)

y=	6.58	Local depth of flow above particle, ft
S_f=	1.2	Safety factor
C_s=	0.3	Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio
		Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio d85/d15 = 1.7 to 5.2) Use 0.30 for angular rock and 0.375 for rounded rock
C_v=	1.36	Velocity distribution coefficient
		use 1.0 for straight channels or the inside of bends
		use 1.283-0.2log(Rc/W) for the outside of bends (1 for Rc/W>26)= 1.36
		Rc= 178 Centerline radius of curvature of Channel bend, ft
		W= 429 Width of water surface at upstream end of channel bend, ft
		Rc/W= 0.414918
		use 1.25 downstream from concrete channels
		use 1.25 at the end of dikes
C_t=	1	Blanket thickness coefficient given as a function of the uniformity ratio d85/d15
		use 1.0 recommended because it is based on very limited data
V_{des}=	10.66	Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s
	V_{des}= 10.66	For natural channels use $V_{des}=V_{avg}(1.74-0.52 \log(Rc/W)$
	V_{des}= 11.04	For trapezoidal channels use $V_{des}=V_{avg}(1.71-0.78 \log(Rc/W)$
V_{avg}=	5.5	Channel cross sectional average velocity, ft/s
K_1=	1.00	Side slope correctional factor — H:1= 4
		k_1=(1-((sin14°) — θ= 14.0 0.24 = radians
		K_1= 1.00
S_g=	2.65	Specific gravity of riprap (usually taken at 2.65)
g=	32.2	Acceleration of gravity, 32.2 ft/s

d_{30}=	**0.79**	**Particle size for which 30% is finer by weight , ft**
d_{50}=	**0.95**	**$d_{50}=1.2d_{30}$, ft**
RIPRAP d_{50} SIZE=	**11.4**	**inches**
$t=1.5d_{50}$=	**17.1**	**Riprap Thickness, inches**

Use 18" thick layer of Soil Riprap (12 inch)

Reference: Lagasse, et. al., NCHRP Report 568, Riprap Design Criteria, Recommended Specifications, and Quality Control, 2006

REVETMENT RIPRAP DESIGN
SIZING

Project: Belford @ HCC | By: CDT | I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
Project No. 115360-01 | Date: 11/16/2016 | Happy Canyon Creek\Bridge Hydraulics

$d_{30} = y(s_f*C_s*C_v*C_t)[(V_{des}/(K_1(S_g-1)*g*y]^{2.5}$

d_{30}=Riprap particle size for which 30% is finer by weight , ft (adapted from USACE Engineering Manual No. 1110-2-1601, 1991)

y=	10.25	Local depth of flow above particle, ft
S_f=	1.2	Safety factor
C_s=	0.3	Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio
		Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio d85/d15 = 1.7 to 5.2) Use 0.30 for angular rock and 0.375 for rounded rock
C_v=	1.33	Velocity distribution coefficient
		use 1.0 for straight channels or the inside of bends
		use 1.283-0.2log(Rc/W) for the outside of bends (1 for Rc/W>26)= 1.33
		Rc= 130 Centerline radius of curvature of Channel bend, ft
		W= 214 Width of water surface at upstream end of channel bend, ft
		Rc/W= 0.607477
		use 1.25 downstream from concrete channels
		use 1.25 at the end of dikes
C_t=	1	Blanket thickness coefficient given as a function of the uniformity ratio d85/d15
		use 1.0 recommended because it is based on very limited data
V_{des}=	9.99	Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s
	V_{des}= 9.99	For natural channels use $V_{des}=V_{avg}(1.74-0.52 \log(Rc/W)$
	V_{des}= 10.13	For trapezoidal channels use $V_{des}=V_{avg}(1.71-0.78 \log(Rc/W)$
V_{avg}=	5.39	Channel cross sectional average velocity, ft/s
K_1=	1.00	Side slope correctional factor
		$k_1=(1-((\sin 14°)$ H:1= 4
		θ= 14.0 0.24 = radians
		K_1= 1.00
S_g=	2.65	Specific gravity of riprap (usually taken at 2.65)
g=	32.2	Acceleration of gravity, 32.2 ft/s

d_{30}=	**0.59**	**Particle size for which 30% is finer by weight , ft**
d_{50}=	**0.71**	**$d_{50}=1.2d_{30}$, ft**
RIPRAP d_{50} SIZE=	**8.5**	**inches**
$t=1.5d_{50}$=	**12.7**	**Riprap Thickness, inches**

Use 18" thick layer of Soil Riprap (12 inch)

Reference: Lagasse, et. al., NCHRP Report 568, Riprap Design Criteria, Recommended Specifications, and Quality Control, 2006

REVETMENT RIPRAP DESIGN
SIZING

Project: Belford @ HCC — By: CDT — I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
Project No. 115360-01 — Date: 11/16/2016 — Happy Canyon Creek\Bridge Hydraulics

$d_{30} = y(s_f*C_s*C_v*C_t)[(V_{des}/(K_1(S_g-1)*g*y]^{2.5}$

d_{30}=Riprap particle size for which 30% is finer by weight , ft (adapted from USACE Engineering Manual No. 1110-2-1601, 1991)

y=	12.17	Local depth of flow above particle, ft
S_f=	1.2	Safety factor
C_s=	0.3	Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio
		Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio d85/d15 = 1.7 to 5.2) Use 0.30 for angular rock and 0.375 for rounded rock
C_v=	1.24	Velocity distribution coefficient
		use 1.0 for straight channels or the inside of bends
		use 1.283-0.2log(Rc/W) for the outside of bends (1 for Rc/W>26)= 1.24
		Rc= 308 Centerline radius of curvature of Channel bend, ft
		W= 196 Width of water surface at upstream end of channel bend, ft
		Rc/W= 1.571429
		use 1.25 downstream from concrete channels
		use 1.25 at the end of dikes
C_t=	1	Blanket thickness coefficient given as a function of the uniformity ratio d85/d15
		use 1.0 recommended because it is based on very limited data
V_{des}=	9.81	Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s
	V_{des}= 9.81	For natural channels use $V_{des}=V_{avg}(1.74-0.52 \log(Rc/W)$
	V_{des}= 9.33	For trapezoidal channels use $V_{des}=V_{avg}(1.71-0.78 \log(Rc/W)$
V_{avg}=	5.99	Channel cross sectional average velocity, ft/s
K_1=	1.00	Side slope correctional factor — H:1= 4
		k_1=(1-((sin14°) — θ= 14.0 0.24 = radians
		K_1= 1.00
S_g=	2.65	Specific gravity of riprap (usually taken at 2.65)
g=	32.2	Acceleration of gravity, 32.2 ft/s

d_{30}=	**0.50**	**Particle size for which 30% is finer by weight , ft**
d_{50}=	**0.60**	**$d_{50}=1.2d_{30}$, ft**
RIPRAP d_{50} SIZE=	**7.2**	**inches**
$t=1.5d_{50}$=	**10.8**	**Riprap Thickness, inches**

Use 18" thick layer of Soil Riprap (12 inch)

Reference: Lagasse, et. al., NCHRP Report 568, Riprap Design Criteria, Recommended Specifications, and Quality Control, 2006

REVETMENT RIPRAP DESIGN
SIZING

Project: Belford @ HCC By: CDT I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
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$d_{30} = y(s_f*C_s*C_v*C_t)[(V_{des}/(K_1(S_g-1)*g*y]^{2.5}$

d_{30}=Riprap particle size for which 30% is finer by weight , ft (adapted from USACE Engineering Manual No. 1110-2-1601, 1991)

y=	13.57	Local depth of flow above particle, ft
S_f=	1.2	Safety factor
C_s=	0.3	Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio
		Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio d85/d15 = 1.7 to 5.2) Use 0.30 for angular rock and 0.375 for rounded rock
C_v=	1.24	Velocity distribution coefficient
		use 1.0 for straight channels or the inside of bends
		use 1.283-0.2log(Rc/W) for the outside of bends (1 for Rc/W>26)= 1.25
		Rc= 351 Centerline radius of curvature of Channel bend, ft
		W= 253 Width of water surface at upstream end of channel bend, ft
		Rc/W= 1.387352
		use 1.25 downstream from concrete channels
		use 1.25 at the end of dikes
C_t=	1	Blanket thickness coefficient given as a function of the uniformity ratio d85/d15
		use 1.0 recommended because it is based on very limited data
V_{des}=	10.81	Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s
		V_{des}= 10.81 For natural channels use $V_{des}=V_{avg}(1.74-0.52 \log(Rc/W)$
		V_{des}= 10.38 For trapezoidal channels use $V_{des}=V_{avg}(1.71-0.78 \log(Rc/W)$
V_{avg}=	6.49	Channel cross sectional average velocity, ft/s
K_1=	1.00	Side slope correctional factor H:1= 4
		k_1=(1-((sin14°) θ= 14.0 0.24 = radians
		K_1= 1.00
S_g=	2.65	Specific gravity of riprap (usually taken at 2.65)
g=	32.2	Acceleration of gravity, 32.2 ft/s

d_{30}=	**0.62**	**Particle size for which 30% is finer by weight , ft**
d_{50}=	**0.75**	**$d_{50}=1.2d_{30}$, ft**
RIPRAP d_{50} SIZE=	**9.0**	**inches**
$t=1.5d_{50}$=	**13.5**	**Riprap Thickness, inches**

Use 18" thick layer of Soil Riprap (12 inch)

Reference: Lagasse, et. al., NCHRP Report 568, Riprap Design Criteria, Recommended Specifications, and Quality Control, 2006

RIPRAP AT BRIDGE ABUTMENTS AND GUIDE BANKS
SIZING

Project: Belford @ HCC — By: CDT — I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
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d_{50} = Y*K/(S_g-1)*(V^2/gy) for Froude numbers less than 0.80
d_{50} = Y*K/(S_g-1)*(V^2/gy)$^{0.14}$ for Froude numbers greater than 0.80
d_{50}=Median stone diamenter, ft (adapted from FHWA's HEC23, Legasse et al, 2001)
SBR= Set Back Ratio = Dist. From main channel/Flow depth in main channel

	Left Abutment	Right Abutment	(Looking downstream)
D=	85	55	Distance from main channel
Y_{ch}=	12.17	12.17	Flow depth in main channel
SBR=	7.0	4.5	Set Back Ratio
Q=	8475	8475	If SBR is >5, then V=$Q_{overbank}$/$A_{overbank}$ (Overbank flow only)
A=	663	1345	If SBR is <5, then V=Q_{total}/A_{total} (Entire bridge opening)
$V_{char.}$=	12.8	6.3	
V=	5.72	3.61	Characteristic average velocity in the contracted section, ft/s
S_g=	2.65	2.65	Specific gravity of riprap (usually taken at 2.65)
g=	32.2	32.2	Acceleration of gravity, 32.2 ft/s
y=	8.15	8.15	Depth of flow in the contracted bridge opening, ft
K=	1.02	1.02	For Froude <0.80 use K=0.89 for spill through and 1.02 for vertical wall abutments
			For Froude >0.80 use K=0.61 for spill through and 0.69 for vertical wall abutments
F=	0.35	0.22	Froude number, (V/(gy)$^{0.5}$
d_{50}=	0.63	0.25	Median stone diamenter, ft for Froude number less than 0.80
d_{50}=	3.76	3.31	Median stone diamenter, ft for Froude number greater than 0.80

	Left Abutment	Right Abutment	
d_{50}=	**0.63**	**0.25**	Median stone diamenter, ft
RIPRAP d_{50} SIZE=	**7.5**	**3.0**	**inches**
t=1.5d_{50}	**11.3**	**4.5**	**Riprap Thickness, inches**

Reference: Lagasse, et. al., NCHRP Report 568, Riprap Design Criteria, Recommended Specifications, and Quality Control, 200

REVETMENT RIPRAP DESIGN
SIZING USING UDFCD CRITERIA

Project:	Belford @ HCC	By: CDT	I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
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d_{50} = ((V*S^0.17)/(4.5)*(Ss-1)^0.66)^2

V=	13.93	Velocity, ft/s
S=	0.0075	Longitudinal Slope, ft/ft
S_s=	2.65	Specific gravity of riprap (usually taken at 2.65)
d_{50}=	**0.94**	**ft**
RIPRAP d_{50} SIZE=	**11.2**	**inches**
t=1.75d50=	**19.7**	**Riprap Thickness, inches**

Riprap for Approach to Drop Structres
Soil Riprap (12 Inch)
2'-0" thick

Reference: UDFCD Manual, Volume 1, Section 4.4.2.3

RIPRAP AT BRIDGE PIERS
SIZING

Project: Belford @ HCC By: CDT I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
Project No. 115360-01 Date: 11/16/2016 Happy Canyon Creek\Bridge Hydraulics

$d_{50} = 0.692(V_{des})^2/(S_g-1)*2*g$

d_{50}=Riprap particle size for which 50% is finer by weight, ft (adapted from FHWA's HEC23, Legasse et al, 2001)

K_1=	1.5	Shape factor equal to 1.5 for round-nose pier, 1.7 for square-faced piers, ft/s
K_2=	0.9	Velocity adjustment factorf or location in the channel
		0.9 for a pier near a bank in a straight reach
		1.7 for a pier located in the main current of flow around a sharp bend
S_g=	2.65	Specific gravity of riprap (usually taken as 2.65)
g=	32.2	Acceleration of gravity, 32.2 ft/s

If only the average channel velocity is known, then $V_{des}=K_1*K_2*V_{avg}$:

V_{avg}=	6.17	Channel average velocity, fps		From bridge hyd. sheet
V_{des}=	8.3295	Design velocity for local conditions at the pier, ft/s	$V_{des}=K_1*K_2*V_{avg}$	

If the local velocity at the pier is known (a 2-D model stream tube), then $Vdes=K_1*V_{local}$:

V_{local}=	7.46	Local velocity in the vicinity of the pier, ft/s		From bridge hyd. sheet
V_{des}=	11.19	Design velocity for local conditions at the pier, ft/s	$V_{des}=K_1*V_{local}$	

V_{des}=	11.19	Design velocity in the vicinity of the pier to be used, ft/s

d_{50}=	0.82	Particle size for which 50% is finer by weight , ft			
d_{50} =	9.8	Riprap size in inches	Use standard size d_{50}= (6", 9", 12" 18", 24")=	24	inches
$t=3d_{50}$=	29.4	Minimum riprap thickness, inches	$t=3d_{50}$=	72.0	

Conclusion

Use 3.00 ft thick layer of
Riprap d50= 12 inches

Reference: Lagasse, et. al., NCHRP Report 568, Riprap Design Criteria, Recommended Specifications, and Quality Control, 2006