

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

A Part of the NE  $\frac{1}{4}$  of Section 7, SE  $\frac{1}{4}$  of Section 6 and SW  $\frac{1}{4}$  of  
Section 5 of Township 5 South and Range 66 West of the 6<sup>th</sup> P.M.,  
Douglas County, Colorado

***Prepared for:***

**Manhard Consulting Ltd.**  
8008 E. Arapahoe Court, Suite 110  
Centennial, CO 80112  
Contact: Rick Moore, P.E.

***Prepared by:***

**Felsburg, Holt & Ullevig**  
6300 South Syracuse Way, Suite 600  
Centennial, CO 80111  
(303) 721-1440  
FAX (303) 721-0832  
[fhu@fhueng.com](mailto:fhu@fhueng.com)  
<http://www.fhueng.com/>

FHU Project No. 115360-01

November 2016  
Updated July 2017

## TABLE OF CONTENTS

	<u>Page</u>
<b>I. GENERAL LOCATION AND DESCRIPTION -----</b>	<b>1</b>
A. Location-----	1
B. Description of Property-----	1
<b>II. DRAINAGE BASINS-----</b>	<b>5</b>
A. Major Basin Description-----	5
<b>III. DRAINAGE FACILITIES DESIGN-----</b>	<b>9</b>
A. General Concept -----	9
B. Specific Details-----	9
<b>IV. HYDRAULIC ANALYSIS -----</b>	<b>12</b>
A. HEC-RAS -----	12
<b>V. SUMMARY -----</b>	<b>14</b>
<b>VI. REFERENCES -----</b>	<b>16</b>

## LIST OF FIGURES

Figure 1. Vicinity Map-----	2
Figure 2. National Resource Conservation Service Map -----	3
Figure 3. Preliminary Flood Insurance Rate Map 08035C0062H -----	6
Figure 4. Preliminary Flood Insurance Rate Map 08035C0066H -----	7
Figure 5. Effective Flood Insurance Rate Map 08035C0062G-----	8
Figure 6. Effective Flood Insurance Rate Map 08035C0066G-----	8

## LIST OF TABLES

Table 1. Area Soil Types-----	4
Table 2. Happy Canyon Creek Peak Flows near Project Area-----	5

## LIST OF APPENDICES

APPENDIX A. FLOODPLAIN WORK MAP

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

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

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

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

APPENDIX F. SUPPLEMENTAL INFORMATION AND PLAN SHEETS

APPENDIX G. PHOTOGRAPHS

## **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  $\frac{1}{4}$  of Section 7, southeast  $\frac{1}{4}$  of Section 6, and southwest  $\frac{1}{4}$  of Section 5 of Township 5 South, Range 66 West of the 6<sup>th</sup> 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.

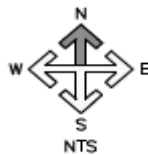
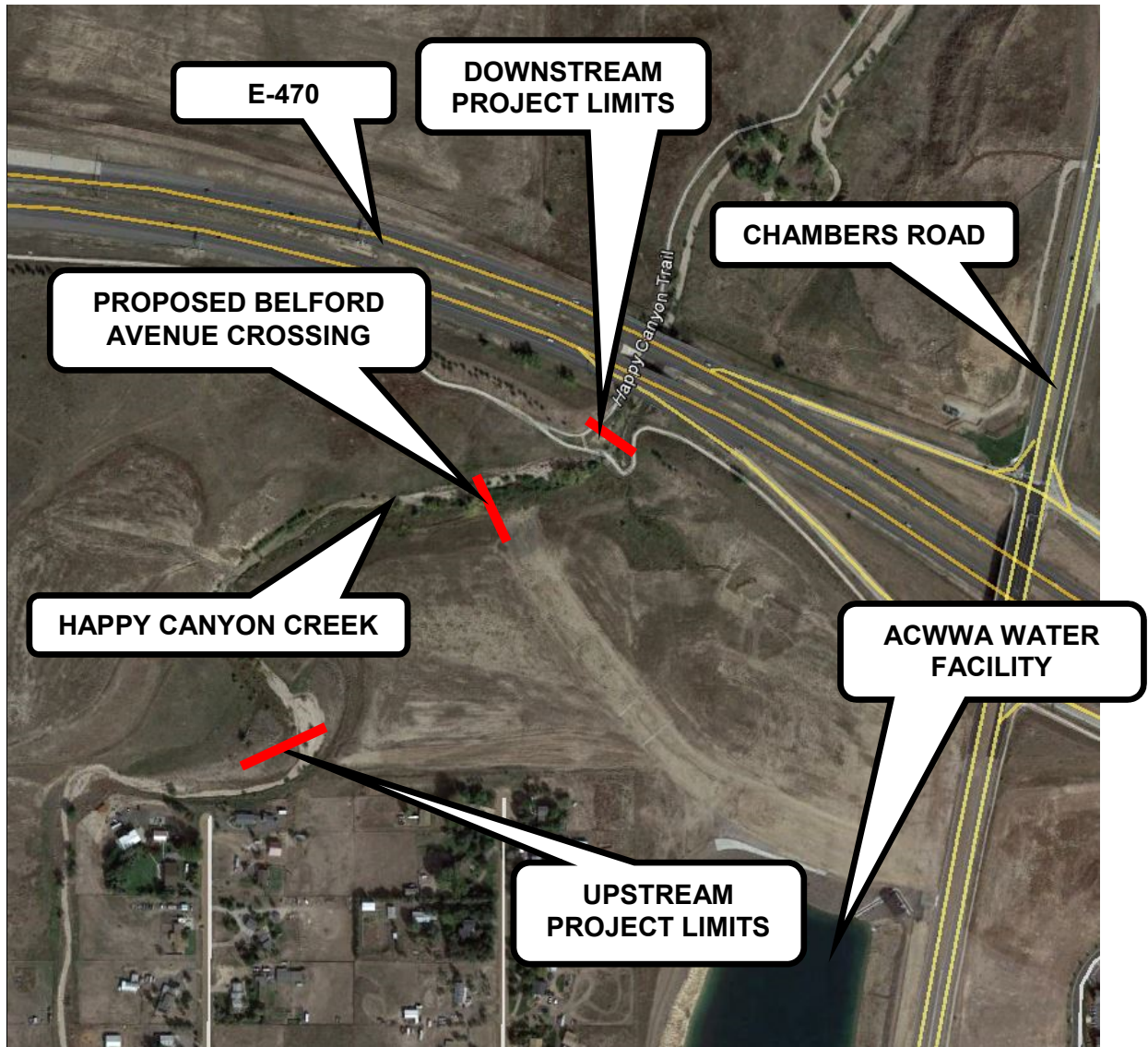
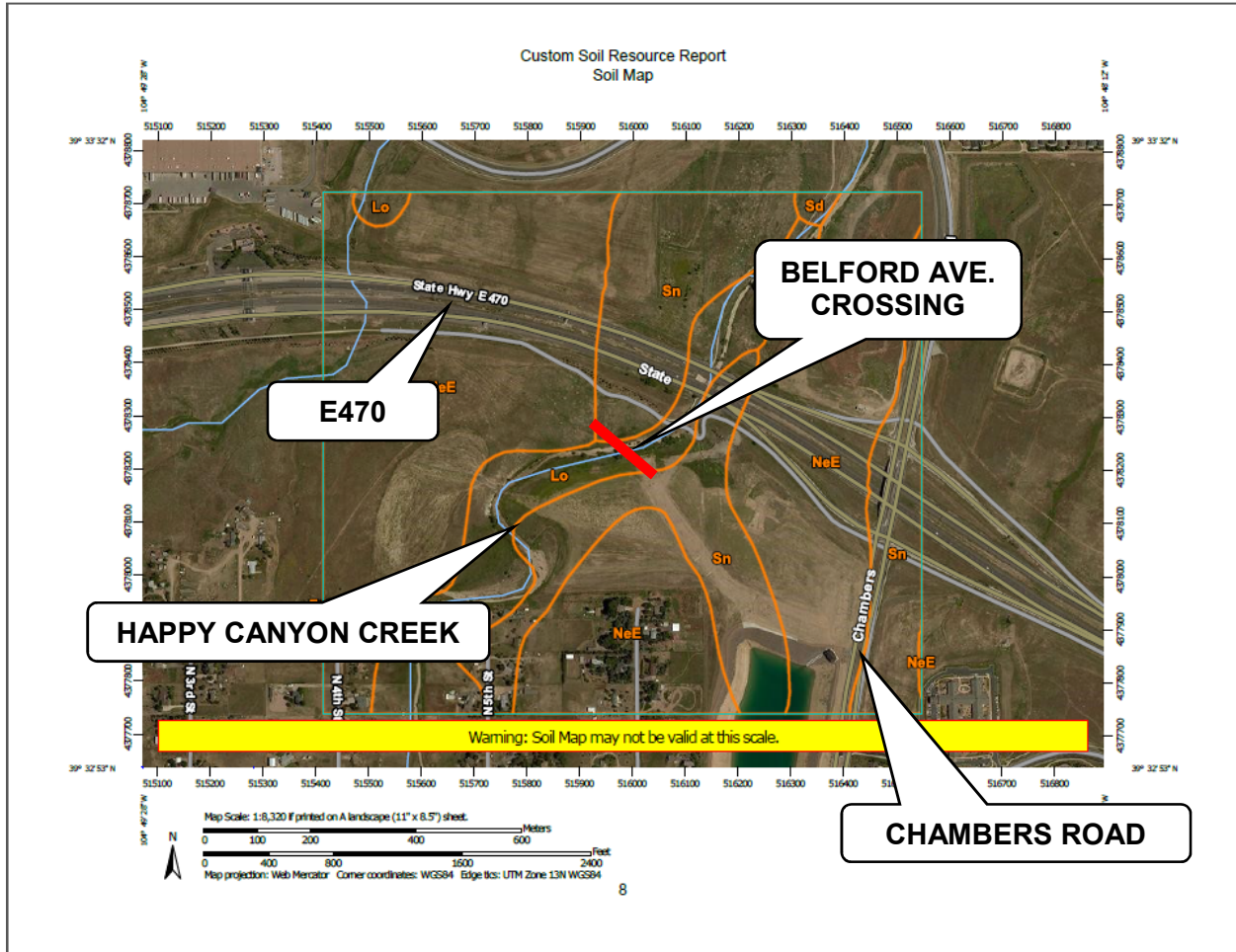


Figure 1. Vicinity Map

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**

<b>Soil Name</b>	<b>Map Symbol</b>	<b>HSG</b>	<b>Runoff Potential</b>	<b>Soil and Water Erosion Hazard</b>
Fondis clay loam, 1 to 3 percent slopes	FoB	C	Medium	Moderately low to moderately high
<i>Loamy alluvial land</i>	<i>Lo</i>	<i>C</i>	<i>Very Low</i>	<i>Moderately high to high</i>
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
<i>Satanta loam</i>	<i>Sn</i>	<i>B</i>	<i>Low</i>	<i>Moderately high to high</i>

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 February 17, 2017, 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 revised FIRM (**Figure 6** and **Reference 2**) was completed on June 30, 2016 based on the FHAD. At the time this document was prepared, the preliminary revised FIRM is being reviewed, but has not yet been accepted by FEMA. The approach for this CLOMR has been coordinated with UDFCD and was determined that the data utilized as part of the Preliminary FIRM 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**

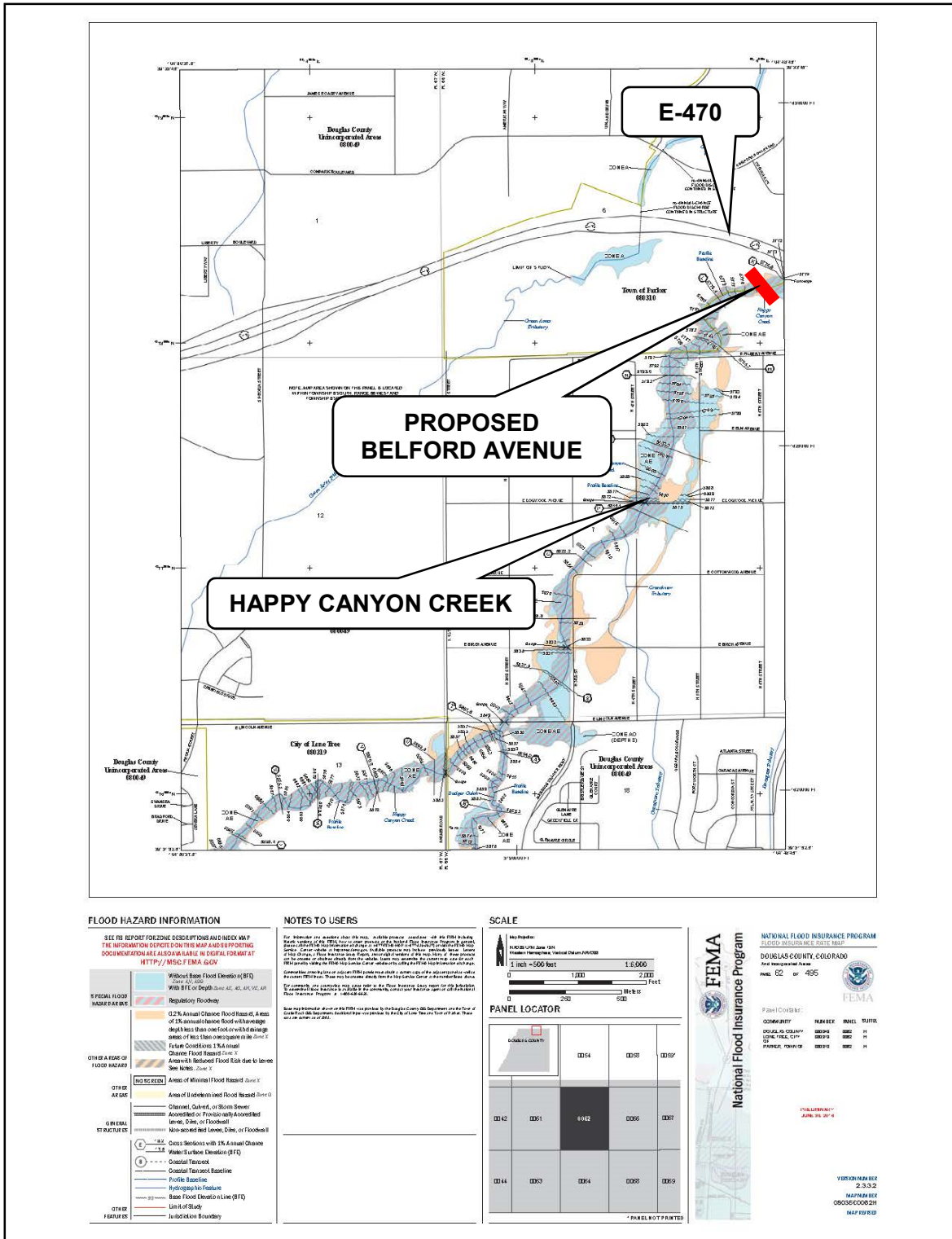
Drainageway	Reference	10-Year	50-Year	100-Year	500-Year
Happy Canyon Creek	FEMA (Effective FIS) *	2,350	4,450	5,610	8,660
	FHAD (Future Flows) **	2,656	6,249	8,355	12,107

Notes:

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

\*\* Flow rates used for design from the FHAD. Flows at Stonegate Tributary Confluence.

**CLOMR for Happy Canyon Creek – Belford Ave Connection**



**Figure 3. Preliminary Flood Insurance Rate Map 08035C0062H**

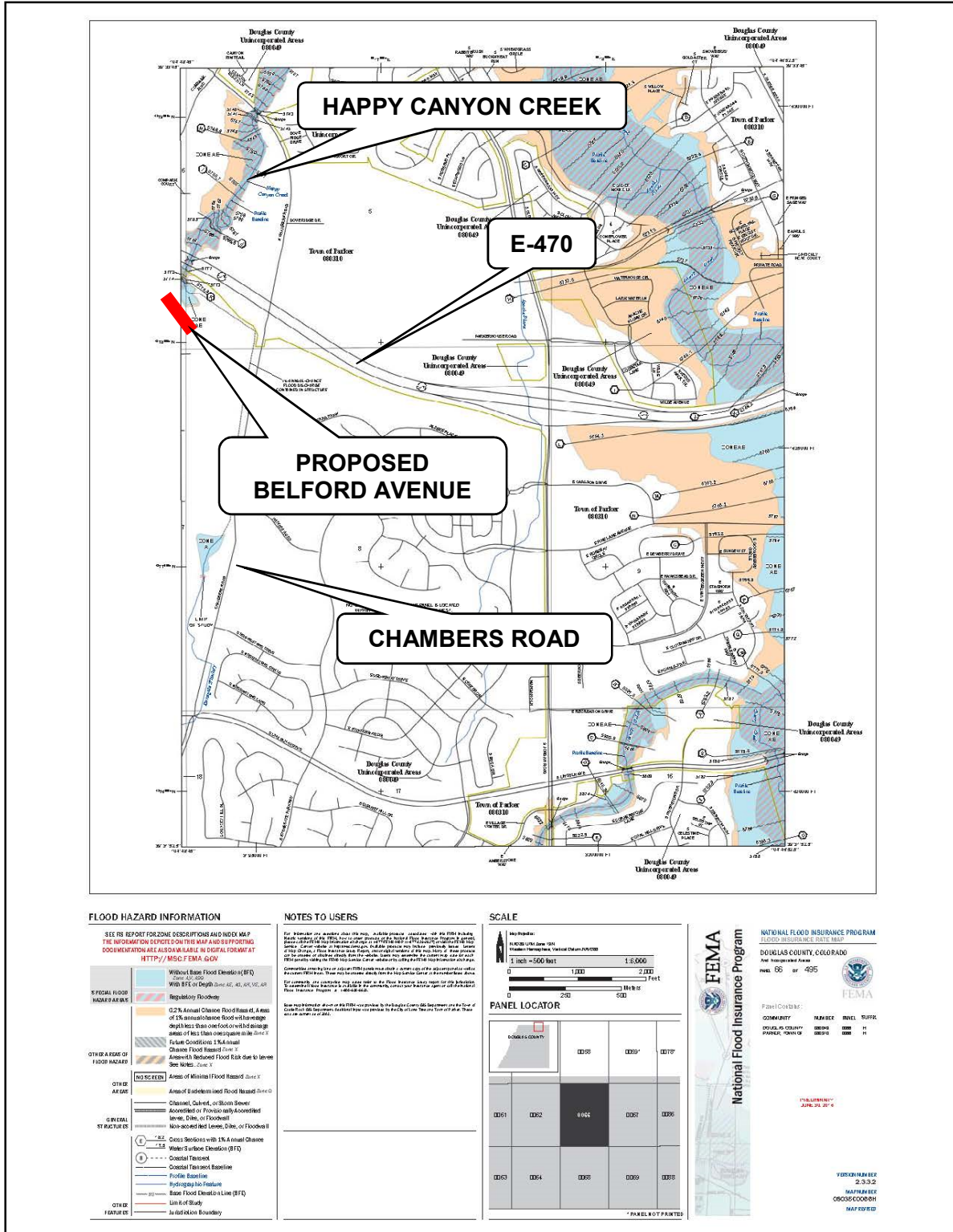
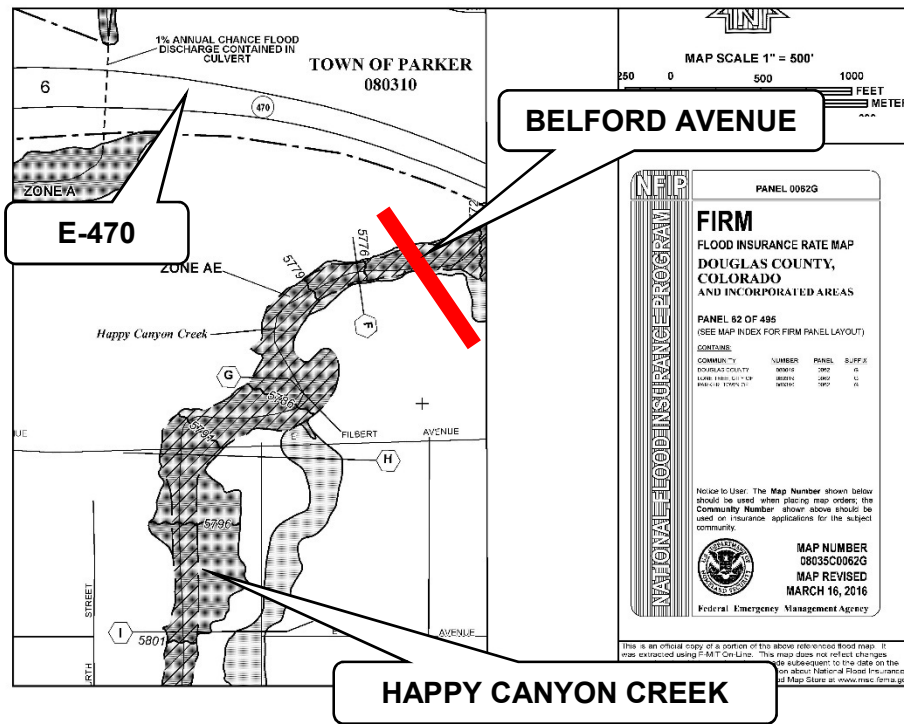


Figure 4. Preliminary Flood Insurance Rate Map 08035C0066H

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



### **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 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 constructed including a realigned low-flow segment of Happy Canyon Creek through the proposed Belford Ave. 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 to also minimize sensitive wetland habitat.

Happy Canyon Creek is conveyed under the existing Cherokee 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 multi-cell 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 UDFCD and 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, associated vegetation, and minimize impacts to existing wetlands.

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 Ave. 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 25 feet wide and connect into the existing low-flow channel section just north of the proposed bridge. This section of low-flow channel will 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 Ave. bridge crossing will be a two span, single 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 (Regional Trail) 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. Both the pedestrian trail and maintenance access have a vertical clearance at the abutment of 10 feet. The proposed elevation of both paths have been designed to keep inundation minimized recognizing the FHAD and MDP future 5-year storm event. The Regional Trail will include a wall adjacent to the creek under the Belford Ave. bridge section to aide against potential sediment accumulation and minimize inundation up to the future 5-year storm event on the trail. 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 Ave.

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 Cherokee 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 aeriels 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 Cherokee 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 performed in November 2015. All of the sections within the project limits, with the exception of a portion of the the most upstream sections, 12694, 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 2685 feet through the project limits. The corrected effective model reach was based off of flown survey and was found to be 2670.23 feet through the project limits. The corrected effective reach was 14.77 feet shorter 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 four 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 25 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 Ave. 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 Ave. and do not impact any habitable structures, but it will cause a rise when compared to the existing conditions (pre-project) water surface elevations for the 100-year floodplain/floodway, all of which will be contained entirely within the existing 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 Cherokee Trail.

The floodway was defined by being set equal to the floodplain section for this reach of Happy Canyon Creek. According to the 2014 FHAD, the floodway was generally set equal to the floodplain because of the channel cross section geometry and is contained within a well-defined channel. Ineffective flows were also set to be consistent with the 2014 FHAD which is also the basis for the pending Preliminary FIRM being reviewed by FEMA. Ineffective flow areas were added to sections just upstream or downstream of structures for contraction and is a typical modeling approach when bridge structures are present.

Sediment transport was not considered part of this CLOMR Report. 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.

## **CERTIFICATION STATEMENT**

"I hereby affirm that this document entitled CLOMR for Happy Canyon Creek – Belford Ave Connection was prepared in accordance with applicable, viable, and pertinent technical data and criteria for the Colorado Water Conservation Board, the Federal Emergency Management Agency, UDFCD, and the Town of Parker. The document, report, and all attachments submitted herewithin were prepared in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the necessary information and accurately prepared the document. Additionally, I hereby certify that no insurable structures are impacted due to the revisions documented in the CLOMR.

SIGNATURE: \_\_\_\_\_  
Registered Professional Engineer  
State of Colorado No. \_\_\_\_\_  
(Affix Seal)

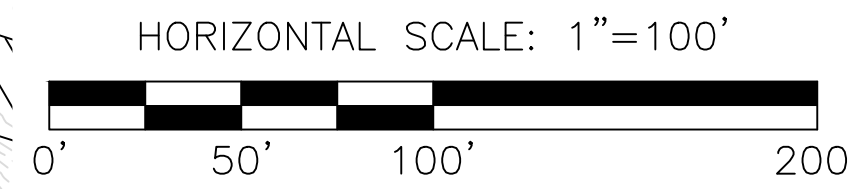
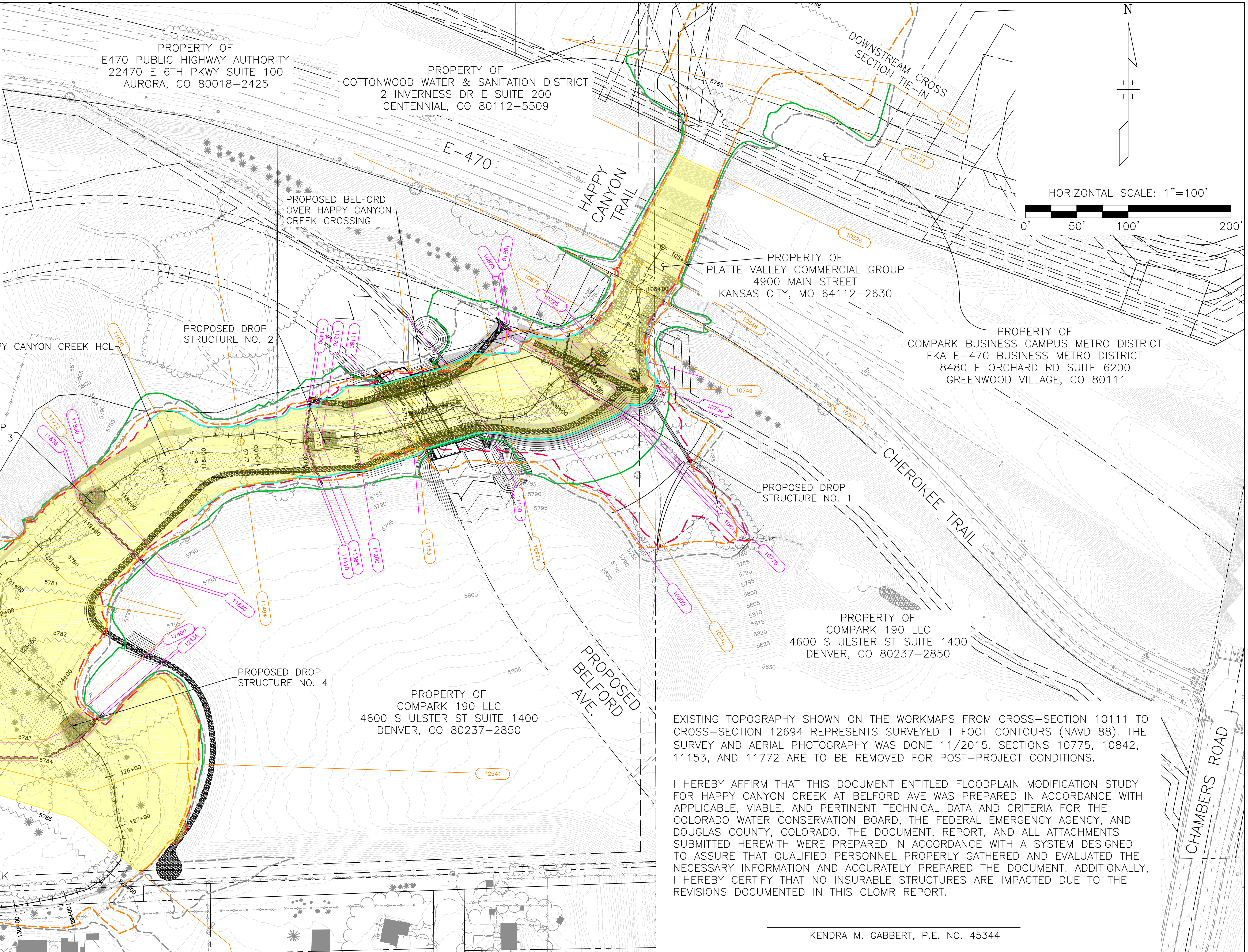
## **VI. REFERENCES**

- 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, 08035CV001C and 08035CV002C, February 17, 2017.

## **APPENDIX A. FLOODPLAIN WORK MAP**

**LEGEND**

- FHAD FLOODWAY LIMITS
- - - 100 YR FHAD FLOODPLAIN LIMITS
- - - 100 YR EXISTING FLOODPLAIN LIMITS
- 100 YR PP FLOODPLAIN LIMITS
- █ 100 YR PP FLOODWAY LIMITS
- 500 YR FHAD FLOODPLAIN LIMITS
- 500 YR PP FLOODPLAIN LIMITS
- 100 YR FHAD BFE
- 12541 FHAD CROSS-SECTION
- 12436 FHU ADDED CROSS-SECTION
- EXISTING ROW
- EXISTING EASEMENT
- SURVEYED 1 FT CONTOURS
- WETLANDS



I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings - Zach Grady

Print Date: 7/24/2017 10:27:37 AM  
 File Name: H115360-01FP-01.dwg  
 Horizontal Scale: Vertical Scale:  
  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	

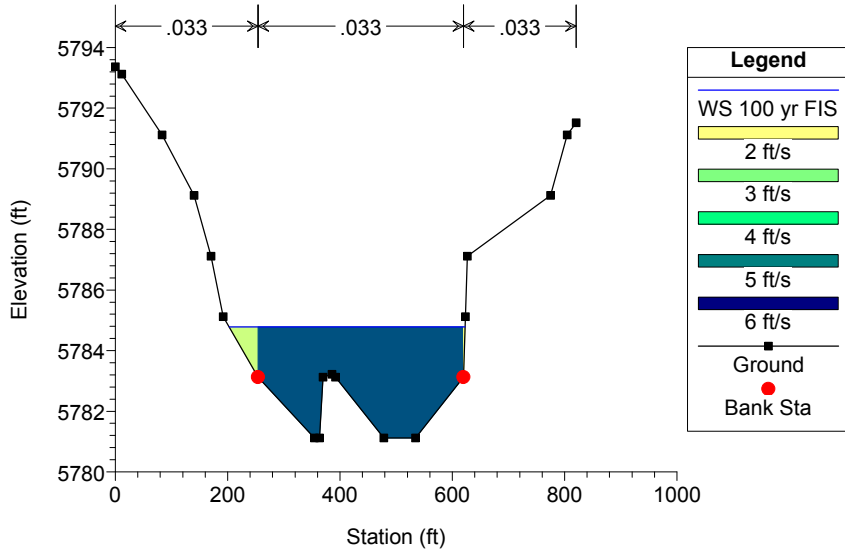
8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph:303.708.0500 fx:303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resource Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK FLOODPLAIN WORK MAP		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: ZJG		
Void:	Subset:	Sheets: 1 of 1	Sheet Number

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

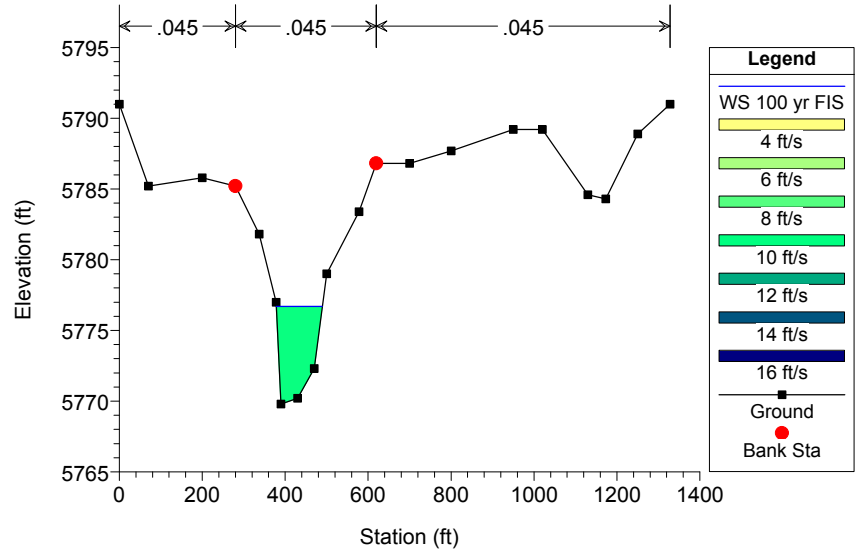
Happy Canyon Clean Plan: Effective 7/20/2017

RS = 12694



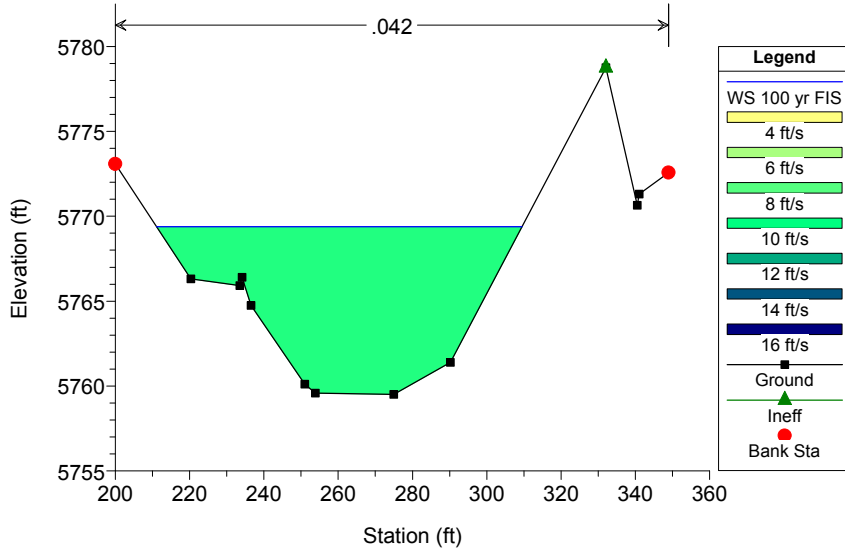
Happy Canyon Clean Plan: Effective 7/20/2017

RS = 11100 FHAD SECT 48 (RS=11390) NEW RS=11100



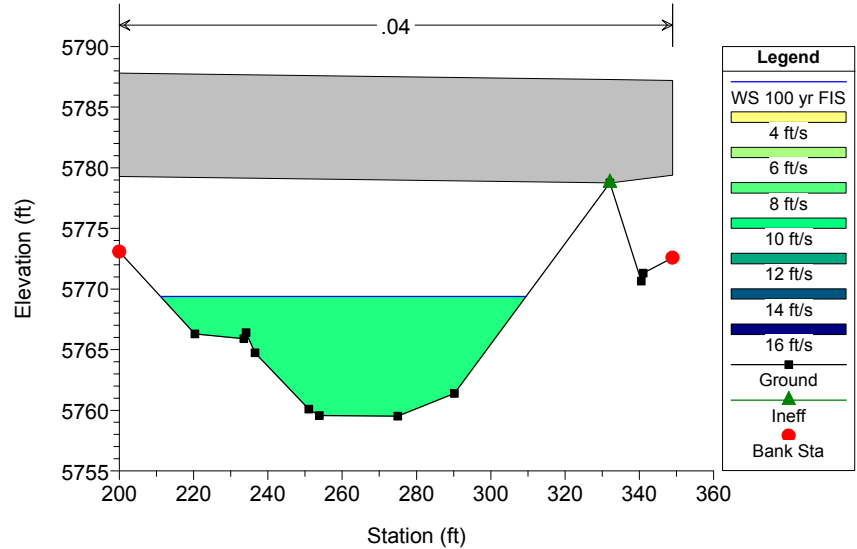
Happy Canyon Clean Plan: Effective 7/20/2017

RS = 10151 Upstream of Bridge RS = 10151



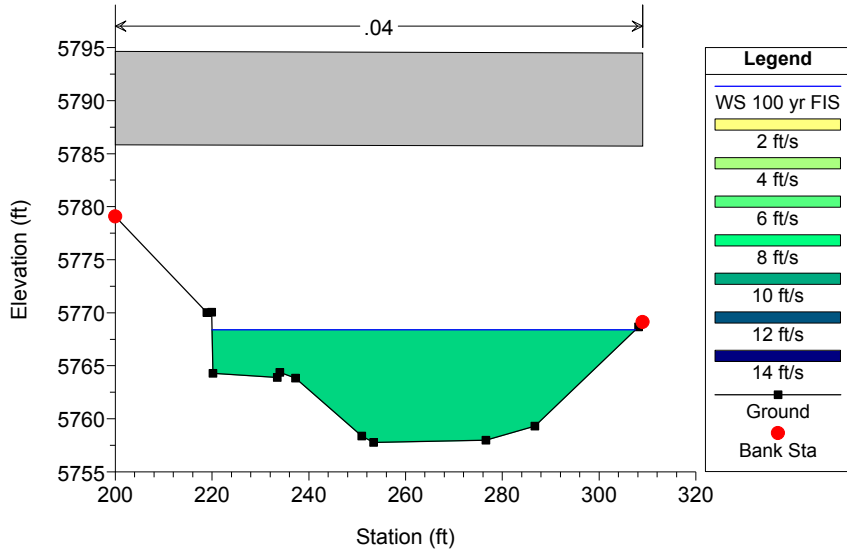
Happy Canyon Clean Plan: Effective 7/20/2017

RS = 10042 BR Existing E-470 Bridge



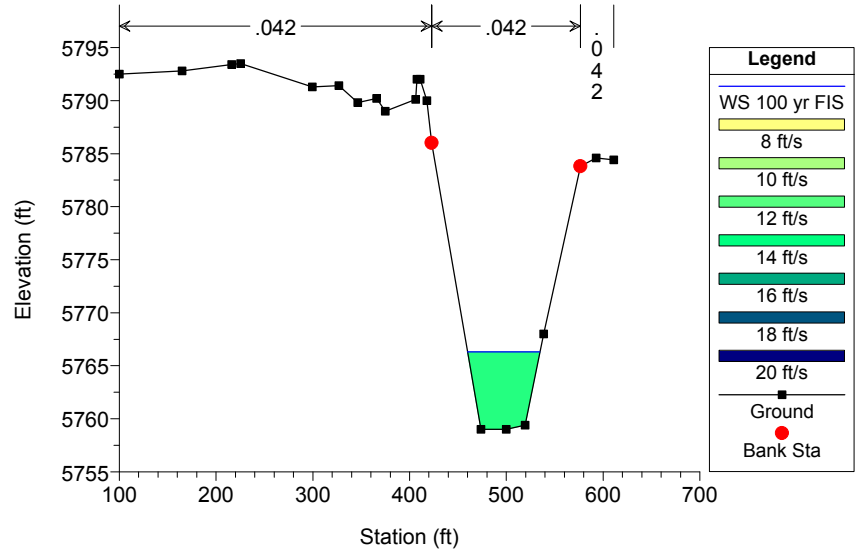
Happy Canyon Clean Plan: Effective 7/20/2017

RS = 10042 BR Existing E-470 Bridge



Happy Canyon Clean Plan: Effective 7/20/2017

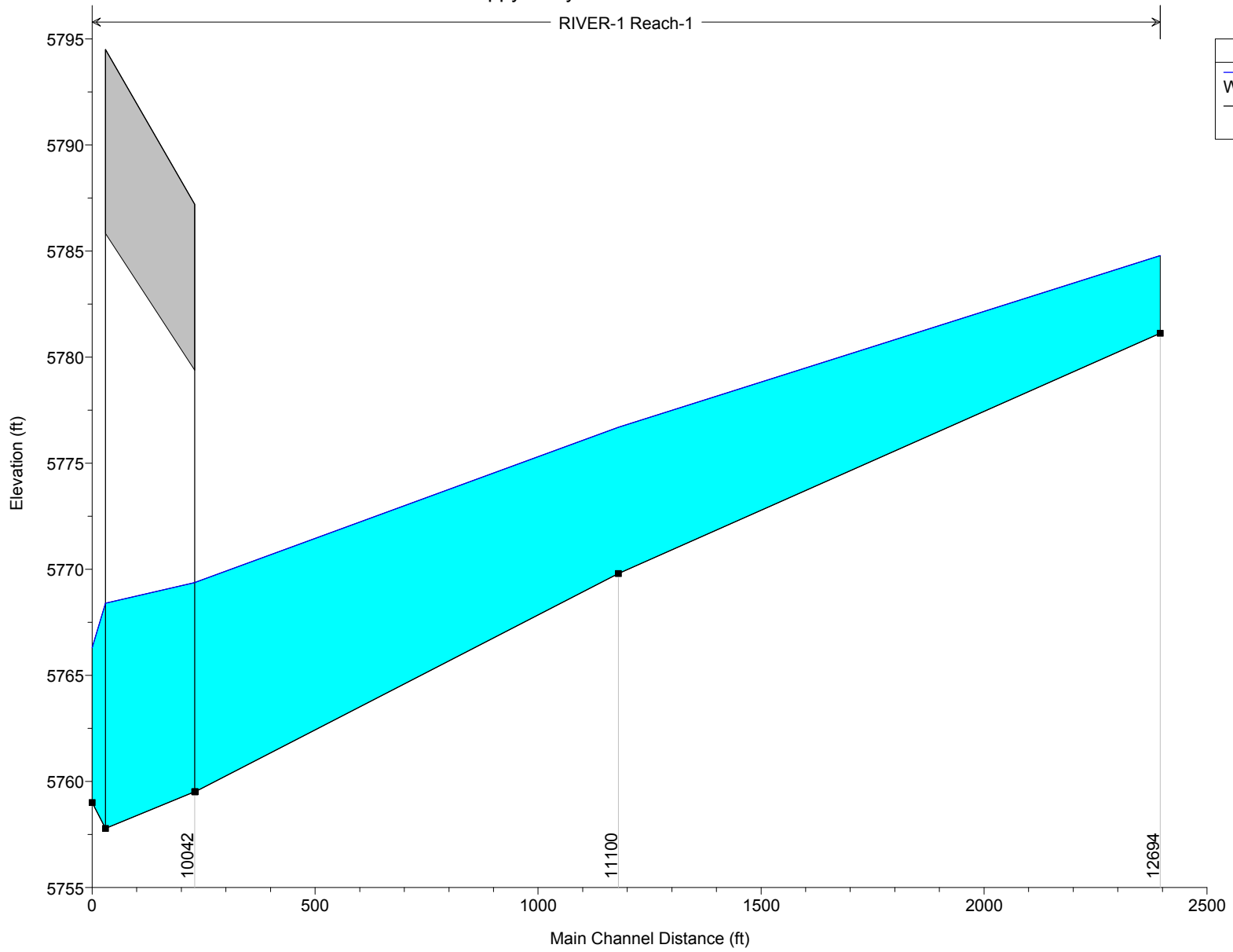
RS = 9920 RS = 9920



Happy Canyon Plan: Effective 7/24/2017

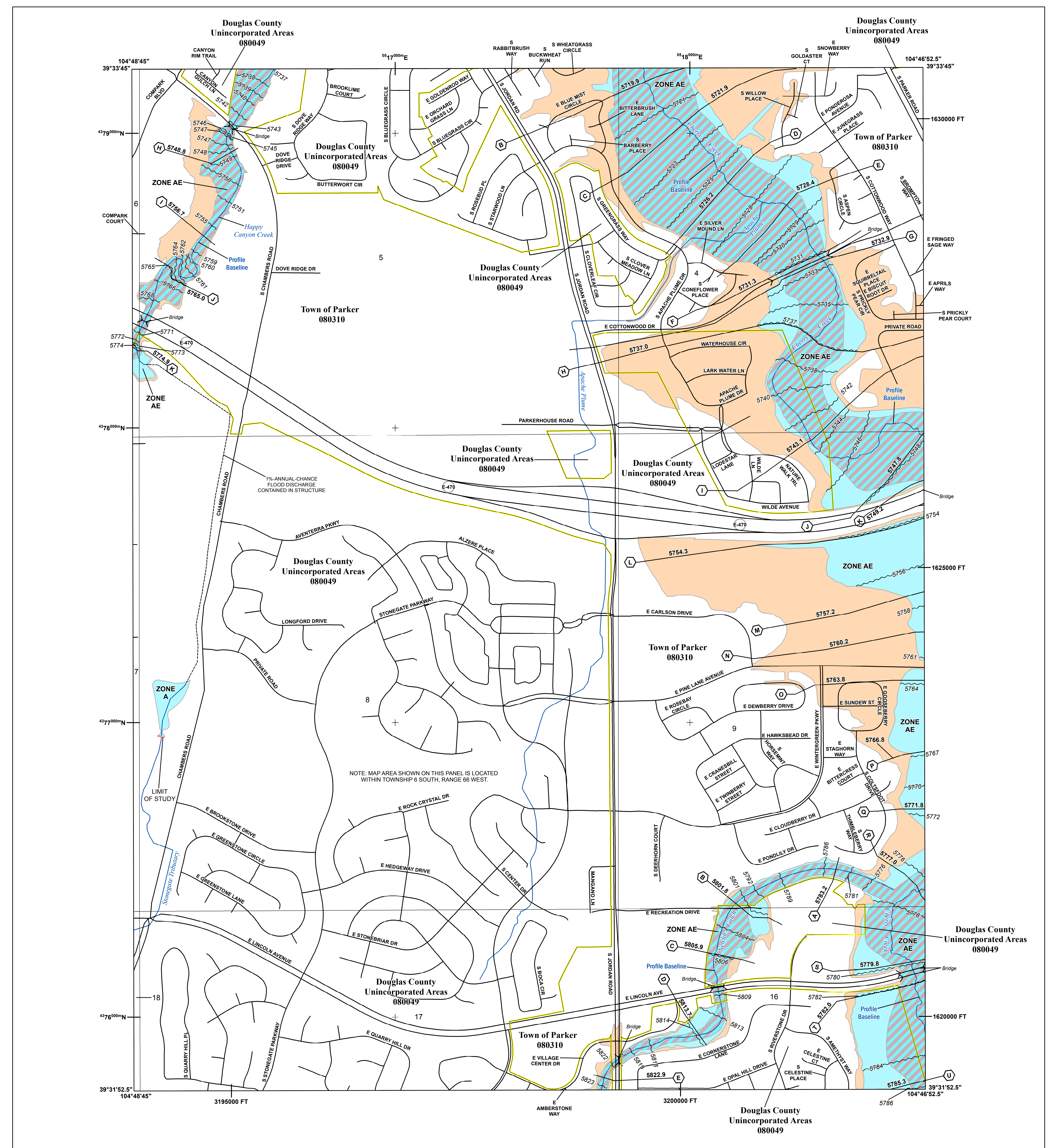
RIVER-1 Reach-1

Legend	
WS 100 yr FIS	
Ground	



HEC-RAS Plan: Effective River: RIVER-1 Reach: Reach-1 Profile: 100 yr FIS

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	12694	100 yr FIS	5560.00	5781.12	5784.78		5785.22	0.003633	5.36	1062.08	420.09	0.57
Reach-1	11100	100 yr FIS	5560.00	5769.80	5776.70		5778.18	0.010246	9.78	568.61	111.18	0.76
Reach-1	10151	100 yr FIS	5700.00	5759.51	5769.38	5767.58	5770.71	0.006167	9.23	617.86	98.41	0.65
Reach-1	10042	Bridge										
Reach-1	9920	100 yr FIS	5700.00	5759.00	5766.30	5766.12	5768.99	0.014116	13.16	433.02	74.84	0.96



**FLOOD HAZARD INFORMATION**

SEE FIS REPORT FOR ZONE DESCRIPTIONS AND INDEX MAP  
**THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT [HTTP://MSC.FEMA.GOV](http://MSC.FEMA.GOV)**

	Without Base Flood Elevation (BFE) Zone A, V, A99
	With BFE or Depth Zone AE, AO, AH, VE, AR
	Regulatory Floodway
	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
	Future Conditions 1% Annual Chance Flood Hazard Zone X
	Area with Reduced Flood Risk due to Levee See Notes, Zone X
	Areas of Minimal Flood Hazard Zone X
	Area of Undetermined Flood Hazard Zone D
	Channel, Culvert, or Storm Sewer
	Accredited or Provisionally Accredited Levee, Dike, or Floodwall
	Non-accredited Levee, Dike, or Floodwall
	Cross Sections with 1% Annual Chance Water Surface Elevation (BFE)
	Coastal Transect
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
	Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary

**NOTES TO USERS**

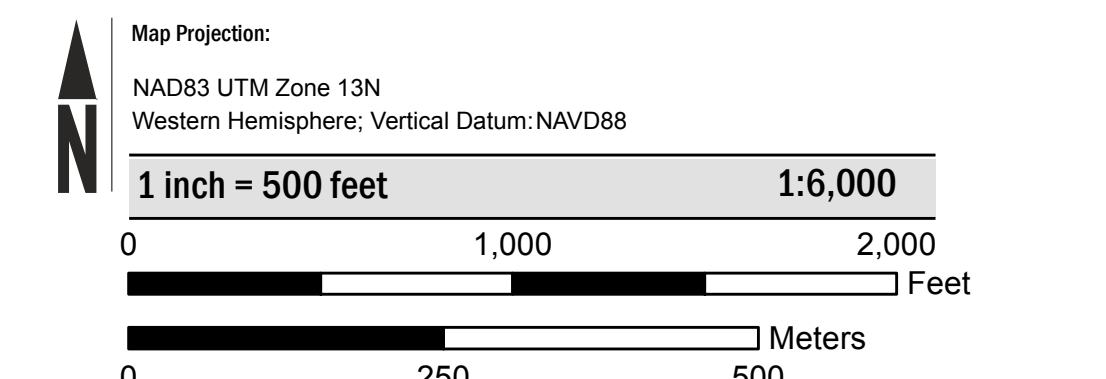
For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service Center website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Map Service Center at the number listed above.

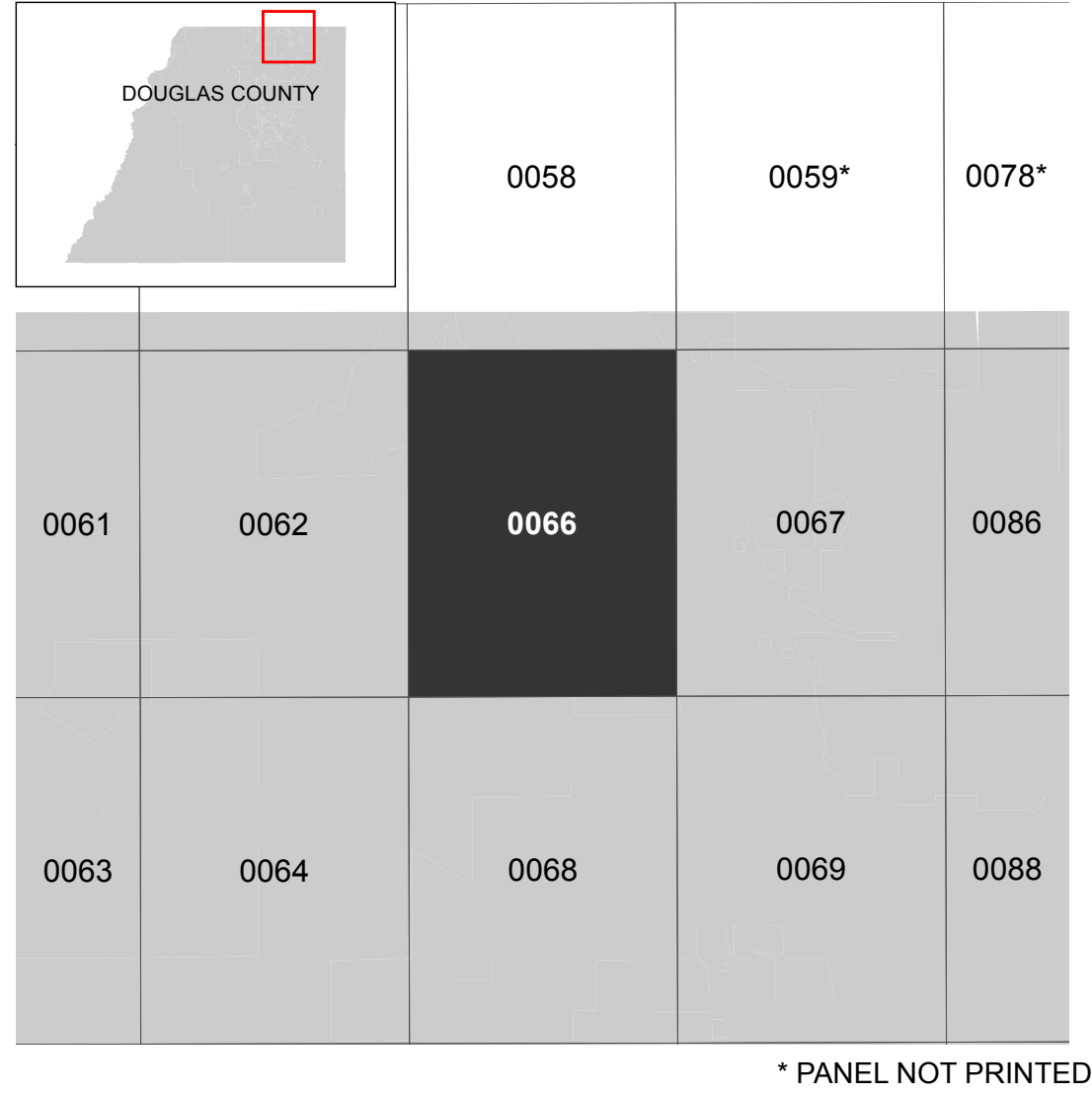
For community and countywide map dates refer to the Flood Insurance Study report for this jurisdiction. To determine if flood insurance is available in the community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Base map information shown on this FIRM was provided by the Douglas County GIS Department and the Town of Castle Rock GIS Department. Additional input was provided by the City of Lone Tree and Town of Parker. These data are current as of 2003.

**SCALE**



**PANEL LOCATOR**



**National Flood Insurance Program**

**NATIONAL FLOOD INSURANCE PROGRAM**  
**FLOOD INSURANCE RATE MAP**

**DOUGLAS COUNTY, COLORADO**  
 And Incorporated Areas

PANEL 66 OF 495

Panel Contains:

COMMUNITY	NUMBER	PANEL SUFFIX
DOUGLAS COUNTY	080049	0066 H
PARKER, TOWN OF	080310	0066 H

PRELIMINARY  
 JUNE 30, 2016

VERSION NUMBER  
 2.3.3.2

MAP NUMBER  
 08035C0066H

MAP REVISED

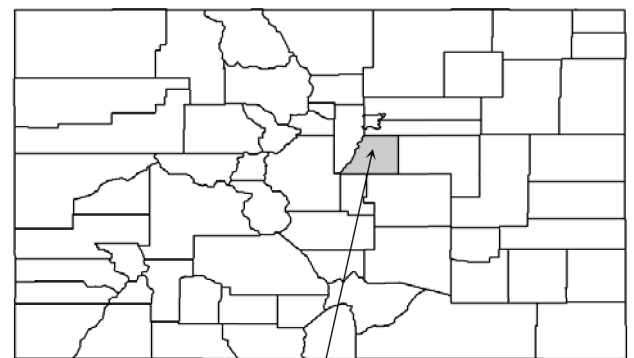


# FLOOD INSURANCE STUDY

VOLUME 1 OF 4



## DOUGLAS COUNTY, COLORADO AND INCORPORATED AREAS



Douglas County

COMMUNITY NAME	COMMUNITY NUMBER
CASTLE PINES, CITY OF	080231
CASTLE ROCK, TOWN OF	080050
DOUGLAS COUNTY (UNINCORPORATED AREAS)	080049
LARKSPUR, TOWN OF	080309
LONE TREE, CITY OF	080319
PARKER, TOWN OF	080310



Revised: February 17, 2017

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER  
08035CV001C

Table 3 – LETTERS OF MAP REVISION

<u>Community</u>	<u>Flooding Source(s) and Project Identifier</u>	<u>Date Issued</u>	<u>Type</u>	
Town of Castle Rock	East Plum Creek Tributary D	May 22, 2003	LOMR	
	Tributary B Castle Rock Factory Store Expansion	September 12, 2002	LOMR	
	Tributary B to East Plum Creek	October 2, 2000	LOMR	
	6400 Tributary East Fork	January 24, 2003	LOMR	
	Tributary D to East Plum Creek	September 12, 2000	LOMR	
	Tributary B to East Plum Creek	December 3, 1999	LOMR	
	Hangmans Gulch	June 18, 1996	LOMR	
	Tributary C to East Plum Creek West Fork of Tributary 6400	August 7, 1995	LOMR	
	Village No. Diversion Channel	April 5, 1995	LOMR	
	Unnamed Tributary to Sellars Gulch	November 21, 1994	LOMR	
	Omni Drainageway	March 10, 1994	LOMR	
	Tributary 6400 East Fork and Tributary 6400 West Fork	January 14, 1994	LOMR	
	Douglas County (Unincorporated Areas)	Newlin Gulch	July 30, 2003	LOMR
		Bayou Gulch / Cherry Creek	July 23, 2003	LOMR
		Sulpher Gulch	June 25, 2003	LOMR
		East Plum Creek Tributary D	May 22, 2003	LOMR
		Happy Canyon Creek	April 24, 2003	LOMR
Tributary A		January 24, 2003	LOMR	
Sulpher Gulch		January 16, 2003	LOMR	
Tributary B to East Plum Creek		September 12, 2002	LOMR	
Newlin Gulch		June 22, 2001	LOMR	
Green Acres Tributary		March 14, 2001	LOMR	
Tributary B to East Plum Creek		October 2, 2000	LOMR	
Tributary A of East Plum Creek		September 11, 2000	LOMR	
Big Dry Creek		June 29, 2000	LOMR	
Tributary B to East Plum Creek		December 3, 1999	LOMR	
Tallman Gulch		March 29, 1999	LOMR	
Sulpher Gulch		May 4, 1998	LOMR	
Willow Creek		April 17, 1998	LOMR	
Newlin Gulch		August 27, 1997	LOMR	
Jordan Road Tributary		March 3, 1997	LOMR	
Tributary C to East Plum Creek		August 7, 1995	LOMR	
Village No. Diversion Channel		April 5, 1995	LOMR	
East Plum Creek		November 18, 1994	LOMR	
Jordan Road Tributary		August 29, 1994	LOMR	
Town of Parker	Tributary 6400 East Fork and Tributary 6400 West Fork	January 14, 1994	LOMR	
	Unnamed Tributary D	December 5, 2003	LOMR	
	Cherry Gulch / Newlin Gulch	July 30, 2003	LOMR	
	Sulpher Gulch	June 25, 2003	LOMR	

## **Pre-countywide Analyses**

For the January 5, 1996, FIS, the synthetic hydrograph method was used to obtain peak discharge for Plum Creek, East Plum Creek, West Plum Creek (at Perry Park), Hangmans Gulch, Sellars Gulch, Unnamed Tributary to Sellars Gulch, Carpenter Creek, Happy Canyon Creek, Newlin Gulch, Baldwin Gulch, Sulphur Gulch, Tallman Gulch, Bayou Gulch, and West Creek. The analysis was based on a 24-hour storm with a Type IIA distribution, as described in the SCS National Engineering Handbook (U.S. Department of Agriculture, 1972). The amount of rainfall was obtained from a precipitation frequency-atlas (U.S. Department of Commerce, 1973) and a real adjustment was applied to convert the point precipitation values to average precipitation over the entire watershed area. Hydrologic soil cover complexes and associated Runoff Curve Numbers were obtained from field investigations, a soil survey of Castle Rock (U.S. Department of Commerce, 1973), an unpublished SCS study of the area, and land use and natural plant coverage maps of Douglas County (U.S. Department of Agriculture, 1971; U.S. Department of Agriculture, 1974; U.S. Department of Agriculture, 1973). Values of 10-, 50-, 100- and 500- year peak discharges were obtained using the computer program developed by the SCS (U.S. Department of Agriculture, 1976). The computed peak discharges compare favorably with the peak discharges estimated using the USGS Technical Manual No. 1 (U.S. Department of the Interior, Technical Manual No.1, 1976).

Discharge magnitudes for floods in Cherry Creek analyzed in the 1996 FIS were based on an analysis of stream gaging data at the USGS stream gages located approximately 2.5 miles south of Franktown and 6 miles northwest of Parker. This information was obtained from a USACE Flood Plain Information report (USACE, 1976). Discharge-frequency relationships for the upstream and downstream limits of the study reach were developed using data from the Franktown and Parker stream gages, respectfully. The presence of 32 flood retarding structures in the Cherry Creek Basin constructed by the SCS was taken into consideration.

A continuous record of flows at stream gaging station No. 0670500, located on the South Platte River at South Platte, is available from 1900 to the present, and stream gaging station No. 06701500, below Cheesman Lake, has a continuous record of flows from 1925 to the present.

Discharge magnitudes for floods analyzed in the 1996 FIS detailed study of the South Platte River and Horse Creek were based on statistical analyses of the previously mentioned stream gaging records, as explained in U.S. Water Resources Counsel Bulletin 17 (U.S. Water Resources Council, 1976).

Discharge-probability relationships for the upstream and downstream study limits were developed using data from the gaging stations below Cheesman Lake and at South Platte, respectively.

Hydrologic information for the streams studied by approximate methods, for the 1996 FIS, was obtained from various sources. Existing UDFCD reports were used

directly for Badger Gulch, Big Dry Creek, Cottonwood Creek, Dad Clark Gulch, Happy Canyon Creek, Marcy Gulch, McMurdo Gulch, and Piney Creek (Howard, Needles, Tammen & Bergendoff, 1977; VTN Engineers, Architects, Planners, 1973; Gingery Associates, Inc., Piney Creek, 1975). A drainage area versus discharge curve was developed using UDFCD information for Happy Canyon Creek Tributary, Jordan Road Tributary, KOA Tributary, Newlin Gulch, South Newlin Gulch, and Oak Gulch. A procedure that was developed by the SCS was used for the 6400 Tributaries (U.S. Department of Agriculture, 1980), the computer model SWMM was used for Tributary A (U.S. Environmental Protection Agency, Computer Model SWMM) and the SCS TR-20 computer program was used to develop hydrologic information for Glade Gulch and Section 34 Tributary (U.S. Department of Agriculture, 1976). Technical Manual No. 1 (U.S. Department of Agriculture, Technical Manual No. 1, 1976) was used for all other approximate-study reaches.

### **Countywide Analyses**

Peak discharges for Big Dry Creek, and Big Dry Creek Tributary C were obtained using version CUHPE/PC of the Colorado Urban Hydrograph Procedure (CUHP) by UDFCD (WRC Engineering, Inc., 1996; Urban Drainage and Flood Control District, 1984). A modified 2-hour design storm distribution recommended by the Urban Storm Drainage Criteria Manual (USDCM) (Urban Drainage and Flood Control District, 1984) was used within CUHP to produce runoff hydrographs required for the flow routing required in the UDFCD Stormwater Management Model (SWMM) (Urban Drainage and Flood Control District, 1989). Values of 10-, 50-, 100, and 500-year peak discharges were obtained using the SWMM computer program.

Peak discharges for Willow Creek, Little Willow Creek, and East Willow Creek were obtained using version CUHPF/PC of the CUHP by UDFCD (Urban Drainage and Flood Control District, 1996). One-hour rainfall depths were developed using criteria from the Douglas County Drainage Criteria Manual (Greenhorne & O'Mara, 1996; Douglas County, 1986) and the USDCM. One-hour rainfall depths distributed over a two-hour design storm were used within CUHP to produce runoff hydrographs required for the flow routing required in the UDFCD Stormwater Management Model (UDSWM386) (Urban Drainage and Flood Control District, 1985). Values of 10-, 50-, and 100-year peak discharges were obtained using the SWMM computer program.

Discharge magnitudes for Daniels Park Drain, Drainageways 6600-02, 6604-01, 6605-01, Highlands Gulch, Indian Creek, Jarre Creek, Lehigh Gulch, Louviers Gulch, Oxide Draw, Plum Creek, Rainbow Creek, Sterling Gulch, and West Plum Creek (near the Plum Creek Confluence) were obtained using version CUHP98 (WRC Engineering, Inc., 2001; Urban Drainage and Flood Control District, 1985) of the CUHP by UDFCD. Design storm distributions were developed using criteria from the Douglas County Drainage Criteria Manual and the USDCM. These storm distributions were used within CUHP to produce runoff hydrographs required for the flow routing required in the UDFCD Stormwater Management Model (UDSWM98) (Urban Drainage and Flood Control District, 1989). Values of 10-,

Table 4 – SUMMARY OF DISCHARGES (Continued)

FLOODING SOURCE AND LOCATION	DRAINAGE	PEAK DISCHARGES (cfs)			
	AREA (sq. miles)	10-YEAR	50-YEAR	100-YEAR	500-YEAR
<b>HANGMANS GULCH</b>					
Downstream of I-25	1.26	305	774	1,008	1,293
At the Confluence of Tributary B	*	229	591	778	933
At Upstream Limit of Detailed Study	0.05	95	209	273	370
<b>HAPPY CANYON CREEK</b>					
At Dogwood Avenue	13.7	2,350	4,450	5,610	8,660
At Birch Avenue	12.5	2,310	4,340	5,460	8,340
At Upstream Limit of Detailed Study	9.0	1,860	3,340	4,160	6,270
<b>HIGHLANDS GULCH</b>					
At Confluence with Plum Creek	2.48	290	1,150	1,890	*
At D&RWG Railroad	2.43	290	1,150	1,890	*
At AT&SF Railroad	2.28	290	1,150	1,890	*
At U.S. HWY 85	2.28	290	1,150	1,770	*
At Upstream Limit of Detailed Study	1.91	290	1,150	1,720	*
<b>HORSE CREEK</b>					
At Confluence with the South Platte River	214.1	*	*	2,873	*
Just downstream of West Creek and Trout Creek Confluence	204.4	*	*	2,679	*
<b>INDIAN CREEK</b>					
At Louviers Road	16.69	1,550	4,520	6,550	*
At Airport Road	16.20	1,500	4,450	6,500	*
At Confluence with Lehigh Gulch	15.33	1,200	3,400	4,800	*
At Private Road (Station 17997)	12.29	1,200	3,400	4,800	*
At Lambert Road	12.11	1,100	3,200	4,400	*
At Rainbow Creek Road	10.97	1,050	2,920	4,100	*
At Confluence with Rainbow Creek	10.44	1,050	2,920	4,100	*
At Cherokee Drive	7.40	1,050	2,920	4,100	*

\*Data not available

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE <sup>1</sup>	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Happy Canyon Creek								
A	5,165	150	685	10.2	5,729.7	5,729.7	5,729.7	0.0
B	6,812	265	810	7.1	5,739.7	5,739.7	5,739.7	0.0
C	8,320	102	466	12.2	5,753.4	5,753.4	5,753.4	0.0
D	9,720	350	1,395	5.2	5,766.3	5,766.3	5,766.3	0.0
E	9,920	407	895	8.9	5,766.3	5,766.3	5,766.3	0.0
F	11,320	110	556	10.0	5,776.7	5,776.7	5,776.7	0.0
G	12,605	430	5,767	1.0	5,784.8	5,784.8	5,784.8	0.0
H	13,490	315	880	6.3	5,792.5	5,792.5	5,793.5	1.0 <sup>2</sup>
I	14,470	171	825	6.8	5,800.4	5,800.4	5,801.4	1.0 <sup>2</sup>
J	15,020	115	607	9.2	5,805.6	5,805.6	5,806.6	1.0 <sup>2</sup>
K	15,570	180	920	6.1	5,808.9	5,808.9	5,809.9	1.0 <sup>2</sup>
L	15,640	205	1,450	3.9	5,813.9	5,813.9	5,814.9	1.0 <sup>2</sup>
M	16,120	110	701	8.0	5,814.9	5,814.9	5,815.9	1.0 <sup>2</sup>
N	16,720	100	519	10.5	5,819.1	5,819.1	5,820.1	1.0 <sup>2</sup>
O	17,170	81	537	10.1	5,824.4	5,824.4	5,824.4	0.0
P	17,835	142	763	7.1	5,827.7	5,827.7	5,828.7	1.0 <sup>2</sup>
Q	18,230	136	498	8.7	5,831.2	5,831.2	5,831.2	0.0
R	18,310	107	977	5.6	5,836.2	5,836.2	5,837.2	1.0
S	19,020	99	509	10.8	5,837.7	5,837.7	5,838.2	0.5
T	19,604	72	540	10.2	5,841.4	5,841.4	5,841.6	0.2
U	19,918	113	716	7.7	5,845.3	5,845.3	5,845.3	0.0
V	20,104	148	803	5.1	5,851.2	5,851.2	5,851.2	0.0
W	20,571	128	423	9.8	5,854.0	5,854.0	5,854.1	0.1
X	20,972	103	437	9.5	5,859.0	5,859.0	5,859.0	0.0
Y	21,036	112	575	7.2	5,860.3	5,860.3	5,860.3	0.0

<sup>1</sup> Feet Above Mouth

<sup>2</sup> Encroachment Limited to Channel Banks; Elevation Increase May Be Less Than 1.0 Foot

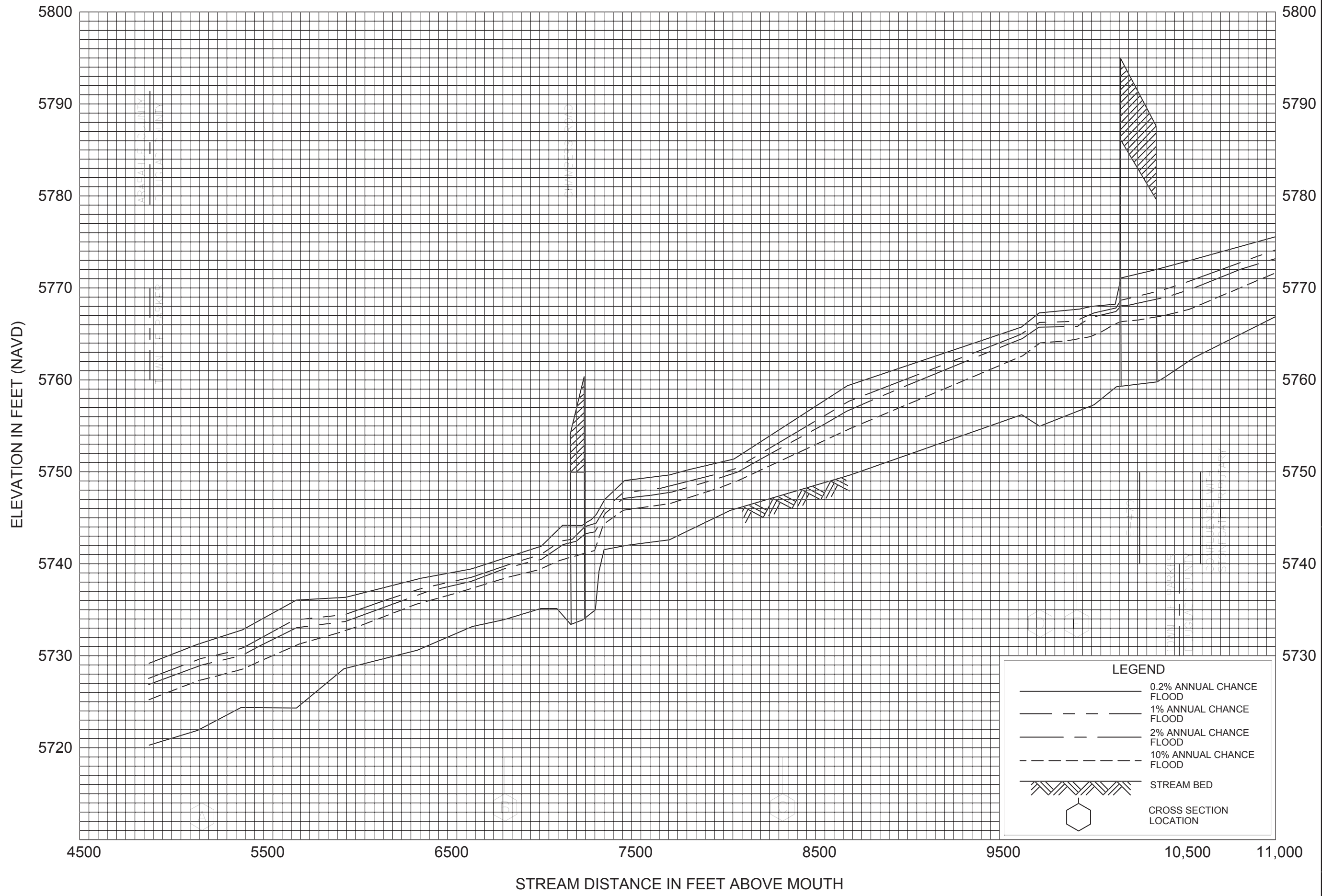
**TABLE 7**

FEDERAL EMERGENCY MANAGEMENT AGENCY

**DOUGLAS COUNTY, CO  
AND INCORPORATED AREAS**

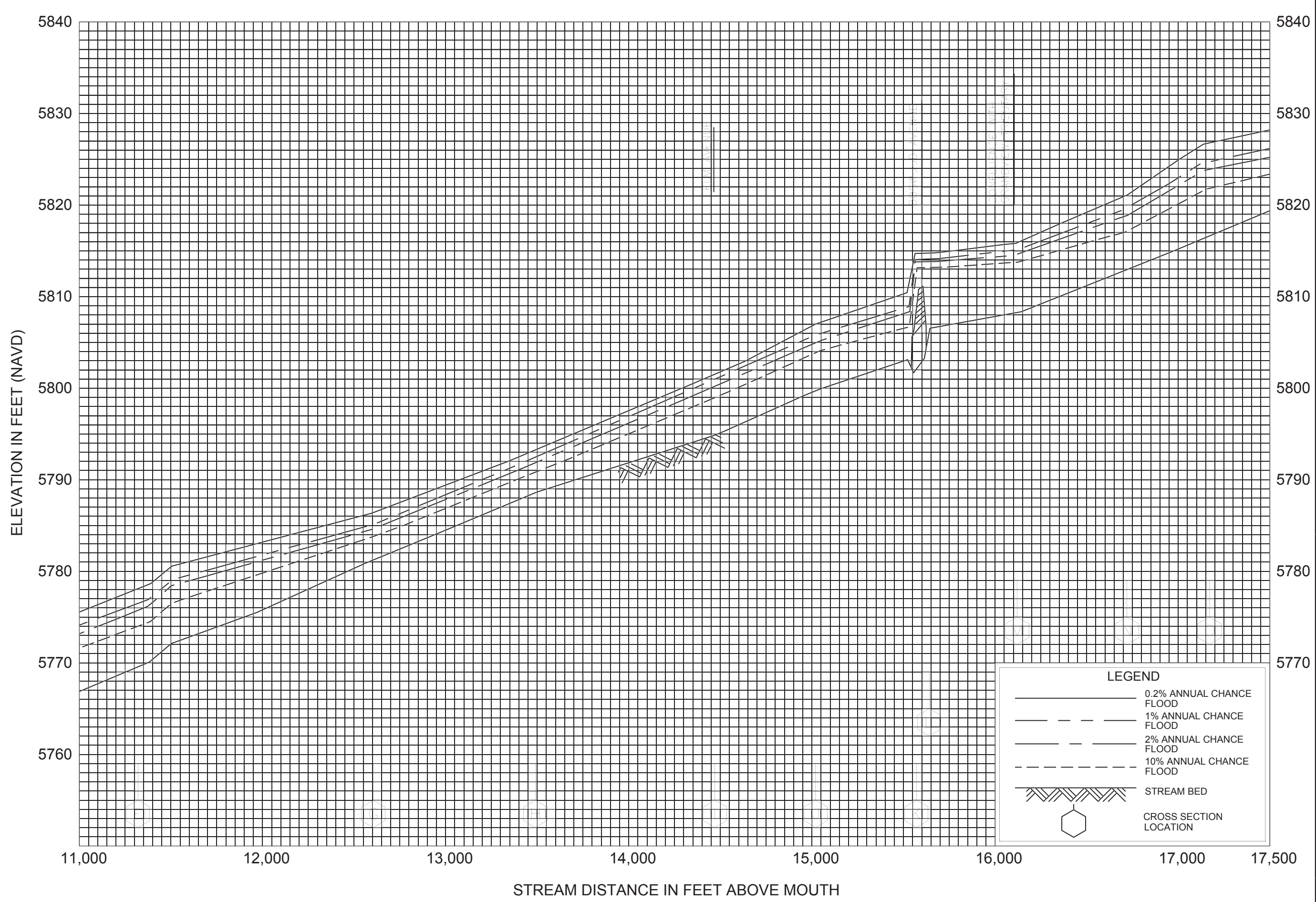
**FLOODWAY DATA**

**HAPPY CANYON CREEK**



FLOOD PROFILES  
HAPPY CANYON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY  
DOUGLAS COUNTY, CO  
AND INCORPORATED AREAS



FLOOD PROFILES  
HAPPY CANYON CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY  
DOUGLAS COUNTY, CO  
AND INCORPORATED AREAS

10JP

# Happy Canyon Creek Flood Hazard Area Delineation (FHAD)

July 2014



CITY OF LONE TREE



**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 Schvien	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 to 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						FUTURE DEVELOPMENT							
					500-YR (cfs)	100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)	500-YR (cfs)	100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)
<b>HAPPY CANYON CREEK</b>																		
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



CITY OF LONE TREE



**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.)

[CLICK HERE TO VIEW REACH 8 MAP](#)

[CLICK HERE TO VIEW REACH 8 PROFILE](#)

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.



NAME: P112-0101 Happy Canyon Creek MDP & FHAD (DFCD) Happy Canyon Creek MDP Technical Appendix 7 AUTOCAD FILES (Conceptual Design) 120104CC-MDP-PLAN.dwg  
 DATE: MAR 28, 2014 TIME: 01:15 AM

No.	DATE	REVISIONS	APPR.

**MULLER ENGINEERING CO., INC.**  
 CONSULTING ENGINEERS  
 777 SOUTH WADSWORTH BLVD. 4-100  
 LAKEWOOD, COLORADO 80226 (303) 988-4939

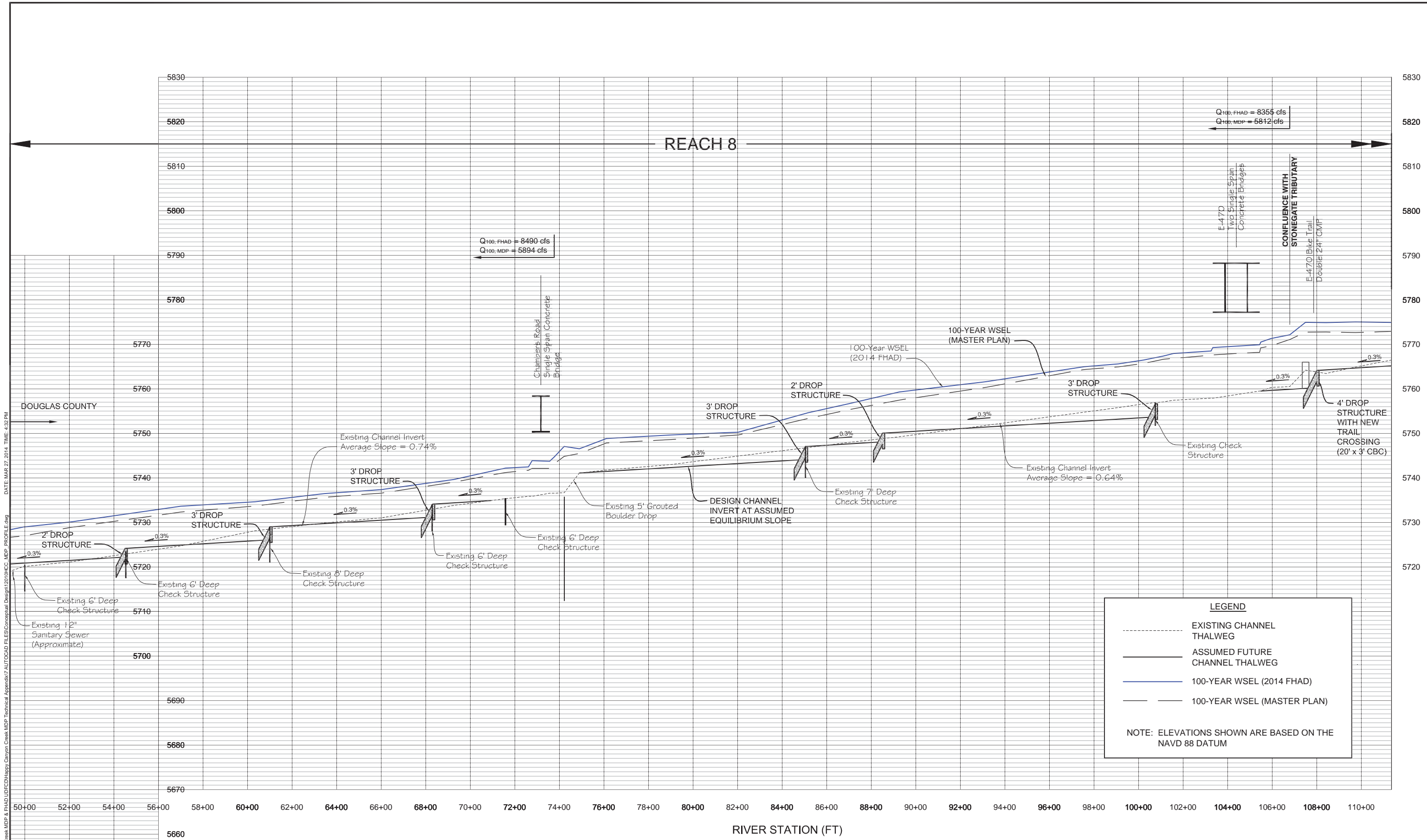
DESIGN: MDC  
 DRAWN: SAR  
 CHECK: JTW



**HAPPY CANYON CREEK  
 MAJOR DRAINAGEWAY PLAN**

**CONCEPTUAL DESIGN PLAN  
 REACH 8**

DATE: MARCH 2014  
 FIGURE NO.



**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

NAME: P:\12-0101\Happy Canyon Creek MDP & FHAD\DFCD\Happy Canyon Creek MDP Technical Appendix 7 AUTOCAD FILES\Conceptual Design\2014\HCC\_MDP\_PROFILE.dwg  
 DATE: MAR 27 2014 TIME: 3:32 PM  
 No. DATE REVISIONS APPR.

No.	DATE	REVISIONS	APPR.

**MULLER ENGINEERING CO., INC.**  
 CONSULTING ENGINEERS  
 777 SOUTH WADSWORTH BLVD. #100  
 LAKEWOOD, COLORADO 80226 (303) 988-4939

DESIGN: MDC  
 DRAWN: SAR  
 CHECK: JTW

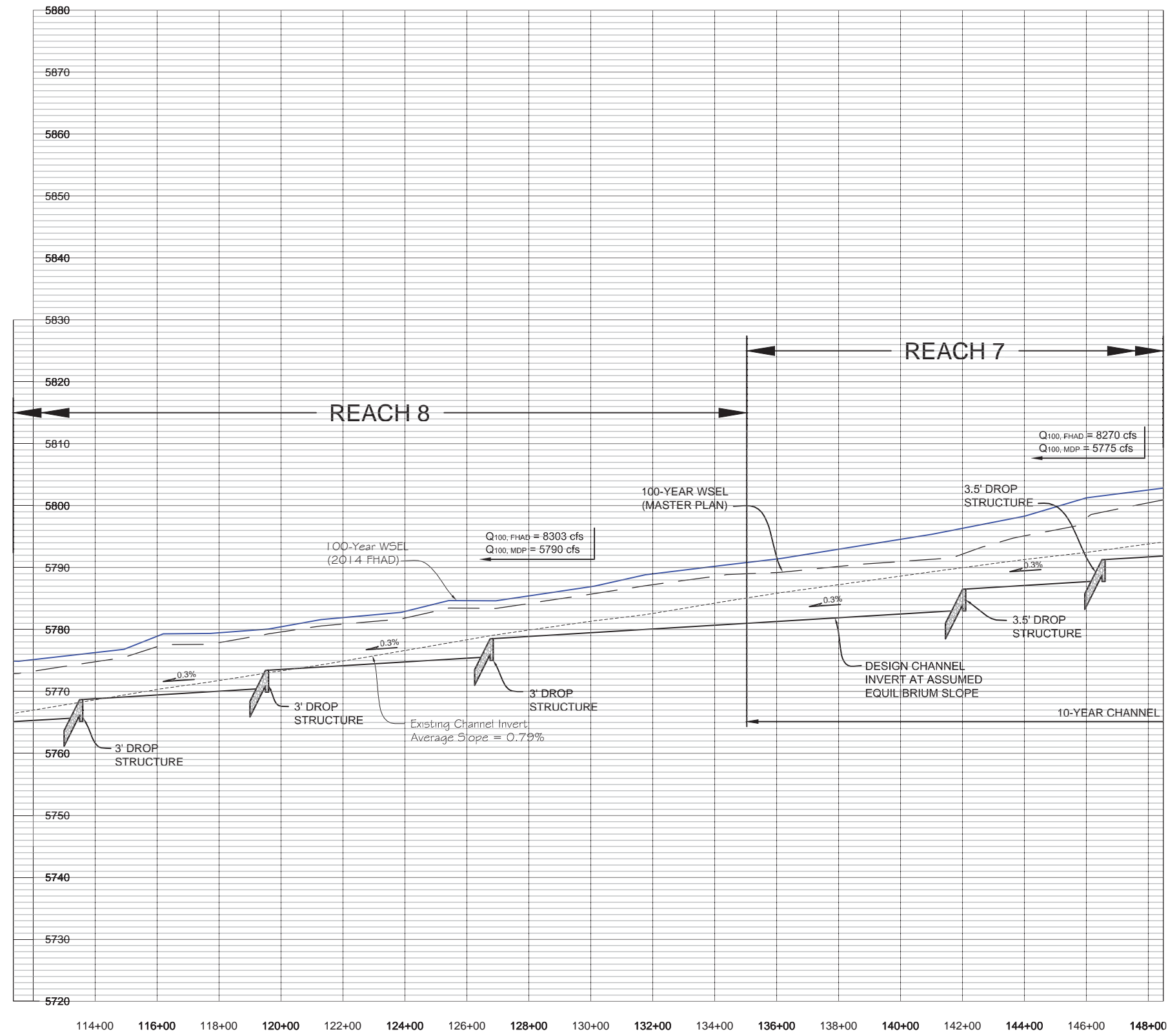


**HAPPY CANYON CREEK**  
**MAJOR DRAINAGEWAY PLAN**

CONCEPTUAL DESIGN PROFILE  
 REACH 8 (1 OF 2)





DATE: MARCH 2014  
 FIGURE NO.

NAME: P:\12-010-01 Happy Canyon Creek MDP & FHAD\DFCD\Happy Canyon Creek MDP Technical Appendix\7 AUTOCAD FILES\Conceptual Design\12010HEC\_MDP\_PROFILE.dwg DATE: MAR 27 2014 TIME: 4:35 PM



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.

**MULLER ENGINEERING CO., INC.**  
CONSULTING ENGINEERS  
777 SOUTH WADSWORTH BLVD. #100  
LAKEWOOD, COLORADO  
80226 (303) 988-4939

DESIGN	MDC
DRAWN	SAR
CHECK	JTW



**HAPPY CANYON CREEK  
MAJOR DRAINAGEWAY PLAN**

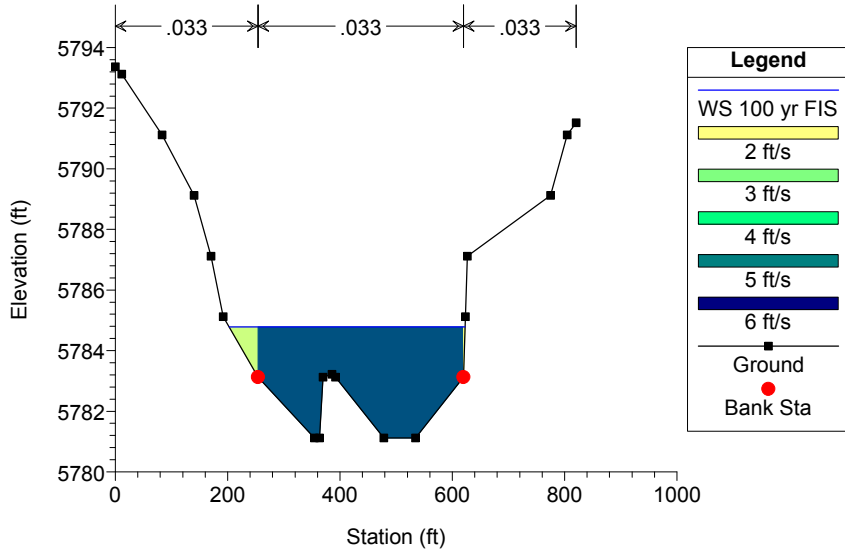
CONCEPTUAL DESIGN PROFILE  
REACH 8 (2 OF 2); REACH 7 (1 OF 2)

DATE	MARCH 2014
FIGURE NO.	

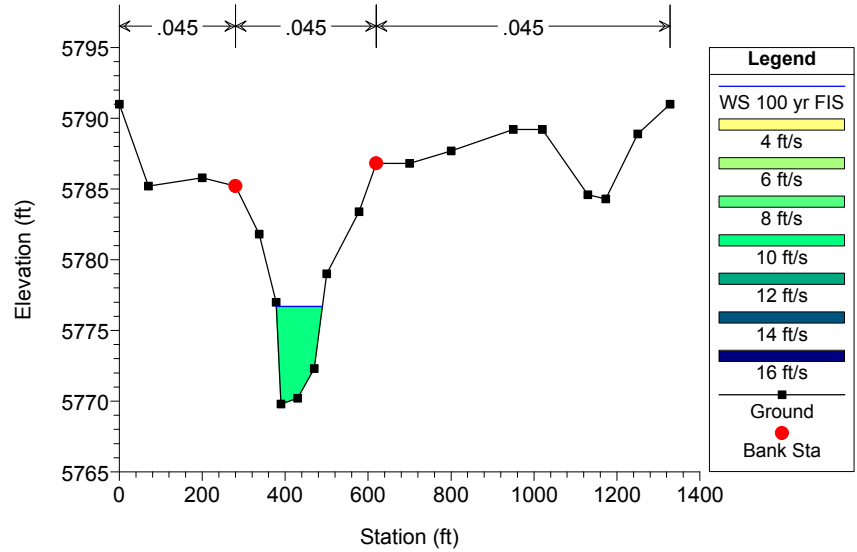


## **APPENDIX C. DUPLICATE EFFECTIVE MODEL (HEC-RAS MODEL)**

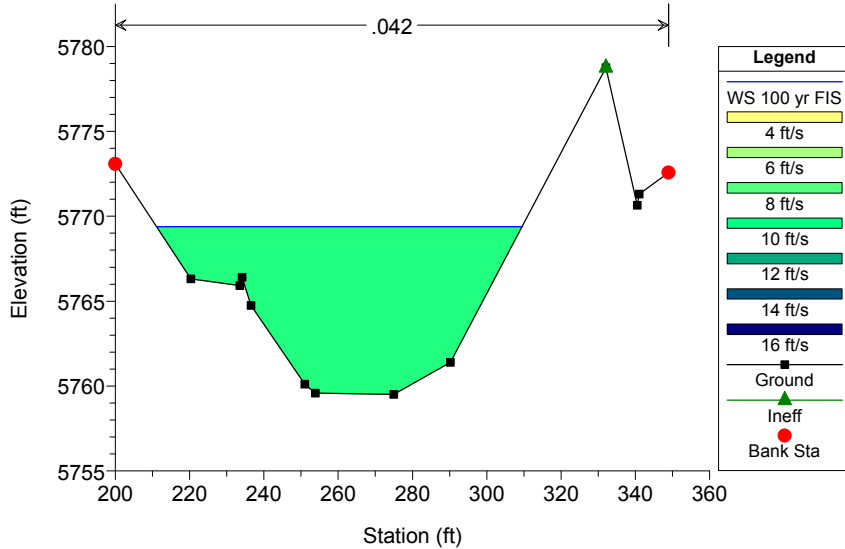
Happy Canyon Clean Plan: Duplicate Effective 7/20/2017  
RS = 12694



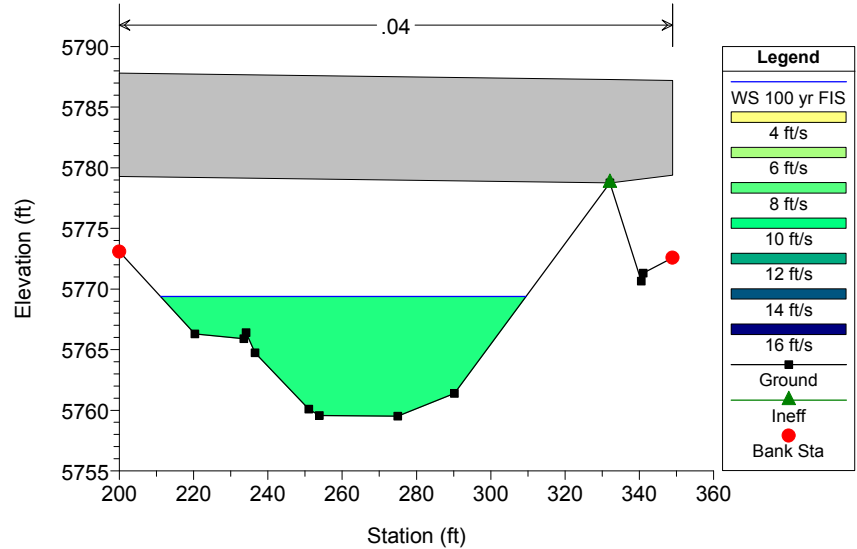
Happy Canyon Clean Plan: Duplicate Effective 7/20/2017  
RS = 11100 FHAD SECT 48 (RS=11390) NEW RS=11100



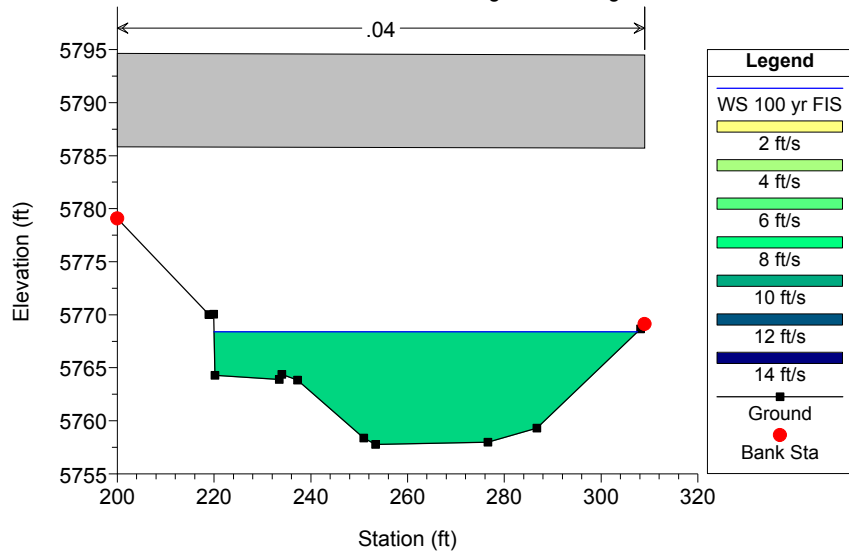
Happy Canyon Clean Plan: Duplicate Effective 7/20/2017  
RS = 10151 Upstream of Bridge RS = 10151



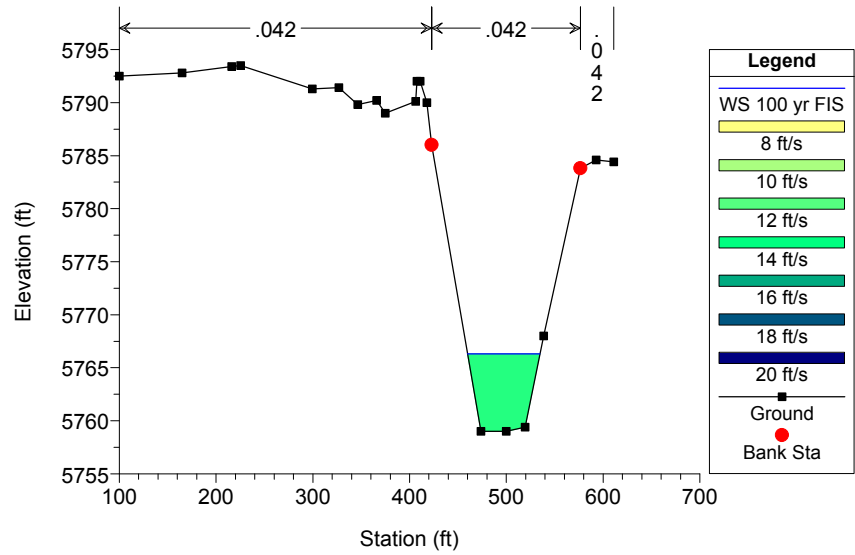
Happy Canyon Clean Plan: Duplicate Effective 7/20/2017  
RS = 10042 BR Existing E-470 Bridge



Happy Canyon Clean Plan: Duplicate Effective 7/20/2017  
 RS = 10042 BR Existing E-470 Bridge



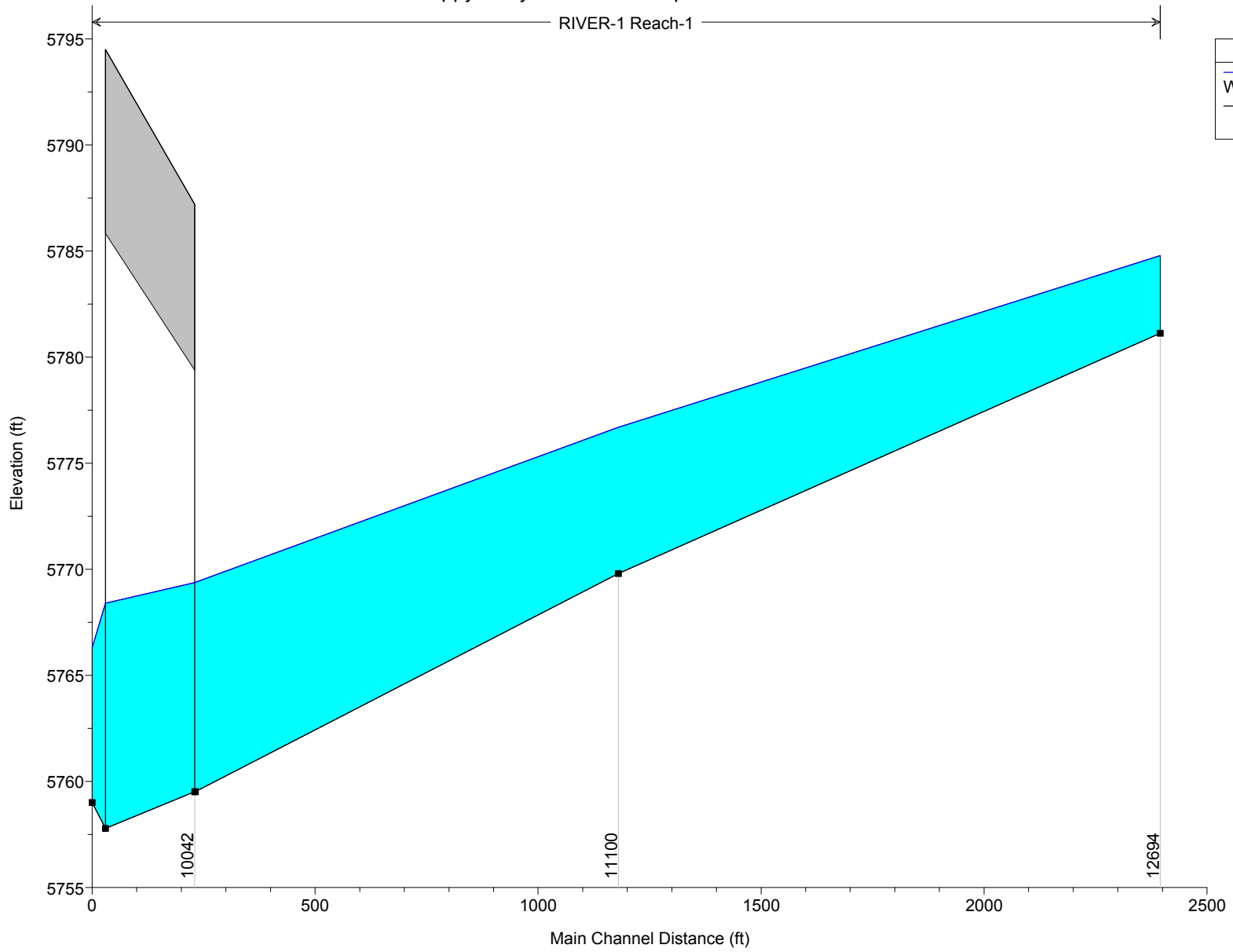
Happy Canyon Clean Plan: Duplicate Effective 7/20/2017  
 RS = 9920 RS = 9920



Happy Canyon Plan: Duplicate Effective 7/24/2017

RIVER-1 Reach-1

Legend	
WS 100 yr FIS	
Ground	

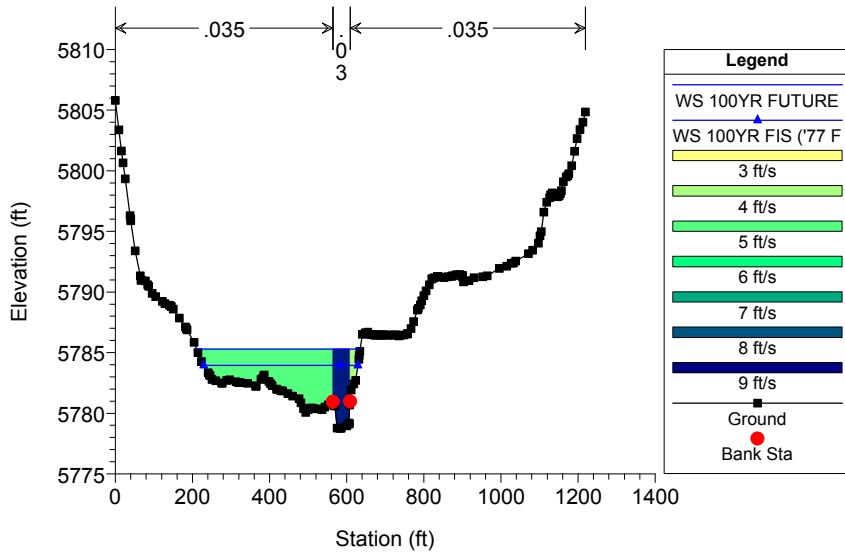


HEC-RAS Plan: Dup Eff River: RIVER-1 Reach: Reach-1 Profile: 100 yr FIS

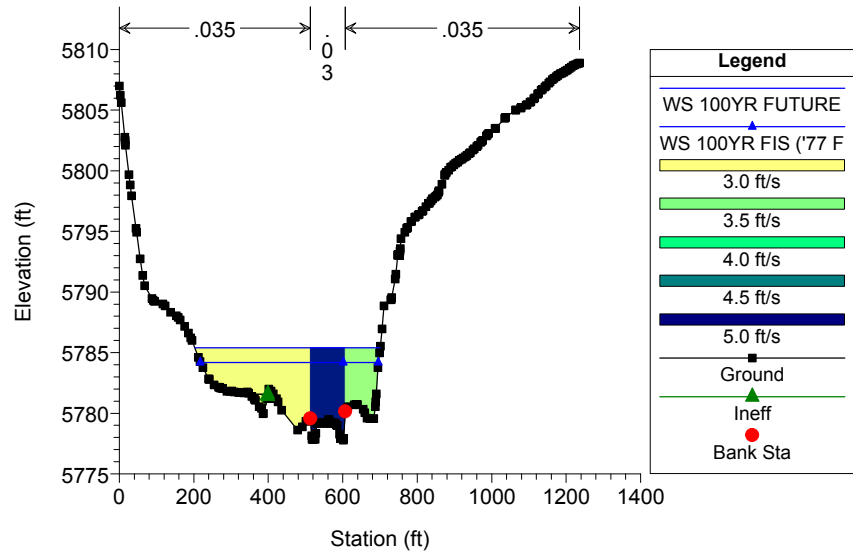
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach-1	12694	100 yr FIS	5560.00	5781.12	5784.78		5785.22	0.003633	5.36	1062.08	420.09	0.57
Reach-1	11100	100 yr FIS	5560.00	5769.80	5776.70		5778.18	0.010246	9.78	568.61	111.18	0.76
Reach-1	10151	100 yr FIS	5700.00	5759.51	5769.38	5767.58	5770.71	0.006167	9.23	617.86	98.41	0.65
Reach-1	10042	Bridge										
Reach-1	9920	100 yr FIS	5700.00	5759.00	5766.30	5766.12	5768.99	0.014116	13.16	433.02	74.84	0.96

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

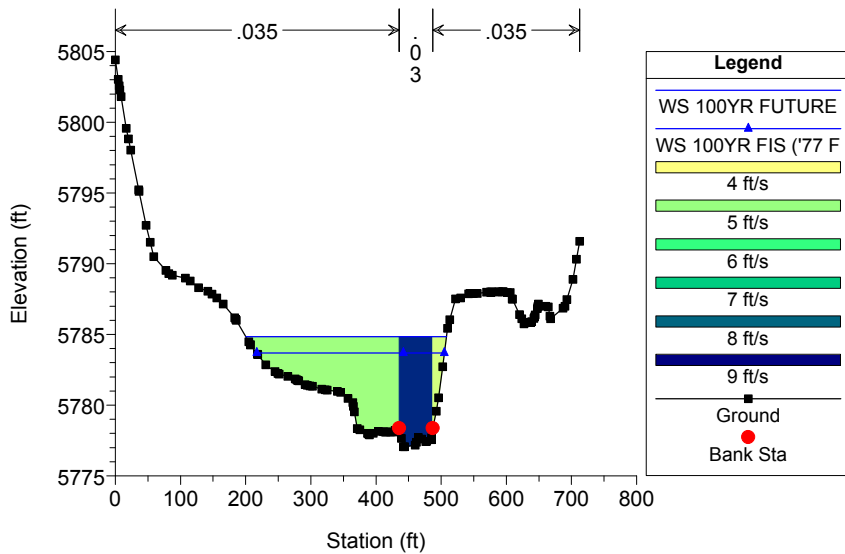
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 12694



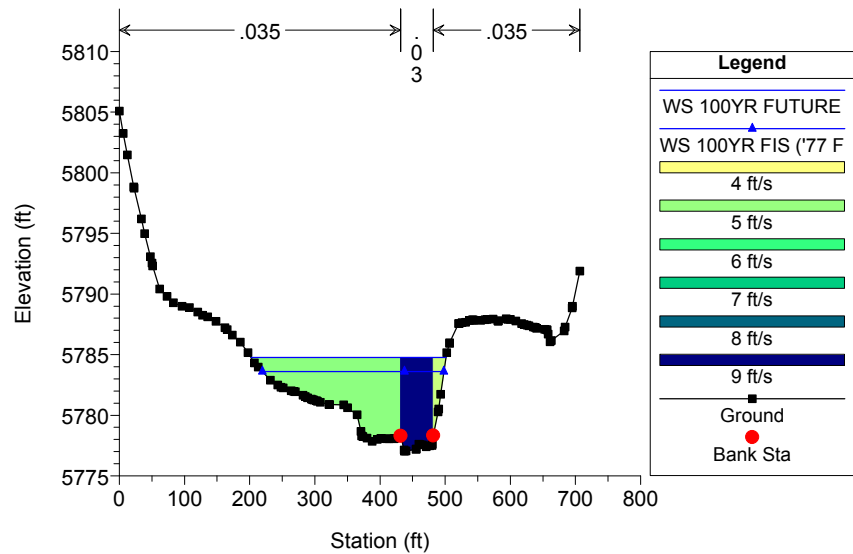
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 12541



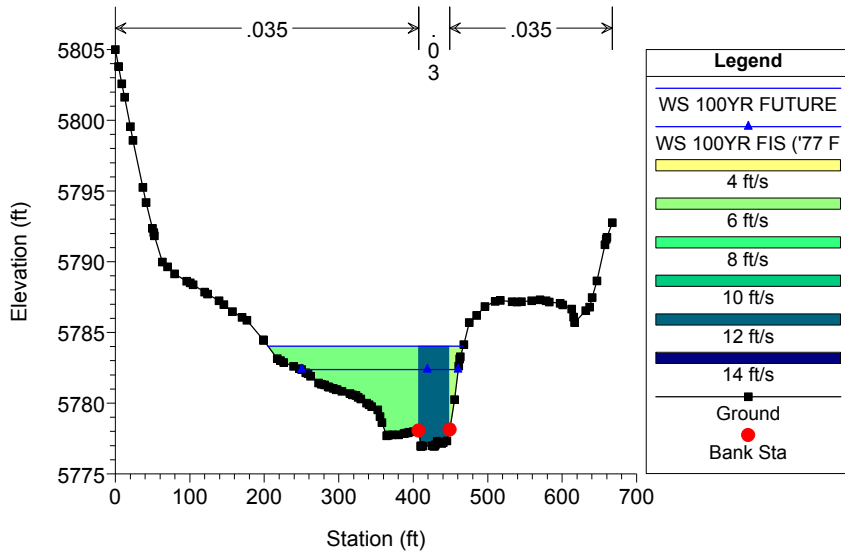
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 12436



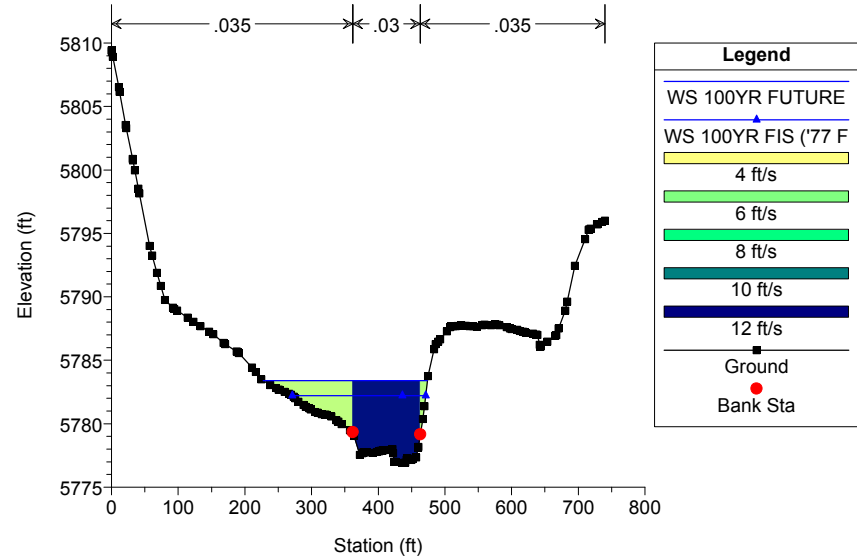
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 12430



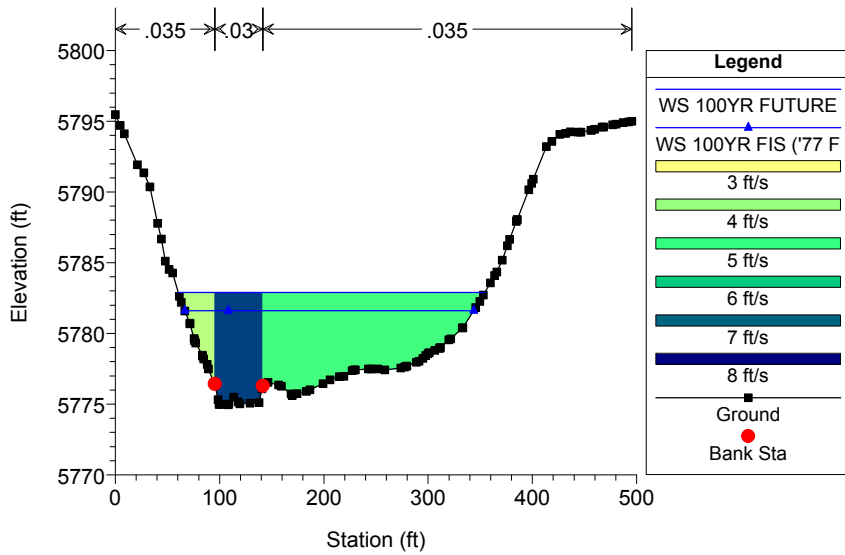
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 12400



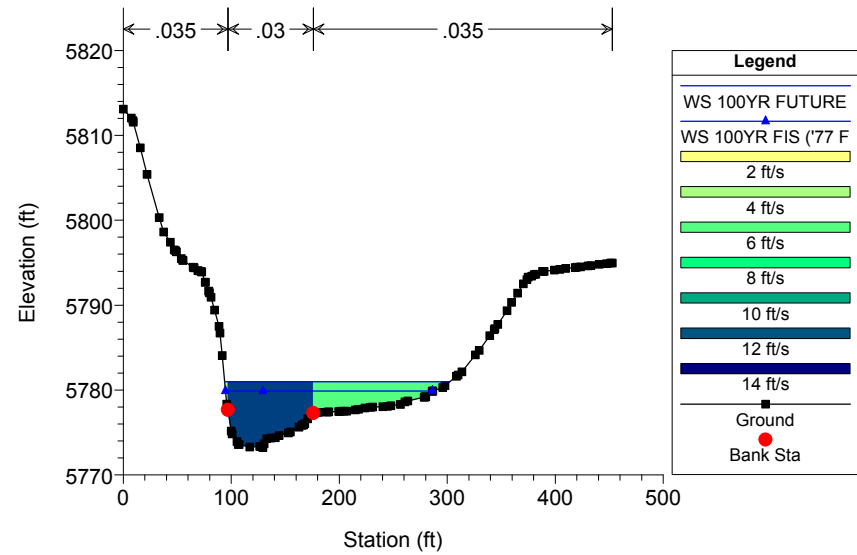
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 12388



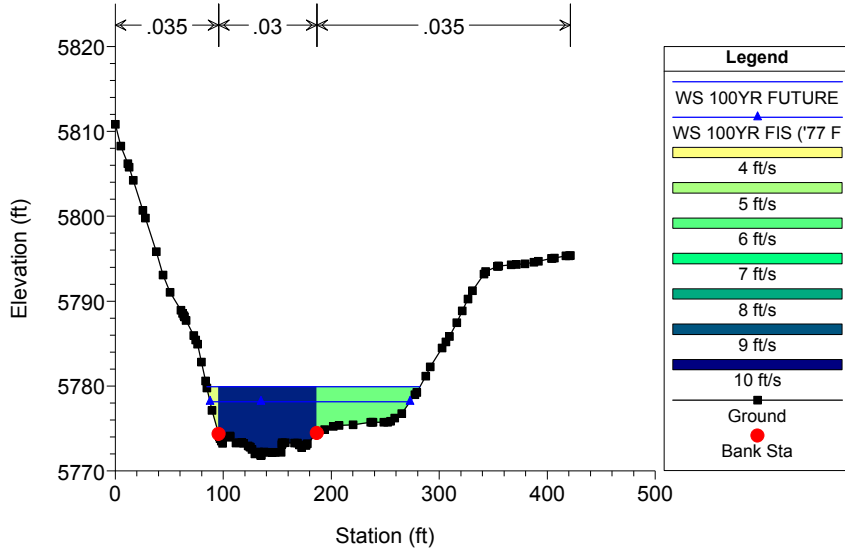
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 12129



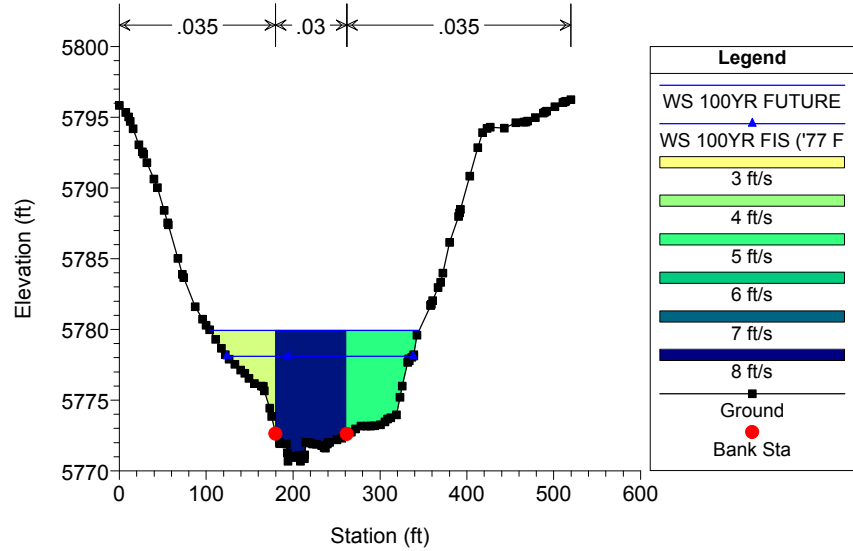
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11959



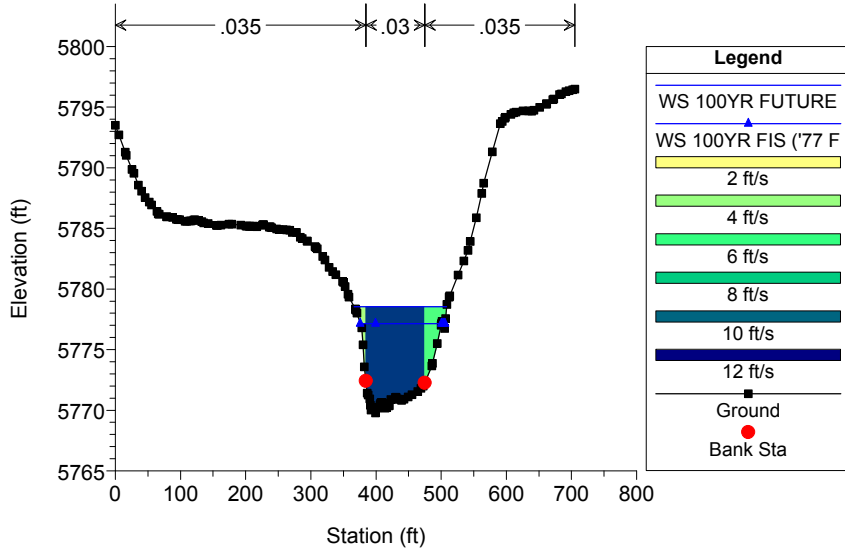
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11772



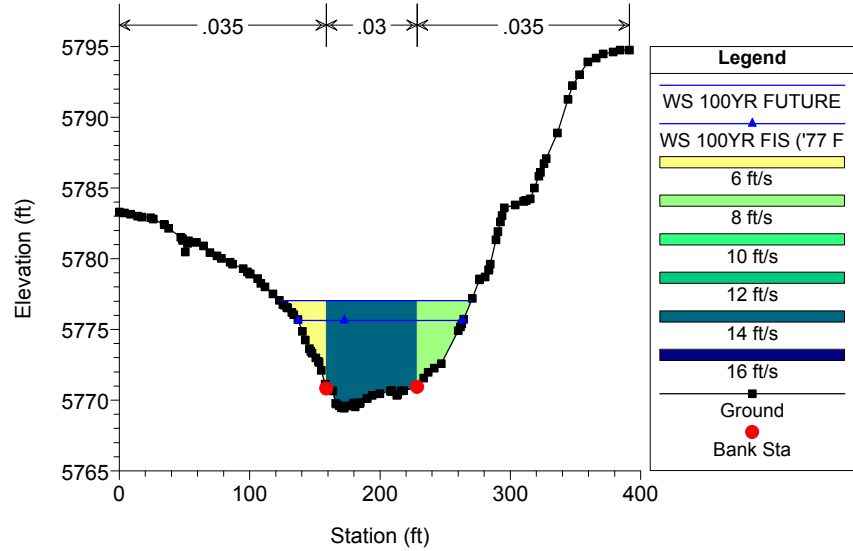
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11620



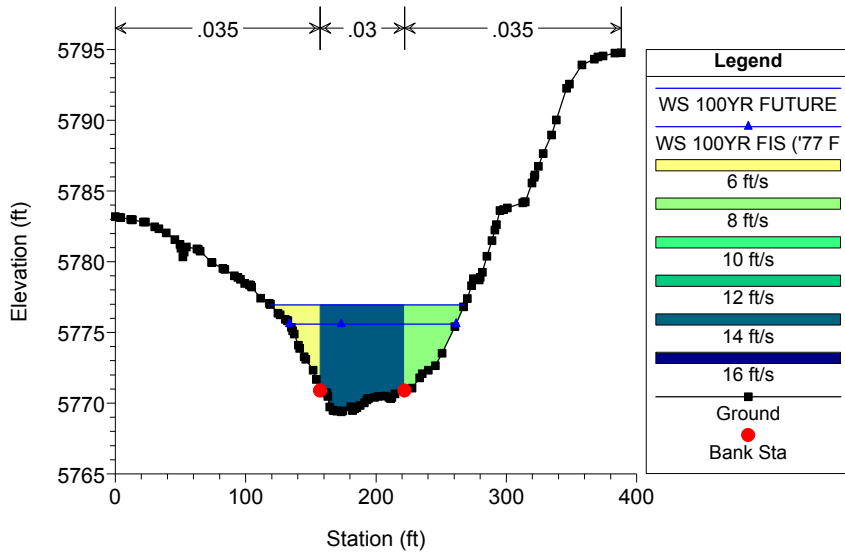
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11494



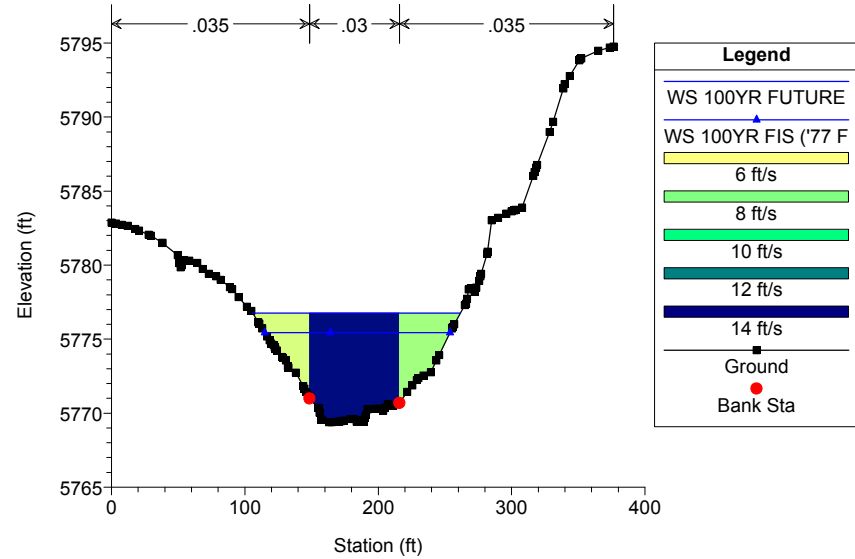
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11410



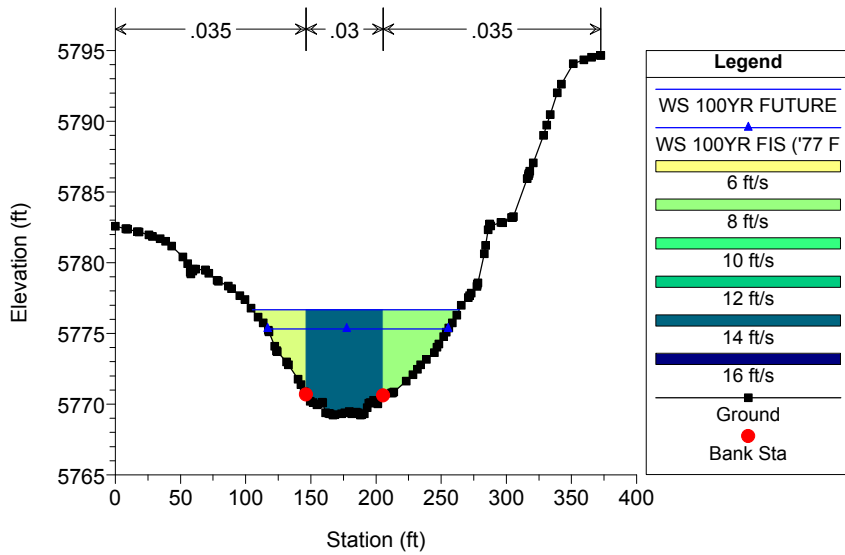
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11400



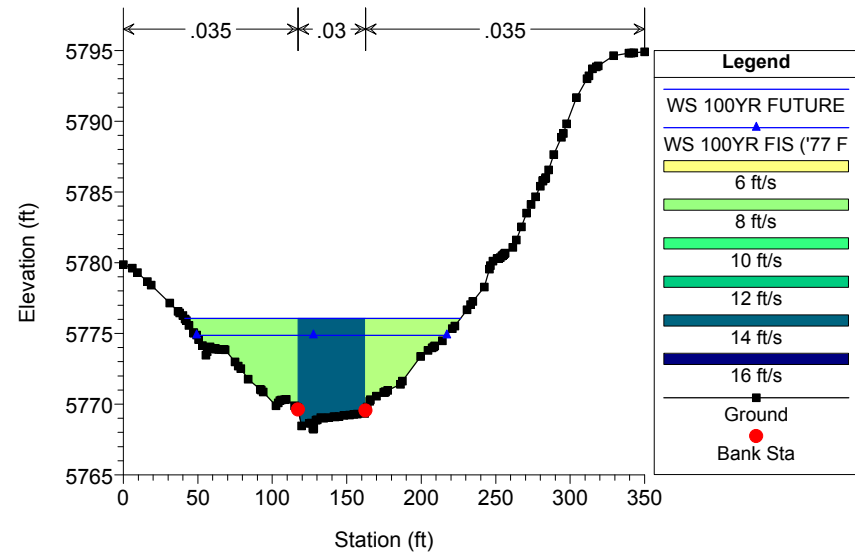
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11385



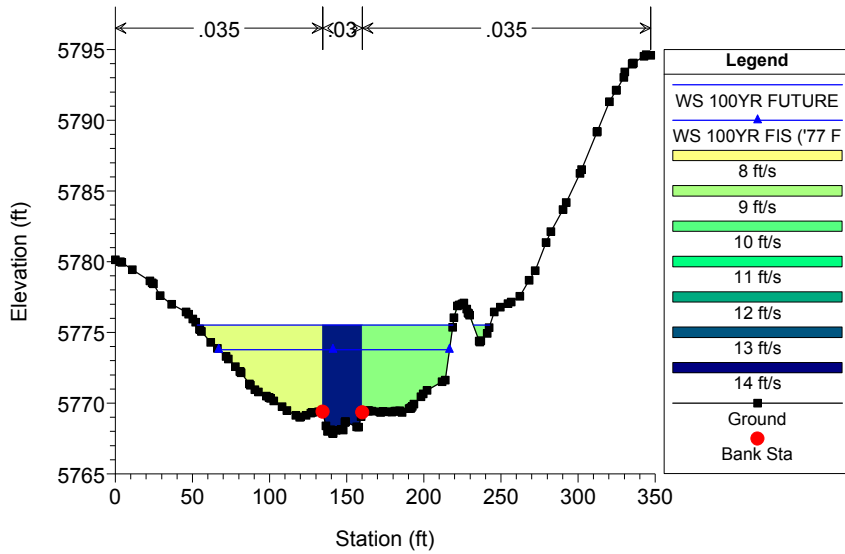
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11370



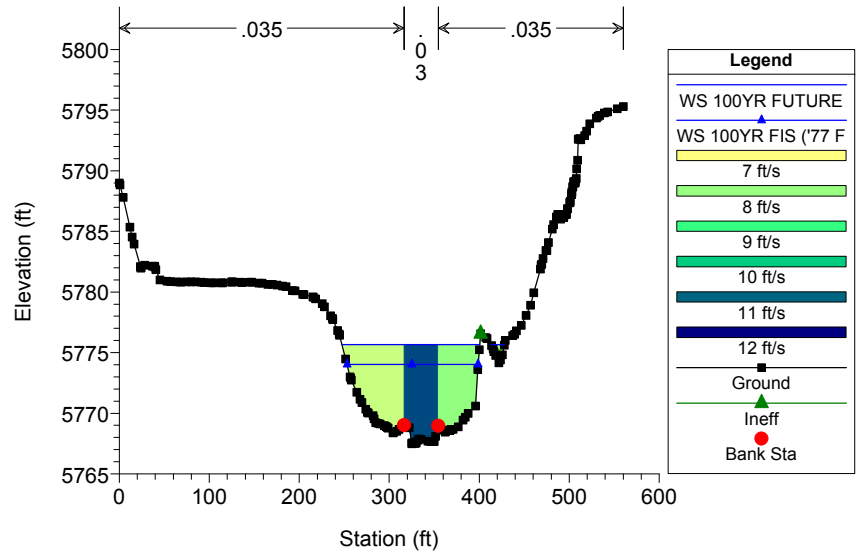
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11280



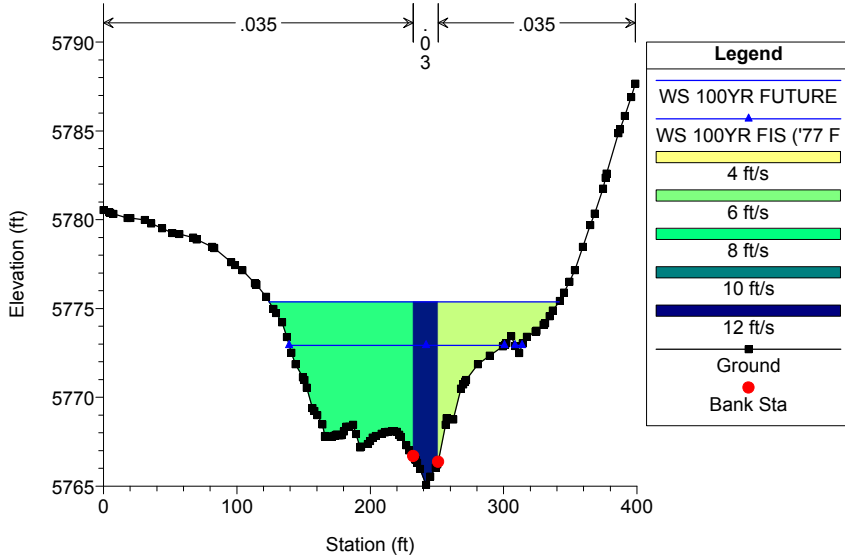
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11180



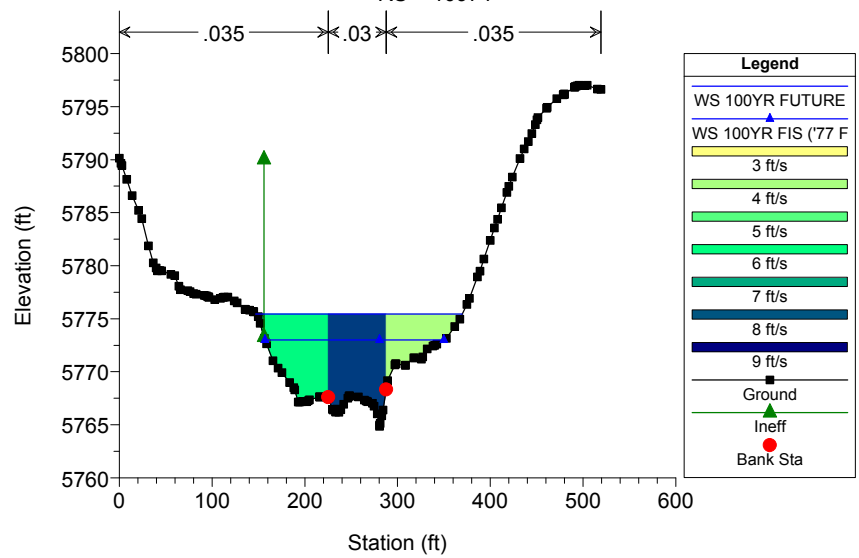
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11153



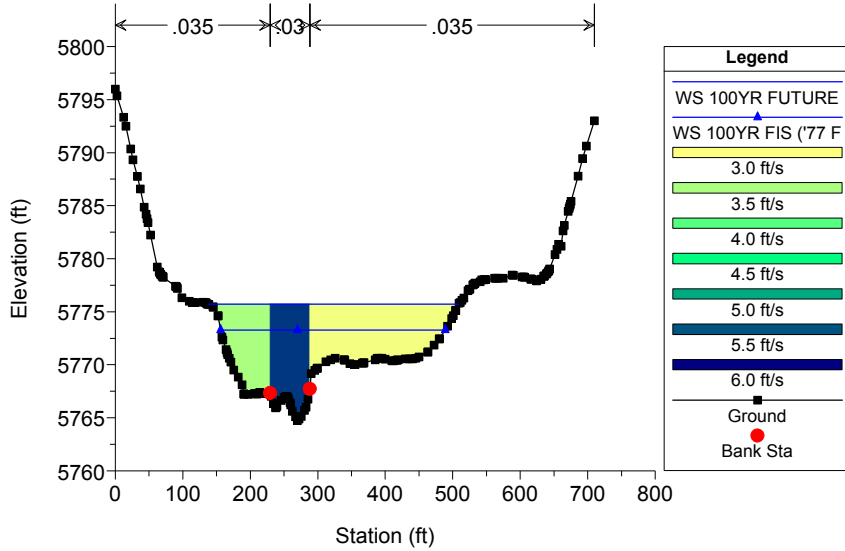
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 11100



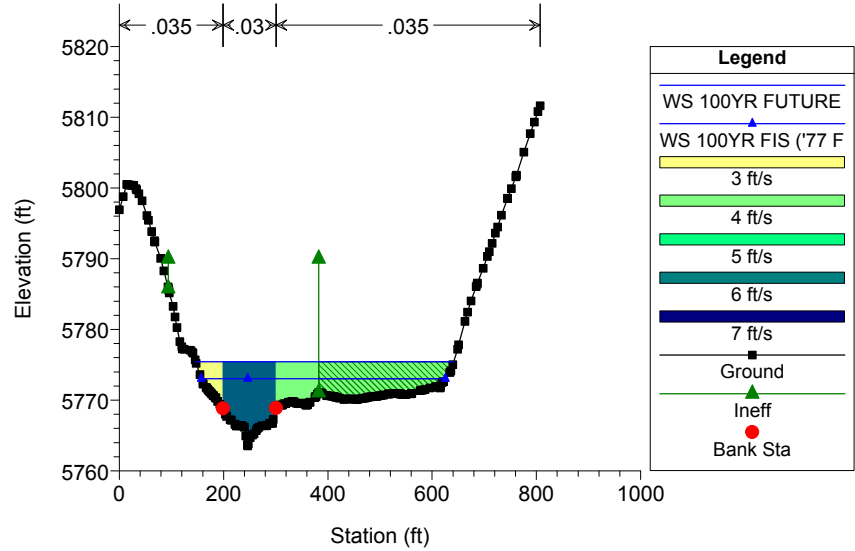
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 10974



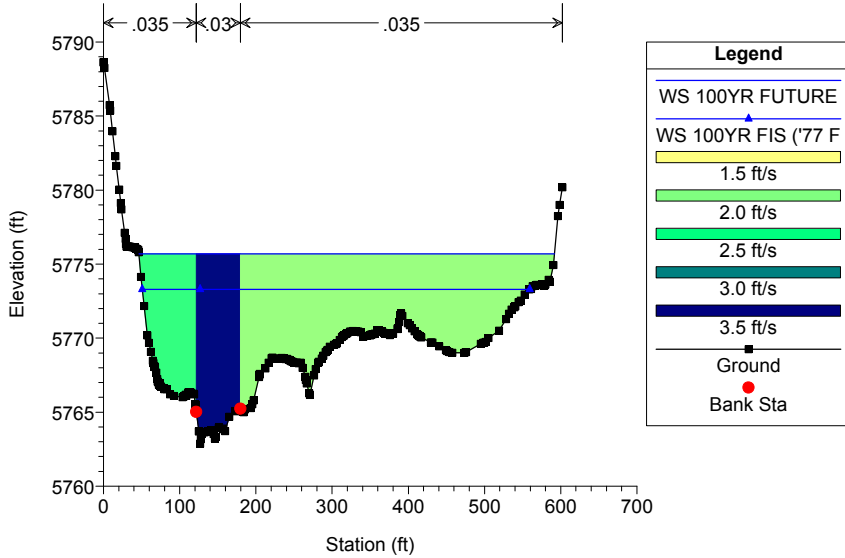
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 10900



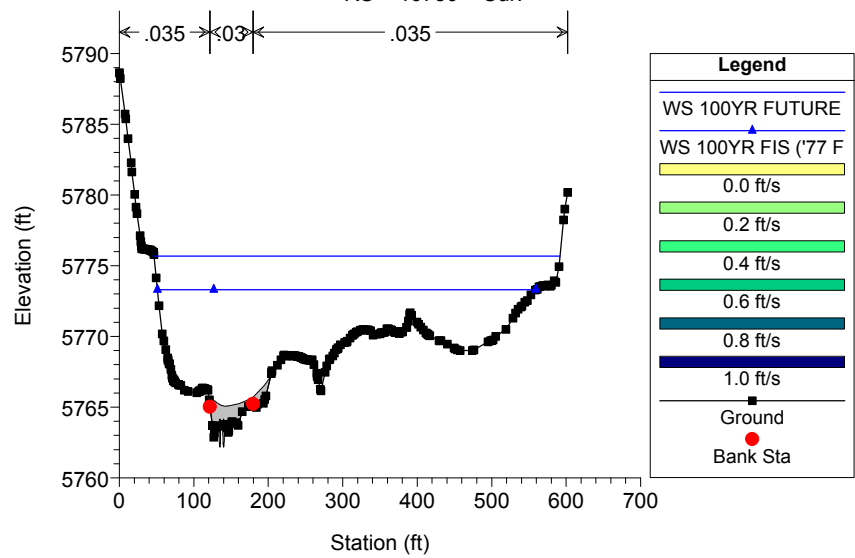
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 10842

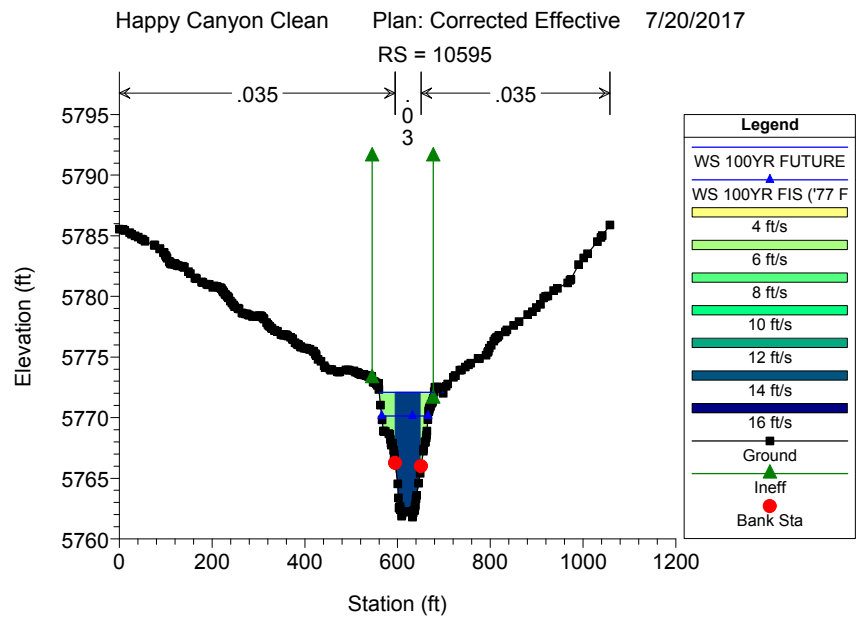
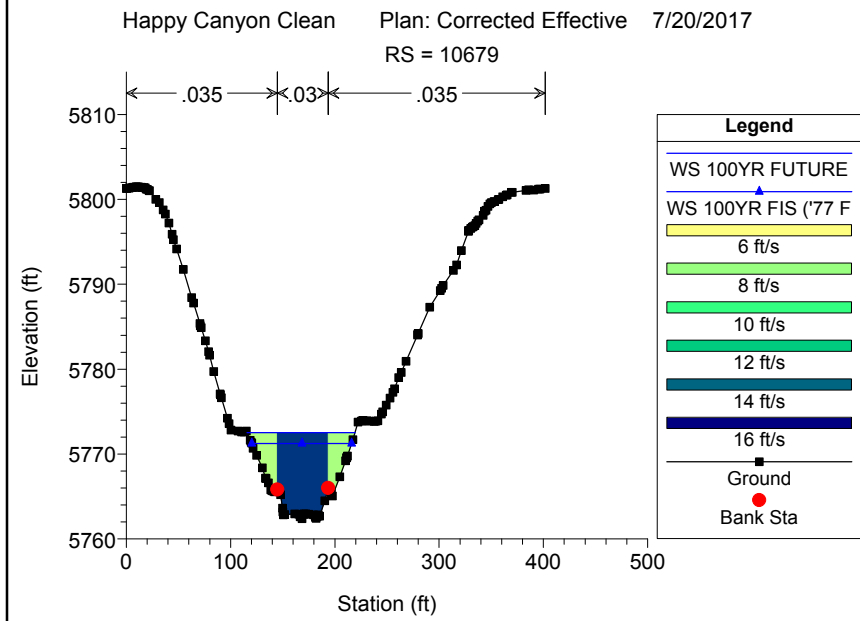
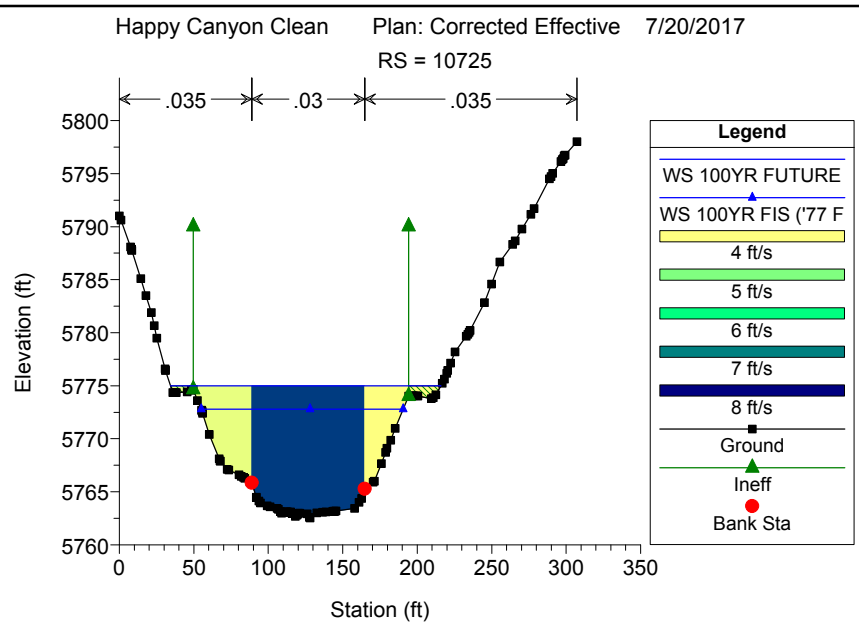
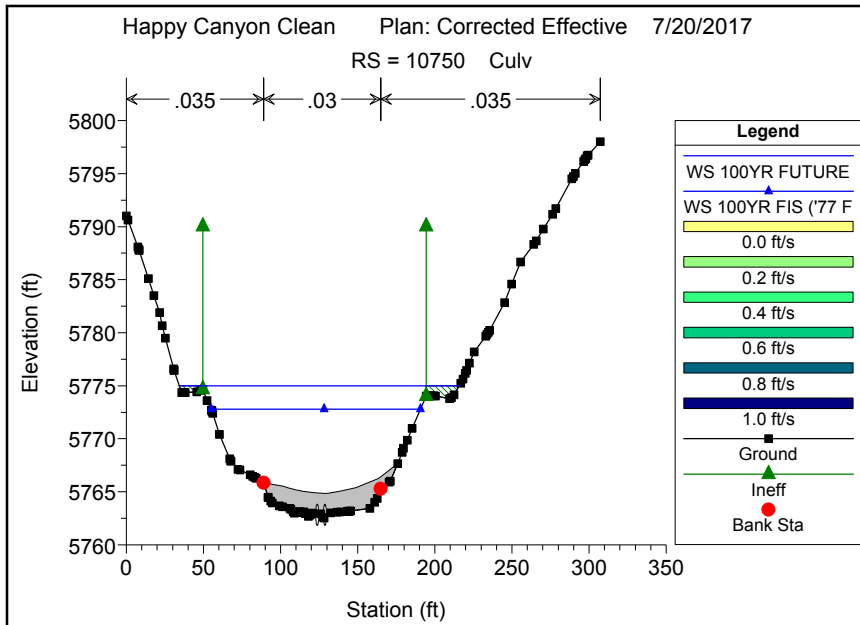


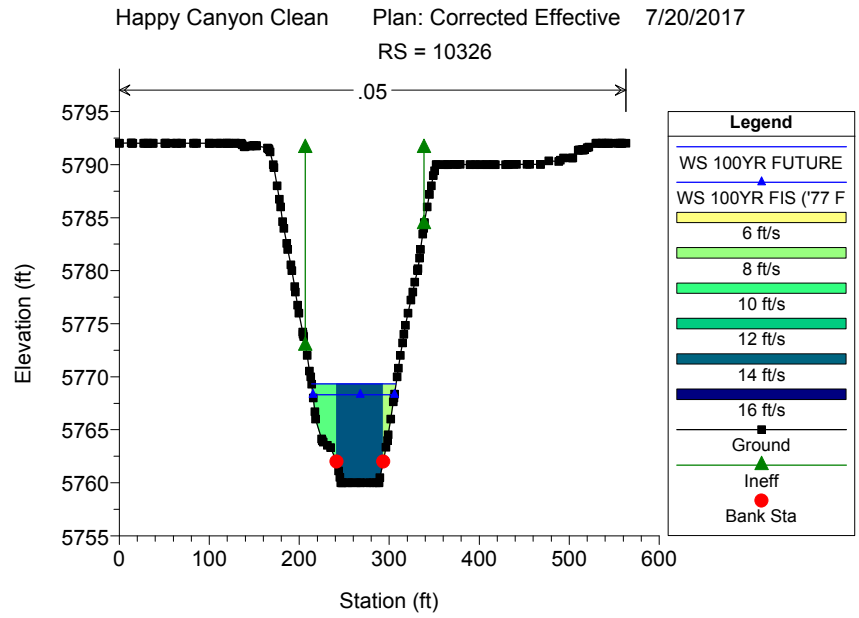
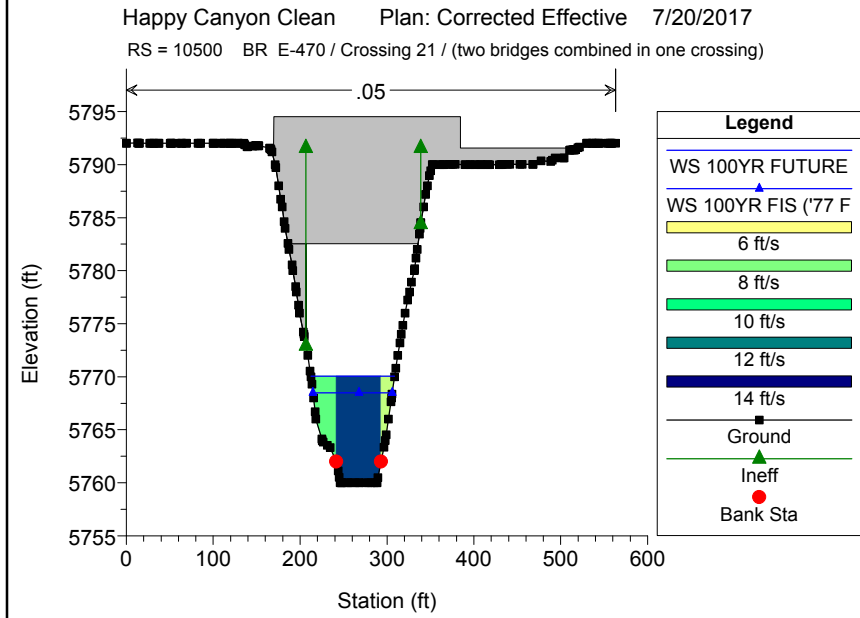
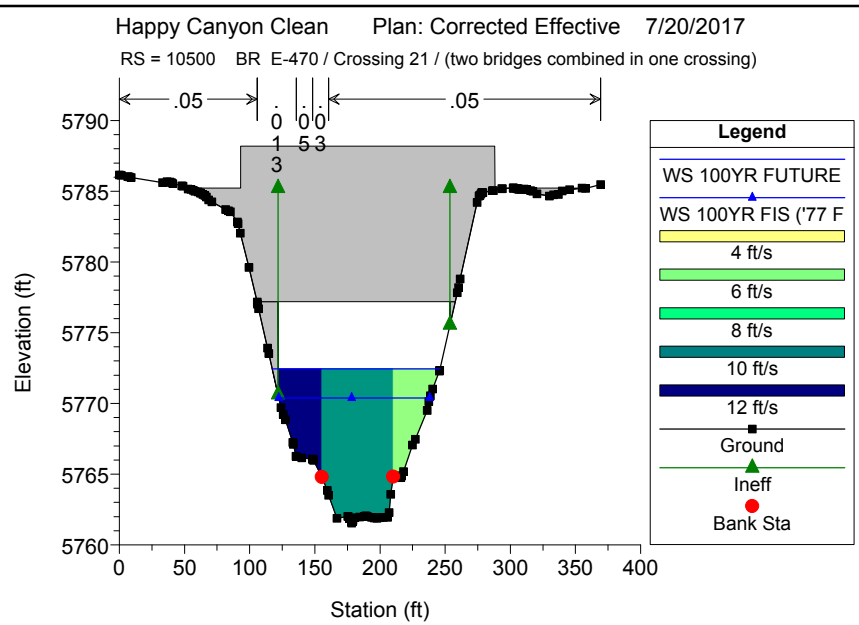
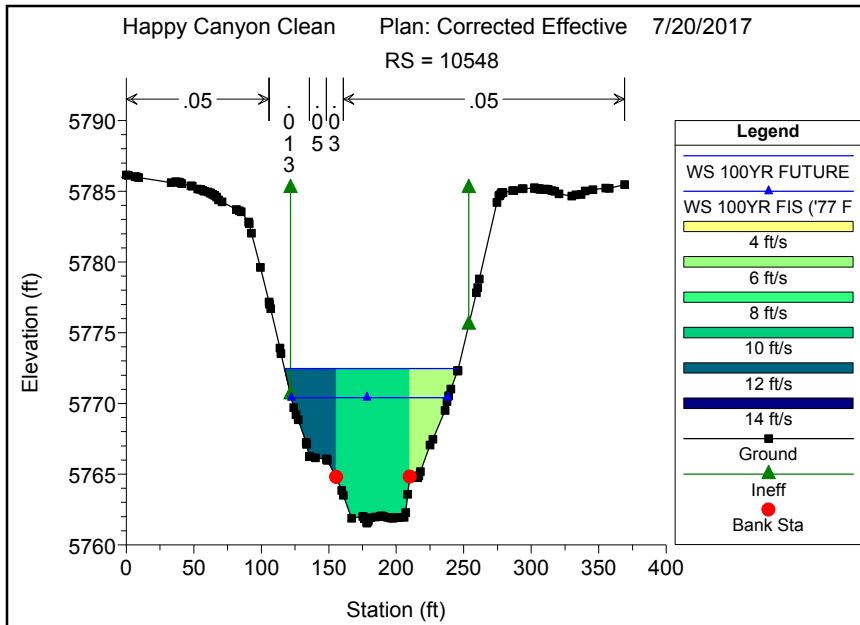
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 10775



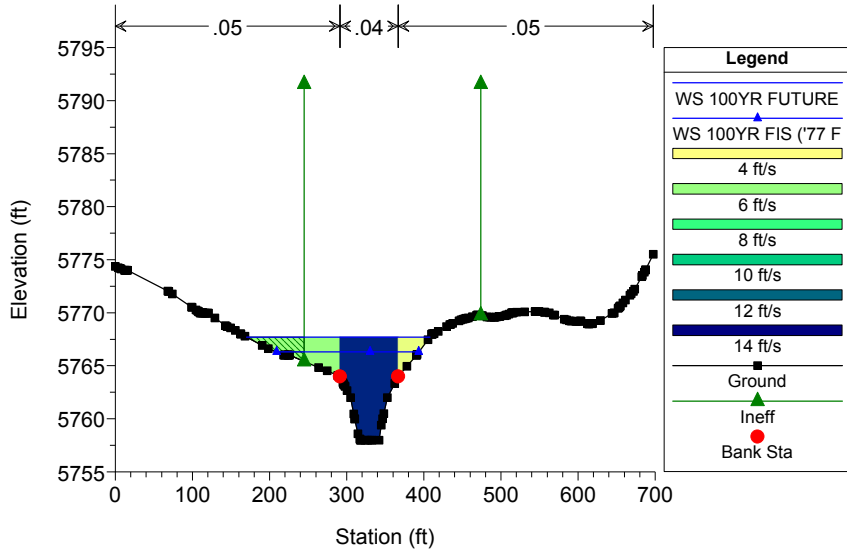
Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 10750 Culv



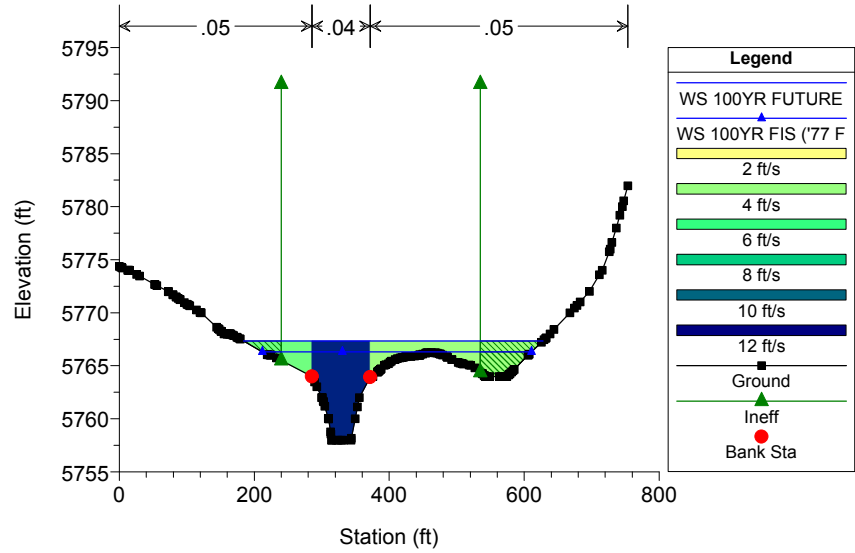




Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 10157

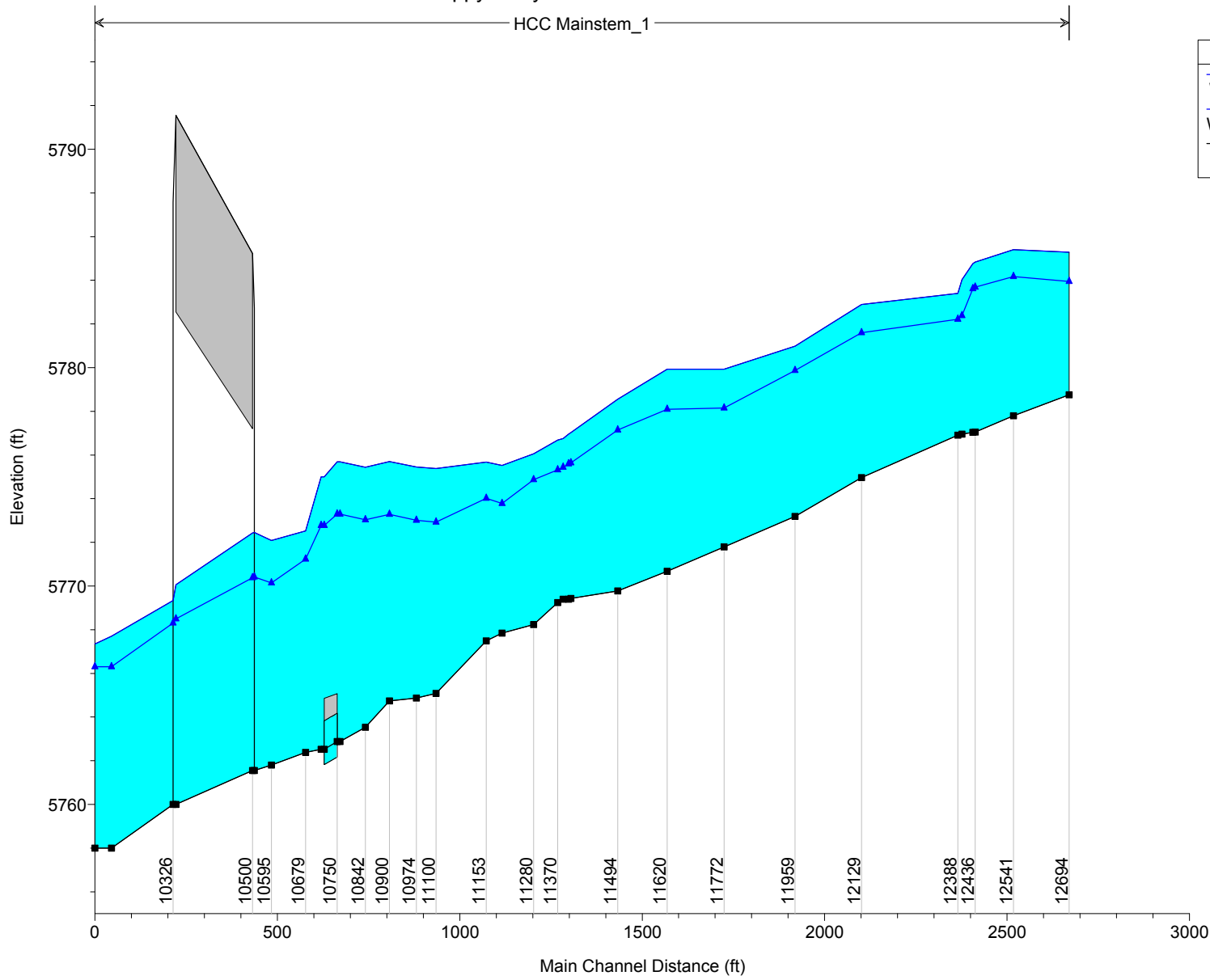


Happy Canyon Clean Plan: Corrected Effective 7/20/2017  
RS = 10111



Happy Canyon Plan: Corrected Effective 7/24/2017

HCC Mainstem\_1



Legend	
WS 100YR FUTURE	▲
WS 100YR FIS ('77 F	—
Ground	■

HEC-RAS Plan: Corr Eff River: HCC Reach: Mainstem\_1

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Mainstem_1	12694	100YR FUTURE	8303.00	5778.76	5785.29		5785.89	0.002885	8.68	1475.77	424.04	0.62
Mainstem_1	12694	100YR FIS ('77 F	5610.00	5778.76	5783.95		5784.76	0.005320	9.96	922.57	399.73	0.81
Mainstem_1	12541	100YR FUTURE	8303.00	5777.80	5785.41		5785.64	0.000810	4.90	2302.56	498.02	0.34
Mainstem_1	12541	100YR FIS ('77 F	5610.00	5777.80	5784.17		5784.38	0.000926	4.56	1701.23	477.86	0.35
Mainstem_1	12436	100YR FUTURE	8303.00	5777.05	5784.84		5785.52	0.002107	8.62	1406.68	307.90	0.56
Mainstem_1	12436	100YR FIS ('77 F	5610.00	5777.05	5783.68		5784.25	0.002161	7.79	1060.37	288.04	0.55
Mainstem_1	12430	100YR FUTURE	8303.00	5777.04	5784.76		5785.50	0.002308	8.98	1351.73	299.18	0.58
Mainstem_1	12430	100YR FIS ('77 F	5610.00	5777.04	5783.61		5784.23	0.002356	8.10	1019.20	278.85	0.57
Mainstem_1	12400	100YR FUTURE	8303.00	5776.95	5784.03	5783.60	5785.35	0.004592	12.05	1034.77	262.35	0.81
Mainstem_1	12400	100YR FIS ('77 F	5610.00	5776.95	5782.38	5782.38	5784.02	0.007589	12.89	634.38	210.23	1.00
Mainstem_1	12388	100YR FUTURE	8303.00	5776.91	5783.40	5783.40	5785.24	0.005516	11.75	874.49	246.29	0.86
Mainstem_1	12388	100YR FIS ('77 F	5610.00	5776.91	5782.21	5782.21	5783.85	0.006318	10.78	607.58	200.04	0.89
Mainstem_1	12129	100YR FUTURE	8303.00	5774.96	5782.90		5783.40	0.001482	7.38	1559.86	294.03	0.47
Mainstem_1	12129	100YR FIS ('77 F	5610.00	5774.96	5781.60		5782.01	0.001517	6.60	1189.16	277.17	0.46
Mainstem_1	11959	100YR FUTURE	8303.00	5773.19	5780.98	5780.98	5782.95	0.005534	12.49	841.19	208.59	0.87
Mainstem_1	11959	100YR FIS ('77 F	5610.00	5773.19	5779.87	5779.87	5781.55	0.005753	11.21	617.05	191.64	0.86
Mainstem_1	11772	100YR FUTURE	8303.00	5771.79	5779.92		5781.10	0.002911	9.61	1034.75	197.53	0.64
Mainstem_1	11772	100YR FIS ('77 F	5610.00	5771.79	5778.16		5779.37	0.004266	9.56	696.15	185.16	0.74
Mainstem_1	11620	100YR FUTURE	8303.00	5770.67	5779.93		5780.65	0.001528	7.80	1346.20	240.35	0.48
Mainstem_1	11620	100YR FIS ('77 F	5610.00	5770.67	5778.09		5778.78	0.001949	7.44	930.38	214.41	0.52
Mainstem_1	11494	100YR FUTURE	8303.00	5769.78	5778.55		5780.27	0.003259	10.91	843.99	141.91	0.70
Mainstem_1	11494	100YR FIS ('77 F	5610.00	5769.78	5777.15		5778.41	0.003078	9.26	653.87	128.05	0.65
Mainstem_1	11410	100YR FUTURE	8303.00	5769.43	5777.03	5777.03	5779.62	0.006282	14.01	708.81	146.91	0.95
Mainstem_1	11410	100YR FIS ('77 F	5610.00	5769.43	5775.64	5775.64	5777.76	0.006778	12.48	519.22	126.42	0.95
Mainstem_1	11400	100YR FUTURE	8303.00	5769.40	5776.95	5776.95	5779.57	0.006479	14.26	708.82	148.61	0.96
Mainstem_1	11400	100YR FIS ('77 F	5610.00	5769.40	5775.59	5775.59	5777.73	0.006887	12.67	520.86	127.82	0.96
Mainstem_1	11385	100YR FUTURE	8303.00	5769.39	5776.76	5776.76	5779.21	0.006085	13.82	735.72	155.85	0.93
Mainstem_1	11385	100YR FIS ('77 F	5610.00	5769.39	5775.44	5775.44	5777.47	0.006428	12.31	542.05	138.84	0.93



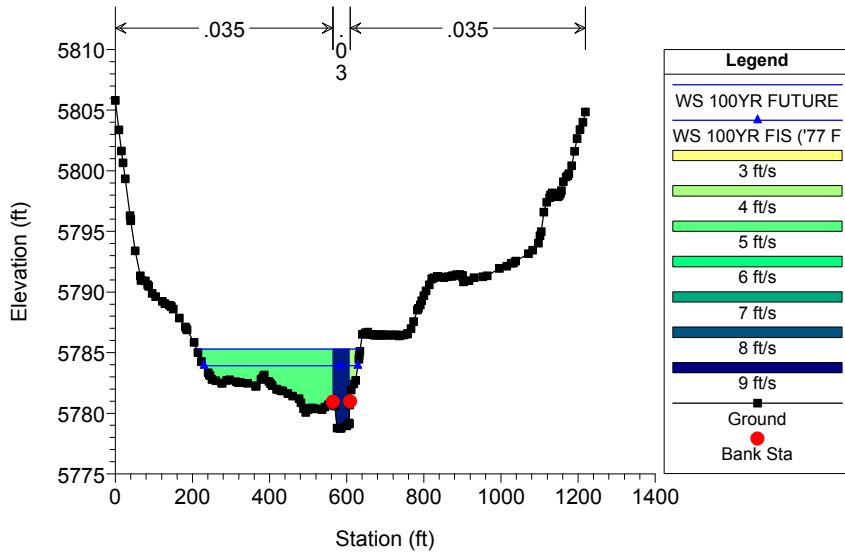
HEC-RAS Plan: Corr Eff River: HCC Reach: Mainstem\_1 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Mainstem_1	10326	100YR FUTURE	8475.00	5760.00	5769.34	5768.71	5772.13	0.012390	14.32	666.57	93.87	0.83
Mainstem_1	10326	100YR FIS ('77 F	5610.00	5760.00	5768.30		5769.97	0.008576	11.00	570.96	90.61	0.68
Mainstem_1	10157	100YR FUTURE	8475.00	5758.00	5767.71	5767.71	5770.13	0.009372	13.29	766.17	237.59	0.87
Mainstem_1	10157	100YR FIS ('77 F	5610.00	5758.00	5766.30	5766.30	5768.32	0.009811	11.78	547.17	184.44	0.86
Mainstem_1	10111	100YR FUTURE	8475.00	5758.00	5767.35	5767.34	5768.99	0.007289	11.32	1017.90	443.82	0.76
Mainstem_1	10111	100YR FIS ('77 F	5610.00	5758.00	5766.30	5766.16	5767.74	0.007205	10.08	708.06	398.68	0.74

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

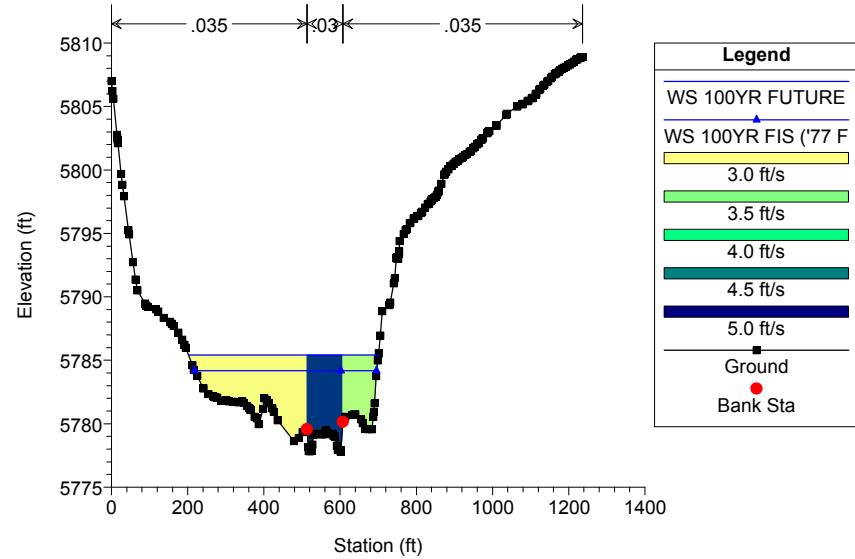
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 12694



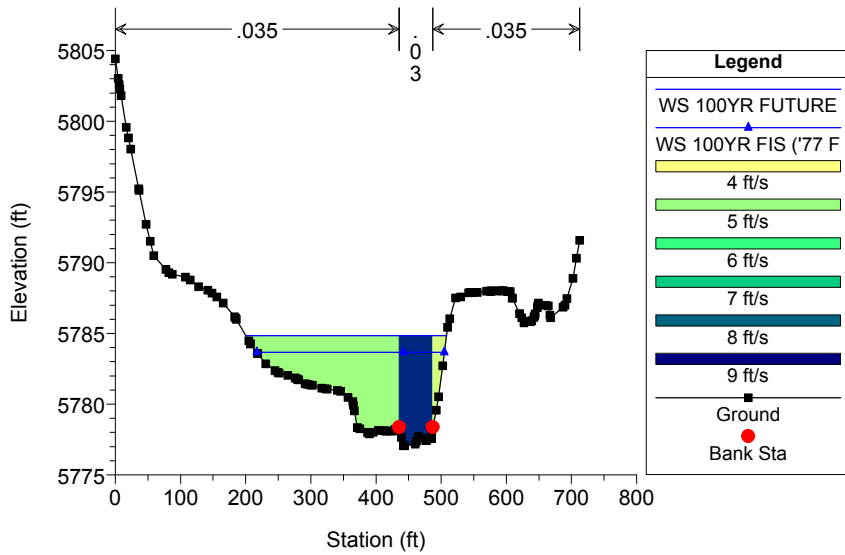
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 12541



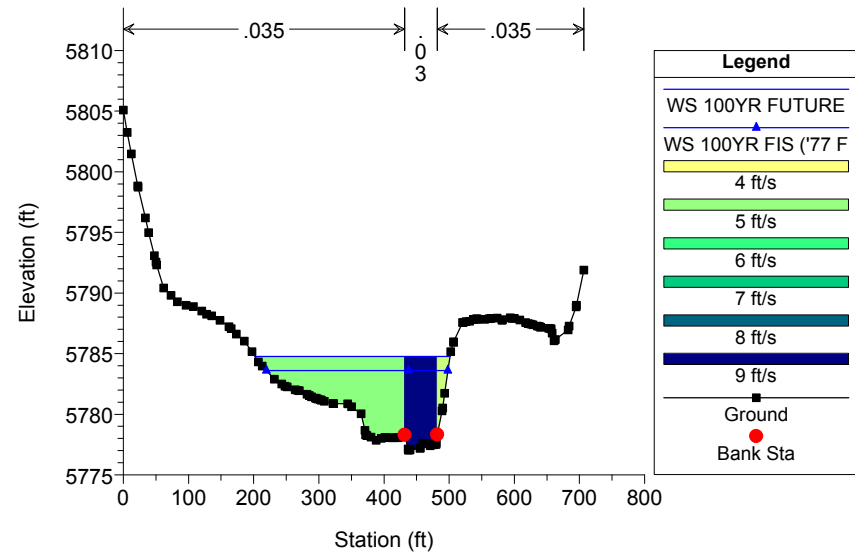
Happy Canyon Clean Plan: Post-Project 7/20/2017

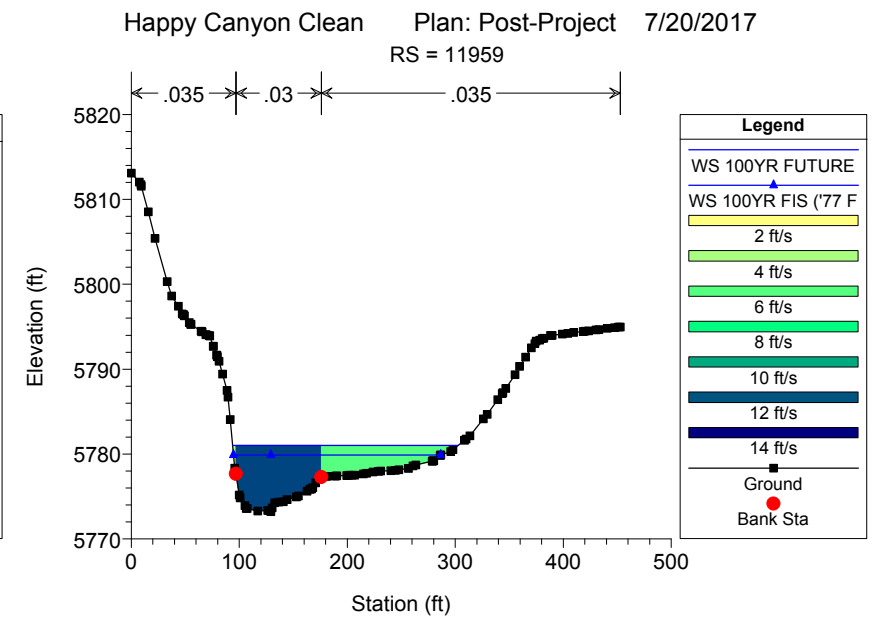
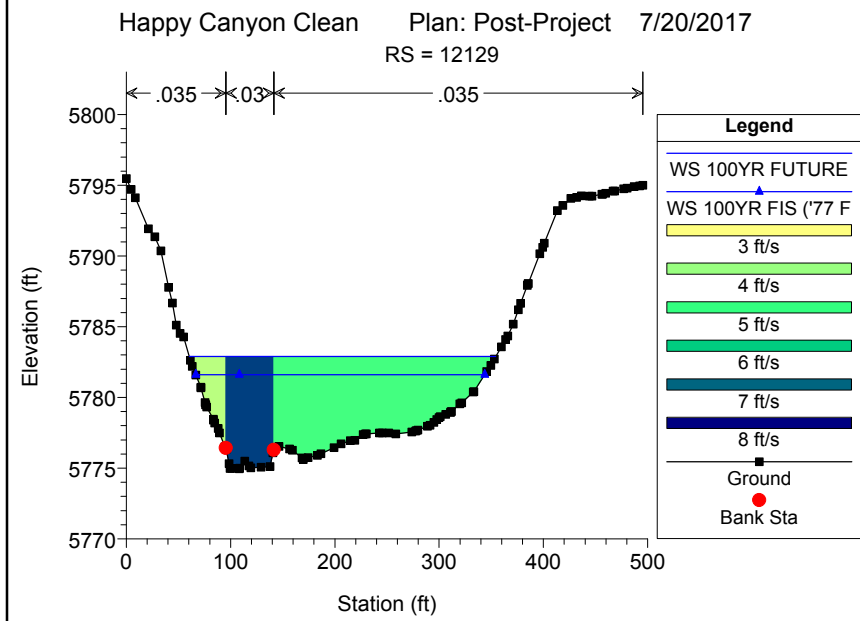
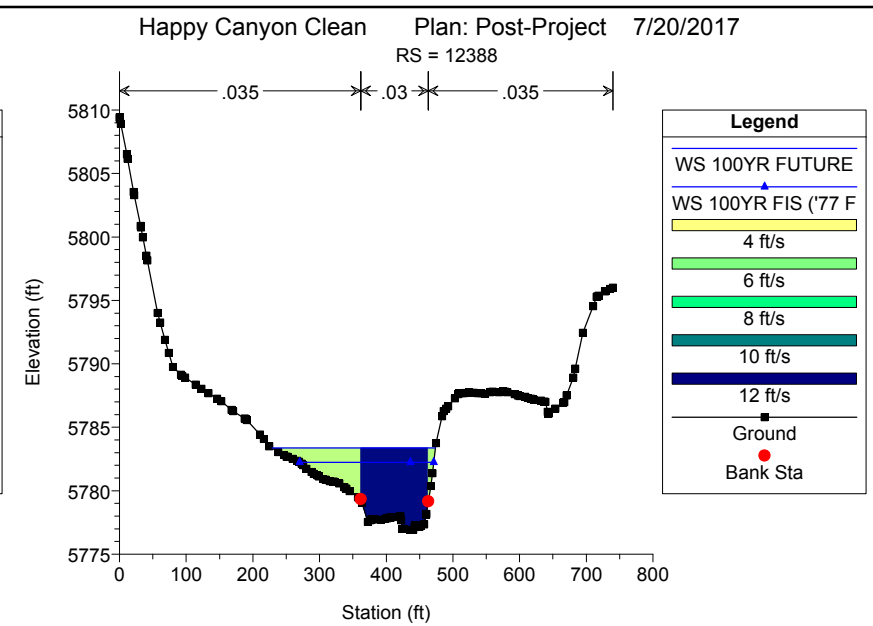
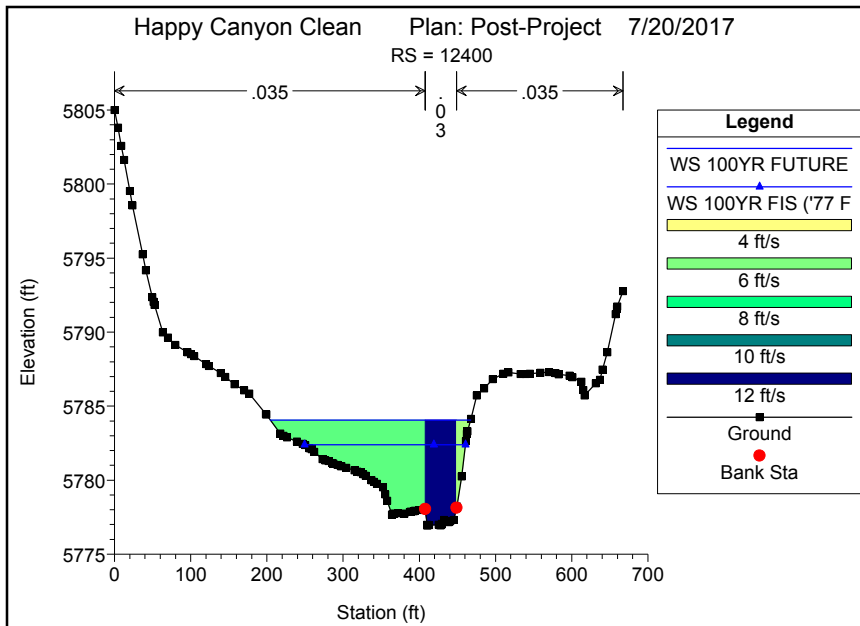
RS = 12436



Happy Canyon Clean Plan: Post-Project 7/20/2017

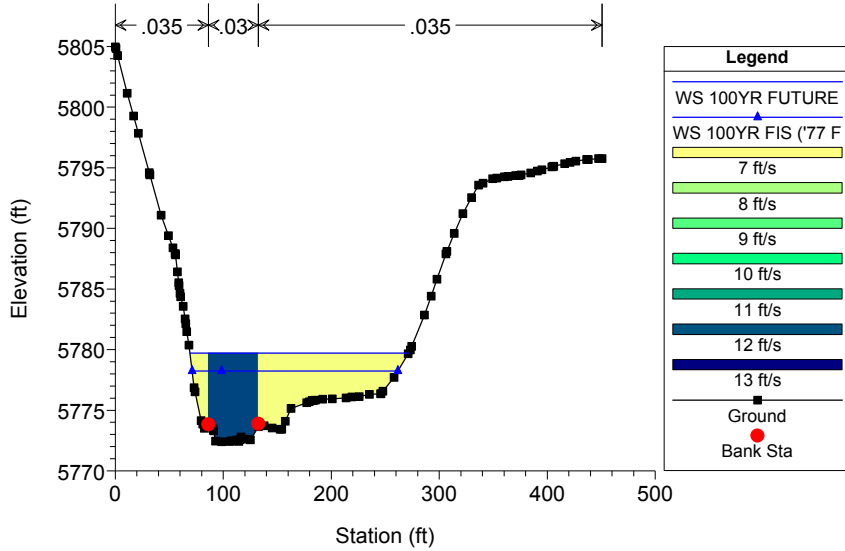
RS = 12430





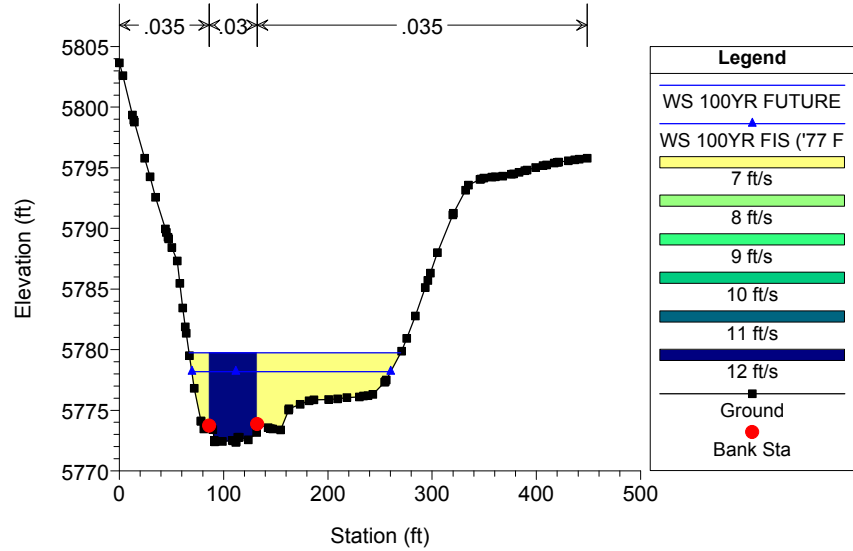
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11835



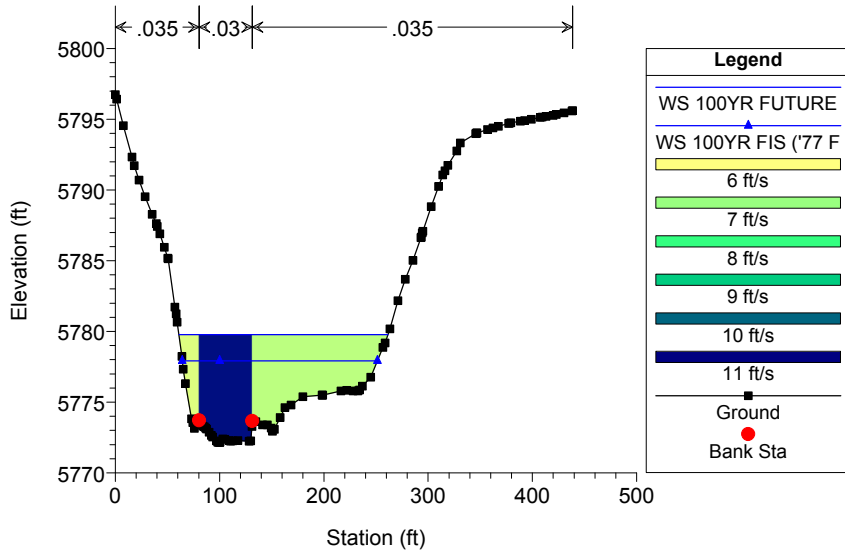
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11830



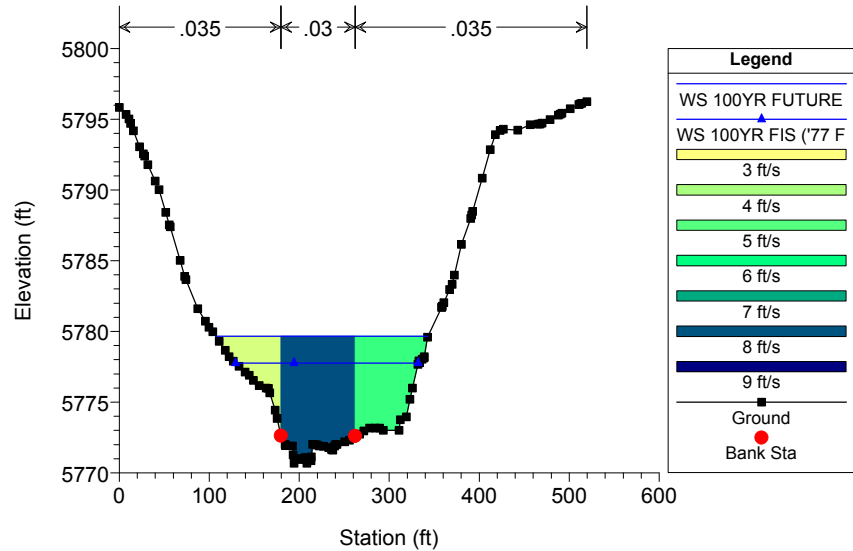
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11800



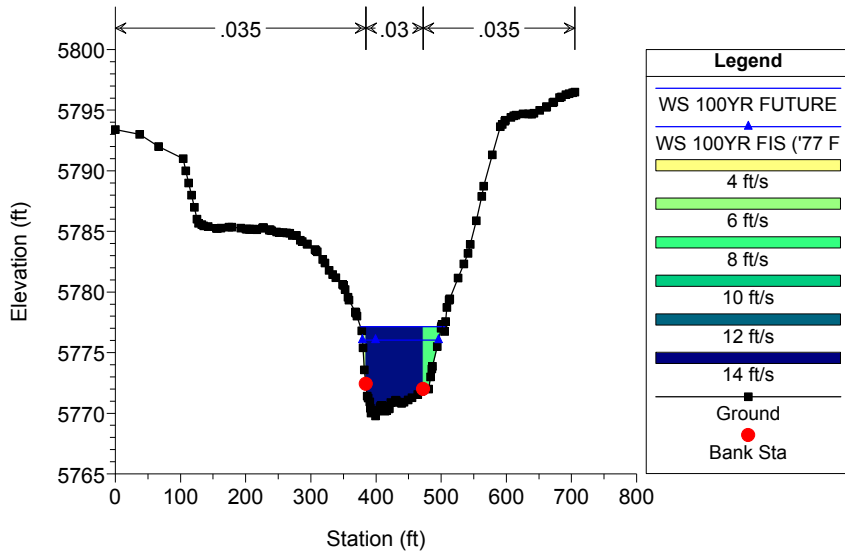
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11620



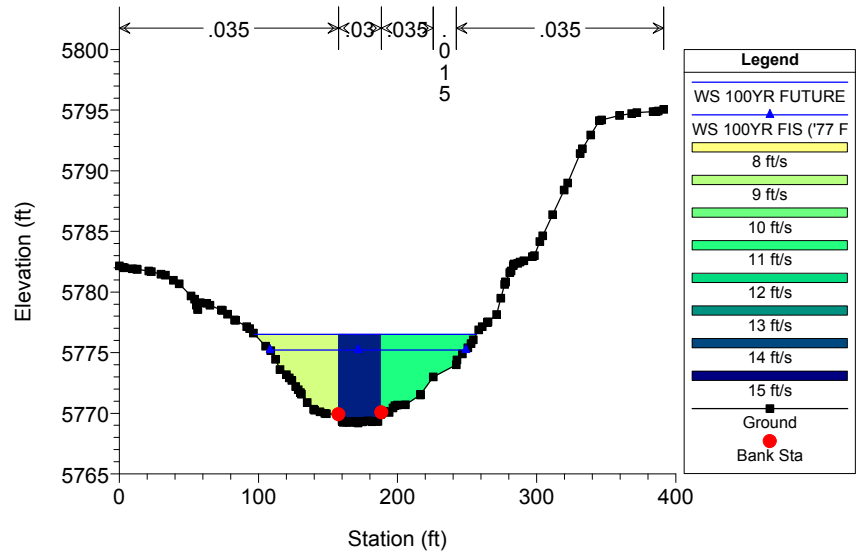
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11494



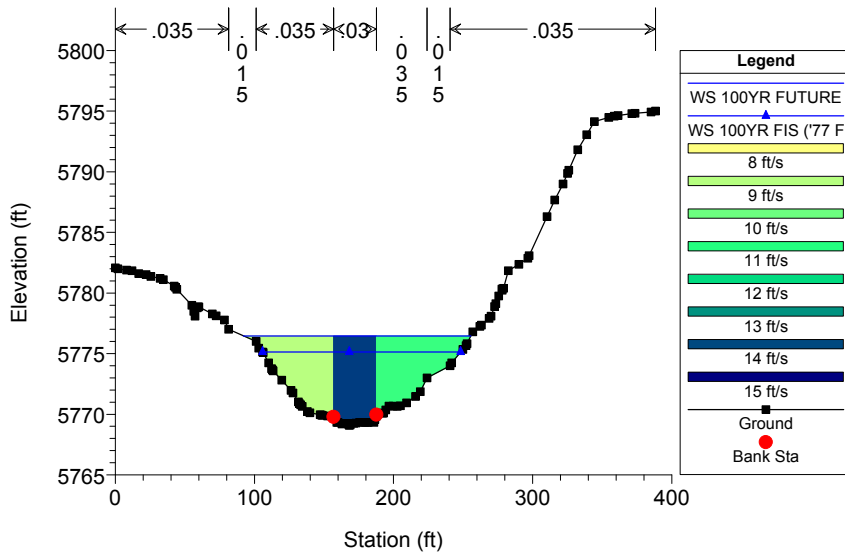
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11410



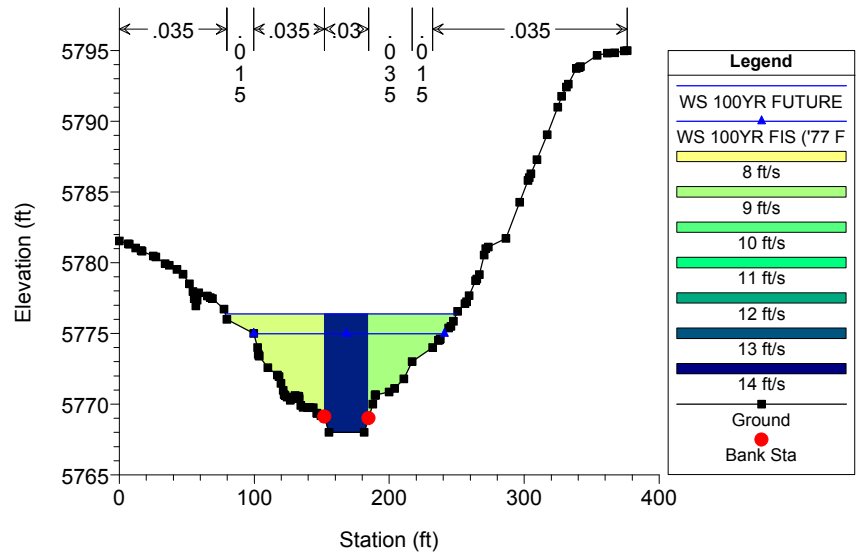
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11400



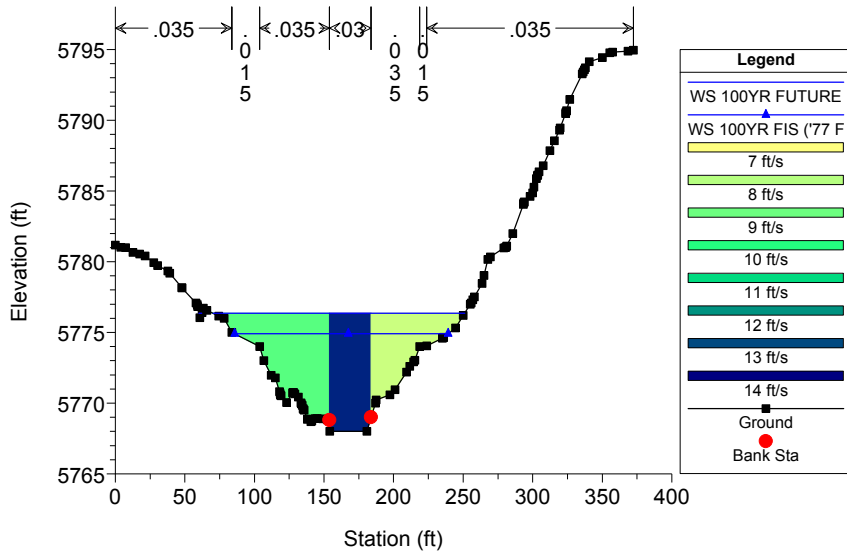
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11385



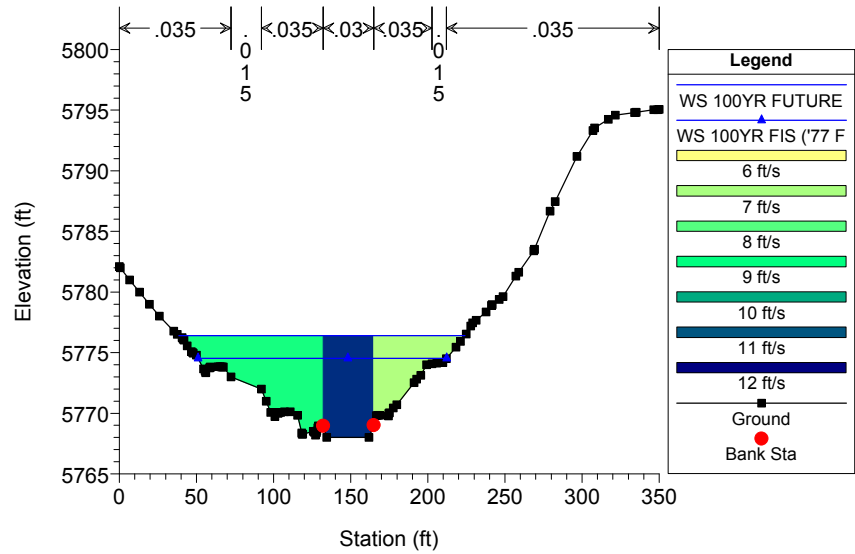
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11370



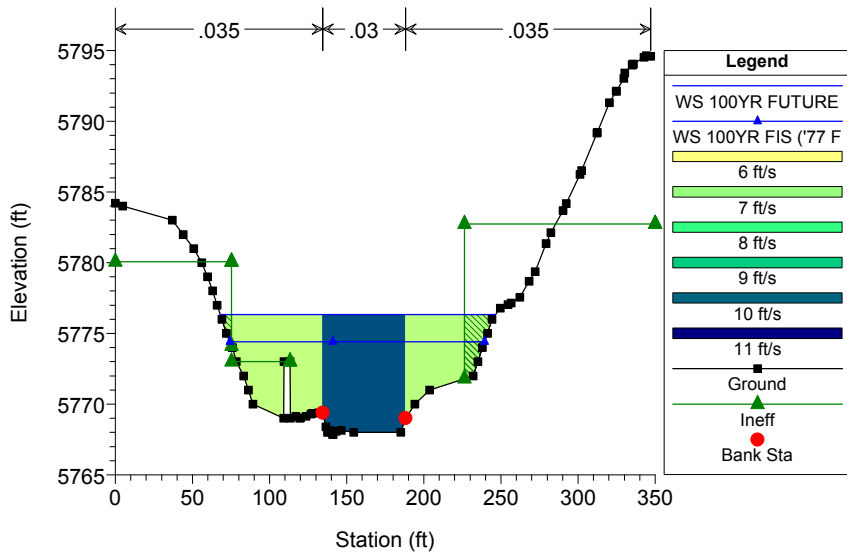
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11280



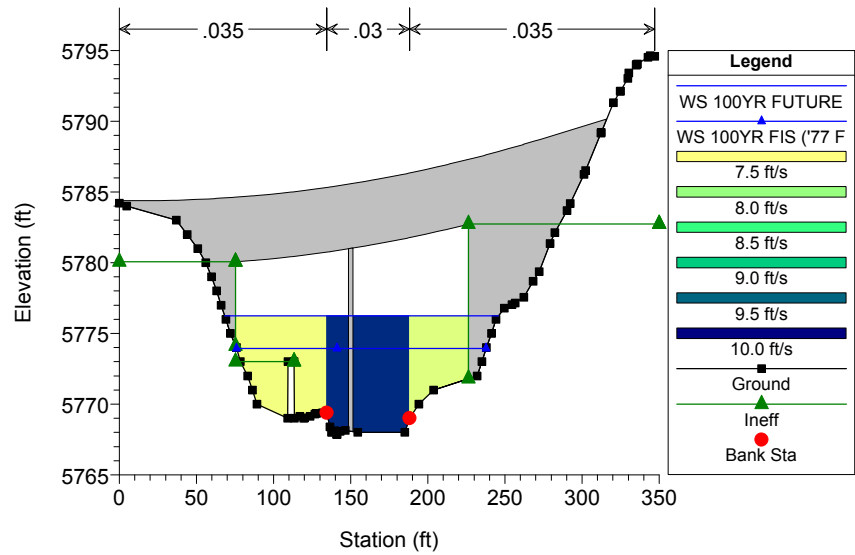
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11180



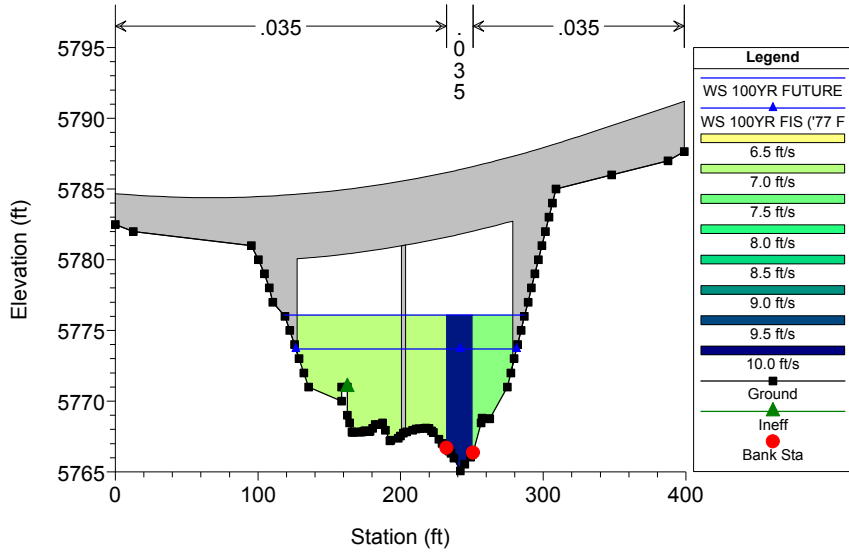
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11150 BR



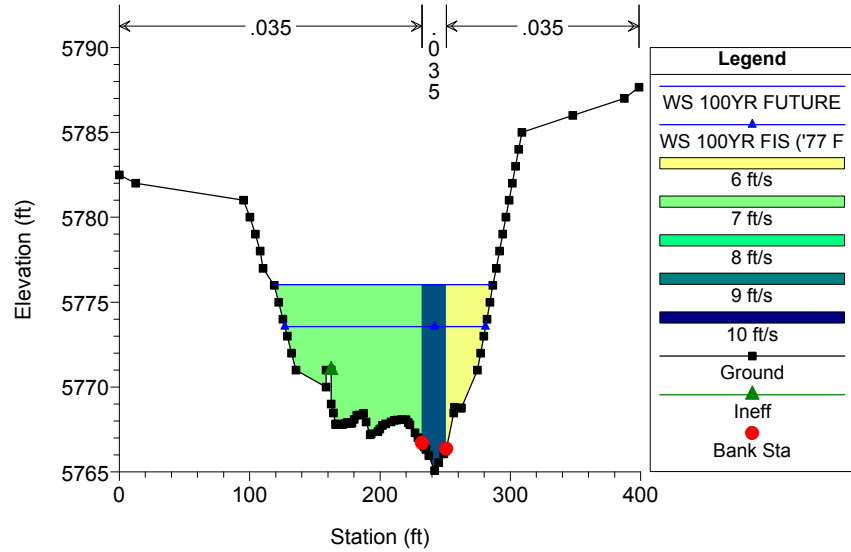
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11150 BR



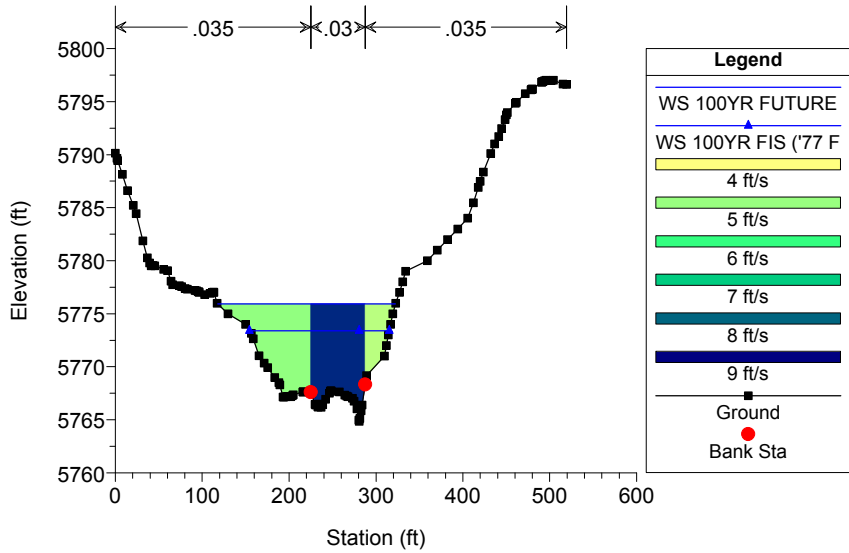
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 11100



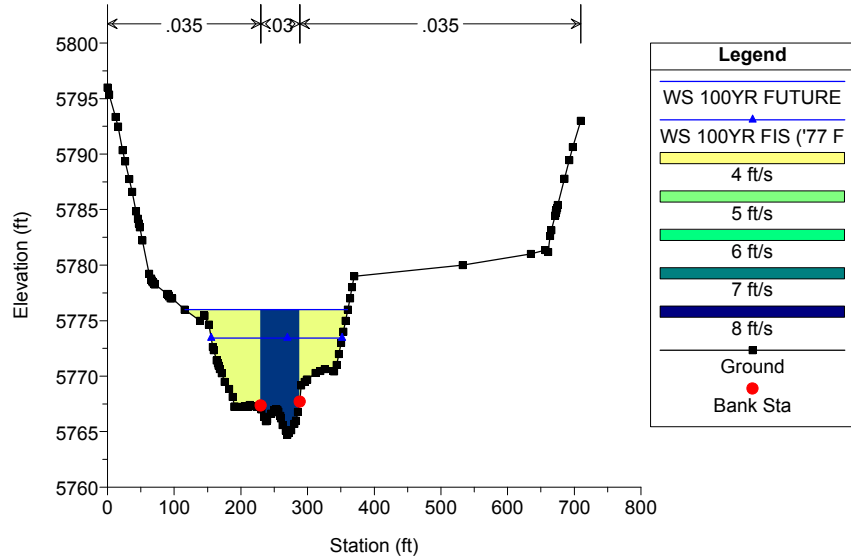
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10974



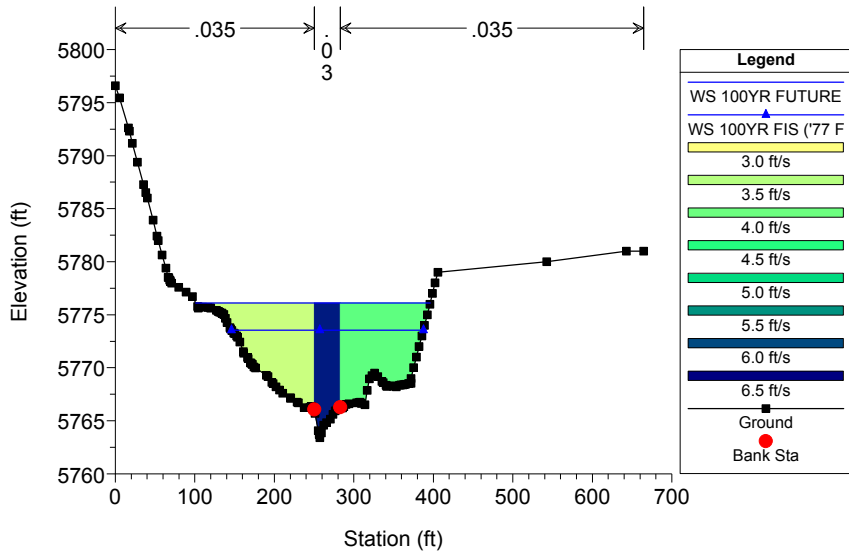
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10900



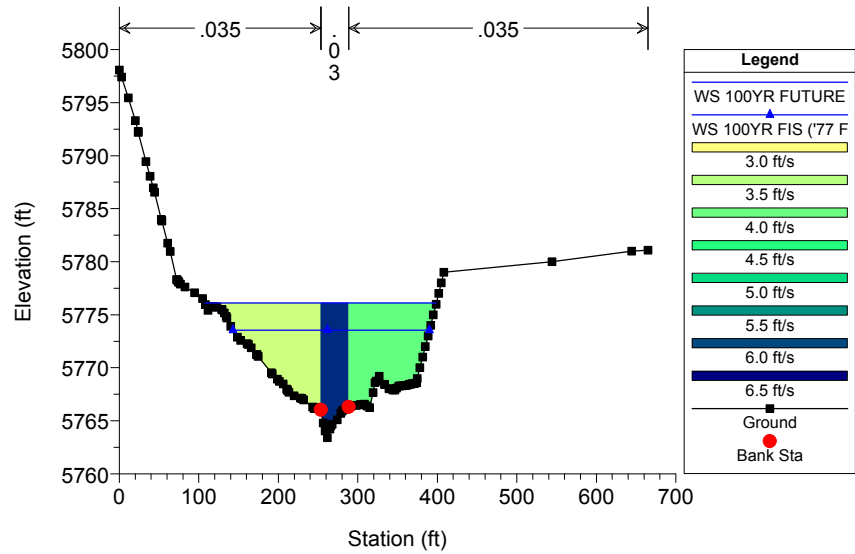
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10825



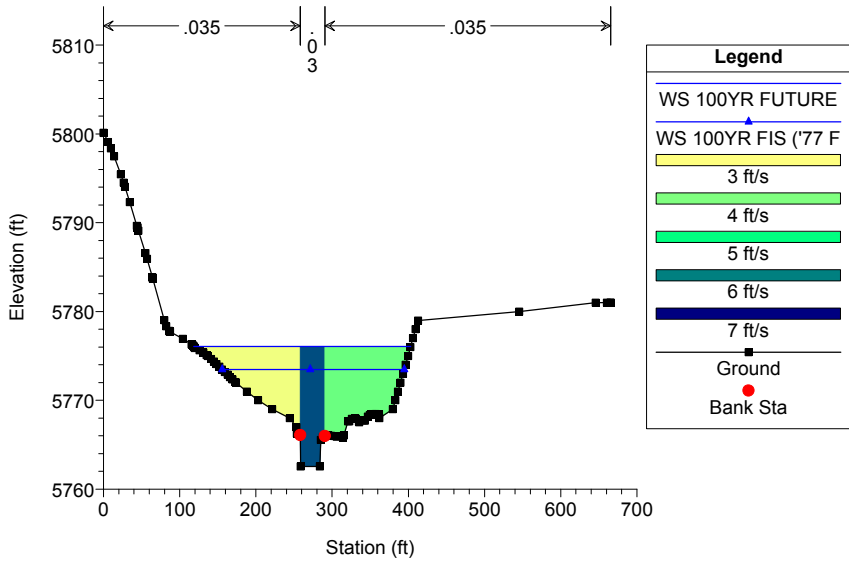
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10819



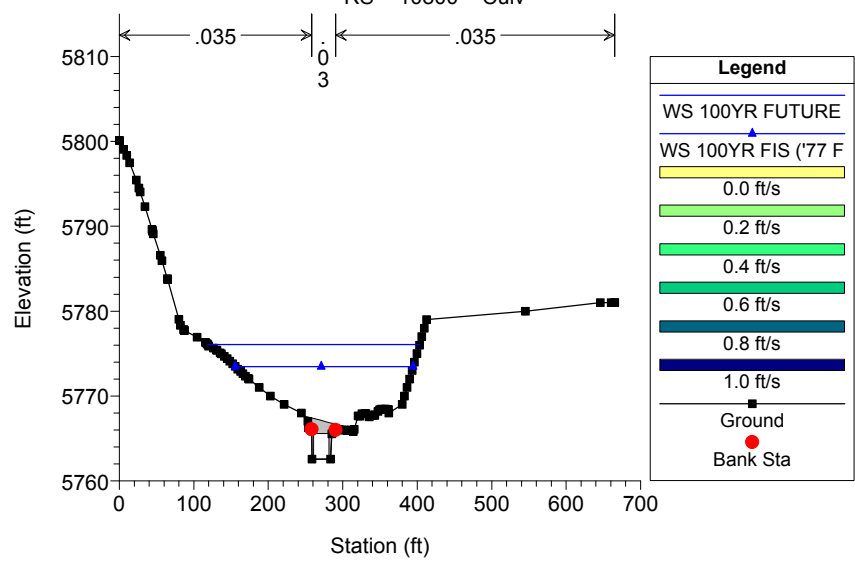
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10810



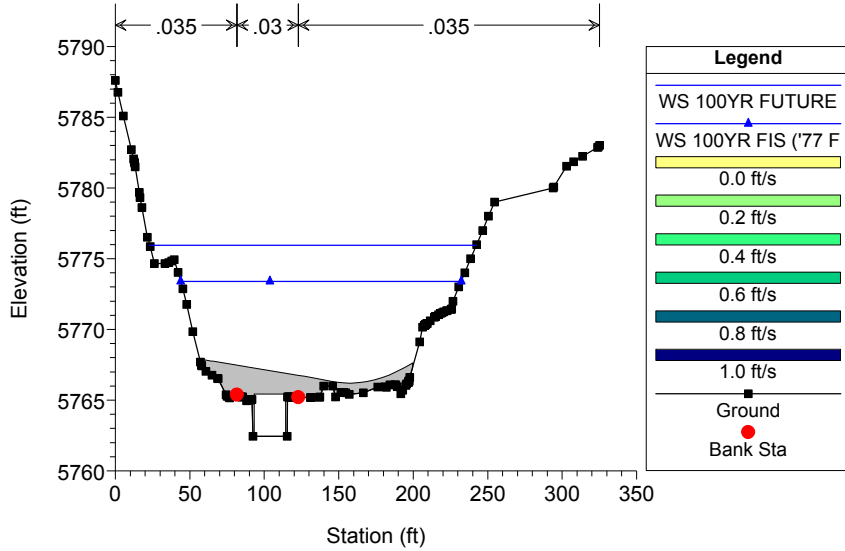
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10800 Culv



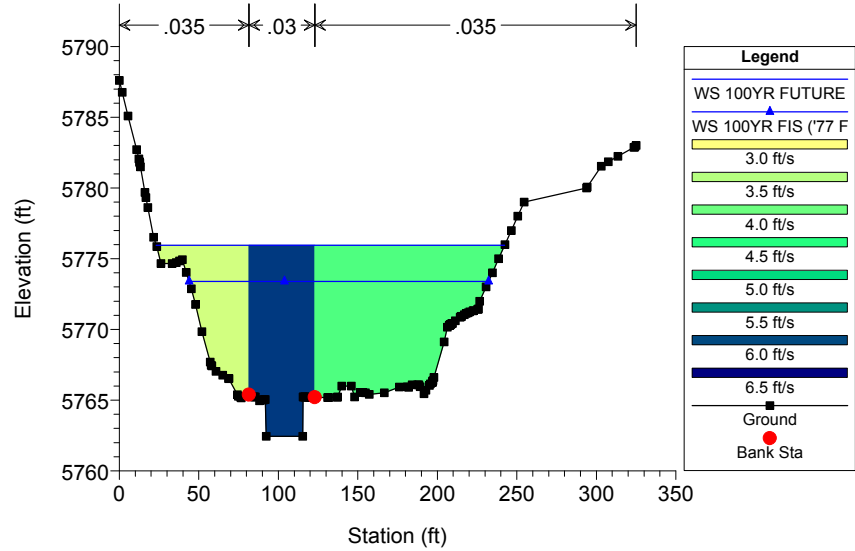
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10800 Culv



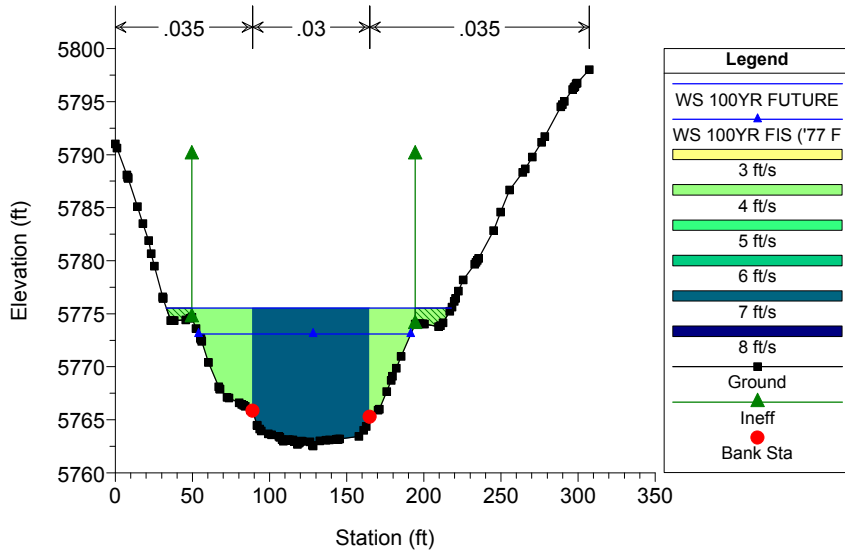
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10750



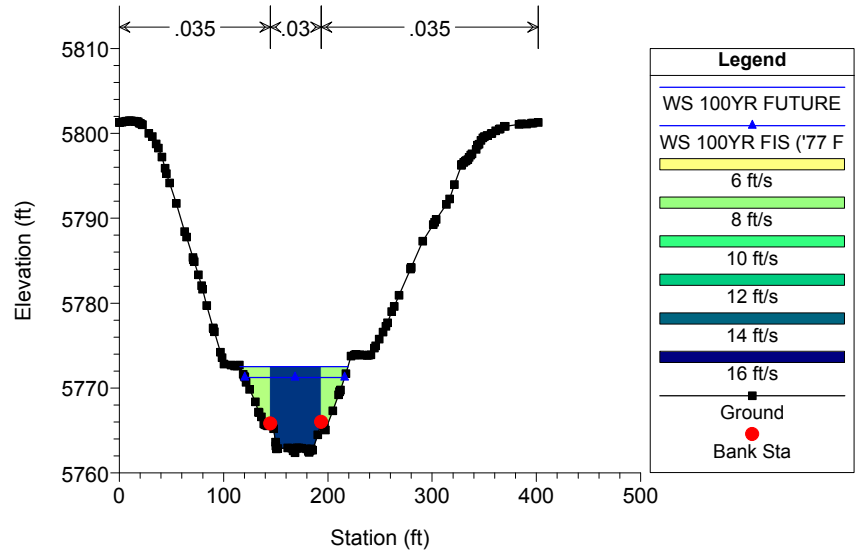
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10725



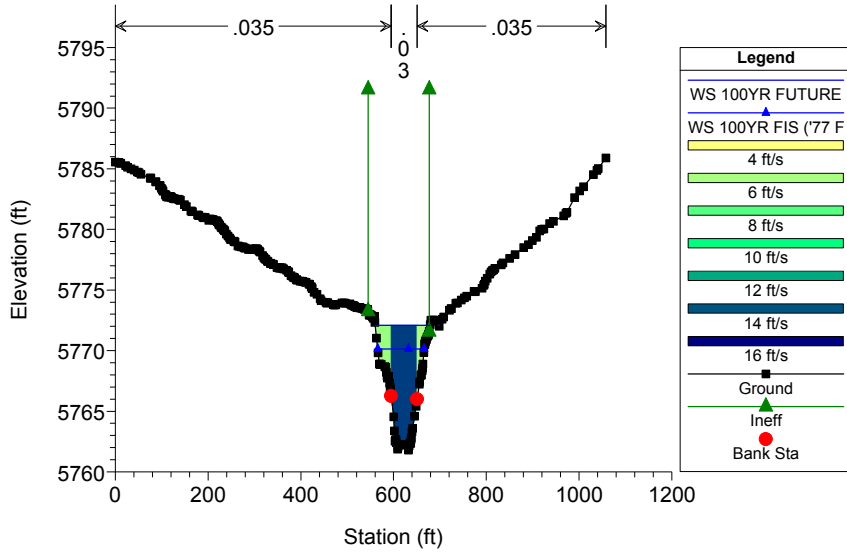
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10679



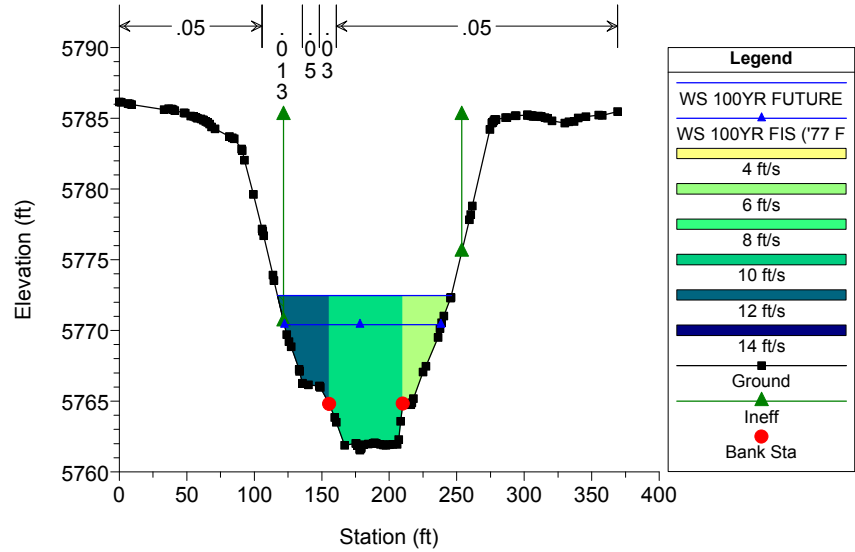
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10595



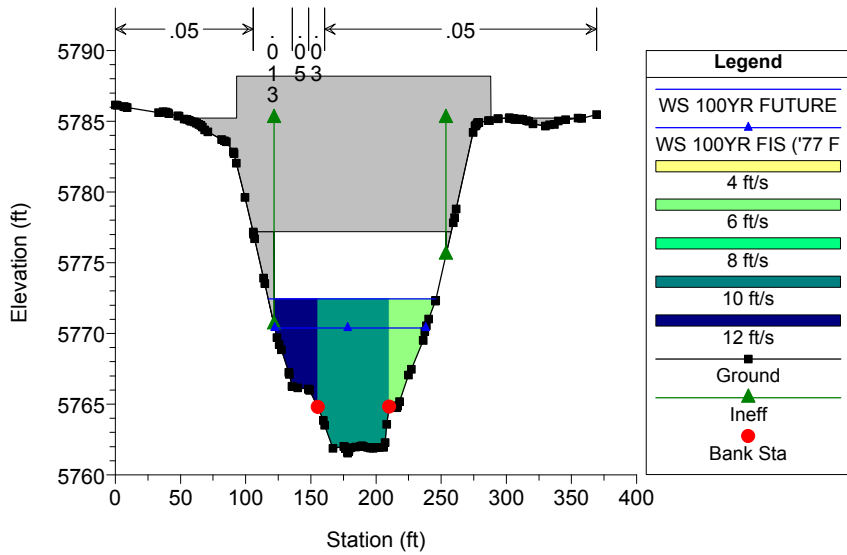
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10548



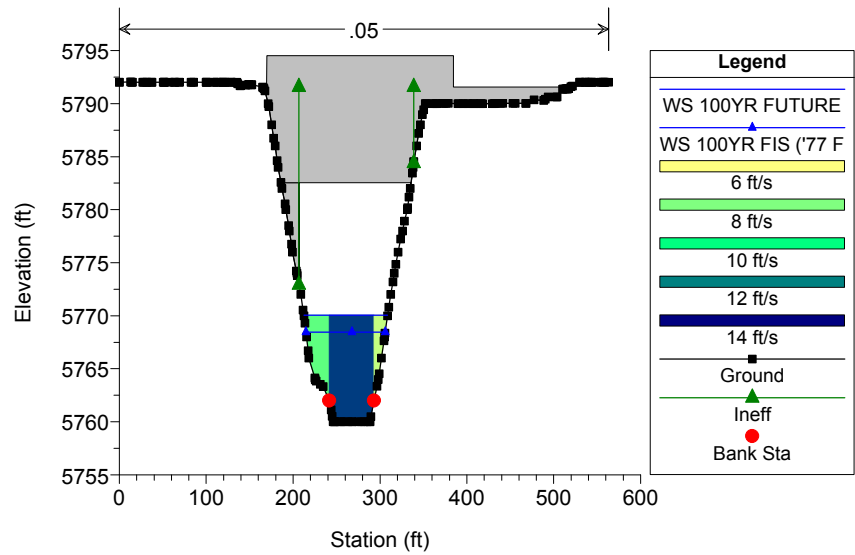
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10500 BR E-470 / Crossing 21 / (two bridges combined in one crossing)



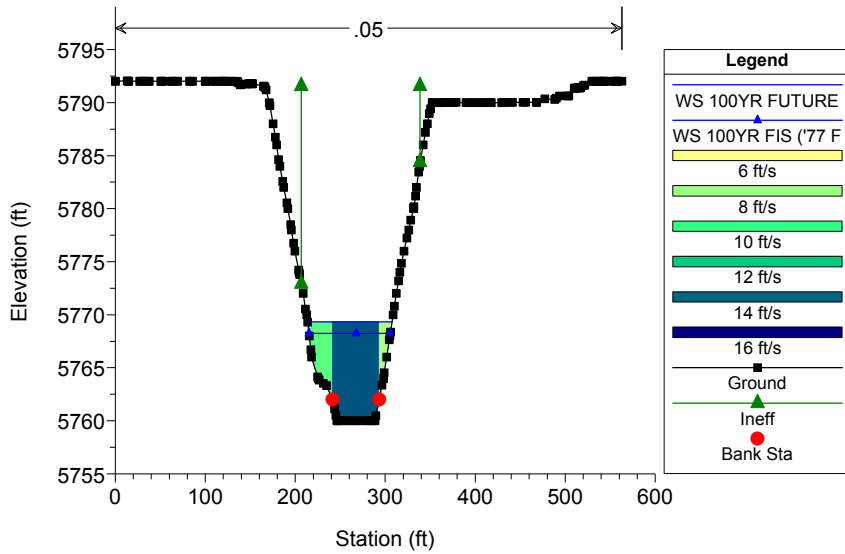
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10500 BR E-470 / Crossing 21 / (two bridges combined in one crossing)



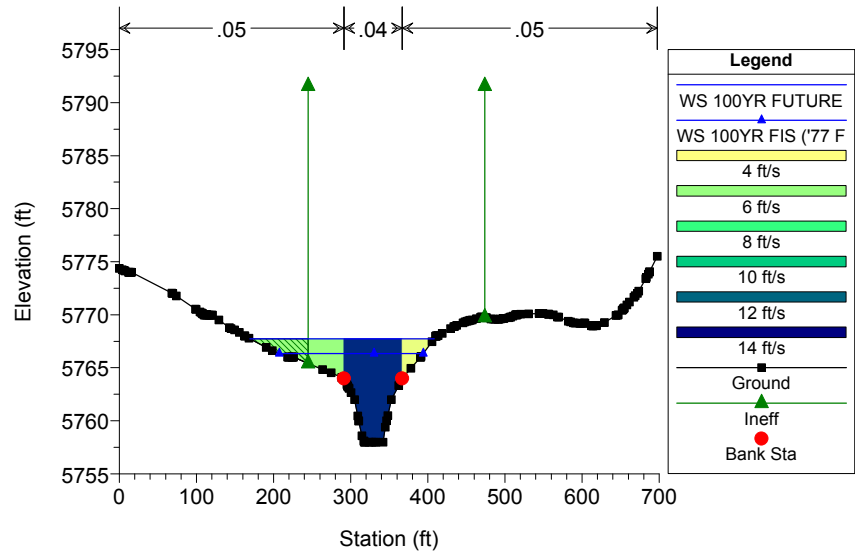
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10326



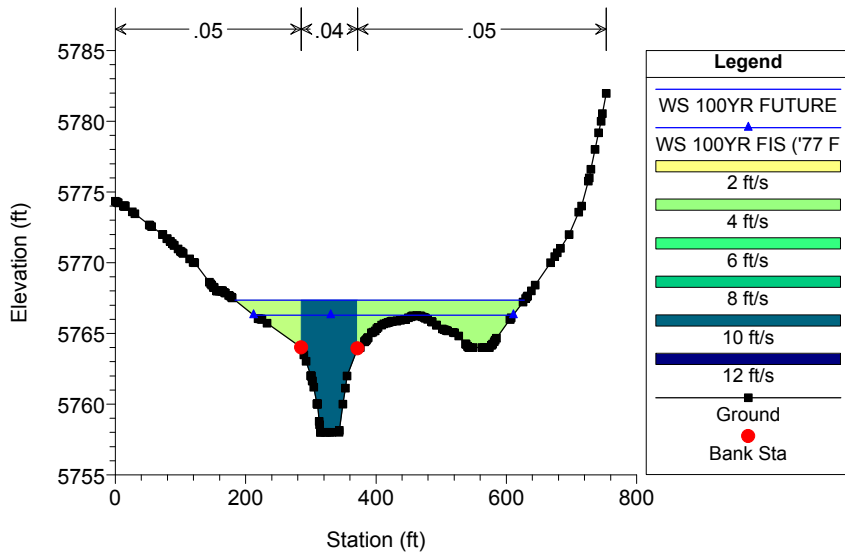
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10157



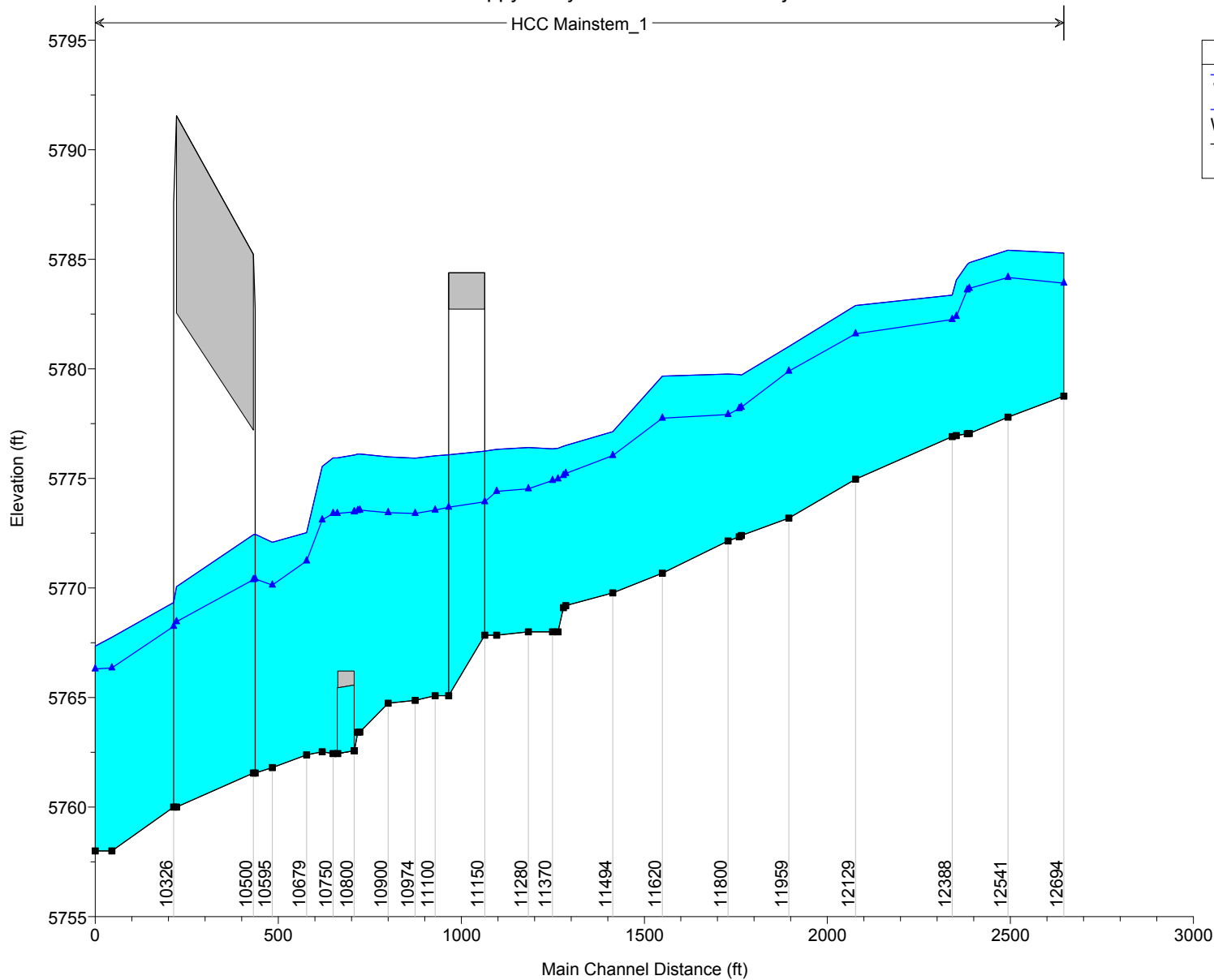
Happy Canyon Clean Plan: Post-Project 7/20/2017

RS = 10111



Happy Canyon Plan: Post-Project 7/24/2017

HCC Mainstem\_1



Legend	
WS 100YR FUTURE	▲
WS 100YR FIS ('77 F	▲
Ground	■

HEC-RAS Plan: Post-Project River: HCC Reach: Mainstem\_1

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Mainstem_1	12694	100YR FUTURE	8303.00	5778.76	5785.29		5785.89	0.002893	8.69	1474.52	423.99	0.62
Mainstem_1	12694	100YR FIS ('77 F	5610.00	5778.76	5783.92	5783.83	5784.76	0.005541	10.12	909.70	398.99	0.83
Mainstem_1	12541	100YR FUTURE	8303.00	5777.80	5785.42		5785.64	0.000770	4.79	2344.05	498.21	0.33
Mainstem_1	12541	100YR FIS ('77 F	5610.00	5777.80	5784.18		5784.37	0.000873	4.43	1738.29	477.92	0.34
Mainstem_1	12436	100YR FUTURE	8303.00	5777.05	5784.84		5785.52	0.002101	8.61	1408.04	307.97	0.56
Mainstem_1	12436	100YR FIS ('77 F	5610.00	5777.05	5783.67		5784.25	0.002177	7.81	1057.56	287.85	0.55
Mainstem_1	12430	100YR FUTURE	8303.00	5777.04	5784.77		5785.50	0.002301	8.97	1353.19	299.25	0.58
Mainstem_1	12430	100YR FIS ('77 F	5610.00	5777.04	5783.60		5784.23	0.002376	8.12	1016.20	278.63	0.57
Mainstem_1	12400	100YR FUTURE	8303.00	5776.95	5784.05	5783.62	5785.35	0.004533	12.00	1039.52	262.70	0.81
Mainstem_1	12400	100YR FIS ('77 F	5610.00	5776.95	5782.40	5782.40	5784.02	0.007464	12.82	638.70	211.16	0.99
Mainstem_1	12388	100YR FUTURE	8303.00	5776.91	5783.36	5783.36	5785.24	0.005668	11.86	865.25	245.14	0.87
Mainstem_1	12388	100YR FIS ('77 F	5610.00	5776.91	5782.25	5782.25	5783.85	0.006142	10.68	614.14	200.92	0.88
Mainstem_1	12129	100YR FUTURE	8303.00	5774.96	5782.89		5783.40	0.001488	7.39	1557.85	293.95	0.47
Mainstem_1	12129	100YR FIS ('77 F	5610.00	5774.96	5781.60		5782.00	0.001521	6.60	1188.08	277.11	0.46
Mainstem_1	11959	100YR FUTURE	8303.00	5773.19	5781.02	5781.02	5782.95	0.005406	12.39	848.43	208.96	0.86
Mainstem_1	11959	100YR FIS ('77 F	5610.00	5773.19	5779.89	5779.89	5781.55	0.005673	11.15	620.42	192.04	0.86
Mainstem_1	11835	100YR FUTURE	8303.00	5772.39	5779.72		5781.23	0.004603	12.19	936.38	202.39	0.81
Mainstem_1	11835	100YR FIS ('77 F	5610.00	5772.39	5778.24	5778.24	5779.78	0.006196	12.07	646.23	190.49	0.91
Mainstem_1	11830	100YR FUTURE	8303.00	5772.34	5779.74		5781.18	0.004377	11.93	953.94	202.95	0.79
Mainstem_1	11830	100YR FIS ('77 F	5610.00	5772.34	5778.19	5778.19	5779.70	0.006157	12.00	649.18	190.71	0.90
Mainstem_1	11800	100YR FUTURE	8303.00	5772.14	5779.76		5781.00	0.003488	10.86	1018.32	200.45	0.71
Mainstem_1	11800	100YR FIS ('77 F	5610.00	5772.14	5777.92	5777.79	5779.34	0.005731	11.44	660.35	187.01	0.87
Mainstem_1	11620	100YR FUTURE	8303.00	5770.67	5779.67		5780.45	0.001708	8.07	1291.73	235.74	0.51
Mainstem_1	11620	100YR FIS ('77 F	5610.00	5770.67	5777.75		5778.53	0.002325	7.83	866.55	203.19	0.56
Mainstem_1	11494	100YR FUTURE	8303.00	5769.78	5777.13	5777.13	5779.86	0.006734	13.72	658.12	127.68	0.97
Mainstem_1	11494	100YR FIS ('77 F	5610.00	5769.78	5776.04	5775.76	5777.95	0.006035	11.43	526.08	117.11	0.89
Mainstem_1	11410	100YR FUTURE	8303.00	5769.19	5776.50	5776.50	5778.75	0.006347	14.58	734.78	158.97	0.96
Mainstem_1	11410	100YR FIS ('77 F	5610.00	5769.19	5775.22	5775.22	5777.12	0.006962	13.39	542.24	140.88	0.97

HEC-RAS Plan: Post-Project River: HCC Reach: Mainstem\_1 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Mainstem_1	11400	100YR FUTURE	8303.00	5769.10	5776.47	5776.47	5778.61	0.005986	14.17	745.21	163.48	0.93
Mainstem_1	11400	100YR FIS ('77 F	5610.00	5769.10	5775.13	5775.13	5777.03	0.007086	13.43	542.22	142.44	0.98
Mainstem_1	11385	100YR FUTURE	8303.00	5768.00	5776.37	5776.24	5778.31	0.004594	13.63	800.89	171.25	0.84
Mainstem_1	11385	100YR FIS ('77 F	5610.00	5768.00	5774.98	5774.93	5776.77	0.005332	12.99	578.87	141.21	0.87
Mainstem_1	11370	100YR FUTURE	8303.00	5768.00	5776.35	5776.14	5778.21	0.004587	13.51	818.92	182.96	0.83
Mainstem_1	11370	100YR FIS ('77 F	5610.00	5768.00	5774.90	5774.90	5776.68	0.005545	13.07	576.33	153.38	0.88
Mainstem_1	11280	100YR FUTURE	8303.00	5768.00	5776.41		5777.84	0.003220	11.47	909.56	185.44	0.70
Mainstem_1	11280	100YR FIS ('77 F	5610.00	5768.00	5774.53	5774.53	5776.21	0.005304	12.41	582.90	161.28	0.86
Mainstem_1	11180	100YR FUTURE	8303.00	5767.85	5776.33	5774.61	5777.53	0.002592	10.23	1011.52	178.49	0.63
Mainstem_1	11180	100YR FIS ('77 F	5610.00	5767.85	5774.41	5773.47	5775.54	0.003477	9.92	720.43	165.06	0.70
Mainstem_1	11150		Bridge									
Mainstem_1	11100	100YR FUTURE	8303.00	5765.08	5776.03	5773.39	5776.89	0.002244	9.37	1149.57	168.05	0.52
Mainstem_1	11100	100YR FIS ('77 F	5610.00	5765.08	5773.55	5772.29	5774.50	0.003690	9.98	751.27	153.96	0.63
Mainstem_1	10974	100YR FUTURE	8303.00	5764.87	5775.92		5776.76	0.001675	8.62	1257.20	204.38	0.51
Mainstem_1	10974	100YR FIS ('77 F	5610.00	5764.87	5773.40		5774.28	0.002551	8.54	798.97	160.66	0.59
Mainstem_1	10900	100YR FUTURE	8303.00	5764.74	5775.98		5776.58	0.001127	7.59	1516.89	244.21	0.43
Mainstem_1	10900	100YR FIS ('77 F	5610.00	5764.74	5773.43		5774.06	0.001624	7.46	976.81	195.96	0.49
Mainstem_1	10825	100YR FUTURE	8303.00	5763.42	5776.11		5776.44	0.000680	6.32	1972.87	294.92	0.33
Mainstem_1	10825	100YR FIS ('77 F	5610.00	5763.42	5773.55		5773.89	0.000950	6.26	1305.73	241.34	0.38
Mainstem_1	10819	100YR FUTURE	8303.00	5763.41	5776.11		5776.44	0.000657	6.21	1979.59	291.34	0.33
Mainstem_1	10819	100YR FIS ('77 F	5610.00	5763.41	5773.53		5773.88	0.000965	6.30	1301.04	247.03	0.38
Mainstem_1	10810	100YR FUTURE	8303.00	5762.57	5776.07	5771.82	5776.43	0.000665	6.40	1938.64	284.58	0.31
Mainstem_1	10810	100YR FIS ('77 F	5610.00	5762.57	5773.47	5770.79	5773.87	0.000967	6.63	1261.27	238.85	0.36
Mainstem_1	10800		Culvert									
Mainstem_1	10750	100YR FUTURE	8303.00	5762.44	5775.94		5776.32	0.000618	6.11	1812.78	219.13	0.31
Mainstem_1	10750	100YR FIS ('77 F	5610.00	5762.44	5773.40		5773.73	0.000718	5.64	1295.37	188.32	0.32
Mainstem_1	10725	100YR FUTURE	8355.00	5762.52	5775.54	5770.34	5776.21	0.000745	7.10	1376.84	184.86	0.36
Mainstem_1	10725	100YR FIS ('77 F	5610.00	5762.52	5773.10	5768.90	5773.64	0.000795	6.31	1027.92	137.68	0.36

HEC-RAS Plan: Post-Project River: HCC Reach: Mainstem\_1 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Mainstem_1	10679	100YR FUTURE	8475.00	5762.39	5772.53	5772.16	5775.47	0.004939	14.96	681.24	103.80	0.87
Mainstem_1	10679	100YR FIS ('77 F	5610.00	5762.39	5771.24		5773.17	0.003865	11.97	552.32	95.94	0.75
Mainstem_1	10595	100YR FUTURE	8475.00	5761.80	5772.08	5772.08	5775.00	0.004822	14.58	690.88	120.70	0.86
Mainstem_1	10595	100YR FIS ('77 F	5610.00	5761.80	5770.13	5770.13	5772.68	0.005509	13.24	478.66	100.18	0.88
Mainstem_1	10548	100YR FUTURE	8475.00	5761.55	5772.46	5770.39	5774.01	0.004638	9.65	904.01	128.82	0.53
Mainstem_1	10548	100YR FIS ('77 F	5610.00	5761.55	5770.42	5768.89	5771.63	0.005623	9.14	658.13	116.08	0.57
Mainstem_1	10500		Bridge									
Mainstem_1	10326	100YR FUTURE	8475.00	5760.00	5769.34	5768.77	5772.13	0.012398	14.33	666.43	93.87	0.83
Mainstem_1	10326	100YR FIS ('77 F	5610.00	5760.00	5768.25		5769.94	0.008801	11.09	565.96	90.44	0.69
Mainstem_1	10157	100YR FUTURE	8475.00	5758.00	5767.74	5767.74	5770.13	0.009174	13.19	772.38	238.97	0.86
Mainstem_1	10157	100YR FIS ('77 F	5610.00	5758.00	5766.35	5766.35	5768.32	0.009491	11.65	554.43	186.49	0.84
Mainstem_1	10111	100YR FUTURE	8475.00	5758.00	5767.35	5767.14	5768.53	0.005790	10.09	1292.58	443.82	0.68
Mainstem_1	10111	100YR FIS ('77 F	5610.00	5758.00	5766.30	5765.87	5767.48	0.006273	9.40	850.14	398.68	0.69

## **APPENDIX F. SUPPLEMENTAL INFORMATION AND PLAN SHEETS**

FEDERAL EMERGENCY MANAGEMENT AGENCY  
PAYMENT INFORMATION FORM

Community Name: \_\_\_\_\_

Project Identifier: \_\_\_\_\_

**THIS FORM MUST BE MAILED, ALONG WITH THE APPROPRIATE FEE, TO THE ADDRESS BELOW OR FAXED TO THE FAX NUMBER BELOW.**

**Please make check or money order payable to the National Flood Insurance Program.**

Type of Request:

- MT-1 application }  
 MT-2 application }

**LOMC Clearinghouse**  
3601 Eisenhower Ave. Suite 500  
Alexandria, VA 22304-6426  
Attn.: LOMC Manager

- EDR application }

**FEMA Project Library**  
3601 Eisenhower Ave. Suite 500  
Alexandria, VA 22304-6426  
FAX (703) 960-9125

Request No. (if known): \_\_\_\_\_ Check No.: \_\_\_\_\_ Amount: \_\_\_\_\_

INITIAL FEE\*  FINAL FEE  FEE BALANCE\*\*  MASTER CARD  VISA  CHECK  MONEY ORDER

\*Note: Check only for EDR and/or Alluvial Fan requests (as appropriate).

\*\*Note: Check only if submitting a corrected fee for an ongoing request.

**COMPLETE THIS SECTION ONLY IF PAYING BY CREDIT CARD**

CARD NUMBER

EXP. DATE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----

Month	Year
-------	------

\_\_\_\_\_ Date \_\_\_\_\_ Signature

NAME (AS IT APPEARS ON CARD): \_\_\_\_\_  
(please print or type)

ADDRESS: \_\_\_\_\_  
(for your credit card receipt-please print or type)

DAYTIME PHONE: \_\_\_\_\_

U.S. DEPARTMENT OF HOMELAND SECURITY  
 FEDERAL EMERGENCY MANAGEMENT AGENCY  
**OVERVIEW & CONCURRENCE FORM**

*O.M.B No. 1660-0016  
 Expires February 28, 2014*

**PAPERWORK BURDEN DISCLOSURE NOTICE**

Public reporting burden for this form is estimated to average 1 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless it displays a valid OMB control number. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Department of Homeland Security, Federal Emergency Management Agency, 1800 South Bell Street, Arlington, VA 20958-3005, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

**PRIVACY ACT STATEMENT**

**AUTHORITY:** The National Flood Insurance Act of 1968, Public Law 90-448, as amended by the Flood Disaster Protection Act of 1973, Public Law 93-234.

**PRINCIPAL PURPOSE(S):** This information is being collected for the purpose of determining an applicant's eligibility to request changes to National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM).

**ROUTINE USE(S):** The information on this form may be disclosed as generally permitted under 5 U.S.C § 552a(b) of the Privacy Act of 1974, as amended. This includes using this information as necessary and authorized by the routine uses published in DHS/FEMA/NFIP/LOMA-1 National Flood Insurance Program (NFIP); Letter of Map Amendment (LOMA) February 15, 2006, 71 FR 7990.

**DISCLOSURE:** The disclosure of information on this form is voluntary; however, failure to provide the information requested may delay or prevent FEMA from processing a determination regarding a requested change to a (NFIP) Flood Insurance Rate Maps (FIRM).

**A. REQUESTED RESPONSE FROM DHS-FEMA**

This request is for a (check one):

- CLOMR: A letter from DHS-FEMA commenting on whether a proposed project, if built as proposed, would justify a map revision, or proposed hydrology changes (See 44 CFR Ch. 1, Parts 60, 65 & 72).
- LOMR: A letter from DHS-FEMA officially revising the current NFIP map to show the changes to floodplains, regulatory floodway or flood elevations. (See 44 CFR Ch. 1, Parts 60, 65 & 72)

**B. OVERVIEW**

1. The NFIP map panel(s) affected for all impacted communities is (are):

Community No.	Community Name	State	Map No.	Panel No.	Effective Date
Example: 480301 480287	City of Katy Harris County	TX TX	48473C 48201C	0005D 0220G	02/08/83 09/28/90
080310	Town of Parker	CO	08035C	0062G	03/16/16
080310	Town of Parker	CO	08035C	0066G	03/16/16

2. a. Flooding Source: Happy Canyon Creek

- b. Types of Flooding:  Riverine     Coastal     Shallow Flooding (e.g., Zones AO and AH)  
 Alluvial fan     Lakes     Other (Attach Description)

3. Project Name/Identifier: Compark at Belford Avenue

4. FEMA zone designations affected: AE, X (choices: A, AH, AO, A1-A30, A99, AE, AR, V, V1-V30, VE, B, C, D, X)

5. Basis for Request and Type of Revision:

a. The basis for this revision request is (check all that apply)

- Physical Change     Improved Methodology/Data     Regulatory Floodway Revision     Base Map Changes  
 Coastal Analysis     Hydraulic Analysis     Hydrologic Analysis     Corrections  
 Weir-Dam Changes     Levee Certification     Alluvial Fan Analysis     Natural Changes  
 New Topographic Data     Other (Attach Description)

Note: A photograph and narrative description of the area of concern is not required, but is very helpful during review.

b. The area of revision encompasses the following structures (check all that apply)

Structures:  Channelization  Levee/Floodwall  Bridge/Culvert  
 Dam  Fill  Other (Attach Description)

6.  Documentation of ESA compliance is submitted (required to initiate CLOMR review). Please refer to the instructions for more information.

**C. REVIEW FEE**

Has the review fee for the appropriate request category been included?  Yes Fee amount: \$6500  
 No, Attach Explanation

Please see the DHS-FEMA Web site at [http://www.fema.gov/plan/prevent/fhm/frm\\_fees.shtm](http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm) for Fee Amounts and Exemptions.

**D. SIGNATURE**

All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Zachary J Grady		Company: Felsburg Holt & Ullevig	
Mailing Address: 6300 South Syracuse Way, Suite 600 Centennial, CO 80111		Daytime Telephone No.: 3037211440	Fax No.: 3037210832
		E-Mail Address: zach.grady@fhueng.com	
Signature of Requester (required):			Date:

As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision (LOMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirements for when fill is placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. For Conditional LOMR requests, the applicant has documented Endangered Species Act (ESA) compliance to FEMA prior to FEMA's review of the Conditional LOMR application. For LOMR requests, I acknowledge that compliance with Sections 9 and 10 of the ESA has been achieved independently of FEMA's process. For actions authorized, funded, or being carried out by Federal or State agencies, documentation from the agency showing its compliance with Section 7(a)(2) of the ESA will be submitted. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title:		Community Name:	
Mailing Address:		Daytime Telephone No.:	Fax No.:
		E-Mail Address:	
Community Official's Signature (required):			Date:

**CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR**

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.2(b) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

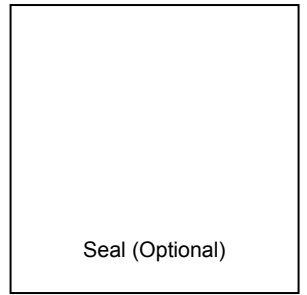
Certifier's Name: Kendra Gabbert		License No.: 45344	Expiration Date: 10/31/2017
Company Name: Felsburg Holt & Ullevig		Telephone No.: 303-721-1440	Fax No.: 303-721-0832
Signature:		Date:	E-Mail Address: kendra.gabbert@fhueng.com

Ensure the forms that are appropriate to your revision request are included in your submittal.

**Form Name and (Number)**

**Required if ...**

- |   |   |
|---|---|
| <input checked="" type="checkbox"/> Riverine Hydrology and Hydraulics Form (Form 2) | New or revised discharges or water-surface elevations   |
| <input checked="" type="checkbox"/> Riverine Structures Form (Form 3)               | Channel is modified, addition/revision of bridge/culverts, addition/revision of levee/floodwall, addition/revision of dam |
| <input type="checkbox"/> Coastal Analysis Form (Form 4)                             | New or revised coastal elevations   |
| <input type="checkbox"/> Coastal Structures Form (Form 5)                           | Addition/revision of coastal structure  |
| <input type="checkbox"/> Alluvial Fan Flooding Form (Form 6)                        | Flood control measures on alluvial fans   |



U.S. DEPARTMENT OF HOMELAND SECURITY  
 FEDERAL EMERGENCY MANAGEMENT AGENCY  
**RIVERINE HYDROLOGY & HYDRAULICS FORM**

*O.M.B No. 1660-0016  
 Expires February 28, 2014*

**PAPERWORK BURDEN DISCLOSURE NOTICE**

Public reporting burden for this form is estimated to average 3.5 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Department of Homeland Security, Federal Emergency Management Agency, 1800 South Bell Street, Arlington VA 20958-3005, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

**PRIVACY ACT STATEMENT**

**AUTHORITY:** The National Flood Insurance Act of 1968, Public Law 90-448, as amended by the Flood Disaster Protection Act of 1973, Public Law 93-234.

**PRINCIPAL PURPOSE(S):** This information is being collected for the purpose of determining an applicant's eligibility to request changes to National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM).

**ROUTINE USE(S):** The information on this form may be disclosed as generally permitted under 5 U.S.C § 552a(b) of the Privacy Act of 1974, as amended. This includes using this information as necessary and authorized by the routine uses published in DHS/FEMA/NFIP/LOMA-1 National Flood Insurance Program (NFIP); Letter of Map Amendment (LOMA) February 15, 2006, 71 FR 7990.

**DISCLOSURE:** The disclosure of information on this form is voluntary; however, failure to provide the information requested may delay or prevent FEMA from processing a determination regarding a requested change to a NFIP Flood Insurance Rate Maps (FIRM).

Flooding Source: Happy Canyon Creek

**Note:** Fill out one form for each flooding source studied

**A. HYDROLOGY**

1. Reason for New Hydrologic Analysis (check all that apply)

- |   |  |  |
|---|--|--|
| <input checked="" type="checkbox"/> Not revised (skip to section B) | <input type="checkbox"/> No existing analysis        | <input type="checkbox"/> Improved data                           |
| <input type="checkbox"/> Alternative methodology                    | <input type="checkbox"/> Proposed Conditions (CLOMR) | <input type="checkbox"/> Changed physical condition of watershed |

2. Comparison of Representative 1%-Annual-Chance Discharges

Location	Drainage Area (Sq. Mi.)	Effective/FIS (cfs)	Revised (cfs)
----------	-------------------------	---------------------	---------------

3. Methodology for New Hydrologic Analysis (check all that apply)

- |   |  |
|---|--|
| <input type="checkbox"/> Statistical Analysis of Gage Records | <input type="checkbox"/> Precipitation/Runoff Model → Specify Model: _____ |
| <input type="checkbox"/> Regional Regression Equations        | <input type="checkbox"/> Other (please attach description)                 |

Please enclose all relevant models in digital format, maps, computations (including computation of parameters), and documentation to support the new analysis.

4. Review/Approval of Analysis

If your community requires a regional, state, or federal agency to review the hydrologic analysis, please attach evidence of approval/review.

5. Impacts of Sediment Transport on Hydrology

Is the hydrology for the revised flooding source(s) affected by sediment transport?  Yes  No

If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation..

**B. HYDRAULICS**

1. Reach to be Revised

	Description	Cross Section	Water-Surface Elevations (ft.)	
			Effective	Proposed/Revised
Downstream Limit*	<u>FIS Section E</u>	<u>10111</u>	<u>5766.3</u>	<u>5766.3</u>
Upstream Limit*	<u>FIS Section G</u>	<u>12694</u>	<u>5784.8</u>	<u>5783.92</u>

\*Proposed/Revised elevations must tie-into the Effective elevations within 0.5 foot at the downstream and upstream limits of revision.

2. Hydraulic Method/Model Used: HEC-RAS 4.1.0

3. Pre-Submittal Review of Hydraulic Models\*

DHS-FEMA has developed two review programs, CHECK-2 and CHECK-RAS, to aid in the review of HEC-2 and HEC-RAS hydraulic models, respectively. We recommend that you review your HEC-2 and HEC-RAS models with CHECK-2 and CHECK-RAS.

4.

<u>Models Submitted</u>	<u>Natural Run</u>	<u>Floodway Run</u>	<u>Datum</u>
Duplicate Effective Model*	File Name: Happy Canyon Plan Name: Duplicate Effective	File Name: N/A Plan Name: N/A	NAVD 88
Corrected Effective Model*	File Name: Happy Canyon Plan Name: Corrected Effective	File Name: N/A Plan Name: N/A	NAVD 88
Existing or Pre-Project Conditions Model	File Name: N/A Plan Name: N/A	File Name: N/A Plan Name: N/A	N/A
Revised or Post-Project Conditions Model	File Name: Happy Canyon Plan Name: Post-Project	File Name: Happy Canyon Plan Name: Post-Project Floodwa	NAVD 88
Other - (attach description)	File Name: N/A Plan Name: N/A	File Name: N/A Plan Name: N/A	N/A

\* For details, refer to the corresponding section of the instructions.

Digital Models Submitted? (Required)

**C. MAPPING REQUIREMENTS**

A **certified topographic work map** must be submitted showing the following information (where applicable): the boundaries of the effective, existing, and proposed conditions 1%-annual-chance floodplain (for approximate Zone A revisions) or the boundaries of the 1%- and 0.2%-annual-chance floodplains and regulatory floodway (for detailed Zone AE, AO, and AH revisions); location and alignment of all cross sections with stationing control indicated; stream, road, and other alignments (e.g., dams, levees, etc.); current community easements and boundaries; boundaries of the requester's property; certification of a registered professional engineer registered in the subject State; location and description of reference marks; and the referenced vertical datum (NGVD, NAVD, etc.).

Digital Mapping (GIS/CADD) Data Submitted (preferred)

Topographic Information: Flown Aerial Survey for Belford Ave.

Source: Manhard Consultants Date: 03-31-16

Accuracy: 1-Foot Interval Contours

Note that the boundaries of the existing or proposed conditions floodplains and regulatory floodway to be shown on the revised FIRM and/or FBFM must tie-in with the effective floodplain and regulatory floodway boundaries. Please attach **a copy of the effective FIRM and/or FBFM**, at the same scale as the original, annotated to show the boundaries of the revised 1%-and 0.2%-annual-chance floodplains and regulatory floodway that tie-in with the boundaries of the effective 1%-and 0.2%-annual-chance floodplain and regulatory floodway at the upstream and downstream limits of the area on revision.

Annotated FIRM and/or FBFM (Required)

**D. COMMON REGULATORY REQUIREMENTS\***

1. For LOMR/CLOMR requests, do Base Flood Elevations (BFEs) increase?  Yes  No
- a. For CLOMR requests, if either of the following is true, please submit **evidence of compliance with Section 65.12 of the NFIP regulations**:
- The proposed project encroaches upon a regulatory floodway and would result in increases above 0.00 foot compared to pre-project conditions.
  - The proposed project encroaches upon a SFHA with or without BFEs established and would result in increases above 1.00 foot compared to pre-project conditions.
- b. Does this LOMR request cause increase in the BFE and/or SFHA compared with the effective BFEs and/or SFHA?  Yes  No  
If Yes, please attach **proof of property owner notification and acceptance (if available)**. Elements of and examples of property owner notifications can be found in the MT-2 Form 2 Instructions.
2. Does the request involve the placement or proposed placement of fill?  Yes  No
- If Yes, the community must be able to certify that the area to be removed from the special flood hazard area, to include any structures or proposed structures, meets all of the standards of the local floodplain ordinances, and is reasonably safe from flooding in accordance with the NFIP regulations set forth at 44 CFR 60.3(A)(3), 65.5(a)(4), and 65.6(a)(14). Please see the MT-2 instructions for more information.
3. For LOMR requests, is the regulatory floodway being revised?  Yes  No
- If Yes, attach **evidence of regulatory floodway revision notification**. As per Paragraph 65.7(b)(1) of the NFIP Regulations, notification is required for requests involving revisions to the regulatory floodway. (Not required for revisions to approximate 1%-annual-chance floodplains [studied Zone A designation] unless a regulatory floodway is being established. Elements and examples of regulatory floodway revision notification can be found in the MT-2 Form 2 Instructions.)
4. For CLOMR requests, please submit documentation to FEMA and the community to show that you have complied with Sections 9 and 10 of the Endangered Species Act (ESA).

For actions authorized, funded, or being carried out by Federal or State agencies, please submit documentation from the agency showing its compliance with Section 7(a)(2) of the ESA. Please see the MT-2 instructions for more detail.

\* Not inclusive of all applicable regulatory requirements. For details, see 44 CFR parts 60 and 65.

**RIVERINE STRUCTURES FORM**

**PAPERWORK BURDEN DISCLOSURE NOTICE**

Public reporting burden for this form is estimated to average 7 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Department of Homeland Security, Federal Emergency Management Agency, 1800 South Bell Street, Arlington, VA 20598-3005, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

**PRIVACY ACT STATEMENT**

**AUTHORITY:** The National Flood Insurance Act of 1968, Public Law 90-448, as amended by the Flood Disaster Protection Act of 1973, Public Law 93-234.

**PRINCIPAL PURPOSE(S):** This information is being collected for the purpose of determining an applicant's eligibility to request changes to National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM).

**ROUTINE USE(S):** The information on this form may be disclosed as generally permitted under 5 U.S.C § 552a(b) of the Privacy Act of 1974, as amended. This includes using this information as necessary and authorized by the routine uses published in DHS/FEMA/NFIP/LOMA-1 National Flood Insurance Program; Letter of Map Amendment (LOMA) February 15, 2006, 71 FR 7990.

**DISCLOSURE:** The disclosure of information on this form is voluntary; however, failure to provide the information requested may delay or prevent FEMA from processing a determination regarding a requested change to a NFIP Flood Insurance Rate Maps (FIRM).

Flooding Source: Happy Canyon Creek

Note: Fill out one form for each flooding source studied.

**A. GENERAL**

Complete the appropriate section(s) for each Structure listed below:

- Channelization.....complete Section B
- Bridge/Culvert.....complete Section C
- Dam.....complete Section D
- Levee/Floodwall.....complete Section E
- Sediment Transport.....complete Section F (if required)

Description Of Modeled Structure

1. Name of Structure: Belford Avenue Bridge  
Type (check one):     Channelization                       Bridge/Culvert                       Levee/Floodwall                       Dam  
Location of Structure: \_\_\_\_\_  
Downstream Limit/Cross Section: 11100  
Upstream Limit/Cross Section: 11180
2. Name of Structure: E-470 Pedestrian Train Crossing  
Type (check one):     Channelization                       Bridge/Culvert                       Levee/Floodwall                       Dam  
Location of Structure: \_\_\_\_\_  
Downstream Limit/Cross Section: 10750  
Upstream Limit/Cross Section: 10810
3. Name of Structure: \_\_\_\_\_  
Type (check one)     Channelization                       Bridge/Culvert                       Levee/Floodwall                       Dam  
Location of Structure: \_\_\_\_\_  
Downstream Limit/Cross Section: \_\_\_\_\_  
Upstream Limit/Cross Section: \_\_\_\_\_

**NOTE: FOR MORE STRUCTURES, ATTACH ADDITIONAL PAGES AS NEEDED.**

B. CHANNELIZATION

Flooding Source: Happy Canyon Creek

Name of Structure: Belford Avenue Bridge

1. Hydraulic Considerations

The channel was designed to carry \_\_\_\_\_ (cfs) and/or the \_\_\_\_\_-year flood.

The design elevation in the channel is based on (check one):

- Subcritical flow
- Critical flow
- Supercritical flow
- Energy grade line

If there is the potential for a hydraulic jump at the following locations, check all that apply and attach an explanation of how the hydraulic jump is controlled without affecting the stability of the channel.

- Inlet to channel
- Outlet of channel
- At Drop Structures
- At Transitions
- Other locations (specify): \_\_\_\_\_

2. Channel Design Plans

Attach the plans of the channelization certified by a registered professional engineer, as described in the instructions.

3. Accessory Structures

The channelization includes (check one):

- Levees [Attach Section E (Levee/Floodwall)]
- Drop structures
- Superelevated sections
- Transitions in cross sectional geometry
- Debris basin/detention basin [Attach Section D (Dam/Basin)]
- Energy dissipator
- Weir
- Other (Describe): \_\_\_\_\_

4. Sediment Transport Considerations

Are the hydraulics of the channel affected by sediment transport?  Yes  No

If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation for why sediment transport was not considered.

C. BRIDGE/CULVERT

Flooding Source: Happy Canyon Creek

Name of Structure: Belford Avenue Bridge

1. This revision reflects (check one):

- Bridge/culvert not modeled in the FIS
- Modified bridge/culvert previously modeled in the FIS
- Revised analysis of bridge/culvert previously modeled in the FIS

2. Hydraulic model used to analyze the structure (e.g., HEC-2 with special bridge routine, WSPRO, HY8): HEC-RAS 4.1.0  
If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structures. Attach justification.

3. Attach plans of the structures certified by a registered professional engineer. The plan detail and information should include the following (check the information that has been provided):

- Dimensions (height, width, span, radius, length)
- Distances Between Cross Sections
- Shape (culverts only)
- Erosion Protection
- Material
- Low Chord Elevations – Upstream and Downstream
- Beveling or Rounding
- Top of Road Elevations – Upstream and Downstream
- Wing Wall Angle
- Structure Invert Elevations – Upstream and Downstream
- Skew Angle
- Stream Invert Elevations – Upstream and Downstream
- Cross-Section Locations

4. Sediment Transport Considerations

Are the hydraulics of the structure affected by sediment transport?  Yes  No

If Yes, then fill out Section F (Sediment Transport) of Form 3. If no, then attach an explanation.

**D. DAM/BASIN**

Flooding Source: \_\_\_\_\_  
 Name of Structure: \_\_\_\_\_

1. This request is for (check one):       Existing dam/basin     New dam/basin     Modification of existing dam/basin
2. The dam/basin was designed by (check one):  Federal agency     State agency     Private organization     Local government agency

Name of the agency or organization: \_\_\_\_\_

3. The Dam was permitted as (check one):     Federal Dam                       State Dam

Provide the permit or identification number (ID) for the dam and the appropriate permitting agency or organization

Permit or ID number \_\_\_\_\_ Permitting Agency or Organization \_\_\_\_\_

- a.     Local Government Dam     Private Dam

Provided related drawings, specification and supporting design information.

4. Does the project involve revised hydrology?     Yes     No

If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2).

Was the dam/basin designed using critical duration storm? (must account for the maximum volume of runoff)

- Yes, provide supporting documentation with your completed Form 2.  
 No, provide a written explanation and justification for not using the critical duration storm.

5. Does the submittal include debris/sediment yield analysis?     Yes     No

If Yes, then fill out Section F (Sediment Transport). If No, then attach your explanation for why debris/sediment analysis was not considered?

6. Does the Base Flood Elevation behind the dam/basin or downstream of the dam/basin change?     Yes     No

If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2) and complete the table below.

FREQUENCY (% annual chance)	Stillwater Elevation Behind the Dam/Basin	
	FIS	REVISED
10-year (10%)	_____	_____
50-year (2%)	_____	_____
100-year (1%)	_____	_____
500-year (0.2%)	_____	_____
Normal Pool Elevation	_____	_____

7. Please attach a copy of the formal Operation and Maintenance Plan

**E. LEVEE/FLOODWALL**

1. System Elements

a. This Levee/Floodwall analysis is based on (check one):

- upgrading of an existing levee/floodwall system       a newly constructed levee/floodwall system       reanalysis of an existing levee/floodwall system

b. Levee elements and locations are (check one):

- earthen embankment, dike, berm, etc.      Station \_\_\_\_\_ to \_\_\_\_\_  
 structural floodwall      Station \_\_\_\_\_ to \_\_\_\_\_  
 Other (describe): \_\_\_\_\_      Station \_\_\_\_\_ to \_\_\_\_\_

c. Structural Type (check one):     monolithic cast-in place reinforced concrete     reinforced concrete masonry block     sheet piling  
 Other (describe): \_\_\_\_\_

d. Has this levee/floodwall system been certified by a Federal agency to provide protection from the base flood?

- Yes     No

If Yes, by which agency? \_\_\_\_\_

e. Attach certified drawings containing the following information (indicate drawing sheet numbers):

- 1. Plan of the levee embankment and floodwall structures. Sheet Numbers: \_\_\_\_\_
- 2. A profile of the levee/floodwall system showing the Base Flood Elevation (BFE), levee and/or wall crest and foundation, and closure locations for the total levee system. Sheet Numbers: \_\_\_\_\_
- 3. A profile of the BFE, closure opening outlet and inlet invert elevations, type and size of opening, and kind of closure. Sheet Numbers: \_\_\_\_\_
- 4. A layout detail for the embankment protection measures. Sheet Numbers: \_\_\_\_\_
- 5. Location, layout, and size and shape of the levee embankment features, foundation treatment, Floodwall structure, closure structures, and pump stations. Sheet Numbers: \_\_\_\_\_

2. Freeboard

a. The minimum freeboard provided above the BFE is:

Riverine

- 3.0 feet or more at the downstream end and throughout  Yes  No
- 3.5 feet or more at the upstream end  Yes  No
- 4.0 feet within 100 feet upstream of all structures and/or constrictions  Yes  No

Coastal

- 1.0 foot above the height of the one percent wave associated with the 1%-annual-chance stillwater surge elevation or maximum wave runup (whichever is greater).  Yes  No
- 2.0 feet above the 1%-annual-chance stillwater surge elevation  Yes  No

Please note, occasionally exceptions are made to the minimum freeboard requirement. If an exception is requested, attach documentation addressing Paragraph 65.10(b)(1)(ii) of the NFIP Regulations.

If No is answered to any of the above, please attach an explanation.

b. Is there an indication from historical records that ice-jamming can affect the BFE?  Yes  No

If Yes, provide ice-jam analysis profile and evidence that the minimum freeboard discussed above still exists.

3. Closures

a. Openings through the levee system (check one):  exists  does not exist

If opening exists, list all closures:

Channel Station	Left or Right Bank	Opening Type	Highest Elevation for Opening Invert	Type of Closure Device

(Extend table on an added sheet as needed and reference)

Note: Geotechnical and geologic data

In addition to the required detailed analysis reports, data obtained during field and laboratory investigations and used in the design analysis for the following system features should be submitted in a tabulated summary form. (Reference U.S. Army Corps of Engineers [USACE] EM-1110-2-1906 Form 2086.)

4. Embankment Protection

- a. The maximum levee slope land side is: \_\_\_\_\_
- b. The maximum levee slope flood side is: \_\_\_\_\_
- c. The range of velocities along the levee during the base flood is: \_\_\_\_\_ (min.) to \_\_\_\_\_ (max.)
- d. Embankment material is protected by (describe what kind): \_\_\_\_\_
- e. Riprap Design Parameters (check one):       Velocity       Tractive stress  
Attach references

Reach	Sideslope	Flow Depth	Velocity	Curve or Straight	Stone Riprap			Depth of Toedown
					D <sub>100</sub>	D <sub>50</sub>	Thickness	
Sta    to								
Sta    to								
Sta    to								
Sta    to								
Sta    to								
Sta    to								

(Extend table on an added sheet as needed and reference each entry)

- f. Is a bedding/filter analysis and design attached?     Yes     No
- g. Describe the analysis used for other kinds of protection used (include copies of the design analysis):

Attach engineering analysis to support construction plans.

5. Embankment And Foundation Stability

- a. Identify locations and describe the basis for selection of critical location for analysis:  
\_\_\_\_\_
  - Overall height: Sta.: \_\_\_\_\_, height \_\_\_\_\_ ft.
  - Limiting foundation soil strength:  
 Strength  $\phi$  = \_\_\_\_\_ degrees, c = \_\_\_\_\_ psf  
 Slope: SS = \_\_\_\_\_ (h) to \_\_\_\_\_ (v)  
 (Repeat as needed on an added sheet for additional locations)
- b. Specify the embankment stability analysis methodology used (e.g., circular arc, sliding block, infinite slope, etc.):  
\_\_\_\_\_
- c. Summary of stability analysis results:

**E. LEVEE/FLOODWALL (CONTINUED)**

5. Embankment And Foundation Stability (continued)

Case	Loading Conditions	Critical Safety Factor	Criteria (Min.)
I	End of construction		1.3
II	Sudden drawdown		1.0
III	Critical flood stage		1.4
IV	Steady seepage at flood stage		1.4
VI	Earthquake (Case I)		1.0

(Reference: USACE EM-1110-2-1913 Table 6-1)

- d. Was a seepage analysis for the embankment performed?  Yes  No  
 If Yes, describe methodology used:
- e. Was a seepage analysis for the foundation performed?  Yes  No
- f. Were uplift pressures at the embankment landside toe checked?  Yes  No
- g. Were seepage exit gradients checked for piping potential?  Yes  No
- h. The duration of the base flood hydrograph against the embankment is \_\_\_\_\_ hours.

Attach engineering analysis to support construction plans.

6. Floodwall And Foundation Stability

- a. Describe analysis submittal based on Code (check one):  UBC (1988)  Other (specify): \_\_\_\_\_
- b. Stability analysis submitted provides for:  Overturning  Sliding If not, explain: \_\_\_\_\_
- c. Loading included in the analyses were:  Lateral earth @  $P_A =$  \_\_\_\_\_ psf;  $P_p =$  \_\_\_\_\_ psf  
 Surcharge-Slope @ \_\_\_\_\_,  surface \_\_\_\_\_ psf  
 Wind @  $P_w =$  \_\_\_\_\_ psf  
 Seepage (Uplift); \_\_\_\_\_  Earthquake @  $P_{eq} =$  \_\_\_\_\_ %g
- 1%-annual-chance significant wave height: \_\_\_\_\_ ft.
- 1%-annual-chance significant wave period: \_\_\_\_\_ sec.
- d. Summary of Stability Analysis Results: Factors of Safety.  
 Itemize for each range in site layout dimension and loading condition limitation for each respective reach.

Loading Condition	Criteria (Min)		Sta	To	Sta	To
	Overturn	Sliding	Overturn	Sliding	Overturn	Sliding
Dead & Wind	1.5	1.5				
Dead & Soil	1.5	1.5				
Dead, Soil, Flood, & Impact	1.5	1.5				
Dead, Soil, & Seismic	1.3	1.3				

(Ref: FEMA 114 Sept 1986; USACE EM 1110-2-2502)  
Note: (Extend table on an added sheet as needed and reference)

**E. LEVEE/FLOODWALL (CONTINUED)**

6. Floodwall And Foundation Stability (continued)

e. Foundation bearing strength for each soil type:

Bearing Pressure	Sustained Load (psf)	Short Term Load (psf)
Computed design maximum		
Maximum allowable		

f. Foundation scour protection  is,  is not provided. If provided, attach explanation and supporting documentation:

Attach engineering analysis to support construction plans.

7. Settlement

a. Has anticipated potential settlement been determined and incorporated into the specified construction elevations to maintain the established freeboard margin?  Yes  No

b. The computed range of settlement is \_\_\_\_\_ ft. to \_\_\_\_\_ ft.

c. Settlement of the levee crest is determined to be primarily from :  Foundation consolidation  Embankment compression  
 Other (Describe): \_\_\_\_\_

d. Differential settlement of floodwalls  has  has not been accommodated in the structural design and construction.

Attach engineering analysis to support construction plans.

8. Interior Drainage

a. Specify size of each interior watershed:

Draining to pressure conduit: \_\_\_\_\_ acres

Draining to ponding area: \_\_\_\_\_ acres

b. Relationships Established

Ponding elevation vs. storage  Yes  No

Ponding elevation vs. gravity flow  Yes  No

Differential head vs. gravity flow  Yes  No

c. The river flow duration curve is enclosed:  Yes  No

d. Specify the discharge capacity of the head pressure conduit: \_\_\_\_\_ cfs

e. Which flooding conditions were analyzed?

- Gravity flow (Interior Watershed)  Yes  No
- Common storm (River Watershed)  Yes  No
- Historical ponding probability  Yes  No
- Coastal wave overtopping  Yes  No

If No for any of the above, attach explanation.

e. Interior drainage has been analyzed based on joint probability of interior and exterior flooding and the capacities of pumping and outlet facilities to provide the established level of flood protection.  Yes  No If No, attach explanation.

g. The rate of seepage through the levee system for the base flood is \_\_\_\_\_ cfs

h. The length of levee system used to drive this seepage rate in item g: \_\_\_\_\_ ft.

**E. LEVEE/FLOODWALL (CONTINUED)**

8. Interior Drainage (continued)

i. Will pumping plants be used for interior drainage?  Yes  No

If Yes, include the number of pumping plants: \_\_\_\_\_ For each pumping plant, list:

	Plant #1	Plant #2
The number of pumps		
The ponding storage capacity		
The maximum pumping rate		
The maximum pumping head		
The pumping starting elevation		
The pumping stopping elevation		
Is the discharge facility protected?		
Is there a flood warning plan?		
How much time is available between warning and flooding?		

Will the operation be automatic?  Yes  No

If the pumps are electric, are there backup power sources?  Yes  No

(Reference: USACE EM-1110-2-3101, 3102, 3103, 3104, and 3105)

Include a copy of supporting documentation of data and analysis. Provide a map showing the flooded area and maximum ponding elevations for all interior watersheds that result in flooding.

9. Other Design Criteria

a. The following items have been addressed as stated:

Liquefaction  is  is not a problem

Hydrocompaction  is  is not a problem

Heave differential movement due to soils of high shrink/swell  is  is not a problem

b. For each of these problems, state the basic facts and corrective action taken:

Attach supporting documentation

c. If the levee/floodwall is new or enlarged, will the structure adversely impact flood levels and/or flow velocities floodside of the structure?  
 Yes  No Attach supporting documentation

d. Sediment Transport Considerations:

Was sediment transport considered?  Yes  No

If Yes, then fill out Section F (Sediment Transport). If No, then attach your explanation for why sediment transport was not considered.

10. Operational Plan And Criteria

a. Are the planned/installed works in full compliance with Part 65.10 of the NFIP Regulations?  Yes  No

b. Does the operation plan incorporate all the provisions for closure devices as required in Paragraph 65.10(c)(1) of the NFIP regulations?  
 Yes  No

c. Does the operation plan incorporate all the provisions for interior drainage as required in Paragraph 65.10(c)(2) of the NFIP regulations?  
 Yes  No If the answer is No to any of the above, please attach supporting documentation.

**E. LEVEE/FLOODWALL (CONTINUED)**

11. Maintenance Plan

Please attach a copy of the formal maintenance plan for the levee/floodwall

12. Operations and Maintenance Plan

Please attach a copy of the formal Operations and Maintenance Plan for the levee/floodwall.

**CERTIFICATION OF THE LEVEE DOCUMENTATION**

This certification is to be signed and sealed by a licensed registered professional engineer authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.10(e) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: \_\_\_\_\_ License No.: \_\_\_\_\_ Expiration Date: \_\_\_\_\_  
Company Name: \_\_\_\_\_ Telephone No.: \_\_\_\_\_ Fax No.: \_\_\_\_\_  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_ E-Mail Address: \_\_\_\_\_

**F. SEDIMENT TRANSPORT**

Flooding Source: \_\_\_\_\_

Name of Structure: \_\_\_\_\_

If there is any indication from historical records that sediment transport (including scour and deposition) can affect the Base Flood Elevation (BFE); and/or based on the stream morphology, vegetative cover, development of the watershed and bank conditions, there is a potential for debris and sediment transport (including scour and deposition) to affect the BFEs, then provide the following information along with the supporting documentation:

Sediment load associated with the base flood discharge: Volume \_\_\_\_\_ acre-feet

Debris load associated with the base flood discharge: Volume \_\_\_\_\_ acre-feet

Sediment transport rate \_\_\_\_\_ (percent concentration by volume)

Method used to estimate sediment transport: \_\_\_\_\_

Most sediment transport formulas are intended for a range of hydraulic conditions and sediment sizes; attach a detailed explanation for using the selected method.

Method used to estimate scour and/or deposition: \_\_\_\_\_

Method used to revise hydraulic or hydrologic analysis (model) to account for sediment transport: \_\_\_\_\_

Please note that bulked flows are used to evaluate the performance of a structure during the base flood; however, FEMA does not map BFEs based on bulked flows.

If a sediment analysis has not been performed, an explanation as to why sediment transport (including scour and deposition) will not affect the BFEs or structures must be provided.

DEPARTMENT OF HOMELAND SECURITY  
FEDERAL EMERGENCY MANAGEMENT AGENCY  
**RIVERINE STRUCTURES FORM**

**O.M.B. NO. 1660-0016**  
**Expires February 28, 2014**

**PAPERWORK BURDEN DISCLOSURE NOTICE**

Public reporting burden for this form is estimated to average 7 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Department of Homeland Security, Federal Emergency Management Agency, 1800 South Bell Street, Arlington, VA 20598-3005, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

**PRIVACY ACT STATEMENT**

**AUTHORITY:** The National Flood Insurance Act of 1968, Public Law 90-448, as amended by the Flood Disaster Protection Act of 1973, Public Law 93-234.

**PRINCIPAL PURPOSE(S):** This information is being collected for the purpose of determining an applicant's eligibility to request changes to National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM).

**ROUTINE USE(S):** The information on this form may be disclosed as generally permitted under 5 U.S.C § 552a(b) of the Privacy Act of 1974, as amended. This includes using this information as necessary and authorized by the routine uses published in DHS/FEMA/NFIP/LOMA-1 National Flood Insurance Program; Letter of Map Amendment (LOMA) February 15, 2006, 71 FR 7990.

**DISCLOSURE:** The disclosure of information on this form is voluntary; however, failure to provide the information requested may delay or prevent FEMA from processing a determination regarding a requested change to a NFIP Flood Insurance Rate Maps (FIRM).

Flooding Source: Happy Canyon Creek

Note: Fill out one form for each flooding source studied.

**A. GENERAL**

Complete the appropriate section(s) for each Structure listed below:

- Channelization.....complete Section B
- Bridge/Culvert.....complete Section C
- Dam.....complete Section D
- Levee/Floodwall.....complete Section E
- Sediment Transport.....complete Section F (if required)

Description Of Modeled Structure

1. Name of Structure: Belford Avenue Bridge  
Type (check one):     Channelization                       Bridge/Culvert                       Levee/Floodwall                       Dam  
Location of Structure: \_\_\_\_\_  
Downstream Limit/Cross Section: 11100  
Upstream Limit/Cross Section: 11180
2. Name of Structure: E-470 Pedestrian Train Crossing  
Type (check one):     Channelization                       Bridge/Culvert                       Levee/Floodwall                       Dam  
Location of Structure: \_\_\_\_\_  
Downstream Limit/Cross Section: 10750  
Upstream Limit/Cross Section: 10810
3. Name of Structure: \_\_\_\_\_  
Type (check one)     Channelization                       Bridge/Culvert                       Levee/Floodwall                       Dam  
Location of Structure: \_\_\_\_\_  
Downstream Limit/Cross Section: \_\_\_\_\_  
Upstream Limit/Cross Section: \_\_\_\_\_

**NOTE: FOR MORE STRUCTURES, ATTACH ADDITIONAL PAGES AS NEEDED.**

B. CHANNELIZATION

Flooding Source: Happy Canyon Creek

Name of Structure: E-470 Pedestrian Trail Crossing

1. Hydraulic Considerations

The channel was designed to carry \_\_\_\_\_ (cfs) and/or the \_\_\_\_\_-year flood.

The design elevation in the channel is based on (check one):

- Subcritical flow
- Critical flow
- Supercritical flow
- Energy grade line

If there is the potential for a hydraulic jump at the following locations, check all that apply and attach an explanation of how the hydraulic jump is controlled without affecting the stability of the channel.

- Inlet to channel
- Outlet of channel
- At Drop Structures
- At Transitions

Other locations (specify): \_\_\_\_\_

2. Channel Design Plans

Attach the plans of the channelization certified by a registered professional engineer, as described in the instructions.

3. Accessory Structures

The channelization includes (check one):

- Levees [Attach Section E (Levee/Floodwall)]
- Drop structures
- Superelevated sections
- Transitions in cross sectional geometry
- Debris basin/detention basin [Attach Section D (Dam/Basin)]
- Energy dissipator
- Weir
- Other (Describe): \_\_\_\_\_

4. Sediment Transport Considerations

Are the hydraulics of the channel affected by sediment transport?  Yes  No

If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation for why sediment transport was not considered.

C. BRIDGE/CULVERT

Flooding Source: Happy Canyon Creek

Name of Structure: E-470 Pedestrian Trail Crossing

1. This revision reflects (check one):

- Bridge/culvert not modeled in the FIS
- Modified bridge/culvert previously modeled in the FIS
- Revised analysis of bridge/culvert previously modeled in the FIS

2. Hydraulic model used to analyze the structure (e.g., HEC-2 with special bridge routine, WSPRO, HY8): HEC-RAS 4.1.0  
If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structures. Attach justification.

3. Attach plans of the structures certified by a registered professional engineer. The plan detail and information should include the following (check the information that has been provided):

- Dimensions (height, width, span, radius, length)
- Distances Between Cross Sections
- Shape (culverts only)
- Erosion Protection
- Material
- Low Chord Elevations – Upstream and Downstream
- Beveling or Rounding
- Top of Road Elevations – Upstream and Downstream
- Wing Wall Angle
- Structure Invert Elevations – Upstream and Downstream
- Skew Angle
- Stream Invert Elevations – Upstream and Downstream
- Cross-Section Locations

4. Sediment Transport Considerations

Are the hydraulics of the structure affected by sediment transport?  Yes  No

If Yes, then fill out Section F (Sediment Transport) of Form 3. If no, then attach an explanation.

**D. DAM/BASIN**

Flooding Source: \_\_\_\_\_  
 Name of Structure: \_\_\_\_\_

1. This request is for (check one):       Existing dam/basin     New dam/basin     Modification of existing dam/basin
2. The dam/basin was designed by (check one):  Federal agency     State agency     Private organization     Local government agency

Name of the agency or organization: \_\_\_\_\_

3. The Dam was permitted as (check one):     Federal Dam                       State Dam

Provide the permit or identification number (ID) for the dam and the appropriate permitting agency or organization

Permit or ID number \_\_\_\_\_ Permitting Agency or Organization \_\_\_\_\_

- a.     Local Government Dam     Private Dam

Provided related drawings, specification and supporting design information.

4. Does the project involve revised hydrology?     Yes     No

If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2).

Was the dam/basin designed using critical duration storm? (must account for the maximum volume of runoff)

- Yes, provide supporting documentation with your completed Form 2.
- No, provide a written explanation and justification for not using the critical duration storm.

5. Does the submittal include debris/sediment yield analysis?     Yes     No

If Yes, then fill out Section F (Sediment Transport). If No, then attach your explanation for why debris/sediment analysis was not considered?

6. Does the Base Flood Elevation behind the dam/basin or downstream of the dam/basin change?     Yes     No

If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2) and complete the table below.

FREQUENCY (% annual chance)	Stillwater Elevation Behind the Dam/Basin	
	FIS	REVISED
10-year (10%)	_____	_____
50-year (2%)	_____	_____
100-year (1%)	_____	_____
500-year (0.2%)	_____	_____
Normal Pool Elevation	_____	_____

7. Please attach a copy of the formal Operation and Maintenance Plan

**E. LEVEE/FLOODWALL**

1. System Elements

a. This Levee/Floodwall analysis is based on (check one):

- upgrading of an existing levee/floodwall system       a newly constructed levee/floodwall system       reanalysis of an existing levee/floodwall system

b. Levee elements and locations are (check one):

- earthen embankment, dike, berm, etc.      Station \_\_\_\_\_ to \_\_\_\_\_  
 structural floodwall      Station \_\_\_\_\_ to \_\_\_\_\_  
 Other (describe): \_\_\_\_\_      Station \_\_\_\_\_ to \_\_\_\_\_

c. Structural Type (check one):     monolithic cast-in place reinforced concrete     reinforced concrete masonry block     sheet piling  
 Other (describe): \_\_\_\_\_

d. Has this levee/floodwall system been certified by a Federal agency to provide protection from the base flood?

- Yes     No

If Yes, by which agency? \_\_\_\_\_

e. Attach certified drawings containing the following information (indicate drawing sheet numbers):

- 1. Plan of the levee embankment and floodwall structures. Sheet Numbers: \_\_\_\_\_
- 2. A profile of the levee/floodwall system showing the Base Flood Elevation (BFE), levee and/or wall crest and foundation, and closure locations for the total levee system. Sheet Numbers: \_\_\_\_\_
- 3. A profile of the BFE, closure opening outlet and inlet invert elevations, type and size of opening, and kind of closure. Sheet Numbers: \_\_\_\_\_
- 4. A layout detail for the embankment protection measures. Sheet Numbers: \_\_\_\_\_
- 5. Location, layout, and size and shape of the levee embankment features, foundation treatment, Floodwall structure, closure structures, and pump stations. Sheet Numbers: \_\_\_\_\_

2. Freeboard

a. The minimum freeboard provided above the BFE is:

Riverine

- 3.0 feet or more at the downstream end and throughout  Yes  No
- 3.5 feet or more at the upstream end  Yes  No
- 4.0 feet within 100 feet upstream of all structures and/or constrictions  Yes  No

Coastal

- 1.0 foot above the height of the one percent wave associated with the 1%-annual-chance stillwater surge elevation or maximum wave runup (whichever is greater).  Yes  No
- 2.0 feet above the 1%-annual-chance stillwater surge elevation  Yes  No

Please note, occasionally exceptions are made to the minimum freeboard requirement. If an exception is requested, attach documentation addressing Paragraph 65.10(b)(1)(ii) of the NFIP Regulations.

If No is answered to any of the above, please attach an explanation.

b. Is there an indication from historical records that ice-jamming can affect the BFE?  Yes  No

If Yes, provide ice-jam analysis profile and evidence that the minimum freeboard discussed above still exists.

3. Closures

a. Openings through the levee system (check one):  exists  does not exist

If opening exists, list all closures:

Channel Station	Left or Right Bank	Opening Type	Highest Elevation for Opening Invert	Type of Closure Device

(Extend table on an added sheet as needed and reference)

Note: Geotechnical and geologic data

In addition to the required detailed analysis reports, data obtained during field and laboratory investigations and used in the design analysis for the following system features should be submitted in a tabulated summary form. (Reference U.S. Army Corps of Engineers [USACE] EM-1110-2-1906 Form 2086.)

4. Embankment Protection

- a. The maximum levee slope land side is: \_\_\_\_\_
- b. The maximum levee slope flood side is: \_\_\_\_\_
- c. The range of velocities along the levee during the base flood is: \_\_\_\_\_ (min.) to \_\_\_\_\_ (max.)
- d. Embankment material is protected by (describe what kind): \_\_\_\_\_
- e. Riprap Design Parameters (check one):       Velocity       Tractive stress  
Attach references

Reach	Sideslope	Flow Depth	Velocity	Curve or Straight	Stone Riprap			Depth of Toedown
					D <sub>100</sub>	D <sub>50</sub>	Thickness	
Sta    to								
Sta    to								
Sta    to								
Sta    to								
Sta    to								
Sta    to								

(Extend table on an added sheet as needed and reference each entry)

- f. Is a bedding/filter analysis and design attached?     Yes     No
- g. Describe the analysis used for other kinds of protection used (include copies of the design analysis):

Attach engineering analysis to support construction plans.

5. Embankment And Foundation Stability

- a. Identify locations and describe the basis for selection of critical location for analysis:  
\_\_\_\_\_
  - Overall height: Sta.: \_\_\_\_\_, height \_\_\_\_\_ ft.
  - Limiting foundation soil strength:  
 Strength  $\phi$  = \_\_\_\_\_ degrees, c = \_\_\_\_\_ psf  
 Slope: SS = \_\_\_\_\_ (h) to \_\_\_\_\_ (v)  
 (Repeat as needed on an added sheet for additional locations)
- b. Specify the embankment stability analysis methodology used (e.g., circular arc, sliding block, infinite slope, etc.):  
\_\_\_\_\_
- c. Summary of stability analysis results:

**E. LEVEE/FLOODWALL (CONTINUED)**

5. Embankment And Foundation Stability (continued)

Case	Loading Conditions	Critical Safety Factor	Criteria (Min.)
I	End of construction		1.3
II	Sudden drawdown		1.0
III	Critical flood stage		1.4
IV	Steady seepage at flood stage		1.4
VI	Earthquake (Case I)		1.0

(Reference: USACE EM-1110-2-1913 Table 6-1)

- d. Was a seepage analysis for the embankment performed?  Yes  No  
 If Yes, describe methodology used:
- e. Was a seepage analysis for the foundation performed?  Yes  No
- f. Were uplift pressures at the embankment landside toe checked?  Yes  No
- g. Were seepage exit gradients checked for piping potential?  Yes  No
- h. The duration of the base flood hydrograph against the embankment is \_\_\_\_\_ hours.

Attach engineering analysis to support construction plans.

6. Floodwall And Foundation Stability

- a. Describe analysis submittal based on Code (check one):  UBC (1988)  Other (specify): \_\_\_\_\_
- b. Stability analysis submitted provides for:  Overturning  Sliding If not, explain: \_\_\_\_\_
- c. Loading included in the analyses were:  Lateral earth @  $P_A =$  \_\_\_\_\_ psf;  $P_p =$  \_\_\_\_\_ psf  
 Surcharge-Slope @ \_\_\_\_\_,  surface \_\_\_\_\_ psf  
 Wind @  $P_w =$  \_\_\_\_\_ psf  
 Seepage (Uplift); \_\_\_\_\_  Earthquake @  $P_{eq} =$  \_\_\_\_\_ %g
- 1%-annual-chance significant wave height: \_\_\_\_\_ ft.  
 1%-annual-chance significant wave period: \_\_\_\_\_ sec.
- d. Summary of Stability Analysis Results: Factors of Safety.  
 Itemize for each range in site layout dimension and loading condition limitation for each respective reach.

Loading Condition	Criteria (Min)		Sta	To	Sta	To
	Overturn	Sliding	Overturn	Sliding	Overturn	Sliding
Dead & Wind	1.5	1.5				
Dead & Soil	1.5	1.5				
Dead, Soil, Flood, & Impact	1.5	1.5				
Dead, Soil, & Seismic	1.3	1.3				

(Ref: FEMA 114 Sept 1986; USACE EM 1110-2-2502)  
Note: (Extend table on an added sheet as needed and reference)

**E. LEVEE/FLOODWALL (CONTINUED)**

6. Floodwall And Foundation Stability (continued)

e. Foundation bearing strength for each soil type:

Bearing Pressure	Sustained Load (psf)	Short Term Load (psf)
Computed design maximum		
Maximum allowable		

f. Foundation scour protection  is,  is not provided. If provided, attach explanation and supporting documentation:

Attach engineering analysis to support construction plans.

7. Settlement

a. Has anticipated potential settlement been determined and incorporated into the specified construction elevations to maintain the established freeboard margin?  Yes  No

b. The computed range of settlement is \_\_\_\_\_ ft. to \_\_\_\_\_ ft.

c. Settlement of the levee crest is determined to be primarily from :  Foundation consolidation  Embankment compression  
 Other (Describe): \_\_\_\_\_

d. Differential settlement of floodwalls  has  has not been accommodated in the structural design and construction.

Attach engineering analysis to support construction plans.

8. Interior Drainage

a. Specify size of each interior watershed:

Draining to pressure conduit: \_\_\_\_\_ acres

Draining to ponding area: \_\_\_\_\_ acres

b. Relationships Established

Ponding elevation vs. storage  Yes  No

Ponding elevation vs. gravity flow  Yes  No

Differential head vs. gravity flow  Yes  No

c. The river flow duration curve is enclosed:  Yes  No

d. Specify the discharge capacity of the head pressure conduit: \_\_\_\_\_ cfs

e. Which flooding conditions were analyzed?

- Gravity flow (Interior Watershed)  Yes  No
- Common storm (River Watershed)  Yes  No
- Historical ponding probability  Yes  No
- Coastal wave overtopping  Yes  No

If No for any of the above, attach explanation.

e. Interior drainage has been analyzed based on joint probability of interior and exterior flooding and the capacities of pumping and outlet facilities to provide the established level of flood protection.  Yes  No If No, attach explanation.

g. The rate of seepage through the levee system for the base flood is \_\_\_\_\_ cfs

h. The length of levee system used to drive this seepage rate in item g: \_\_\_\_\_ ft.

**E. LEVEE/FLOODWALL (CONTINUED)**

8. Interior Drainage (continued)

i. Will pumping plants be used for interior drainage?  Yes  No

If Yes, include the number of pumping plants: \_\_\_\_\_ For each pumping plant, list:

	Plant #1	Plant #2
The number of pumps		
The ponding storage capacity		
The maximum pumping rate		
The maximum pumping head		
The pumping starting elevation		
The pumping stopping elevation		
Is the discharge facility protected?		
Is there a flood warning plan?		
How much time is available between warning and flooding?		

Will the operation be automatic?  Yes  No

If the pumps are electric, are there backup power sources?  Yes  No

(Reference: USACE EM-1110-2-3101, 3102, 3103, 3104, and 3105)

Include a copy of supporting documentation of data and analysis. Provide a map showing the flooded area and maximum ponding elevations for all interior watersheds that result in flooding.

9. Other Design Criteria

a. The following items have been addressed as stated:

Liquefaction  is  is not a problem

Hydrocompaction  is  is not a problem

Heave differential movement due to soils of high shrink/swell  is  is not a problem

b. For each of these problems, state the basic facts and corrective action taken:

Attach supporting documentation

c. If the levee/floodwall is new or enlarged, will the structure adversely impact flood levels and/or flow velocities floodside of the structure?  
 Yes  No Attach supporting documentation

d. Sediment Transport Considerations:

Was sediment transport considered?  Yes  No

If Yes, then fill out Section F (Sediment Transport). If No, then attach your explanation for why sediment transport was not considered.

10. Operational Plan And Criteria

a. Are the planned/installed works in full compliance with Part 65.10 of the NFIP Regulations?  Yes  No

b. Does the operation plan incorporate all the provisions for closure devices as required in Paragraph 65.10(c)(1) of the NFIP regulations?  
 Yes  No

c. Does the operation plan incorporate all the provisions for interior drainage as required in Paragraph 65.10(c)(2) of the NFIP regulations?  
 Yes  No If the answer is No to any of the above, please attach supporting documentation.

**E. LEVEE/FLOODWALL (CONTINUED)**

11. Maintenance Plan

Please attach a copy of the formal maintenance plan for the levee/floodwall

12. Operations and Maintenance Plan

Please attach a copy of the formal Operations and Maintenance Plan for the levee/floodwall.

**CERTIFICATION OF THE LEVEE DOCUMENTATION**

This certification is to be signed and sealed by a licensed registered professional engineer authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.10(e) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: \_\_\_\_\_ License No.: \_\_\_\_\_ Expiration Date: \_\_\_\_\_  
Company Name: \_\_\_\_\_ Telephone No.: \_\_\_\_\_ Fax No.: \_\_\_\_\_  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_ E-Mail Address: \_\_\_\_\_

**F. SEDIMENT TRANSPORT**

Flooding Source: \_\_\_\_\_

Name of Structure: \_\_\_\_\_

If there is any indication from historical records that sediment transport (including scour and deposition) can affect the Base Flood Elevation (BFE); and/or based on the stream morphology, vegetative cover, development of the watershed and bank conditions, there is a potential for debris and sediment transport (including scour and deposition) to affect the BFEs, then provide the following information along with the supporting documentation:

Sediment load associated with the base flood discharge: Volume \_\_\_\_\_ acre-feet

Debris load associated with the base flood discharge: Volume \_\_\_\_\_ acre-feet

Sediment transport rate \_\_\_\_\_ (percent concentration by volume)

Method used to estimate sediment transport: \_\_\_\_\_

Most sediment transport formulas are intended for a range of hydraulic conditions and sediment sizes; attach a detailed explanation for using the selected method.

Method used to estimate scour and/or deposition: \_\_\_\_\_

Method used to revise hydraulic or hydrologic analysis (model) to account for sediment transport: \_\_\_\_\_

Please note that bulked flows are used to evaluate the performance of a structure during the base flood; however, FEMA does not map BFEs based on bulked flows.

If a sediment analysis has not been performed, an explanation as to why sediment transport (including scour and deposition) will not affect the BFEs or structures must be provided.



RECEIVED

APR 14 2016

SMITH ENVIRONMENTAL & ENGINEERING  
*Delivering Sustainable Environmental Solutions*

<b>U.S. FISH AND WILDLIFE SERVICE</b>	
<input checked="" type="checkbox"/> NO CONCERNS	
<input type="checkbox"/> CONCUR NOT LIKELY TO ADVERSELY AFFECT	
<input type="checkbox"/> NO COMMENT	
<i>Drue L. DeBerry</i>	<i>5/9/16</i>
<b>DRUE L. DEBERRY</b>	<b>DATE</b>
<b>ACTING COLORADO FIELD SUPERVISOR</b>	

## 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



**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 6<sup>th</sup> 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).



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*), reedtop (*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
<b>BIRDS</b>		
Least Tern ( <i>Sterna antillarum</i> )	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 ( <i>Strix occidentalis lucida</i> )	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 ( <i>Charadrius melodus</i> )	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 ( <i>Grus americana</i> )	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.
<b>FISH</b>		
Greenback cutthroat trout ( <i>Oncorhynchus clarki stomias</i> )	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 ( <i>Scaphirhynchus albus</i> )	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.
<b>MAMMALS</b>		
Preble's meadow jumping mouse ( <i>Zapus hudsonius preblei</i> )	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 ( <i>Zapus hudsonius preblei</i> ) (Urban Drainage and Flood Control District 2010). Therefore SMITH believes the proposed Project will have no effect on this species.
<b>PLANTS</b>		
Colorado butterfly plant ( <i>Gaura neomexicana</i> var. <i>coloradensis</i> )	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 ( <i>Spiranthes diluvialis</i> )	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

<i>(Platanthera praeclara)</i>	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](http://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



**Photo 1.** 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.

July 24, 2017

Platte Valley Commercial Corp.  
4900 Main St.  
Kansas City, MO. 64112

**Re: Notification of proposed changes to the FEMA Flood Insurance Rate Map (FIRM) and proposed changes to the floodway for Happy Canyon Creek associated with the Belford Avenue Bridge and Happy Canyon Creek Project.**

**Notice for Property: No Address, Parcel #: 2233-050-00-009**

To Whom It May Concern,

The Flood Insurance Rate Map (FIRM) for a community depicts the Special Flood Hazard Area (SFHA), the area which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The floodway is the portion of the floodplain that includes the channel of a river or other watercourse and the adjacent land area that must be reserved in order to discharge the 1% annual chance (base) flood without cumulatively increasing the water-surface elevation by more than a designated height. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

Manhard Consulting Ltd. is applying for a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA) to revise FIRM's 08035C0062G and 08035C0066G for the Town of Parker, Douglas County, Colorado. Manhard Consulting Ltd is proposing a new bridge structure over Happy Canyon Creek that will connect Belford Avenue from S. Peoria St. to the west to S. Chambers Road to the east. The Belford Ave. bridge structure will be built in phases. The first phase includes the eastbound roadway lanes, sidewalk and southern half of the bridge structure. A future phase will include the westbound lanes, sidewalk and remaining north half of the bridge structure.

The proposed project will result in increases in the 1% annual chance (base) water-surface elevations for a portion of Happy Canyon Creek, when comparing existing conditions to proposed conditions. A rise does occur on your property.

Once the project has been completed, a Letter of Map Revision (LOMR) request should be submitted that will, in part, revise the following flood hazards along Happy Canyon Creek.

1. The floodway will be revised from downstream (north) of E-470 to north of Filbert Avenue along Happy Canyon Creek.
2. Base Flood Elevations (BFEs) will both increase and decrease along Happy Canyon Creek. On your property, the BFEs will decrease.
3. The SFHA will both increase and decrease along Happy Canyon Creek. On your property, the SFHA will decrease about 0.1 feet.

This letter is to inform you of the proposed project that may affect flood elevations on your property at Parcel #: 2233-050-00-009 located in Douglas County, Colorado. This letter is also to inform you of the potential changes to the effective flood hazard information that would result after the project is completed and a LOMR request is submitted to FEMA.

Maps and detailed analysis of the proposed flood hazard revisions can be reviewed at the Town of Parker at 20120 E. Mainstreet, Parker, CO 80138. If you have any questions or concerns about the proposed project or its effect on your property, you may contact Mr. Rick Moore at either 303-708-

0500 or by email at [rick.moore@manhard.com](mailto:rick.moore@manhard.com) or Mr. Jacob James at the Town of Parker at 303-840-9546.

Sincerely,

Rick Moore, P.E.  
Project Manager

July 24, 2017

E470 Public Highway Authority  
22470 E. 6<sup>th</sup> Pkwy STE 100  
Aurora, CO. 80018

**Re: Notification of proposed changes to the FEMA Flood Insurance Rate Map (FIRM) and proposed changes to the floodway for Happy Canyon Creek associated with the Belford Avenue Bridge and Happy Canyon Creek Project.**

**Notice for Property: No Address, Parcel #: 2233-064-99-002**

To Whom It May Concern,

The Flood Insurance Rate Map (FIRM) for a community depicts the Special Flood Hazard Area (SFHA), the area which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The floodway is the portion of the floodplain that includes the channel of a river or other watercourse and the adjacent land area that must be reserved in order to discharge the 1% annual chance (base) flood without cumulatively increasing the water-surface elevation by more than a designated height. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

Manhard Consulting Ltd. is applying for a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA) to revise FIRM's 08035C0062G and 08035C0066G for the Town of Parker, Douglas County, Colorado. Manhard Consulting Ltd is proposing a new bridge structure over Happy Canyon Creek that will connect Belford Avenue from S. Peoria St. to the west to S. Chambers Road to the east. The Belford Ave. bridge structure will be built in phases. The first phase includes the eastbound roadway lanes, sidewalk and southern half of the bridge structure. A future phase will include the westbound lanes, sidewalk and remaining north half of the bridge structure.

The proposed project will result in increases in the 1% annual chance (base) water-surface elevations for a portion of Happy Canyon Creek, when comparing existing conditions to proposed conditions. A rise does occur on your property.

Once the project has been completed, a Letter of Map Revision (LOMR) request should be submitted that will, in part, revise the following flood hazards along Happy Canyon Creek.

1. The floodway will be revised from downstream (north) of E-470 to north of Filbert Avenue along Happy Canyon Creek.
2. Base Flood Elevations (BFEs) will both increase and decrease along Happy Canyon Creek. On your property, the BFEs will decrease.
3. The SFHA will both increase and decrease along Happy Canyon Creek. On your property, the SFHA will decrease about 0.1 feet.

This letter is to inform you of the proposed project that may affect flood elevations on your property at Parcel #: 2233-064-99-002 located in Douglas County, Colorado. This letter is also to inform you of the potential changes to the effective flood hazard information that would result after the project is completed and a LOMR request is submitted to FEMA.

Maps and detailed analysis of the proposed flood hazard revisions can be reviewed at the Town of Parker at 20120 E. Mainstreet, Parker, CO 80138. If you have any questions or concerns about the proposed project or its effect on your property, you may contact Mr. Rick Moore at either 303-708-

0500 or by email at [rick.moore@manhard.com](mailto:rick.moore@manhard.com) or Mr. Jacob James at the Town of Parker at 303-840-9546.

Sincerely,

Rick Moore, P.E.  
Project Manager

July 24, 2017

470 Compark LLC  
C/O MPV Compark Management LLC 290  
Fillmore St. STE 2  
Denver, CO. 80206

**Re: Notification of proposed changes to the FEMA Flood Insurance Rate Map (FIRM) and proposed changes to the floodway for Happy Canyon Creek associated with the Belford Avenue Bridge and Happy Canyon Creek Project.**

**Notice for Property: No Address, Parcel #: 2233-064-00-012**

To Whom It May Concern,

The Flood Insurance Rate Map (FIRM) for a community depicts the Special Flood Hazard Area (SFHA), the area which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The floodway is the portion of the floodplain that includes the channel of a river or other watercourse and the adjacent land area that must be reserved in order to discharge the 1% annual chance (base) flood without cumulatively increasing the water-surface elevation by more than a designated height. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

Manhard Consulting Ltd. is applying for a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA) to revise FIRM's 08035C0062G and 08035C0066G for the Town of Parker, Douglas County, Colorado. Manhard Consulting Ltd is proposing a new bridge structure over Happy Canyon Creek that will connect Belford Avenue from S. Peoria St. to the west to S. Chambers Road to the east. The Belford Ave. bridge structure will be built in phases. The first phase includes the eastbound roadway lanes, sidewalk and southern half of the bridge structure. A future phase will include the westbound lanes, sidewalk and remaining north half of the bridge structure.

The proposed project will result in increases in the 1% annual chance (base) water-surface elevations for a portion of Happy Canyon Creek, when comparing existing conditions to proposed conditions. A rise does occur on your property.

Once the project has been completed, a Letter of Map Revision (LOMR) request should be submitted that will, in part, revise the following flood hazards along Happy Canyon Creek.

1. The floodway will be revised from downstream (north) of E-470 to north of Filbert Avenue along Happy Canyon Creek.
2. Base Flood Elevations (BFEs) will both increase and decrease along Happy Canyon Creek. On your property, the BFEs will both increase and decrease.
3. The SFHA will both increase and decrease along Happy Canyon Creek. On your property, the SFHA will both increase about 0.6 feet and decrease about 1.1 feet.

This letter is to inform you of the proposed project that may affect flood elevations on your property at Parcel #: 2233-064-00-012 located in Douglas County, Colorado. This letter is also to inform you of the potential changes to the effective flood hazard information that would result after the project is completed and a LOMR request is submitted to FEMA.

Maps and detailed analysis of the proposed flood hazard revisions can be reviewed at the Town of Parker at 20120 E. Mainstreet, Parker, CO 80138. If you have any questions or concerns about the proposed project or its effect on your property, you may contact Mr. Rick Moore at either 303-708-

0500 or by email at [rick.moore@manhard.com](mailto:rick.moore@manhard.com) or Mr. Jacob James at the Town of Parker at 303-840-9546.

Sincerely,

Rick Moore, P.E.  
Project Manager

July 24, 2017

Compark 190 LLC  
Attn: Steve Gruenler  
4600 S. Ulster St. STE 1400  
Denver, CO. 80237

**Re: Notification of proposed changes to the FEMA Flood Insurance Rate Map (FIRM) and proposed changes to the floodway for Happy Canyon Creek associated with the Belford Avenue Bridge and Happy Canyon Creek Project.**

**Notice for Property: No Address, Parcel #: 2233-053-00-001**

To Whom It May Concern,

The Flood Insurance Rate Map (FIRM) for a community depicts the Special Flood Hazard Area (SFHA), the area which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The floodway is the portion of the floodplain that includes the channel of a river or other watercourse and the adjacent land area that must be reserved in order to discharge the 1% annual chance (base) flood without cumulatively increasing the water-surface elevation by more than a designated height. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

Manhard Consulting Ltd. is applying for a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA) to revise FIRM's 08035C0062G and 08035C0066G for the Town of Parker, Douglas County, Colorado. Manhard Consulting Ltd is proposing a new bridge structure over Happy Canyon Creek that will connect Belford Avenue from S. Peoria St. to the west to S. Chambers Road to the east. The Belford Ave. bridge structure will be built in phases. The first phase includes the eastbound roadway lanes, sidewalk and southern half of the bridge structure. A future phase will include the westbound lanes, sidewalk and remaining north half of the bridge structure.

The proposed project will result in increases in the 1% annual chance (base) water-surface elevations for a portion of Happy Canyon Creek, when comparing existing conditions to proposed conditions. A rise does occur on your property.

Once the project has been completed, a Letter of Map Revision (LOMR) request should be submitted that will, in part, revise the following flood hazards along Happy Canyon Creek.

1. The floodway will be revised from downstream (north) of E-470 to north of Filbert Avenue along Happy Canyon Creek.
2. Base Flood Elevations (BFEs) will both increase and decrease along Happy Canyon Creek. On your property, the BFEs will both increase and decrease.
3. The SFHA will both increase and decrease along Happy Canyon Creek. On your property, the SFHA will both increase about 0.6 feet and decrease about 1.1 feet.

This letter is to inform you of the proposed project that may affect flood elevations on your property at Parcel #: 2233-053-00-001 located in Douglas County, Colorado. This letter is also to inform you of the potential changes to the effective flood hazard information that would result after the project is completed and a LOMR request is submitted to FEMA.

Maps and detailed analysis of the proposed flood hazard revisions can be reviewed at the Town of Parker at 20120 E. Mainstreet, Parker, CO 80138. If you have any questions or concerns about the proposed project or its effect on your property, you may contact Mr. Rick Moore at either 303-708-

0500 or by email at [rick.moore@manhard.com](mailto:rick.moore@manhard.com) or Mr. Jacob James at the Town of Parker at 303-840-9546.

Sincerely,

Rick Moore, P.E.  
Project Manager



## UDFCD DLOMC Submittal - BFE Comparison Table

<b>Project Name :</b>	<b>115360-01 Compark/Belford Avenue</b>
<b>Flooding Source:</b>	<b>Happy Canyon Creek</b>
<b>Company:</b>	<b>Felsburg Holt &amp; Ullevig</b>
<b>Completed By:</b>	<b>ZJG</b>

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	-	5766.4	-	-	-	0.1	-
-	10326	10326	-	10326	10326	-	-	5768.3	-	5768.3	-	-	-	-0.1	-
-	10548	10548	-	10548	10548	-	-	5770.4	-	5770.4	-	-	-	0.0	-
-	10595	10597	-	10595	10597	-	-	5770.1	-	5770.1	-	-	-	0.0	-
-	10679	10691	-	10679	10691	-	-	5771.2	-	5771.2	-	-	-	0.0	-
-	10725	10735	-	10725	10735	-	-	5772.8	-	5773.1	-	-	-	0.3	-
-	-	-	-	10750	10764	-	-	-	-	5773.4	-	-	-	-	-
-	10775	10786	-	-	-	-	-	5773.3	-	-	-	-	-	-	-
-	-	-	-	10810	10823	-	-	-	-	5773.5	-	-	-	-	-
-	-	-	-	10819	10833	-	-	-	-	5773.5	-	-	-	-	-
-	-	-	-	10825	10838	-	-	-	-	5773.6	-	-	-	-	-
-	10842	10856	-	-	-	-	-	5773.0	-	-	-	-	-	-	-
-	10900	10922	-	10900	10915	-	-	5773.3	-	5773.4	-	-	-	0.1	-
-	10974	10995	-	10974	10989	-	-	5773.0	-	5773.4	-	-	-	0.4	-
-	11100	11050	-	11100	11043	-	-	5772.9	-	5773.6	-	-	-	0.6	-
-	11153	11187	-	-	-	-	-	5774.0	-	-	-	-	-	-	-
-	11180	11230	-	11180	11215	-	-	5773.8	-	5774.4	-	-	-	0.6	-
-	11280	11321	-	11280	11312	-	-	5774.9	-	5774.5	-	-	-	-0.3	-
-	11370	11424	-	11370	11411	-	-	5775.3	-	5774.9	-	-	-	-0.4	-
-	11385	11440	-	11385	11426	-	-	5775.4	-	5775.0	-	-	-	-0.5	-
-	11400	11458	-	11400	11441	-	-	5775.6	-	5775.1	-	-	-	-0.5	-
-	11410	11465	-	11410	11447	-	-	5775.6	-	5775.2	-	-	-	-0.4	-
11320 (F)	11494	11544	-	11494	11526	5776.7	5776.7	5777.2	-	5776.0	0.0	0.4	-	-1.1	-0.7
-	11620	11680	-	11620	11662	-	-	5778.1	-	5777.8	-	-	-	-0.3	-
-	11772	11836	-	-	-	-	-	5778.2	-	-	-	-	-	-	-
-	-	-	-	11800	11979	-	-	-	-	5777.9	-	-	-	-	-
-	-	-	-	11830	-	-	-	-	-	5778.2	-	-	-	-	-
-	-	-	-	11835	12011	-	-	-	-	5778.2	-	-	-	-	-
-	11959	12030	-	11959	-	-	-	5779.9	-	5779.9	-	-	-	-	-
-	12129	12213	-	12129	12194	-	-	5781.6	-	5781.6	-	-	-	0.0	-
-	12388	12478	-	12388	12460	-	-	5782.2	-	5782.3	-	-	-	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	-	5783.7	-	-	-	0.0	-
-	12541	12631	-	12541	12613	-	-	5784.2	-	5784.2	-	-	-	0.0	-
12605 (G)	12694	12777	-	12694	12759	5784.8	5784.8	5784.0	-	5783.9	0.0	-0.8	-	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 LOMC AGREEMENT TABLE

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

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

Page: 1 of 1  
 Date: 7/24/2017

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!	399	397	2	399	397	2	*
		10157	45	45	0%	45	45	0%	186	182	4	186	182	4	*
D/S XS - E-470 Bridge		10326	169	169	0%	214	214	0%	90	91	0	90	91	0	*
U/S XS - E-470 Bridge		10548	223	223	0%	437	437	0%	116	116	0	116	116	0	*
		10595	46	48	4%	484	486	0%	100	101	1	100	101	1	*
		10679	94	94	0%	578	580	0%	96	96	0	96	96	0	*
		10725	43	44	2%	620	623	1%	138	138	1	138	138	1	*
D/S XS - E-470 Trail Crossing		10750	29	29	0%	650	653	1%	188	190	2	188	190	2	*
U/S XS - E-470 Trail Crossing		10810	59	59	0%	708	711	0%	239	236	3	239	236	3	*
		10819	9	10	14%	717	722	1%	247	244	3	247	244	3	*
		10825	6	5	11%	723	727	1%	241	238	4	241	238	4	*
		10900	77	76	1%	800	803	0%	196	199	3	196	199	3	*
		10974	74	74	0%	874	877	0%	161	161	1	161	161	1	*
D/S XS - Belford Avenue		11100	54	54	0%	928	931	0%	154	154	0	154	154	0	*
U/S XS - Belford Avenue		11180	168	169	0%	1097	1100	0%	165	160	5	165	160	5	*
		11280	87	86	1%	1183	1186	0%	161	166	5	161	166	5	*
		11370	66	66	0%	1249	1252	0%	153	153	1	153	153	1	*
		11385	15	15	0%	1264	1267	0%	141	141	0	141	141	0	*
		11400	15	15	0%	1279	1282	0%	142	142	0	142	142	0	*
		11410	6	6	0%	1285	1288	0%	141	141	0	141	141	0	*
		11494	128	129	0%	1414	1417	0%	117	117	0	117	117	0	*
		11620	136	136	0%	1550	1552	0%	203	202	1	203	202	1	*
		11800	179	179	0%	1729	1732	0%	187	188	1	187	188	1	*
		11830	30	35	14%	1759	1767	0%	191	193	2	191	193	2	*
		11835	6	6	0%	1765	1773	0%	190	194	4	190	194	4	*
		11959	130	130	0%	1895	1903	0%	192	192	0	192	192	0	*
		12129	182	182	0%	2077	2085	0%	277	277	0	277	277	0	*
		12388	264	266	1%	2341	2351	0%	201	206	5	201	206	5	*
		12400	11	11	0%	2352	2362	0%	211	216	5	211	216	5	*
		12430	30	30	0%	2382	2392	0%	279	278	1	279	278	1	*
		12436	6	6	0%	2388	2398	0%	288	287	1	288	287	1	*
		12541	105	105	0%	2493	2504	0%	478	478	0	478	478	0	*
		12694	153	146	4%	2646	2650	0%	399	401	2	399	401	2	*
ACCEPTABLE TOLERANCES =			+/- 5% of Model			+/- 5% of Model			+/- 25 Feet						

\* - Floodway = Floodplain



Vratio

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

$$V_{shear} = V_* = (g y_s S)^{1/2}$$

$$V_{*100} = (32.16 * 8.49 * 0.002589)^{1/2} = 0.84$$

$$V_{*500} = (32.16 * 11.45 * 0.00166)^{1/2} = 0.78$$

d50 size = 0.005 ft (1.5 mm)

$$V_{fall} = w = 0.7$$

$$V_{ratio100} = V_{*100} / w = 0.84 / 0.7 = 1.2$$

$$V_{ratio500} = V_{*500} / w = 0.78 / 0.7 = 1.1$$

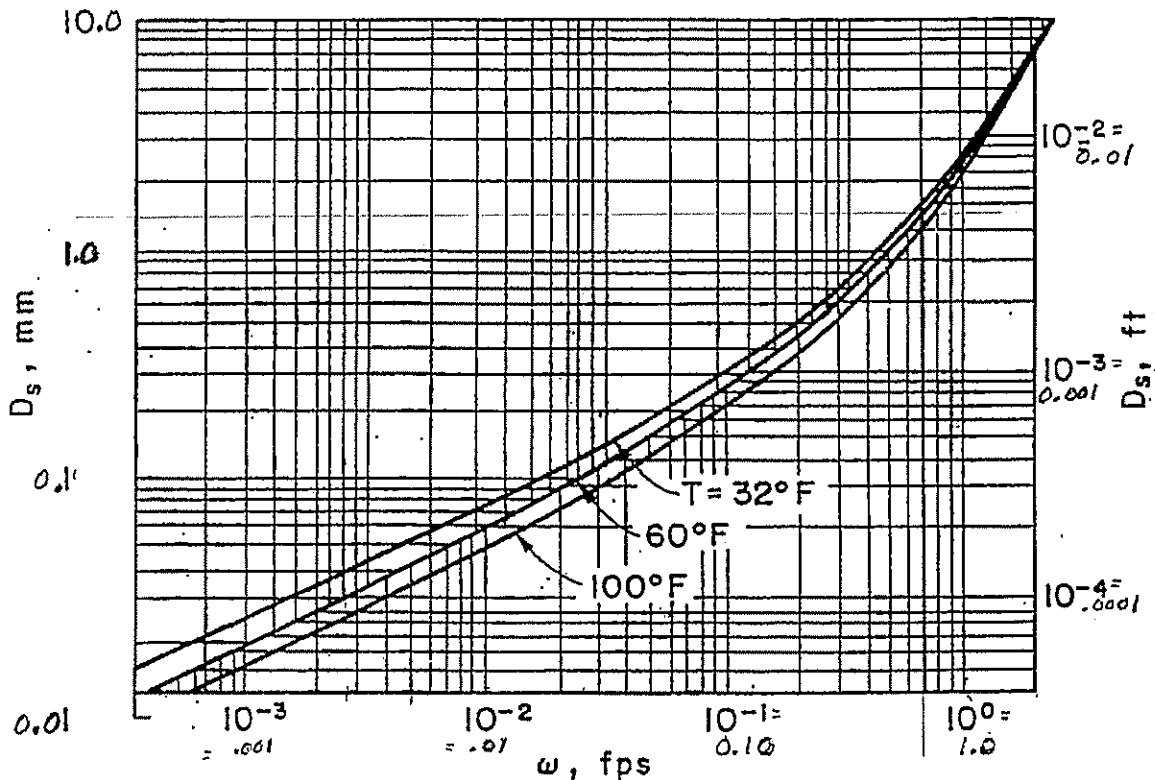


Figure 3. Fall Velocity of Sand-Sized Particles.

Determine if Contraction Scour is live bed or clear water

$$V_c = \frac{\text{Critical Velocity}}{11.52} y_1^{1/6} D_{50}^{1/3}$$

Upstream flow depth

$$V_{c100} = \frac{11.17}{11.52} \times \frac{8.49^{1/6}}{1} \times \frac{0.005^{1/3}}{1} = 2.73$$

$$V_{100 \text{ main channel}} = 8.21 \therefore \text{Live Bed Scour}$$

If  $V_{c100} < V_{100 \text{ MC}}$  then Live Bed Scour

If  $V_{c100} > V_{100 \text{ MC}}$  then Clear Water

$$V_{c500} = \frac{11.17}{11.52} \times \frac{11.45^{1/6}}{1} \times \frac{0.005^{1/3}}{1} = 2.87$$

$$V_{500 \text{ MC}} = 8.24 \therefore \text{Live Bed Scour}$$

CLEAR WATER SCOUR

Avg. Scour Depth  $Y_s = \left[ \frac{Q^2}{120 D_m^{2/3} W^2} \right]^{3/7} - Y_1$

Q bridge  
depth of flow in channel  
bottom width of bridge less piers (low chord)  
 $1.25 D_{50} = 1.25 * \underline{\hspace{1cm}} = \underline{\hspace{1cm}}$

$Y_{s100} = \left[ \frac{Q^2}{120 * \underline{\hspace{1cm}}^{2/3} \underline{\hspace{1cm}}^2} \right]^{3/7} - \underline{\hspace{1cm}} = \underline{\hspace{1cm}}$  ft.

**DOES NOT APPLY**

$Y_{s500} = \left[ \frac{Q^2}{120 * \underline{\hspace{1cm}}^{2/3} \underline{\hspace{1cm}}^2} \right]^{3/7} - \underline{\hspace{1cm}} = \underline{\hspace{1cm}}$  ft.

LIVE BED SCOUR

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

Flow in cont. main channel which is often Q<sub>total</sub>  
Avg. bottom width of the main channel at approach cross section  
Avg. depth in upstream main channel  
Flow in approach main channel that transports sediment  
Avg. bottom width of the contracted section.

V*/lw	K <sub>1</sub>
< 0.5	0.59
0.5-2.0	0.64
> 2.0	0.69

$Y_{z(100)} = \left\{ \frac{8303}{8027} \right\}^{0.857} * \left\{ \frac{160}{145} \right\}^{0.64} * 8.49 = 9.31$

$Y_s = Y_2 - Y_1 = 9.31 - 8.49 = 0.82'$

$Y_{z(500)} = \left\{ \frac{12024}{10913} \right\}^{0.857} * \left\{ \frac{160}{145} \right\}^{0.64} * 11.45 = 13.25$

$Y_s = Y_2 - Y_1 = 13.25 - 11.45 = 1.8'$

Contraction Scour  
100 yr =  $\frac{0.82'}{\underline{\hspace{1cm}}}$   
500 yr =  $\frac{1.8'}{\underline{\hspace{1cm}}}$

Clear Water OR  
Live-Bed Scour at Abutments

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

(To ineffective flow boundary)  
 length of Abutment  
 Projected Normal to flow  
 Approach  
 Froude No.

Avg Depth in floodplain  
 Abutment coefficient  
 Coefficient of abutment angle  
 Avg Depth in floodplain  
 $K_2 = (90/90)^{0.13}$

Vert. wall abut.	$K=1.00$
" " "	$K=0.92$
with wing walls SP11 through abut.	$K=0.55$
	$K_2 = (90/90)^{0.13}$
	$K_2 = (90/90)^{0.13} = 1.0$

LEFT ABUTMENT

RIGHT ABUTMENT

$$y_{s/100} = \frac{4.91}{100} \left[ 2.27 * 1.0 * 1.0 * \left( \frac{14}{4.91} \right)^{0.43} * \frac{0.7}{0.7} + 1 \right]$$

= 18.98

$$y_{s/100} = \frac{4.91}{100} \left[ 2.27 * 1.0 * 1.0 * \left( \frac{12}{4.91} \right)^{0.43} * \frac{0.7}{0.7} + 1 \right]$$

= 18.08

$$y_{s/500} = \frac{6.79}{500} \left[ 2.27 * 1.0 * 1.0 * \left( \frac{14}{6.79} \right)^{0.43} * \frac{0.49}{0.49} + 1 \right]$$

= 20.41

$$y_{s/500} = \frac{6.79}{500} \left[ 2.27 * 1.0 * 1.0 * \left( \frac{12}{6.79} \right)^{0.43} * \frac{0.49}{0.49} + 1 \right]$$

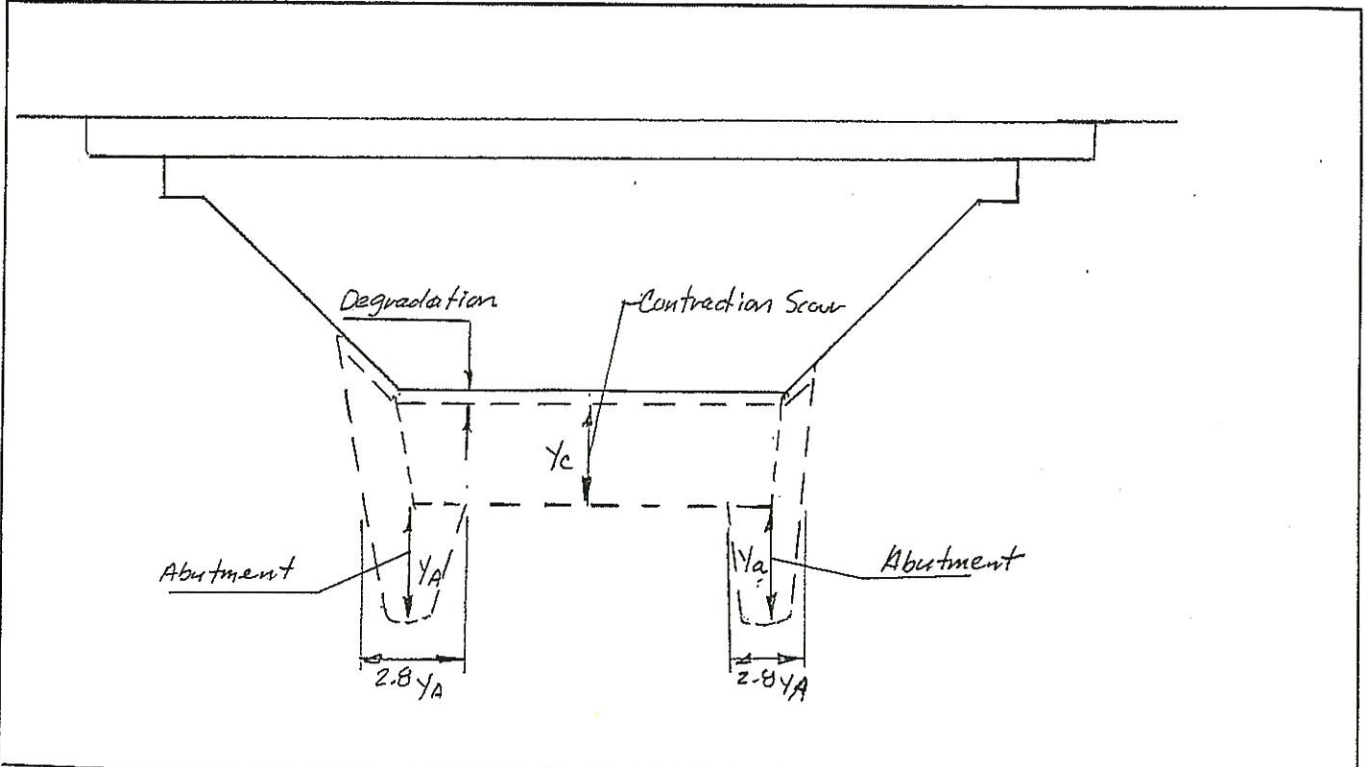
= 19.53

Notes:

Values above represent calculated scour without abutment protection.  
 This project proposes a D<sub>50</sub> = 24" riprap, 4' thick along both sloping abutments, bridge approach, and ends.

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.



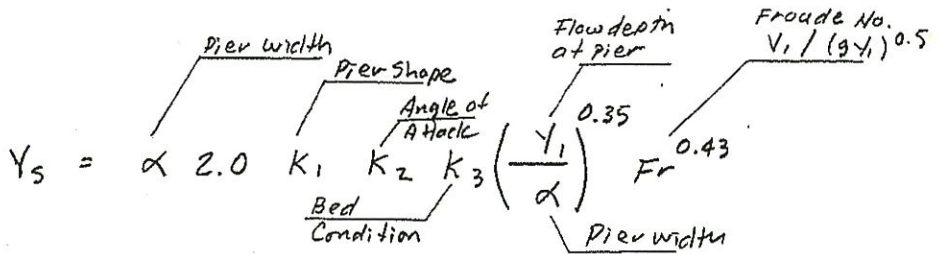
	100 - YEAR			500 - YEAR		
	LEFT	CHAN.	RT.	LEFT	CH.	RT.
Degradation	0	2.0	0	0	2.0	0
Contraction	0.82	0.82	0.82	1.8	1.8	1.8
Abutment	18.98	—	18.08	20.41	—	19.53
Total	19.8	2.82	18.9	22.21	3.8	21.33

Pier						
------	--	--	--	--	--	--

Local Scour at Pier

100 yr      500 yr  
 $V = \underline{10.3} \text{ fps}$      $\underline{10.1} \text{ fps} = \text{Velocity upstream of the pier}$   
 $Y_1 = \underline{8.1} \text{ ft}$        $\underline{11.25} \text{ ft} = \text{Depth of flow upstream of pier}$

$\underline{0}$  = Angle of attack of the flow  
 $\underline{3.5 \text{ ft}}$  = Pier width  
 $\underline{21 \text{ ft}}$  = Pier Length (3.5 x 6)  
 $\underline{1.0}$  =  $k_1$  Circular  
 $\underline{1.0}$  =  $k_2$   
 $\underline{1.1}$  =  $k_3$   
 $F_{100} = \underline{0.63}$      $F_{500} = \underline{0.53} = \text{Froude}$
















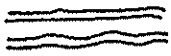



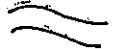



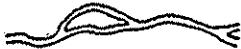

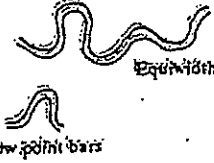
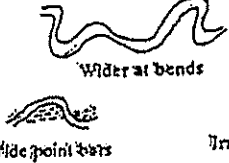
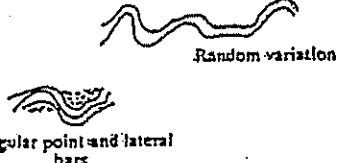


$$Y_{s_{100}} = \frac{3.5 \cdot 2.0 \cdot 1.0 \cdot 1.0 \cdot 1.1 \cdot \left(\frac{8.1}{3.5}\right)^{0.35} \cdot 0.63^{0.43}}{1}$$

= 8.47 ft.

$$Y_{s_{500}} = \frac{3.5 \cdot 2.0 \cdot 1.0 \cdot 1.0 \cdot 1.1 \cdot \left(\frac{11.25}{3.5}\right)^{0.35} \cdot 0.53^{0.43}}{1}$$

= 8.82 ft.

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 anabranching ( < 5 percent )	 Locally anabranching ( 5-35 percent )	 Generally anabranching ( > 35 percent )		
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS ( SECT. 2.2.12 )	 Narrow point bars	 Wide point bars	 Irregular point and lateral bars		

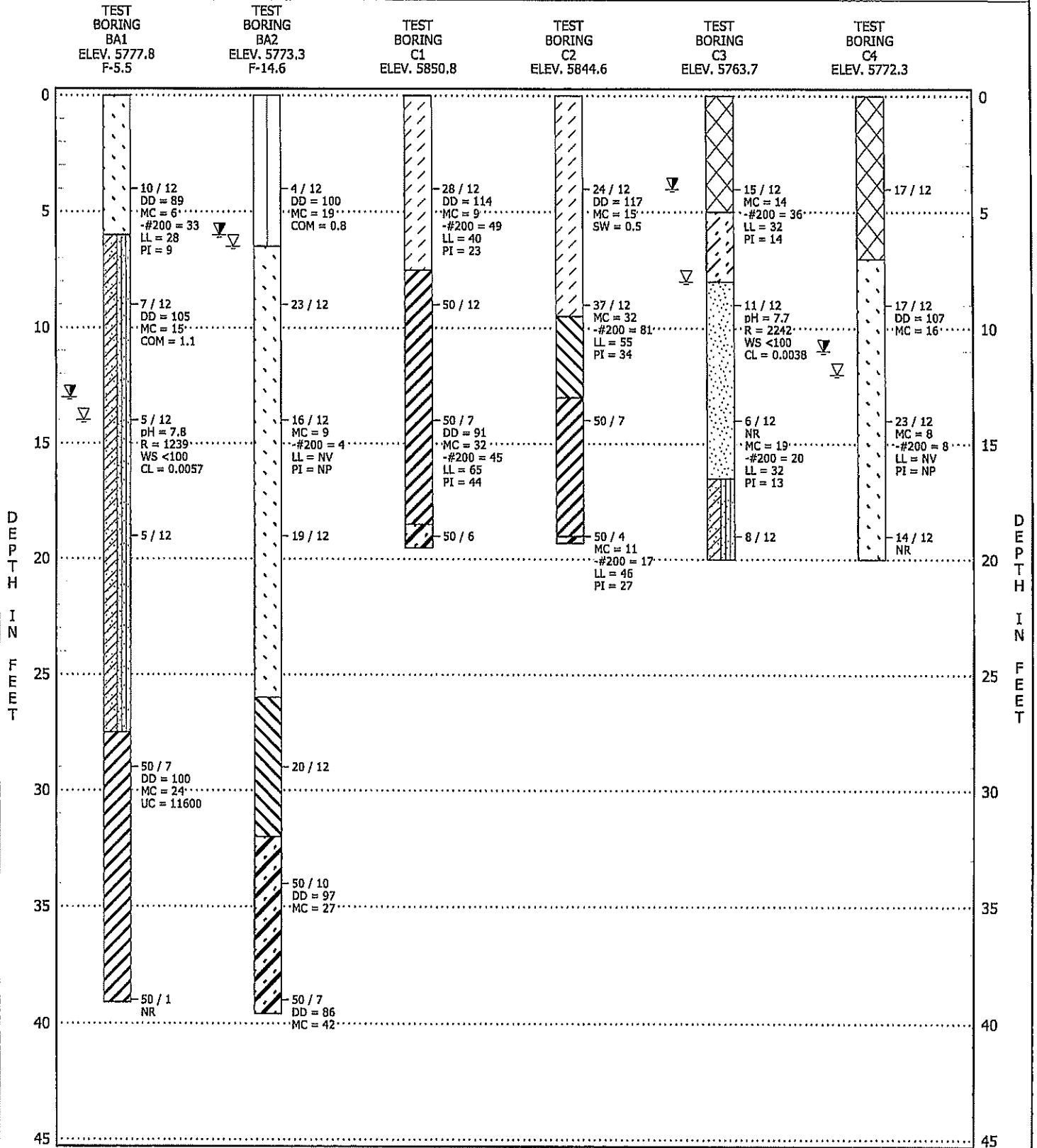
## GEOMORPHIC FACTORS THAT AFFECT STREAM STABILITY

CLIENT 470 Compark, LLC c/o MPV Compark Management, LLC

PROJECT NAME Compark Village South

PROJECT NUMBER 153733

PROJECT LOCATION Parker, Douglas County, Colorado



SEE FIGURE 7 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS  
FIGURE 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

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

Upper limit:  $n \leq 0.15$  for above equation

~~$$n_{18^{\circ}-42^{\circ}(1/2)} = \frac{0.097 * \text{[Green Box]}^{0.16}}{\ln(2.55 * \text{[Green Box]})} = \frac{0.000}{\text{#NUM!}} = \text{#NUM!}$$~~

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

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

Low-flow  $n$  y= 3  
d= 1.5

$$n_{18^{\circ}-42^{\circ}(2/3)} = \frac{0.086 * \text{[Green Box]}^{0.16}}{\ln(2.55 * \text{[Green Box]})} = \frac{0.096}{1.629} = 0.059$$

2

High-flow  $n$  y= 7.76  
d= 1.5

$$n_{18^{\circ}-42^{\circ}(2/3)} = \frac{0.086 * \text{[Green Box]}^{0.16}}{\ln(2.55 * \text{[Green Box]})} = \frac{0.114}{2.985} = 0.038$$

5.1733

Upper limit:  $n \leq 0.12$  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

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

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

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)

**Note: This project will use B24 boulders grouted 2/3 of the height. UDFCD recommends a minimum of B24 size due to maintenance concerns.**

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

Rock Sizing Parameter, $R_p$	Grouted Boulders <sup>1</sup>
	Boulder Classification <sup>2</sup>
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

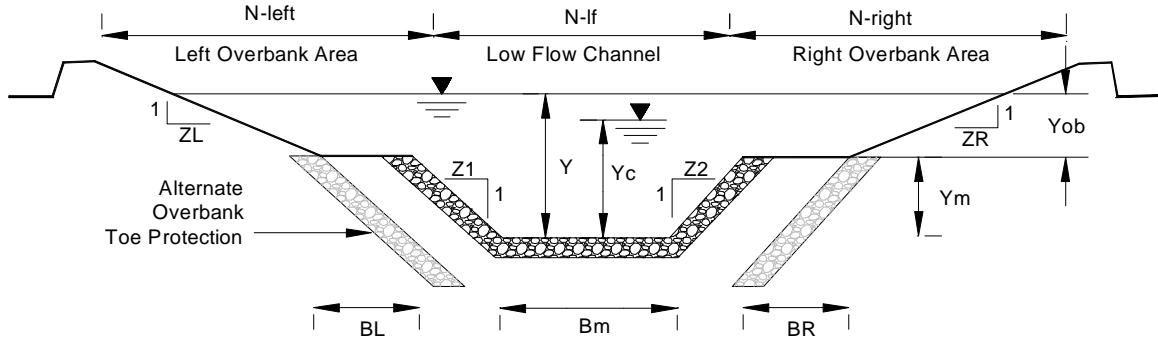
<sup>1</sup> Grouted to no less than 1/3 the height (+1"/- 0"), no more than 1/2 (+0"/- 1") of boulder height.

<sup>2</sup> 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
Low Flow Channel Bottom Width	Bm = 15.00 ft	Left Overbank Side Slope	ZL = 0.03 ft/ft
Low Flow Channel Left Side Slope	Z1 = 4.00 ft/ft	Left Overbank Manning's n	n-left = 0.0350
Low Flow Channel Right Side Slope	Z2 = 4.00 ft/ft	Right Overbank Bottom Width	BR = 20.00 ft
Low Flow Channel Manning's Nn for Qd	n-lf = 0.0590	Right Overbank Side Slope	ZR = 2.50 ft/ft
Low Flow Channel Manning's Nn for Q100 (See USDCM Vol. II, n vs. Depth Graph)	n-m-Q100 = 0.0380	Right Overbank Manning's n	n-right = 0.0350
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

Top width	Tlf = 39.0 ft
Flow area	Alf = 81.0 sq ft
Wetted perimeter	Plf = 39.7 ft
<b>Discharge (Calculated)</b>	<b>Qlf = 284.8 cfs</b>
<b>Velocity</b>	<b>Vlf = 3.5 fps</b>
<b>Froude number</b>	<b>Fr-lf = 0.43</b>
Qd Critical Velocity	Vlfc = 6.74 fps
Qd Critical Depth	Ylfc = 1.88 ft

### Low Flow Channel Flow Condition for Q100

Top width	Tm = 39.0 ft
Flow area	Am = 270.2 sq ft
Wetted perimeter	Pm = 39.7 ft
<b>Discharge</b>	<b>Qm = 3,292.1 cfs</b>
<b>Velocity</b>	<b>Vm = 12.2 fps</b>
<b>Froude number</b>	<b>Fr-m = 0.82</b>
100-Yr. Critical Velocity	Vmc = 14.0 fps
100-Yr. Critical Depth	Ymc = 7.0 ft

### Left Overbank Flow Condition for Q100

Top width	TL = 75.1 ft
Flow area	AL = 364.0600 sq ft
Wetted perimeter	PL = 79.8500 ft
<b>Discharge</b>	<b>QL = 3,690.5 cfs</b>
<b>Velocity</b>	<b>VL = 10.1 fps</b>
<b>Froude number</b>	<b>FrL = 0.81</b>
100-Yr. Critical Velocity	VLc = 11.7 fps
100-Yr. Critical Depth in Overbanks	YLc = 4.2 ft

### Right Overbank Flow Condition for Q100

Top width	TR = 32.1 ft
Flow area	AR = 126.4000 sq ft
Wetted perimeter	PR = 33.0600 ft
<b>Discharge</b>	<b>QR = 1,139.5 cfs</b>
<b>Velocity</b>	<b>VR = 9.0 fps</b>
<b>Froude number</b>	<b>FrR = 0.80</b>
100-Yr. Critical Velocity	VRc = 10.6 fps
100-Yr. Critical Depth in Overbanks	YRc = 4.2 ft

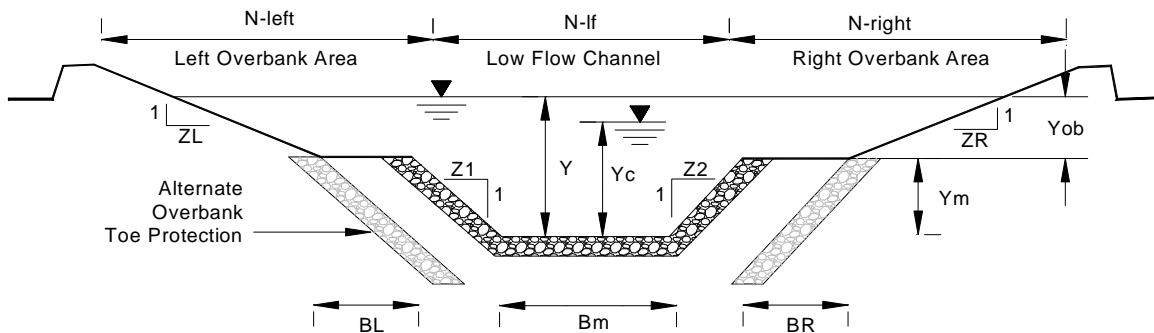
### Composite Cross-Section Flow Condition for Q100

Top width	T = 146.3 ft	<b>Discharge</b>	<b>Q = 8,122.1 cfs</b>
Channel Depth Y	Y = 7.85 ft	<b>Velocity</b>	<b>V = 10.7 fps</b>
Flow area	A = 760.6 sq ft	<b>Froude number</b>	<b>Fr = 0.83</b>
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
Low Flow Channel Bottom Width	Bm = 15.00 ft	Left Overbank Side Slope	ZL = 0.03 ft/ft
Low Flow Channel Left Side Slope	Z1 = 4.00 ft/ft	Left Overbank Manning's n	n-left = 0.0350
Low Flow Channel Right Side Slope	Z2 = 4.00 ft/ft	Right Overbank Bottom Width	BR = 20.00 ft
Low Flow Channel Manning's Nn for Qd	n-lf = 0.0590	Right Overbank Side Slope	ZR = 2.50 ft/ft
Low Flow Channel Manning's Nn for Q100 (See USDCM Vol. II, n vs. Depth Graph)	n-m-Q100 = 0.0380	Right Overbank Manning's n	n-right = 0.0350
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

Top width	Tlf = 39.0 ft
Flow area	Alf = 81.0 sq ft
Wetted perimeter	Plf = 39.7 ft
<b>Discharge (Calculated)</b>	<b>Qlf = 1,039.9 cfs</b>
<b>Velocity</b>	<b>Vlf = 12.8 fps</b>
<b>Froude number</b>	<b>Fr-lf = 1.57</b>
Qd Critical Velocity	Vlfc = 9.03 fps
Qd Critical Depth	Ylfc = 3.81 ft

### Low Flow Channel Flow Condition for Q100

Top width	Tm = 39.0 ft
Flow area	Am = 270.2 sq ft
Wetted perimeter	Pm = 39.7 ft
<b>Discharge</b>	<b>Qm = 12,020.9 cfs</b>
<b>Velocity</b>	<b>Vm = 44.5 fps</b>
<b>Froude number</b>	<b>Fr-m = 2.98</b>
100-Yr. Critical Velocity	Vmc = 16.2 fps
100-Yr. Critical Depth	Ymc = 7.9 ft

### Left Overbank Flow Condition for Q100

Top width	TL = 75.2 ft
Flow area	AL = 364.1000 sq ft
Wetted perimeter	PL = 79.8500 ft
<b>Discharge</b>	<b>QL = 13,478.3 cfs</b>
<b>Velocity</b>	<b>VL = 37.0 fps</b>
<b>Froude number</b>	<b>FrL = 2.96</b>
100-Yr. Critical Velocity	VLc = 17.9 fps
100-Yr. Critical Depth in Overbanks	YLc = 10.0 ft

### Right Overbank Flow Condition for Q100

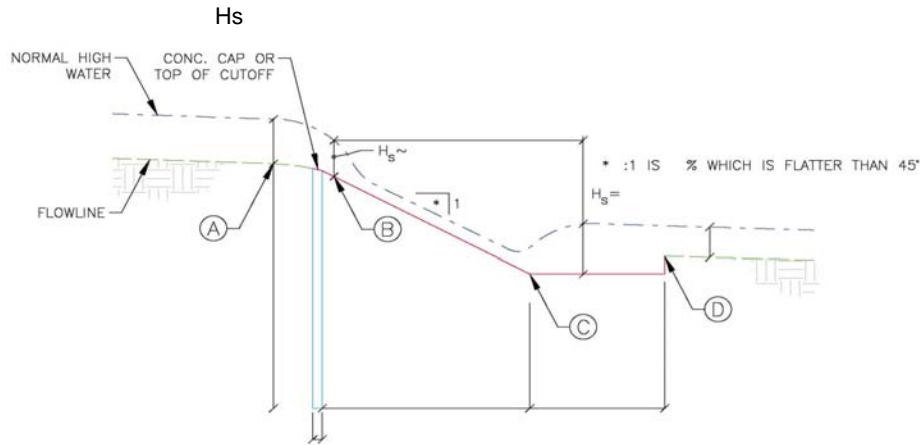
Top width	TR = 32.1 ft
Flow area	AR = 126.4000 sq ft
Wetted perimeter	PR = 33.0600 ft
<b>Discharge</b>	<b>QR = 4,160.9 cfs</b>
<b>Velocity</b>	<b>VR = 32.9 fps</b>
<b>Froude number</b>	<b>FrR = 2.92</b>
100-Yr. Critical Velocity	VRc = 14.6 fps
100-Yr. Critical Depth in Overbanks	YRc = 9.1 ft

### 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	<b>Froude number</b>	<b>Fr = 3.01</b>
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

1. Lane's Weighed Creep Method

$$C_w = \frac{\left( \frac{L_H}{3} + L_v \right)}{H_s} \quad \text{UDFCD Volume 2 Equation 9-5}$$



From (A) to (B)  $L_H = 8.0$   $L_v = 0 + 0.25 = 0.25$  '   
 $H_s \sim 0.25$  (Change in water surface elevation between A & B)

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

From (A) to (C)  $L_H = 38.0$   $L_v = 3 + 0.25 = 3.25$  '   
 $H_s = 1.06$  (Change in water surface elevation between A & C)

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

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

Notes: Soil samples at the site located along Happy Canyon Creek provided by A.G. Wassenaar Inc. indicates coarse to medium 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.

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

Average LWC Ratio per UDFCD Table 9-3 to the right is:  $\rightarrow$  **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: 7/24/2017                      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=	8.4	Local depth of flow above particle, ft		
S <sub>f</sub> =	1.2	Safety factor		
C <sub>s</sub> =	0.3	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 <sub>v</sub> =	1.35	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)=	1.35	
		Rc=	130	Centerline radius of curvature of Channel bend, ft
		W=	294	Width of water surface at upstream end of channel bend, ft
		Rc/W=	0.442177	
		use 1.25 downstream from concrete channels		
		use 1.25 at the end of dikes		
C <sub>t</sub> =	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 <sub>des</sub> =	10.26	Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s		
		V <sub>des</sub> =	10.26	For natural channels use V <sub>des</sub> =V <sub>avg</sub> (1.74-0.52 log(Rc/W))
		V <sub>des</sub> =	10.59	For trapezoidal channels use V <sub>des</sub> =V <sub>avg</sub> (1.71-0.78 log(Rc/W))
V <sub>avg</sub> =	5.33	Channel cross sectional average velocity, ft/s		
K <sub>1</sub> =	1.00	Side slope correctional factor	H:1=	4
		k <sub>1</sub> =(1-(sin14°)	θ=	14.0      0.24 = radians
			K <sub>1</sub> =	1.00
S <sub>g</sub> =	2.65	Specific gravity of riprap (usually taken at 2.65)		
g=	32.2	Acceleration of gravity, 32.2 ft/s		

<b>d<sub>30</sub>=</b>	<b>0.67</b>	<b>Particle size for which 30% is finer by weight, ft</b>	
<b>d<sub>50</sub>=</b>	<b>0.81</b>	<b>d<sub>50</sub>=1.2d<sub>30</sub>, ft</b>	
<b>RIPRAP d<sub>50</sub> SIZE=</b>	<b>9.7</b>	<b>inches</b>	<b>Use Soil Riprap (12 inch) (2'-0" thick) @ 120+25 to 122+25 RT.</b>
<b>t=1.5d<sub>50</sub>=</b>	<b>14.5</b>	<b>Riprap Thickness, inches</b>	

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: 7/24/2017                      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=	7.35	Local depth of flow above particle, ft		
S <sub>f</sub> =	1.2	Safety factor		
C <sub>s</sub> =	0.3	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 <sub>v</sub> =	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)=	1.26	
		Rc=	308	Centerline radius of curvature of Channel bend, ft
		W=	236	Width of water surface at upstream end of channel bend, ft
		Rc/W=	1.305085	
		use 1.25 downstream from concrete channels		
		use 1.25 at the end of dikes		
C <sub>t</sub> =	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 <sub>des</sub> =	10.80	Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s		
		V <sub>des</sub> =	10.80	For natural channels use V <sub>des</sub> =V <sub>avg</sub> (1.74-0.52 log(Rc/W))
		V <sub>des</sub> =	10.42	For trapezoidal channels use V <sub>des</sub> =V <sub>avg</sub> (1.71-0.78 log(Rc/W))
V <sub>avg</sub> =	6.43	Channel cross sectional average velocity, ft/s		
K <sub>1</sub> =	1.00	Side slope correctional factor	H:1=	4
		k <sub>1</sub> =(1-(sin14°)	θ=	14.0      0.24 = radians
			K <sub>1</sub> =	1.00
S <sub>g</sub> =	2.65	Specific gravity of riprap (usually taken at 2.65)		
g=	32.2	Acceleration of gravity, 32.2 ft/s		

$d_{30}$ = 0.72 Particle size for which 30% is finer by weight, ft  
 $d_{50}$ = 0.87  $d_{50}=1.2d_{30}$ , ft  
**RIPRAP d<sub>50</sub> SIZE= 10.4 inches**  
 $t=1.5d_{50}$ = 15.6 Riprap Thickness, inches

**Use Soil Riprap (12 inch) (2'-0" thick)  
@ 116+25 to 118+75 RT.**

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

**REVETMENT RIPRAP DESIGN  
SIZING USING UDFCD CRITERIA**

Project: Belford @ HCC	By: CDT	I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\
Project No. 115360-01	Date: 7/24/2017	Happy Canyon Creek\Bridge Hydraulics

$$d_{50} \geq \frac{(V \cdot S^{0.17})}{(4.5) \cdot (G_s - 1)^{0.66}} \cdot 12$$

V=	14.58	Velocity, ft/s	<i>(Worst case velocity at Drop 2.)</i>
S=	0.0075	Longitudinal Slope, ft/ft	
G <sub>s</sub> =	2.65	Specific gravity of riprap (usually taken at 2.65)	

d <sub>50</sub> =	1.03	ft	
<b>RIPRAP d<sub>50</sub> SIZE=</b>	<b>12.3</b>	<b>inches</b>	
<b>t=1.75d<sub>50</sub>=</b>	<b>21.6</b>	<b>Riprap Thickness, inches</b>	

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

Reference: UDFCD Manual, Volume 1, Section 8.1.1 Equation 8-11

**RIPRAP AT BRIDGE ABUTMENTS AND GUIDE BANKS  
SIZING**

Project: Belford @ HCC                      By: CDT                      I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\  
Project No. 115360-01                      Date: 7/24/2017                      Happy Canyon Creek\Bridge Hydraulics

$d_{50} = Y \cdot K / (S_g - 1) \cdot (V^2 / gy)$  for Froude numbers less than 0.80  
 $d_{50} = Y \cdot K / (S_g - 1) \cdot (V^2 / gy)^{0.14}$  for Froude numbers greater than 0.80  
 $d_{50}$  = Median stone diameter, 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		
D =	114	37	Distance from main channel	
$Y_{ch}$ =	8.33	8.33	Flow depth in main channel	
SBR =	13.7	4.4	Set Back Ratio	
Q =	5317	1203	If SBR is >5, then $V = Q_{overbank} / A_{overbank}$ (Overbank flow only)	$Q_{total} = 8303$ cfs
A =	762	198	If SBR is <5, then $V = Q_{total} / A_{total}$ (Entire bridge opening)	$A_{total} = 1150$ (sq ft)
$V_{char.}$ =	7.0	7.2		
V =	7.56	7.66	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 =	8.24	8.24	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 =	0.46	0.47	Froude number, $(V/(gy))^{0.5}$	
$d_{50}$ =	1.10	1.13	Median stone diameter, ft for Froude number less than 0.80	
$d_{50}$ =	4.11	4.12	Median stone diameter, ft for Froude number greater than 0.80	

	Left Abutment	Right Abutment	
$d_{50}$ =	1.10	1.13	Median stone diameter, ft
RIPRAP $d_{50}$ SIZE =	13.2	13.5	inches
$t = 1.5d_{50}$	19.8	20.3	Riprap Thickness, inches

**Riprap for Bridge Abutments**  
**Soil Riprap (18 Inch) (3'-0" thick)**  
**& Riprap (18 Inch) (3'-0" thick)**

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



**RIPRAP FOR OVERTOPPING FLOW  
FOR SLOPES 4:1 AND FLATTER**

Project: Belford @ HCC      By: CDT      I:\115360-01 - Compark at Belford\CADD\Hydraulics\Calculations\  
 Proj. No. 115360-01      Date: 7/24/2017      Happy Canyon Creek\Bridge Hydraulics

**Weir formula**       $H=(Q/C*L)^{.67}$   
 Q= 8303 Discharge, cfs (FHAD Future 100yr c.f.s)  
 C= 2.6 Weir coefficient  
 L= 310 Length of broad crested weir, ft  
 H= 4.77 Overtopping depth, ft

**Median Rock Size**       $d_{50}=k_u*q^{.52}/C_u^{.25}*S^{.75}*(\sin a/Sg \cos a-1)(\cos a \tan p-\sin a)^{.11}$   
 K<sub>u</sub>= 0.525 Constant for English units  
 q= 26.8 Unit discharge at failure, ft<sup>3</sup>/ft  
 C<sub>u</sub>= 4.5 Coefficient of uniformity of the riprap, d<sub>60</sub>/d<sub>10</sub>  
 S= 0.25 Slope of the embankment, ft/ft  
 S<sub>g</sub>= 2.65 Specific gravity of the riprap  
 α= 4 Slope of the embankment, H:1      H:1= 4.0      θ= 14.0      0.24 = radians  
 φ= 1 Angle of repose for riprap, H:1      H:1= 1.0      θ= 45.0      0.79 = radians  
 d<sub>50</sub>= 1.01 Smallest possible median rock size, d<sub>50</sub>, ft  
 d<sub>50</sub>= 12.1 Smallest possible median rock size, d<sub>50</sub>, in  
 Use a d<sub>50</sub> of 15 inches (from Table C8.1)

**Interstitial Velocity**       $V_i=(2.48(g*d_{50})^{.5})*(S^{.58}/C_u^{.22})$   
 g= 32.2 Acceleration due to gravity, ft/sec  
 d<sub>50</sub>= 1.25 Particle size for which 50% is finer by weight, ft  
 S= 0.25 Slope, ft/ft  
 C<sub>u</sub>= 4.5 Coefficient of uniformity of the riprap, d<sub>60</sub>/d<sub>10</sub>  
 V<sub>i</sub>= 0.25 ft/sec  
 η= 0.45 porosity  
 V<sub>avg</sub>= 0.11 ft/sec

**Thickness of riprap as if all of the flow were through the riprap**       $t=q/V_{avg}$ , ft  
 t= 238.3 thickness of riprap layer, ft  
 2\*d<sub>50</sub>= 2.5 ft      **FALSE If "t" is < than 2\*d<sub>50</sub>, then design is complete and a 2d<sub>50</sub> thickness is ok**  
 Use a d<sub>50</sub> of 15 in.      **0 If "t" is > than 2\*d<sub>50</sub>, then continue**

**Allowable flow depth over riprap**       $h=(0.06(Sg-1)d_{50}\tan\phi)/(0.97S)$   
 h= 0.51 ft depth

**Calculate Manning roughness coefficient, n**       $n=.034(d_{50})^{.1667}$   
 n= 0.04

**Calculator Unit Discharge, q**       $q=1.489/n^*.y^{.19}*S^{.05}$   
 q<sub>1</sub>= 6.86 ft<sup>3</sup>/s/ft

**Calculate the Required Interstitial Flow through the riprap and the flow provided by a riprap thickness of 2d<sub>50</sub>**  
 q<sub>2</sub>= 19.92 ft<sup>3</sup>/s/ft      q<sub>2</sub>=q<sub>f</sub>-q<sub>1</sub>  
 q= 0.28 ft<sup>3</sup>/s/ft      q=2d<sub>50</sub>\*V<sub>avg</sub>

t=2d<sub>50</sub>= 3      **If q is > than or equal to q<sub>2</sub>, then the design is complete with a 2d<sub>50</sub>**  
 t= 18      **If not, then increase riprap size to next higher gradation (C8.1)      3**

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

**Table C8.1. Minimum and maximum allowable particle size in inches.**

Nominal Riprap Class by Median Particle Diameter		d <sub>15</sub>		d <sub>50</sub>		d <sub>85</sub>		d <sub>100</sub>
Class	Size	Min	Max	Min	Max	Min	Max	Max
I	6 in	3.7	5.2	5.7	6.9	7.8	9.2	12.0
II	9 in	5.5	7.8	8.5	10.5	11.5	14.0	18.0
III	12 in	7.3	10.5	11.5	14.0	15.5	18.5	24.0
IV	15 in	9.2	13.0	14.5	17.5	19.5	23.0	30.0
V	18 in	11.0	15.5	17.0	20.5	23.5	27.5	36.0
VI	21 in	13.0	18.5	20.0	24.0	27.5	32.5	42.0
VII	24 in	14.5	21.0	23.0	27.5	31.0	37.0	48.0
VIII	30 in	18.5	26.0	28.5	34.5	39.0	46.0	60.0
IX	36 in	22.0	31.5	34.0	41.5	47.0	55.5	72.0
X	42 in	25.5	36.5	40.0	48.5	54.5	64.5	84.0

Cu, Coef. Of Uniform. (d <sub>60</sub> /d <sub>10</sub> )
4.5
4
4.5
4
3.7

Note: Particle size d corresponds to the intermediate (B) axis of the particle.

(CDOT)

## FREEBOARD REQUIREMENTS

Project: Belford Avenue @ Happy Canyon Creek      File Name: Freeboard.xlsx  
Date: 24-Jul-17      FHU Project #: 115360-01

$F_b = 0.1 * Q^{0.3} + 0.008 * V^2$  (English Units)

RE: UDFCD defers to CDOT Roadway Design Manual

### REQUIRED FREEBOARD

$Q_{100} =$	8303	cfs	(Design Q)
$V_{100} =$	8.21	fps	(Average Velocity)
$F_b =$	2.04	ft.	(Required Freeboard)

### AVAILABLE FREEBOARD

Low chord elevation =	5780.07
Design W.S. elevation =	<u>5776.33</u>
Available freeboard =	3.74 ft.

**DROP STRUCTURE TABULATION**

INDEX			ITEM NO.	CONTRACT ITEM	UNIT	GSB	
BOOK	PAGE	SHEET				PLAN	AS CONST.
			206	FILTER MATERIAL (CLASS A)	CY	107	
			206	STRUCTURE EXCAVATION	CY	130	
			206	STRUCTURE BACKFILL (CLASS 1)	CY	118	
			207	TOPSOIL	CY	956	
			501	STEEL SHEET PILING (TYPE II)	SF	9010	
			506	RIPRAP (12 INCH)	CY	51	
			506	SOIL RIPRAP (12 INCH)	CY	3290	
			506	24 INCH GROUTED BOULDERS	CY	458	
			601	CONCRETE CLASS D (BOX CULVERT)	CY	26	
			602	REINFORCING STEEL	LB	2250	
			602	REINFORCING STEEL (EPOXY COATED)	LB	717	
			603	48 INCH REINFORCED CONCRETE PIPE (CIP)	LF	186	
			603	48 INCH REINFORCED CONCRETE END SECTION	EA	1	
			603	10X3 FOOT CONCRETE BOX CULVERT (PRECAST)	LF	90	
			604	INLET TYPE D (10 FOOT)	EA	1	
			604	INLET SPECIAL	EA	1	
			619	8 INCH PLASTIC PIPE	LF	267	

**NOTES:**

- 24 INCH GROUTED BOULDERS SHALL BE PAID FOR AS GROUTED RIPRAP (24 INCH).
- SEE CBMP PLANS FOR TABULATION OF EROSION CONTROL ITEMS.
- FOR UNCLASSIFIED EXCAVATION SEE EARTHWORK SUMMARY. COST OF EXCAVATION FOR ALL GROUTED RIPRAP AND SOIL RIPRAP IS INCLUDED IN THE COST OF THE BID ITEM.
- DROP STRUCTURE TABULATION QUANTITIES HAVE BEEN CARRIED FORWARD TO THE SUMMARY OF APPROXIMATE QUANTITIES SHEETS.
- 10X3 FOOT CONCRETE BOX CULVERT (PRECAST) QUANTITY SHOW IS FOR DUAL BOX CULVERTS AT CHEROKEE TRAIL.

**STORM DRAINAGE INFRASTRUCTURE NOTES**

- ALL STORM DRAINAGE IMPROVEMENTS ARE SUBJECT TO COMPLIANCE WITH THE COLORADO DEPARTMENT OF TRANSPORTATION (CDOT) CURRENT EDITION OF THE STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, M & S STANDARDS, AND ALL STANDARD SPECIAL PROVISIONS CURRENTLY USED BY CDOT, WITH THE MODIFICATIONS SET FORTH IN THE TOWN OF PARKER'S STORM DRAINAGE AND ENVIRONMENTAL CRITERIA MANUAL (SDECM), AS AMENDED.
- THE CONTRACTOR SHALL COMPLY WITH THE "COLORADO WATER QUALITY CONTROL ACT" (TITLE 25, ARTICLE 8 CRS), THE "PROTECTION OF FISHING STREAMS" TITLE 33, ARTICLE 5, CRS), THE "CLEAN WATER ACT" (33 USC 1344), "CHERRY CREEK RESERVOIR CONTROL REGULATION NO. 72" (5 CCR 1002-72), THE REGULATION PROMULGATED, CERTIFICATION OR PERMITS ISSUES, AND THE REQUIREMENTS PRESENTED IN THE SDECM REVISION TO SECTION 107 AND THE CONSTRUCTION BMP PLAN. IN THE EVENT OF CONFLICTS BETWEEN THESE REQUIREMENTS AND WATER QUALITY CONTROL LAWS, RULES, OR REGULATIONS OF OTHER FEDERAL, OR STATE AGENCIES, THE MORE RESTRICTIVE LAWS, RULES, OR REGULATIONS SHALL APPLY.
- INSPECTIONS: CONSTRUCTION SHALL NOT BEGIN UNTIL A GRADING PERMIT HAS BEEN ISSUED FOR THE PROJECT. THE CONTRACTOR SHALL NOTIFY THE TOWN OF PARKER ENGINEERING DEPARTMENT (PUBLIC WORKS) TO SCHEDULE INSPECTIONS A MINIMUM OF 48 HOURS PRIOR THE CONSTRUCTION OF ALL DRAINAGE INFRASTRUCTURE (STORM SEWERS, INLETS, MANHOLES, ENERGY DISSIPATORS, RIPRAP, GROUTED BOULDERS, DETENTION POND OUTLET STRUCTURES, FOREBAYS, TRICKLE CHANNELS, ETC). FAILURE TO NOTIFY THE ENGINEERING DEPARTMENT FOR INSPECTIONS MAY RESULT IN NON-ACCEPTANCE OF THE INFRASTRUCTURE BY THE TOWN. URBAN DRAINAGE AND FLOOD CONTROL DISTRICT MUST ALSO BE NOTIFIED IN A SIMILAR MANNER FOR ALL MAINTENANCE ELIGIBLE DRAINAGE INFRASTRUCTURES (CONSULT WITH STORMWATER ENGINEERING DIVISION).
- STRUCTURAL BACKFILL (CDOT CLASS 1) SHALL BE COMPACTED TO CONFORM TO CDOT STANDARD SPECIFICATION 203.03. STRUCTURAL BACKFILL (CDOT CLASS 2) SHALL CONFORM TO CDOT STANDARD SPECIFICATION 203.07. AT THE CONTRACTOR'S OPTION, STRUCTURAL BACKFILL (SQUEEGEE) MEETING THE GRADATION REQUIREMENTS CONTAINED IN REVISION OF SECTION 206 OF THE CDOT STANDARD SPECIFICATIONS AS PRESENTED IN THE SDECM, MAY BE SUBSTITUTED FOR STRUCTURE BACKFILL (CLASS 1) OR CLASS 2) FOR BACKFILLING OF CULVERT PIPES, STORM SEWER PIPES, MANHOLES AND INLET STRUCTURES; HOWEVER, THE TOP 2 FEET BELOW SUBGRADE ELEVATION SHALL BE THE REQUIRED EMBANKMENT MATERIAL.
- ALL EXCAVATIONS SHALL MEET OSHA REQUIREMENTS.
- TESTING: PROBATIONARY ACCEPTANCE OF STORM DRAINAGE IMPROVEMENTS WILL BE CONTINGENT UPON SATISFACTORY TESTING RESULTS. IN ALL CASES WHERE TESTS INDICATE COMPACTION LESS THAN THAT REQUIRED BY TOWN SPECIFICATIONS, ADDITIONAL COMPACTION AND TESTS WILL BE REQUIRED UNTIL THE SPECIFICATIONS ARE MET. FREQUENCY OF TESTING WILL BE AS FOLLOWS:  
 1 TEST FOR SUBGRADE AND 1 TEST FOR BACKFILL AT EVERY ABOVE GROUND APPURTENANCE (MANHOLES, INLETS, ETC)  
 1 TEST EVERY 200 LF OF MAINLINE TRENCH EVERY 1 FOOT OF BACKFILL LIFT AND WITHIN 1 FOOT FROM ALL STRUCTURES.

- ALLOWABLE STORM SEWER CONDUIT MATERIAL WITHIN THE TOWN OF PARKER SHALL BE LIMITED TO REINFORCED CONCRETE PIPE (RCP) CONFORMING TO CDOT STANDARD SPECIFICATION 706.02.
- ALL RCP JOINTS SHALL BE MANUFACTURED IN ACCORDANCE WITH ASTM C443. RUBBER GASKETS SHALL BE USED ON ALL PIPE JOINTS CONFORMING TO ASTM C443. ALL RCP SECTIONS SHALL BE JOINED IN SUCH A MANNER THAT THE ENDS ARE FULLY ENTERED AND THE INNER SURFACES ARE REASONABLE FLUSH. AVERAGE JOINT GAP THAT EXCEEDS 1/2 INCH SHALL BE FILLED WITH AN APPROVED FLEXIBLE PLASTIC SEALANT.
- JOINT RESTRAINTS AND TOE-WALLS, CONFORMING TO CDOT M&S STANDARD PLAN NO. M-601-11 SHALL BE USED ON ALL RCP FLARED END SECTION OUTFALLS.
- EPOXY COATED REBAR SHALL BE USED AS REINFORCING STEEL ON ALL STORM INLETS AND STRUCTURES. REFERENCE CDOT M&S STANDARD PLAN NO. M-604-10, 11, 12, AND 13.
- CDOT CLASS D CONCRETE SHALL BE USED FOR ALL CONCRETE DRAINAGE STRUCTURES.
- PRE-CAST INLETS AND MANHOLE BASES SHALL NOT BE USED WITHIN THE TOWN OF PARKER RIGHT-OF-WAY, WITH THE EXCEPTION OF CDOT TYPE C AND D INLETS.
- TWO- (2) MANHOLE ACCESS POINTS ARE REQUIRED ON ALL TYPE "R" CURB INLETS GREATER THAN OR EQUAL TO TEN (10) FEET IN LENGTH AS PRESENTED IN CDOT M&S STANDARD PLAN NO. M-604-12.
- ALL GROUTING (BOULDERS, RIPRAP) SHALL BE IN ACCORDANCE WITH THE REVISION OF SECTION 506 OF THE CDOT STANDARD SPECIFICATIONS AS PRESENTED IN THE SDECM.
- ALL BOULDERS AND RIPRAP SHALL BE SELECTED AND PLACED IN ACCORDANCE WITH THE REVISION OF SECTION 506 OF THE CDOT STANDARD SPECIFICATIONS AS PRESENTED IN THE SDECM.
- CONTRACTOR SHALL REFER TO THE TOWN OF PARKER'S CONSTRUCTION BEST MANAGEMENT PRACTICES DETAILS AND NOTES FOR ALL REQUIREMENTS RELATING TO RE-VEGETATION, SEDIMENT AND EROSION CONTROL REQUIREMENTS FOR CONSTRUCTION ACTIVITIES.
- PIPE BELLS SHALL NOT BE CAST INTO MANHOLE BASES OR INLETS.

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

Print Date: 7/24/2017 10:13:41 AM		Sheet Revisions			As Constructed		BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE TABULATION		Project No./Code														
File Name: H115360-01DROP01?ab.dwg					No Revisions:																		
Horizontal Scale: N.T.S. Vertical Scale: N.T.S.		<table border="1"> <thead> <tr> <th>Date</th> <th>Comments</th> <th>Initials</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>		Date	Comments	Initials										Revised:		Designer: CDT		Structure			
Date	Comments	Initials																					
 6300 South Syracuse Way, Suite 600 Centennial, CO 80111 tel 303.721.1440 fax 303.721.0832		<input checked="" type="checkbox"/> (R-X)		Void:		Detailer: KLT		Numbers															
						Subset: Drainage		Sheets: DD-01 of 19		Sheet Number													

**HAPPY CANYON CREEK DROP STRUCTURE NO. 1 STEEL SHEET PILE CUTOFF WALL POINT DATA**

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
W1	27804.35	94876.28	5772.18	SHEET PILE CUTOFF WALL - FINISHED GRADE EL.
W2	27868.05	94779.67	5766.32	SHEET PILE CUTOFF WALL - FINISHED GRADE EL.
W3	27906.48	94753.03	5766.46	SHEET PILE CUTOFF WALL - FINISHED GRADE EL.
W4	27969.48	94765.25	5775.67	SHEET PILE CUTOFF WALL - FINISHED GRADE EL.

**HAPPY CANYON CREEK DROP STRUCTURE GRADING POINT DATA**

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
G1	27872.10	94962.88	5779.00	FINISHED GRADE
G2	27823.77	94932.12	5779.00	FINISHED GRADE
G3	27808.04	94890.63	5779.00	FINISHED GRADE
G4	27766.29	94809.24	5779.00	FINISHED GRADE
G5	27745.18	94744.70	5779.00	FINISHED GRADE

**HAPPY CANYON CREEK DROP STRUCTURE NO. 2 STEEL SHEET PILE CUTOFF WALL POINT DATA**

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
W1	27675.42	94283.50	5777.39	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W2	27745.88	94255.72	5769.99	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W3	27770.71	94252.88	5769.21	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W4	27834.84	94262.40	5776.14	CONCRETE CUTOFF WALL - FINISHED GRADE EL.

**HAPPY CANYON CREEK DROP STRUCTURE SOIL RIPRAP (12 INCH) POINT DATA**

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
SR1	27769.57	94610.05	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR2	27835.00	94932.41	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR3	27801.00	94604.71	5765.86	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR4	27800.24	94631.57	5767.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR5	27797.05	94661.68	5769.72	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR6	27804.21	94763.47	5770.47	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR7	27862.90	94848.01	5766.25	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR8	27885.85	94800.95	5765.45	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR9	27876.75	94787.82	5765.88	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR10	27864.82	94785.47	5766.43	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR11	27871.26	94540.03	5768.10	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR12	27892.28	94575.67	5770.18	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR13	27920.57	94605.87	5772.85	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR14	27943.91	94626.32	5774.63	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR15	27967.25	94646.78	5775.74	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR16	27912.28	94510.88	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR17	27925.40	94519.82	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR18	27937.13	94566.79	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR19	27941.73	94573.15	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR20	27962.64	94597.85	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR21	27970.79	94607.21	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR22	27995.66	94624.88	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR23	27980.39	94661.70	5776.11	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR24	27988.53	94666.66	5776.90	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR25	27956.85	94747.12	5773.49	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR26	27965.72	94770.00	5773.56	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR27	27950.72	94782.27	5766.42	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR28	27950.92	94822.32	5764.33	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR29	27942.21	94828.37	5763.57	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR30	27923.33	94841.50	5764.91	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR31	27904.97	94854.26	5765.01	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR32	27881.83	94903.47	5766.84	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR35	27821.75	94260.96	5774.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR36	27816.88	94288.38	5772.05	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR37	27814.22	94331.33	5770.01	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR38	27821.34	94373.78	5769.37	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
SR39	27831.26	94408.21	5769.24	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.

**HAPPY CANYON CREEK DROP STRUCTURE NO. 3 STEEL SHEET PILE CUTOFF WALL POINT DATA**

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
W1	27522.92	93938.45	5781.00	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W2	27627.16	93827.68	5772.57	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W3	27648.54	93814.47	5772.41	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W4	27680.82	93804.64	5781.00	CONCRETE CUTOFF WALL - FINISHED GRADE EL.

**HAPPY CANYON CREEK DROP STRUCTURE NO. 4 STEEL SHEET PILE CUTOFF WALL POINT DATA**


POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
W1	27224.37	93849.23	5785.98	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W2	27201.63	93834.88	5777.63	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W3	27174.38	93805.42	5777.06	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W4	27143.34	93746.45	5778.26	CONCRETE CUTOFF WALL - FINISHED GRADE EL.
W5	27143.34	93579.99	5784.32	CONCRETE CUTOFF WALL - FINISHED GRADE EL.

**HAPPY CANYON CREEK DROP STRUCTURE CHANNEL REVETMENT SOIL RIPRAP (12 INCH) POINT DATA**

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
CR1	27384.46	93620.98	5776.96	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR2	27409.72	93613.85	5776.89	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR3	27455.43	93616.23	5776.93	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR4	27504.52	93635.29	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR5	27521.43	93646.91	5777.11	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR6	27547.94	93676.17	5776.07	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR7	27561.71	93693.16	5776.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR8	27566.68	93697.18	5776.04	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR9	27669.93	93800.97	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR10	27681.39	93814.88	5776.99	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR11	27699.52	93838.94	5776.86	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR12	27713.46	93854.66	5777.09	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR13	27724.95	93872.92	5776.90	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR14	27732.94	93886.34	5777.00	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR15	27743.41	93902.84	5777.05	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR16	27754.96	93929.13	5776.62	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR17	27765.52	93944.63	5775.94	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR18	27769.88	93961.99	5775.77	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR19	27781.73	93978.73	5775.97	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR20	27782.09	94006.03	5775.95	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.
CR21	27787.18	94029.84	5776.06	LIMITS OF SOIL RIPRAP (12 INCH) - FINISHED GRADE EL.

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

Print Date: 7/18/2017 1:52:23 PM  
 File Name: H115360-01DROPO2point Data.dwg  
 Horizontal Scale: N.T.S. Vertical Scale: N.T.S.



6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

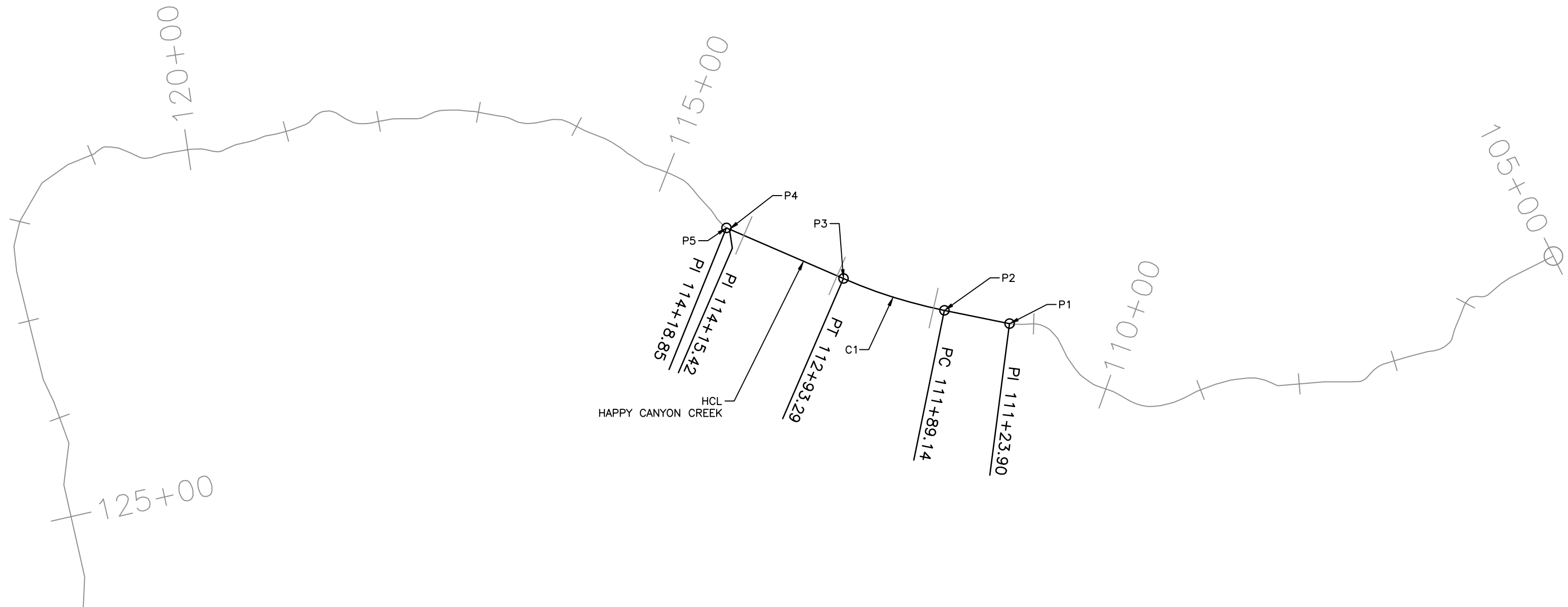
Sheet Revisions			
(R-X)	Date	Comments	Initials



8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph 303.708.0800 fax 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE POINT DATA DETAIL		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-02 of 19	Sheet Number

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



**COORDINATE DATA**

POINT	STATION	BEARING	NORTHING	EASTING
P1	PI 111+23.90		27812.91	94517.55
P2	PC 111+89.14	S71° 31' 51.06"W	27792.24	94455.67
P3	PT 112+93.29	C1	27769.74	94354.17
P4	PI 114+15.42	S83° 27' 55.88"W	27755.84	94232.84
P5	PI 114+18.85	S82° 04' 13.05"W	27755.40	94229.71

**CURVE DATA**

CURVE	DELTA	RADIUS	LENGTH	TANGENT
C1	11° 56' 4.83"	500	104.15	52.26



HORIZONTAL SCALE: 1"=200'

Print Date: 7/18/2017 1:52:35 PM  
 File Name: H115360-01DROPO3Geom.dwg  
 Horizontal Scale: 1"=100' Vertical Scale: N.T.S.

6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

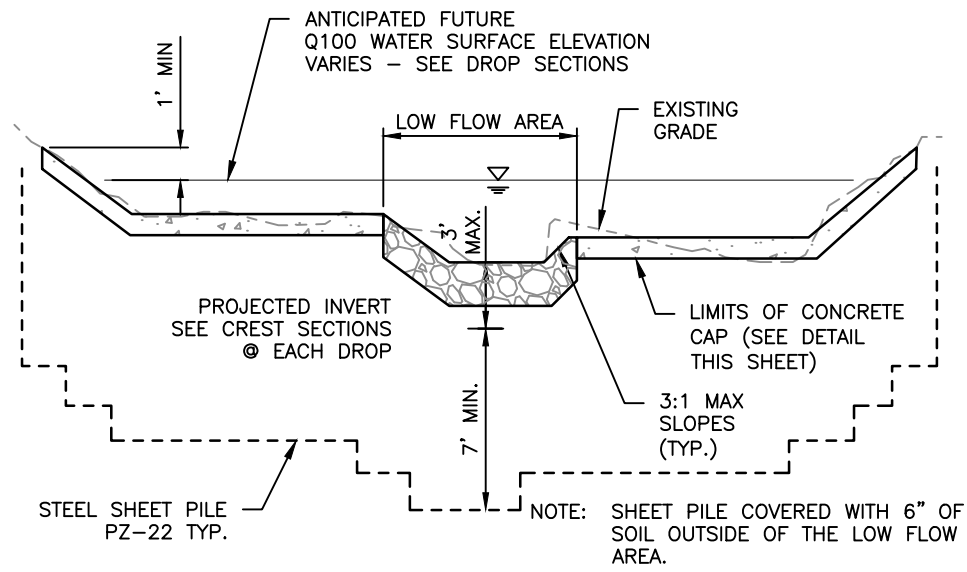
Sheet Revisions		
Date	Comments	Initials

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph 303.708.0900 fax 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

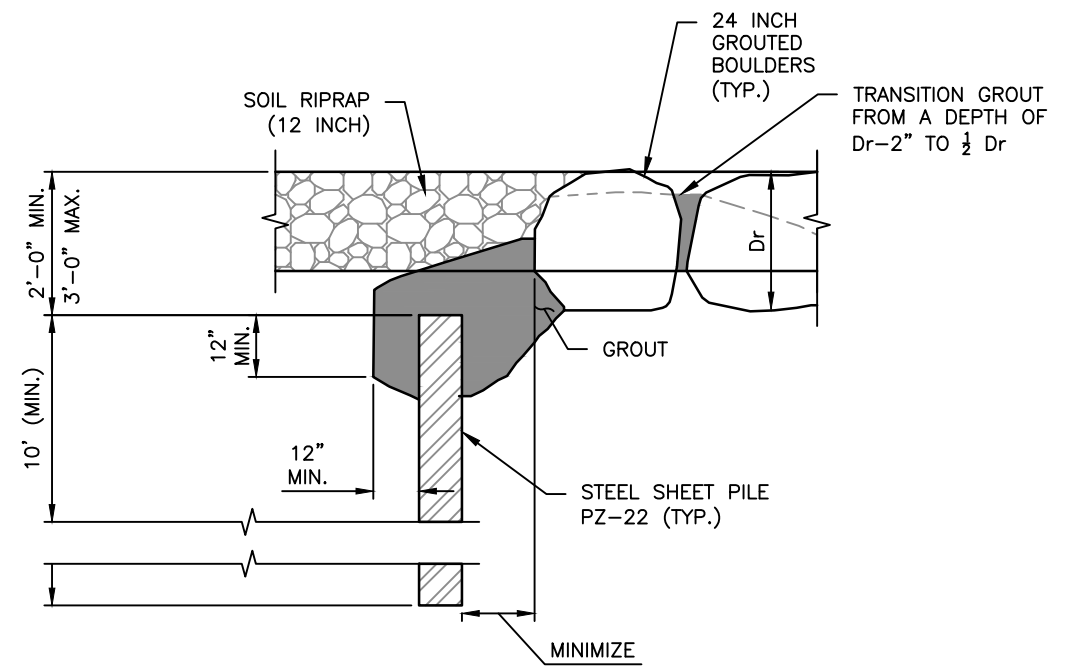
As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE HCL GEOMETRY LAYOUT		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-03 of 19	Sheet Number



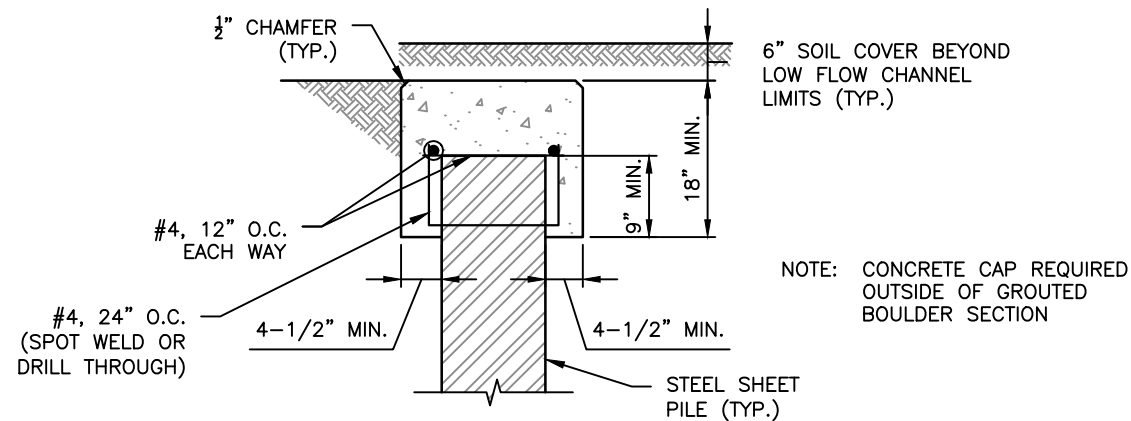
Know what's below.  
Call before you dig.



**SHEET PILE TYPICAL SECTION**  
N.T.S.



**SHEET PILE CUTOFF CONNECTION  
(GROUTED BOULDER)**  
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: 7/18/2017 1:52:44 PM	
File Name: H115360-01DROPO4Sheet Pile Det.dwg	
Horizontal Scale: N.T.S.	Vertical Scale: N.T.S.
6300 South Syracuse Way, Suite 600 Centennial, CO 80111 tel 303.721.1440 fax 303.721.0832	

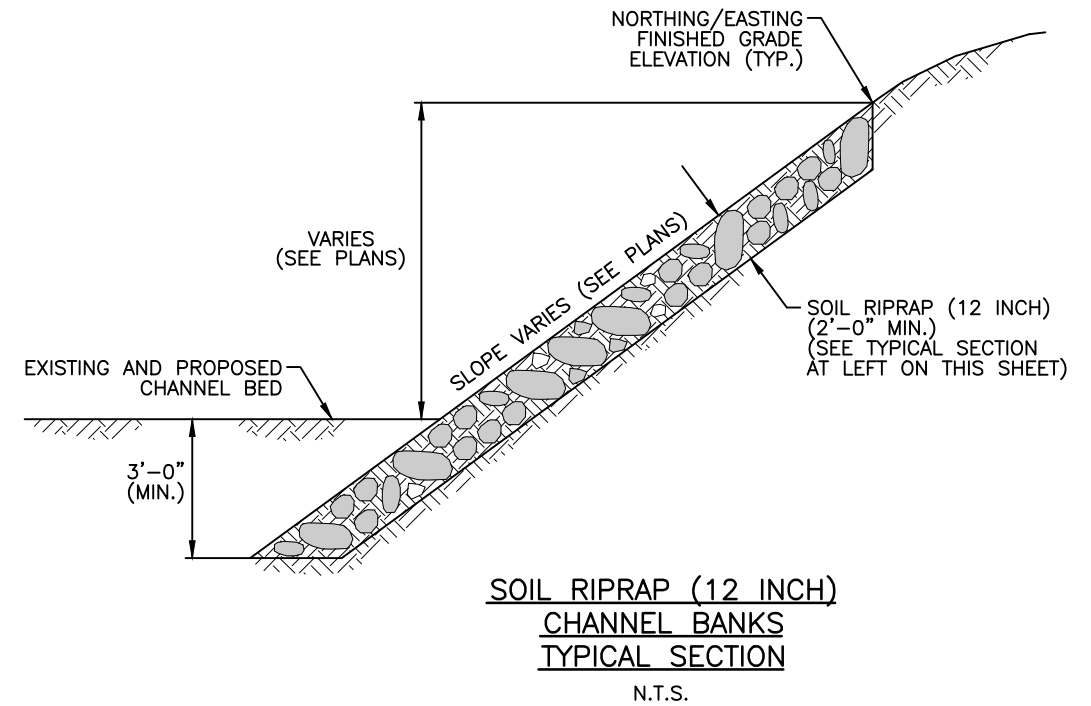
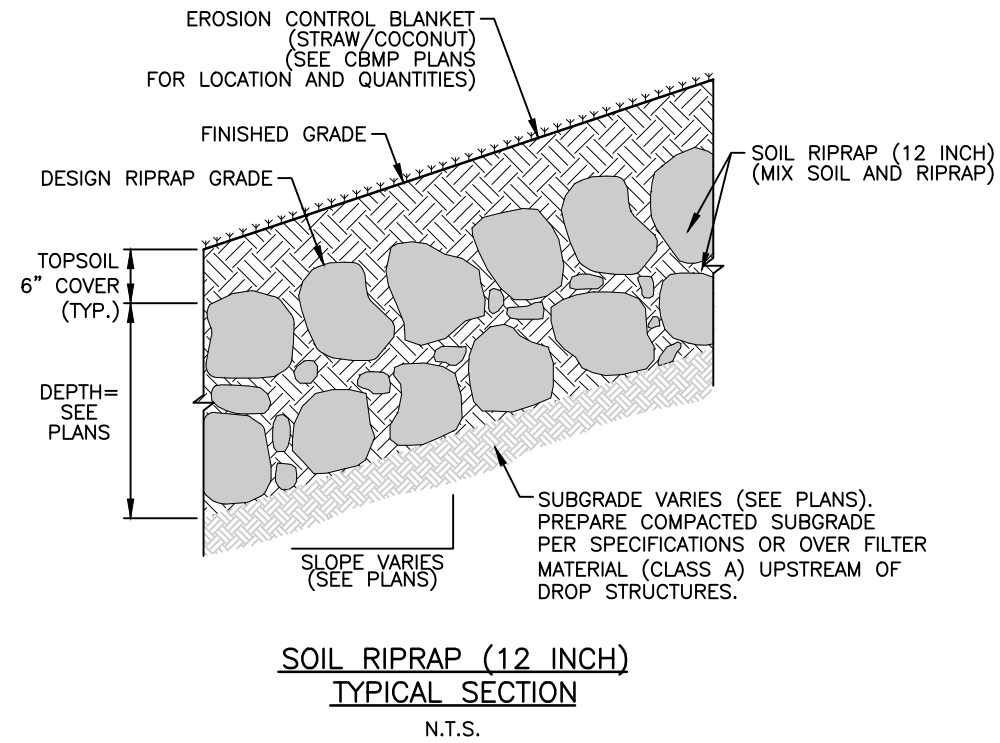
Sheet Revisions			
Date	Comments	Initials	

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph 303.708.0900 fax 303.708.0400 manhard.com  
Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE SHEET PILE DETAILS		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-04 of 19	Sheet Number



Know what's below.  
Call before you dig.



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 UNIFORMLY 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 CBMP PLANS AND SPECIFICATIONS.

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

Print Date: 7/18/2017 1:52:54 PM	
File Name: H115360-01DROPO5Soil Riprap Det.dwg	
Horizontal Scale: N.T.S.	Vertical Scale: N.T.S.
6300 South Syracuse Way, Suite 600 Centennial, CO 80111 tel 303.721.1440 fax 303.721.0832	

Sheet Revisions			
(R-X)	Date	Comments	Initials



As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DETAILS		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-05 of 19	Sheet Number



Know what's below.  
Call before you dig.

GROUT NOTES

BOULDER PLACEMENT NOTES:

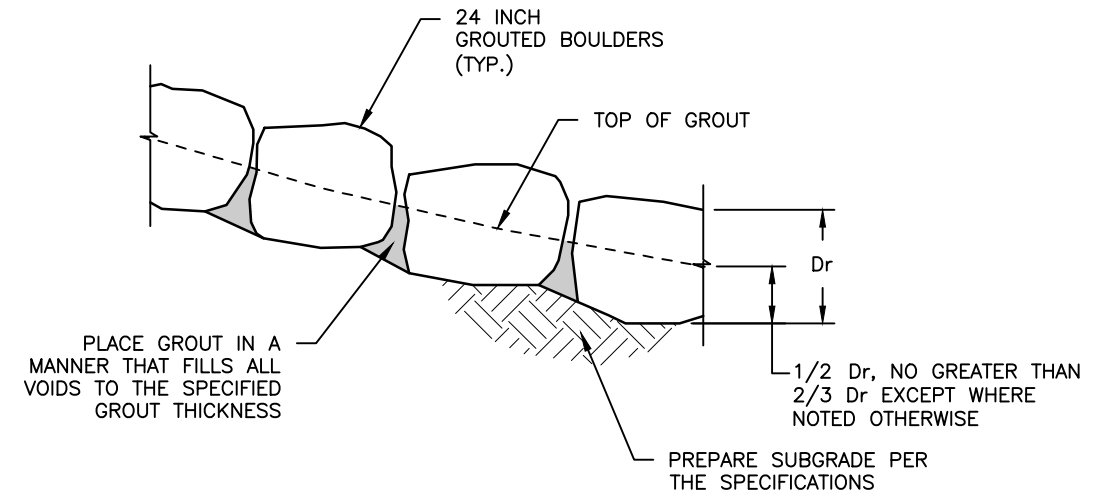
1. PLACE BOULDERS WITH THE REQUIRED BOULDER HEIGHT VERTICAL. PLACE BOULDERS AS TIGHTLY TOGETHER AS POSSIBLE (WITHOUT TOUCHING) WHILE PROVIDING ENOUGH ROOM BETWEEN THEM TO THOROUGHLY VIBRATE THE GROUT AND TO ENSURE NO GAPS IN THE GROUT. THE SMALL DIMENSION OF A 2X4 CAN BE USED AS A GUIDE TO CHECK MINIMUM 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.

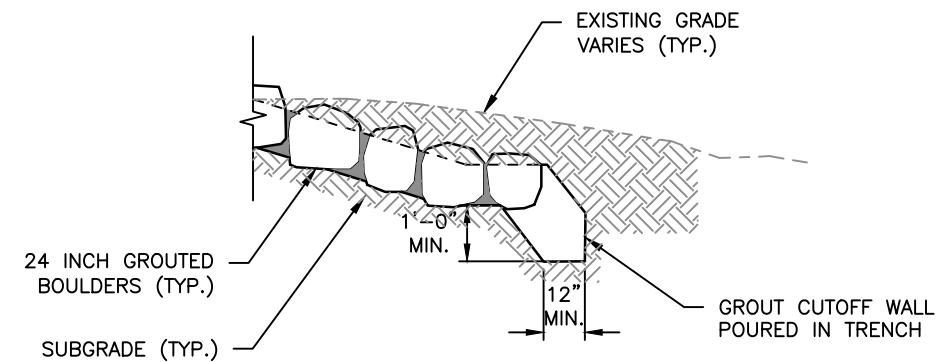
GROUT PLACEMENT SPECIFICATIONS:

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.

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

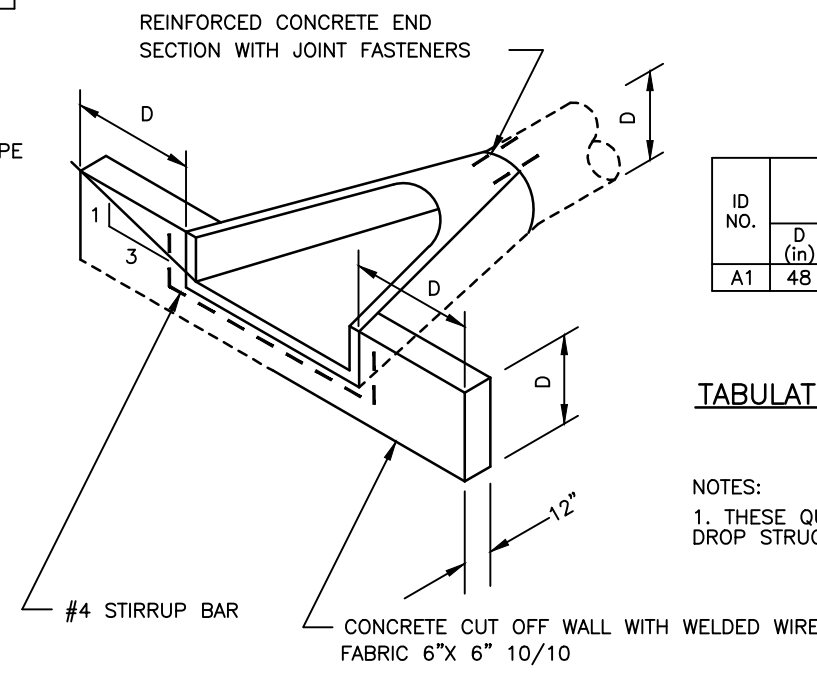
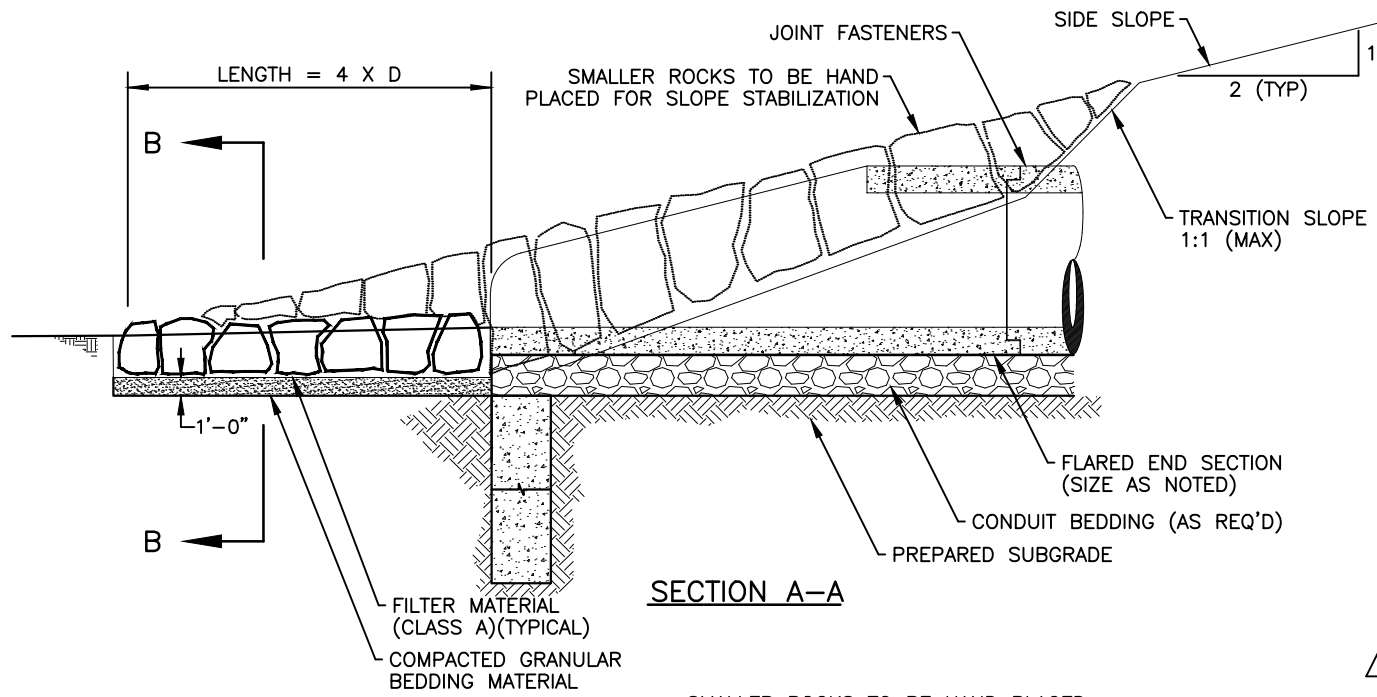
Print Date: 7/18/2017 1:53:03 PM
File Name: H115360-01DROPO6Grouted Boulder Det.dwg
Horizontal Scale: N.T.S. Vertical Scale: N.T.S.
6300 South Syracuse Way, Suite 600 Centennial, CO 80111 tel 303.721.1440 fax 303.721.0832

Sheet Revisions			
(R-X)	Date	Comments	Initials



As Constructed	BELFORD-HAPPY CANYON CREEK		Project No./Code
No Revisions:	HAPPY CANYON CREEK DROP STRUCTURE		
Revised:	Designer: CDT	Structure Numbers	Sheet Number
Void:	Detailer: KLT	Sheets: DD-06 of 19	
	Subset: Drainage		

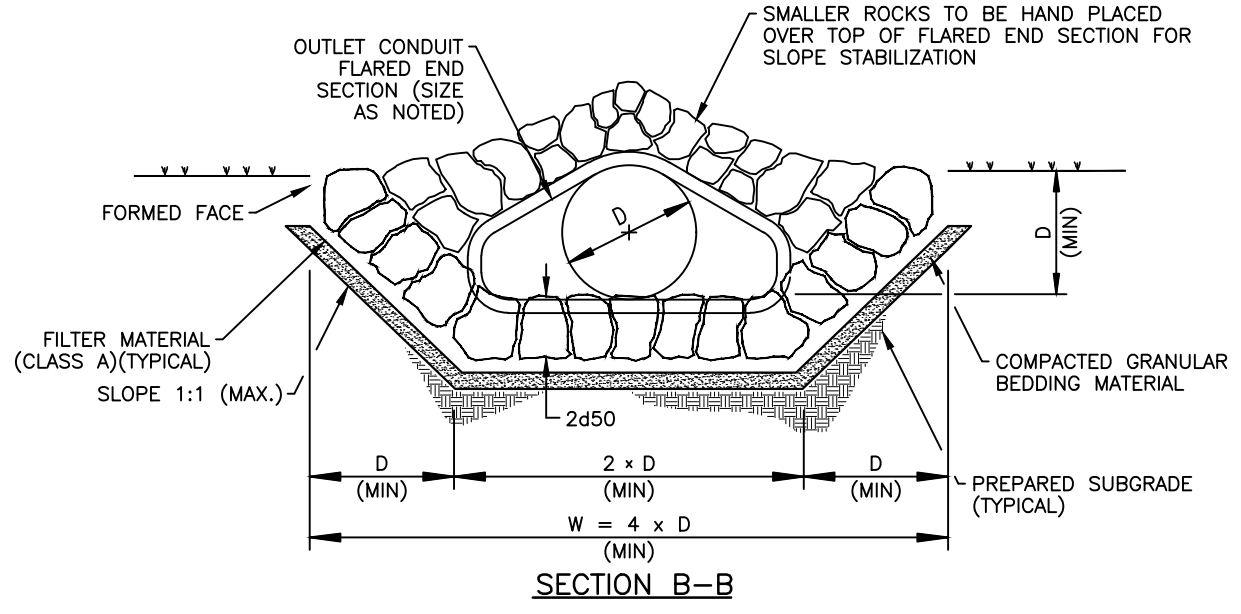
I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\ Zach.Grady



ID NO.	DIMENSIONS					QUANTITIES	
	D (in)	W (ft)	L (ft)	RIPRAP TYPE	d50 (in)	RIPRAP (12 INCH) (CY)	FILTER MATERIAL (CLASS A) (CY)
A1	48	16	16	M	12	19	9

**TABULATION OF RIPRAP AND GEOTEXTILE MATERIAL AT CULVERT INLETS & OUTLETS**

NOTES:  
1. THESE QUANTITIES HAVE BEEN CARRIED FORWARD TO THE DROP STRUCTURE TABULATION.



**CONCRETE TOEWALL AND END SECTION FOR REINFORCED CONCRETE PIPE**

- NOTES:
1. D= INSIDE DIAMETER OF REINFORCED CONCRETE PIPE.
  2. CONCRETE FOR THE TOEWALL SHALL BE CONCRETE CLASS D (WALL)
  3. EACH REINFORCED CONCRETE END SECTION SHALL BE CONNECTED TO THE REINFORCED CONCRETE PIPE WITH CONCRETE PIPE JOINT FASTENERS (2-EACH). CONCRETE PIPE JOINT FASTENERS SHALL BE INCLUDED IN THE COST OF THE REINFORCED CONCRETE END SECTION.
  4. ALL CONCRETE, REINFORCING, CONNECTIONS, STRUCTURE EXCAVATION, AND EXTRA WORK REQUIRED TO CONSTRUCT THE CONCRETE TOEWALL SHALL BE PAID FOR AS CONCRETE CLASS D (WALL).
  5. ALL REINFORCED CONCRETE PIPE EXTENSIONS SHALL HAVE A CONCRETE COLLAR AND SHALL BE INCLUDED IN THE COST OF THE REINFORCED CONCRETE PIPE.
  6. REMOVED RIPRAP MAY BE UTILIZED FOR RIPRAP (12 INCH) UNLESS DIRECTED OTHERWISE BY THE ENGINEER.

Print Date: 7/18/2017 1:53:13 PM  
 File Name: H115360-01DROP07?utlet Protection Det.dwg  
 Horizontal Scale: NTS Vertical Scale: NTS

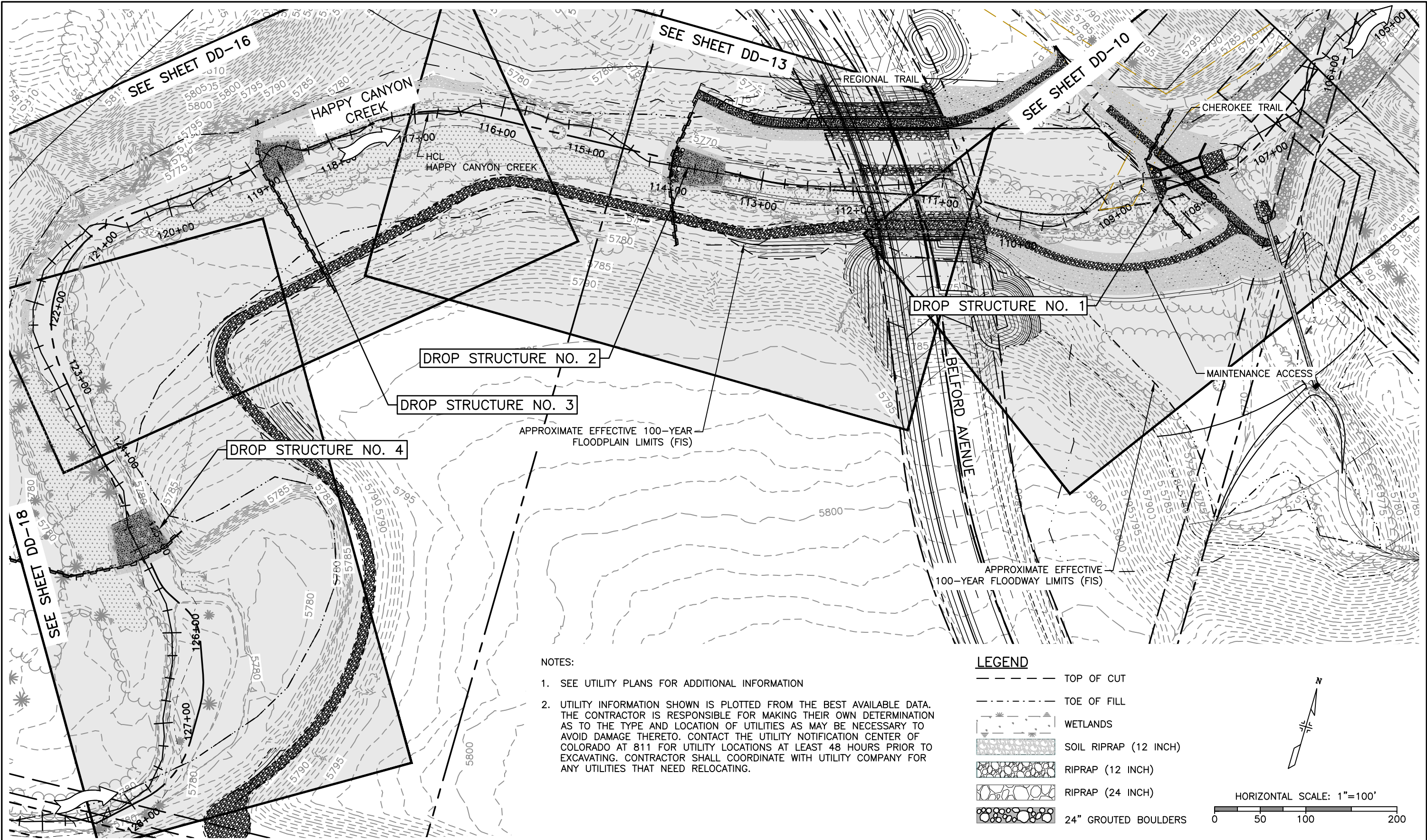
**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	

**Manhard CONSULTING LTD**

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph: 303.708.0900 fax: 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK DRAINAGE		Project No./Code
No Revisions:	OUTLET PROTECTION DETAILS		
Revised:	Designer: CDT	Structure Numbers	
	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-07 of 19	Sheet Number



- NOTES:
1. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION
  2. 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)
- RIPRAP (24 INCH)
- 24" GROUTED BOULDERS

HORIZONTAL SCALE: 1"=100'

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

Print Date: 7/18/2017 1:56:13 PM  
 File Name: H115360-01DROPO8?eymap.dwg  
 Horizontal Scale: 1"=50' Vertical Scale: N.T.S.

**FELSBURG  
HOLT &  
ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	

**Manhard  
CONSULTING LTD**

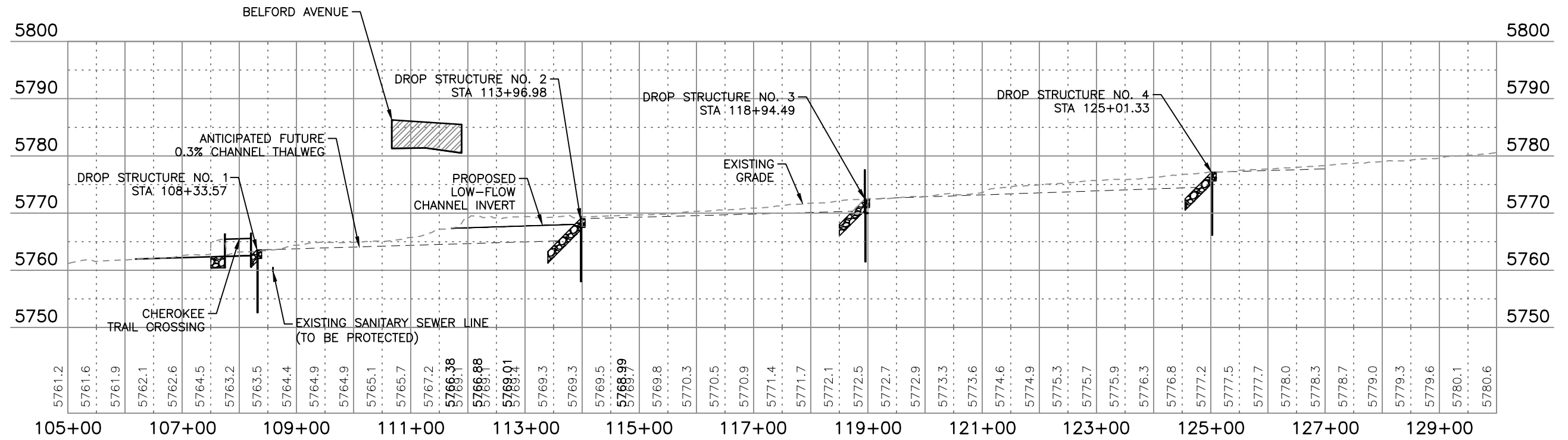
8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph:303.708.0900 fax:303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resource Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE PLAN		Project No./Code
No Revisions:	Designer:	CDT	
Revised:	Detailer:	KLT	
Void:	Subset:	Drainage	
		Structure Numbers:	
		Sheets:	DD-08 of 19

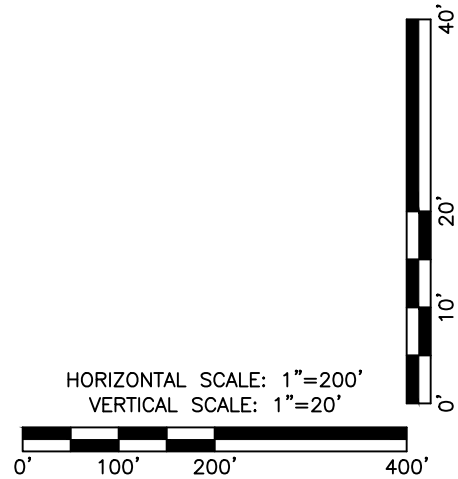
Sheet Number

NOTES

- 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.
- 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

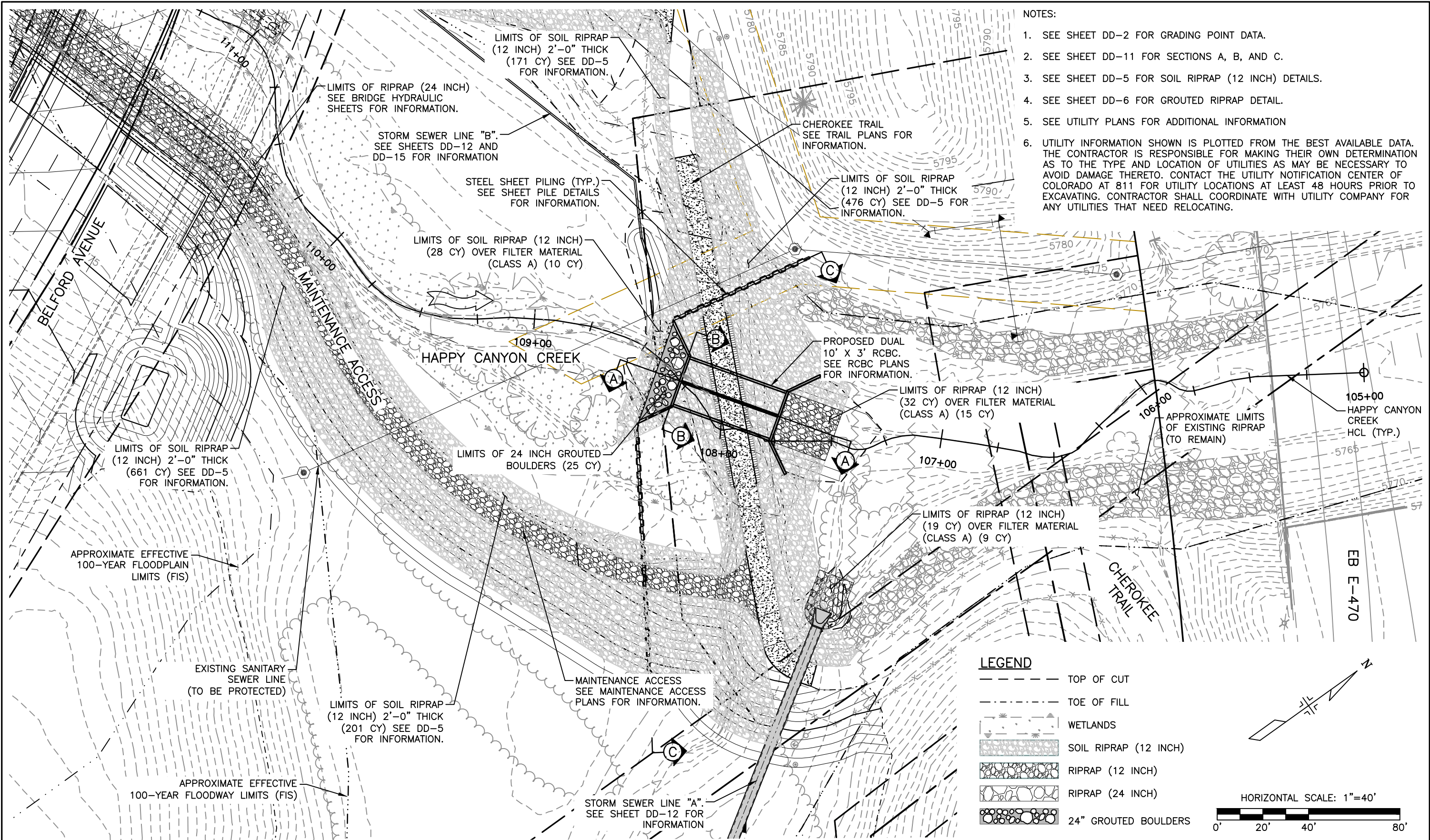
Print Date: 7/18/2017 1:56:48 PM	
File Name: H115360-01DROPO9?rofile.dwg	
Horizontal Scale: 1"=100'	Vertical Scale: 1"=10'
6300 South Syracuse Way, Suite 600 Centennial, CO 80111 tel 303.721.1440 fax 303.721.0832	

Sheet Revisions		
Date	Comments	Initials



As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE PROFILE		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-09 of 19	Sheet Number

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-11 FOR SECTIONS A, B, AND C.
  3. SEE SHEET DD-5 FOR SOIL RIPRAP (12 INCH) DETAILS.
  4. SEE SHEET DD-6 FOR GROUDED 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)
  - RIPRAP (24 INCH)
  - 24" GROUDED BOULDERS
- HORIZONTAL SCALE: 1"=40'
- 0' 20' 40' 80'

Print Date: 7/18/2017 1:59:20 PM  
 File Name: H115360-01DROP10Drop1 Plan.dwg  
 Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	

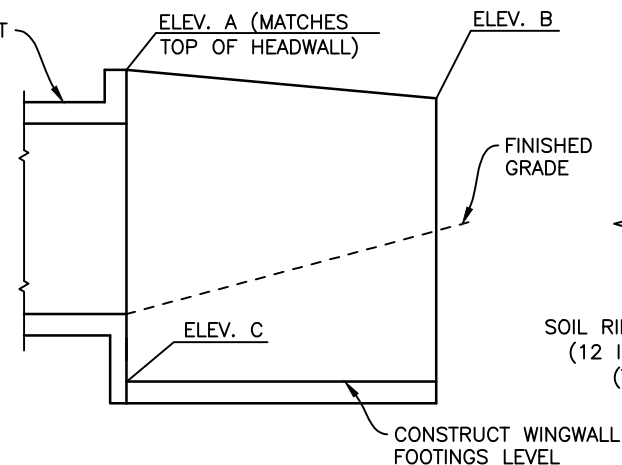
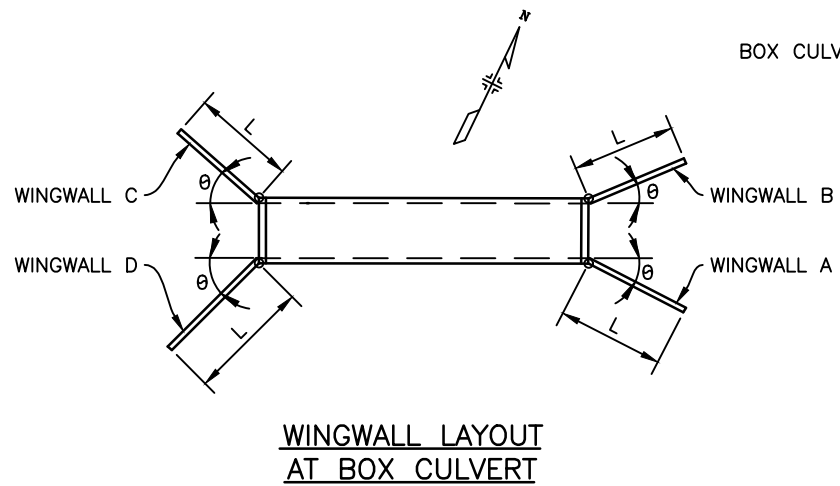
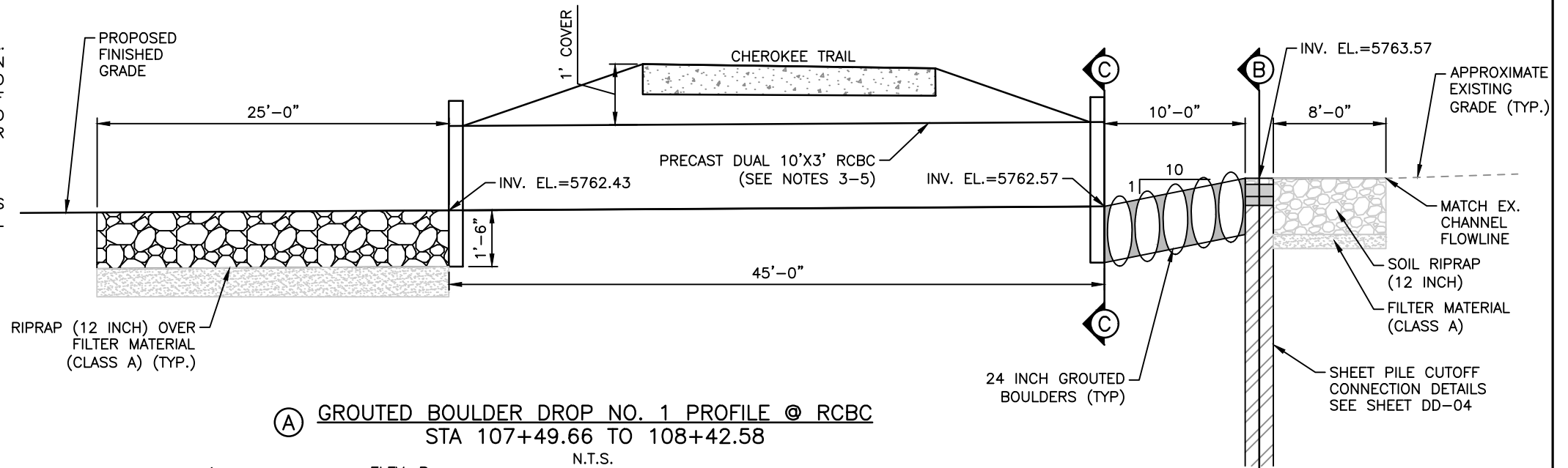
**Manhard CONSULTING LTD**

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph 303.708.0800 fax 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

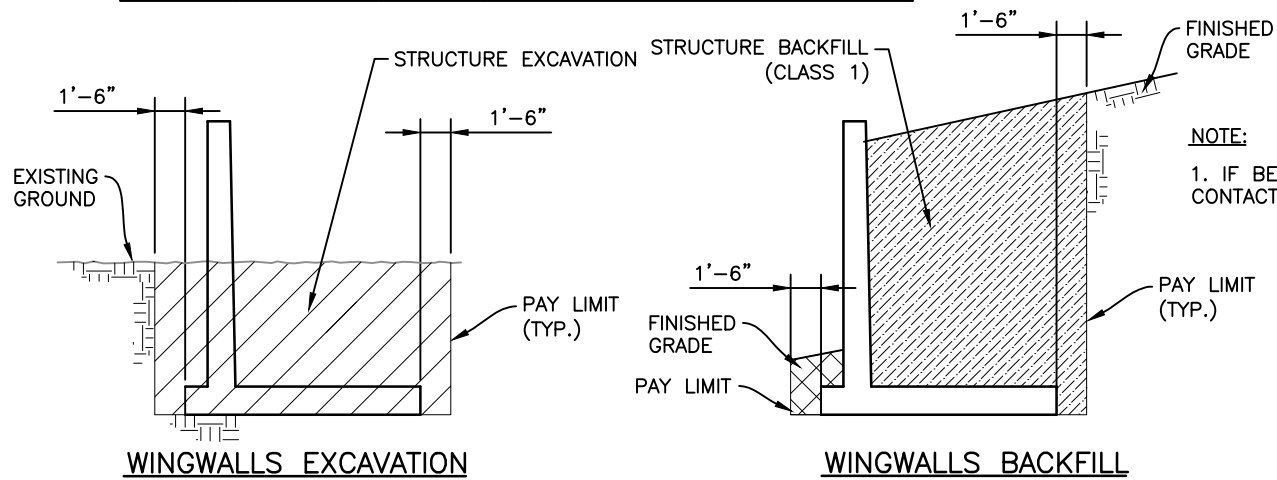
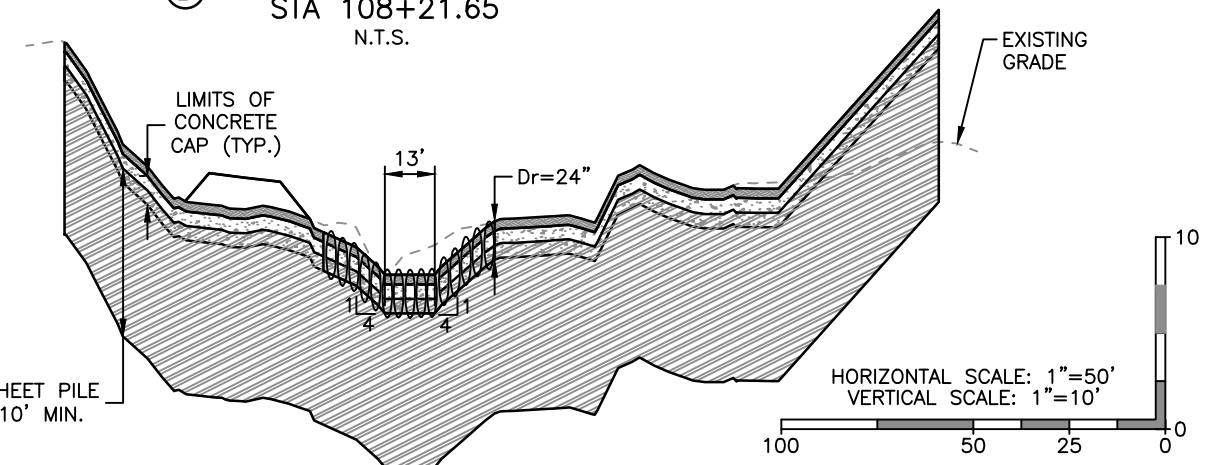
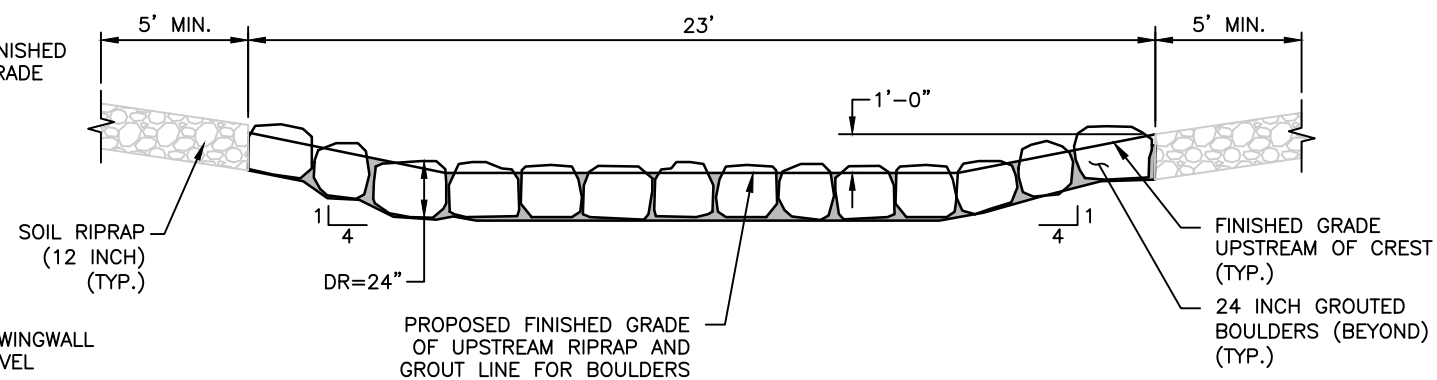
As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 1 PLAN		Project No./Code
No Revisions:	Designer:	CDT	
Revised:	Detailer:	KLT	
Void:	Subset:	Drainage	
Structure Numbers		DD-10 of 19	Sheet Number

NOTES

- 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.
- SEE UTILITY PLANS FOR ADDITIONAL INFORMATION.
- PRECAST BOX CULVERT MUST CONFORM TO CDOT M-STANDARDS M-603-2.
- FOR CAST-IN-PLACE END SECTIONS, USE M-601-2 FOR WALL THICKNESSES AND REINFORCEMENT SIZE AND SPACINGS WITH S=10 FT, R=6 FT, AND FILL HEIGHT = 0-5 FT.
- FOR WINGWALLS, USE M-601-20.



WINGWALL	θ	L	ELEV. A	ELEV. B	ELEV. C
A	45°0'0"	15'-6"	5767.18	5763.43	5760.43
B	45°0'0"	15'-6"	5767.18	5763.43	5760.43
C	45°0'0"	15'-6"	5767.32	5763.57	5760.57
D	45°0'0"	15'-6"	5767.32	5763.57	5760.57



NOTE:  
1. IF BEDROCK IS ENCOUNTERED, CONTACT ENGINEER PRIOR TO PROCEEDING.

DROP STRUCTURE NO. 1

HAPPY CANYON CREEK HYDRAULICS  
Q100= 8,303 C.F.S  
Q100 VELOCITY = 6.21 F.P.S  
FROUDE No.=0.33  
FOR INFO ONLY

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

Print Date: 7/18/2017 1:59:45 PM  
File Name: H115360-01DROP10Drop1 Prof Sect.dwg  
Horizontal Scale: 1"=50' Vertical Scale: 1"=10'  
FELSBURG HOLT & ULLEVIG  
6300 South Syracuse Way, Suite 600  
Centennial, CO 80111  
tel 303.721.1440  
fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	

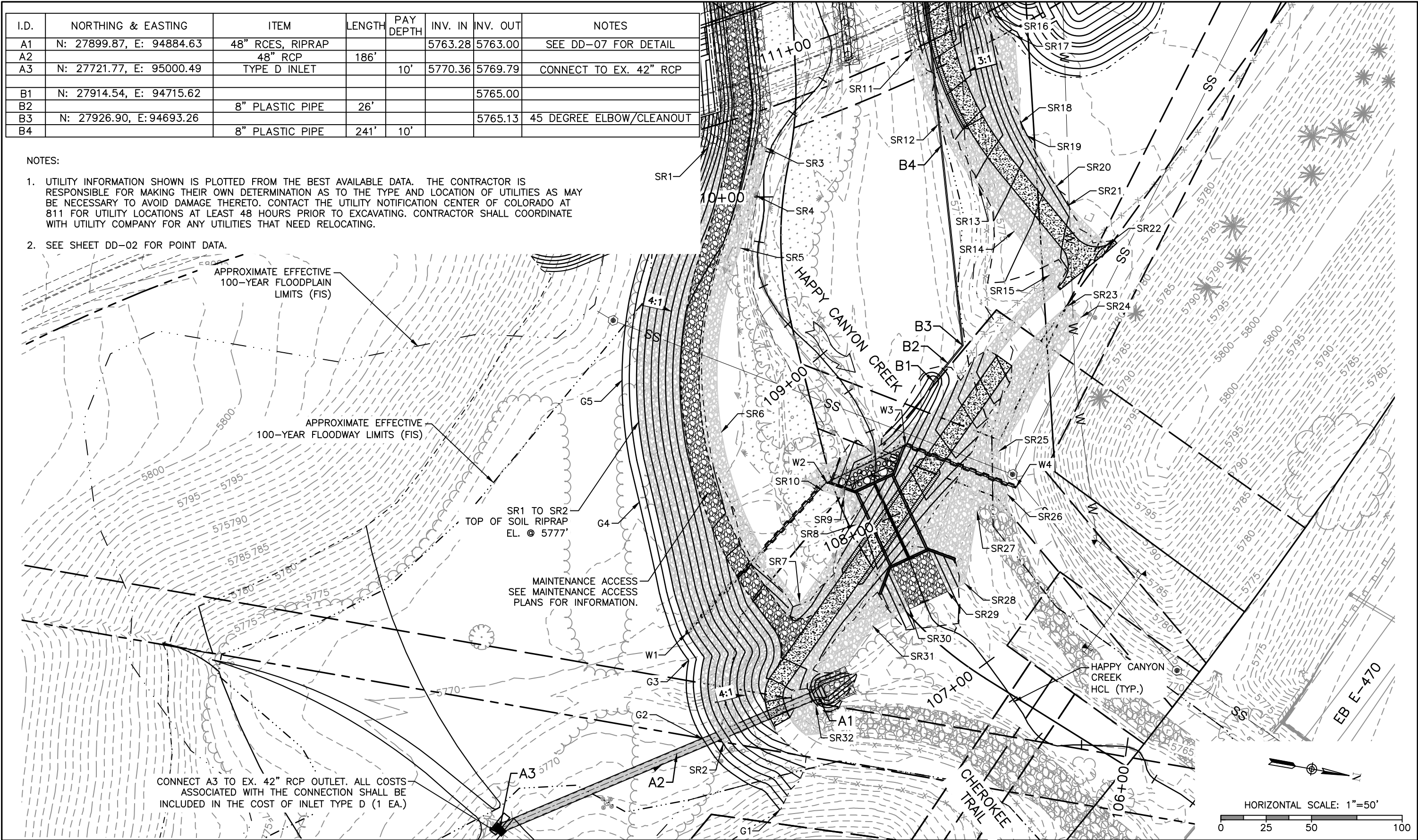


As Constructed		BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 1 PROFILE/DETAILS		Project No./Code
No Revisions:		Designer:	CDT	
Revised:		Detailer:	KLT	
Void:		Subset:	Drainage	
		Structure Numbers:		
		Sheets:	DD-11 of 19	Sheet Number

I.D.	NORTHING & EASTING	ITEM	LENGTH	PAY DEPTH	INV. IN	INV. OUT	NOTES
A1	N: 27899.87, E: 94884.63	48" RCES, RIPRAP			5763.28	5763.00	SEE DD-07 FOR DETAIL
A2		48" RCP	186'				
A3	N: 27721.77, E: 95000.49	TYPE D INLET		10'	5770.36	5769.79	CONNECT TO EX. 42" RCP
B1	N: 27914.54, E: 94715.62					5765.00	
B2		8" PLASTIC PIPE	26'				
B3	N: 27926.90, E: 94693.26					5765.13	45 DEGREE ELBOW/CLEANOUT
B4		8" PLASTIC PIPE	241'	10'			

NOTES:

- 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.
- SEE SHEET DD-02 FOR POINT DATA.



CONNECT A3 TO EX. 42" RCP OUTLET. ALL COSTS ASSOCIATED WITH THE CONNECTION SHALL BE INCLUDED IN THE COST OF INLET TYPE D (1 EA.)

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

Print Date: 7/18/2017 2:02:39 PM  
 File Name: H115360-01DROP12Grading Drop1.dwg  
 Horizontal Scale: 1"=25' Vertical Scale: N.T.S.

**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

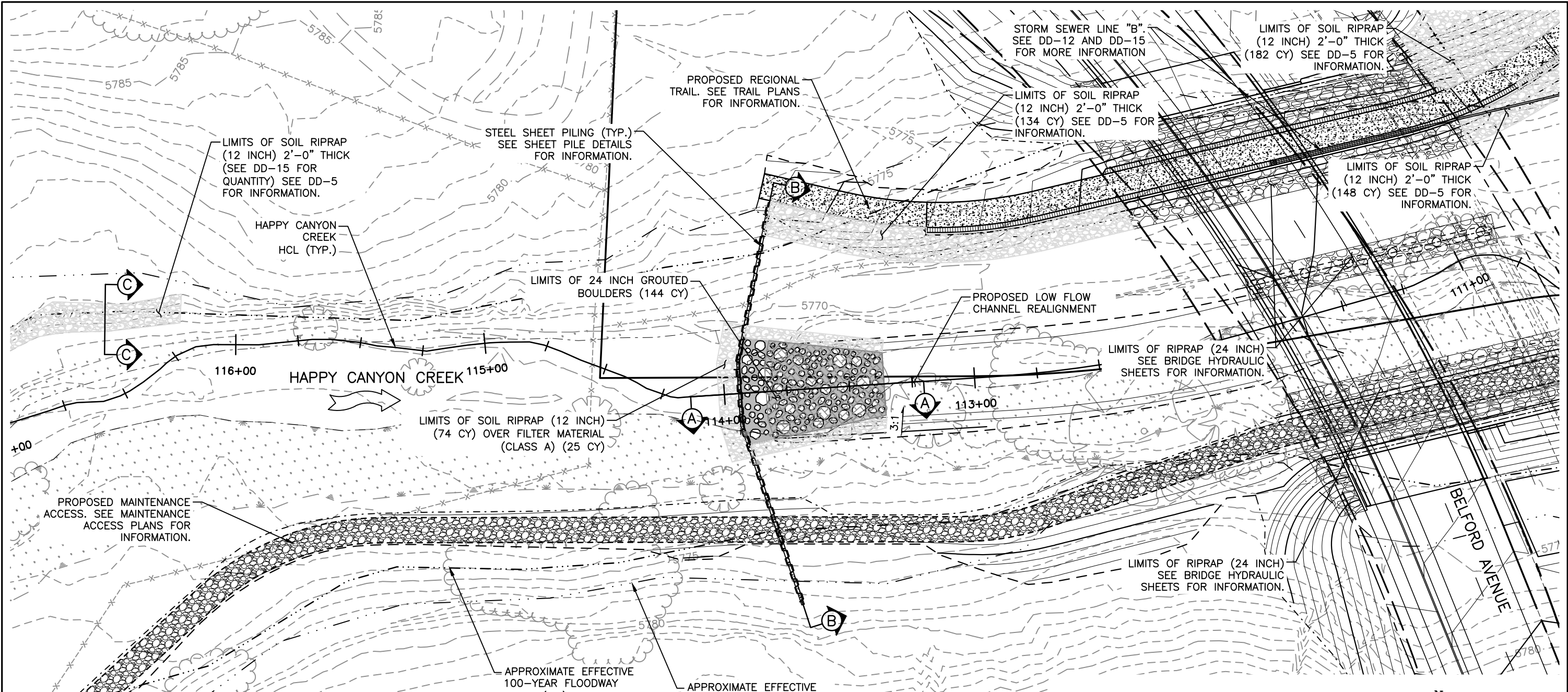
Sheet Revisions			
Date	Comments	Initials	

**Manhard CONSULTING LTD**

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph: 303.708.0900 fax: 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed		BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 1 GRADING DETAIL	
No Revisions:		Designer:	CDT
Revised:		Detailer:	KLT
Void:		Subst:	Drainage
		Structure Numbers:	
		Sheets:	DD-12 of 19

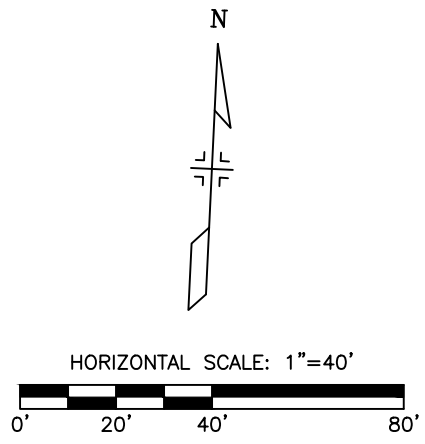
Project No./Code	
Sheet Number	



- NOTES:
1. SEE SHEET DD-2 FOR GRADING POINT DATA.
  2. SEE SHEET DD-14 FOR SECTIONS A, AND B.
  3. SEE SHEET DD-5 FOR SOIL RIPRAP (12 INCH) DETAILS.
  4. SEE SHEET DD-6 FOR GROUDED 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.

© SOIL RIPRAP SECTION  
N.T.S.  
STA 116+16.00 TO STA 118+80.00

- LEGEND**
- TOP OF CUT
  - - - - - TOE OF FILL
  - WETLANDS
  - SOIL RIPRAP (12 INCH)
  - RIPRAP (12 INCH)
  - RIPRAP (24 INCH)
  - 24" GROUDED BOULDERS



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

Print Date: 7/18/2017 2:05:09 PM  
 File Name: H115360-01DROP13Drop2 Plan.dwg  
 Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

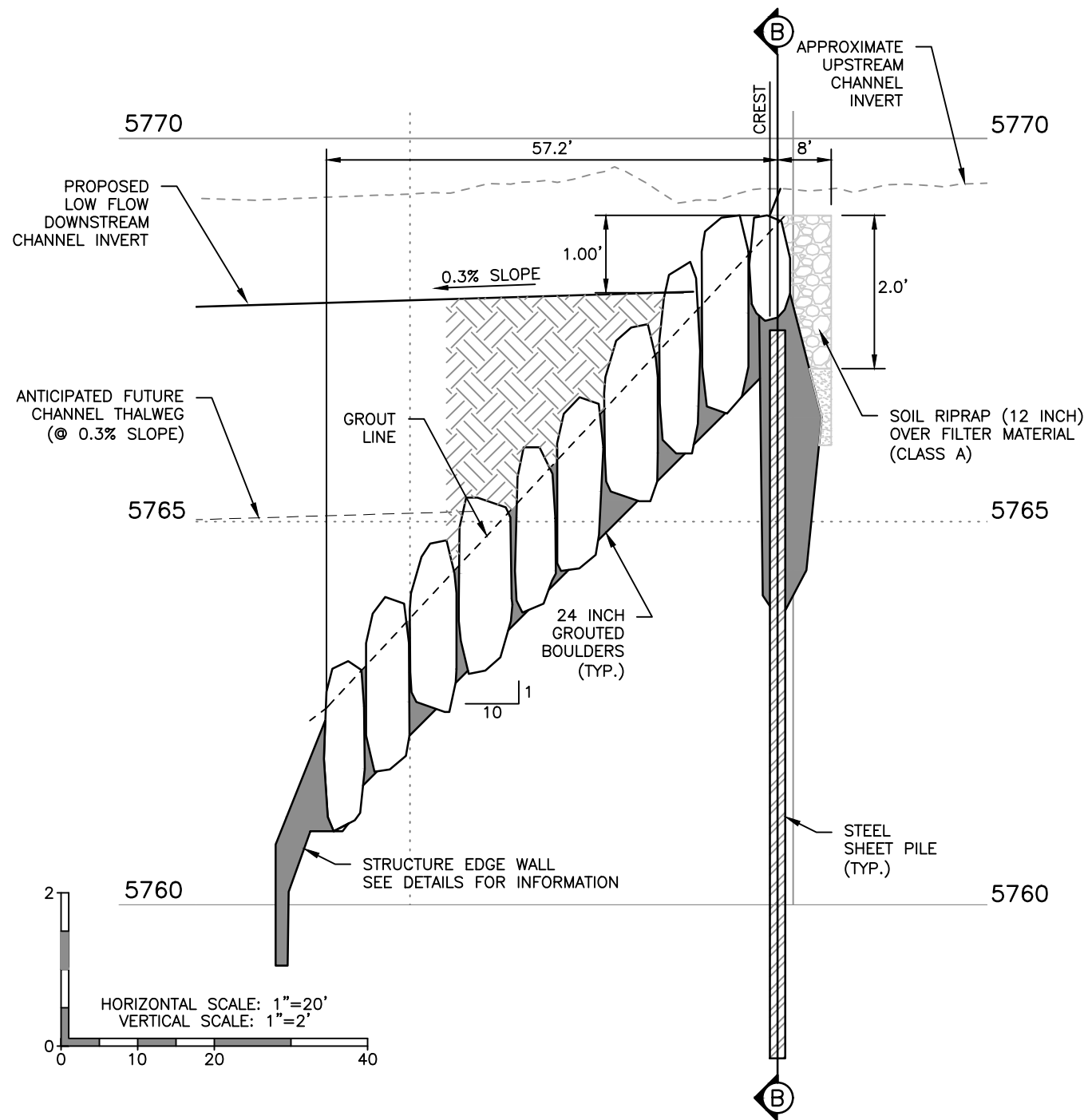
Sheet Revisions			
Date	Comments	Initials	

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph:303.708.0900 fax:303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

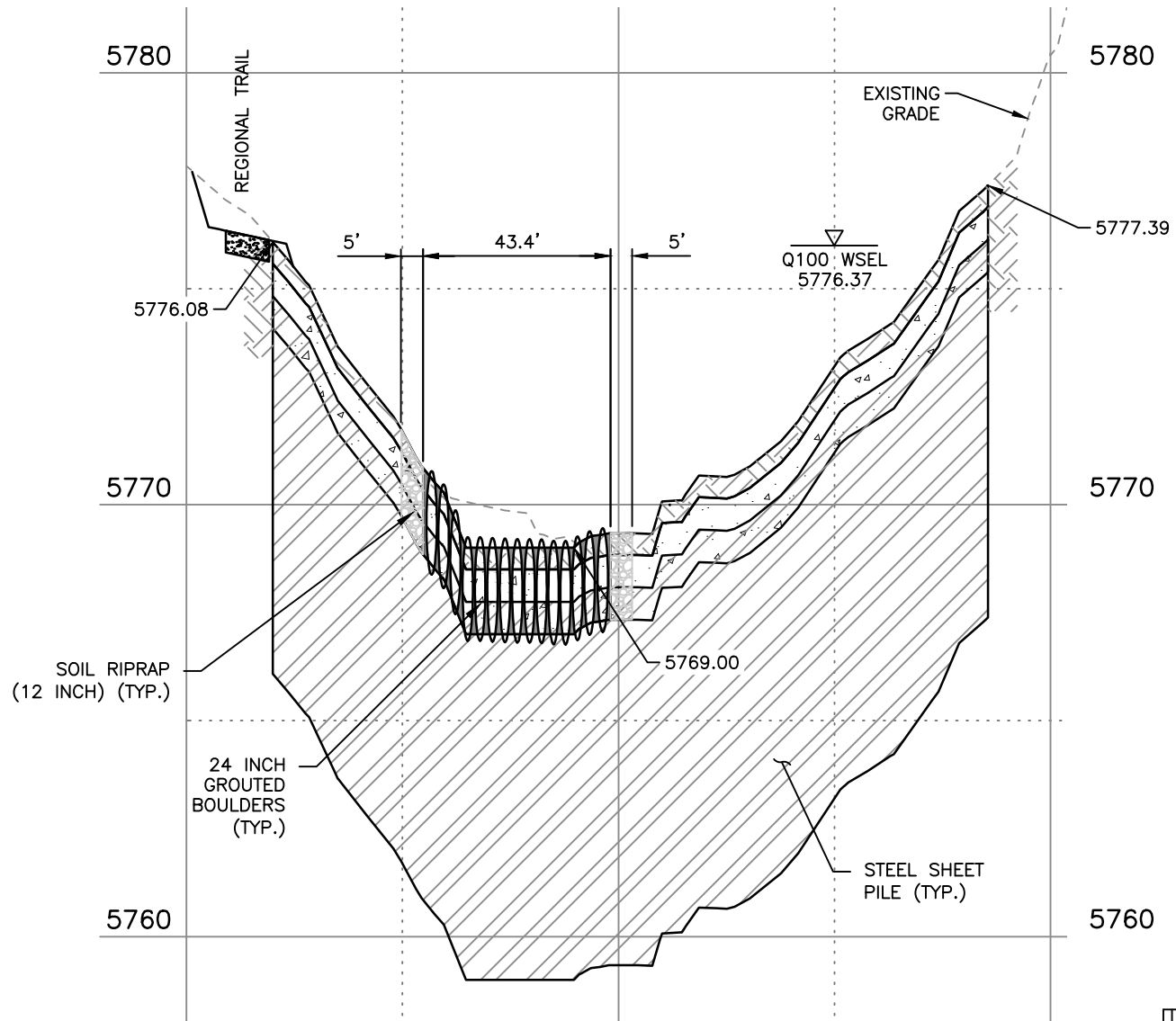
As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 2 PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT	Sheets: DD-13 of 19	Sheet Number
Void:	Subset: Drainage		

NOTES

- 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.
- SEE UTILITY PLANS FOR ADDITIONAL INFORMATION.



(A) **GRAUTED BOULDER DROP NO. 2 PROFILE**  
STA 113+39.80 TO 114+04.98



(B) **CREST SECTION**  
STATION 113+96.98

HAPPY CANYON CREEK HYDRAULICS	
Q100=	8,303 C.F.S
Q100 VELOCITY =	14.17 F.P.S
FROUDE No.=	0.93
FOR INFO ONLY	

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

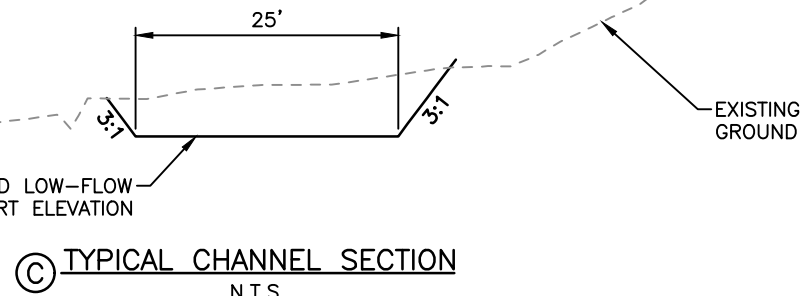
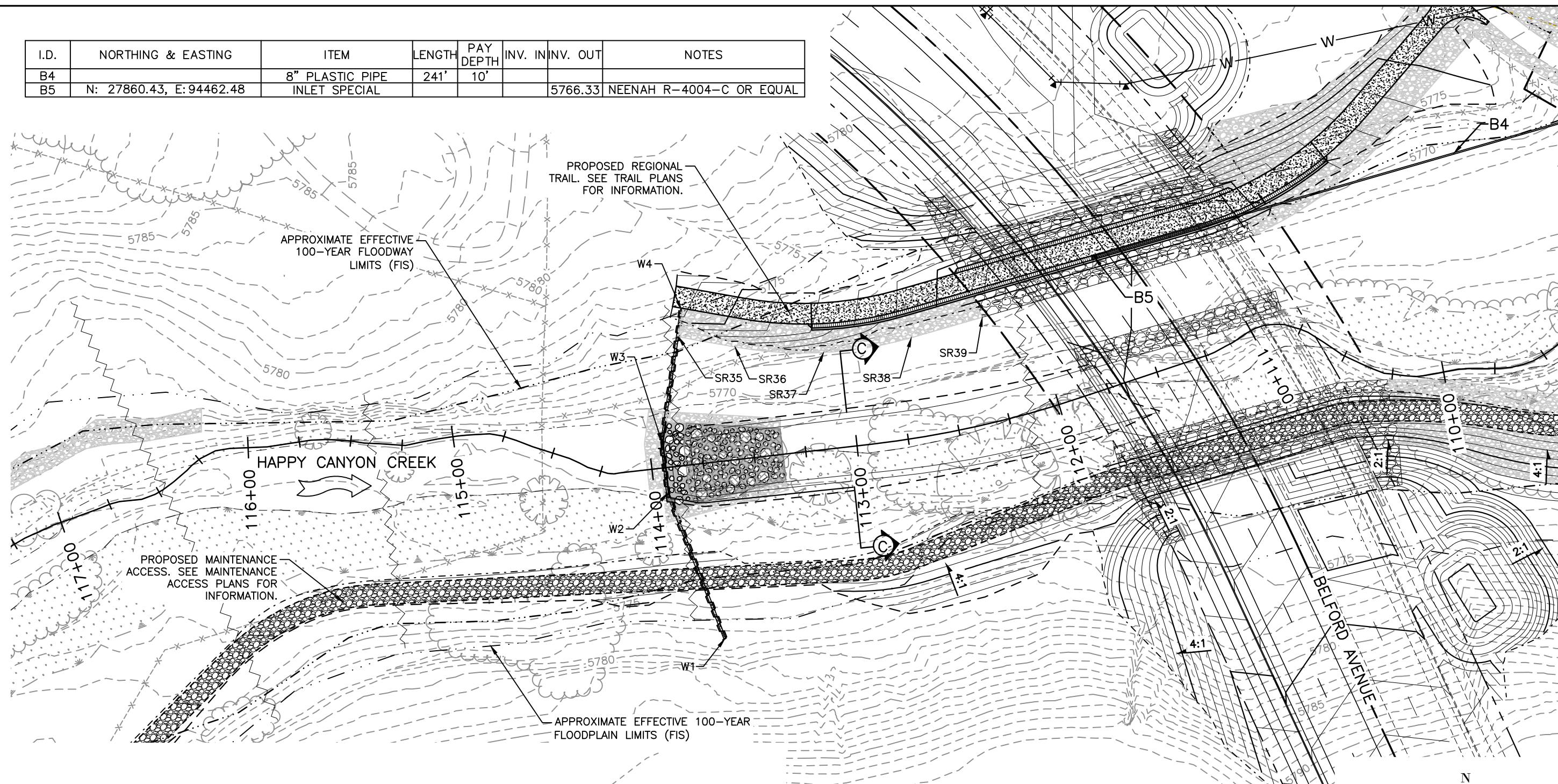
Print Date: 7/18/2017 2:05:47 PM
File Name: H115360-01DROP14Drop2 Prof Sect.dwg
Horizontal Scale: As Noted Vertical Scale: As Noted
6300 South Syracuse Way, Suite 600 Centennial, CO 80111 tel 303.721.1440 fax 303.721.0832

Sheet Revisions		
Date	Comments	Initials

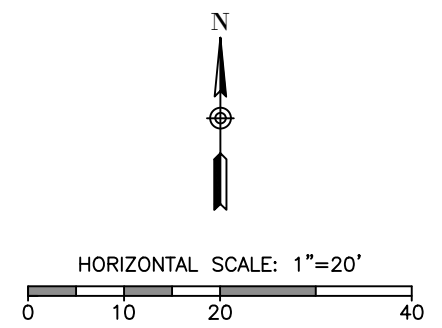


As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 2 PROFILE/DETAILS		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-14 of 19	Sheet Number

I.D.	NORTHING & EASTING	ITEM	LENGTH	PAY DEPTH	INV. IN	INV. OUT	NOTES
B4		8" PLASTIC PIPE	241'	10'			
B5	N: 27860.43, E: 94462.48	INLET SPECIAL				5766.33	NEENAH R-4004-C OR EQUAL



- NOTES:
- 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.
  - SEE SHEET DD-02 FOR POINT DATA.



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

Print Date: 7/18/2017 2:08:11 PM  
 File Name: H115360-01DROP15Grading Drop 2.dwg  
 Horizontal Scale: 1"=10' Vertical Scale: N.T.S.

**FELSBURG  
HOLT &  
ULLEVIG**

6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	

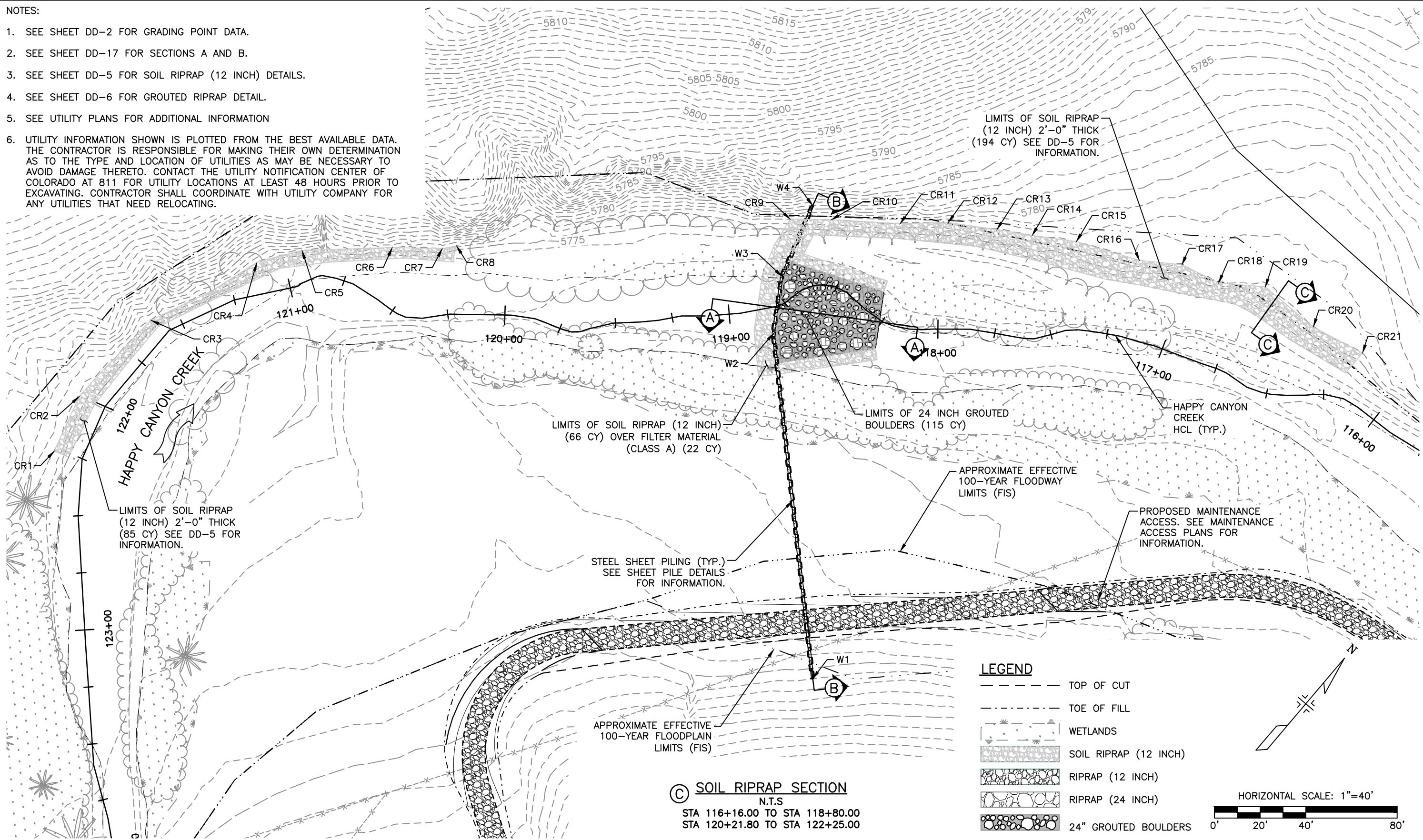
**Manhard CONSULTING LTD**

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph 303.708.0900 fax 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 2 GRADING DETAIL		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT	Sheets: DD-15 of 19	Sheet Number
Void:	Subset: Drainage		

NOTES:

1. SEE SHEET DD-2 FOR GRADING POINT DATA.
2. SEE SHEET DD-17 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
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.



© SOIL RIPRAP SECTION  
N.T.S.  
STA 116+16.00 TO STA 118+80.00  
STA 120+21.80 TO STA 122+25.00

LEGEND

- TOP OF CUT
  - TOE OF FILL
  - WETLANDS
  - SOIL RIPRAP (12 INCH)
  - RIPRAP (12 INCH)
  - RIPRAP (24 INCH)
  - 24" GROUTED BOULDERS
- HORIZONTAL SCALE: 1"=40'

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

Print Date: 7/18/2017 2:11:06 PM  
 File Name: H115360-01DROP16Drop3 Plan.dwg  
 Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

FELSBURG  
HOLT &  
ULLEVIG

6300 South Syracuse Way, Suite 600  
Centennial, CO 80111  
tel 303.721.1440  
fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	

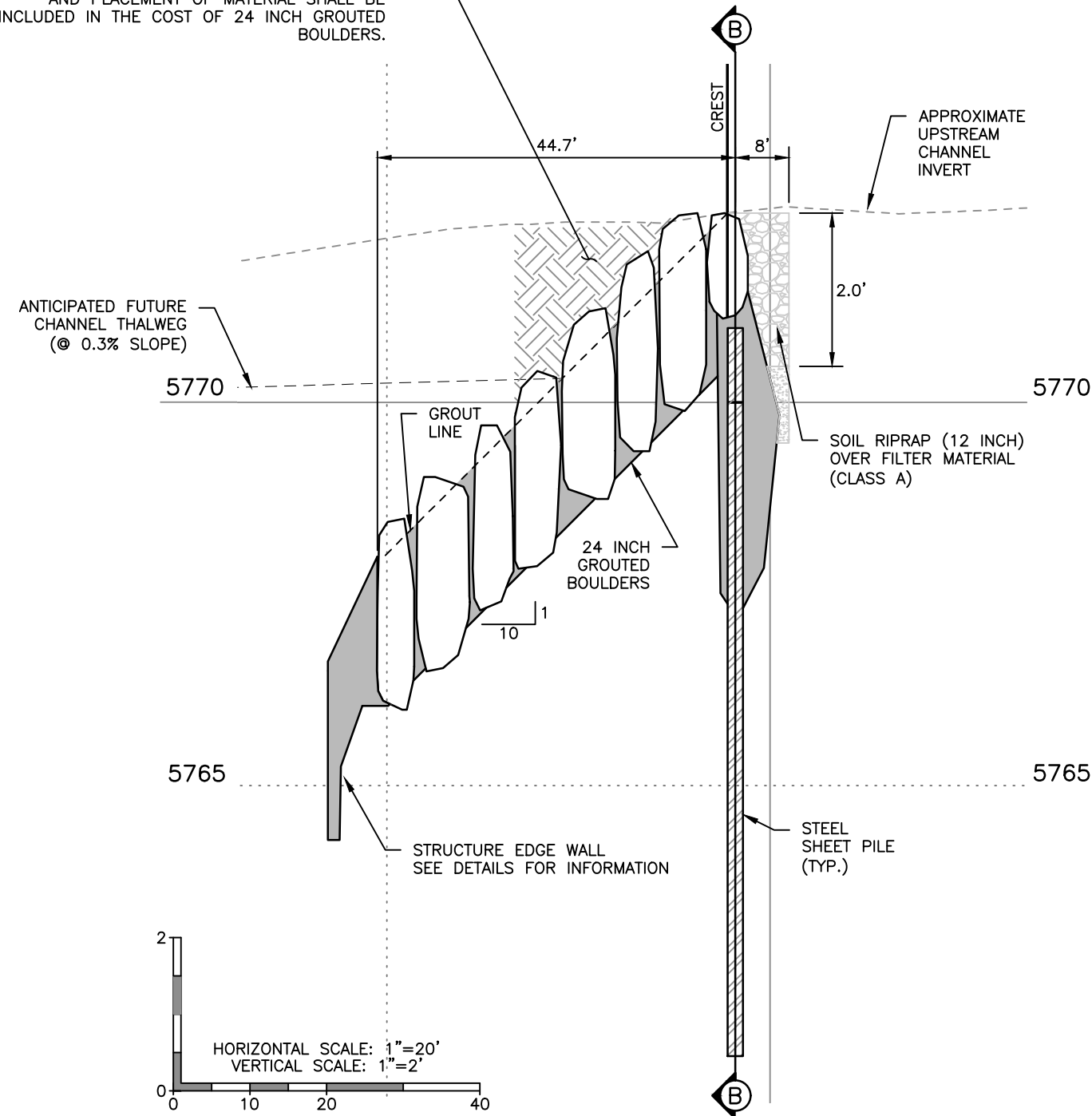
8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph 303.708.0800 fax 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 3 PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT	Numbers	
Void:	Subset: Drainage	Sheets: DD-16 of 19	Sheet Number

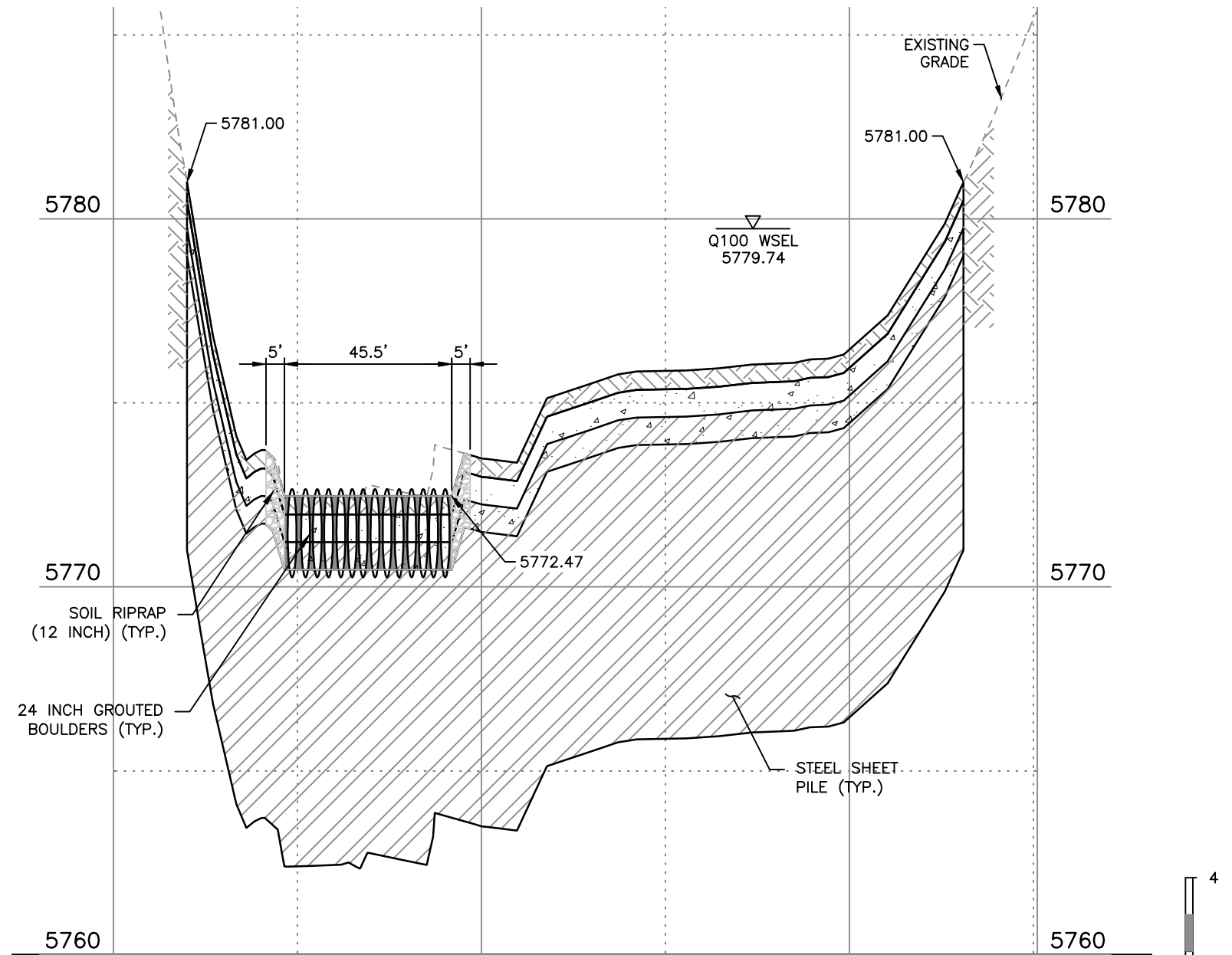
NOTES

- 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.
- SEE UTILITY PLANS FOR ADDITIONAL INFORMATION.

MATERIAL SHALL BE EXCAVATED FOR 24 INCH GROUTED BOULDERS AND STOCKPILED. STOCKPILED MATERIAL SHALL BE REAPPLIED AFTER DROP STRUCTURE IS CONSTRUCTED. ALL EXCAVATION, DEWATERING, STOCKPILING, AND PLACEMENT OF MATERIAL SHALL BE INCLUDED IN THE COST OF 24 INCH GROUTED BOULDERS.



**(A) GROUTED BOULDER DROP NO. 3 PROFILE**  
STA 118+49.81 TO 119+02.49



**(B) CREST SECTION**  
STATION 118+94.49

**DROP STRUCTURE NO. 3**

HORIZONTAL SCALE: 1"=40'  
VERTICAL SCALE: 1"=4'

**HAPPY CANYON CREEK HYDRAULICS**  
Q100= 8,303 C.F.S  
Q100 VELOCITY = 11.93 F.P.S  
FROUDE No.=0.79  
FOR INFO ONLY

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

Print Date: 7/18/2017 2:13:42 PM  
File Name: H115360-01DROP17Drop3 Prof Sect.dwg  
Horizontal Scale: As Noted Vertical Scale: As Noted

**FELSBURG HOLT & ULLEVIG**  
6300 South Syracuse Way, Suite 600  
Centennial, CO 80111  
tel 303.721.1440  
fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	



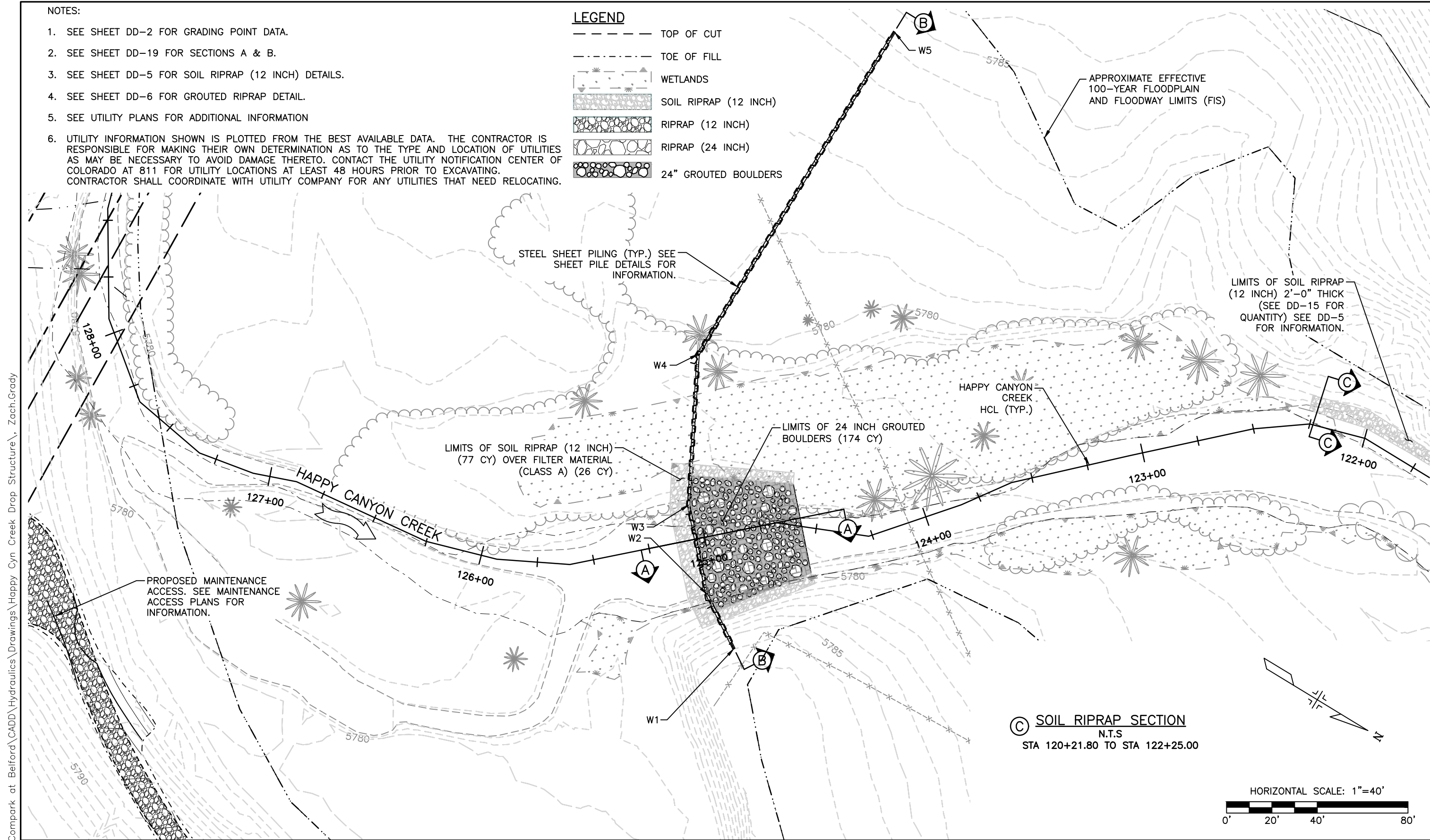
As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 3 PROFILE/DETAILS		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Drainage	Sheets: DD-17 of 19	Sheet Number

**NOTES:**

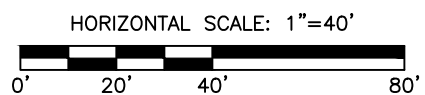
1. SEE SHEET DD-2 FOR GRADING POINT DATA.
2. SEE SHEET DD-19 FOR SECTIONS A & B.
3. SEE SHEET DD-5 FOR SOIL RIPRAP (12 INCH) DETAILS.
4. SEE SHEET DD-6 FOR GROUTED RIPRAP DETAIL.
5. SEE UTILITY PLANS FOR ADDITIONAL INFORMATION
6. UTILITY INFORMATION SHOWN IS PLOTTED FROM THE BEST AVAILABLE DATA. THE 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
- [Symbol] WETLANDS
- [Symbol] SOIL RIPRAP (12 INCH)
- [Symbol] RIPRAP (12 INCH)
- [Symbol] RIPRAP (24 INCH)
- [Symbol] 24" GROUTED BOULDERS



© SOIL RIPRAP SECTION  
N.T.S.  
STA 120+21.80 TO STA 122+25.00



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

Print Date: 7/18/2017 2:16:27 PM  
 File Name: H115360-01DROP18Drop4 Plan.dwg  
 Horizontal Scale: 1"=20' Vertical Scale: N.T.S.

Sheet Revisions			
Date	Comments	Initials	



As Constructed	
No Revisions:	
Revised:	
Void:	

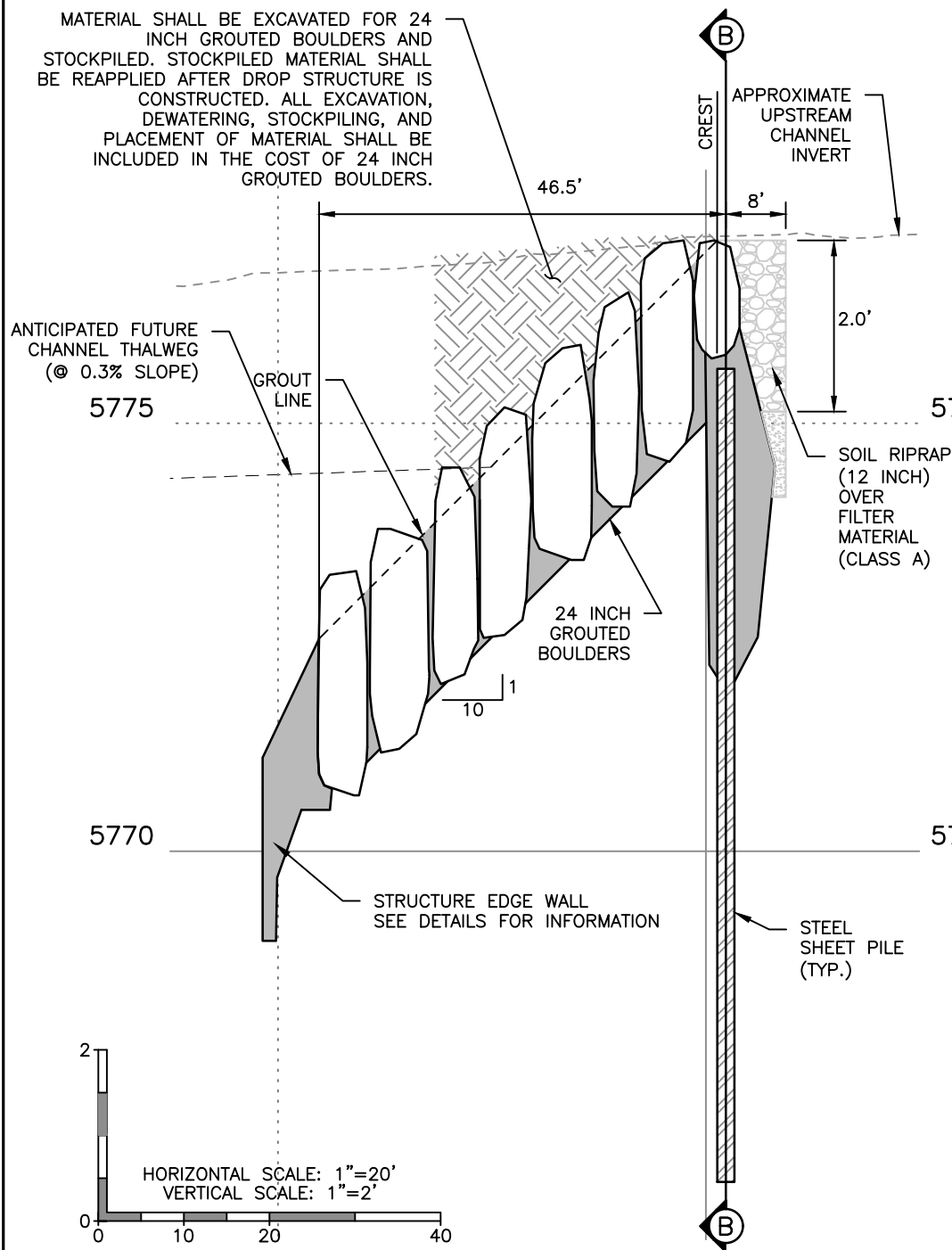
BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 4 PLAN			
Designer:	CDT	Structure	
Detailer:	KLT	Numbers	
Subset:	Drainage	Sheets:	DD-18 of 19

Project No./Code	
Sheet Number	

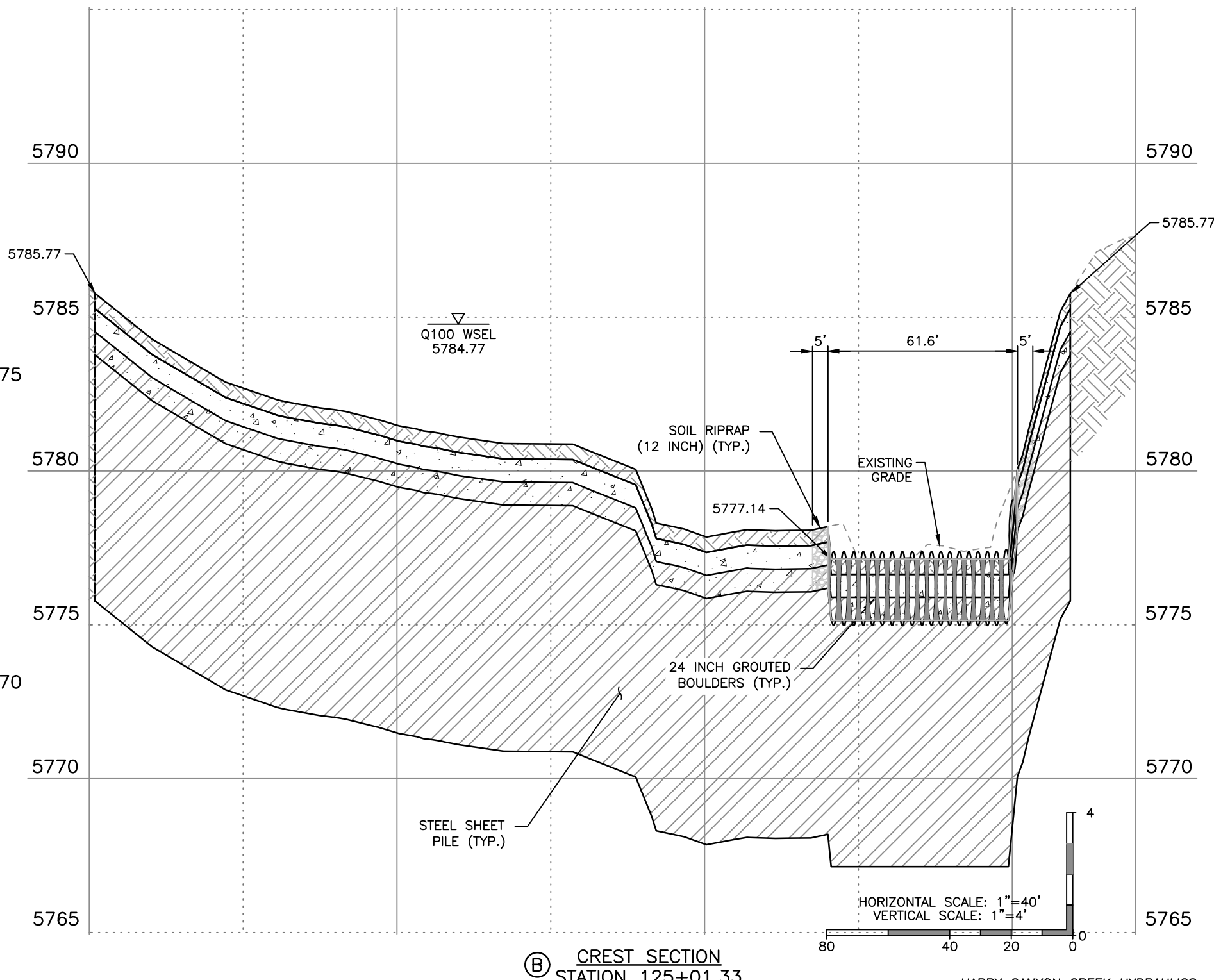
NOTES

- 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.
- SEE UTILITY PLANS FOR ADDITIONAL INFORMATION.

MATERIAL SHALL BE EXCAVATED FOR 24 INCH GROUDED BOULDERS AND STOCKPILED. STOCKPILED MATERIAL SHALL BE REAPPLIED AFTER DROP STRUCTURE IS CONSTRUCTED. ALL EXCAVATION, DEWATERING, STOCKPILING, AND PLACEMENT OF MATERIAL SHALL BE INCLUDED IN THE COST OF 24 INCH GROUDED BOULDERS.



**(A) GROUDED BOULDER DROP NO. 4 PROFILE**  
STA 124+54.81 TO 125+09.33



**(B) CREST SECTION**  
STATION 125+01.33

**DROP STRUCTURE NO. 4**

HAPPY CANYON CREEK HYDRAULICS	
Q100=	8,303 C.F.S
Q100 VELOCITY =	8.97 F.P.S
FROUDE No.=	0.58
FOR INFO ONLY	

Print Date: 7/18/2017 2:18:27 PM  
File Name: H115360-01DROP19Drop4 Prof Sect.dwg  
Horizontal Scale: As Noted Vertical Scale: As Noted  
FELSBURG HOLT & ULLEVIG  
6300 South Syracuse Way, Suite 600  
Centennial, CO 80111  
tel 303.721.1440  
fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	



As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE DROP NO. 4 PROFILE/DETAILS		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT	Sheets: DD-19 of 19	Sheet Number
Void:	Subset: Drainage		

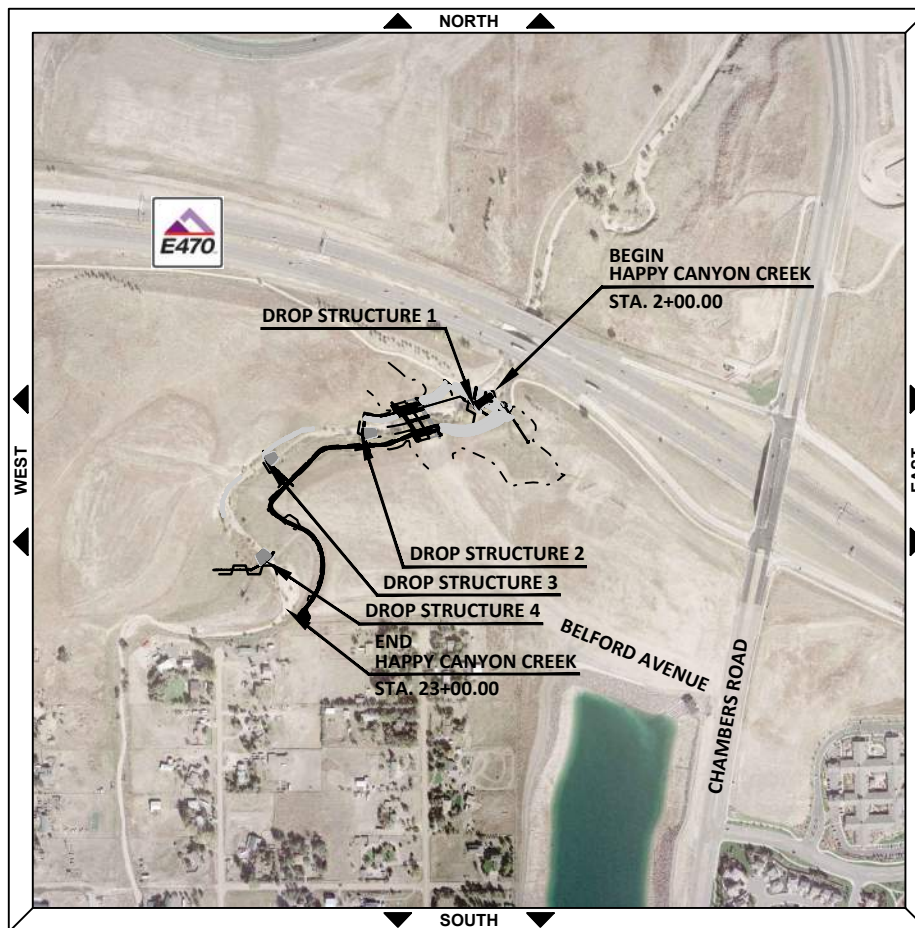
I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\Happy Cyn Creek Drop Structure\ Zach.Grady



**FOR PLANS**  
**CONSTRUCTION BEST MANAGEMENT PRACTICES**  
**BELFORD AVENUE BRIDGE AND HAPPY CANYON CREEK**  
**TOWN OF PARKER, COUNTY OF DOUGLAS, STATE OF COLORADO**

SCALE OF ORIGINAL DRAWINGS

ON PLAN      1" = 80'



INDEX OF SHEETS

SHEET NO.	SUBSET SHEETS	DESCRIPTION
61	EL-1	CBMP TITLE SHEET
62	ET-1	TABULATION OF EROSION CONTROL QUANTITIES
63	EI-1	INITIAL CBMP PLAN
64	EN-1	INTERIM CBMP PLAN
65	EF-1	FINAL CBMP PLAN

**TOWN OF PARKER APPROVALS**

THE TOWN OF PARKER REVIEW CONSTITUTES GENERAL COMPLIANCE WITH THE TOWNS STANDARDS AND APPROVED VARIANCES, SUBJECT TO THESE PLANS BEING STAMPED, SIGNED, AND DATED BY THE PROFESSIONAL ENGINEER OF RECORD. REVIEW BY THE TOWN DOES NOT CONSTITUTE APPROVAL OF THE PLAN DESIGN OR ACCURACY AND CORRECTNESS OF ENGINEERING CALCULATION. ERRORS IN THE DESIGN OR CALCULATIONS REMAIN THE RESPONSIBILITY OF THE REGISTERED PROFESSIONAL ENGINEER WHOSE STAMP AND SIGNATURE ARE AFFIXED TO THIS DOCUMENT.

THIS REVIEW DOES NOT CONSTITUTE APPROVAL OF ANY PRIVATE ON-SITE IMPROVEMENTS WHICH MAY BE SHOWN. CONSTRUCTION CANNOT COMMENCE UNTIL ALL REQUIRED DRAINAGE/TRAFFIC REPORT(S), FINAL DEVELOPMENT PLAN(S), SPECIAL REVIEW(S), GRADING PERMIT, AND/OR OTHER PERMITS ARE COMPLETE, APPROVED AND ON FILE WITH THE TOWN OF PARKER.

TOWN OF PARKER, PUBLIC WORKS DIRECTOR	DATE
TOWN OF PARKER, PUBLIC WORKS MANAGER – STORMWATER	DATE
TOWN OF PARKER, PUBLIC WORKS MANAGER – TRANSPORTATION	DATE

**BASIS OF BEARING:**

THE WEST LINE OF THE SOUTHWEST QUARTER OF SECTION 6, TOWNSHIP 6 SOUTH, RANGE 66 WEST OF THE SIXTH PRINCIPAL MERIDIAN BEING MONUMENTED AS SHOWN HEREON HAVING A BEARING OF NORTH 00°29'49" WEST, AS DETERMINED BY GPS OBSERVATION FROM NGS CONTROL POINTS IN THE COLORADO CENTRAL ZONE, STATE PLAN COORDINATE SYSTEM, TOWN OF PARKER, COUNTY OF DOUGLAS, STATE OF COLORADO.

**BENCHMARKS: (COMPARK SOUTH)**

**SOURCE BENCHMARKS:**  
 DOUGLAS COUNTY BM 1.115010  
 A DOUGLAS COUNTY GIS MONUMENT SET IN CONCRETE LOCATED APPROXIMATELY 130 FEET SOUTHWESTERLY OF THE CENTERLINE OF CHAMBERS ROAD AND 95 FEET NORTHWESTERLY OF THE CENTERLINE OF COMPARK BOULEVARD.  
 ELEVATION = 5752.84 (NAVD 88)

**SITE BENCHMARKS:**  
 A NO. 5 REBAR WITH 2" ALUMINUM CAP STAMPED "LS 28286, 2001" FOUND AT THE SOUTHWEST CORNER OF SECTION 6, T6S, R66W LOCATED ON THE WEST LINE OF FIRST STREET APPROXIMATELY 1000 FEET NORTH OF ELM AVENUE.  
 ELEVATION = 5845.51

A 2.5" IRON PIPE WITH 3.25" ALUMINUM CAP STAMPED "PLS 12405, 1997" FOUND AT THE SOUTHEAST CORNER OF SECTION 6, T6S, R66W LOCATED APPROXIMATELY 960 FEET NORTH OF THE CENTERLINE OF AVENTERRA PARKWAY AND APPROXIMATELY 1050 FEET WEST OF THE CENTERLINE OF CHAMBERS ROAD.  
 ELEVATION = 5808.06

Print Date: 7/18/2017 2:51:44 PM  
 File Name: E115360-01TTL01DROP.dwg  
 Horizontal Scale: NTS      Vertical Scale: NTS

**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	



As Constructed	BELFORD-HAPPY CANYON CREEK CBMP TITLE SHEET		Project No./Code
No Revisions:			
Revised:	Designer: CDT	Structure Numbers	
	Detailer: KLT		
Void:	Subset: EROSION	Sheets: EL-1 of 1	Sheet Number 83

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

**TABULATION OF EROSION CONTROL QUANTITIES**

DRAWING NUMBER	CHECK DAM <b>CD</b>	*CONCRETE WASHOUT STRUCTURE <b>CWA</b>	*VEHICLE TRACKING CONTROL <b>VTC</b>	*STABILIZED STAGING AREA <b>SSA</b>	SEEDING (NATIVE) <b>SMC</b>	MULCHING (WEED FREE STRAW) <b>SMC</b>	*CULVERT PROTECTION <b>CP</b>	DEWATERING <b>D</b>	*SEDIMENT CONTROL LOG (12 INCH) <b>SCL</b>	EROSION CONTROL BLANKET (STRAW/COCONUT) <b>ECB</b>	DIVERSION DITCH <b>DD</b>	CONSTRUCTION FENCE <b>CF</b>	SILT FENCE <b>SF</b>	#INLET PROTECTION AREA INLETS NOT IN PAVEMENT <b>IPAN</b>	##ROUGH CUT STREET CONTROL <b>RCSC</b>	TEMPORARY SEDIMENT BASIN <b>TSB</b>	TEMPORARY STREAM CONTROL <b>TSC</b>
	LF	EACH	EACH	SY	ACRE	ACRE	LF	LS	LF	SY	LF	LF	LF	EA	LF	EA	EA
INITIAL (EI-1)	275	2	2	2300			40		1680		312	8275	440				4
INTERIM (EN-1)							60	1	1760					1	480	2	
FINAL (EF-1)					5.8	5.8				1795							
<b>PROJECT TOTALS</b>	<b>275</b>	<b>2</b>	<b>2</b>	<b>2300</b>	<b>5.8</b>	<b>5.8</b>	<b>100</b>	<b>1</b>	<b>3440</b>	<b>1795</b>	<b>312</b>	<b>8275</b>	<b>440</b>	<b>1</b>	<b>480</b>	<b>2</b>	<b>4</b>

1. THESE QUANTITIES HAVE BEEN TAKEN FORWARD TO THE SUMMARY OF APPROXIMATE QUANTITIES.
  2. FOR DETAILS, SEE CBMP STANDARD NOTES AND DETAILS.
  3. CHECK DAMS ARE NOT TO BE REMOVED UNLESS DIRECTED BY THE PROJECT ENGINEER.
  4. MULCH TACKIFIER IS REQUIRED AND IS INCLUDED IN THE COST OF MULCHING.
  5. SEE CBMP SHEETS FOR ADDITIONAL PLACEMENT INFORMATION.
  6. LOCATION OF STOCKPILES, INCLUDING TOPSOIL, IMPORTED AGGREGATES, EXCESS MATERIALS, STORAGE AND STAGING AREAS FOR EQUIPMENT FUEL, LUBRICANT, CHEMICAL (AND OTHER MATERIALS), WASTE STORAGE, BORROW AND DISPOSAL AREAS SHALL BE LOCATED PRIOR TO CONSTRUCTION WITH IN THE DEFINED LIMITS OF CONSTRUCTION BY THE PROJECT ENGINEER.
- \* THESE ITEMS SHALL BE PAID FOR AS PLACE AND REMOVE.  
 # THESE ITEMS SHALL BE PAID FOR AS INLET PROTECTION (EACH).  
 ## ROUGH CUT STREET CONTROL SHALL BE PAID FOR AS AGGREGATE BAG (LF)

**ADDITIONAL SEDIMENT/EROSION CONTROL:**

IT IS ESTIMATED THAT BLADING (120 HORSEPOWER), DOZING (100 HORSEPOWER), COMBINATION LOADER (125 HORSEPOWER) AND/OR BACKHOE (75 HORSEPOWER) AND/OR LABORER MAY BE REQUIRED FOR MISCELLANEOUS EROSION CONTROL WORK AS DIRECTED BY THE ENGINEER. WORK SHALL BE PAID FOR AS 208 SEDIMENT REMOVAL AND DISPOSAL (40 HRS). EROSION CONTROL MANAGEMENT WILL BE REQUIRED FOR THIS PROJECT AND SHALL BE PAID FOR AS 208 EROSION CONTROL MANAGEMENT (30 DAYS).

**WATER CONTROL NOTES – TEMPORARY STREAM CONTROL**

1. THE CONTRACTOR SHALL DEVELOP AND SUBMIT A WATER CONTROL PLAN TO THE TOWN OF PARKER FOR REVIEW AND APPROVAL TWO WEEKS PRIOR TO BEGINNING CONSTRUCTION. WATER CONTROL INCLUDES CHANNEL BASE FLOW, STORMWATER RUNOFF, AND GROUNDWATER. THE CONTRACTOR'S WATER CONTROL PLAN SHALL INCLUDE ALL MEANS AND METHODS NECESSARY IN CONVEYING WATER THROUGH AND FROM THE PROJECT SITE SO THAT THE WATER QUALITY OR PROPERTY DOWNSTREAM OF THE PROJECT LIMITS ARE NOT IMPACTED NEGATIVELY FROM THE PROJECT'S CONSTRUCTION ACTIVITIES.
2. THE CONTRACTOR'S MEANS AND METHODS INCLUDED IN THE CONTRACTOR'S APPROVED WATER CONTROL PLAN MAY INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING: PLASTIC LINED DIVERSION DITCHES, TEMPORARY PIPING, HOSES, CUTOFF WALLS, CHECK DAMS, PUMPS, GENERATORS, SOUND PROOFING, TEMPORARY POWER, SHEET PILE, SHORING, SEDIMENT TRAPS, SEDIMENT BASINS, FILTER BAGS, REINFORCED ROCK BERMS, STREAM CROSSINGS, RIPRAP PADS, RIPRAP, CRUSHED ROCK AND ANY OTHER WATER CONTROL MEASURES NECESSARY AND APPROVED BY THE TOWN OF PARKER.
3. GIVEN THE NATURE OF THE PROJECT SITE'S TERRAIN AND SCOPE OF WORK, THE CONTRACTOR'S WATER CONTROL PLAN AND PROPOSAL SHALL ACCOUNT FOR THE NEED TO RELOCATE WATER CONTROL MEASURES AS NEEDED BASED ON THE CONTRACTOR'S ACTUAL CONSTRUCTION SEQUENCE AND SELECTED MEANS AND METHODS.
4. WATER QUALITY SHALL BE ONE OF THE CONTRACTOR'S PRIMARY CONCERNS. THE CONTRACTOR'S IMPLEMENTED WATER CONTROL PLAN WILL BE INSPECTED DAILY. IF FOR ANY REASON THE CONTRACTOR'S IMPLEMENTED WATER CONTROL PLAN NEEDS CORRECTIVE ACTION OR IF THE CONTRACTOR IS DIRECTED BY THE TOWN OF PARKER OR THE OWNER'S REPRESENTATIVE TO MAKE REPAIRS, THE CONTRACTOR SHALL MAKE SUCH CORRECTIONS IMMEDIATELY.
5. THE APPROXIMATE 2-YR DISCHARGE FOR HAPPY CANYON CREEK IS 309 CFS. THE AVERAGE BASE FLOW RATE IS UNKNOWN. THE ESTIMATED AVERAGE BASE FLOW RATE IS APPROXIMATELY 1 CFS.
6. ALL STREAM DIVERSION DITCHES NEED TO BE PLASTIC LINED AT A MINIMUM AS DIRECTED BY THE TOWN OF PARKER.
7. ALL TEMPORARY STREAM CROSSINGS SHALL BE COMPLETELY RIPRAP REINFORCED AND HAVE PLASTIC LINING UNDER THE RIPRAP. THE CONTRACTOR'S SELECTED STREAM CROSSING SHALL ACCOMMODATE PASSAGE FOR BASE FLOWS AND AT NO TIME SHALL CONTRACTORS' EQUIPMENT HAVE DIRECT CONTACT WITH ANY STREAM FLOW.
8. ALL INCIDENTAL WATER CONTROL ITEMS SHALL BE PAID FOR AS TEMPORARY STREAM CROSSING (EA).

**CBMP LEGEND**

	<b>CD</b> CHECK DAM
	<b>CF</b> CONSTRUCTION FENCE
	<b>CP</b> CULVERT PROTECTION
	<b>CWA</b> CONCRETE WASHOUT AREA
	<b>D</b> DEWATERING
	<b>DD</b> DIVERSION DITCH
	<b>ECB</b> EROSION CONTROL BLANKET (STRAW/COCONUT)
	<b>IPAN</b> INLET PROTECTION FOR AREA INLETS NOT IN PAVEMENT
	<b>RCSC</b> ROUGH CUT STREET CONTROL
	<b>SCL</b> SEDIMENT CONTROL LOG (12 INCH)
	<b>SF</b> SILT FENCE
	<b>SMC</b> SEEDING MULCHING AND CRIMPING
	<b>SSA</b> STABILIZED STAGING AREA
	<b>TSB</b> TEMPORARY SEDIMENT BASIN
	<b>TSC</b> TEMPORARY STREAM CONTROL
	<b>VTC</b> VEHICLE TRACKING CONTROL

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

Print Date: 7/18/2017 2:52:10 PM  
 File Name: E115360-01TAB01ΔROP.dwg  
 Horizontal Scale: NTS Vertical Scale: NTS

**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

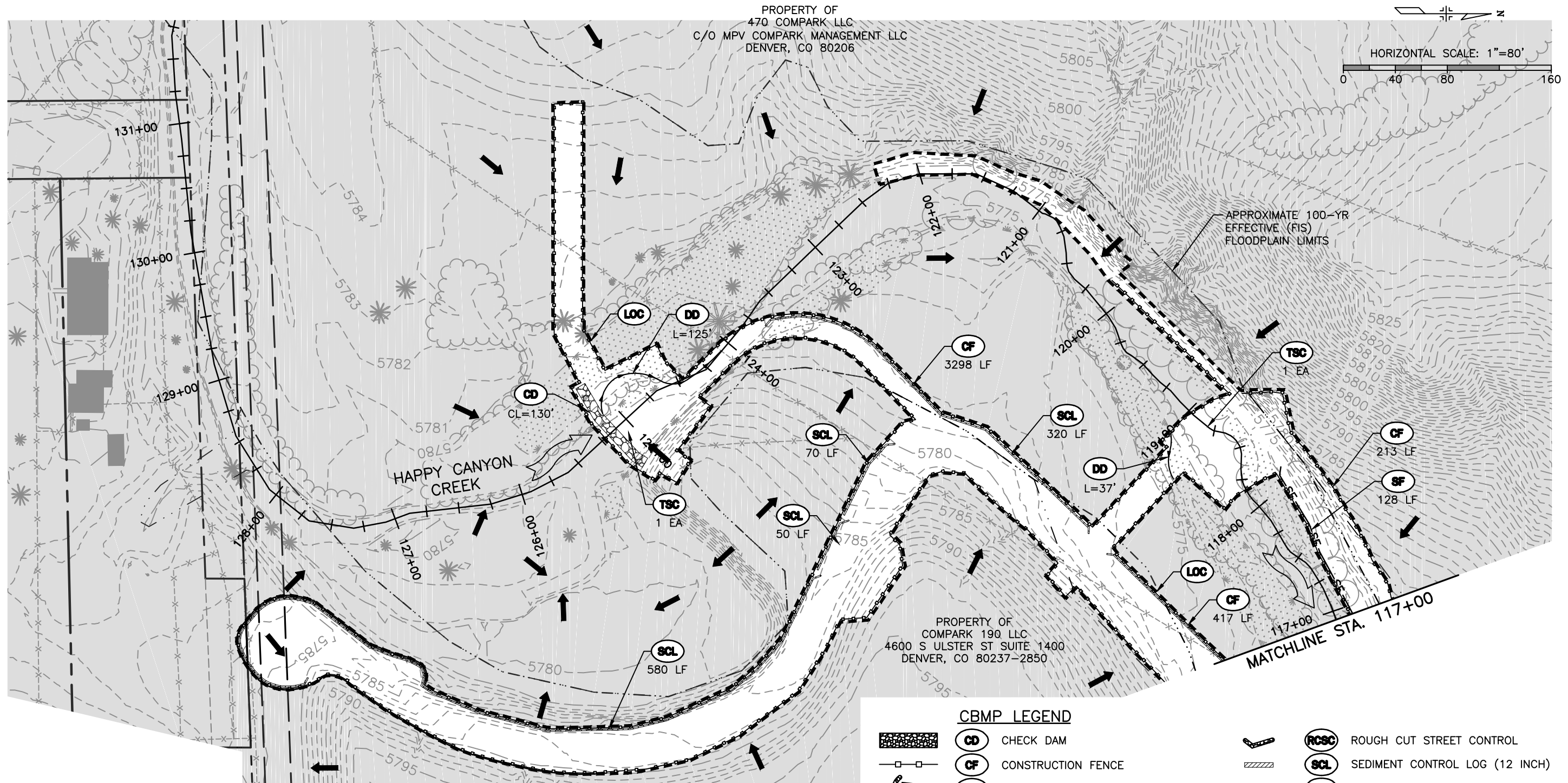
Sheet Revisions			
Date	Comments	Initials	

**Manhard CONSULTING LTD**

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph:303.708.0900 fax:303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK TABULATION OF EROSION CONTROL QUANTITIES		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: EROSION	Sheets: ET-1 of 1	Sheet Number 84

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



**LEGEND**

- TOP OF CUT
- - - TOE OF FILL
- LIMITS OF CONSTRUCTION
- ← GENERAL FLOW DIRECTION
- WETLANDS

- NOTES:**
- TEMPORARY CONSTRUCTION EASEMENTS SHALL NOT BE CLEARED AND GRUBBED UNLESS IT IS REQUIRED IN ORDER TO CONSTRUCT THE ROADWAY SECTION. THE CONTRACTOR SHALL USE PARTICULAR CARE TO MINIMIZE DAMAGE TO PLANTINGS WITHIN THE PROPERTY.
  - ALL DIRTY STREETS, CURBS, GUTTER, SIDEWALKS, LITTER AND OTHER CONSTRUCTION TRASH/DEBRIS, ETC. MUST BE THOROUGHLY CLEANED THROUGHOUT THE DAY AS THESE AREAS BECOME SOILED. NO EXCEPTIONS WILL BE MADE.

**CBMP LEGEND**

	<b>CD</b> CHECK DAM		<b>RCSC</b> ROUGH CUT STREET CONTROL
	<b>CF</b> CONSTRUCTION FENCE		<b>SCL</b> SEDIMENT CONTROL LOG (12 INCH)
	<b>CP</b> CULVERT PROTECTION		<b>SF</b> SILT FENCE
	<b>CWA</b> CONCRETE WASHOUT AREA		<b>SMC</b> SEEDING MULCHING AND CRIMPING
	<b>D</b> DEWATERING		<b>SSA</b> STABILIZED STAGING AREA
	<b>DD</b> DIVERSION DITCH		<b>TSB</b> TEMPORARY SEDIMENT BASIN
	<b>ECB</b> EROSION CONTROL BLANKET (STRAW/COCONUT)		<b>TSC</b> TEMPORARY STREAM CONTROL (SEE WATER CONTROL NOTES ON ET-1)
	<b>IPAN</b> INLET PROTECTION FOR AREA INLETS NOT IN PAVEMENT		<b>VTC</b> VEHICLE TRACKING CONTROL

Print Date: 7/18/2017 2:52:23 PM  
 File Name: H115360-01DROP01?rosion-INI.dwg  
 Horizontal Scale: 1"=80' Vertical Scale: N.T.S.

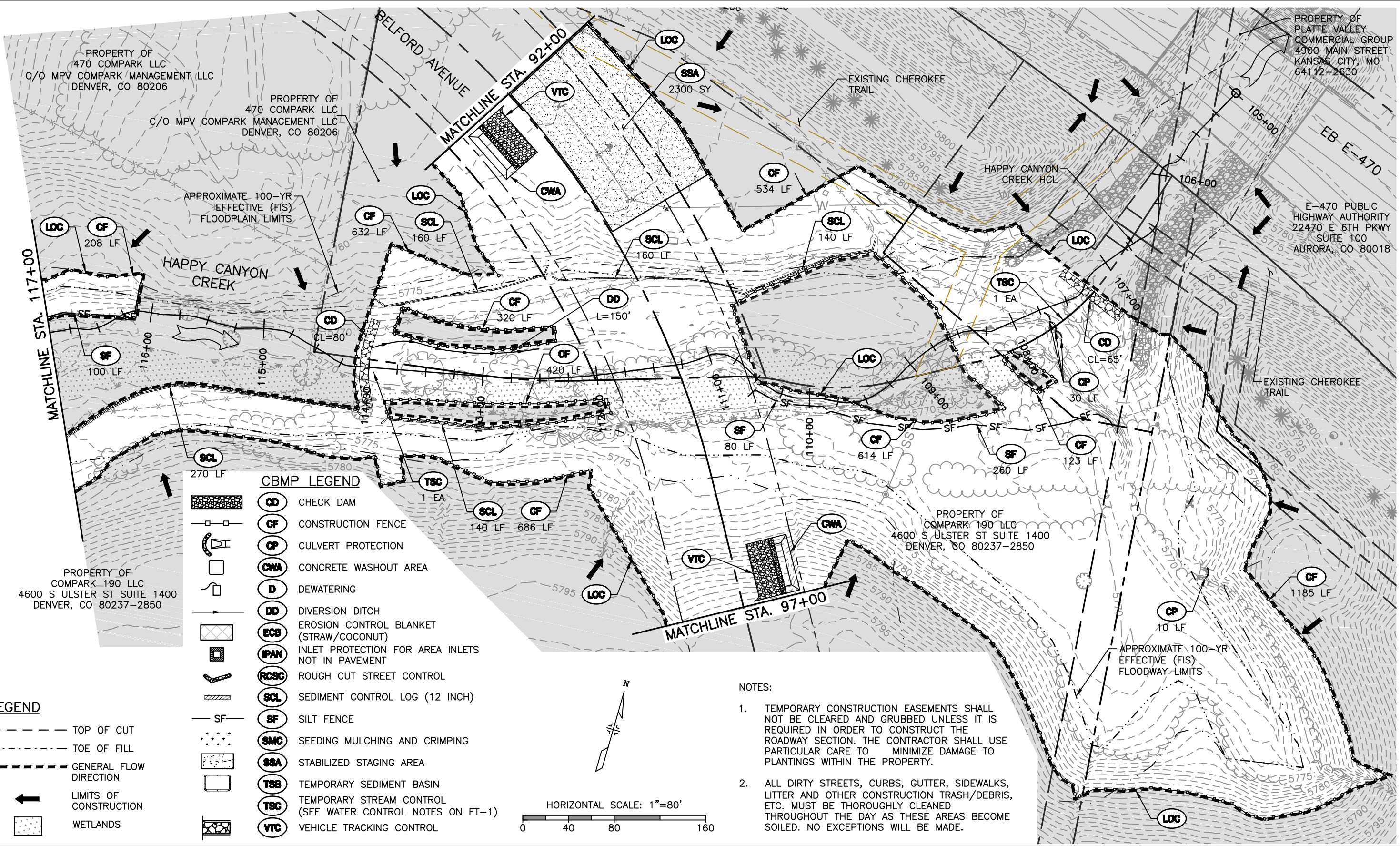
**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
Date	Comments	Initials	



As Constructed	PEORIA & BELFORD INTERSECTION HAPPY CANYON CREEK DROP STRUCTURE INITIAL CBMP PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Erosion	Sheets: El-1 of 2	Sheet Number 85

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



**CBMP LEGEND**

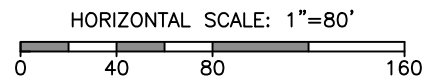
- CD** CHECK DAM
- CF** CONSTRUCTION FENCE
- CP** CULVERT PROTECTION
- CWA** CONCRETE WASHOUT AREA
- D** DEWATERING
- DD** DIVERSION DITCH
- ECB** EROSION CONTROL BLANKET (STRAW/COCONUT)
- IPAN** INLET PROTECTION FOR AREA INLETS NOT IN PAVEMENT
- RCSC** ROUGH CUT STREET CONTROL
- SCL** SEDIMENT CONTROL LOG (12 INCH)
- SF** SILT FENCE
- SMC** SEEDING MULCHING AND CRIMPING
- SSA** STABILIZED STAGING AREA
- TSB** TEMPORARY SEDIMENT BASIN
- TSC** TEMPORARY STREAM CONTROL (SEE WATER CONTROL NOTES ON ET-1)
- VTC** VEHICLE TRACKING CONTROL

**LEGEND**

- TOP OF CUT
- TOE OF FILL
- GENERAL FLOW DIRECTION
- LIMITS OF CONSTRUCTION
- WETLANDS

**NOTES:**

1. TEMPORARY CONSTRUCTION EASEMENTS SHALL NOT BE CLEARED AND GRUBBED UNLESS IT IS REQUIRED IN ORDER TO CONSTRUCT THE ROADWAY SECTION. THE CONTRACTOR SHALL USE PARTICULAR CARE TO MINIMIZE DAMAGE TO PLANTINGS WITHIN THE PROPERTY.
2. ALL DIRTY STREETS, CURBS, GUTTER, SIDEWALKS, LITTER AND OTHER CONSTRUCTION TRASH/DEBRIS, ETC. MUST BE THOROUGHLY CLEANED THROUGHOUT THE DAY AS THESE AREAS BECOME SOILED. NO EXCEPTIONS WILL BE MADE.



Print Date: 7/18/2017 2:54:19 PM  
 File Name: H115360-01DROP02?rosion-INI.dwg  
 Horizontal Scale: 1"=80' Vertical Scale: N.T.S.

**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

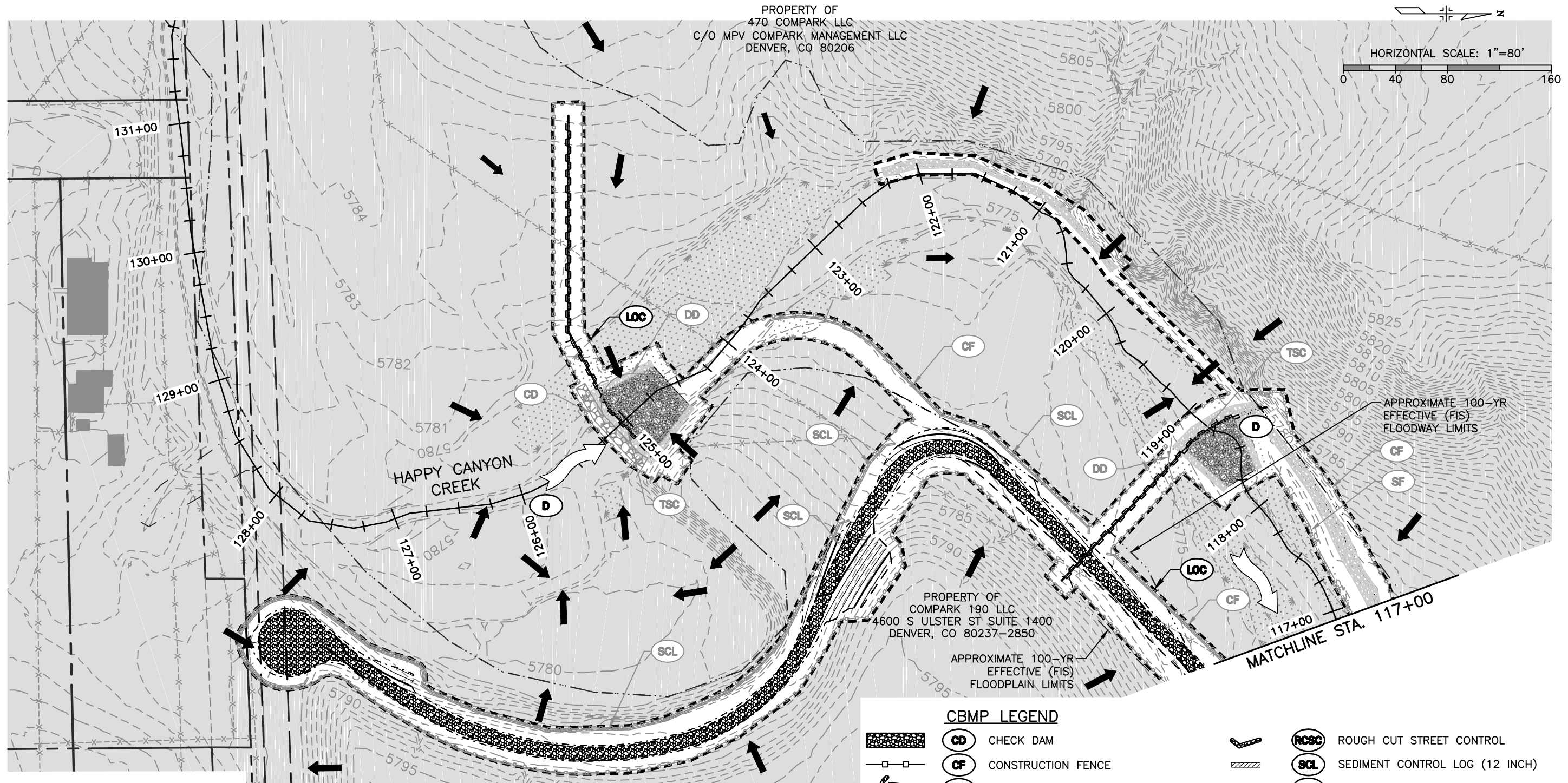
Sheet Revisions			
Date	Comments	Initials	

**Manhard CONSULTING LTD**

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph:303.708.0900 fax:303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resource Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

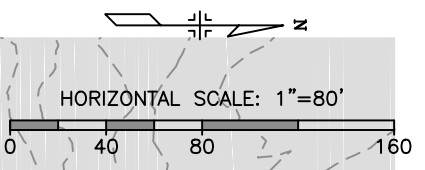
As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE INITIAL CBMP PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Erosion	Sheets: EI-2 of 2	Sheet Number 86

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



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



**LEGEND**

- TOP OF CUT
- - - TOE OF FILL
- - - LIMITS OF CONSTRUCTION
- ← GENERAL FLOW DIRECTION
- WETLANDS

- NOTES:**
- TEMPORARY CONSTRUCTION EASEMENTS SHALL NOT BE CLEARED AND GRUBBED UNLESS IT IS REQUIRED IN ORDER TO CONSTRUCT THE ROADWAY SECTION. THE CONTRACTOR SHALL USE PARTICULAR CARE TO MINIMIZE DAMAGE TO PLANTINGS WITHIN THE PROPERTY.
  - \* EROSION CONTROL ITEMS INSTALLED IN THE INITIAL EROSION CONTROL PLAN SHALL REMAIN IN PLACE FOR INTERIM PHASES OF CONSTRUCTION AND SHALL BE REMOVED, MODIFIED OR REPLACED AT THE DIRECTION OF THE PROJECT ENGINEER. THESE ITEMS SHALL BE PAID FOR AS PLACE AND REMOVE.

**CBMP LEGEND**

	CD CHECK DAM		RCSC ROUGH CUT STREET CONTROL
	CF CONSTRUCTION FENCE		SCL SEDIMENT CONTROL LOG (12 INCH)
	CP CULVERT PROTECTION		SF SILT FENCE
	CWA CONCRETE WASHOUT AREA		SMC SEEDING MULCHING AND CRIMPING
	D DEWATERING		SSA STABILIZED STAGING AREA
	DD DIVERSION DITCH		TSB TEMPORARY SEDIMENT BASIN
	ECB EROSION CONTROL BLANKET (STRAW/COCONUT)		TSC TEMPORARY STREAM CONTROL (SEE WATER CONTROL NOTES SHEET ET-1)
	IPAN INLET PROTECTION FOR AREA INLETS NOT IN PAVEMENT		VTC VEHICLE TRACKING CONTROL

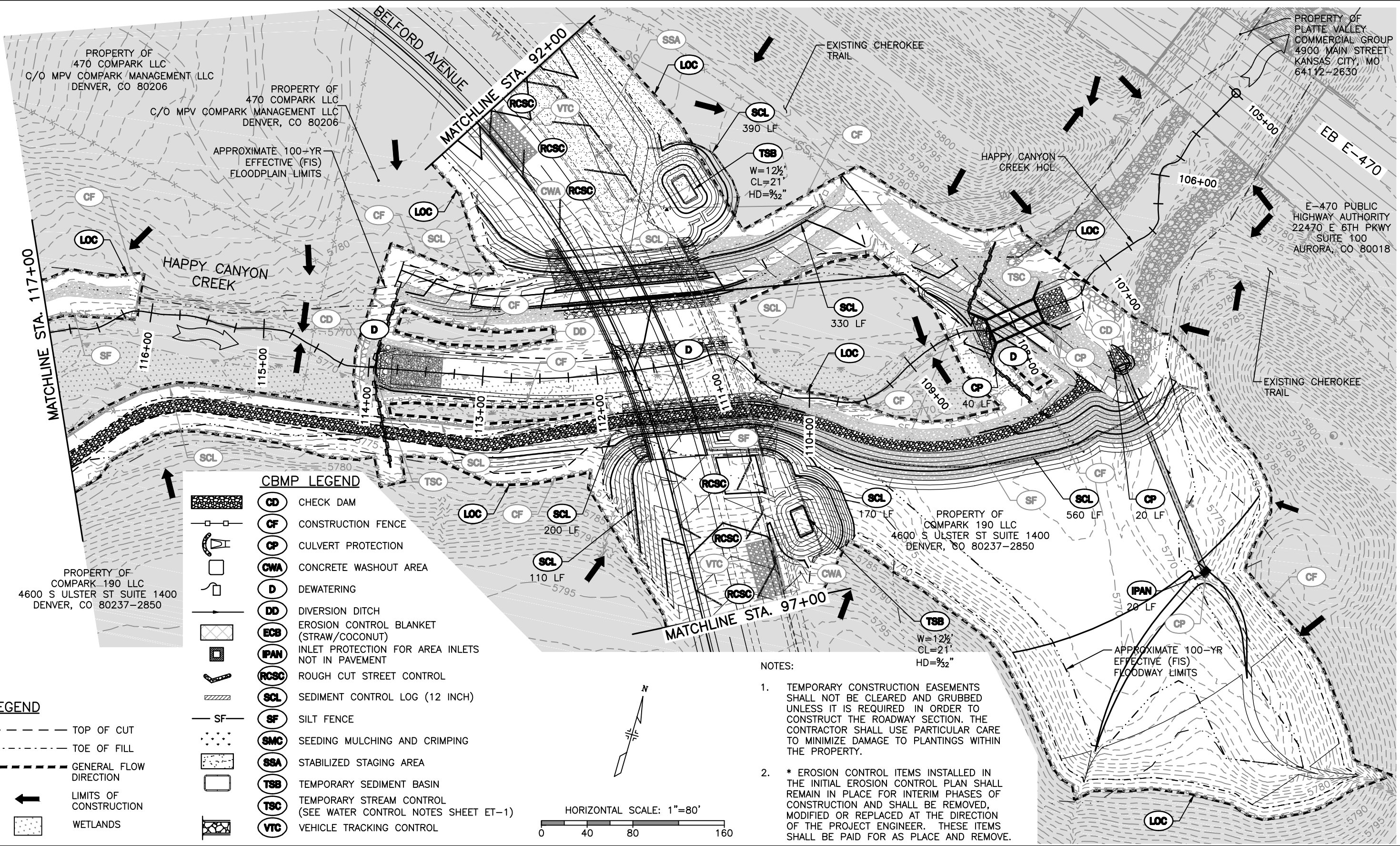
Print Date: 7/18/2017 2:56:32 PM  
 File Name: H115360-01DROP01?rosion-INT.dwg  
 Horizontal Scale: 1"=80' Vertical Scale: N.T.S.

Sheet Revisions			
Date	Comments	Initials	



As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE INTERIM CBMP PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Erosion	Sheets: EN-1 of 2	Sheet Number 87

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



**CBMP LEGEND**

- CD CHECK DAM
- CF CONSTRUCTION FENCE
- CP CULVERT PROTECTION
- CWA CONCRETE WASHOUT AREA
- D DEWATERING
- DD DIVERSION DITCH
- ECB EROSION CONTROL BLANKET (STRAW/COCONUT)
- IPAN INLET PROTECTION FOR AREA INLETS NOT IN PAVEMENT
- RCSC ROUGH CUT STREET CONTROL
- SCL SEDIMENT CONTROL LOG (12 INCH)
- SF SILT FENCE
- SMC SEEDING MULCHING AND CRIMPING
- SSA STABILIZED STAGING AREA
- TSB TEMPORARY SEDIMENT BASIN
- TSC TEMPORARY STREAM CONTROL (SEE WATER CONTROL NOTES SHEET ET-1)
- VTC VEHICLE TRACKING CONTROL

**LEGEND**

- TOP OF CUT
- TOE OF FILL
- GENERAL FLOW DIRECTION
- LIMITS OF CONSTRUCTION
- WETLANDS

**NOTES:**

1. TEMPORARY CONSTRUCTION EASEMENTS SHALL NOT BE CLEARED AND GRUBBED UNLESS IT IS REQUIRED IN ORDER TO CONSTRUCT THE ROADWAY SECTION. THE CONTRACTOR SHALL USE PARTICULAR CARE TO MINIMIZE DAMAGE TO PLANTINGS WITHIN THE PROPERTY.
2. \* EROSION CONTROL ITEMS INSTALLED IN THE INITIAL EROSION CONTROL PLAN SHALL REMAIN IN PLACE FOR INTERIM PHASES OF CONSTRUCTION AND SHALL BE REMOVED, MODIFIED OR REPLACED AT THE DIRECTION OF THE PROJECT ENGINEER. THESE ITEMS SHALL BE PAID FOR AS PLACE AND REMOVE.

HORIZONTAL SCALE: 1"=80'

Print Date: 7/18/2017 2:58:32 PM  
 File Name: H115360-01DROP02?rosion-INT.dwg  
 Horizontal Scale: 1"=80' Vertical Scale: N.T.S.

**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

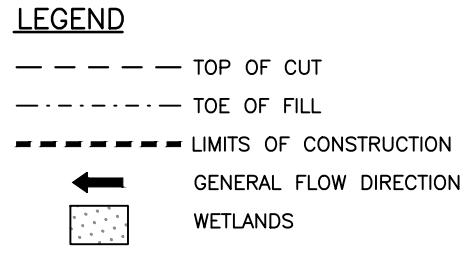
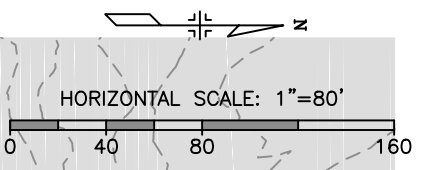
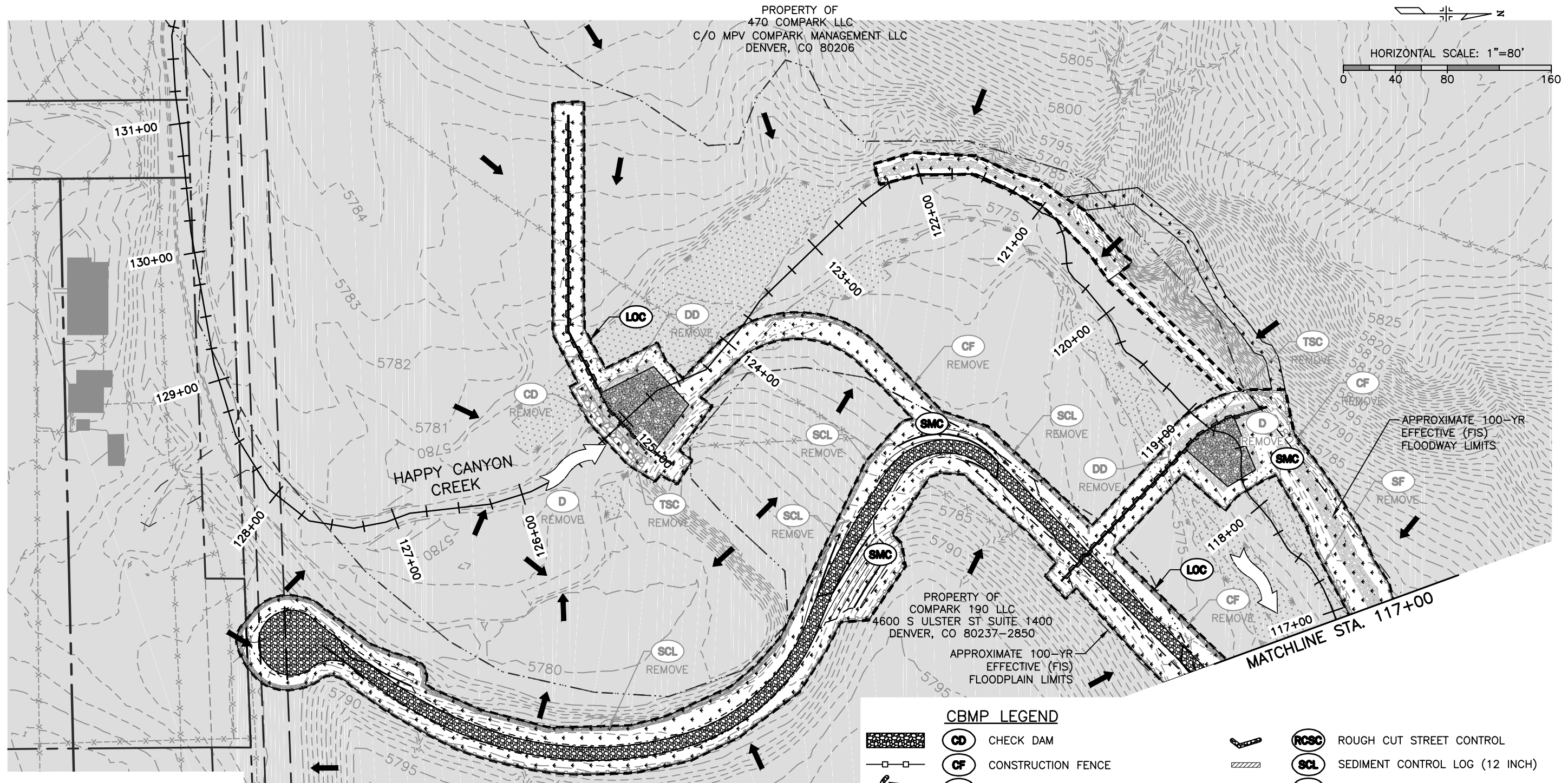
Sheet Revisions			
(R-X)	Date	Comments	Initials

**Manhard CONSULTING LTD**

8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph 303.708.0900 fax 303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE INTERIM CBMP PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	Sheet Number 88
Revised:	Detailer: KLT		
Void:	Subset: Erosion	Sheets: EN-2 of 2	

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



**NOTES:**

- TEMPORARY CONSTRUCTION EASEMENTS SHALL NOT BE CLEARED AND GRUBBED UNLESS IT IS REQUIRED IN ORDER TO CONSTRUCT THE ROADWAY SECTION. THE CONTRACTOR SHALL USE PARTICULAR CARE TO MINIMIZE DAMAGE TO PLANTINGS WITHIN THE PROPERTY.
- \* EROSION CONTROL ITEMS INSTALLED IN THE INITIAL EROSION CONTROL PLAN SHALL REMAIN IN PLACE FOR INTERIM PHASES OF CONSTRUCTION AND SHALL BE REMOVED, MODIFIED OR REPLACED AT THE DIRECTION OF THE PROJECT ENGINEER. THESE ITEMS SHALL BE PAID FOR AS PLACE AND REMOVE.

**CBMP LEGEND**

	CD CHECK DAM		RCSC ROUGH CUT STREET CONTROL
	CF CONSTRUCTION FENCE		SCL SEDIMENT CONTROL LOG (12 INCH)
	CP CULVERT PROTECTION		SF SILT FENCE
	CWA CONCRETE WASHOUT AREA		SMC SEEDING MULCHING AND CRIMPING
	D DEWATERING		SSA STABILIZED STAGING AREA
	DD DIVERSION DITCH		TSB TEMPORARY SEDIMENT BASIN
	ECB EROSION CONTROL BLANKET (STRAW/COCONUT)		TSC TEMPORARY STREAM CONTROL (SEE WATER CONTROL NOTES SHEET ET-1)
	IPAN INLET PROTECTION FOR AREA INLETS NOT IN PAVEMENT		VTC VEHICLE TRACKING CONTROL

Print Date: 7/18/2017 3:00:43 PM  
 File Name: H115360-01DROP01?rosion-FIN.dwg  
 Horizontal Scale: 1"=80' Vertical Scale: N.T.S.

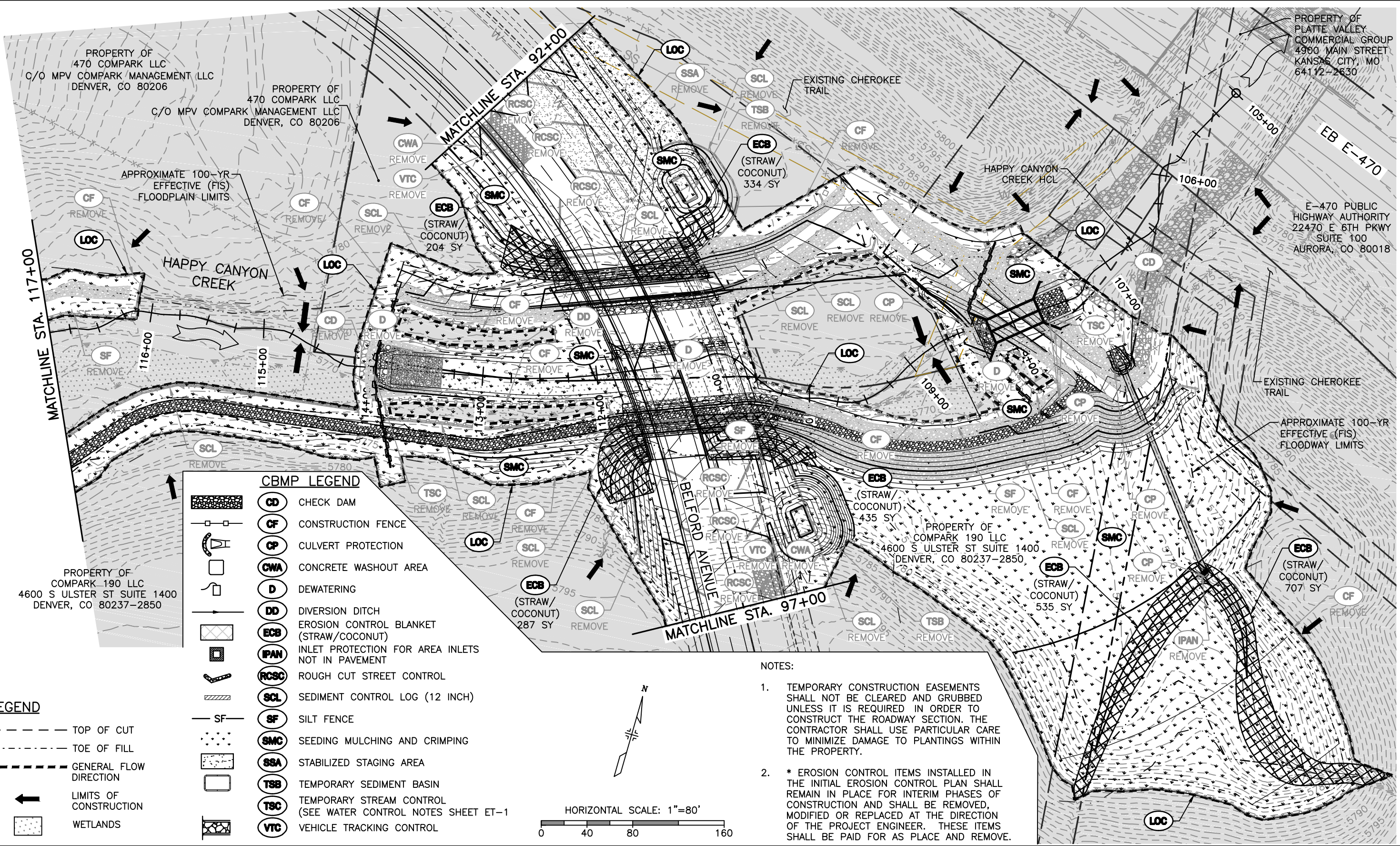
Sheet Revisions			
Date	Comments	Initials	



As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE FINAL CBMP PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Erosion	Sheets: EF-1 of 2	Sheet Number 89

**FELSBURG HOLT & ULLEVIG**  
 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

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



**CBMP LEGEND**

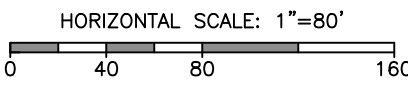
- CD CHECK DAM
- CF CONSTRUCTION FENCE
- CP CULVERT PROTECTION
- CWA CONCRETE WASHOUT AREA
- D DEWATERING
- DD DIVERSION DITCH
- ECB EROSION CONTROL BLANKET (STRAW/COCONUT)
- IPAN INLET PROTECTION FOR AREA INLETS NOT IN PAVEMENT
- RCSC ROUGH CUT STREET CONTROL
- SCL SEDIMENT CONTROL LOG (12 INCH)
- SF SILT FENCE
- SMC SEEDING MULCHING AND CRIMPING
- SSA STABILIZED STAGING AREA
- TSB TEMPORARY SEDIMENT BASIN
- TSC TEMPORARY STREAM CONTROL (SEE WATER CONTROL NOTES SHEET ET-1)
- VTC VEHICLE TRACKING CONTROL

**LEGEND**

- TOP OF CUT
- TOE OF FILL
- GENERAL FLOW DIRECTION
- LIMITS OF CONSTRUCTION
- WETLANDS

**NOTES:**

1. TEMPORARY CONSTRUCTION EASEMENTS SHALL NOT BE CLEARED AND GRUBBED UNLESS IT IS REQUIRED IN ORDER TO CONSTRUCT THE ROADWAY SECTION. THE CONTRACTOR SHALL USE PARTICULAR CARE TO MINIMIZE DAMAGE TO PLANTINGS WITHIN THE PROPERTY.
2. \* EROSION CONTROL ITEMS INSTALLED IN THE INITIAL EROSION CONTROL PLAN SHALL REMAIN IN PLACE FOR INTERIM PHASES OF CONSTRUCTION AND SHALL BE REMOVED, MODIFIED OR REPLACED AT THE DIRECTION OF THE PROJECT ENGINEER. THESE ITEMS SHALL BE PAID FOR AS PLACE AND REMOVE.



Print Date: 7/18/2017 3:02:54 PM  
 File Name: H115360-01DROPO2?rosion-FIN.dwg  
 Horizontal Scale: 1"=80' Vertical Scale: N.T.S.  

 6300 South Syracuse Way, Suite 600  
 Centennial, CO 80111  
 tel 303.721.1440  
 fax 303.721.0832

Sheet Revisions			
(R-X)	Date	Comments	Initials

**Manhard CONSULTING LTD**  
8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph:303.708.0900 fax:303.708.0400 manhard.com  
 Civil Engineers • Surveyors • Water Resources Engineers • Water & Wastewater Engineers  
 Construction Managers • Environmental Scientists • Landscape Architects • Planners

As Constructed	BELFORD-HAPPY CANYON CREEK HAPPY CANYON CREEK DROP STRUCTURE FINAL CBMP PLAN		Project No./Code
No Revisions:	Designer: CDT	Structure Numbers	
Revised:	Detailer: KLT		
Void:	Subset: Erosion	Sheets: EF-2 of 2	Sheet Number 90

## **APPENDIX G. PHOTOGRAPHS**



**Photo #1.**

Looking north towards the E-470 crossing. Photo taken from existing CherokeeTrail looking downstream.



**Photo #2.**

Photo taken from existing Cherokee Trail looking upstream to the south.



**Photo #3.**

Looking upstream towards the south. Photo taken from center of channel with Grandview Estates in the background. This location is approximately 500 feet upstream of the proposed Belford Avenue bridge crossing.



**Photo #4.**

Looking downstream to the north. Photo taken from center of channel with E-470 in the background. This photo was taken from the same location as Photo #3.