Final Drainage Report

Compark Village South, Filing No. 1 – Belford Ave Site Plan Amendment Parker, Colorado

P.N. CLCPKC3

Prepared for:
Belford North Metropolitan District
8390 East Crescent Parkway
Greenwood Village, CO 80111

Prepared By:

7600 E Orchard Road, Suite 150-N
Greenwood Village, Colorado 80111
Contact: Gary Iwata, P.E.
303-708-0500

Submitted: March 15, 2021
Revised: June 18, 2021
Revised: July 26, 2021

This final drainage report for Compark South, Filing No, 1 – Belford Ave Site Plan Amendment was prepared by me or under my direct supervision in accordance with the provisions of the *Town of Parker Storm Drainage and Environmental Criteria Manual*. I understand that the Town of Parker and its designated town authority do not and will not assume liability for drainage facilities designed by others.

_____

Gary T. Iwata, P.E.
Registered Professional Engineer
State of Colorado No. 37642

This final drainage report for Compark South, Filing No, 1 – Belford Ave Site Plan Amendment was prepared by me or under my direct supervision in accordance with the provisions of the *Town of Parker Storm Drainage and Environmental Criteria Manual*. I understand that the Town of Parker and its designated town authority do not and will not assume liability for drainage facilities designed by others.

_____

Gary T. Iwata, P.E.
Registered Professional Engineer
State of Colorado No. 37642

TABLE OF CONTENTS

APPENDICES

APPENDIX A
Maps

- Vicinity Map
- FEMA Flood Information Rate Map
- Soils Map

APPENDIX B
Hydrologic Analysis

- UDFCD Table 6-3
- UDFCD Table 6-4
- UDFCD Table 6-5
- UDFCD Figures 6-1, 6-2 & 6-3
- Composite C Calculations
- Time of Concentration Calculations
- Storm Runoff Calculations

APPENDIX C
Hydraulic Analysis

- Inlet Capacity Calculations
- StormCAD Storm Sewer Design
    - 5-Year Storm Table and Profiles
    - 100-Year Storm Table and Profiles
- Full Spectrum Detention Basin Design

APPENDIX D

- Drainage Basin Map
- Compark Village South Filing No. 1 Drainage Map

APPENDIX E

- CLOMR report
- CLOMR approval letter
- USACOE NWP verification
- Town of Parker Floodplain Development Application

I. GENERAL LOCATION AND DESCRIPTION

A. Scope

This project is part of the Compark Village South development. The purpose of this report is to demonstrate the feasibility of the proposed storm drainage system planned to control the stormwater associated with a portion of Belford Avenue and a future development. Drainage criteria are in accordance with the *Town of Parker Storm Drainage and Environmental Criteria Manual* (*Town Criteria*) *and Urban Drainage and Flood Control District Criteria Manual* (*Urban Drainage Criteria*).

B. Location

Compark Village South Filing No, 3 – Belford Ave East lies within the south half of Section 6, Township 6 South, Range 66 West of the Sixth Principal Meridian, Town of Parker, Colorado. General project area boundaries include Highway E-470 to the north, the future Compark Village South Filing No. 3 residential development to the south, Compark Village South Filing No. 1 to the north, and Happy Canyon Creek to the east (see vicinity map in Appendix A). The project lies within drainage basin F as described in the Compark Village South Filing No. 1 drainage report (see map in Appendix D). The project includes a 1,585-foot continuation of a major collector road, Belford Avenue, running east-west connecting South Peoria Street to South Chambers Road.

C. Description of Property

The Compark Village South Filing No. 3 – Belford Ave Development Site consists of approximately 5.5 acres, and is mostly vacant with ground cover consisting of native grasses and shrubs. Onsite soils consist of Newlin gravelly sandy loam, Satanta loam and Loamy alluvial land in the area of the proposed bridge crossing. These soils are classified as hydrologic group B. Refer to Appendix A of this report for excerpts of the SCS soil survey summary.

D. Floodplain Information

Compark Village South Filing No. 3 – Belford Ave is located within the Happy Canyon Creek major drainage basin which has a regulatory 100-year floodplain. Firm Map No 08035C0062G, Effective date: March 16, 2016 reflects a Zone AE and Zone X floodplain across the eastern edge of the site. Refer to Appendix A for FIRMETTE copies of the FIRM Map. A

Floodplain Development Permit from the Town of Parker will be required for any construction within the documented floodplains on the property.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Description

The entirety of this project lies within the Happy Canyon Creek drainage basin, which has been studied by the Urban Drainage and Flood Control District under the following studies:

- UDFCD – Outfall System Planning – Happy Canyon Creek Watershed within Douglas County, prepared by Kiowa Consultants, June 1993. Urban Drainage in conjunction with sponsor partners Town of Parker and Douglas County are planning on updating the Happy Canyon Creek OSP.

- Green Acres Tributary is a part of the Happy Canyon Creek watershed. The upstream area of the Green Acres Tributary contains several existing and proposed development projects that contain features for which drainage studies have been prepared. All current upstream drainage features are part of the Meridian Office Park, Filings 4 & 5 (reference 5) master drainage analysis.

- Happy Canyon Creek Major Drainageway Plan, prepared by Muller Engineering Company, March 2014.

- Amendment to Happy Canyon Creek Major Drainageway Plan, March 2014, prepared by Manhard Consulting, February 2016.

The project area has further been described in the Compark Village Filing No. 1 Drainage Report as Basin F, comprised of 45 total acres. See Appendix D for the drainage map of this area.

B. Sub-Basin Description

The proposed site will be divided into several drainage sub-basins. These sub-basins have been determined based on land use, area, roadway slopes, storm sewer locations and inlet capacities. The developed site will generally follow the existing drainage patterns and runoff will be conveyed via overland flow and storm sewer to a proposed detention basin located directly south of the east side of the site.

BEL-E1

Drainage basin BEL-E1 is composed of landscaped area, sidewalk, and the south half of a portion of Belford Avenue. Storm water will flow northeast toward Design Point 1 where it will be collected by Inlet A. This is an on grade 10' Type R inlet with the capacity to handle the runoff from a 5 year storm event. From there, storm water will be conveyed to the proposed detention/water quality basin just southeast of Belford Avenue via storm sewer. This detention basin discharges directly to Happy Canyon Creek. In the 100 year storm event, 0.08 cfs excess runoff will bypass Inlet A and Inlet B and flow into sub basin BEL-E3 where it will be intercepted by Inlet C at Design Point 3.

BEL-E2

Drainage basin BEL-E2 is composed of landscaped area, sidewalk, and the south half of a portion of Belford Avenue. Storm water will flow east toward Design Point 2 where it will be collected by Inlet B. This is an on grade 10' Type R inlet with the capacity to handle the runoff from a 5 year storm event. From there, storm water will be conveyed to the proposed detention/water quality basin just southeast of Belford Avenue via storm sewer. This detention basin discharges directly to Happy Canyon Creek. In the 100 year storm event, 0.21 cfs excess runoff will bypass Inlet B and flow into sub basin BEL-E3 where it will be intercepted by Inlet C at Design Point 3.

BEL-E3

Drainage basin BEL-E3 is composed of landscaped area, sidewalk, and a continuation of the south half of Belford Avenue. Storm water will flow from the northwest and southeast towards Design Point 3 where it will be collected by Inlet C. This is a 10' Type R inlet in sump with the capacity to handle the runoff from a 100 year storm event plus the bypass from basins BEL-E1 and BEL-E2. Inlet C is in a 500-foot sag vertical curve. Street capacity for this inlet has been analyzed at 100-feet from the low point, showing adequate street capacity and conformance to section 6.3.2 of the Town Criteria. From there, storm water will be conveyed to the proposed detention/water quality basin just southeast of Belford Avenue via storm sewer. This detention basin discharges directly to Happy Canyon Creek.

BEL-E4

Drainage basin BEL-E4 is composed of landscaped area, sidewalk, and a continuation of the south half of Belford Avenue, as well as, the south half of the proposed bridge over Happy Canyon Creek. This drainage basin also includes approximately 150' of Belford Avenue located within the proposed Chambers Highpoint project. Storm water will flow from the southeast towards Design Point 3 where it will be collected by Inlet C. This is a 10' Type R inlet in sump with the capacity to handle the runoff from a 100 year storm event for BEL-E3 and BEL-E4 plus the bypass from basins BEL-E1 and BEL-E2. This inlet will also collect 0.1 cfs from Chambers Highpoint in the 5 yr storm and 3.0 cfs in the 100 yr storm. Inlet C is in a 500-foot sag vertical curve. Street capacity for this inlet has been analyzed at 100-feet from the low point, showing adequate street capacity and conformance to section 6.3.2 of the Town Criteria. From there, storm water will be conveyed to the proposed detention/water quality basin just southeast of Belford Avenue via storm sewer. This detention basin discharges directly to Happy Canyon Creek.

BEL-E5

Drainage basin BEL-E5 is composed of future landscaped area, sidewalk, and the north half of a portion of Belford Avenue. Storm water will flow northeast toward Design Point 4 where it will be collected by Inlet D. This is an on grade 10' Type R inlet with the capacity to handle the runoff from a 5 year storm event. From there, storm water will be conveyed to the proposed detention/water quality basin just southeast of Belford Avenue via storm sewer. This detention basin discharges directly to Happy Canyon Creek. In the 100 year storm event, 0.36 cfs excess runoff will bypass Inlet D and flow into sub basin BEL-E6 where it will be intercepted by Inlet E at Design Point 5.

BEL-E6

Drainage basin BEL-E6 is composed of future landscaped area, sidewalk, and the north half of a portion of Belford Avenue. Storm water will flow east toward Design Point 5 where it will be collected by Inlet E. This is an on grade 10' Type R inlet with the capacity to handle the runoff from a 5 year storm event. From there, storm water will be conveyed to the proposed detention/water quality basin just southeast of Belford Avenue via storm sewer. This detention basin discharges directly to Happy Canyon Creek. In the 100 year storm event, 0.67 cfs excess runoff will bypass Inlet E and flow

into sub basin BEL-E7 where it will be intercepted by Inlet F at Design Point 6.

BEL-E7

Drainage basin BEL-E7 is composed of future landscaped area, sidewalk, and the north half of a portion of Belford Avenue Storm water will flow from the northwest towards Design Point 6 where it will be collected by Inlet F. This is a 10' Type R inlet in sump with the capacity to handle the runoff from a 100 year storm event plus the bypass from basin BEL-E5 and BEL-E6. Inlet F is in a 500-foot sag vertical curve. Street capacity for this inlet has been analyzed at 100-feet from the low point, showing adequate street capacity and conformance to section 6.3.2 of the Town Criteria. From there, storm water will be conveyed to the proposed detention/water quality pond just southeast of Belford Avenue via storm sewer. This pond discharges directly to Happy Canyon Creek.

BEL-E8

Drainage basin BEL-E8 is composed of landscaped area, sidewalk, and a continuation of the north half of Belford Avenue, as well as, the north half of the proposed bridge over Happy Canyon Creek. This drainage basin also includes approximately 150' of Belford Avenue located within the proposed Chambers Highpoint project. Storm water will flow from the southeast towards Design Point 6 where it will be collected by Inlet F. This is a 10' Type R inlet in sump with the capacity to handle the runoff from a 100 year storm event for BEL-E3 and BEL-E4. Inlet F is in a 500-foot sag vertical curve. Street capacity for this inlet has been analyzed at 100-feet from the low point, showing adequate street capacity and conformance to section 6.3.2 of the Town Criteria. From there, storm water will be conveyed to the proposed detention/water quality basin just southeast of Belford Avenue via storm sewer. This detention basin discharges directly to Happy Canyon Creek.

POND

The drainage for the portion of Belford Avenue being constructed, as well as, future construction of Belford Avenue, and a future residential development, will all drain to the proposed detention basin. The pond is comprised of landscape area with drainage features such as a trickle channel, forebays, and an outlet structure. The detention basin has been designed with the 7.2 acres of Belford Avenue drainage, 1.08 acres from the pond area itself, and 6.5 acres of drainage from the development that will

follow in the future, indicated by basin F3. The detention basin has been designed for the areas described and shown on the attached drainage map in appendix D. Any areas outside of the basins shown have not been included in the detention basin volume calculation. The detention basin discharges directly to Happy Canyon Creek.

F3

Drainage basin F3 in its existing state is composed of undeveloped land and drains directly to Happy Canyon Creek. In developed conditions, it was assumed that the drainage basin would be 6.5 acres, making the total drainage area to the pond 14.77 acres. The imperviousness of the F3 subbasin was assumed to be 75%. The imperviousness of the basin was assumed to be 61% over the entire 14.77 acres. In developed conditions, there will be a need for an inlet to capture the runoff from basin F3. Since walls are being constructed inside the detention basin, an inlet will be installed with pipe to the detention basin that will be used in the future development of the basin. The drainage for the development of this basin will be addressed by a separate drainage report.

The Compark Village Filing No. 1 Drainage Report identifies the area as Basin F, which totals 45 acres. The detention basin has been designed to accommodate the 14.77 acres tributary to the detention basin, leaving the remaining 30+/- acres draining to Happy Canyon Creek as it had in the existing condition.

III. DRAINAGE CHANNELS

A. Happy Canyon Creek

Happy Canyon Creek is a major basin that is tributary to Cherry Creek. The portion of Happy Canyon Creek thalweg that extends through the proposed site is a natural sandy bottom channel. The thalweg has an existing natural meander bend located near the southwest corner of the site. No apparent head cutting exists within this channel reach. The active channel is a dry stream bed that experiences active flows during wet seasonal conditions.

As discussed earlier, a Zone AE and Zone X floodplain exist along Happy Canyon Creek. It is anticipated that bank stabilization will be required along the outer edges of the existing meander bends. No major channel improvements are contemplated for Happy Canyon Creek, except the construction of a roadway bridge crossing needed for Belford Avenue and installation of grade control structures. This bridge structure will span the

existing floodplain. Floodplain mitigation is anticipated through the thalweg. Felsburg Holt & Ullevig (FHU) has been contracted to perform the proposed bridge design and floodplain mitigation. All proposed improvements to Happy Canyon Creek are addressed in the "Conditional Letter of Map Revision (CLOMR) for Happy Canyon Creek at Belford Avenue" found in Appendix E.

A CLOMR has been obtained from FEMA to construct the proposed bridge crossing and proposed improvements to Happy Canyon Creek. The CLOMR was issued November 20, 2019 and the Case No. is 19-08-0690R.(See Appendix E)

Verification has been obtained from the USACOE that the proposed Happy Canyon improvements are authorized by Nationwide Permit (NWP) 29, Residential Developments.(See Appendix E for verification letter)

A floodplain development permit will be required from the Town of Parker for the proposed bridge and channel improvements.

UDFCD and the Town of Parker have sponsored an update to the existing Happy Canyon Creek Outfall Systems Plan (OSP) and the 2014 Happy Canyon Creek Major Drainageway Plan (MDP). Any recommendations to channel upgrades to this reach of Happy Canyon Creek need to meet the recommendations of the OSP and 2014 MDP. Channel design and the Happy Canyon Creek bridge design must be reviewed and approved by UDFCD prior to the approval of associated drawings.

Note: All channel improvement design and construction shall meet the minimum requirements of the UDFCD maintenance eligibility program.

IV. DRAINAGE DESIGN CRITERIA

A. Regulations

The regulations, guidelines, and drainage design criteria to be used are those contained within the *Town of Parker Storm Drainage Design and Environmental Criteria* and the *Urban Storm Drainage Criteria Manual*. The general drainage concept is to construct a full spectrum detention basin to provide detention and water quality before releasing runoff from Belford Avenue and future residential development into Happy Canyon Creek.

The Town's Stream Preservation Standards will be met by providing a natural, undisturbed buffer between the proposed improvements and the Happy Canyon Creek, providing a maintenance road for the length of Happy Canyon Creek within this project and constructing grade control structures within Happy Canyon Creek to minimize erosion of the channel and thereby provide a more stable channel to minimize water pollution, enhance vegetation communities and thereby provide wildlife habitats.

B. Hydrologic Criteria

The Town of Parker *Storm Drainage and Environmental Criteria Manual* and the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual* were used for the storm drainage system design.

The following criteria was utilized in developing the proposed drainage system:

- The proposed drainage system is designed to match, as best as possible, the historic drainage patterns occurring at the site.
- The proposed drainage system attempts to limit the diversion of storm runoff from one basin to another (basin transfer).
- Runoff generated from drainage sub-basins is conveyed via the proposed storm sewer system into the proposed detention and water quality pond.

Design Rainfall: UDFCD rainfall data is used to determine peak runoff values. The 5-year and 100-year frequency storms are used as the minor and major design storms respectively.

Runoff Calculation: Peak storm runoff is determined using the rational formula,

Q = CIA (CFS)
C = Runoff coefficient based on surface impermeability
I = Rainfall intensity in inches per hour
A = Drainage basin area in acres

UDFCD Imperviousness Values (Table 6-3) and Runoff Coefficients (Table 6-5) were used to develop basin runoff coefficients. These tables can be found in Appendix B. The runoff coefficients are weighted for each applicable sub-basin to more accurately reflect the runoff characteristics of the site.

Time of Concentration is determined using the criteria in Sections 3.4.1 and 3.4.2 of the UDFCD Criteria Manual. These calculations are included in Appendix B.

Rainfall intensities are determined using the Town of Parker's *Storm Drainage and Environmental Criteria Manual* Point Rainfall data and Intensity-Duration curves. The rainfall intensities utilized were:

ONE HOUR RAINFALL DEPTH TABLE

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

2 year		5 year		10 year		100 year	
Time (min.)	Intensity P_1 (in/hr)	Time (min.)	Intensity P_1 (in/hr)	Time (min.)	Intensity P_1 (in/hr)	Time (min.)	Intensity P_1 (in/hr)
60	0.83	60	1.09	60	1.33	60	2.31

C. Hydraulic Criteria

The following *Town Criteria* were utilized in determining allowable street flow.

Minor Storm (5-yr) from Table 2.4

- Collector Street – No curb overtopping. Flow Spread must leave at least a 10 foot width free of water. (5-feet on each side of crown for roads without median. 10-feet on each side of median for roads with a median.)

Major Storm (100-yr) from table 2.5

- Local and Collector Streets – The depth of water at the gutter flowline shall not exceed 12 inches. A minimum of 18-inches must be provided from the water surface elevation to the lowest floor elevation or window well opening elevation for structures that are adjacent to the roadway (this includes residential dwellings, public, commercial and industrial buildings).

For the major and minor storm events, allowable capacity was determined using UD-Inlet version 4.06 by UDFCD.

The following *Town Criteria* were utilized in determining proposed drainage system pipe sizes:

Minor Storm (5-yr)

- the hydraulic grade line must be located below the crown of the pipe

Major Storm (100-yr)

- the hydraulic grade must be located 12-inches below finished grade as a maximum condition.

For the major and minor storm events, HGL's were calculated utilizing Bentley StormCAD modelling software.

V. DRAINAGE FACILITY DESIGN

A. General Concept

Stormwater runoff from the proposed improvements will generally follow existing drainage patterns from northwest to southeast on the site. Overland flow and a proposed storm sewer system will route the runoff to the proposed detention and water quality basin. This detention basin will release restricted flows directly into Happy Canyon Creek.

B. Specific Details

As mentioned previously in this report, the site will be divided into several drainage sub-basins. The onsite runoff will be routed through the site via the proposed roadways and gutters where it will be intercepted by a number of on-grade inlets and inlets located in roadway sumps. This runoff will be routed, via storm sewer, directly to the proposed detention/water quality basin. The detention basin has been sized to accommodate the flows resulting from the areas shown on the drainage map. Any area outside of the basins depicted on the drainage map and described in this report have not been considered as tributary to the proposed detention basin.

The proposed full spectrum detention/water quality basin has been sized to intercept surface runoff from a portion of Belford Avenue, as shown on the drainage map, and a developed residential area, referred to as F3 in the sub-basin descriptions, for a total of approximately 14.77 acres (Full Buildout). The detention basin will release attenuated flows into the existing natural drainageway of Happy Canyon Creek via an outlet structure. The outlet structure has been designed to release controlled WQCV, EURV, and 100-year volume flows, allowing for sediment and trash removal and decreasing adverse downstream impacts. The detention basin will restrict 100 year flows from the developed project to 90% of the historic flows of the project area. Required detention volumes were calculated using the MHFD-Detention

spreadsheet v4.04 as described in the Town of Parker Storm Drainage and Environmental Criteria Manual. Basin tables and charts used in the rational method analysis, along with calculation sheets, are provided in Appendix B.

C. Variance from Criteria

No variances will be required for this project.

VI. ENVIRONMENTAL PROTECTION CRITERIA

A. General

Site drainage improvements are intended to minimize the impact to the environment. The proposed improvements to the Happy Canyon Creek required permitting through FEMA. As part of this permitting process, requirements regarding potential impacts to wetland areas and to threatened and endangered species were identified and the proper permitting was obtained. Specifics are included in the "Conditional Letter of Map Revision (CLOMR) for Happy Canyon Creek at Belford Avenue", page 14. (See Appendix E).

B. Construction BMP Plan

Construction BMPs shall be placed during the appropriate construction phases to minimize soil erosion and the movement of sediment offsite. Construction BMPs shall be placed in two phases (Phase A and Phase B). The intent of the Phase A BMPs are to fulfill water quality objectives during the overlot and roadway rough grading phase of the project. Once Phase A rough grading and earthmoving is completed, Phase B BMP placement will commence. Phase B includes fine grading, utility construction, and street construction. Construction Plans will contain all appropriate Stormwater Management Details. In addition, a Stormwater Management Plan will be prepared to meet the town of Parker, State of Colorado, and Environmental Protection Agency criteria.

VII. CONCLUSION

This drainage report is intended to comply with all major standards of the Town of Parker and the Urban Drainage Flood Control District. This overall plan for the site's drainage design is effective and economical for controlling damage due to excess storm runoff and minimizing erosive discharges. This plan is intended to

integrate into the future basin planning efforts by UDFCD, Douglas County and the Town of Parker when the Happy Canyon Creek Outfall System Planning study is updated.

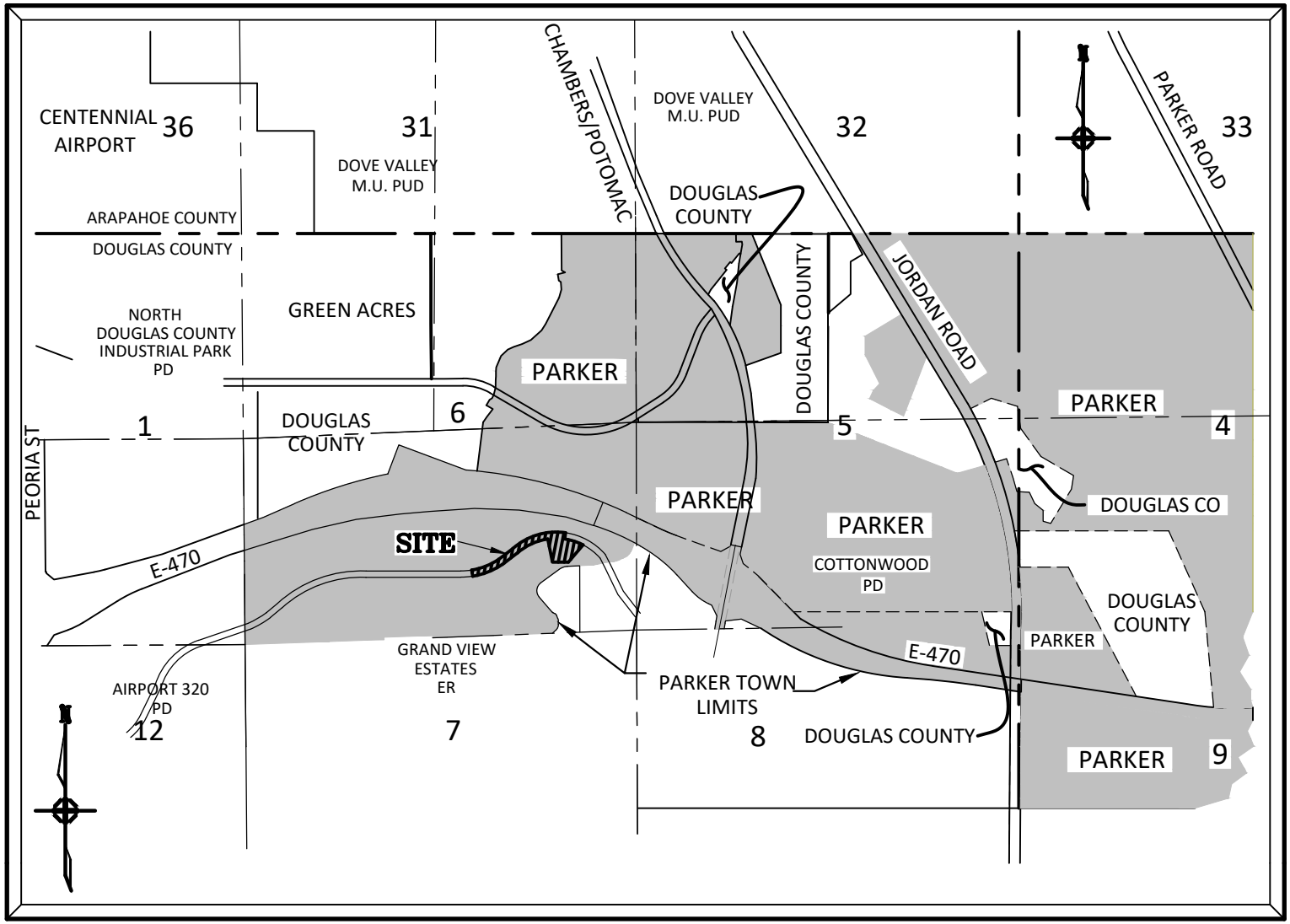
VII.REFERENCES

1. *Soil Survey of Castle Rock Area*, US Department of Agriculture Soil Conservation Service, September 23, 2014.
2. *Town of Parker Storm Drainage and Environmental Criteria Manual*, last revised February 2014.
3. *Urban Storm Drainage Criteria Manual*, Volumes 1–3, Urban Drainage and Flood Control District, 2010, with current revisions.
4. *UDFCD – Outfall System Planning – Happy Canyon Creek Watershed within Douglas County*, prepared by Kiowa Consultants, June 1993.
5. UDFCD – Happy Canyon Creek Master Drainage Plan, Muller Engineering March 2014.
6. Amendment to Happy Canyon Creek Major Drainageway Plan, March 2014, prepared by Manhard Consulting, February 2016.

APPENDIX A

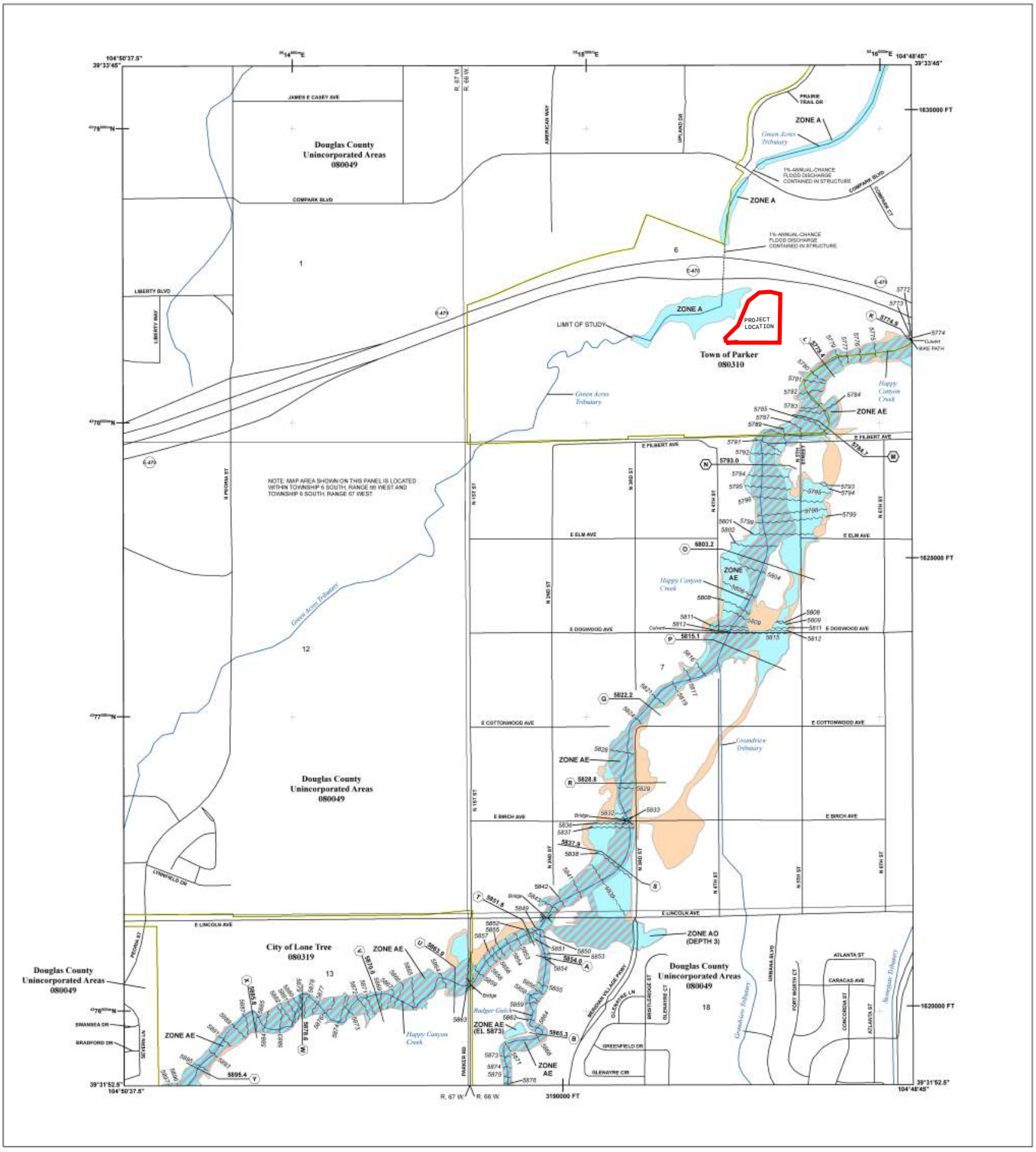
Maps

- Vicinity Map
- FEMA Flood Information Rate Map
- Soils Map



VICINITY MAP

N.T.S.



FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT HTTPS://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) Zone A, V, A99
	With BFE or Depth Zone AE, AO, AH, VE, AR
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	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
OTHER AREAS	NO SCREEN Areas of Minimal Flood Hazard Zone X
	Area of Undetermined Flood Hazard Zone D
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
	18.2 / E / 17.6 Cross Sections with 1% Annual Chance Water Surface Elevation (BFE)
	B Coastal Transect
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
	513 Base Flood Elevation Line (BFE)
OTHER FEATURES	Limit of Study
	Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://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.

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 Flood 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 2018.

SCALE

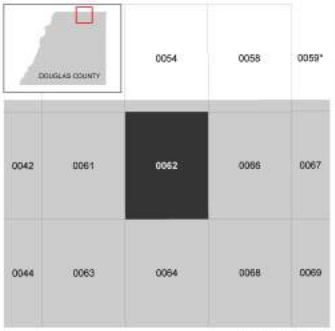
Map Projection:
NAD83 UTM Zone 13N
Western Hemisphere; Vertical Datum NAVD88

1 inch = 500 feet 1:6,000

0 1,000 2,000 Feet

0 250 500 Meters

PANEL LOCATOR



* PANEL NOT PRINTED

FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

DOUGLAS COUNTY, COLORADO
and Incorporated Areas

PANEL 62 OF 495

FEMA

Panel Contains:

COMMUNITY	NUMBER	PANEL	SUFFIX
DOUGLAS COUNTY	080049	0062	H
LONE TREE, CITY OF	080319	0062	H
PARKER, TOWN OF	080310	0062	H

VERSION NUMBER
2.3.3.2

MAP NUMBER
08035C0062H

MAP REVISED
SEPTEMBER 4, 2020

Soil Map—Castle Rock Area, Colorado
(Compark Village South - Belford Ave East)

Map Scale: 1:2,600 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 35 70 140 210

Feet
0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Castle Rock Area, Colorado
Survey Area Data: Version 13, Jun 5, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 3, 2018—Dec 4, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Lo	Loamy alluvial land	0.6	13.3%
NeE	Newlin gravelly sandy loam, 8 to 30 percent slopes	2.8	59.6%
Sn	Satanta loam	1.3	27.1%
Totals for Area of Interest		**4.8**	**100.0%**

APPENDIX B

Hydrologic Analysis

- UDFCD Table 6-3
- UDFCD Table 6-4
- UDFCD Table 6-5
- UDFCD Figures 6-1, 6-2 & 6-3
- Composite C Calculations
- Time of Concentration Calculations
- Storm Runoff Calculations

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential lots (lot area only)**:**	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

Table 6-4. Runoff coefficient equations based on NRCS soil group and storm return period

NRCS Soil Group		Storm Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
A	$C_A = 0.84i^{1.302}$	$C_A = 0.86i^{1.276}$	$C_A = 0.87i^{1.232}$	$C_A = 0.84i^{1.124}$	$C_A = 0.85i+0.025$	$C_A = 0.78i+0.110$	$C_A = 0.65i+0.254$
B	$C_B = 0.84i^{1.169}$	$C_B = 0.86i^{1.088}$	$C_B = 0.81i+0.057$	$C_B = 0.63i+0.249$	$C_B = 0.56i+0.328$	$C_B = 0.47i+0.426$	$C_B = 0.37i+0.536$
C/D	$C_{C/D} = 0.83i^{1.122}$	$C_{C/D} = 0.82i+0.035$	$C_{C/D} = 0.74i+0.132$	$C_{C/D} = 0.56i+0.319$	$C_{C/D} = 0.49i+0.393$	$C_{C/D} = 0.41i+0.484$	$C_{C/D} = 0.32i+0.588$

Where:

i = % imperviousness (expressed as a decimal)

C_A = Runoff coefficient for Natural Resources Conservation Service (NRCS) HSG A soils

C_B = Runoff coefficient for NRCS HSG B soils

$C_{C/D}$ = Runoff coefficient for NRCS HSG C and D soils.

The values for various catchment imperviousness and storm return periods are presented graphically in Figures 6-1 through 6-3, and are tabulated in Table 6-5. These coefficients were developed for the Denver region to work in conjunction with the time of concentration recommendations in Section 2.4. Use of these coefficients and this procedure outside of the semi-arid climate found in the Denver region may not be valid. The UD-Rational Excel workbook performs all the needed calculations to find the runoff coefficient given the soil type and imperviousness and the reader may want to take advantage of this macro-enabled Excel workbook that is available for download from the UDFCD's website www.udfcd.org.

See Examples 7.1 and 7.2 that illustrate the Rational Method.

Table 6-5. Runoff coefficients, *c*

Total or Effective % Impervious	NRCS Hydrologic Soil Group A						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.01	0.01	0.01	0.04	0.13	0.27
5%	0.02	0.02	0.02	0.03	0.07	0.15	0.29
10%	0.04	0.05	0.05	0.07	0.11	0.19	0.32
15%	0.07	0.08	0.08	0.1	0.15	0.23	0.35
20%	0.1	0.11	0.12	0.14	0.2	0.27	0.38
25%	0.14	0.15	0.16	0.19	0.24	0.3	0.42
30%	0.18	0.19	0.2	0.23	0.28	0.34	0.45
35%	0.21	0.23	0.24	0.27	0.32	0.38	0.48
40%	0.25	0.27	0.28	0.32	0.37	0.42	0.51
45%	0.3	0.31	0.33	0.36	0.41	0.46	0.54
50%	0.34	0.36	0.37	0.41	0.45	0.5	0.58
55%	0.39	0.4	0.42	0.45	0.49	0.54	0.61
60%	0.43	0.45	0.47	0.5	0.54	0.58	0.64
65%	0.48	0.5	0.51	0.54	0.58	0.62	0.67
70%	0.53	0.55	0.56	0.59	0.62	0.65	0.71
75%	0.58	0.6	0.61	0.64	0.66	0.69	0.74
80%	0.63	0.65	0.66	0.69	0.71	0.73	0.77
85%	0.68	0.7	0.71	0.74	0.75	0.77	0.8
90%	0.73	0.75	0.77	0.79	0.79	0.81	0.84
95%	0.79	0.81	0.82	0.83	0.84	0.85	0.87
100%	0.84	0.86	0.87	0.88	0.88	0.89	0.9
Total or Effective % Impervious	**NRCS Hydrologic Soil Group B**						
	2-Year	**5-Year**	**10-Year**	**25-Year**	**50-Year**	**100-Year**	**500-Year**
2%	0.01	0.01	0.07	0.26	0.34	0.44	0.54
5%	0.03	0.03	0.1	0.28	0.36	0.45	0.55
10%	0.06	0.07	0.14	0.31	0.38	0.47	0.57
15%	0.09	0.11	0.18	0.34	0.41	0.5	0.59
20%	0.13	0.15	0.22	0.38	0.44	0.52	0.61
25%	0.17	0.19	0.26	0.41	0.47	0.54	0.63
30%	0.2	0.23	0.3	0.44	0.49	0.57	0.65
35%	0.24	0.27	0.34	0.47	0.52	0.59	0.66
40%	0.29	0.32	0.38	0.5	0.55	0.61	0.68
45%	0.33	0.36	0.42	0.53	0.58	0.64	0.7
50%	0.37	0.4	0.46	0.56	0.61	0.66	0.72
55%	0.42	0.45	0.5	0.6	0.63	0.68	0.74
60%	0.46	0.49	0.54	0.63	0.66	0.71	0.76
65%	0.5	0.54	0.58	0.66	0.69	0.73	0.77
70%	0.55	0.58	0.62	0.69	0.72	0.75	0.79
75%	0.6	0.63	0.66	0.72	0.75	0.78	0.81
80%	0.64	0.67	0.7	0.75	0.77	0.8	0.83
85%	0.69	0.72	0.74	0.78	0.8	0.82	0.85
90%	0.74	0.76	0.78	0.81	0.83	0.84	0.87
95%	0.79	0.81	0.82	0.85	0.86	0.87	0.88
100%	0.84	0.86	0.86	0.88	0.89	0.89	0.9

Table 6-5. Runoff coefficients, *c* (continued)

Total or Effective % Impervious	NRCS Hydrologic Soil Group C						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.05	0.15	0.33	0.40	0.49	0.59
5%	0.03	0.08	0.17	0.35	0.42	0.5	0.6
10%	0.06	0.12	0.21	0.37	0.44	0.52	0.62
15%	0.1	0.16	0.24	0.4	0.47	0.55	0.64
20%	0.14	0.2	0.28	0.43	0.49	0.57	0.65
25%	0.18	0.24	0.32	0.46	0.52	0.59	0.67
30%	0.22	0.28	0.35	0.49	0.54	0.61	0.68
35%	0.26	0.32	0.39	0.51	0.57	0.63	0.7
40%	0.3	0.36	0.43	0.54	0.59	0.65	0.71
45%	0.34	0.4	0.46	0.57	0.62	0.67	0.73
50%	0.38	0.44	0.5	0.6	0.64	0.69	0.75
55%	0.43	0.48	0.54	0.63	0.66	0.71	0.76
60%	0.47	0.52	0.57	0.65	0.69	0.73	0.78
65%	0.51	0.56	0.61	0.68	0.71	0.75	0.79
70%	0.56	0.61	0.65	0.71	0.74	0.77	0.81
75%	0.6	0.65	0.68	0.74	0.76	0.79	0.82
80%	0.65	0.69	0.72	0.77	0.79	0.81	0.84
85%	0.7	0.73	0.76	0.79	0.81	0.83	0.86
90%	0.74	0.77	0.79	0.82	0.84	0.85	0.87
95%	0.79	0.81	0.83	0.85	0.86	0.87	0.89
100%	0.83	0.85	0.87	0.88	0.89	0.89	0.9

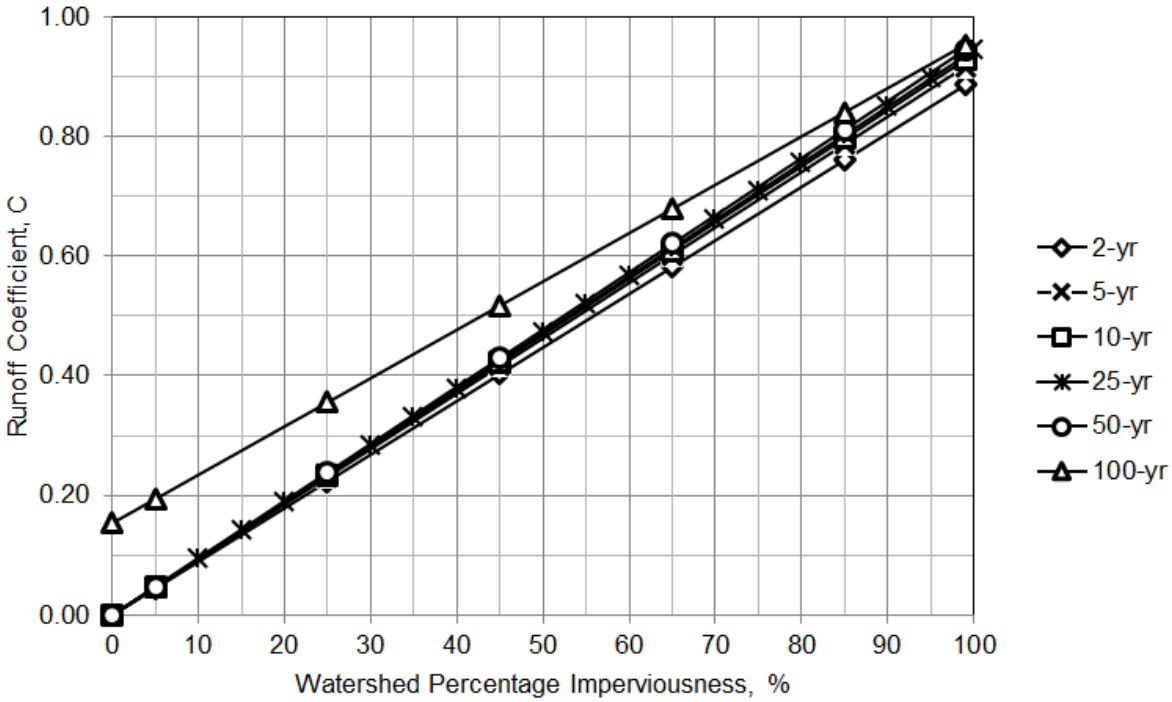


Figure 6-1. Runoff coefficient vs. watershed imperviousness NRCS HSG A

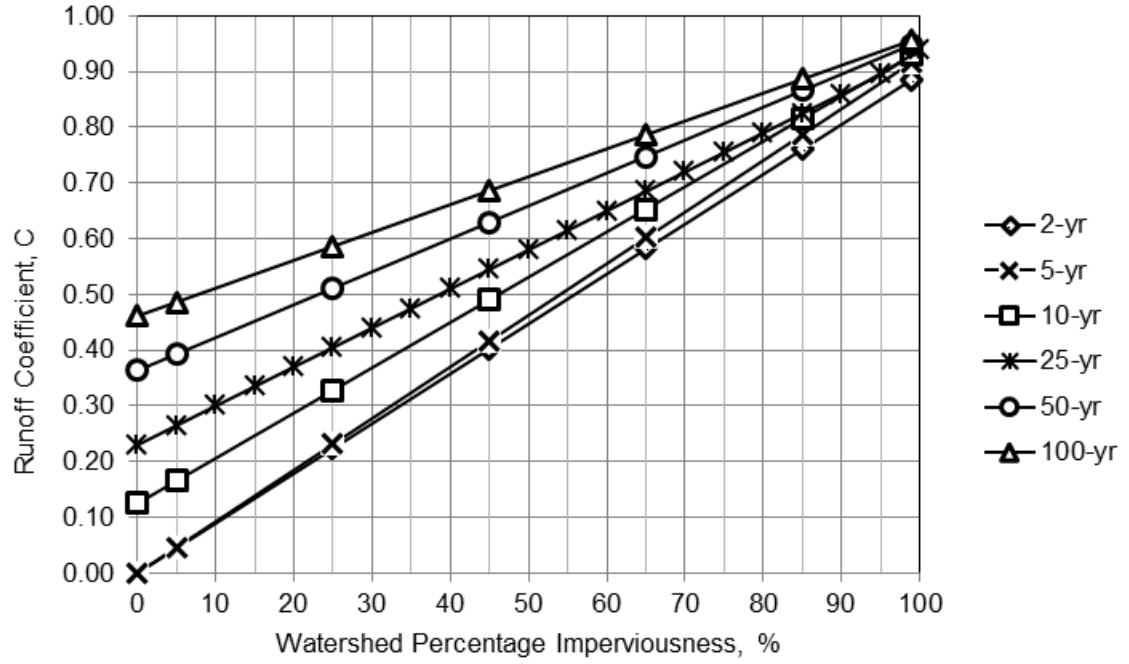


Figure 6-2. Runoff coefficient vs. watershed imperviousness NRCS HSG B

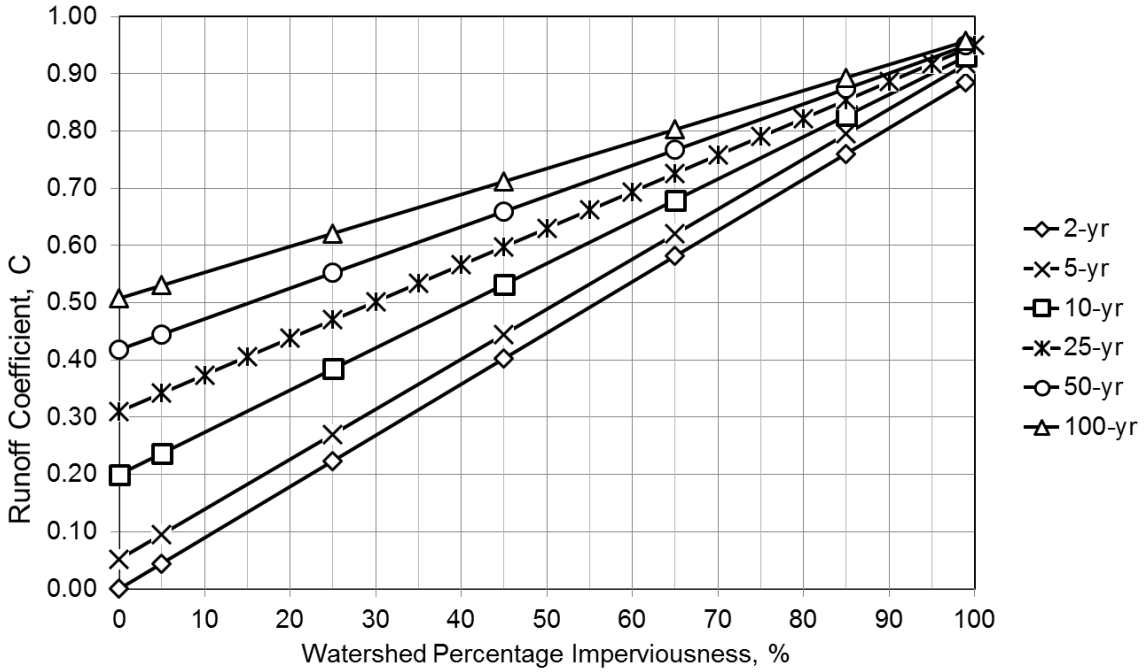


Figure 6-3. Runoff coefficient vs. watershed imperviousness NRCS HSG C and D

COMPOSITE C CALCULATION

PROJECT MANE: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

NRCS Hydrologic Soil Group: B

Lawns, clayey soil			2% Impervious	
2 yr = 0.01	5 yr = 0.01	10 yr = 0.07	100 yr = 0.44	
Paved			100% Impervious	
2 yr = 0.84	5 yr = 0.86	10 yr = 0.87	100 yr = 0.90	
Roofs			90% Impervious	
2 yr = 0.74	5 yr = 0.77	10 yr = 0.79	100 yr = 0.85	
Drive and walks			90% Impervious	
2 yr = 0.74	5 yr = 0.77	10 yr = 0.79	100 yr = 0.85	

PROPOSED DRAINAGE AREA

BASIN ID	A_{total} (ft^2)		Lawns, clayey soil (ft^2)	Paved (ft^2)	Roofs (ft^2)	Drive and walks (ft^2)	A_{total} (Ac)	COMPOSITE C 2 yr	5 yr	10 yr	100 yr	Percent Impervious
BEL-E1	39980		15597	21487		2896	0.92	0.51	0.52	0.55	0.72	61%
BEL-E2	44557		16404	24917		3236	1.02	0.53	0.54	0.57	0.73	63%
BEL-E3	20774		5594	13365		1815	0.48	0.61	0.62	0.65	0.77	73%
BEL-E4	18344		1654	15850		840	0.42	0.76	0.78	0.79	0.86	91%
BEL-E5	55481		27615	25139		2727	1.27	0.42	0.43	0.47	0.67	51%
BEL-E6	87902		61489	23215		3198	2.02	0.26	0.26	0.31	0.58	31%
BEL-E7	23254		6437	14722		2095	0.53	0.60	0.62	0.64	0.77	72%
BEL-E8	22712		4343	17384		985	0.52	0.68	0.69	0.71	0.81	81%
F3 (Tract G	283303		70948	212355			6.50	0.60	0.65	0.69	0.79	75%
POND	47171		47171				1.08	0.01	0.01	0.07	0.44	2%
Subtotals:	643,478	0	257,252	368,434	0	17,792						61%

Drainage Area= 14.77

TIME OF CONCENTRATION *(Rational Method)*

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

SUB-BASIN DATA			INITIAL TIME (t_i)			TRAVEL TIME (t_t)				t_c CHECK (URBANIZED BASINS)		FINAL t_c	REMARKS
BASIN ID	C_5	AREA Ac	LENGTH (ft)	SLOPE (ft/ft)	t_i (min)	LENGTH (ft)	SLOPE (ft/ft)	C_v	t_t (min)	TRAVEL LENGTH (ft)	$T_{c\ Reg}$ (min)	(min)	
BEL-E1	0.52	0.92	41	0.020	5.32	540	0.030	20.00	2.60	540.00	18.58	7.92	
BEL-E2	0.54	1.02	51	0.020	5.74	505	0.032	20.00	2.35	505.00	17.89	8.09	
BEL-E3	0.62	0.48	51	0.020	4.89	825	0.033	20.00	3.78	825.00	17.58	8.67	
BEL-E4	0.78	0.42	150	0.034	4.76	222	0.020	20.00	1.31	222.00	11.79	6.07	
BEL-E5	0.43	1.27	58	0.020	7.30	527	0.030	20.00	2.54	527.00	20.53	9.84	
BEL-E6	0.26	2.02	149	0.020	14.69	517	0.030	20.00	2.49	517.00	24.44	17.18	
BEL-E7	0.62	0.53	40	0.020	4.39	824	0.033	20.00	3.78	824.00	17.73	8.17	
BEL-E8	0.69	0.52	150	0.034	6.03	235	0.020	20.00	1.38	235.00	13.62	7.42	
POND	0.01	1.08	75	0.250	5.89	10	0.010	20.00	0.08	10.00	25.84	5.97	

RUNOFF COMPUTATIONS

(RATIONAL METHOD)

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

BASIN ID	DESIGN POINT	AREA Ac	COMPOSITE C				A*C				t_c (min)	INTENSITY (in/hr)				Q (cfs)			
			2 yr	5 yr	10 yr	100 yr	2 yr	5 yr	10 yr	100 yr		2 yr	5 yr	10 yr	100 yr	2 yr	5 yr	10 yr	100 yr
BEL-E1	1	0.92	0.51	0.52	0.55	0.72	0.47	0.48	0.51	0.66	7.92	2.45	3.22	3.92	6.81	1.14	1.54	1.99	4.48
BEL-E2	2	1.02	0.53	0.54	0.57	0.73	0.54	0.55	0.58	0.74	8.09	2.43	3.19	3.89	6.76	1.31	1.76	2.27	5.03
BEL-E3	3	0.48	0.61	0.62	0.65	0.77	0.29	0.30	0.31	0.37	8.67	2.37	3.11	3.80	6.60	0.69	0.93	1.17	2.43
BEL-E4	3	0.42	0.76	0.78	0.79	0.86	0.32	0.33	0.33	0.36	6.07	2.67	3.50	4.27	7.42	0.85	1.15	1.43	2.68
BEL-E5	4	1.27	0.42	0.43	0.47	0.67	0.54	0.55	0.60	0.85	9.84	2.26	2.97	3.62	6.29	1.21	1.63	2.16	5.36
BEL-E6	5	2.02	0.26	0.26	0.31	0.58	0.52	0.53	0.62	1.16	17.18	1.76	2.32	2.83	4.91	0.91	1.23	1.75	5.71
BEL-E7	6	0.53	0.60	0.62	0.64	0.77	0.32	0.33	0.34	0.41	8.17	2.42	3.18	3.88	6.74	0.78	1.05	1.33	2.76
BEL-E8	6	0.52	0.68	0.69	0.71	0.81	0.35	0.36	0.37	0.42	7.42	2.50	3.29	4.01	6.97	0.88	1.19	1.49	2.94
POND	7	1.08	0.01	0.01	0.07	0.44	0.01	0.01	0.08	0.48	5.97	2.68	3.52	4.29	7.46	0.03	0.04	0.33	3.55
																	10.51		31.39

APPENDIX C

Hydraulic Analysis

- Inlet Capacity Calculations
- StormCAD Storm Sewer Design
    - 5-Year Storm Table and Profiles
    - 100-Year Storm Table and Profiles
- Full Spectrum Detention Basin Design

5 yr Capacity Calculations (Rational Method)

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

FLOWS					STREET CAPACITY			INLET CAPACITY AND CARRY-OVER						
Basin ID Number	Design Point	Direct Flow Qd (cfs)	Carry-over flow Qco (cfs)	Total Flow Qt (cfs)	Minimum Street Slope (%)	Maximum Street Capacity (cfs)	Capacity Check	Inlet ID	Type	Condition	Inlet Capacity (cfs)	Intercepted Flow (cfs)	Carry-Over Flow (cfs)	Carry-Over to Design
BEL-E1	1	1.54	0.00	1.54	3.12	17.1	OK	A	10' Type R	On Grade	1.60	1.54	-	N/A
BEL-E2	2	1.76	0.00	1.76	3.12	17.5	OK	B	10' Type R	On Grade	1.80	1.76	-	N/A
BEL-E3	3	0.93	0.00	0.93	0			C						
BEL-E4	3	1.15	1.03	2.18	0	16.9	OK	C	10' Type R	In Sump	10.50	2.18	-	N/A
BEL-E5	4	1.63	0.00	1.63	3.12	17.5	OK	D	10' Type R	On Grade	1.63	1.63	0.00	N/A
BEL-E6	5	1.23	0.00	1.23	3.12	17.5	OK	E	10' Type R	On Grade	1.23	1.23	-	N/A
BEL-E7	6	1.05	0.00	1.05	0			F					-	
BEL-E8	6	1.19	0.00	1.19	0	16.9	OK	F	10' Type R	In Sump	10.50		-	N/A
													-	
CHAMBERS	3	0.00	0.10	0.10				C						3
HP														
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	

5 yr Capacity Calculations (Rational Method)

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

Manhard CONSULTING

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

FLOWS					STREET CAPACITY			INLET CAPACITY AND CARRY-OVER						
Basin ID Number	Design Point	Direct Flow Qd (cfs)	Carry-over flow Qco (cfs)	Total Flow Qt (cfs)	Minimum Street Slope (%)	Maximum Street Capacity (cfs)	Capacity Check	Inlet ID	Type	Condition	Inlet Capacity (cfs)	Intercepted Flow (cfs)	Carry-Over Flow (cfs)	Carry-Over to Design
BEL-E1	1	1.54	0.00	1.54	3.12	17.1	OK	A	10' Type R	On Grade	1.60	1.54	-	N/A
BEL-E2	2	1.76	0.00	1.76	3.12	17.5	OK	B	10' Type R	On Grade	1.80	1.76	-	N/A
BEL-E3	3	0.93	0.00	0.93	0			C						
BEL-E4	3	1.15	1.03	2.18	0	16.9	OK	C	10' Type R	In Sump	10.50	2.18	-	N/A
BEL-E5	4	1.63	0.00	1.63	3.12	17.5	OK	D	10' Type R	On Grade	1.63	1.63	0.00	N/A
BEL-E6	5	1.23	0.00	1.23	3.12	17.5	OK	E	10' Type R	On Grade	1.23	1.23	-	N/A
BEL-E7	6	1.05	0.00	1.05	0			F					-	
BEL-E8	6	1.19	0.00	1.19	0	16.9	OK	F	10' Type R	In Sump	10.50		-	N/A
													-	
CHAMBERS	3	0.00	0.10	0.10				C						3
HP														
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	

100 yr Capacity Calculations (Rational Method)

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

FLOWS					STREET CAPACITY			INLET CAPACITY AND CARRY-OVER						
Basin ID Number	Design Point	Direct Flow Qd (cfs)	Carry-over flow Qco (cfs)	Total Flow Qt (cfs)	Minimum Street Slope (%)	Maximum Street Capacity (cfs)	Capacity Check	Inlet ID	Type	Condition	Inlet Capacity (cfs)	Intercepted Flow (cfs)	Carry-Over Flow (cfs)	Carry-Over to Design
BEL-E1	1	4.48	0.00	4.48	3.12	139	OK	A	10' Type R	On Grade	4.40	4.40	0.08	2
BEL-E2	2	5.03	0.08	5.11	3.12	139	OK	B	10' Type R	On Grade	4.80	4.80	0.31	3
BEL-E3	3	2.43	0.31	2.74	0			C						
BEL-E4	3	2.68	5.74	8.42	0	164.9	OK	C	10' Type R	In Sump	23.80	8.42	-	N/A
BEL-E5	4	5.36	0.00	5.36	3	139	OK	D	10' Type R	In Sump	5.00	5.00	0.36	5
BEL-E6	5	5.71	0.36	6.07	3	139	OK	E	10' Type R	On Grade	5.40	5.40	0.67	6
BEL-E7	6	2.76	0.67	3.43			OK	F					-	6
BEL-E8	6	2.94	3.43	6.37	0	164.9	OK	F	10' Type R	In Sump	23.80	6.37	-	
													-	
HAMBERS I	3	0.00	3.00	3.00				C						3
HP														
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	

2 yr Capacity Calculations (Rational Method)

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

FLOWS					STREET CAPACITY			INLET CAPACITY AND CARRY-OVER						
Basin ID Number	Design Point	Direct Flow Qd (cfs)	Carry-over flow Qco (cfs)	Total Flow Qt (cfs)	Minimum Street Slope (%)	Maximum Street Capacity (cfs)	Capacity Check	Inlet ID	Type	Condition	Inlet Capacity (cfs)	Intercepted Flow (cfs)	Carry-Over Flow (cfs)	Carry-Over to Design
BEL-E1	1	1.14	0.00	1.14			NOT OK					0.00	1.14	
BEL-E2	2	1.31	0.00	1.31			NOT OK					0.00	1.31	
BEL-E4	3	0.85	0.00	0.85			NOT OK					0.00	0.85	
BEL-E5	4	1.21	0.00	1.21			NOT OK					0.00	1.21	
BEL-E6	5	0.91	0.00	0.91			NOT OK					0.00	0.91	
BEL-E7	6	0.78	0.00	0.78			NOT OK					0.00	0.78	
POND	7	0.03	0.00	0.03			NOT OK					0.00	0.03	
	0												-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	

10 yr Capacity Calculations (Rational Method)

PROJECT NAME: Compark Village South - Belford Avenue East
PROJECT NO: CLCPKC3
LOCATION: Town of Parker, Colorado

*Calculations on this sheet come from UDFCD: Urban Storm Drainage Criteria Manual (V.1) (2017)

FLOWS					STREET CAPACITY			INLET CAPACITY AND CARRY-OVER						
Basin ID Number	Design Point	Direct Flow Qd (cfs)	Carry-over flow Qco (cfs)	Total Flow Qt (cfs)	Minimum Street Slope (%)	Maximum Street Capacity (cfs)	Capacity Check	Inlet ID	Type	Condition	Inlet Capacity (cfs)	Intercepted Flow (cfs)	Carry-Over Flow (cfs)	Carry-Over to Design
BEL-E1	1	1.99	0.00	1.99			NOT OK					0.00	1.99	
BEL-E2	2	2.27	0.00	2.27			NOT OK					0.00	2.27	
BEL-E4	3	1.43	0.00	1.43			NOT OK					0.00	1.43	
BEL-E5	4	2.16	0.00	2.16			NOT OK					0.00	2.16	
BEL-E6	5	1.75	0.00	1.75			NOT OK					0.00	1.75	
BEL-E7	6	1.33	0.00	1.33			NOT OK					0.00	1.33	
POND	7	0.33	0.00	0.33			NOT OK					0.00	0.33	
	0												-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	
													-	

Version 4.06 Released August 2018

INLET MANAGEMENT

Worksheet Protected

INLET NAME	INL-A	INL-B	INL-C	INL-D	INL-E	INL-F
Site Type (Urban or Rural)						
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	In Sump	On Grade	On Grade	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	1.5	1.8	2.1	1.6	1.2	2.2
Major Q_{Known} (cfs)	4.5	5.0	5.1	5.4	5.7	5.7

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	INL-A	User-Defined	No Bypass Flow Received	INL-D	INL-E
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.1	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.1	3.3	0.0	0.4	0.7

Watershed Characteristics

Subcatchment Area (acres)						
Percent Impervious						
NRCS Soil Type						

Watershed Profile

Overland Slope (ft/ft)						
Overland Length (ft)						
Channel Slope (ft/ft)						
Channel Length (ft)						

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)						
One-Hour Precipitation, P_1 (inches)						

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)						
One-Hour Precipitation, P_1 (inches)						

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**1.5**	**1.8**	**2.2**	**1.6**	**1.2**	**2.2**
Major Total Design Peak Flow, Q (cfs)	**4.5**	**5.1**	**8.4**	**5.4**	**6.1**	**6.4**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	N/A	0.0	0.0	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	0.1	0.3	N/A	0.4	0.7	N/A

Minor Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A	N/A	N/A

Major Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A	N/A	N/A

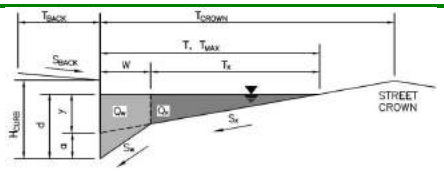
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark Village South - Belford Ave East

Inlet ID: INL-A



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.031	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

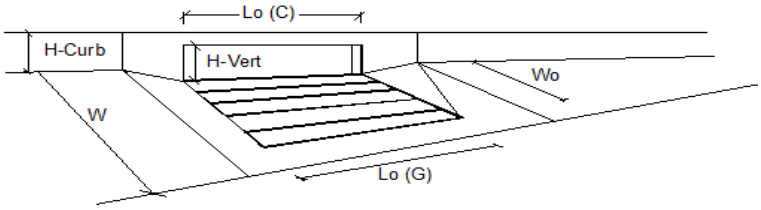
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**17.5**	**139.0**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	

Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.5**	**4.4**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.1**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**97**	**%**

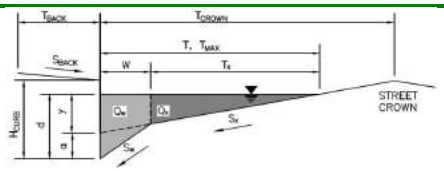
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark Village South - Belford Ave East

Inlet ID: INL-B



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.031	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

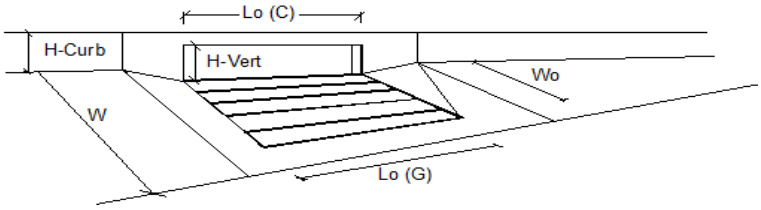
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**17.5**	**139.0**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	

Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.8**	**4.8**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.3**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**94**	**%**

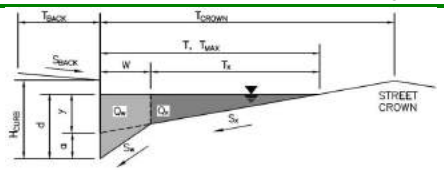
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark Village South - Belford Ave East

Inlet ID: INL-C



Gutter Geometry (Enter data in the blue cells)

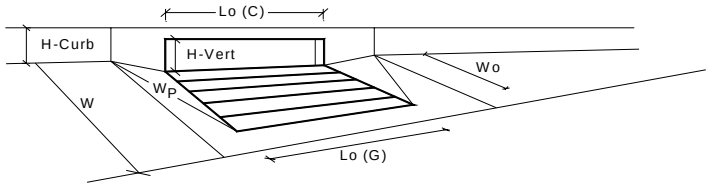
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	2	2	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	6.0	10.4	inches
Grate Information		MINOR	MAJOR	Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.70	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.57	0.98	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.93	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**10.5**	**23.8**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	2.2	8.4	cfs

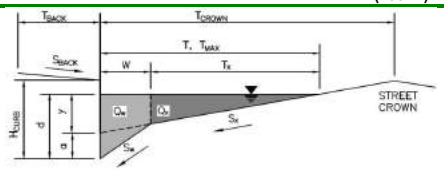
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Belford Avenue

Inlet ID: INL-C (100FT)



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.015	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**16.9**	**164.9**	**cfs**

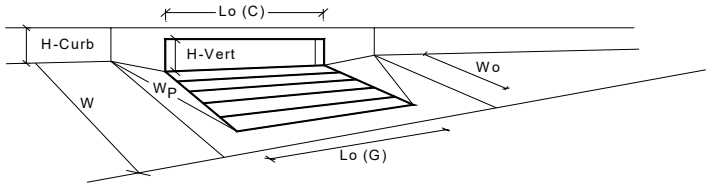
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Per the requirements of *Town Criteria* Section 6.3.2, this sheet is provided to show the street drainage capacity at 100' from the lowpoint where inlet-C is located. Street slopes are equal at 100' on either side of the inlet.

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00 inches
Number of Unit Inlets (Grate or Curb Opening)		No =	2	2
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	10.4 inches
Grate Information			MINOR	MAJOR ☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A feet
Width of a Unit Grate		W_o =	N/A	N/A feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A
Curb Opening Information			MINOR	MAJOR
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00 feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00 inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00 inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40 degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00 feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.70 ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.57	0.98
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	0.93	1.00
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**10.5**	**23.8** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	5.5	13.2 cfs

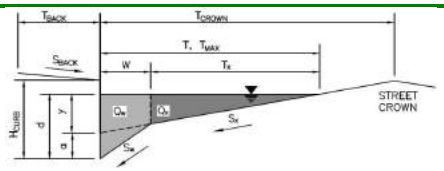
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark Village South - Belford Ave East

Inlet ID: INL-D



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.031	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

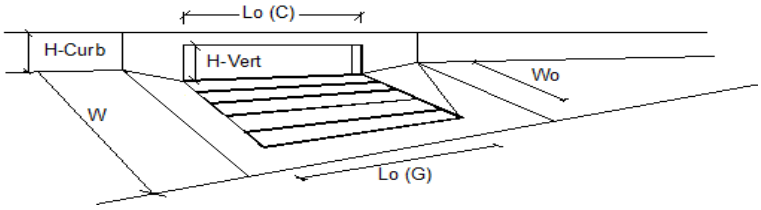
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**17.5**	**139.0**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	

Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.6**	**5.0**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.4**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**93**	**%**

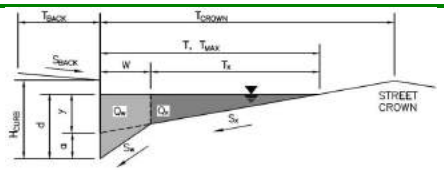
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark Village South - Belford Ave East

Inlet ID: INL-E



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.031	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

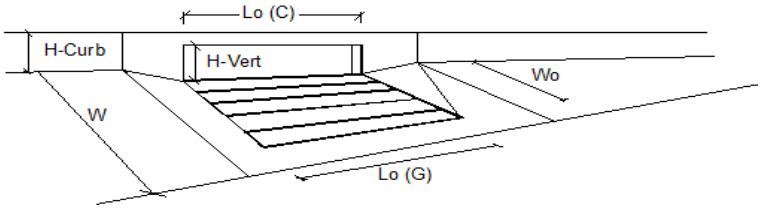
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**17.5**	**139.0**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.2**	**5.4**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.7**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**89**	**%**

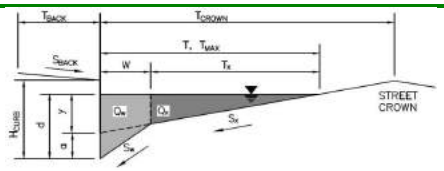
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark Village South - Belford Ave East

Inlet ID: INL-F



Gutter Geometry (Enter data in the blue cells)

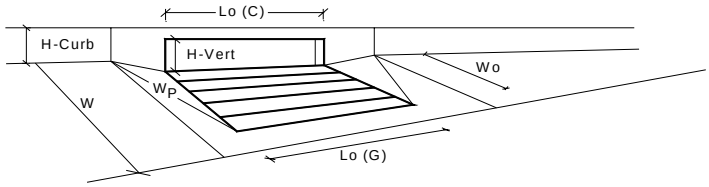
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

Version 4.06 Released August 2018



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	2	2	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	6.0	10.4	inches
Grate Information		MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.70	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.57	0.98	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.93	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**10.5**	**23.8**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	2.2	6.4	cfs

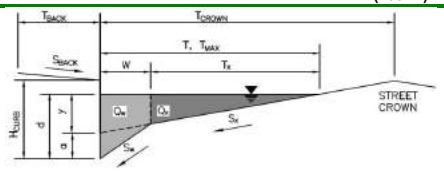
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Belford Avenue

Inlet ID: INL-F (100FT)



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.015	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	32.0	37.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**16.9**	**164.9**	**cfs**

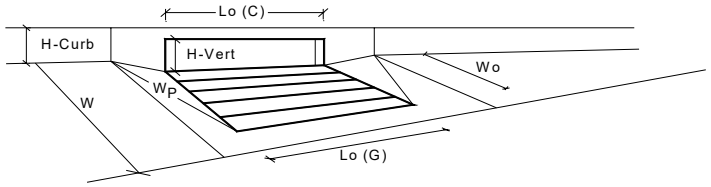
Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Per the requirements of *Town Criteria* Section 6.3.2, this sheet is provided to show the street drainage capacity at 100' from the lowpoint where inlet-F is located. Street slopes are equal at 100' on either side of the lowpoint.

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00 inches
Number of Unit Inlets (Grate or Curb Opening)		No =	2	2
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	10.4 inches
Grate Information			MINOR	MAJOR ☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A feet
Width of a Unit Grate		W_o =	N/A	N/A feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A
Curb Opening Information			MINOR	MAJOR
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00 feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00 inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00 inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40 degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00 feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67
Low Head Performance Reduction (Calculated)			MINOR	MAJOR
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.70 ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.57	0.98
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	0.93	1.00
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A
			MINOR	MAJOR
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**10.5**	**23.8** **cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	5.1	13.7 cfs

Version 4.06 Released August 2018

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Approach Inlet North	Approach Inlet South
Site Type (Urban or Rural)	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	On Grade	On Grade
Inlet Type	Denver No. 16 Valley Grate	Denver No. 16 Valley Grate

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	1.2	1.2
Major Q_{Known} (cfs)	2.7	2.9

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	User-Defined	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	3.0	0.0

Watershed Characteristics

Subcatchment Area (acres)		
Percent Impervious		
NRCS Soil Type		

Watershed Profile

Overland Slope (ft/ft)		
Overland Length (ft)		
Channel Slope (ft/ft)		
Channel Length (ft)		

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)		
One-Hour Precipitation, P_1 (inches)		
C_1		
C_2		
C_3		
User-defined C		
User-defined 5-yr C_5		
User-defined T_c		

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)		
One-Hour Precipitation, P_1 (inches)		
C_1		
C_2		
C_3		
User-defined C		
User-defined 5-yr C_5		
User-defined T_c		

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**1.2**	**1.2**
Major Total Design Peak Flow, Q (cfs)	**5.7**	**2.9**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.3	0.4
Major Flow Bypassed Downstream, Q_b (cfs)	3.6	1.5

Minor Storm (Calculated) Analysis of Flow Time

C	N/A	N/A
C_5	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A
Overland Flow Time, Ti	N/A	N/A
Channel Travel Time, Tt	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A
Regional T_c	N/A	N/A
Recommended T_c	N/A	N/A
T_c selected by User	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A

Major Storm (Calculated) Analysis of Flow Time

C	N/A	N/A
C_5	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A
Overland Flow Time, Ti	N/A	N/A
Channel Travel Time, Tt	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A
Regional T_c	N/A	N/A
Recommended T_c	N/A	N/A
T_c selected by User	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A

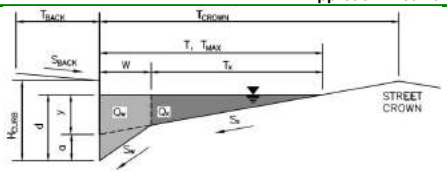
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark - Belford Ave at Happy Canyon Creek

Inlet ID: Approach Inlet North



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.016	
Height of Curb at Gutter Flow Line	H_{CURB} =	8.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.013	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	27.0	27.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	8.0	8.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

Maximum Capacity for 1/2 Street based On Allowable Spread

		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	6.48	6.48	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.51	1.51	inches
Water Depth at Gutter Flowline	d =	7.99	7.99	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	25.0	25.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.217	0.217	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	31.3	31.3	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	8.7	8.7	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**40.0**	**40.0**	**cfs**
Flow Velocity within the Gutter Section	V =	7.4	7.4	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	4.9	4.9	

Maximum Capacity for 1/2 Street based on Allowable Depth

		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	27.0	27.0	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	25.0	25.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.216	0.216	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	31.4	31.4	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	31.4	31.4	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	8.7	8.7	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	40.1	40.1	cfs
Average Flow Velocity Within the Gutter Section	V =	7.4	7.4	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	5.0	5.0	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d ≥ 6") Storm	R =	1.00	1.00	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**40.1**	**40.1**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	8.00	8.00	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	0.00	0.00	inches

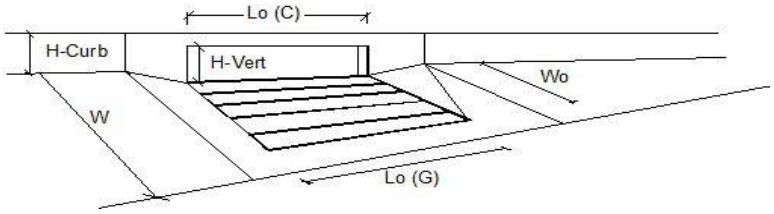
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**40.0**	**40.0**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.06 Released August 2018



Design Information (Input)	Denver No. 16 Valley Grate		MINOR	MAJOR	
Type of Inlet		Type =	Denver No. 16 Valley Grate		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	2.0	2.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	3.00	3.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	1.73	1.73	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C_f-G =	0.50	0.50	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C_f-C =	N/A	N/A	
Street Hydraulics: OK - Q < Allowable Street Capacity'			MINOR	MAJOR	
Design Discharge for Half of Street (from Sheet *Inlet Management*)		**Q_o =**	**1.2**	**5.7**	cfs
Water Spread Width		T =	5.5	12.3	ft
Water Depth at Flowline (outside of local depression)		d =	2.8	4.5	inches
Water Depth at Street Crown (or at T_{MAX})		d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E_o =	0.855	0.480	
Discharge outside the Gutter Section W, carried in Section T_x		Q_x =	0.2	3.0	cfs
Discharge within the Gutter Section W		Q_w =	1.0	2.7	cfs
Discharge Behind the Curb Face		Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A_W =	0.31	0.58	sq ft
Velocity within the Gutter Section W		V_W =	3.2	4.7	fps
Water Depth for Design Condition		d_{LOCAL} =	4.8	6.5	inches
Grate Analysis (Calculated)			MINOR	MAJOR	
Total Length of Inlet Grate Opening		L =	3.00	3.00	ft
Ratio of Grate Flow to Design Flow		$E_{o\text{-}GRATE}$ =	0.809	0.440	
Under No-Clogging Condition			MINOR	MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V_o =	1.86	1.86	fps
Interception Rate of Frontal Flow		R_f =	0.93	0.86	
Interception Rate of Side Flow		R_x =	0.22	0.15	
Interception Capacity		Q_i =	0.9	2.6	cfs
Under Clogging Condition			MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoef =	1.00	1.00	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	0.50	0.50	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L_e =	1.50	1.50	ft
Minimum Velocity Where Grate Splash-Over Begins		V_o =	1.07	1.07	fps
Interception Rate of Frontal Flow		R_f =	0.86	0.78	
Interception Rate of Side Flow		R_x =	0.05	0.04	
Actual Interception Capacity		**Q_a =**	**0.8**	**2.1**	cfs
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)		**Q_b =**	**0.3**	**3.6**	cfs
Curb or Slotted Inlet Opening Analysis (Calculated)			MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)		S_e =	N/A	N/A	ft/ft
Required Length L_T to Have 100% Interception		L_T =	N/A	N/A	ft
Under No-Clogging Condition			MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)		L =	N/A	N/A	ft
Interception Capacity		Q_i =	N/A	N/A	cfs
Under Clogging Condition			MINOR	MAJOR	
Clogging Coefficient		CurbCoef =	N/A	N/A	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	N/A	N/A	
Effective (Unclogged) Length		L_e =	N/A	N/A	ft
Actual Interception Capacity		**Q_a =**	**N/A**	**N/A**	cfs
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a		**Q_b =**	**N/A**	**N/A**	cfs
Summary			MINOR	MAJOR	
Total Inlet Interception Capacity		**Q =**	**0.8**	**2.1**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)		**Q_b =**	**0.3**	**3.6**	**cfs**
Capture Percentage = Q_a/Q_o =		**C% =**	**70**	**36**	**%**

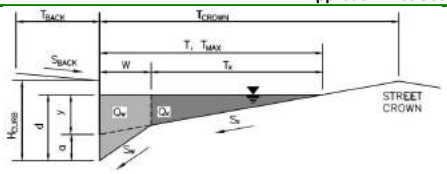
Version 4.06 Released August 2018

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Compark - Belford Ave at Happy Canyon Creek

Inlet ID: Approach Inlet South



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.013	
Height of Curb at Gutter Flow Line	H_{CURB} =	8.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	37.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.013	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	27.0	27.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	8.0	8.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

Maximum Capacity for 1/2 Street based On Allowable Spread

		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	6.48	6.48	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	2.0	2.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	1.51	1.51	inches
Water Depth at Gutter Flowline	d =	7.99	7.99	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	25.0	25.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.217	0.217	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	31.3	31.3	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	8.7	8.7	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**40.0**	**40.0**	**cfs**
Flow Velocity within the Gutter Section	V =	7.4	7.4	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	4.9	4.9	

Maximum Capacity for 1/2 Street based on Allowable Depth

		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	27.0	27.0	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	25.0	25.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.216	0.216	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	31.4	31.4	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	31.4	31.4	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	8.7	8.7	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	40.1	40.1	cfs
Average Flow Velocity Within the Gutter Section	V =	7.4	7.4	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	5.0	5.0	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d ≥ 6") Storm	R =	1.00	1.00	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**40.1**	**40.1**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	8.00	8.00	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	0.00	0.00	inches

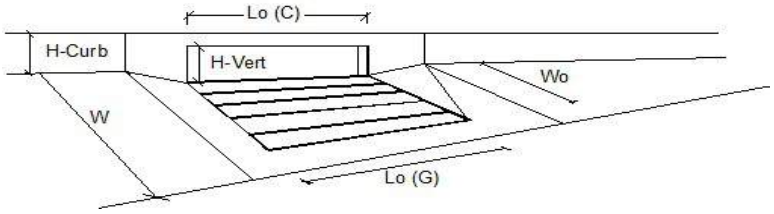
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**40.0**	**40.0**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.06 Released August 2018



Design Information (Input)	Denver No. 16 Valley Grate		MINOR	MAJOR	
Type of Inlet		Type =	Denver No. 16 Valley Grate		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	2.0	2.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	3.00	3.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	1.73	1.73	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C_f-G =	0.50	0.50	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C_f-C =	N/A	N/A	
Street Hydraulics: OK - Q < Allowable Street Capacity'			MINOR	MAJOR	
Design Discharge for Half of Street (from Sheet *Inlet Management*)		**Q_o =**	**1.2**	**2.9**	cfs
Water Spread Width		T =	5.7	9.2	ft
Water Depth at Flowline (outside of local depression)		d =	2.9	3.7	inches
Water Depth at Street Crown (or at T_{MAX})		d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E_o =	0.846	0.621	
Discharge outside the Gutter Section W, carried in Section T_x		Q_x =	0.2	1.1	cfs
Discharge within the Gutter Section W		Q_w =	1.0	1.8	cfs
Discharge Behind the Curb Face		Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A_W =	0.31	0.45	sq ft
Velocity within the Gutter Section W		V_W =	3.2	4.0	fps
Water Depth for Design Condition		d_{LOCAL} =	4.9	5.7	inches
Grate Analysis (Calculated)			MINOR	MAJOR	
Total Length of Inlet Grate Opening		L =	3.00	3.00	ft
Ratio of Grate Flow to Design Flow		$E_{o\text{-}GRATE}$ =	0.800	0.576	
Under No-Clogging Condition			MINOR	MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V_o =	1.86	1.86	fps
Interception Rate of Frontal Flow		R_f =	0.93	0.89	
Interception Rate of Side Flow		R_x =	0.22	0.18	
Interception Capacity		Q_i =	0.9	1.7	cfs
Under Clogging Condition			MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoef =	1.00	1.00	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	0.50	0.50	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L_e =	1.50	1.50	ft
Minimum Velocity Where Grate Splash-Over Begins		V_o =	1.07	1.07	fps
Interception Rate of Frontal Flow		R_f =	0.85	0.82	
Interception Rate of Side Flow		R_x =	0.05	0.04	
Actual Interception Capacity		**Q_a =**	**0.8**	**1.4**	cfs
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)		**Q_b =**	**0.4**	**1.5**	cfs
Curb or Slotted Inlet Opening Analysis (Calculated)			MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)		S_e =	N/A	N/A	ft/ft
Required Length L_T to Have 100% Interception		L_T =	N/A	N/A	ft
Under No-Clogging Condition			MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)		L =	N/A	N/A	ft
Interception Capacity		Q_i =	N/A	N/A	cfs
Under Clogging Condition			MINOR	MAJOR	
Clogging Coefficient		CurbCoef =	N/A	N/A	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	N/A	N/A	
Effective (Unclogged) Length		L_e =	N/A	N/A	ft
Actual Interception Capacity		**Q_a =**	**N/A**	**N/A**	cfs
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a		**Q_b =**	**N/A**	**N/A**	cfs
Summary			MINOR	MAJOR	
Total Inlet Interception Capacity		**Q =**	**0.8**	**1.4**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)		**Q_b =**	**0.4**	**1.5**	**cfs**
Capture Percentage = Q_a/Q_o =		**C% =**	**70**	**49**	**%**

FlexTable: Catch Basin Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Total Out) (cfs)	Velocity (In) (ft/s)	Velocity (Out) (ft/s)	Hydraulic Grade Line (In) (ft)	Notes
INL-A	5,811.25	5,805.52	1.54	3.29	3.29	5,805.99	15' TYPE R
INL-B	5,792.88	5,787.93	1.76	3.42	3.42	5,788.43	15' TYPE R
INL-BR1	5,783.62	5,779.79	0.80	2.74	2.74	5,780.12	TYPE16 Valley Grate
INL-BR2	5,783.87	5,780.30	0.80	2.74	2.74	5,780.63	TYPE 16 Valley Grate
INL-C	5,784.05	5,779.00	7.02	1.09	4.84	5,779.94	15' TYPE R
INL-D	5,809.56	5,806.21	1.63	3.35	3.35	5,806.69	5' TYPE R
INL-E	5,790.83	5,787.93	1.23	3.09	3.09	5,788.34	10' TYPE R
INL-F	5,784.05	5,779.41	4.27	1.88	4.15	5,780.14	10' TYPE R
OS-1	5,783.00	5,773.70	0.20	1.90	1.90	5,773.86	POND OUTLET

Bentley Systems, Inc. Haestad Methods Solution Center
27 Siemon Company Drive Suite 200 W Watertown, CT 06795 USA
+1-203-755-1666

FlexTable: Manhole Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Total Out) (cfs)	Velocity (In) (ft/s)	Velocity (Out) (ft/s)	Bolted Cover?	Notes
STMH-1	5,811.31	5,804.47	3.17	6.19	4.09	False	5'
STMH-2	5,801.84	5,793.90	3.17	8.08	4.09	False	4'
STMH-3	5,792.98	5,786.87	6.16	4.10	4.64	False	6'
STMH-4	5,786.93	5,776.24	17.45	1.99	2.47	False	7'
STMH-5	5,784.38	5,778.47	11.29	5.90	5.02	False	7'

Bentley Systems, Inc. Haestad Methods Solution Center
27 Siemon Company Drive Suite 200 W Watertown, CT 06795 USA
+1-203-755-1666

Compark Village South
Belford Ave Amd
5 yr Storm

FlexTable: Conduit Table

Start Node	Stop Node	Diameter (in)	Material	Length (Unified) (ft)	Invert (Start) (ft)	Invert (Stop) (ft)	Flow (cfs)	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Slope (Calculated) (ft/ft)	Manning's n	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
INL-A	STMH-1	18.0	Concrete	27.4	5,805.52	5,804.69	1.54	18.28	6.29	0.030	0.013	5,805.99	5,804.99
STMH-1	STMH-2	18.0	Concrete	305.1	5,804.47	5,794.10	3.17	19.36	8.08	0.034	0.013	5,805.15	5,794.51
INL-D	STMH-1	18.0	Concrete	50.8	5,806.21	5,804.69	1.63	18.16	6.37	0.030	0.013	5,806.69	5,804.99
STMH-2	STMH-3	18.0	Concrete	272.0	5,793.90	5,787.37	3.17	16.28	7.14	0.024	0.013	5,794.58	5,787.82
STMH-3	STMH-4	24.0	Concrete	142.9	5,786.87	5,777.45	6.16	58.09	12.03	0.066	0.013	5,787.75	5,779.37
INL-B	STMH-3	18.0	Concrete	27.9	5,787.93	5,787.37	1.76	14.89	5.65	0.020	0.013	5,788.43	5,787.72
INL-E	STMH-3	18.0	Concrete	51.6	5,787.93	5,787.37	1.23	10.94	4.10	0.011	0.013	5,788.34	5,787.71
STMH-5	STMH-4	36.0	Concrete	253.3	5,778.47	5,776.44	11.29	59.71	6.49	0.008	0.013	5,779.54	5,779.37
STMH-4	FES-01	36.0	Concrete	82.8	5,776.24	5,775.41	17.45	66.78	2.47	0.010	0.013	5,779.37	5,779.31
INL-C	STMH-5	24.0	Concrete	39.0	5,779.00	5,778.67	7.02	20.80	5.98	0.008	0.013	5,779.94	5,779.48
INL-F	STMH-5	24.0	Concrete	39.0	5,779.41	5,779.08	4.27	20.80	5.21	0.008	0.013	5,780.14	5,779.70
OS-1	FES H	18.0	Concrete	106.3	5,773.70	5,773.00	0.20	8.52	2.00	0.007	0.013	5,773.86	5,773.16
INL-BR2	INL-F	18.0	Concrete	59.9	5,780.30	5,779.70	0.80	10.52	3.52	0.010	0.013	5,780.63	5,780.14
INL-BR1	INL-C	18.0	Concrete	24.5	5,779.79	5,779.29	0.80	15.01	4.51	0.020	0.013	5,780.12	5,779.94

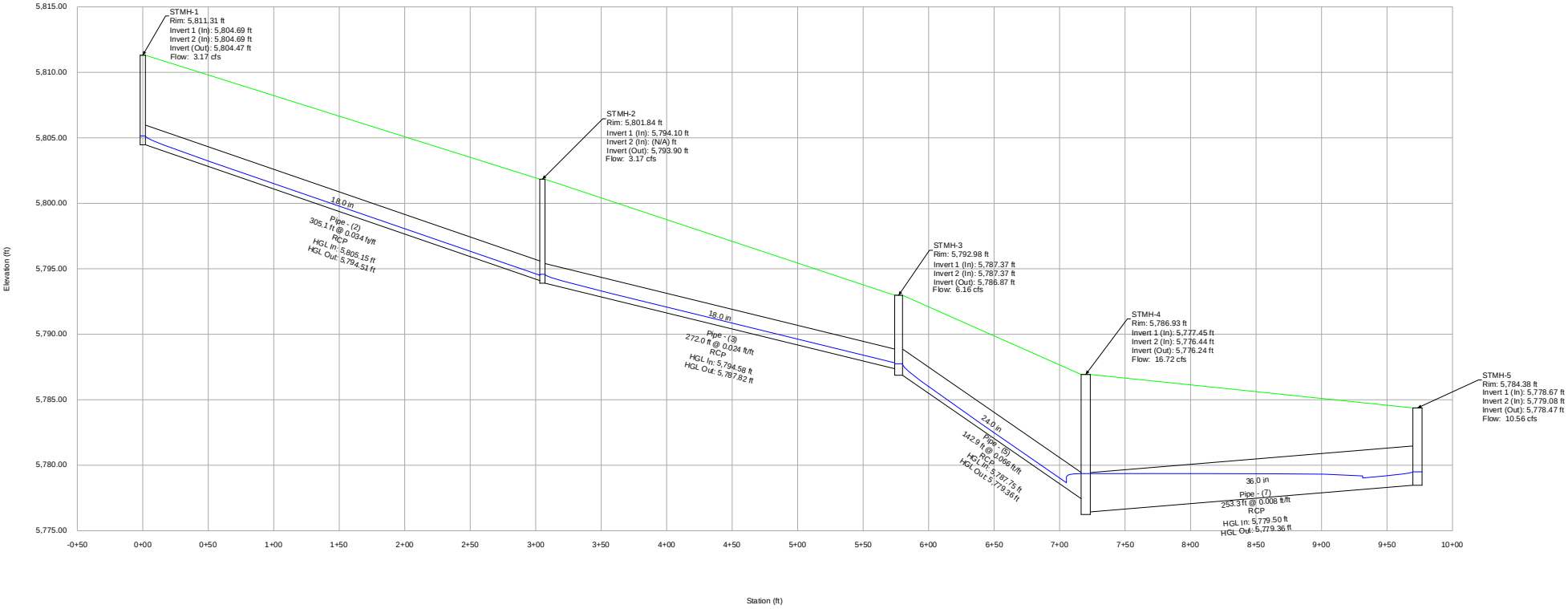
FlexTable: Outfall Table

Label	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Boundary Condition Type	Elevation (User Defined Tailwater) (ft)	Hydraulic Grade (ft)	Flow (Total Out) (cfs)	Notes
FES-01	5,781.70	5,775.41	User Defined Tailwater	5,779.31	5,779.31	16.72	Pond Outfall
FES H	5,776.00	5,773.00	User Defined Tailwater	5,772.00	5,773.16	0.20	Forebay 2

Compark Village South
Belford Ave Amd
5 yr Storm

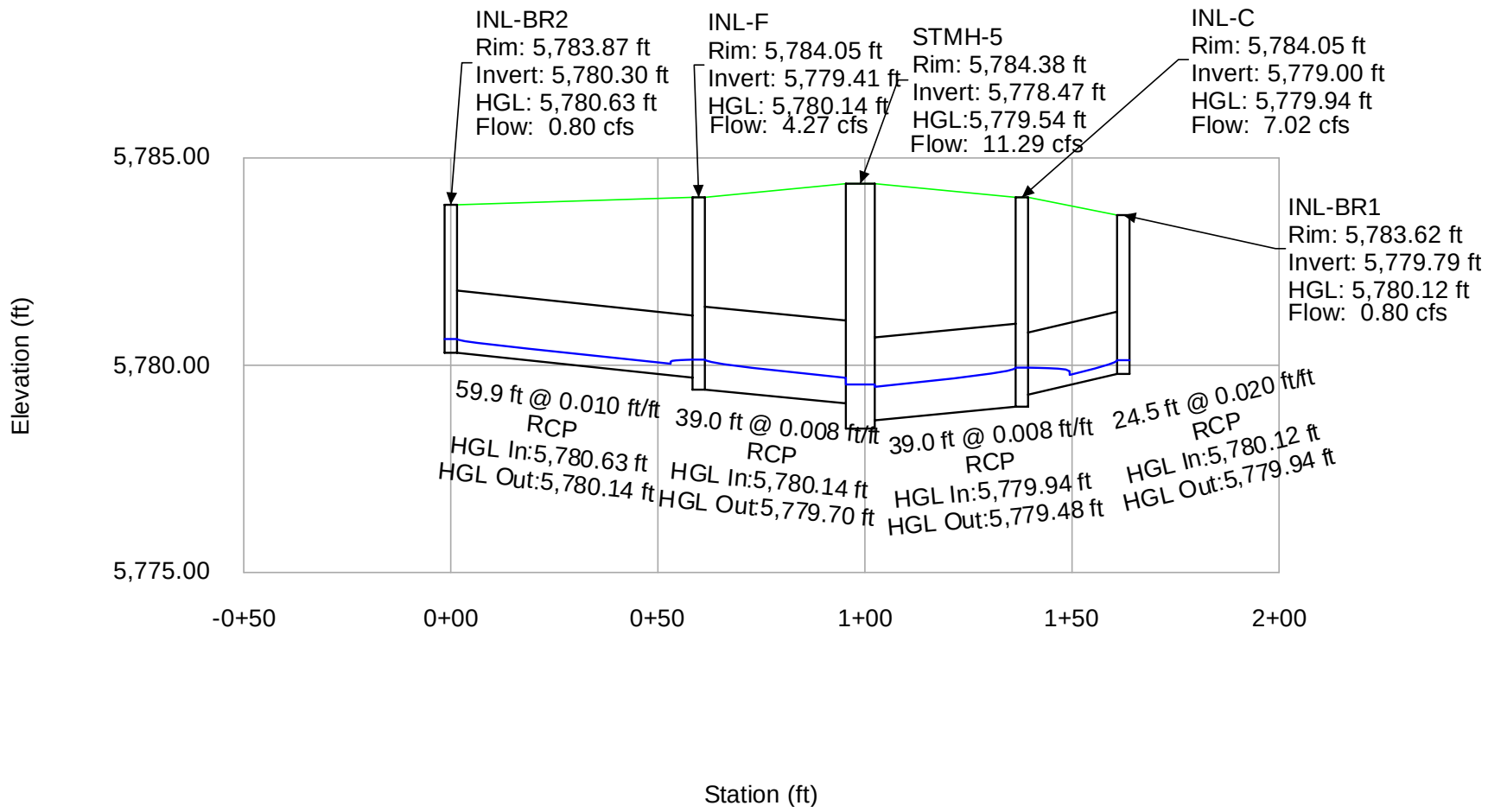
Profile Report

Engineering Profile - STMH 1 - STMH 5 (Belford Storm (5YEAR)(FULL WIDTH).stsw)



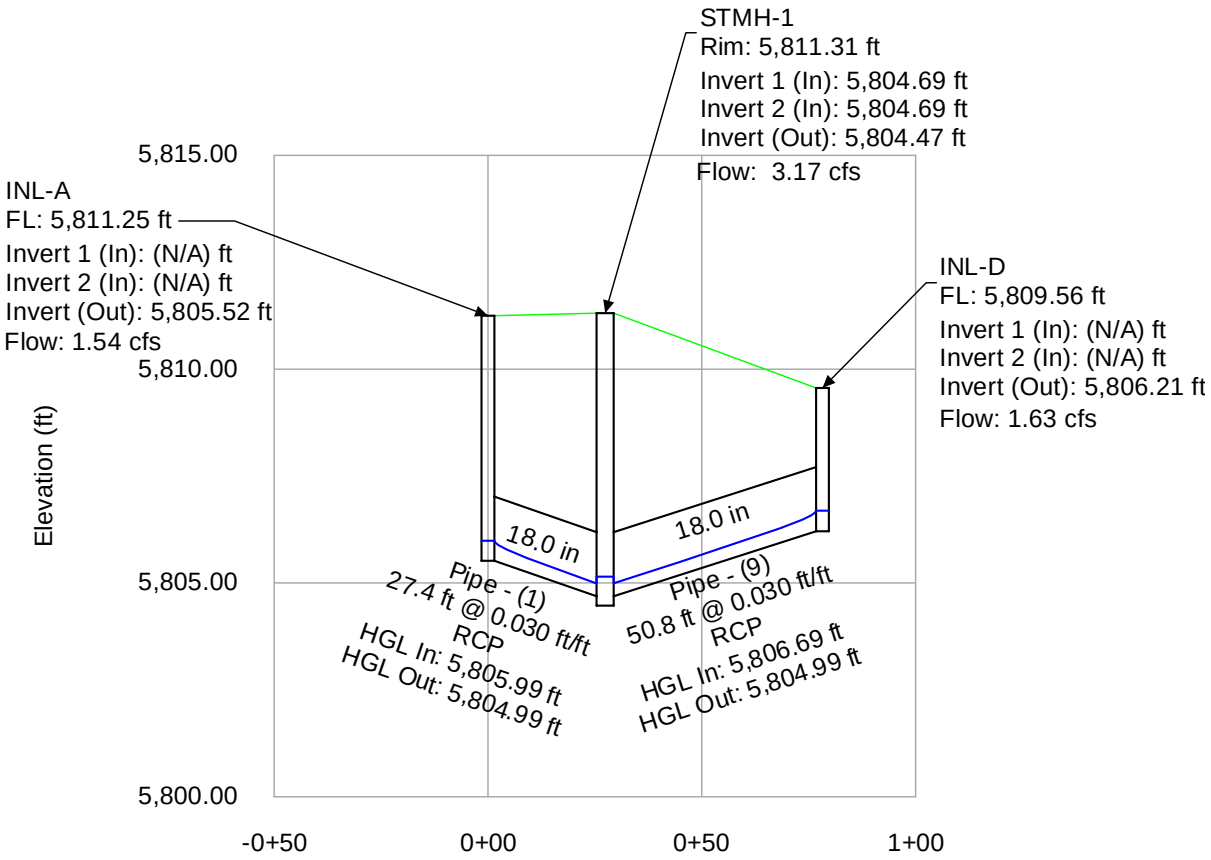
Profile Report

Engineering Profile - INL BR1-INL BR2 (Belford Storm (5YEAR)(FULL WIDTH).stsw)



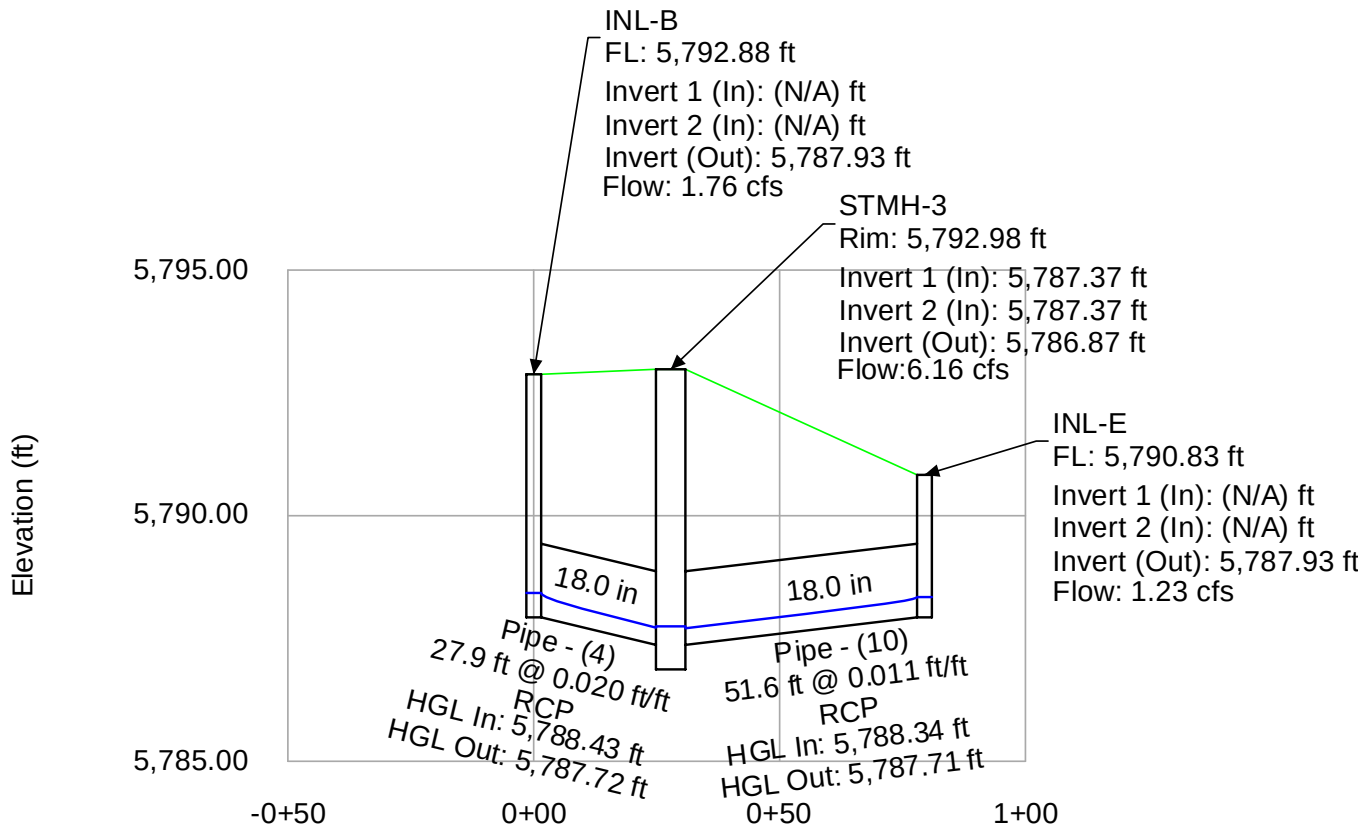
Profile Report

Engineering Profile - INL A - INL D (Belford Storm (5YEAR)(FULL WIDTH).stsw)



Profile Report

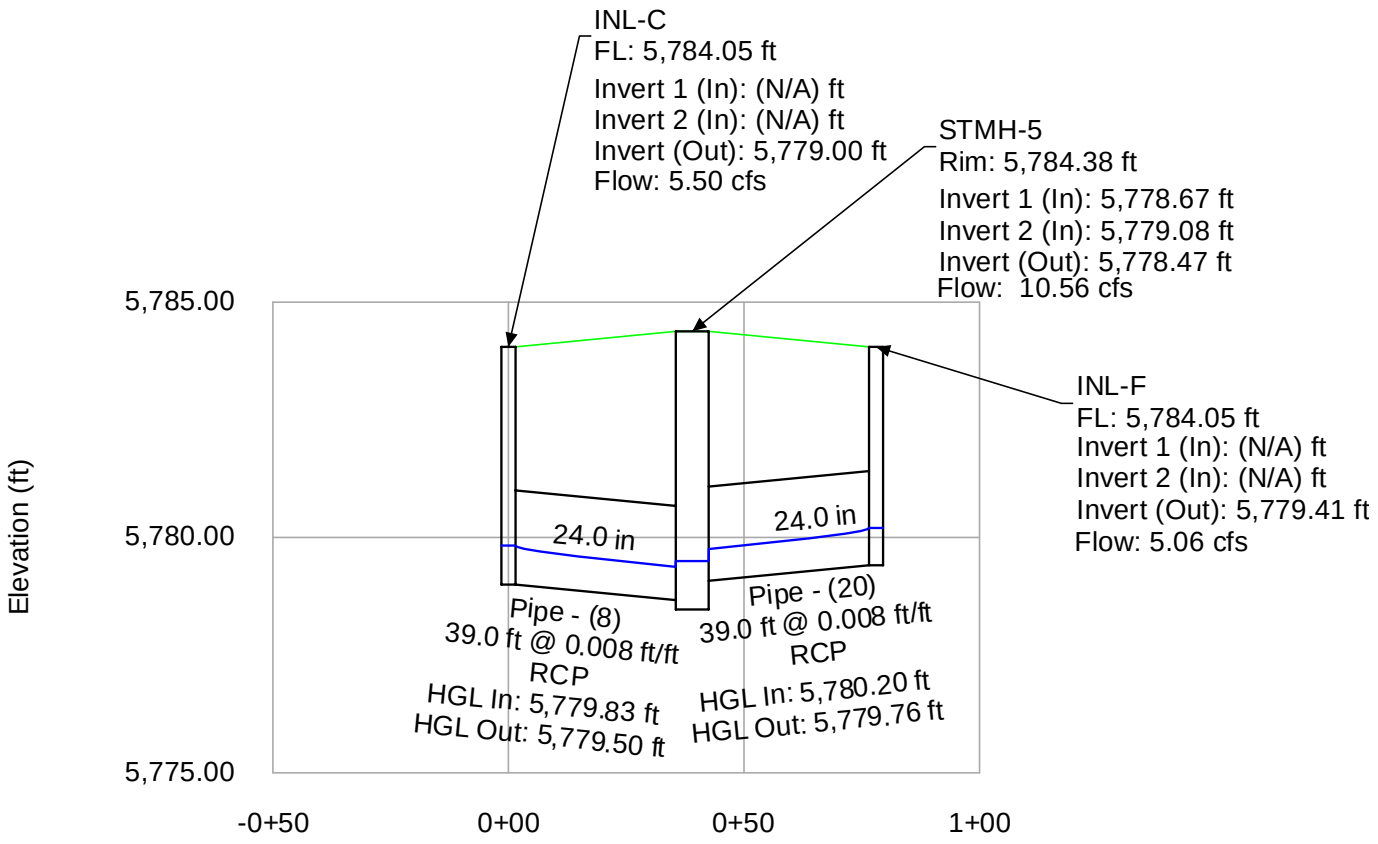
Engineering Profile - INL B - INL E (Belford Storm (5YEAR)(FULL WIDTH).stsw)



Bentley Systems, Inc. Haestad Methods Solution Center
27 Siemon Company Drive Suite 200 W Watertown, CT 06795 USA +1-203-755-1666

Profile Report

Engineering Profile - INL C - INL F (Belford Storm (5YEAR)(FULL WIDTH).stsw)



FlexTable: Catch Basin Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Total Out) (cfs)	Velocity (In) (ft/s)	Velocity (Out) (ft/s)	Hydraulic Grade Line (In) (ft)	Notes
INL-A	5,811.25	5,805.52	4.40	4.56	4.56	5,806.32	15' TYPE R
INL-B	5,792.88	5,787.93	4.80	4.70	4.70	5,788.77	15' TYPE R
INL-BR1	5,783.62	5,779.79	1.40	0.79	0.79	5,781.60	TYPE 16 VALLEY
INL-BR2	5,783.87	5,780.30	2.10	1.29	1.29	5,781.60	TYPE 16 VALLEY
INL-C	5,784.05	5,779.00	8.42	0.79	2.68	5,781.60	15' TYPE R
INL-D	5,809.56	5,806.21	5.00	4.77	4.77	5,807.07	5' TYPE R
INL-E	5,790.83	5,787.93	5.40	4.91	4.91	5,788.83	10' TYPE R
INL-F	5,784.05	5,779.41	6.37	1.19	2.03	5,781.58	10' TYPE R
OS-1	5,783.00	5,773.70	12.90	6.01	6.01	5,774.99	POND OUTLET

Bentley Systems, Inc. Haestad Methods Solution Center
27 Siemon Company Drive Suite 200 W Watertown, CT 06795 USA
+1-203-755-1666

FlexTable: Manhole Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Flow (Total Out) (cfs)	Velocity (In) (ft/s)	Velocity (Out) (ft/s)	Bolted Cover?	Notes
STMH-1	5,811.31	5,804.47	9.40	4.16	6.28	False	5'
STMH-2	5,801.84	5,793.90	9.40	10.88	6.28	False	4'
STMH-3	5,792.98	5,786.87	19.60	9.54	7.31	False	6'
STMH-4	5,786.93	5,776.24	34.39	6.24	4.87	False	7'
STMH-5	5,784.38	5,778.47	14.79	2.03	2.09	False	7'

Bentley Systems, Inc. Haestad Methods Solution Center
27 Siemon Company Drive Suite 200 W Watertown, CT 06795 USA
+1-203-755-1666

Compark Village South
Belford Ave Amd
100 yr Storm

FlexTable: Conduit Table

Start Node	Stop Node	Diameter (in)	Material	Length (Unified) (ft)	Invert (Start) (ft)	Invert (Stop) (ft)	Flow (cfs)	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Slope (Calculated) (ft/ft)	Manning's n	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
INL-A	STMH-1	18.0	Concrete	27.4	5,805.52	5,804.69	4.40	18.28	8.51	0.030	0.013	5,806.32	5,805.65
STMH-1	STMH-2	18.0	Concrete	305.1	5,804.47	5,794.10	9.40	19.36	10.88	0.034	0.013	5,805.65	5,794.84
INL-D	STMH-1	18.0	Concrete	50.8	5,806.21	5,804.69	5.00	18.16	8.78	0.030	0.013	5,807.07	5,805.65
STMH-2	STMH-3	18.0	Concrete	272.0	5,793.90	5,787.37	9.40	16.28	9.54	0.024	0.013	5,795.08	5,788.19
STMH-3	STMH-4	24.0	Concrete	142.9	5,786.87	5,777.45	19.60	58.09	16.69	0.066	0.013	5,788.46	5,781.42
INL-B	STMH-3	18.0	Concrete	27.9	5,787.93	5,787.37	4.80	14.89	7.51	0.020	0.013	5,788.77	5,788.46
INL-E	STMH-3	18.0	Concrete	51.6	5,787.93	5,787.37	5.40	10.94	6.17	0.011	0.013	5,788.83	5,788.46
STMH-5	STMH-4	36.0	Concrete	253.3	5,778.47	5,776.44	14.79	59.71	2.09	0.008	0.013	5,781.54	5,781.42
STMH-4	FES-01	36.0	Concrete	82.8	5,776.24	5,775.41	34.39	66.78	4.87	0.010	0.013	5,781.42	5,781.20
INL-C	STMH-5	24.0	Concrete	39.0	5,779.00	5,778.67	8.42	20.80	2.68	0.008	0.013	5,781.60	5,781.54
INL-F	STMH-5	24.0	Concrete	39.0	5,779.41	5,779.08	6.37	20.80	2.03	0.008	0.013	5,781.58	5,781.54
OS-1	FES H	24.0	Concrete	106.3	5,773.70	5,773.00	12.90	18.35	6.33	0.007	0.013	5,774.99	5,774.24
INL-BR1	INL-C	18.0	Concrete	24.5	5,779.79	5,779.29	1.40	15.01	0.79	0.020	0.013	5,781.60	5,781.60
INL-BR2	INL-F	18.0	Concrete	59.9	5,780.30	5,779.70	2.10	10.52	4.64	0.010	0.013	5,781.60	5,781.58

Compark Village South
Belford Ave Amd
100 yr Storm

Outfall Table

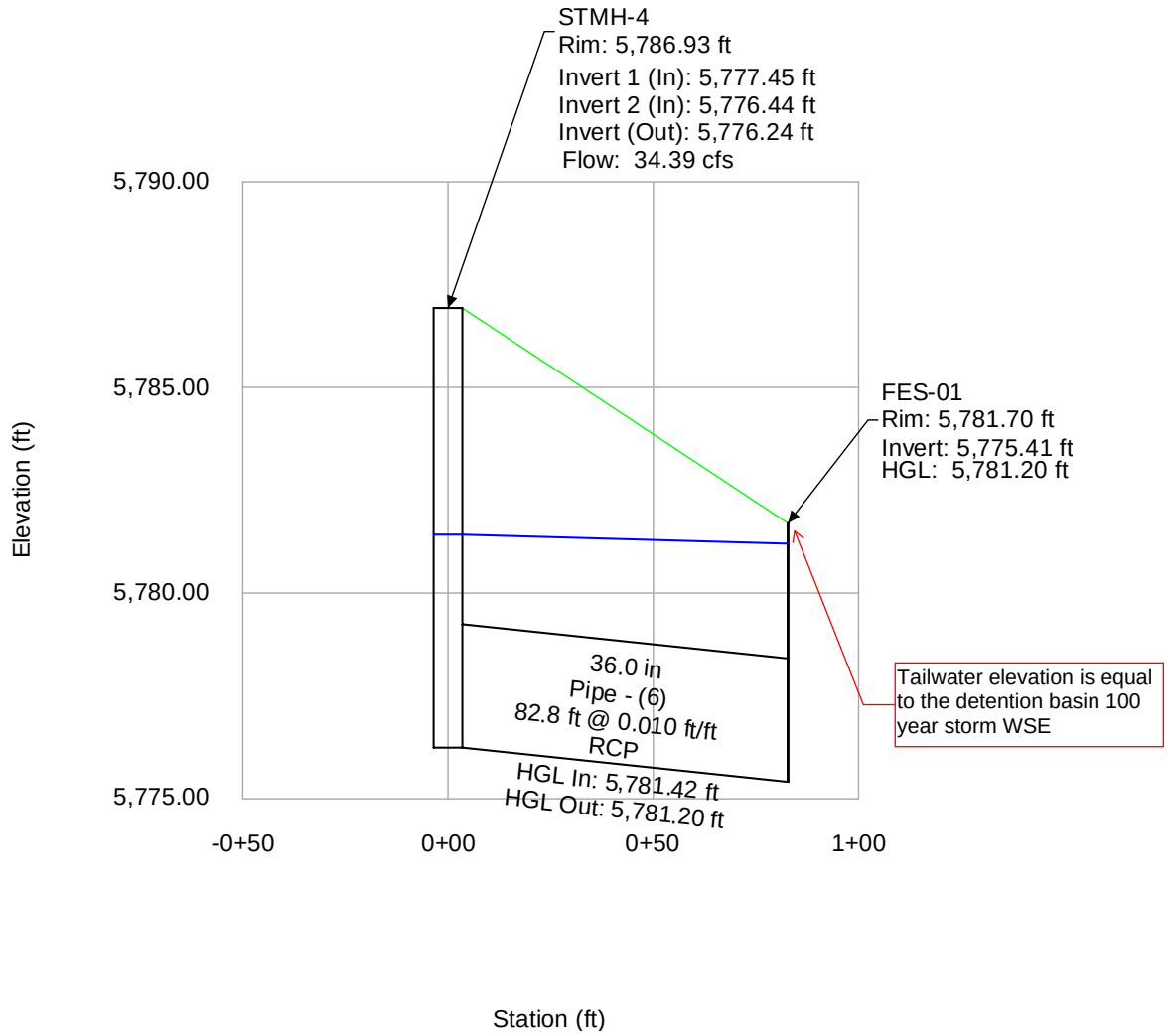
FlexTable: Outfall Table

Label	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Boundary Condition Type	Elevation (User Defined Tailwater) (ft)	Hydraulic Grade (ft)	Flow (Total Out) (cfs)	Notes
FES-01	5,781.70	5,775.41	User Defined Tailwater	5,781.20	5,781.20	34.39	FOREBAY 2
FES H	5,776.00	5,773.00	Free Outfall		5,774.35	12.90	POND OUTFALL

Compark Village South
Belford Ave Amd
100 yr Storm

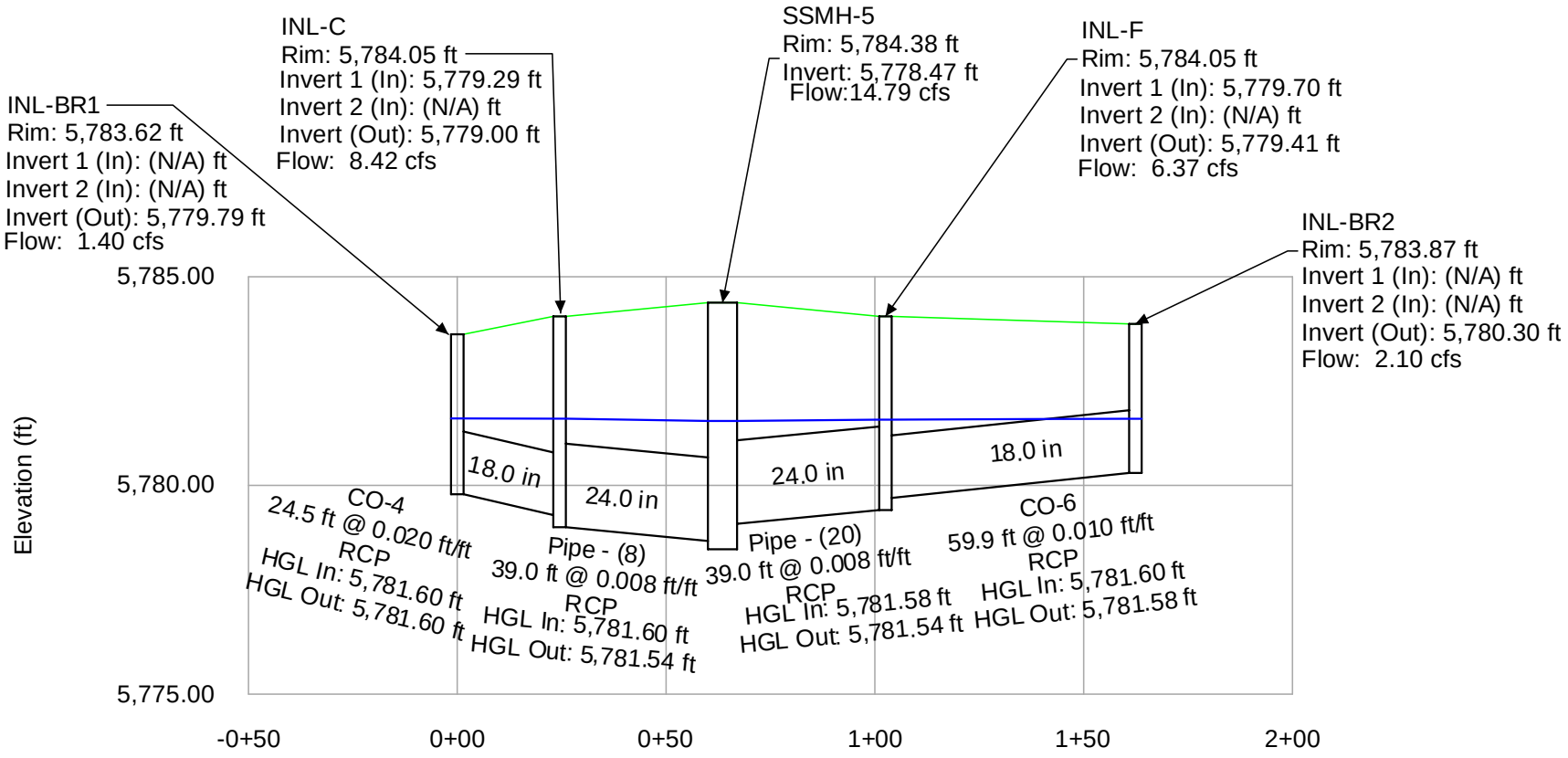
Profile Report

Engineering Profile - SSMH 4 - FES 01 (Belford Storm (100YEAR)(FULL WIDTH).stsw)



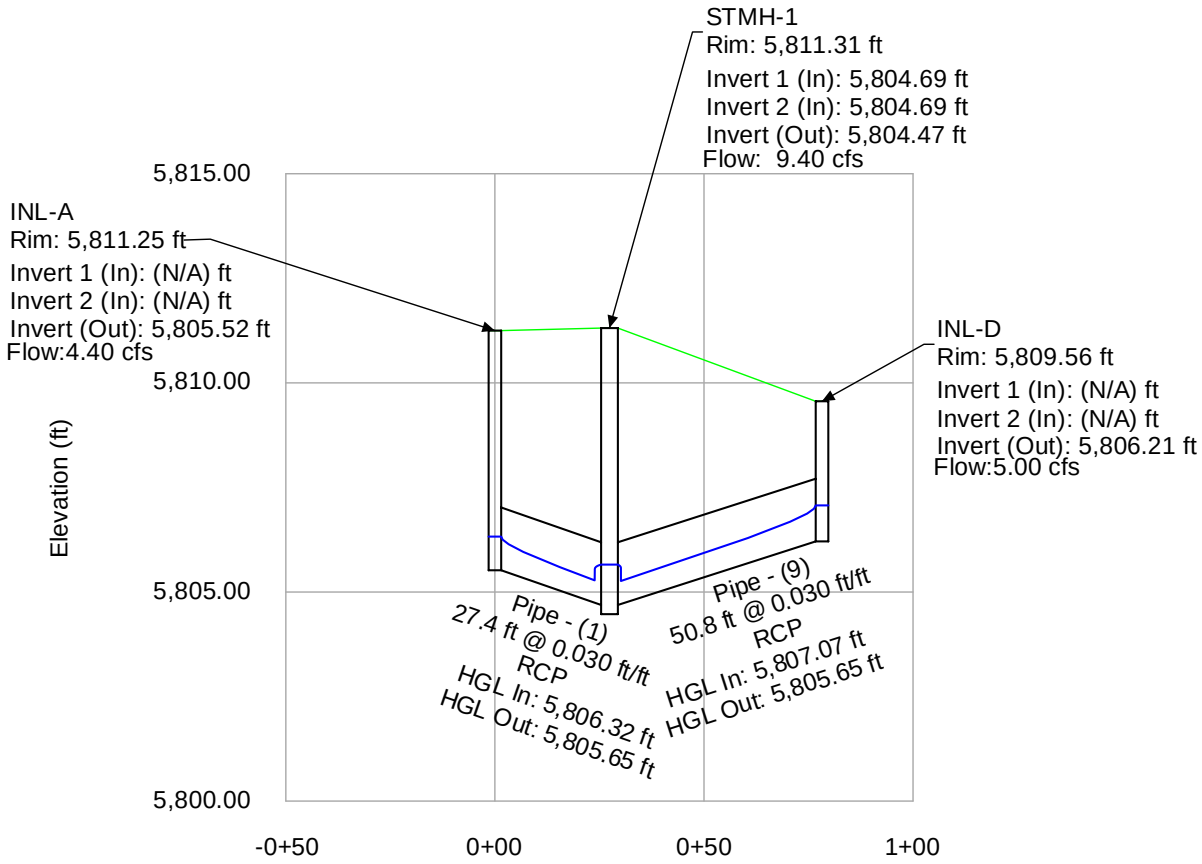
Profile Report

Engineering Profile - INL-BR1-INL-BR2 (Belford Storm (100YEAR)(FULL WIDTH).stsw)



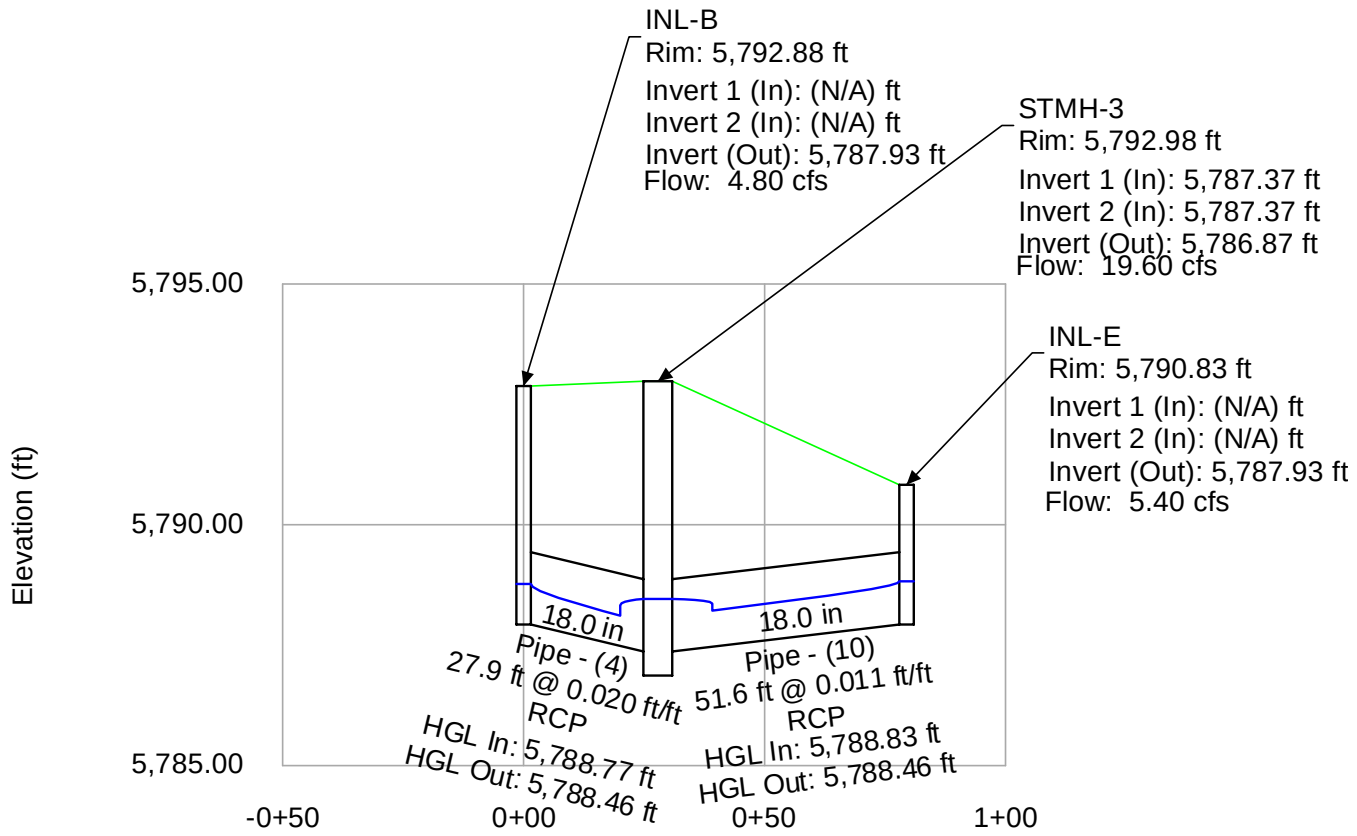
Profile Report

Engineering Profile - INL A - INL D (Belford Storm (100YEAR)(FULL WIDTH).stsw)



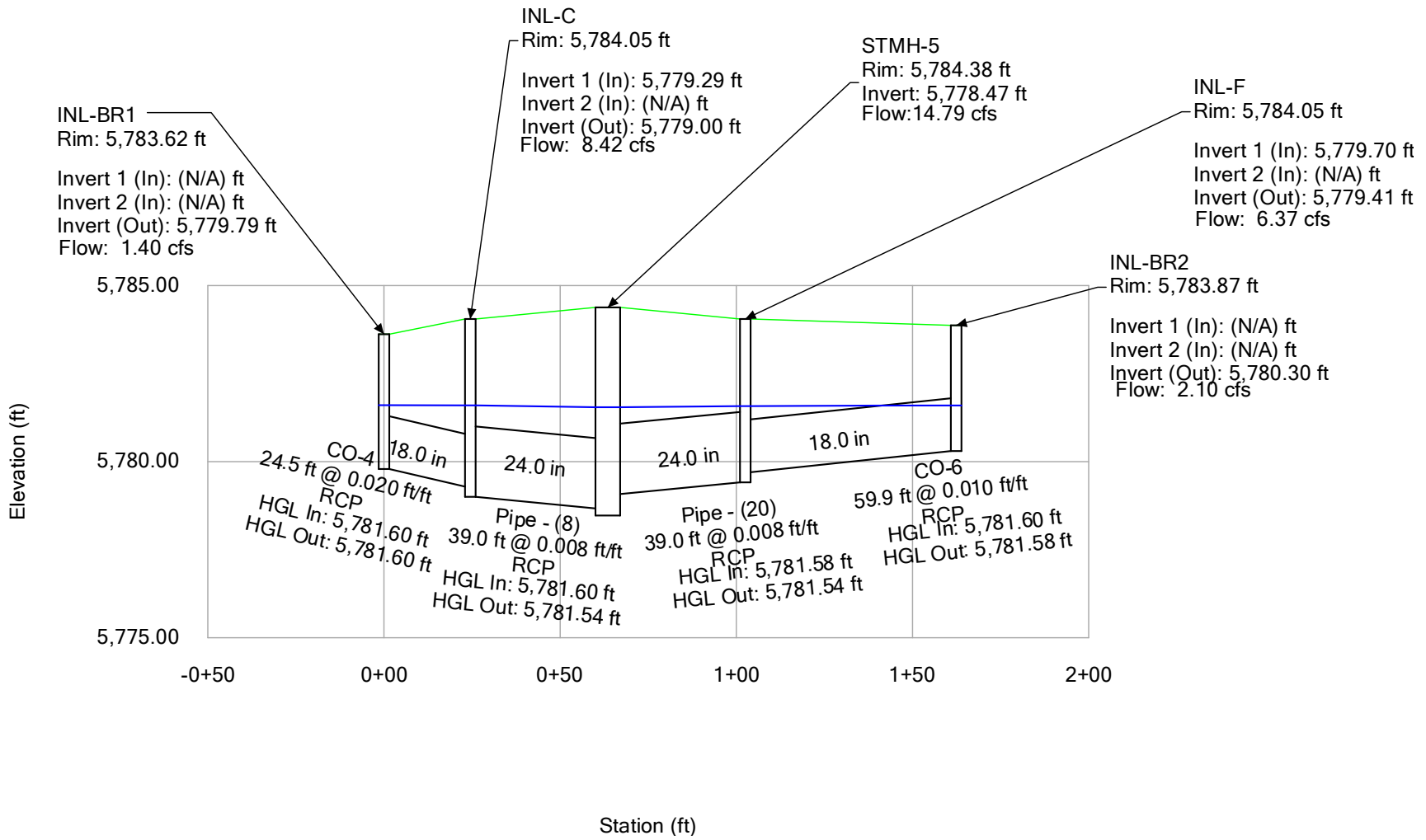
Profile Report

Engineering Profile - INL B - INL E (Belford Storm (100YEAR)(FULL WIDTH).stsw)



Profile Report

Engineering Profile - INL-BR1 - INL-BR2 (Belford Storm (100YEAR)(FULL WIDTH).stsw)

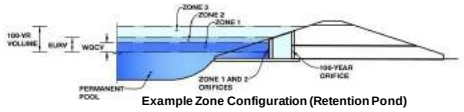


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.04 (February 2021)

Project: Compark Village South - Belford Ave East

Basin ID: Happy Canyon Detention Basin



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	EDB	
Watershed Area =	14.77	acres
Watershed Length =	1,585	ft
Watershed Length to Centroid =	793	ft
Watershed Slope =	0.030	ft/ft
Watershed Imperviousness =	61.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides
Water Quality Capture Volume (WQCV) =	0.295	acre-feet	acre-feet
Excess Urban Runoff Volume (EURV) =	0.979	acre-feet	acre-feet
2-yr Runoff Volume (P1 = 0.82 in.) =	0.557	acre-feet	inches
5-yr Runoff Volume (P1 = 1.1 in.) =	0.794	acre-feet	inches
10-yr Runoff Volume (P1 = 1.34 in.) =	1.051	acre-feet	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	1.525	acre-feet	inches
50-yr Runoff Volume (P1 = 1.98 in.) =	1.881	acre-feet	inches
100-yr Runoff Volume (P1 = 2.29 in.) =	2.313	acre-feet	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	3.320	acre-feet	inches
Approximate 2-yr Detention Volume =	0.521	acre-feet	
Approximate 5-yr Detention Volume =	0.745	acre-feet	
Approximate 10-yr Detention Volume =	1.000	acre-feet	
Approximate 25-yr Detention Volume =	1.193	acre-feet	
Approximate 50-yr Detention Volume =	1.295	acre-feet	
Approximate 100-yr Detention Volume =	1.457	acre-feet	

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.295	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.684	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.478	acre-feet
Total Detention Basin Volume =	1.457	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio (R_{LW}) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	user	acre-feet

Depth Increment = ft

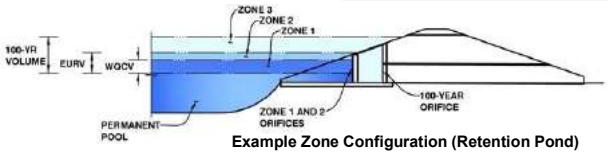
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	120	0.003		
5774.28	--	0.45	--	--	--	120	0.003	54	0.001
5775	--	1.17	--	--	--	860	0.020	407	0.009
5776	--	2.17	--	--	--	3,531	0.081	2,602	0.060
5777	--	3.17	--	--	--	8,670	0.199	8,703	0.200
5778	--	4.17	--	--	--	10,190	0.234	18,133	0.416
5779	--	5.17	--	--	--	11,950	0.274	29,203	0.670
5780.04 - EURV	--	6.21	--	--	--	14,145	0.325	42,772	0.982
5781.20 100-Year	--	7.35	--	--	--	16,860	0.387	60,445	1.388
5782	--	8.17	--	--	--	18,805	0.432	75,068	1.723
5782.4 - Spillway	--	8.57	--	--	--	20,700	0.475	82,969	1.905
5783	--	9.17	--	--	--	22,325	0.513	95,876	2.201
5784 - Top Berm	--	10.17	--	--	--	25,616	0.588	119,847	2.751

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)

Project: Compark Village South - Belford Ave East

Basin ID: Happy Canyon Detention Basin



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.63	0.295	Orifice Plate
Zone 2 (EURV)	6.20	0.684	Orifice Plate
Zone 3 (100-year)	7.53	0.478	Weir&Pipe (Restrict)
Total (all zones)		1.457	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	9.792E-03	ft^2
Depth at top of Zone using Orifice Plate =	6.25	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	1.41	sq. inches (diameter = 1-5/16 inches)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	2.67	5.33					
Orifice Area (sq. inches)	1.41	1.41	1.41					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe)

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	6.25	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	6.25	N/A	feet
Overflow Weir Front Edge Length =	5.67	N/A	feet	Overflow Weir Slope Length =	2.92	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	11.43	N/A	
Horiz. Length of Weir Sides =	2.92	N/A	feet	Overflow Grate Open Area w/o Debris =	11.52	N/A	ft^2
Overflow Grate Type =	Type C Grate	N/A		Overflow Grate Open Area w/ Debris =	11.52	N/A	ft^2
Debris Clogging % =	0%	N/A	%				

Calculated Parameters for Overflow Weir

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.13	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	1.01	N/A	ft^2
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.48	N/A	feet
Restrictor Plate Height Above Pipe Invert =	10.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.68	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	8.57	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.56	feet
Spillway Crest Length =	23.00	feet	Stage at Top of Freeboard =	10.13	feet
Spillway End Slopes =	10.00	H:V	Basin Area at Top of Freeboard =	0.59	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	2.73	acre-ft

Calculated Parameters for Spillway

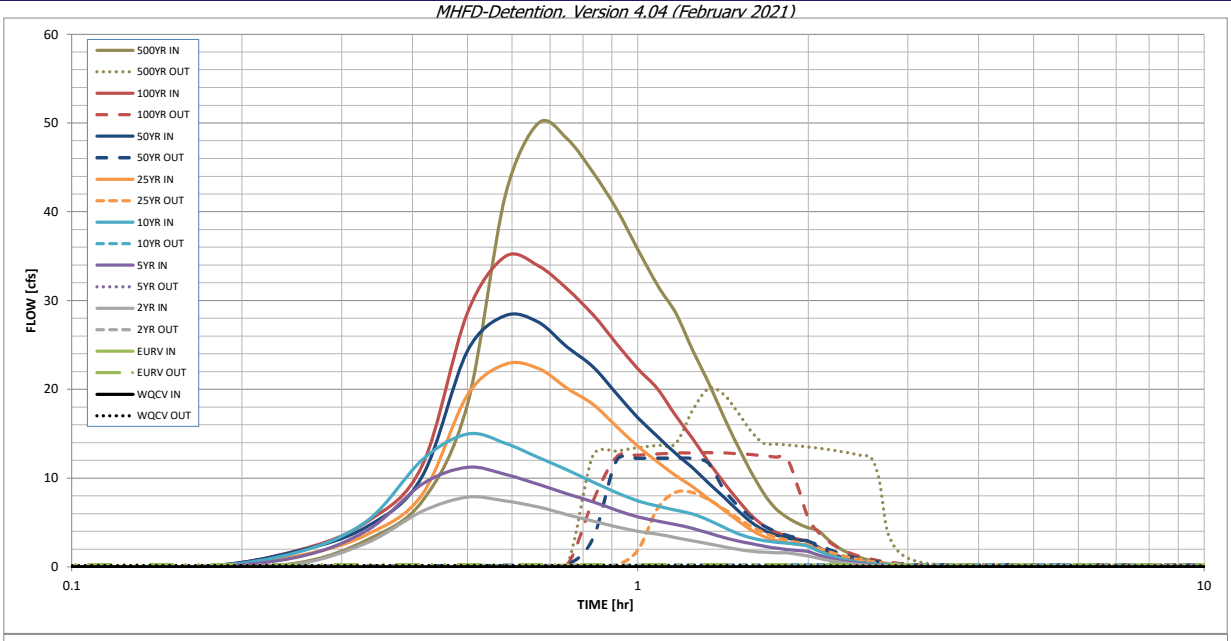
Routed Hydrograph Results

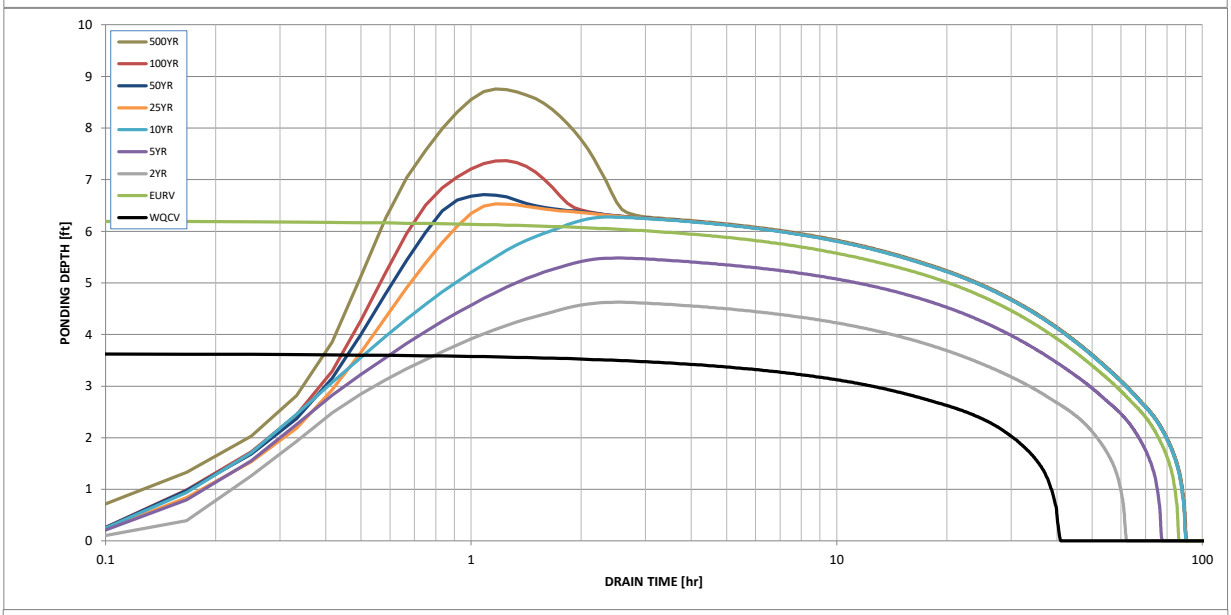
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

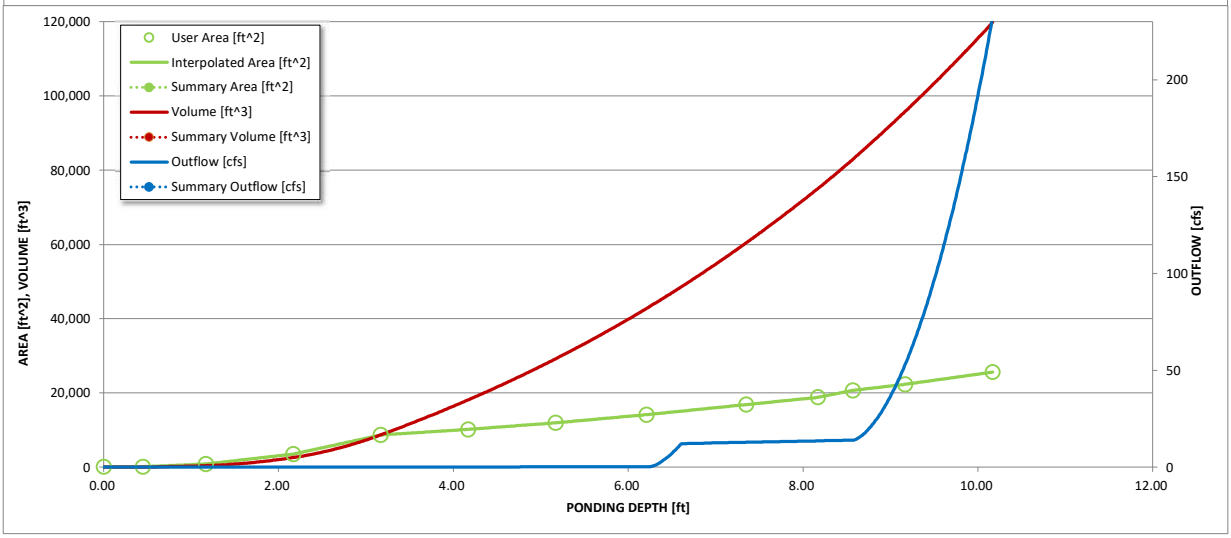
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.82	1.10	1.34	1.69	1.98	2.29	3.08
CUHP Runoff Volume (acre-ft) =	0.295	0.979	0.557	0.794	1.051	1.525	1.881	2.313	3.320
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.557	0.794	1.051	1.525	1.881	2.313	3.320
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.1	0.2	1.9	6.9	9.9	13.9	22.2
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.01	0.13	0.47	0.67	0.94	1.50
Peak Inflow Q (cfs) =	N/A	N/A	7.9	11.2	15.0	22.8	28.3	35.0	50.0
Peak Outflow Q (cfs) =	0.1	0.2	0.2	0.2	0.5	8.4	12.2	12.9	20.1
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.1	0.2	1.2	1.2	0.9	0.9
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.0	0.7	1.0	1.1	1.2
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	79	58	72	83	80	78	76	71
Time to Drain 99% of Inflow Volume (hours) =	**40**	83	60	75	87	86	85	84	83
Maximum Ponding Depth (ft) =	3.63	6.21	4.62	5.48	6.28	6.53	6.71	7.37	8.76
Area at Maximum Ponding Depth (acres) =	0.22	0.32	0.25	0.29	0.33	0.34	0.35	0.39	0.49
Maximum Volume Stored (acre-ft) =	0.295	0.982	0.526	0.758	1.001	1.085	1.148	1.391	1.991

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)







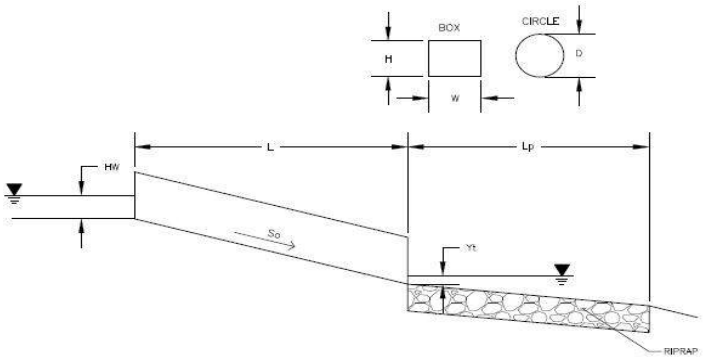
S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETERMINATION OF CULVERT HEADWATER AND OUTLET PROTECTION

MHFD-Culvert, Version 4.00 (May 2020)

Project: Belford Avenue Site Plan Amendment

ID: HC Detention Basin Outlet



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Design Information:

Design Discharge	Q =	12.6	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	18	inches
Inlet Edge Type (Choose from pull-down list)		Grooved Edge Projecting	
OR:			
Box Culvert:		OR	
Barrel Height (Rise) in Feet	H (Rise) =		ft
Barrel Width (Span) in Feet	W (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	# Barrels =	1	
Inlet Elevation	Elev IN =	5773.7	ft
Outlet Elevation OR Slope	Elev OUT =	5773	ft
Culvert Length	L =	106	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	$Y_{t,\ Elevation}$ =	5777	ft
Max Allowable Channel Velocity	V =	4	ft/s

Calculated Results:

Culvert Cross Sectional Area Available	A =	1.77	ft^2
Culvert Normal Depth	Y_n =	1.50	ft
Culvert Critical Depth	Y_c =	1.34	ft
Froude Number	Fr =	-	Pressure flow!
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	1.92	
Sum of All Loss Coefficients	k_s =	3.12	ft
Headwater:			
Inlet Control Headwater	HW_I =	2.64	ft
Outlet Control Headwater	HW_O =	5.76	ft
Design Headwater Elevation	HW =	5779.46	ft
Headwater/Diameter OR Headwater/Rise Ratio	HW/D =	3.84	HW/D > 1.5!
Outlet Protection:			
Flow/(Diameter^2.5)	Q/D^2.5 =	4.57	$ft^{0.5}/s$
Tailwater Surface Height	Y_t =	4.00	ft
Tailwater/Diameter	Yt/D =	2.67	
Expansion Factor	1/(2*tan(Θ)) =	5.81	
Flow Area at Max Channel Velocity	A_t =	3.15	ft^2
Width of Equivalent Conduit for Multiple Barrels	W_{eq} =	-	ft
Length of Riprap Protection	L_p =	5	ft
Width of Riprap Protection at Downstream End	T =	3	ft
Adjusted Diameter for Supercritical Flow	Da =	-	ft
Minimum Theoretical Riprap Size	d_{50} min=	1	in
Nominal Riprap Size	d_{50} nominal=	6	in
MHFD Riprap Type	Type =	VL	

MINIMUM SIZE BASED
ON PIPE CHARACTERISTICS

Culvert Calculator Report
Belford Avenue Site Plan Amendment - HC Det Basin Outfall

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	5,781.20	ft	Headwater Depth/Height	4.09	
Computed Headwater Elev	5,779.84	ft	Discharge	12.90	cfs
Inlet Control HW Elev.	5,777.00	ft	Tailwater Elevation	5,777.00	ft
Outlet Control HW Elev.	5,779.84	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	5,773.70	ft	Downstream Invert	5,773.00	ft
Length	106.00	ft	Constructed Slope	0.006604	ft/ft

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	4.00	ft
Slope Type	N/A		Normal Depth	N/A	ft
Flow Regime	N/A		Critical Depth	1.35	ft
Velocity Downstream	7.30	ft/s	Critical Slope	0.013297	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	5,779.84	ft	Upstream Velocity Head	0.83	ft
Ke	0.50		Entrance Loss	0.41	ft

Inlet Control Properties					
Inlet Control HW Elev.	5,777.00	ft	Flow Control	Submerged	
Inlet Type	Square edge w/headwall		Area Full	1.8	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

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_f=	1.2	Safety factor
C_s=	0.3	Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio
		Stability coefficient (for blanket thickness=d100 or 1.5d50 whichever is greater, and uniformity ratio d85/d15 = 1.7 to 5.2) Use 0.30 for angular rock and 0.375 for rounded rock
C_v=	1.24	Velocity distribution coefficient
		use 1.0 for straight channels or the inside of bends
		use 1.283-0.2log(Rc/W) for the outside of bends (1 for Rc/W>26)= 1.26
		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_t=	1	Blanket thickness coefficient given as a function of the uniformity ratio d85/d15
		use 1.0 recommended because it is based on very limited data
V_{des}=	10.80	Characteristic velocity for design, defined as the depth-averaged velocity at a point 20% upslope from the toe of the revetment, ft/s
		V_{des}= 10.80 For natural channels use $V_{des}=V_{avg}(1.74-0.52 \log(Rc/W)$
		V_{des}= 10.42 For trapezoidal channels use $V_{des}=V_{avg}(1.71-0.78 \log(Rc/W)$
V_{avg}=	6.43	Channel cross sectional average velocity, ft/s
K_1=	1.00	Side slope correctional factor
		k_1=(1-((sin14°) H:1= 4
		θ= 14.0 0.24 = radians
		K_1= 1.00
S_g=	2.65	Specific gravity of riprap (usually taken at 2.65)
g=	32.2	Acceleration of gravity, 32.2 ft/s

d_{30}=	**0.72**	**Particle size for which 30% is finer by weight , ft**
d_{50}=	**0.87**	**$d_{50}=1.2d_{30}$, ft**
RIPRAP d_{50} 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

MATCH DET BASIN OUTFALL PROTECTION SIZING TO HAPPY CANYON CREEK PROPOSED BANK PROTECTION RIP RAP SIZING, d_{50}=12"

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} >/= ((V*S^0.17)/(4.5)*(Gs-1)^0.66)^2

V=	14.58	Velocity, ft/s	*(Worst case velocity at Drop 2.)*
S=	0.0075	Longitudinal Slope, ft/ft	
G_s=	2.65	Specific gravity of riprap (usually taken at 2.65)	
d_{50}=	**1.03**	**ft**	
RIPRAP d_{50} SIZE=	**12.3**	**inches**	
t=1.75d50=	**21.6**	**Riprap Thickness, inches**	

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

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

LIMITS OF SOIL RIPRAP (12 INCH) 2'-0" THICK (278 CY) OVER FILTER MATERIAL (CLASS A) 1'-0" THICK (139 CY). SEE DD-04.

STORM SEWER LINE "B". SEE DD-12 AND DD-16 FOR MORE INFORMATION

LIMITS OF SOIL RIPRAP (12 INCH) 2'-0" THICK (182 CY) OVER FILTER MATERIAL (CLASS A) 1'-0" THICK (91 CY). SEE DD-04.

STEEL SHEET PILING (TYP.) (1930 SF). SEE SHEET DD-03.

PROPOSED REGIONAL TRAIL. SEE TRAIL PLANS FOR INFORMATION.

LIMITS OF SOIL RIPRAP (12 INCH) 2'-0" THICK (286 CY) OVER FILTER MATERIAL (CLASS A) 1'-0" THICK (143 CY). SEE DD-04.

LIMITS OF SOIL RIPRAP (12 INCH) 2'-0" THICK OVER FILTER MATERIAL (CLASS A) 1'-0" THICK. (SEE DD-18 FOR ADDITIONAL INFORMATION.

HAPPY CANYON CREEK HCL (TYP.)

LIMITS OF 24 INCH GROUTED BOULDERS (263 CY)

PROPOSED LOW FLOW CHANNEL REALIGNMENT

LIMITS OF RIPRAP (18 INCH) SEE BRIDGE HYDRAULIC SHEETS FOR INFORMATION.

HAPPY CANYON CREEK

LIMITS OF SOIL RIPRAP (12 INCH) (96 CY) OVER FILTER MATERIAL (CLASS A) (16 CY) & FILTER MATERIAL (CLASS C) (16 CY). SEE DD-03.

PROPOSED MAINTENANCE ACCESS. SEE MAINTENANCE ACCESS PLANS FOR INFORMATION.

LIMITS OF RIPRAP (18 INCH) SEE BRIDGE HYDRAULIC SHEETS FOR INFORMATION.

BELFORD AVENUE

APPROXIMATE EFFECTIVE 100-YEAR FLOODWAY LIMITS (FIS)

APPROXIMATE EFFECTIVE 100-YEAR FLOODPLAIN LIMITS (FIS)

NOTES:

1. SEE SHEET DD-15 FOR DROP NO. 1 POINT DATA.
2. SEE SHEET DD-14 FOR SECTIONS A AND B.
3. SEE SHEET DD-04 FOR SOIL RIPRAP DETAILS.
4. SEE SHEET DD-05 FOR GROUTED BOULDER DETAILS.
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 (18 INCH)
- 24" GROUTED BOULDERS
- 24" GROUTED BOULDERS (BURIED)

N

HORIZONTAL SCALE: 1"=40'

0' 20' 40' 80'

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

Print Date: 4/16/2019 8:59:24 AM
File Name: H115360-01DROP13Δrop1 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

(R-X)	Sheet Revisions		
	Date	Comments	Initials

Manhard CONSULTING LTD
8008 S. 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
No Revisions:
Revised:
Void:

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

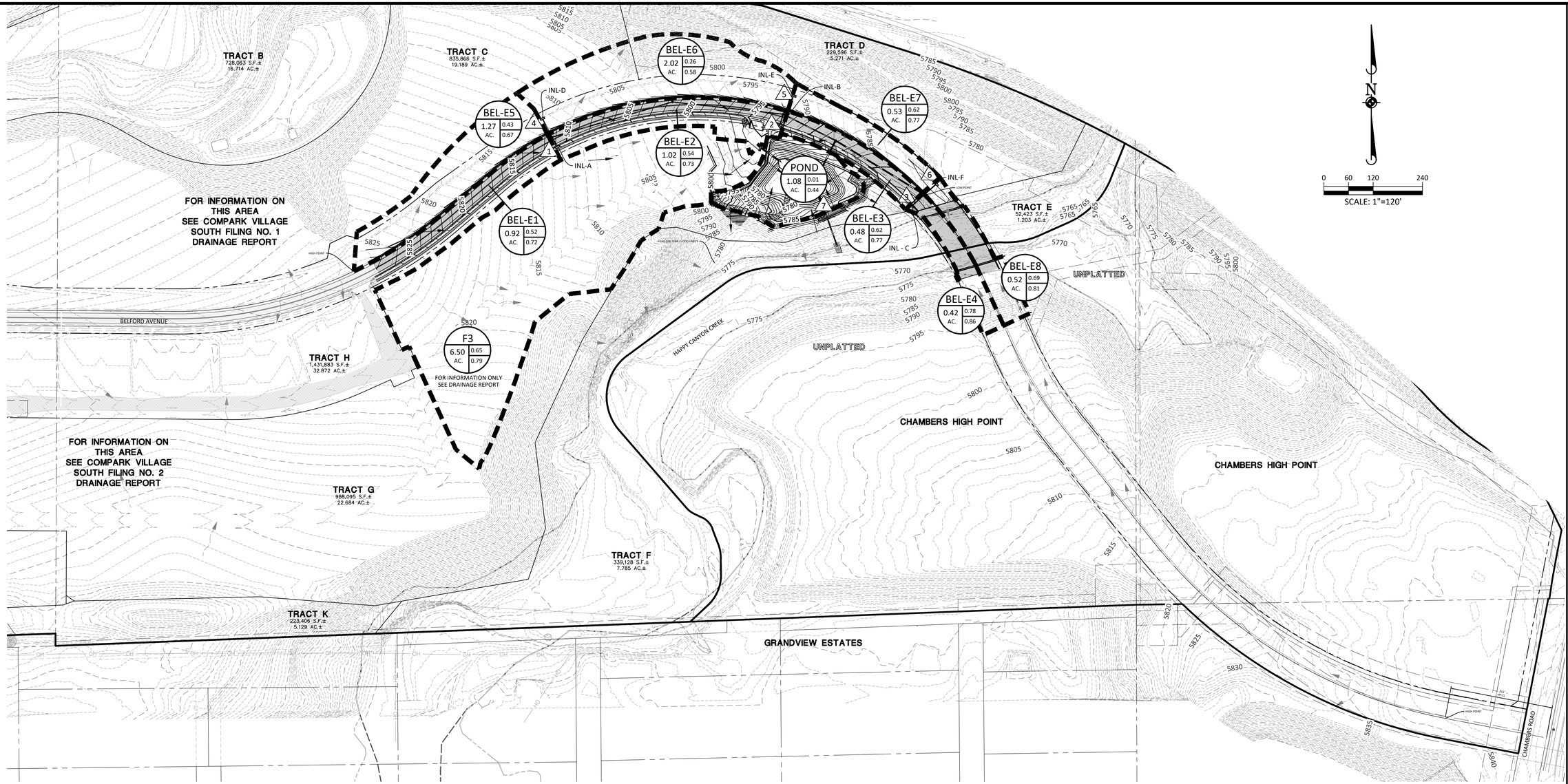
Designer: CDT
Detailer: ZJG
Subset: Drainage
Structure Numbers:
Sheets: DD-13 of 22

Project No./Code

Sheet Number

APPENDIX D

- Drainage Basin Map
- Compark Village South Filing No.1 Drainage Report Basin Map



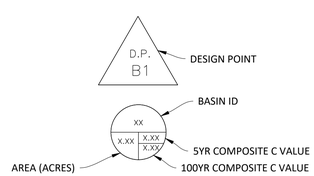
DRAINAGE SUMMARY TABLE

BASIN ID	5 YEAR COMPOSITE C	100 YEAR COMPOSITE C	5 YEAR RUNOFF (CFS)	100 YEAR RUNOFF (CFS)
BEL-E1	0.52	0.72	1.54	4.48
BEL-E2	0.54	0.73	1.76	5.03
BEL-E3	0.62	0.77	0.93	2.43
BEL-E4	0.78	0.86	1.15	2.68
BEL-E5	0.43	0.67	1.63	5.36
BEL-E6	0.26	0.58	1.23	5.71
BEL-E7	0.62	0.77	1.05	2.76
BEL-E8	0.69	0.81	1.19	2.94
F3 (Tract G)	0.65	0.79		
POND	0.01	0.44	0.04	3.55
		TOTAL	10.52	34.94

ROUTED FLOWS TABLE

RECEIVING BASIN	TRIBUTARY DESIGN POINTS	5 YEAR TOTAL FLOW (CFS)	100 YEAR TOTAL FLOW (CFS)
POND	1, 2, 3, 4, 5, 6	10.52	34.94

**ONLY BELFORD AVE RUNOFF SHOWN HERE, NO PROPOSED FLOW FROM TRACT G INCLUDED, TRACT G IS INCLUDED IN DETENTION BASIN SIZING



PREDOMINANT SOIL TYPE IS NRCS HYDROLOGICAL SOIL GROUP B

DRAWN BY | REVISIONS | DATE

Manhard CONSULTING LTD
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

COMPARK VILLAGE SOUTH - BELFORD AVENUE
PARKER, COLORADO
PROPOSED DRAINAGE MAP

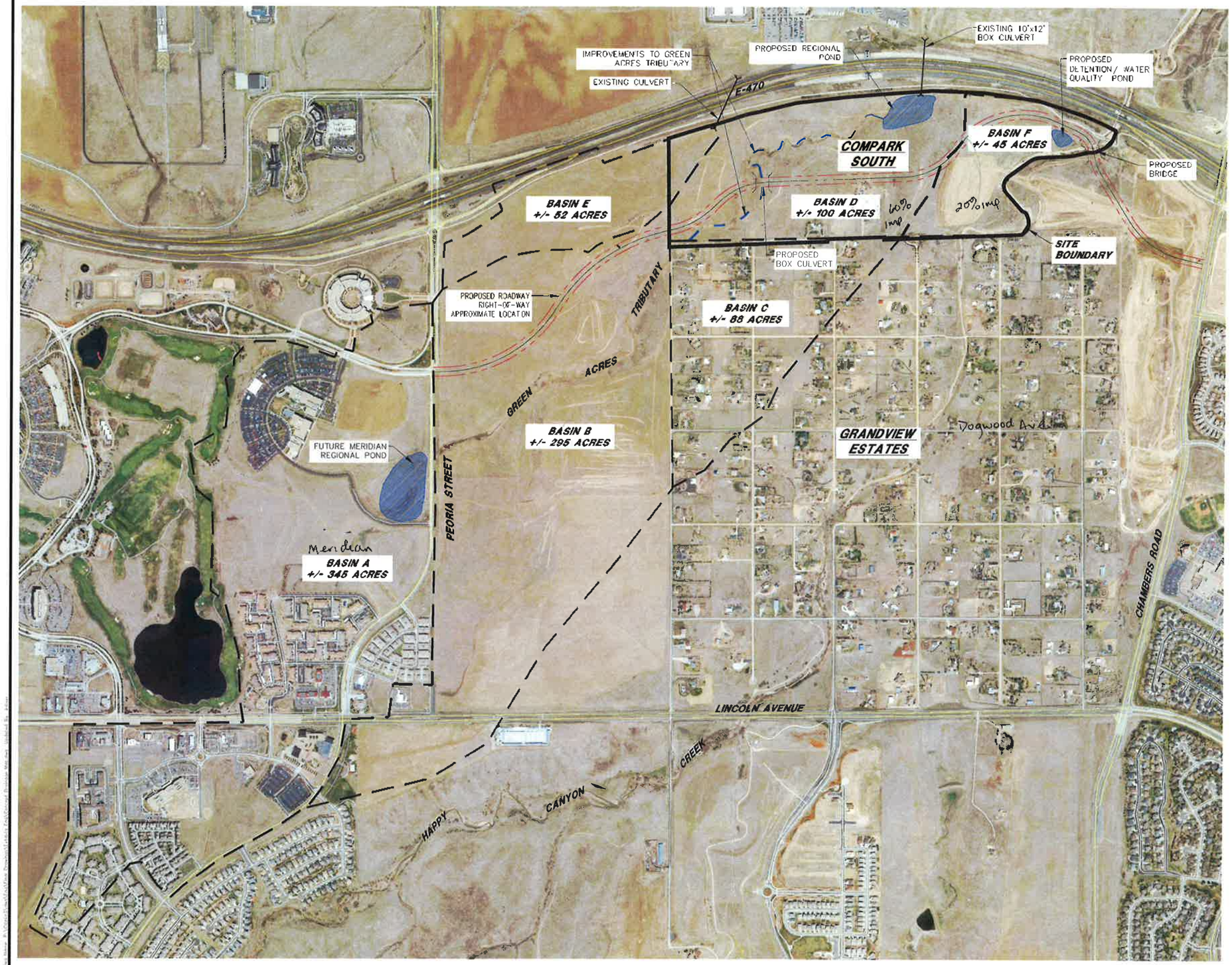
PROJ. MGR.: GTI
PROJ. ASSOC.: ASD
DRAWN BY: JMP
DATE: 03/15/2021

SHEET 1 OF 1

CLCPKC3

DRAINAGE MAP

Plotted: 3/18/2021 9:33 AM Dwg Name: P:\Clcpkc3\ComSouth09 - Belford Ave East\Documents\Engineering\Storm\Water Reports\Drainage Exhibits\Pre-Residential\Drainage Basins.dwg Updated By: ADrucker



CARROLL & LANGE-MANHARD
A MANHARD CONSULTING COMPANY

CHAMBERS CROSSING
PARKER, COLORADO
GREEN ACRES TRIBUTARY DRAINAGE EXHIBIT

PROJ. MGR. SB
DESIGNED JK
DRAWN JK
CHKD. JK
DATE 08/30/11
SCALE +/- 1"=500'

EXHIBIT
1

CLOPKC3 110482

APPENDIX E

- CLOMR report
- CLOMR approval letter
- USACOE NWP verification
- Town of Parker Floodplain Development Application

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

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

Prepared for:

Manhard Consulting Ltd.
7600 East Orchard Rd, Suite 150-N
Greenwood Village, CO 80111
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
http://www.fhueng.com/

FHU Project No. 115360-01

November 2016
Updated April 2019

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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/E-470 regional trails.
- Undeveloped land on both sides of Happy Canyon Creek.

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

B. Description of Property

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

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

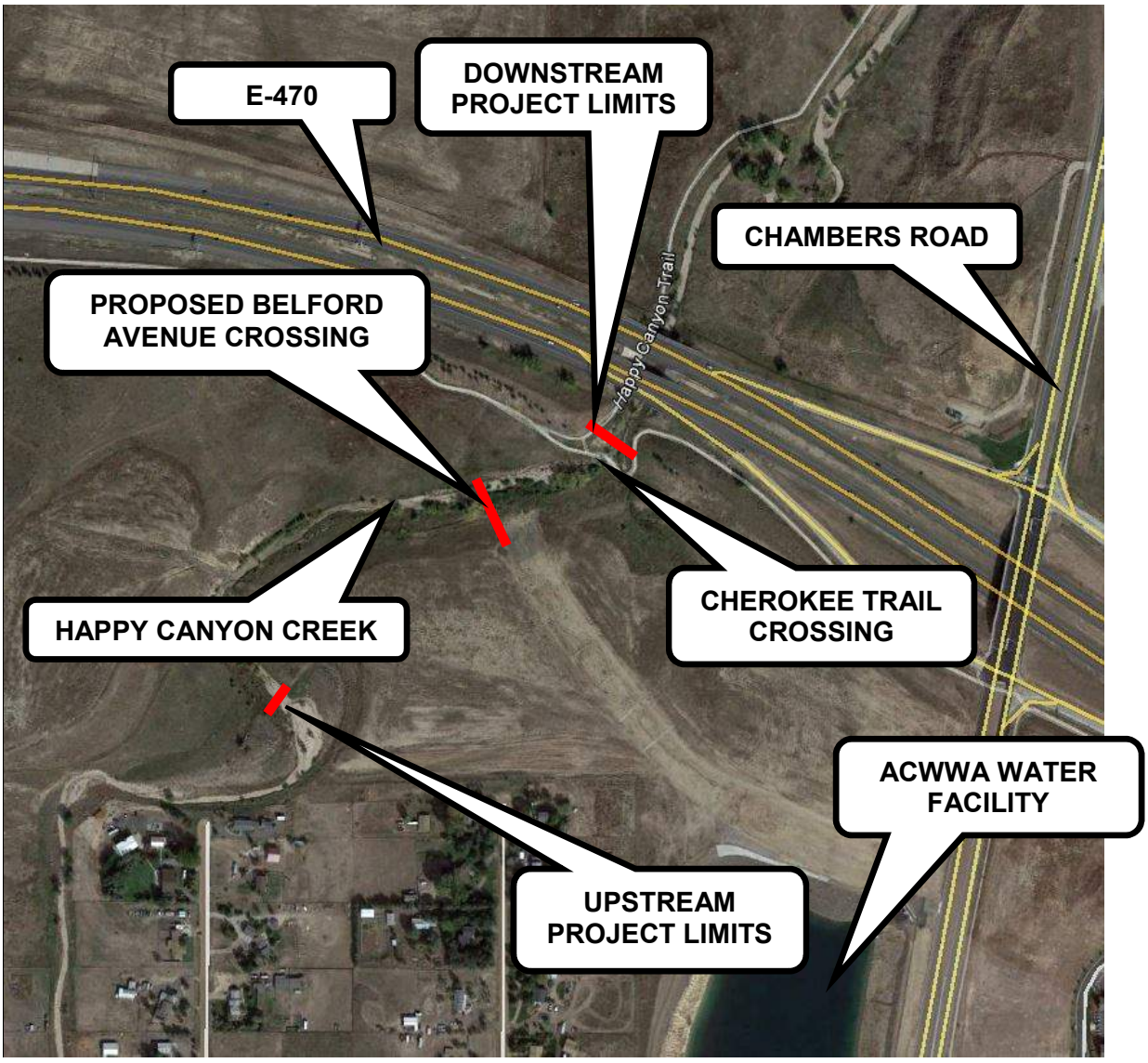


Figure 1. Vicinity Map

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

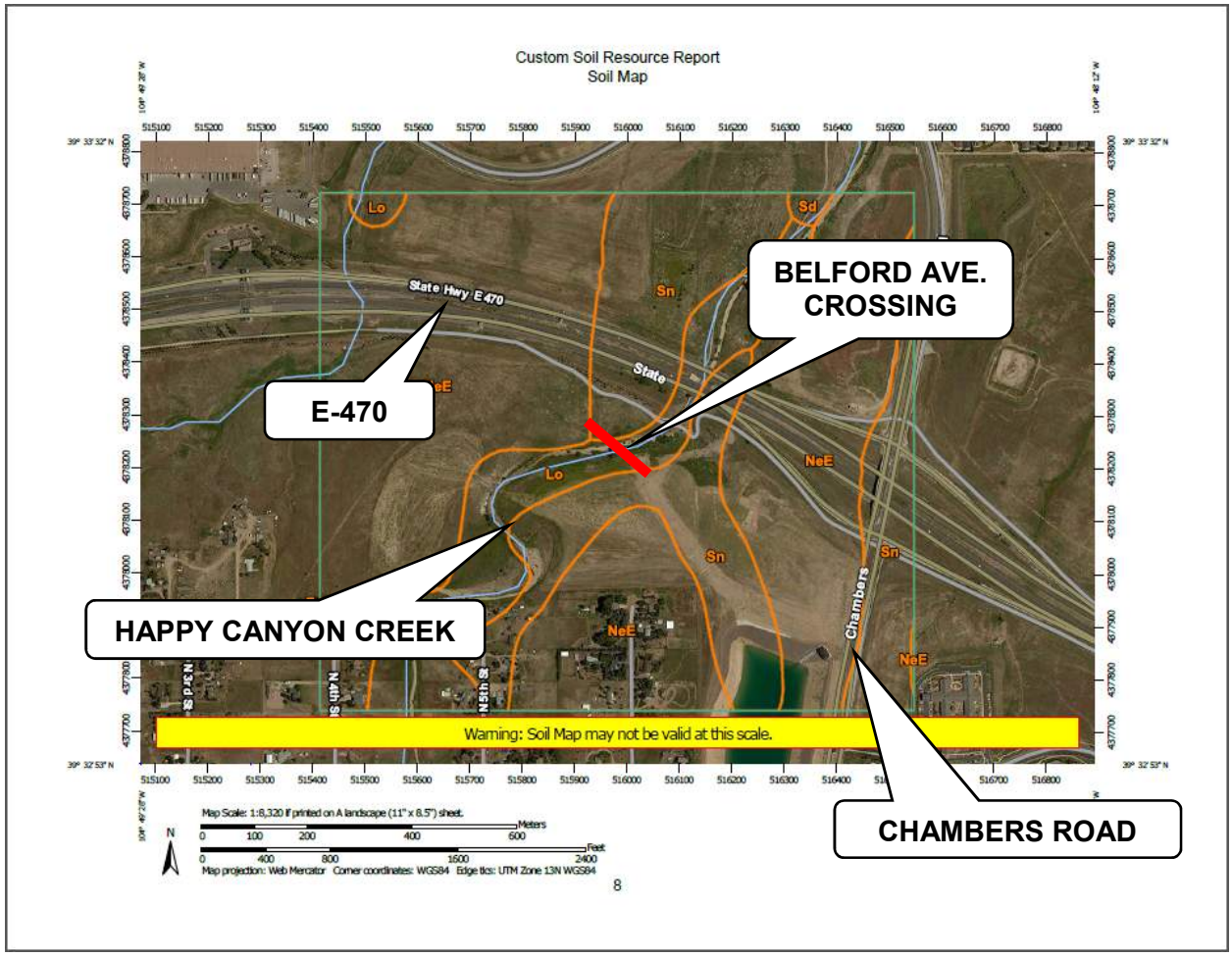


Figure 2. National Resource Conservation Service Map

Table 1. Area Soil Types

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

Notes:

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

Soils identified in the immediate project area are *italicized*

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

II. DRAINAGE BASINS

A. Major Basin Description

Happy Canyon Creek Major Basin

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

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 the Happy Canyon Creek to Tallman Gulch FHAD (November 1977) by Howard, Needles, Tammen & Bergendoff (**Reference 4**).

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.

A preliminary revised FIRM (**Figure 6** and **Reference 2**) was completed on June 30, 2016 (with 08035C0062H being updated December 13, 2018 outside of the project limits) 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 used 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. Due to the ongoing Physical Map Revision (PMR), the project was also tied into the effective FIRM and FIS, which can be found in **Appendix G**.

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.

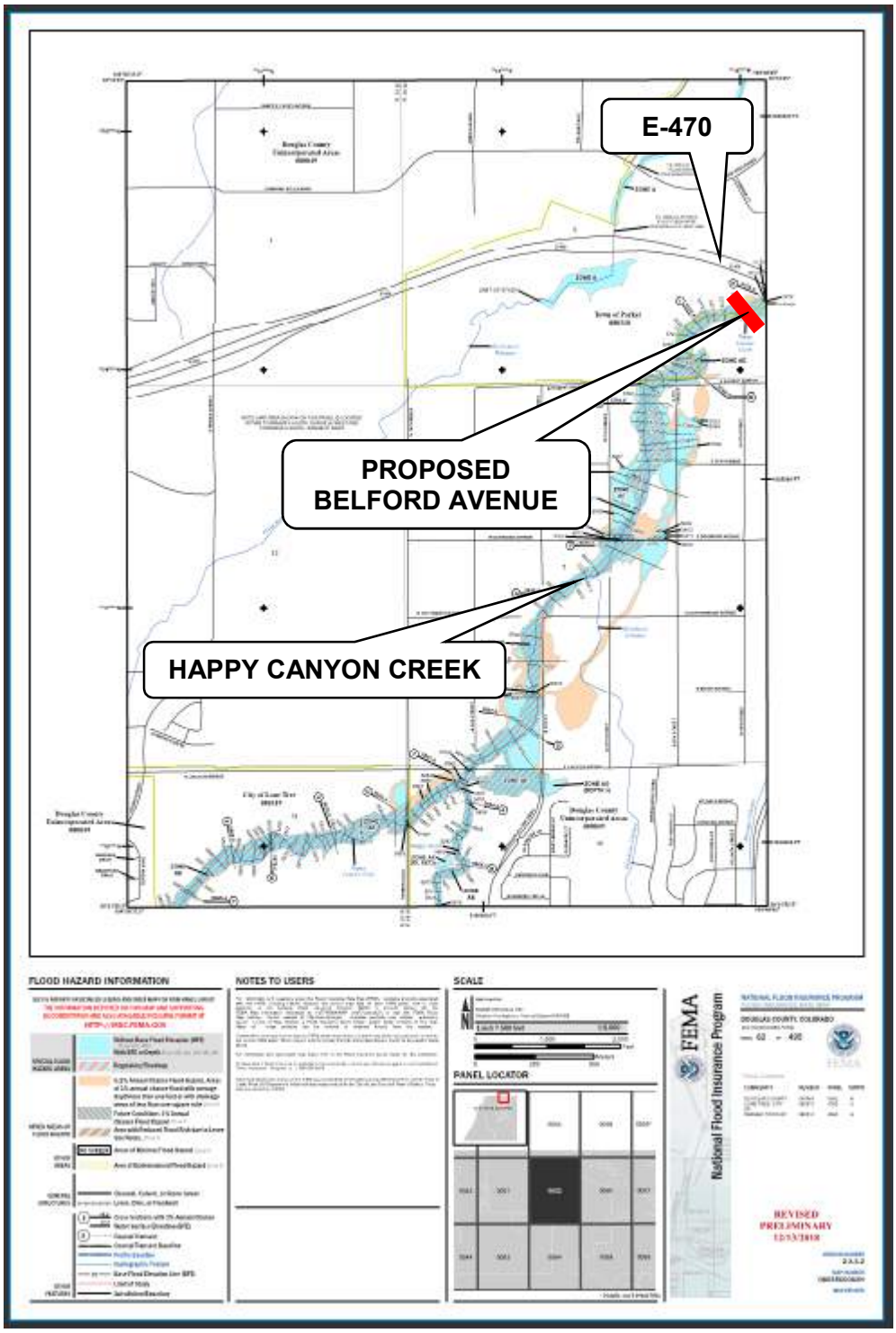


Figure 3. Preliminary Flood Insurance Rate Map 08035C0062H

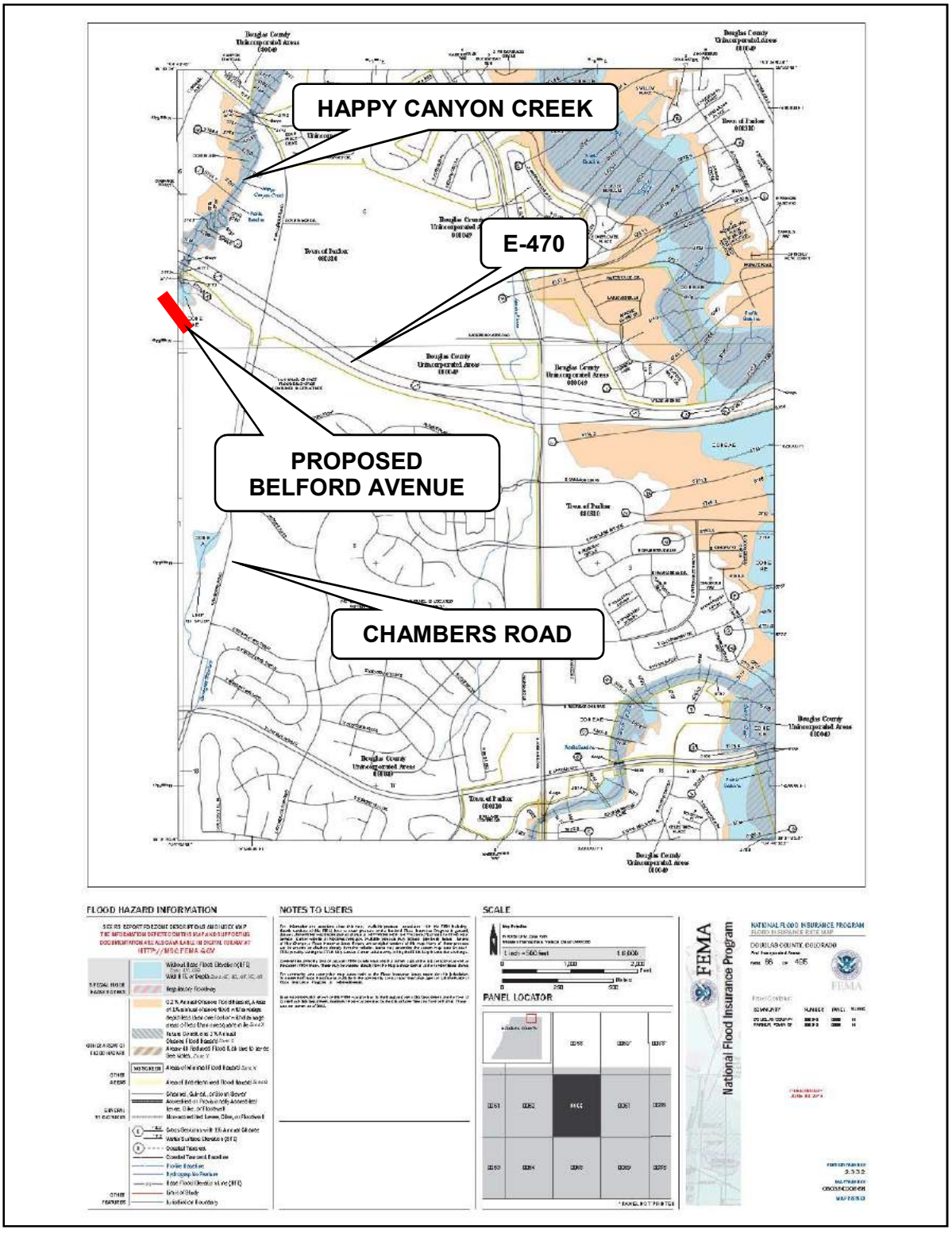


Figure 4. Preliminary Flood Insurance Rate Map 08035C0066H

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

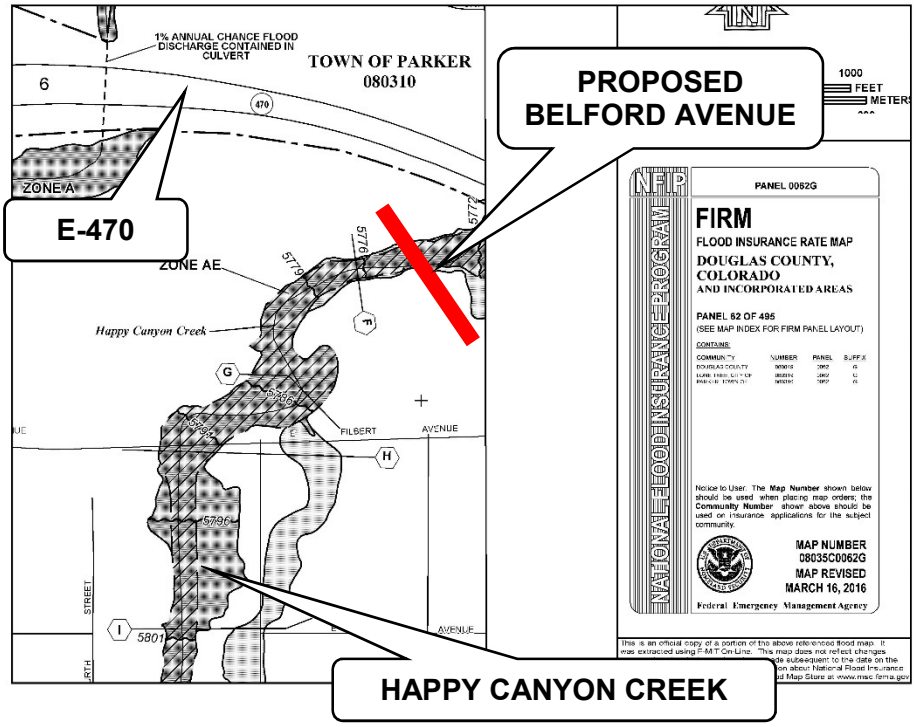


Figure 5. Effective Flood Insurance Rate Map 08035C0062G

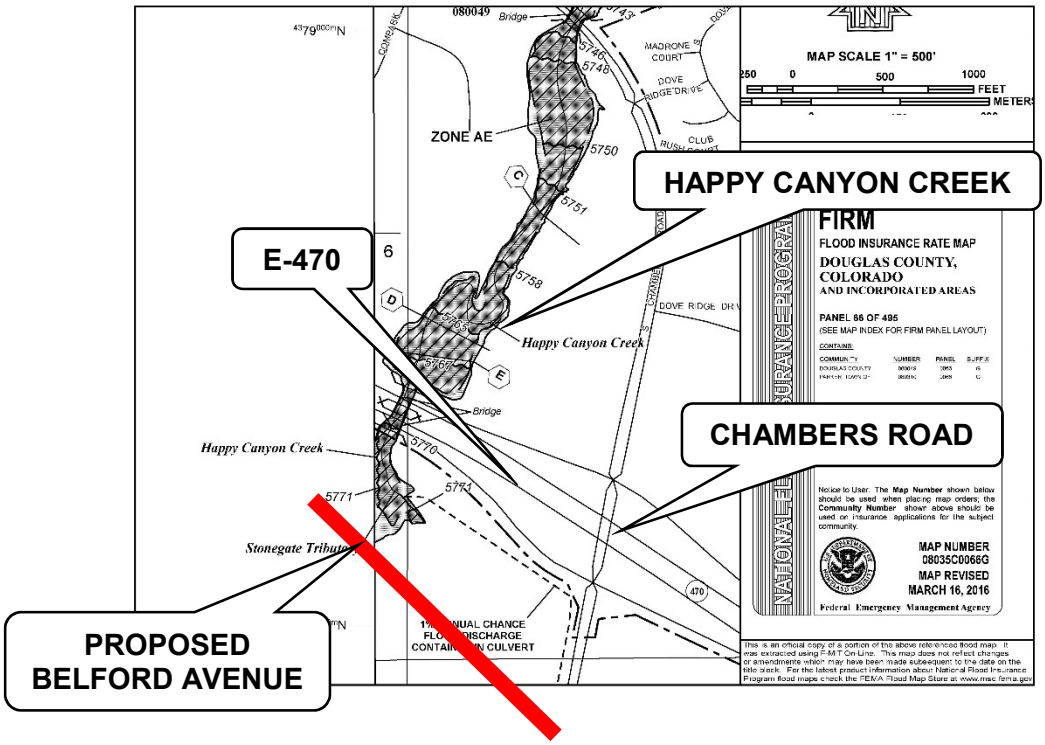


Figure 6. Effective Flood Insurance Rate Map 08035C0066G

III. DRAINAGE FACILITIES DESIGN

A. General Concept

Compark plans to develop the area south of E-470 and will add a connection between Chambers Road and Peoria Street via Belford Avenue. Belford Avenue will cross over Happy Canyon Creek via a new bridge structure. The Belford Avenue crossing over Happy Canyon Creek will be approximately 560 feet south of E-470 and 2,000 feet west of Chambers Road. As part of the development, the Cherokee Trail (parallel to E-470) will also be reconstructed with a new multi-cell reinforced concrete box culvert (RCBC) crossing. There will also be three drop structures constructed including a realigned low-flow segment of Happy Canyon Creek through the proposed Belford Avenue 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 impacts.

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 and will be completed as part of this project.

The channel improvements include three grouted sloping boulder (GSB) drop structures, right overbank grading on the upstream side of the reach within the project limits, 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 within the channel was provided based on recommendations provided in the MDP per the future 2-year flow and water surface elevation of approximately 3 feet. The three GSBs are located upstream of Belford Avenue.

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

The right overbank (near stream station 125+00) will be widened to help relieve the pinch point in the current floodplain and to help mitigate velocity and shear stress through this section. It will also help reconnect the floodplain to the active channel. Historical photos suggest that this section of Happy Canyon Creek has remained relatively stable for the past 80 years. The overbank grading design was coordinated with the environmental consultant for the project to avoid any additional wetland impacts. The cut section in the right overbank starts approximately 1 foot above the ordinary high water mark. The designed 2 percent bench extends approximately 123 feet to an intersection point with an adjacent 4:1 cut slope that ties into the existing grade prior to the proposed maintenance trail. Comparing the velocities and the shear stresses in both the pre- and post-hydraulic models, it was shown that both were reduced with the cut overbank section.

The two most upstream GSBs will primarily be contained to the existing active low-flow channel section and remain buried until the anticipated future equilibrium slope is achieved as the surrounding area develops and runoff rates increase. The low-flow channel realignment section associated with the GSB upstream of Belford Avenue is being proposed to direct the low-flow channel section away from the proposed piers for the new bridge structure. The low-flow channel will be 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 Belford Avenue Bridge crossing will be a two-span 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 width of the bridge is 93 feet. There will be a single pier with six 42-inch columns on top of 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 has 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 Avenue Bridge section to aid 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 will be protected by riprap revetment, where applicable. The adjacent fill

slopes from Belford Avenue near the bridge section are 4:1. The 100-year and 500-year storm events will be conveyed within the proposed bridge section and not overtop Belford Avenue.

The alignment of Belford Avenue is adjacent to ACWWA's emergency overflow section for the reservoir along the west side of Chambers Road. It is anticipated that Belford Avenue will provide a conveyance of the emergency overflow in the event the spillway is used. The proposed Belford Avenue vertical alignment continues west downgrade 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. Overtopping protection (soil riprap) has been sized and provided at the trail crossing according to the future 10-year storm event identified in the FHAD. The MDP provided a conceptual longitudinal slope for the trail crossing that included a drop structure immediately upstream of the crossing. Coordination with the Town of Parker and UDFCD concluded that maintenance may be an issue with the configuration and the drop structure was removed with the new invert elevations of the multi-cell box aligning with the existing channel invert elevations to facilitate potential sediment accumulation on the downstream side of the crossing to help ease any anticipated maintenance operations.

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 - FHAD

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 effective model.

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 (5.0.7).

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. Elevations were taken from 2-foot interval topography obtained from the Denver Democratic National Convention (DNC) LIDAR survey by Sanborn Geospatial. Manning's n's were based off aerials and photos. Cross sections outside of the project limits were taken out of the model, with a new boundary condition set to the most downstream section.

In addition to the existing sections, 13 new sections were added and one existing section was deleted. The existing section was deleted so that the existing 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 1-foot interval contours taken from a flown survey performed in November 2015. All the sections, except for sections 10111, 10157, 10326, 10548, 12129, and 12388 were updated with this flown survey data. The reasons these were omitted from being updated was because there was no work being done in these areas and to provide a tie in to the existing FHAD 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 the effective FIS and was 2685 feet through the project limits. The corrected effective model reach was based off 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 Avenue crossing. The post-project conditions model is included in **Appendix E** for information.

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

B. HEC-RAS – Effective FIS

The process for tying the hydraulic model into the FEMA Effective FIS/FIRM was similar to the hydraulic model used to tie into the FHAD. There were a few changes, however, which include:

- The effective model was created from a HEC-2 model that was made to accompany the 1977 Howard, Needles, Tammen & Bergendoff FHAD. The HEC-2 model was imported into HECRAS (5.0.7) and ran. The comparison can be found in **Appendix G**.
- The duplicate model consists of the effective model, with a datum shift made. The 1977 HEC-2 model provided was in NGVD29 datum and was shifted to the NAVD88 datum.
- In the corrected effective model, sections were added from the 2014 FHAD and the new drop structures/bridge/channel improvements to provide a base of comparison between the corrected effective and the post-project conditions model. To be able to tie into the effective FIS water surface elevation, section 12541 was taken from a Letter of Map Revision (LOMR) model performed by Carroll and Lange in 2003. The reason this model was chosen was because it was the most recent model that closely matched the effective FIS profile. All Manning's n's were kept consistent with the values in the effective model.
- Because no changes have occurred since the date of the corrected effective model, the corrected effective model is also the pre-project conditions model.
- The post-project conditions model used the same process for tying into both the 2014 FHAD and the effective FIS/FIRM.

V. SUMMARY

If the proposed improvements are built per plan, the floodplain and floodway as shown on the hydraulic analysis and drawings will not cause overtopping of Belford Avenue 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. 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. The 2014 FHAD hydraulic model included a floodway encroachment analysis, but did not include floodway encroachment values for portions of Happy Canyon Creek within these CLOMR limits. The floodway encroachment for this CLOMR was based off the 2014 FHAD model utilizing the same approach for consistency and representation of the post-project floodway limits. Ineffective flow areas 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 as 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.

VI. NATIONAL FLOOD INSURANCE PROGRAM REGULATION REQUIREMENTS

This project is in a FEMA-designated Zone “AE” area with defined BFE’s and floodways. The hydraulic analysis indicates a maximum rise in WSE of 1.8-ft in the post-project conditions model when compared to the corrected effective model. The width of the post-project Special Flood Hazard Area (SFHA) tie-in is within 5% of the effective FIRM’s scale. The floodplain work map provided in **Appendix A** details the post-project elevations and widths of the effective Zone “AE” floodplain limits for Happy Canyon Creek.

A Habitat Suitability Assessment for Happy Canyon Creek Improvement Project was prepared by Smith Environmental and Engineers (April 2016). The study determined that there are ten potential threatened or endangered species as determined by US Fish and Wildlife Service including; Least Tern, Mexican Spotted Owl, Piping Plover, Whooping Crane, Greenback cutthroat trout, Pallid sturgeon, Preble’s meadow jumping mouse, Colorado butterfly plant, Ute ladies’-tresses orchid, and Western prairie fringed orchid. Smith concluded that they believe that none of these threatened or endangered species will be affected by this project.

Due to permanent impacts to jurisdictional wetlands and other Waters of the U.S., authorization to conduct the project activities is provided under a Section 404 Individual Permit issued by the USACE. USACE provided authorization on November 13, 2017.

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 herewith 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: Kendra M. Gabbert

Registered Professional Engineer
State of Colorado No. 45344
(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 December 13, 2018 and June 30, 2016, respectively.

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 PRE-PROJECT FLOODPLAIN LIMITS
- PRE-PROJECT FLOODWAY LIMITS
- 100 YR POST-PROJECT FLOODPLAIN LIMITS
- POST-PROJECT FLOODWAY LIMITS
- 500 YR FHAD FLOODPLAIN LIMITS
- 500 YR PRE-PROJECT FLOODPLAIN LIMITS
- 500 YR POST-PROJECT FLOODPLAIN LIMITS
- 100 YR FHAD BFE
- 100 YR POST-PROJECT BFE
- 12541 2014 FHAD CROSS-SECTION
- 12436 FHU ADDED CROSS-SECTION
- 2014 FHAD CROSS-SECTION (TO BE REMOVED)
- EXISTING ROW
- EXISTING EASEMENT
- SURVEYED 1 FT CONTOURS
- WETLANDS

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

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

E-470

HAPPY CANYON TRAIL

DOWNSTREAM CROSS SECTION TIE-IN

PROPOSED BELFORD OVER HAPPY CANYON CREEK CROSSING

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

PROPOSED DROP STRUCTURE NO. 1

HAPPY CANYON CREEK HCL

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

PROPOSED DROP STRUCTURE NO. 2

CHEROKEE TRAIL CROSSING

CHEROKEE TRAIL

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

PROPOSED DROP STRUCTURE NO. 3

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

PROPOSED BELFORD AVE.

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

UPSTREAM CROSS SECTION TIE-IN

CHAMBERS ROAD

FLOW

HAPPY CANYON CREEK

N

HORIZONTAL SCALE: 1"=100'

0' 50' 100' 200'

EXISTING TOPOGRAPHY SHOWN ON THE WORKMAPS FROM CROSS-SECTION 10111 TO CROSS-SECTION 12694 REPRESENTS SURVEYED 1 FOOT CONTOURS (NAVD 88). THE SURVEY AND AERIAL PHOTOGRAPHY WAS DONE 11/2015. SECTIONS 10775, 10842, 11153, AND 11772 ARE TO BE REMOVED FOR POST-PROJECT CONDITIONS.

I HEREBY AFFIRM THAT THIS DOCUMENT ENTITLED FLOODPLAIN MODIFICATION STUDY FOR HAPPY CANYON CREEK AT BELFORD AVE WAS PREPARED IN ACCORDANCE WITH APPLICABLE, VIABLE, AND PERTINENT TECHNICAL DATA AND CRITERIA FOR THE COLORADO WATER CONSERVATION BOARD, THE FEDERAL EMERGENCY AGENCY, AND DOUGLAS COUNTY, COLORADO. THE DOCUMENT, REPORT, AND ALL ATTACHMENTS SUBMITTED HEREWITH WERE PREPARED IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE NECESSARY INFORMATION AND COMPETENTLY PREPARED THE DOCUMENT. ADDITIONALLY, I HEREBY CERTIFY THAT NO INSURABLE STRUCTURES ARE IMPACTED DUE TO THE REVISIONS DOCUMENTED IN THIS CLOMR REPORT.

COLORADO REGISTERED 45344 PROFESSIONAL ENGINEER

Kendra M. Gabbert 4/23/19

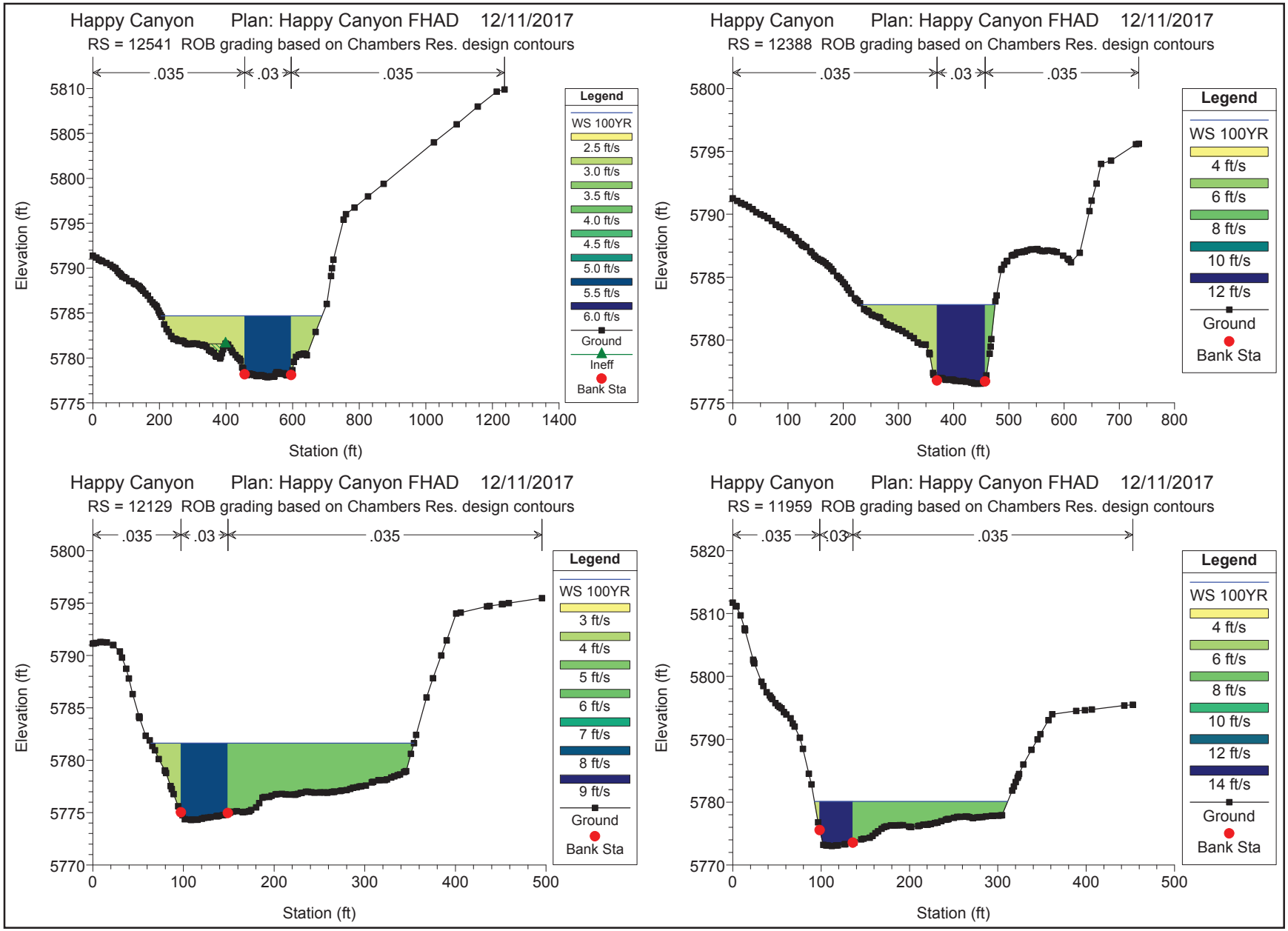
KENDRA M. GABBERT, P.E. #45344

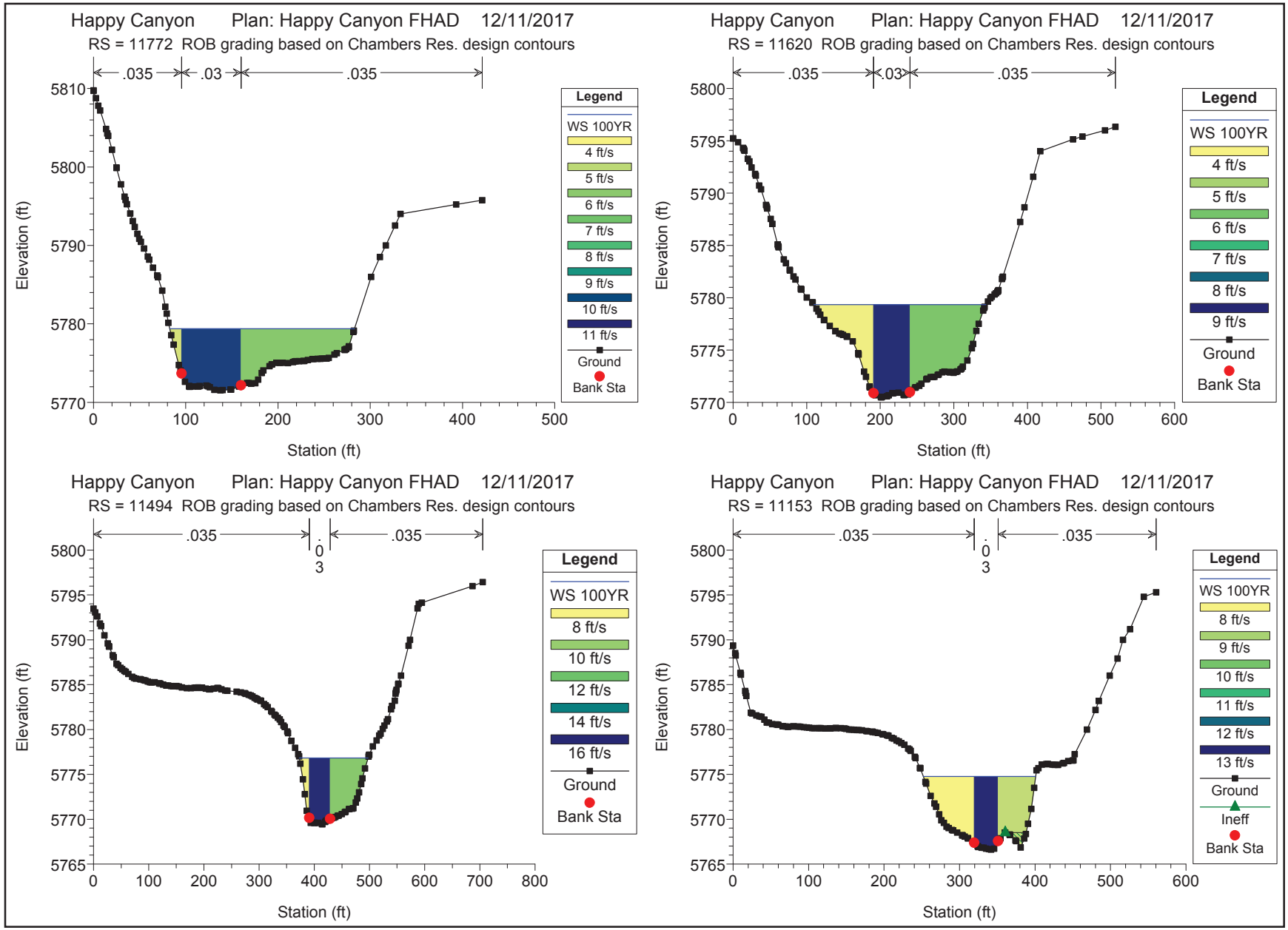
Print Date: 4/19/2019 9:21:25 AM	Sheet Revisions	As Constructed	BELFORD/HAPPY CANYON CREEK FLOODPLAIN WORK MAP
File Name: H115360-01FP-01 (FHAD).dwg	Date / Comments / Initials	No Revisions:	Project No./Code
Horizontal Scale: Vertical Scale:		Revised:	Designer: CDT; Detailer: ZJG; Subset:
FELSBURG HOLT & ULLEVIG, 6300 South Syracuse Way, Suite 600, Centennial, CO 80111, tel 303.721.1440, fax 303.721.0832		Void:	Structure Numbers; Sheets: 1 of 1; Sheet Number

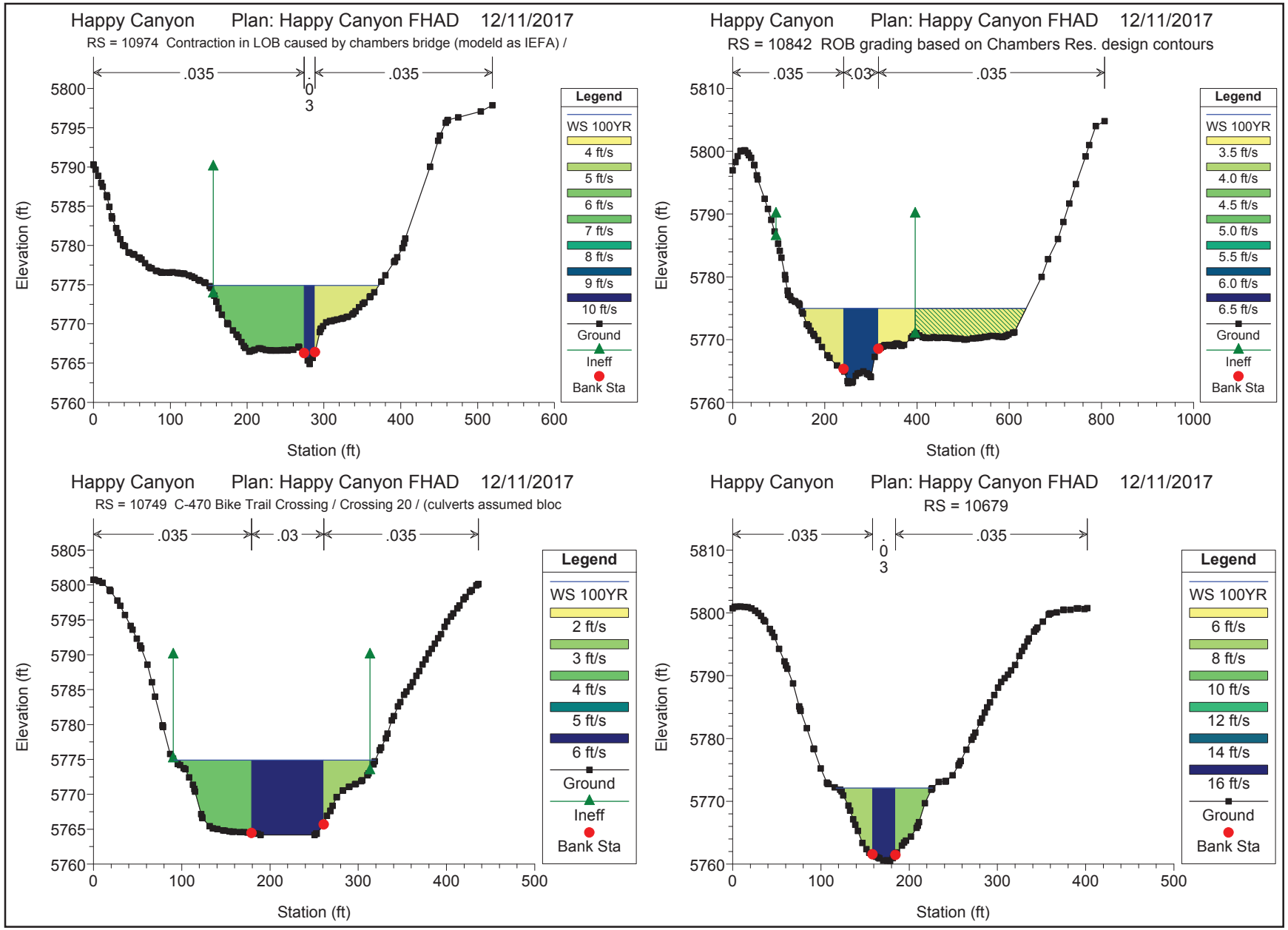
Manhard CONSULTING LTD
8008 E. Arapahoe Court, Suite 110, Centennial, CO 80112 ph:303.708.0500 fx:303.708.0400 manhard.com
Civil Engineers • Surveyors • Water Resource Engineers • Water & Wastewater Engineers
Construction Managers • Environmental Scientists • Landscape Architects • Planners

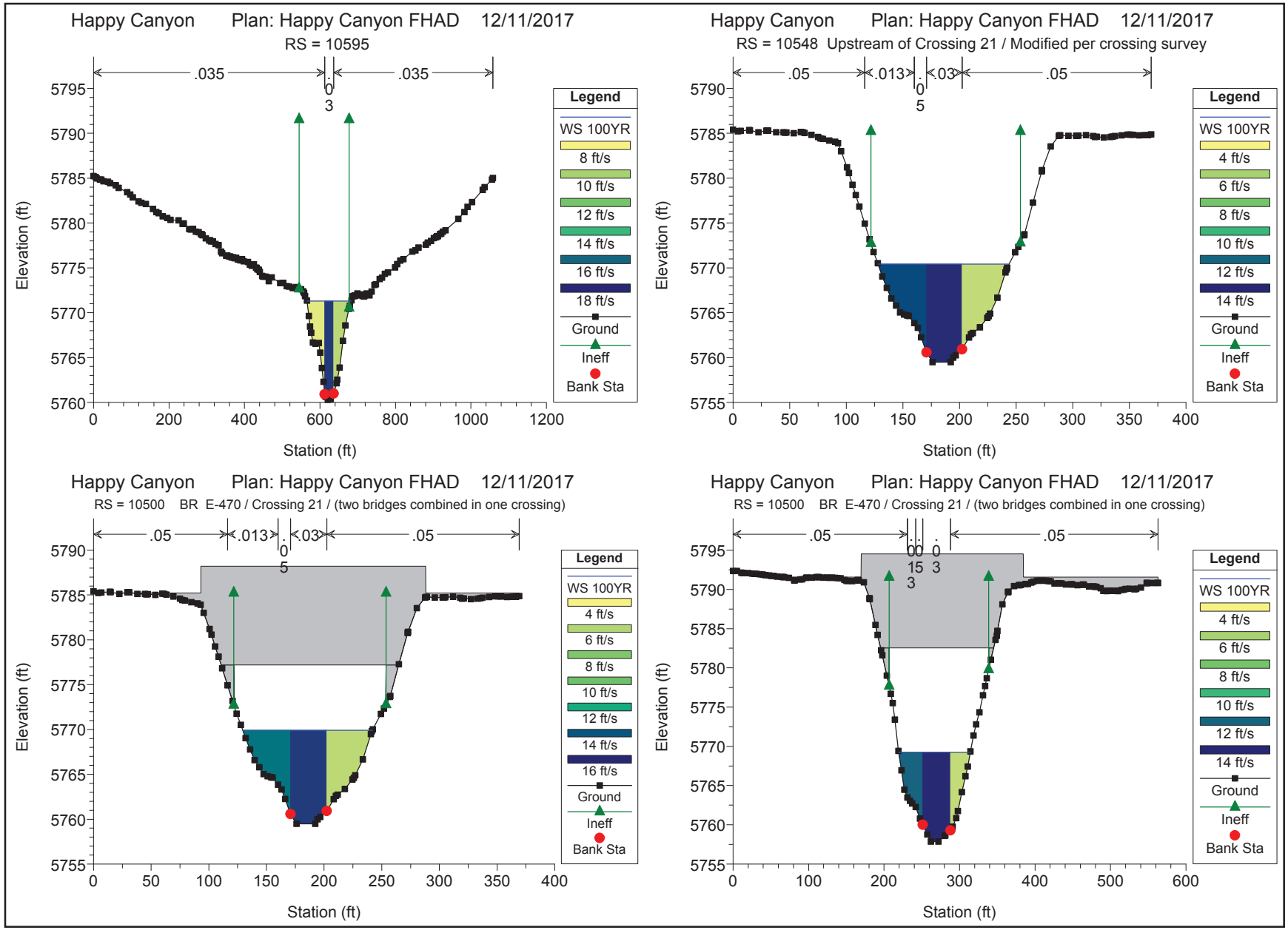
I:\115360-01 - Compark at Belford\CADD\Hydraulics\Drawings\, Zach.Grady

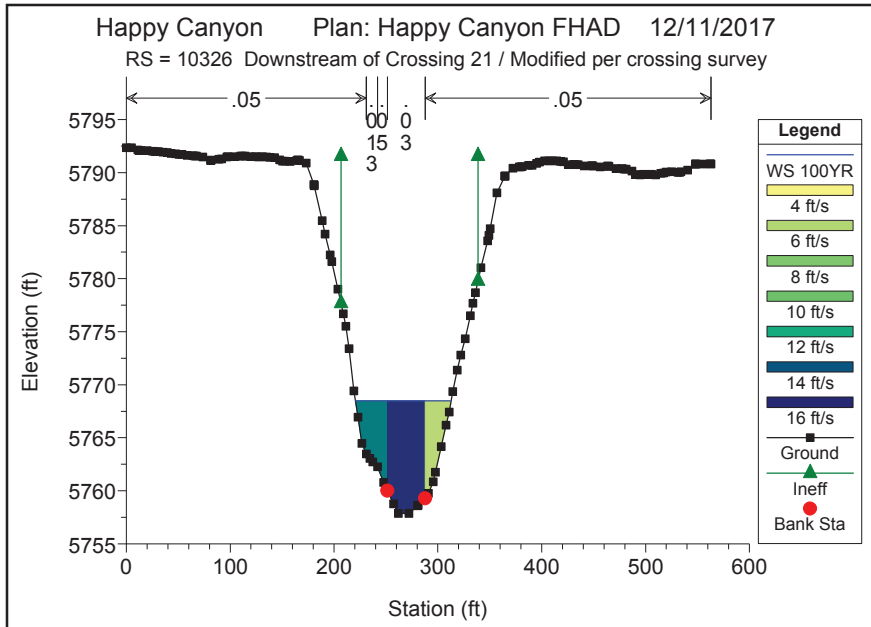
APPENDIX B. EFFECTIVE MODEL, SUPPORTING INFORMATION FROM FHAD AND MDP

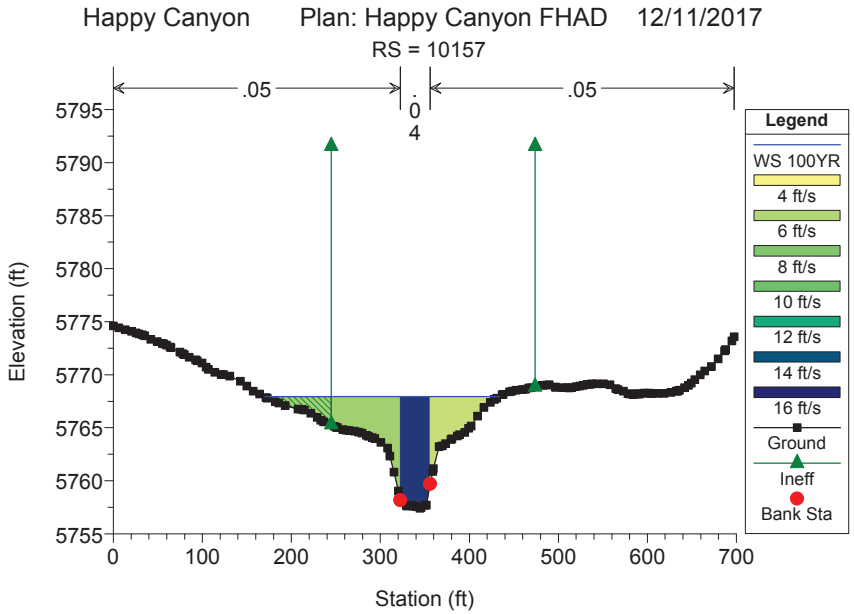

Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 12541 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
2.5 ft/s
3.0 ft/s
3.5 ft/s
4.0 ft/s
4.5 ft/s
5.0 ft/s
5.5 ft/s
6.0 ft/s
Ground
Ineff
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 12388 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 12129 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 11959 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta

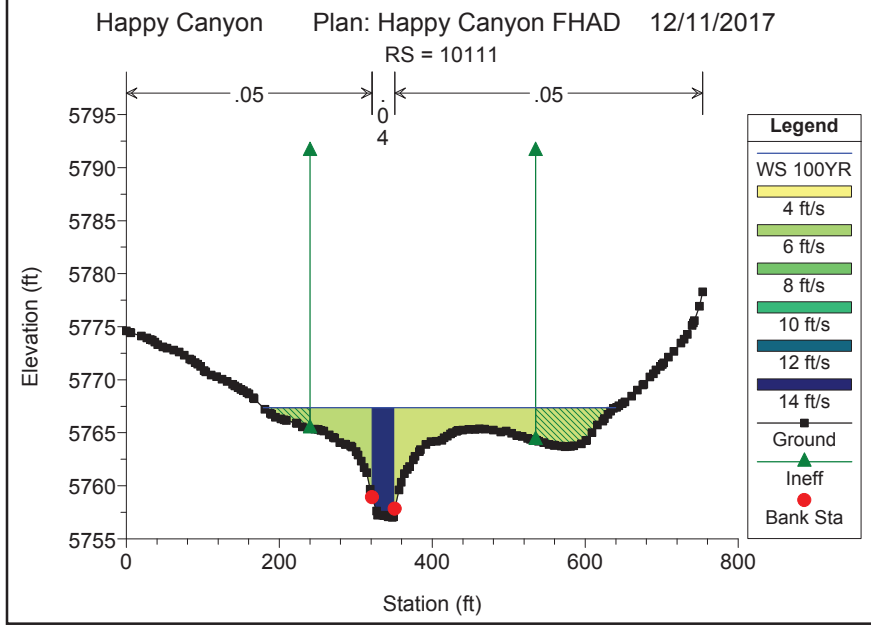

Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 11772 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
11 ft/s
Ground
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 11620 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 11494 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 11153 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
Ground
Ineff
Bank Sta

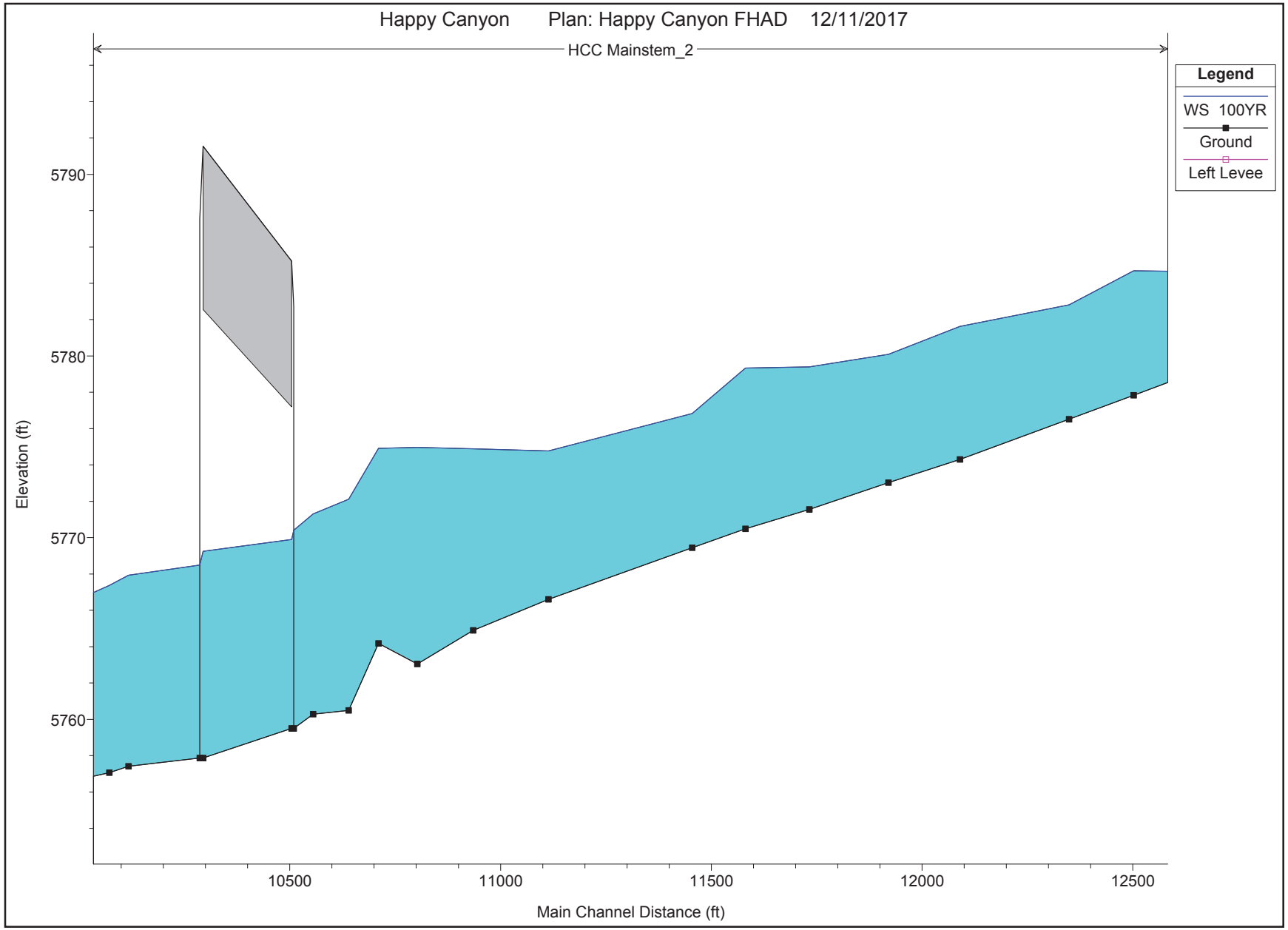

Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10974 Contraction in LOB caused by chambers bridge (modeld as IEFA) /
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
Ground
Ineff
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10842 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
3.5 ft/s
4.0 ft/s
4.5 ft/s
5.0 ft/s
5.5 ft/s
6.0 ft/s
6.5 ft/s
Ground
Ineff
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10749 C-470 Bike Trail Crossing / Crossing 20 / (culverts assumed bloc
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10679
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Bank Sta


Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10595
.035
.035
0.03
Elevation (ft)
Station (ft)
Legend
WS 100YR
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
18 ft/s
Ground
Ineff
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10548 Upstream of Crossing 21 / Modified per crossing survey
.05
.013
.03
.05
0.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10500 BR E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.013
.03
.05
0.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Ineff
Bank Sta
Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10500 BR E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.05
0.03
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta


Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10326 Downstream of Crossing 21 / Modified per crossing survey
.05
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Ineff
Bank Sta

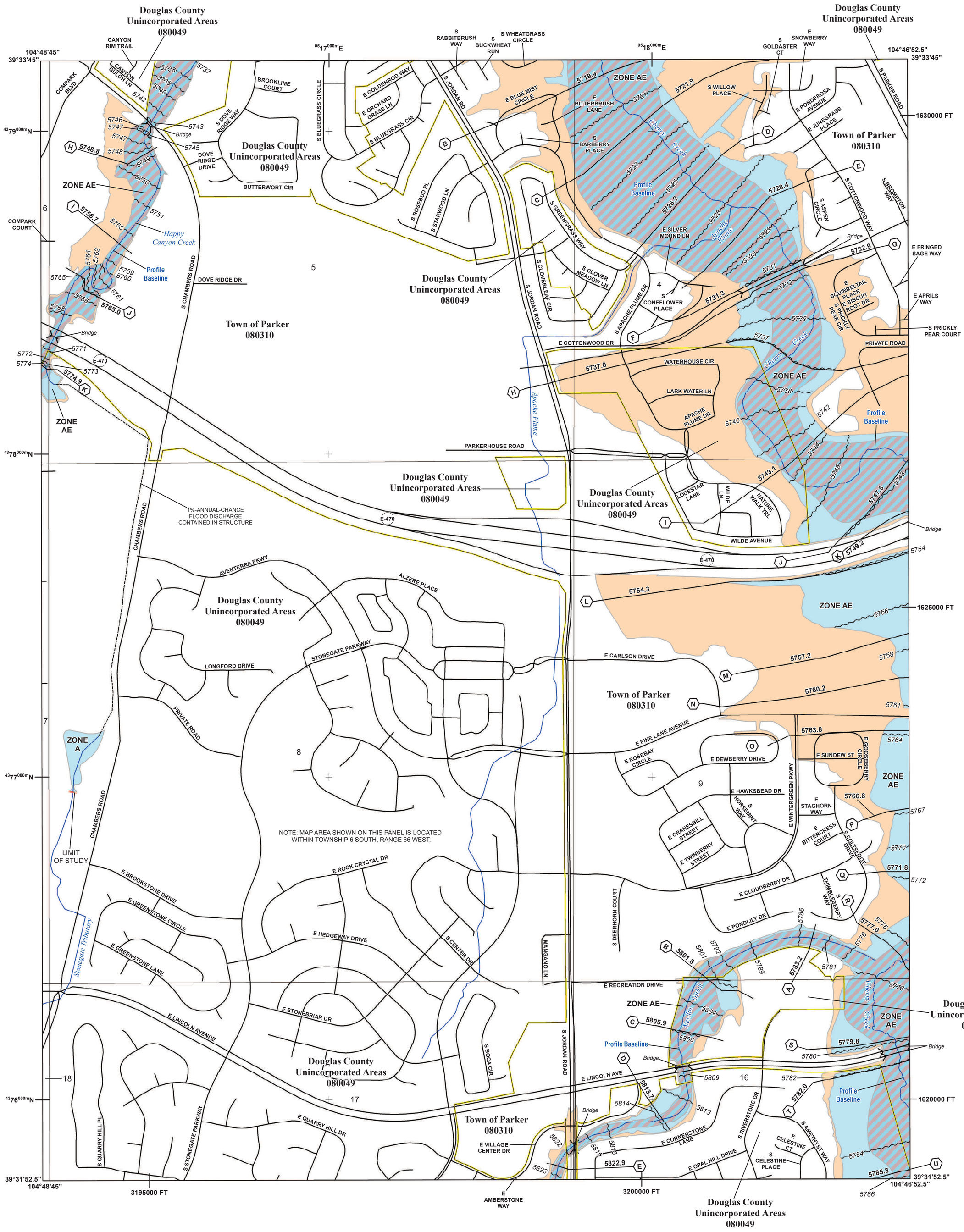

Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10157
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Ineff
Bank Sta


Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
RS = 10111
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta


Happy Canyon Plan: Happy Canyon FHAD 12/11/2017
HCC Mainstem_2
Legend
WS 100YR
Ground
Left Levee
Elevation (ft)
5790
5780
5770
5760
10500
11000
11500
12000
12500
Main Channel Distance (ft)

HEC-RAS Plan: HCC FP Locations: User Defined Profile: 100YR

River	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)	
HCC	Mainstem_2	12541	100YR	8303.00	5777.84	5784.69		5785.03	0.001004	5.52	2022.16	483.35	0.38
HCC	Mainstem_2	12388	100YR	8303.00	5776.52	5782.81	5782.81	5784.62	0.005234	11.95	892.48	242.94	0.85
HCC	Mainstem_2	12129	100YR	8303.00	5774.30	5781.63		5782.26	0.001998	8.17	1408.13	290.17	0.54
HCC	Mainstem_2	11959	100YR	8303.00	5773.03	5780.09	5780.09	5781.85	0.006149	13.74	884.80	218.85	0.93
HCC	Mainstem_2	11772	100YR	8303.00	5771.55	5779.40		5780.57	0.002909	10.16	1054.05	200.27	0.66
HCC	Mainstem_2	11620	100YR	8303.00	5770.49	5779.34		5780.12	0.001764	8.74	1306.82	233.63	0.52
HCC	Mainstem_2	11494	100YR	8303.00	5769.44	5776.83	5776.83	5779.55	0.007225	15.63	676.32	124.59	1.03
HCC	Mainstem_2	11153	100YR	8303.00	5766.60	5774.78		5776.43	0.004287	12.84	864.20	148.85	0.81
HCC	Mainstem_2	10974	100YR	8303.00	5764.90	5774.90		5775.66	0.001946	9.55	1266.70	221.32	0.55
HCC	Mainstem_2	10842	100YR	8303.00	5763.05	5774.97		5775.39	0.000700	6.11	1766.97	488.93	0.34
HCC	Mainstem_2	10749	100YR	8355.00	5764.18	5774.91		5775.33	0.000606	5.89	1758.39	227.81	0.32
HCC	Mainstem_2	10679	100YR	8475.00	5760.49	5772.12		5774.61	0.003915	15.51	767.67	109.39	0.82
HCC	Mainstem_2	10595	100YR	8475.00	5760.29	5771.30	5771.30	5774.20	0.004959	17.00	719.36	116.92	0.91
HCC	Mainstem_2	10548	100YR	8475.00	5759.50	5770.41	5769.60	5772.80	0.003288	13.62	781.50	115.79	0.74
HCC	Mainstem_2	10500		Bridge									
HCC	Mainstem_2	10326	100YR	8475.00	5757.88	5768.50	5768.05	5771.58	0.004427	15.23	662.20	92.30	0.85
HCC	Mainstem_2	10157	100YR	8475.00	5757.42	5767.93	5767.93	5770.22	0.007470	14.89	900.59	263.34	0.82
HCC	Mainstem_2	10111	100YR	8475.00	5757.06	5767.37	5767.37	5768.88	0.006080	13.31	1175.37	460.75	0.74



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

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A,V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 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*

OTHER AREAS
- NO SCREEN Areas of Minimal Flood Hazard *Zone X*
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Accredited or Provisionally Accredited Levee, Dike, or Floodwall
- Non-accredited Levee, Dike, or Floodwall

OTHER FEATURES
- 18.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation (BFE)
- 8 Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 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

N

Map Projection:

NAD83 UTM Zone 13N
Western Hemisphere; Vertical Datum: NAVD88

1 inch = 500 feet 1:6,000

0 1,000 2,000 Feet

0 250 500 Meters

PANEL LOCATOR

* PANEL NOT PRINTED

FEMA National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

DOUGLAS COUNTY, COLORADO
And Incorporated Areas

PANEL 66 OF 495

Panel Contains:

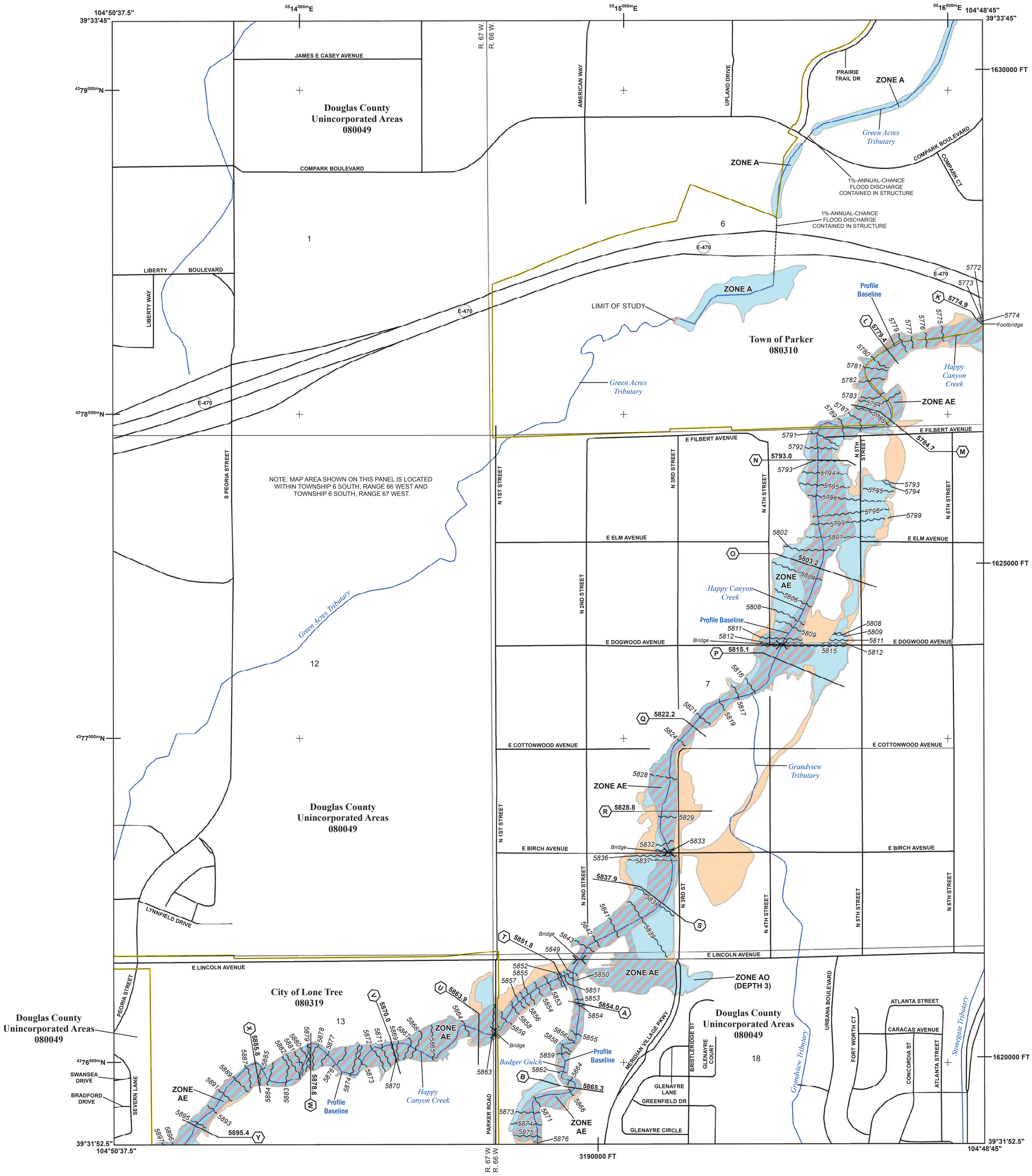
COMMUNITY	NUMBER	PANEL	SUFFIX
DOUGLAS COUNTY	080049	0066	H
PARKER, TOWN OF	080310	0066	H

PRELIMINARY
JUNE 30, 2016

VERSION NUMBER
2.3.3.2

MAP NUMBER
08035C0066H

MAP REVISED



FLOOD 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

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A,V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 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*

OTHER AREAS
- NO SCREEN Areas of Minimal Flood Hazard *Zone X*
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Accredited or Provisionally Accredited Levee, Dike, or Floodwall
- Non-accredited Levee, Dike, or Floodwall

OTHER FEATURES
- E 18.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation (BFE)
- 8 Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 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

N

Map Projection:
NAD83 UTM Zone 13N
Western Hemisphere; Vertical Datum: NAVD88

1 inch = 500 feet 1:6,000

0 1,000 2,000 Feet

0 250 500 Meters

PANEL LOCATOR

		0054	0058	0059*
0042	0061	**0062**	0066	0067
0044	0063	0064	0068	0069

* PANEL NOT PRINTED

FEMA National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

DOUGLAS COUNTY, COLORADO
And Incorporated Areas

PANEL 62 OF 495

FEMA

Panel Contains:

COMMUNITY	NUMBER	PANEL	SUFFIX
DOUGLAS COUNTY	080049	0062	H
LONE TREE, CITY OF	080319	0062	H
PARKER, TOWN OF	080310	0062	H

PRELIMINARY
JUNE 30, 2016

VERSION NUMBER
2.3.3.2

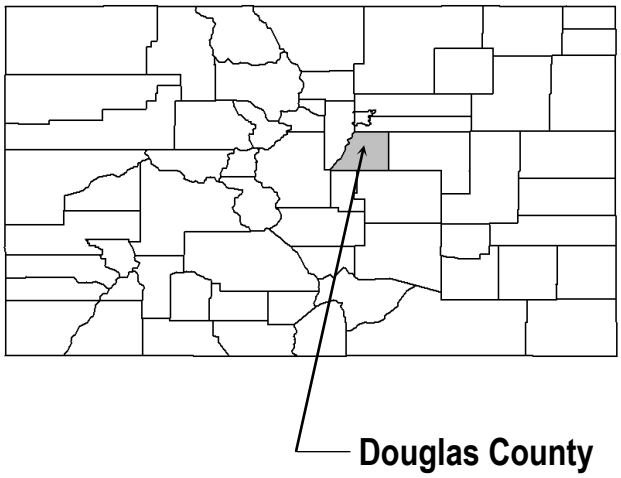
MAP NUMBER
08035C0062H

MAP REVISED

FLOOD INSURANCE STUDY

VOLUME 1 OF 4

DOUGLAS COUNTY, COLORADO
AND INCORPORATED AREAS



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

Notice

This preliminary FIS report includes only revised Flood Profiles and Floodway Data tables. See "Notice to Flood Insurance Study Users" page for additional details.

REVISED PRELIMINARY
DECEMBER 13, 2018
REVISED:

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
08035CV001D

TABLE 4 – SUMMARY OF DISCHARGES – continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
HANGMANS GULCH					
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
HAPPY CANYON CREEK					
At Cherry Creek	7.22	3,050	6,970	9,235	13,367
Upstream of Green Acres Tributary	7.05	2,670	6,325	8,449	12,231
At Chambers Road	6.88	2,691	6,356	8,490	12,288
Upstream of Stonegate Tributary	6.70	2,656	6,249	8,355	12,107
Grandview Estates	6.44	2,647	6,212	8,303	12,024
At Elm Avenue	6.26	2,647	6,189	8,270	11,971
Upstream of Grandview Tributary	6.16	2,461	5,803	7,777	11,308
At Cottonwood Avenue	5.92	2,432	5,735	7,689	11,181
At Lincoln Avenue	5.77	2,434	5,718	7,664	11,139
Upstream of Badger Gulch	5.63	2,073	4,690	6,247	8,985
1,100 feet West of West Parker Road	5.54	2,069	4,670	6,224	8,950
At East Boundary of Meridian Commons	5.18	2,007	4,541	6,066	8,726
At West boundary of Meridian Commons	4.77	1,930	4,383	5,872	8,440
At Ridgegate Parkway	4.42	1,871	4,264	5,726	8,218
At I-25	2.82	1,604	3,648	4,920	6,988
Downstream of Oak Hills Tributary	014	1,544	3,497	4,708	6,659
Upstream of Oak Hills Tributary	2.44	1,065	2,260	3,017	4,261
Upstream of Beverly Hills Tributary	1.78	695	1,417	1,834	2,496
At Castle Pines City Limit	1.3	588	1,133	1,409	1,856

*Data not available

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Happy Canyon Creek								
F	5,206	169	859	14.2	5,730.1	5,730.1	5,730.1	0.0
G	6,345	418	1,378	7.5	5,736.4	5,736.4	5,736.4	0.0
H	7,611	327	1,467	8.5	5,748.8	5,748.8	5,748.8	0.0
I	8,700	114	706	14.7	5,756.7	5,756.7	5,756.7	0.0
J	9,756	378	1,459	6.6	5,765.0	5,765.0	5,765.0	0.0
K	10,750	217	1,756	5.9	5,774.9	5,774.9	5,774.9	0.0
L	11,772	200	1,054	10.2	5,779.4	5,779.4	5,779.4	0.0
M	12,694	423	1,365	8.1	5,784.7	5,784.7	5,784.7	0.0
N	13,800	231	1,043	10.5	5,793.0	5,793.0	5,793.4	0.4
O	14,907	346	1,173	12.4	5,803.2	5,803.2	5,803.2	0.0
P	15,928	427	1,982	4.2	5,815.1	5,815.1	5,815.6	0.5
Q	17,100	90	605	16.6	5,822.2	5,822.2	5,822.3	0.1
R	18,063	205	968	12.8	5,828.8	5,828.8	5,828.8	0.0
S	19,040	233	1,778	4.3	5,837.9	5,837.9	5,838.4	0.5
T	20,347	160	914	7.0	5,851.8	5,851.8	5,851.8	0.0
U	21,423	315	1,808	5.5	5,863.9	5,863.9	5,863.9	0.0
V	22,534	207	740	14.7	5,870.0	5,870.0	5,870.0	0.0
W	23,660	270	905	12.7	5,878.6	5,878.6	5,878.6	0.0
X	24,604	241	805	13.6	5,885.8	5,885.8	5,885.8	0.0
Y	25,498	202	1,010	11.0	5,895.4	5,895.4	5,895.4	0.0
Z	26,842	220	681	11.5	5,906.5	5,906.5	5,906.5	0.0
AA	27,900	165	732	8.5	5,918.4	5,918.4	5,918.4	0.0
AB	29,034	415	1,552	3.9	5,932.4	5,932.4	5,932.4	0.0
AC	29,970	103	503	11.4	5,940.5	5,940.5	5,940.5	0.0

[1] Feet upstream of Cherry Creek

TABLE 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

ARAPAHOE COUNTY, CO

AND INCORPORATED AREAS

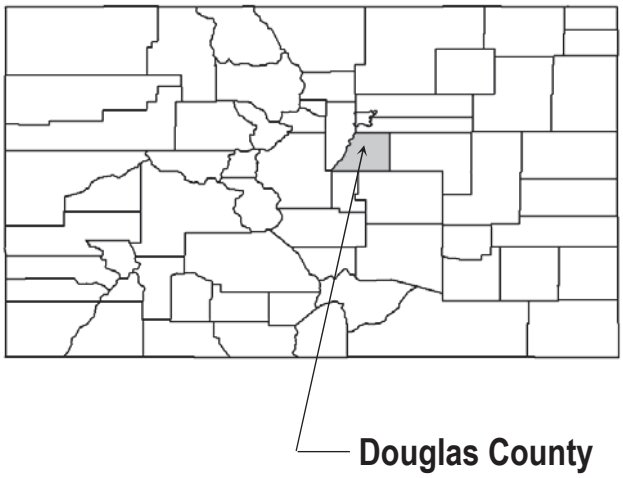
FLOODWAY DATA

HAPPY CANYON CREEK

FLOOD INSURANCE STUDY

VOLUME 2 OF 3

DOUGLAS COUNTY, COLORADO
AND INCORPORATED AREAS



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

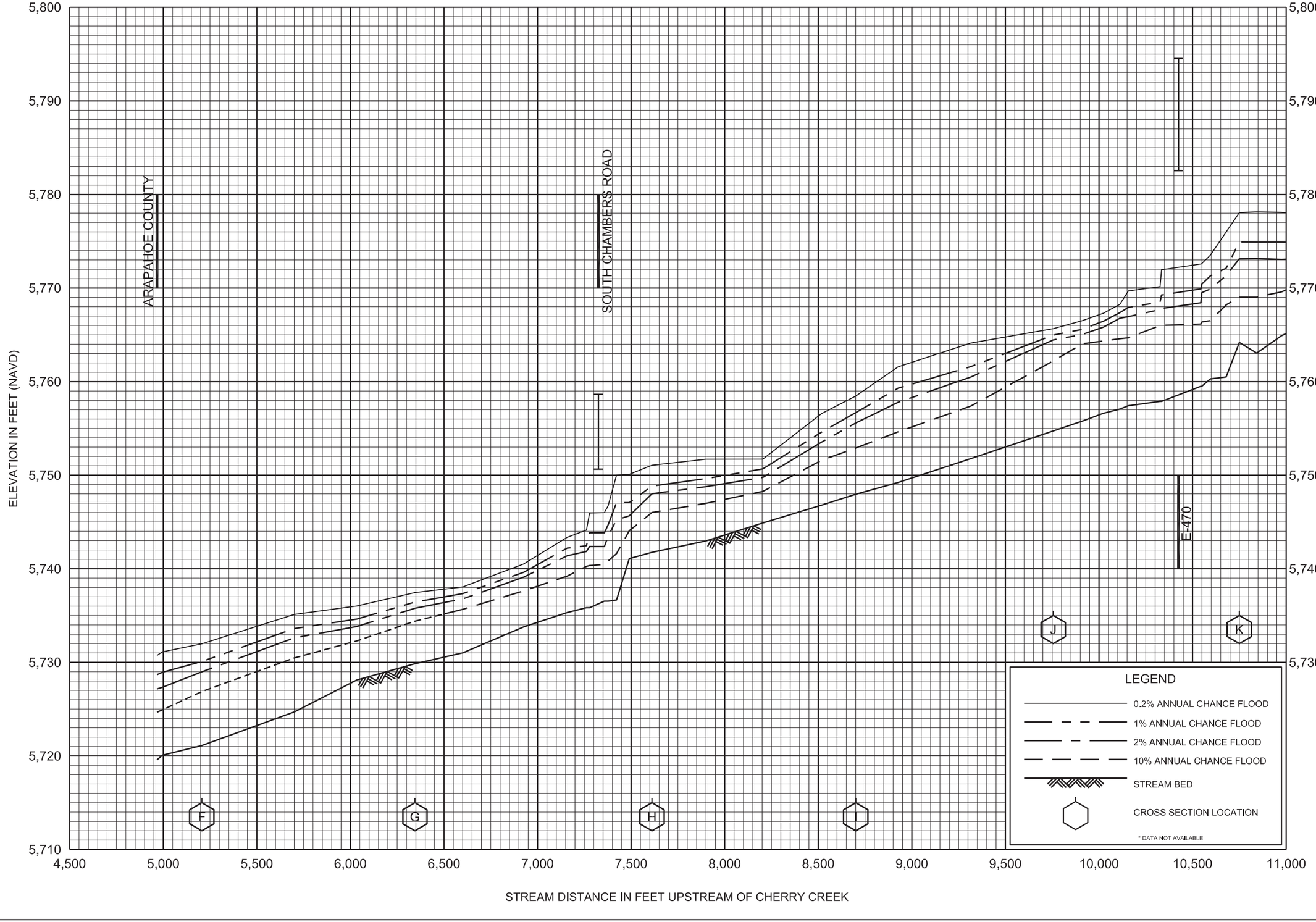
Notice

This preliminary FIS report includes only revised Flood Profiles and Floodway Data tables. See "Notice to Flood Insurance Study Users" page for additional details.

PRELIMINARY
JUNE 30, 2016

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
08035CV002C



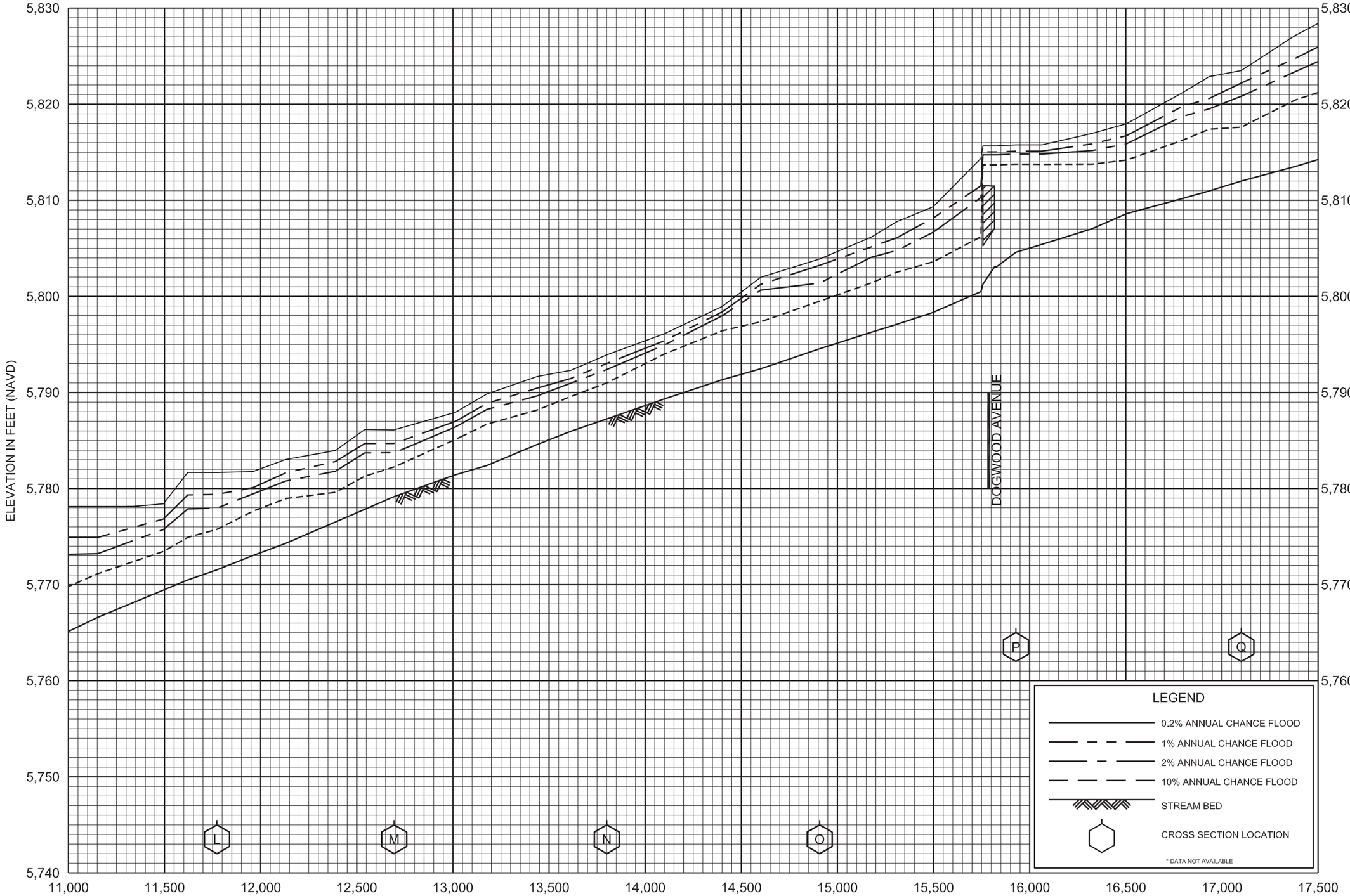
FLOOD PROFILES

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

Happy Canyon Creek
Flood Hazard Area Delineation (FHAD)

July 2014

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

DOUGLAS COUNTY COLORADO

CITY OF LONE TREE

Town of Parker COLORADO

Southeast Metro Stormwater Authority

MULLER

1.5 Data Collection

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

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

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

Table 1-2
Happy Canyon Creek FIRM Panels

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

1.6 Acknowledgements

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

Table 1-3
Project Participants

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

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

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

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

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

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

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

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

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

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

2.3 Reach Description

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

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

Happy Canyon Creek Reach 8 – Town of Parker

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

Happy Canyon Creek Reach 8

Happy Canyon Creek Reach 9 – Arapahoe County

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

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

Happy Canyon Creek Reach 9

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

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

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

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

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

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

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

Table B-4
Peak Flows

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

COMPARISON OF WATER SURFACE ELEVATIONS
MAINSTEM - FHAD v. REGULATORY WSEL

Study by: Douglas County / FEMA
Datum: 1988
Project ID: 06-08-B443P (Latest Available LOMR for Study Reach)
Study Date: 2006

		100-YEAR FLOW						
		FIS FLOW (cfs)	FHAD FLOW (cfs)	Δ (FHAD MINUS LOMR FLOW - cfs)	REGULATORY WSEL (NGVD)	REGULATORY WSEL (NAVD 88)	FHAD WSEL	Δ (FHAD MINUS REGULATORY)
FIS Cross Section ID	FHAD Station	100-year	100-year	100-year	100-year	100-year	100-year	100-year
A	5206	5610	8490	2880.00		5729.70	5730.1	0.39
B	6925	5610	8490	2880.00		5739.70	5739.6	-0.08
C	8517	5610	8475	2865.00		5753.40	5754.6	1.20
D	9910	5610	8475	2865.00		5766.30	5765.6	-0.72
E	10111	5610	8475	2865.00		5766.30	5767.4	1.07
F	11494	5610	8303	2693.00		5776.70	5776.8	0.13
G	12541	5610	8303	2693.00		5785.10	5784.7	-0.41
H	13613	5610	8270	2660.00		5792.40	5791.5	-0.94
I	14600	5610	8270	2660.00		5800.40	5801.2	0.84
J	15175	5610	8246	2636.00		5805.60	5805.2	-0.45
K	15746	5610	8246	2636.00		5808.90	5811.5	2.61
L	15827	5610	8246	2636.00		5813.90	5815.0	1.13
M	16325	5460	7777	2317.00		5814.90	5815.9	0.97
N	16933	5460	7689	2229.00		5819.10	5820.6	1.49
O	17380	5460	7689	2229.00		5824.40	5824.8	0.37
P	18063	5460	7664	2204.00		5827.70	5828.4	0.67
Q	18469	5460	7664	2204.00		5831.10	5832.5	1.43
R	18540	5460	7664	2204.00	5833.10	5836.31	5836.2	-0.09
S	19255	4160	7664	3504.00	5835.70	5838.91	5838.7	-0.21
T	19835	4160	7664	3504.00	5841.80	5845.01	5842.1	-2.90
U	20126	4160	7664	3504.00	5844.00	5847.21	5848.2	1.01
V	20347	4160	6247	2087.00	5849.60	5852.81	5851.8	-0.99
W	20809	4160	6224	2064.00	5851.00	5854.21	5857.5	3.25
X	21209	4160	6224	2064.00	5852.70	5855.91	5860.2	4.24
Y	21274	4160	6224	2064.00	5856.60	5859.81	5863.1	3.25
Z	22055	4160	6224	2064.00	5860.30	5863.51	5864.9	1.37
AA	23097	4160	6066	1906.00	5870.10	5873.31	5873.7	0.36
AB	24604	4160	6066	1906.00	5883.30	5886.51	5885.8	-0.75

These values revised by 2006 LOMR

Happy Canyon Creek Major Drainageway Plan

March 2014

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

DOUGLAS COUNTY COLORADO

CITY OF LONE TREE

Town of Parker COLORADO

Southeast Metro Stormwater Authority

MULLER

Reach 8 – Town of Parker

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

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

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

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

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

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

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

CLICK HERE TO VIEW REACH 8 MAP

CLICK HERE TO VIEW REACH 8 PROFILE

Green Acres Tributary

Compark Blvd.

Town of Parker

E-470

S. Chambers Rd.

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

DESIGN CONTOURS
FOR CHAMBERS
RESERVOIR PROJECT
(TYPICAL)

FUTURE ROAD ALIGNMENT

3' DROP
STRUCTURE

100-YEAR
FLOODPLAIN WITH
IMPROVEMENTS

FILL OVERBANK TO ELIMINATE
FLOODPLAIN EXPANSION

EXTEND 42" RCP

100-Year
Floodplain
(2014 FHAD)

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

E-470 Bike Path
Existing Double
24" CMP

E-470
Existing Single Span
Concrete Bridge

Existing Check
Structure

Existing 7' Deep
Check Structure

2' DROP
STRUCTURE

Existing 6' Deep
Check Structure

4' DROP
STRUCTURE

2' DROP
STRUCTURE

South Chambers Road
Existing Single Span
Concrete Bridge

Existing 5' Grouted
Boulder Drop

Existing 8' Deep
Check Structure

Existing Stonegate
Tributary 42" Pipeline

REACH 8

0' 100' 200' 400'

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

NAME: P:\12-010.01 Happy Canyon Creek MDP & FHAD UDFCD\Happy Canyon Creek MDP Technical Appendix\7 AUTOCAD FILES\Conceptual Design\12010HCC_MDP_PLAN.dwg

No.	DATE	REVISIONS	APPR.

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

DESIGN MDC
DRAWN SAR
CHECK JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

CONCEPTUAL DESIGN PLAN
REACH 8

DATE
MARCH 2014
FIGURE NO.

REACH 8

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

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

DOUGLAS COUNTY

Chambers Road
Single Span Concrete Bridge

E-470
Two Single Span Concrete Bridges

CONFLUENCE WITH STONEGATE TRIBUTARY

E-470 Bike Trail
Double 24" CMP

100-Year WSEL (2014 FHAD)

100-YEAR WSEL (MASTER PLAN)

Existing Channel Invert
Average Slope = 0.74%

Existing Channel Invert
Average Slope = 0.64%

3' DROP STRUCTURE

2' DROP STRUCTURE

3' DROP STRUCTURE

2' DROP STRUCTURE

3' DROP STRUCTURE

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

0.3%

Existing Check Structure

Existing 7' Deep Check Structure

DESIGN CHANNEL INVERT AT ASSUMED EQUILIBRIUM SLOPE

Existing 5' Grouted Boulder Drop

Existing 6' Deep Check Structure

Existing 8' Deep Check Structure

Existing 6' Deep Check Structure

Existing 6' Deep Check Structure

Existing 12" Sanitary Sewer (Approximate)

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

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

RIVER STATION (FT)

LEGEND

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

NOTE: ELEVATIONS SHOWN ARE BASED ON THE NAVD 88 DATUM

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

No.	DATE	REVISIONS	APPR.

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

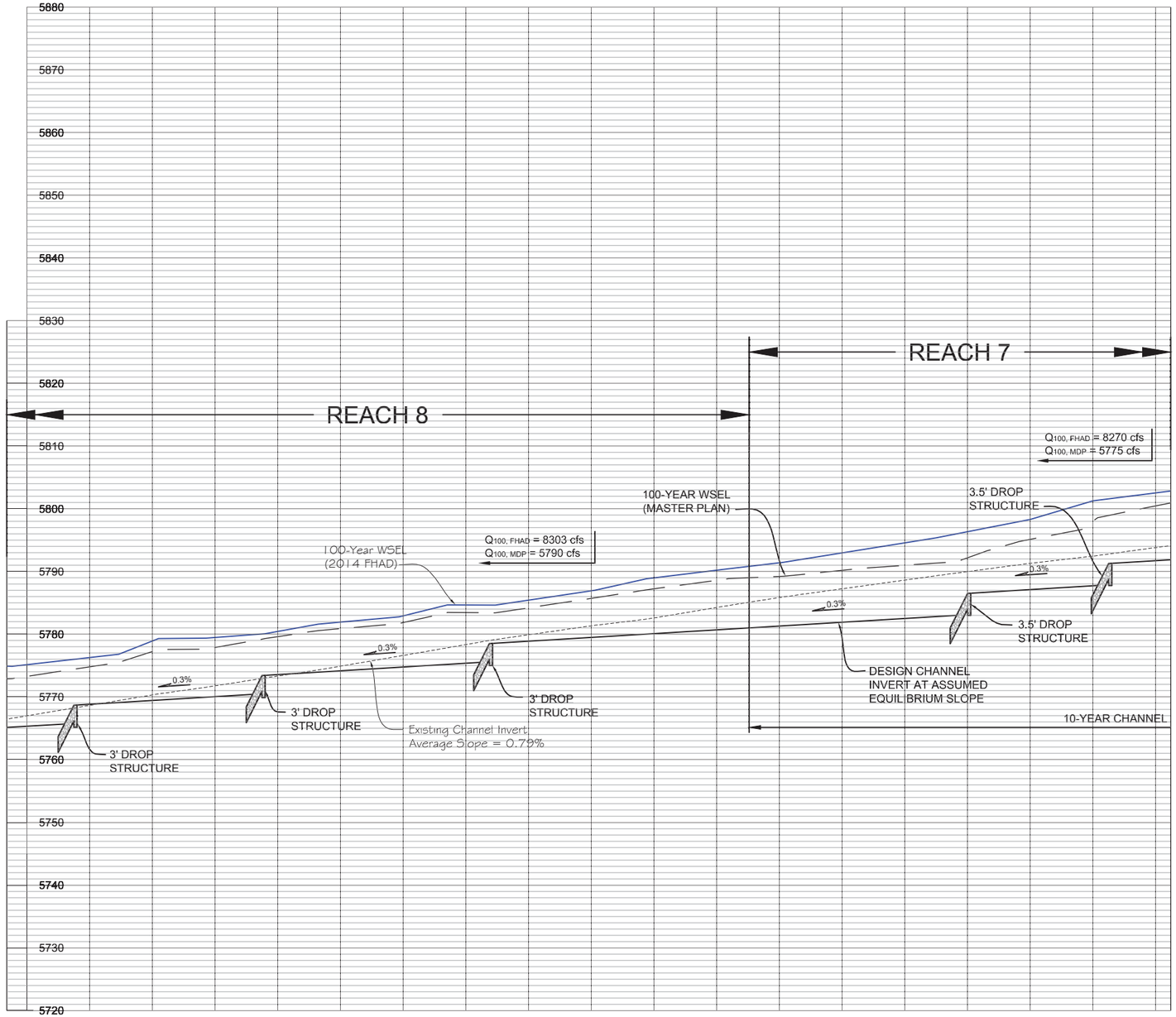
DESIGN	MDC
DRAWN	SAR
CHECK	JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

CONCEPTUAL DESIGN PROFILE
REACH 8 (1 OF 2)

DATE: MARCH 2014
FIGURE NO.

DATE: MAR 27, 2014 TIME: 4:32 PM
NAME: P:\12-010.01 Happy Canyon Creek MDP & FHAD UDFCD\Happy Canyon Creek MDP Technical Appendix\7 AUTOCAD FILES\Conceptual Design\12010HCC_MDP_PROFILE.dwg



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

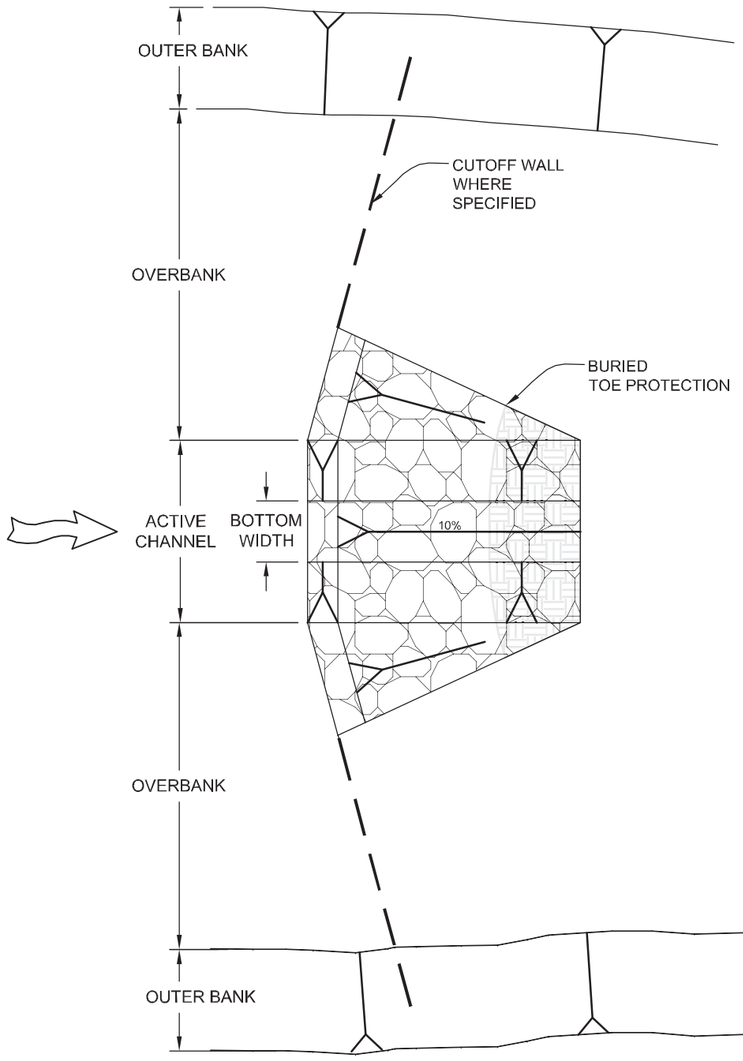
DESIGN MDC
DRAWN SAR
CHECK JTW

HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

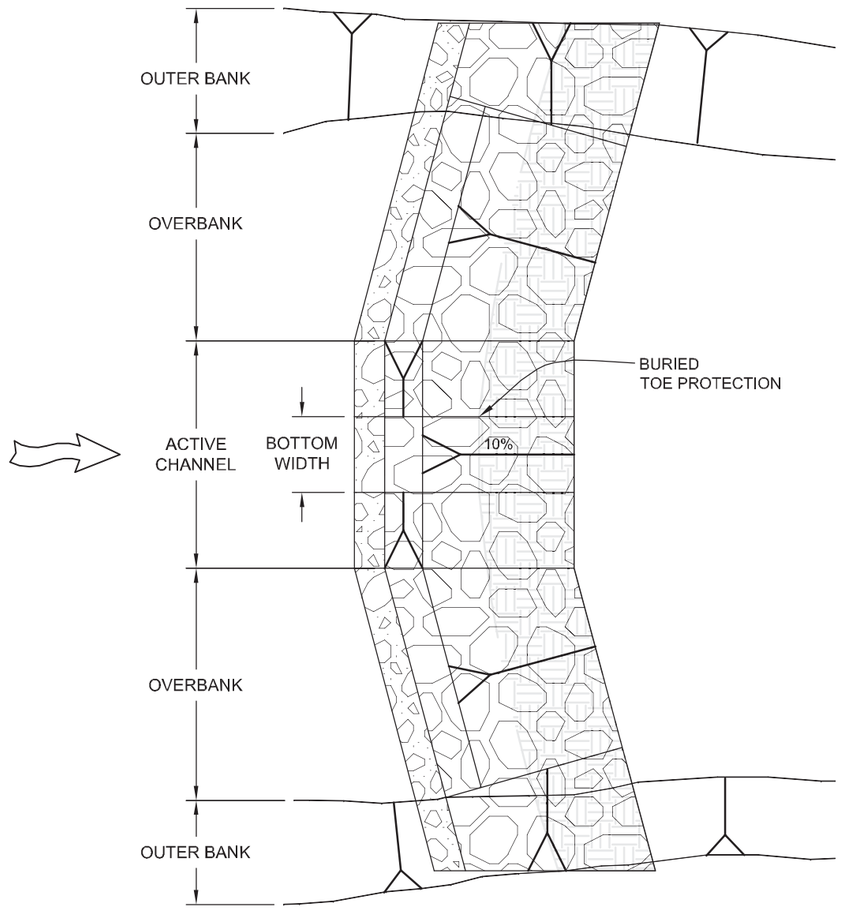
CONCEPTUAL DESIGN PROFILE
REACH 8 (2 OF 2); REACH 7 (1 OF 2)

DATE MARCH 2014
FIGURE NO.

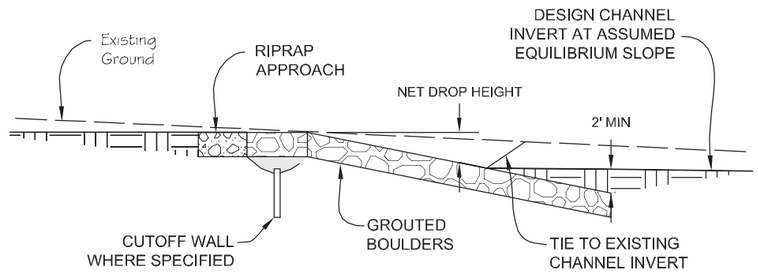
NAME: P:\12-010.01 Happy Canyon Creek MDP & FHAD UDFCD\Happy Canyon Creek MDP Technical Appendix\7 AUTOCAD FILES\Conceptual Design\12010HCC_MDP_PROFILE.dwg DATE: MAR 27, 2014 TIME: 4:33 PM



DROP STRUCTURE PLAN
LOW-FLOW



DROP STRUCTURE PLAN
FULL WIDTH



DROP STRUCTURE
PROFILE

No.	DATE	REVISIONS	APPR.

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

PROJECT NO. 12-010.01

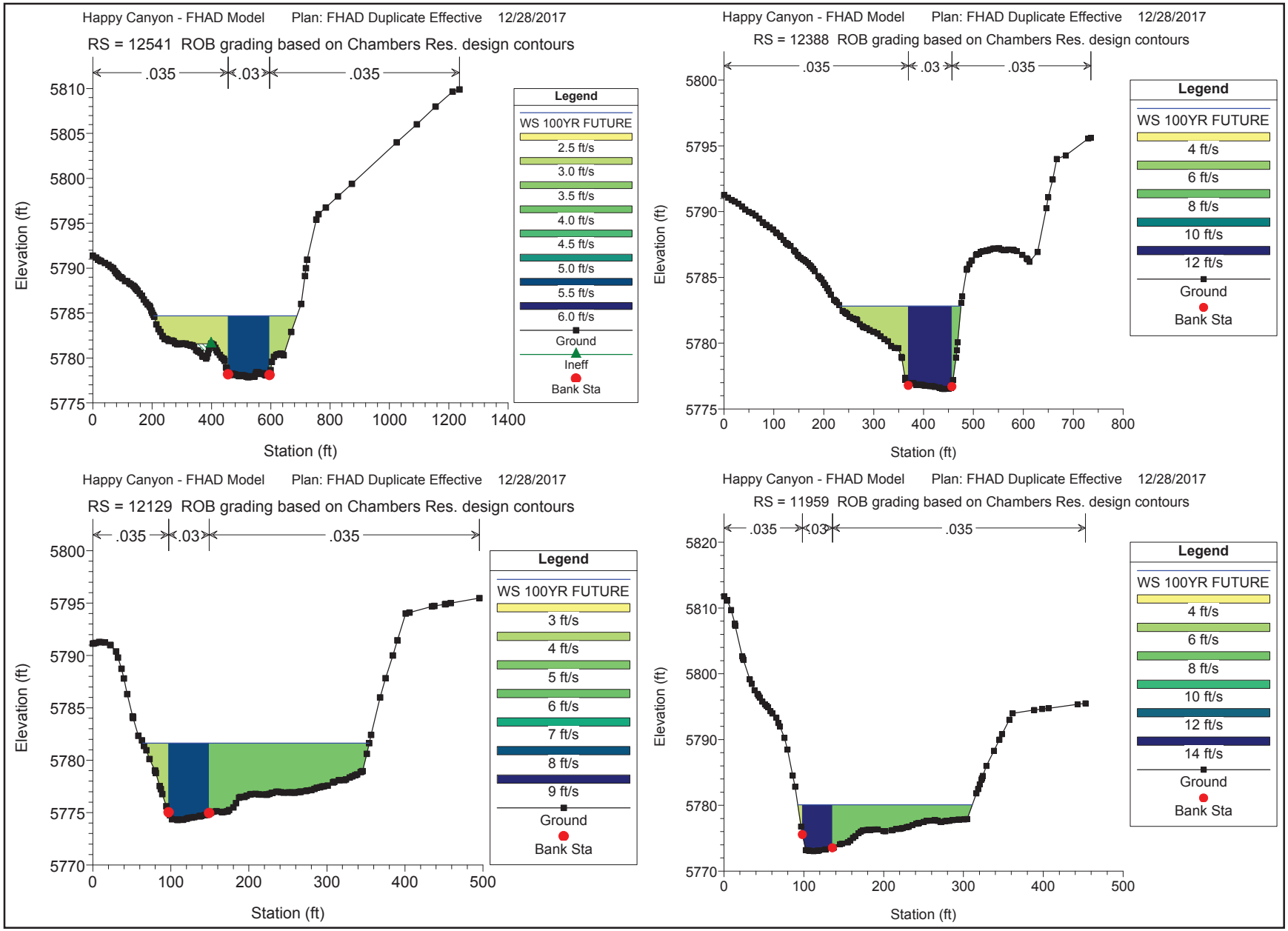
DESIGN	MDC
DRAWN	SAR
CHECK	JTW

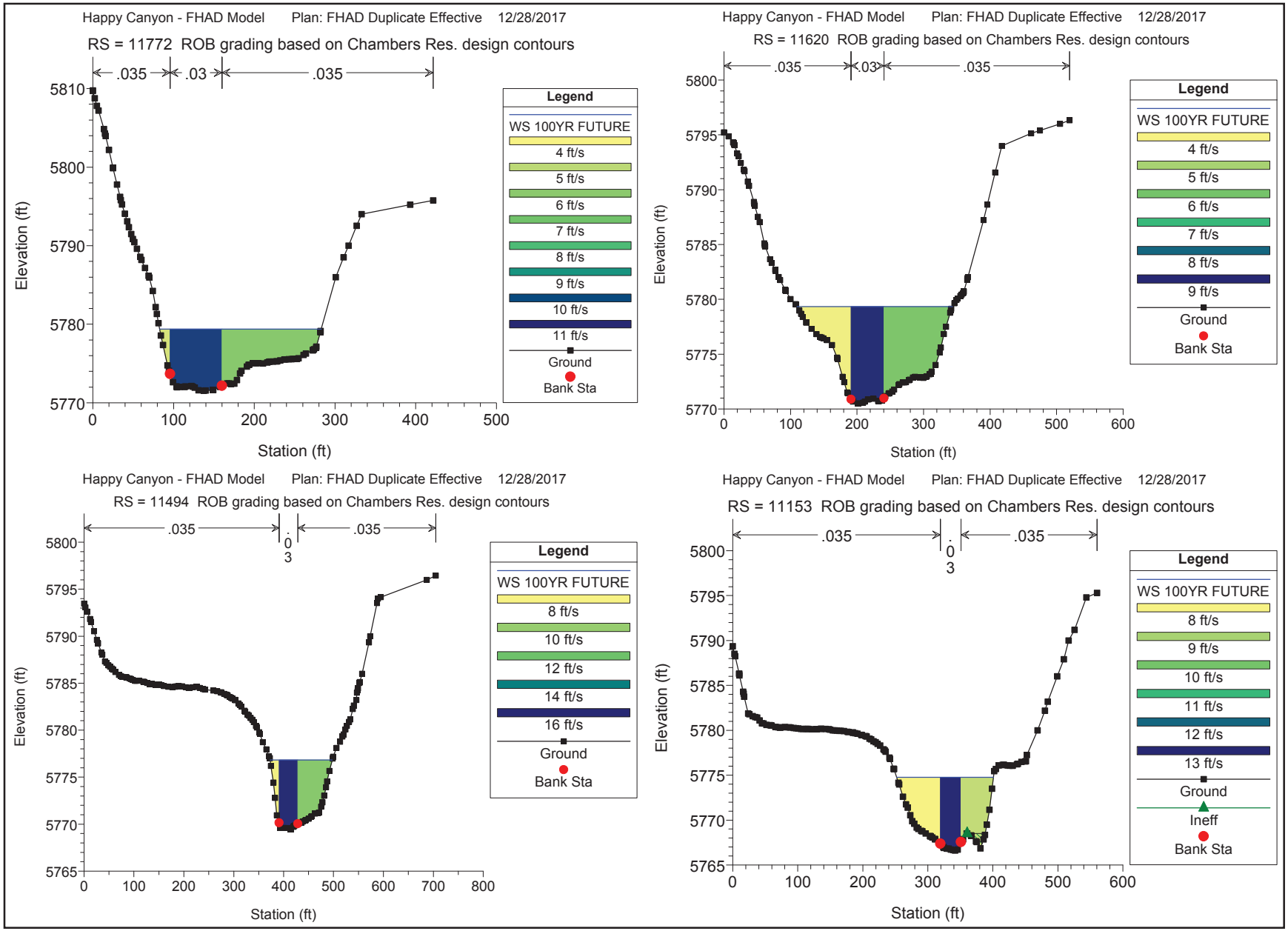
HAPPY CANYON CREEK
MAJOR DRAINAGEWAY PLAN

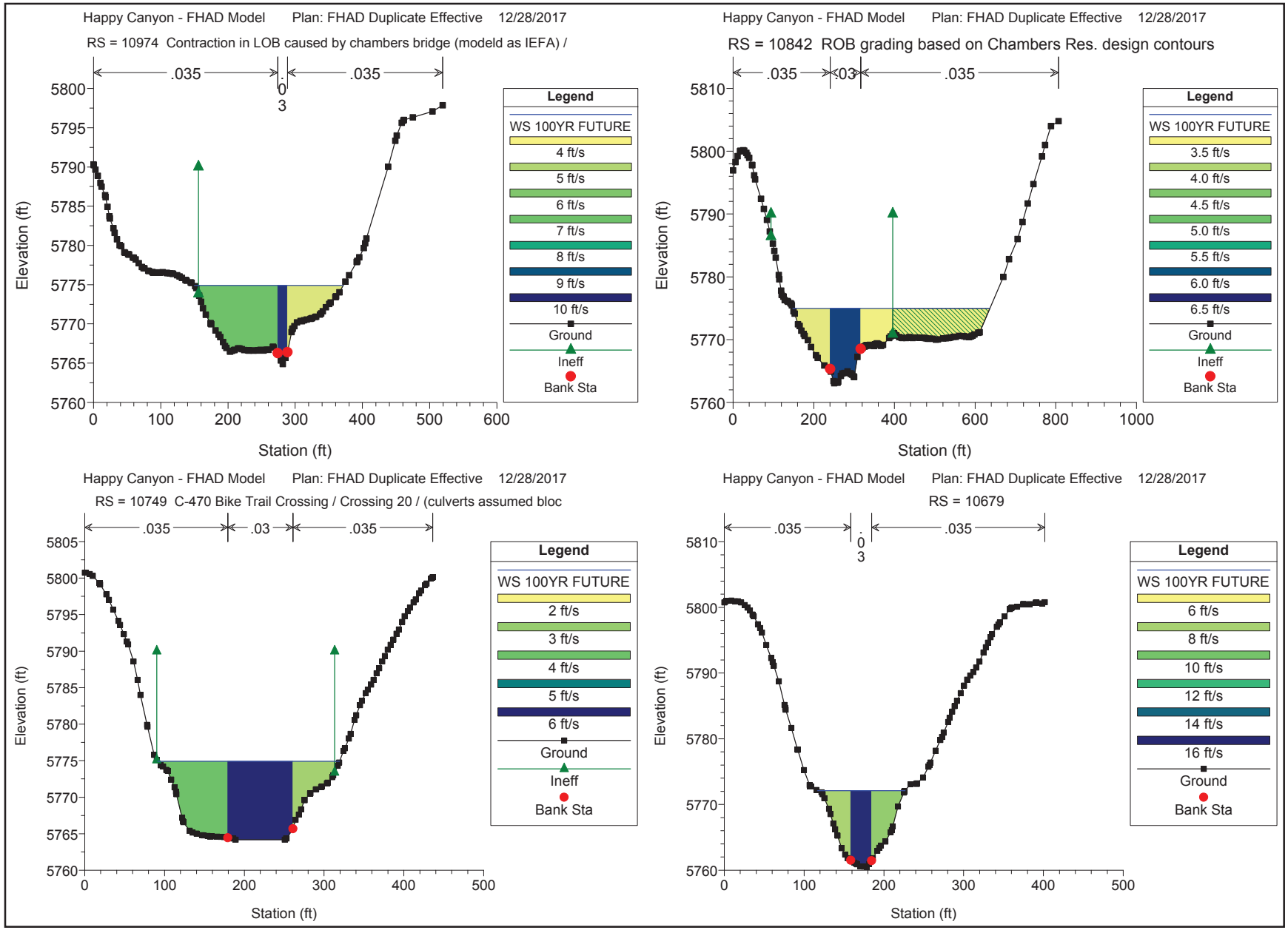
CONCEPTUAL DESIGN
TYPICAL DROP STRUCTURE DETAILS

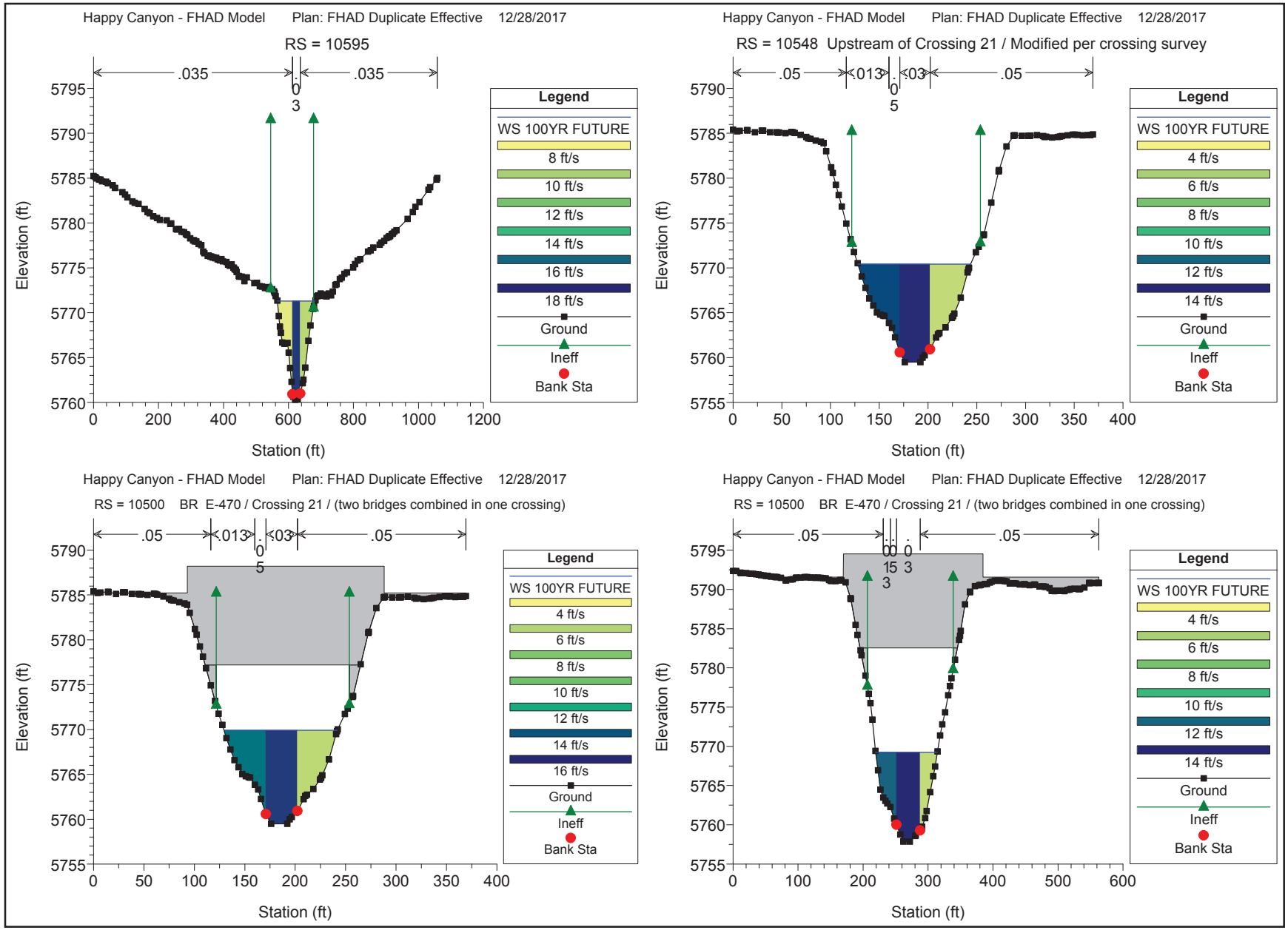
DATE: MARCH 2014
FIGURE NO. G-5

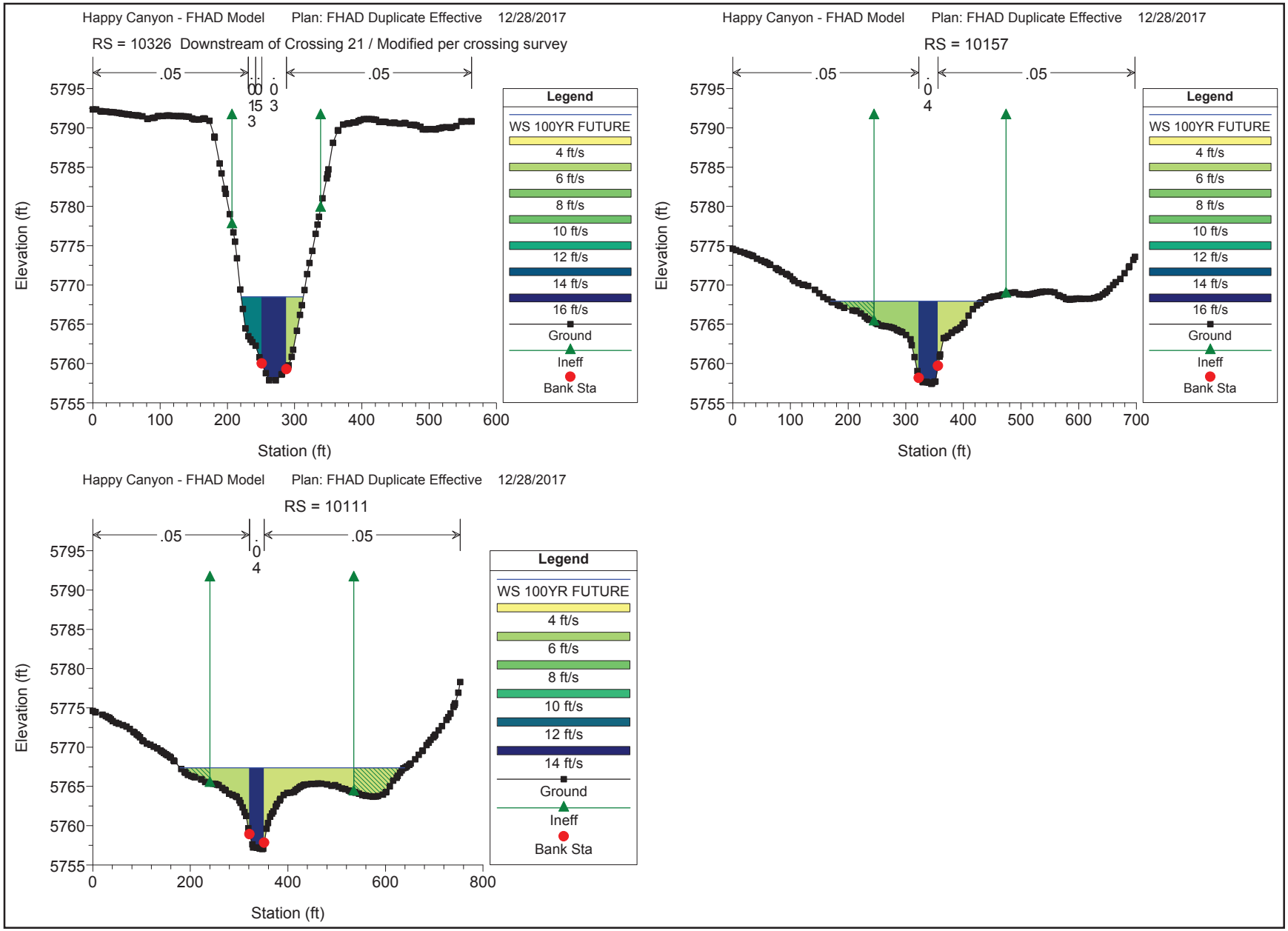
APPENDIX C. DUPLICATE EFFECTIVE MODEL (HEC-RAS MODEL)

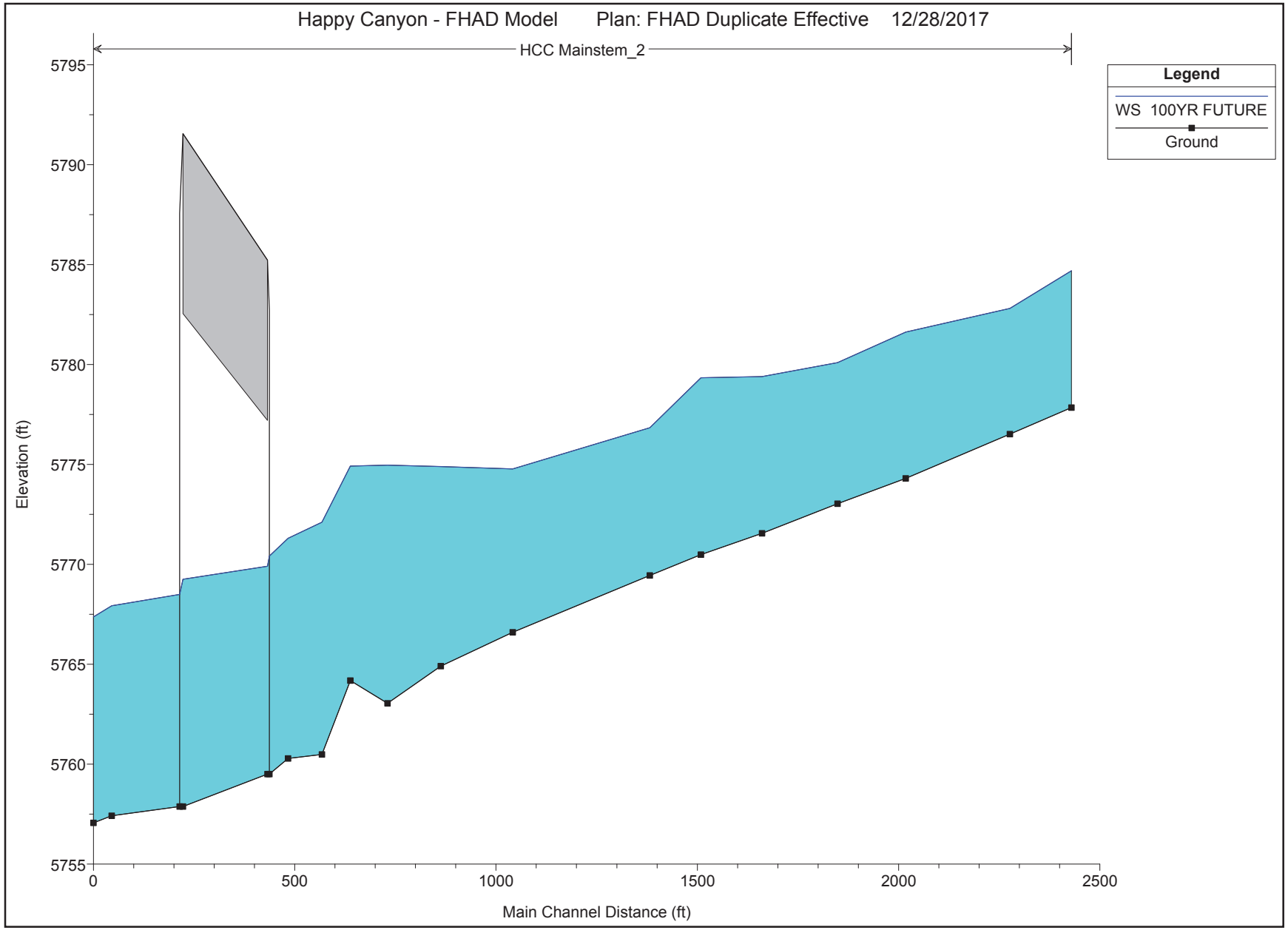

Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 12541 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
2.5 ft/s
3.0 ft/s
3.5 ft/s
4.0 ft/s
4.5 ft/s
5.0 ft/s
5.5 ft/s
6.0 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 12388 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 12129 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
3 ft/s
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 11959 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta


Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 11772 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
11 ft/s
Ground
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 11620 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
Ground
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 11494 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 11153 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
Ground
Ineff
Bank Sta


Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10974 Contraction in LOB caused by chambers bridge (modeld as IEFA) /
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
5 ft/s
6 ft/s
7 ft/s
8 ft/s
9 ft/s
10 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10842 ROB grading based on Chambers Res. design contours
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
3.5 ft/s
4.0 ft/s
4.5 ft/s
5.0 ft/s
5.5 ft/s
6.0 ft/s
6.5 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10749 C-470 Bike Trail Crossing / Crossing 20 / (culverts assumed bloc
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
2 ft/s
3 ft/s
4 ft/s
5 ft/s
6 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10679
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Bank Sta


Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10595
.035
.035
.0
3
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
18 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10548 Upstream of Crossing 21 / Modified per crossing survey
.05
.013
.0
5
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10500 BR E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.013
.0
5
.03
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10500 BR E-470 / Crossing 21 / (two bridges combined in one crossing)
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta

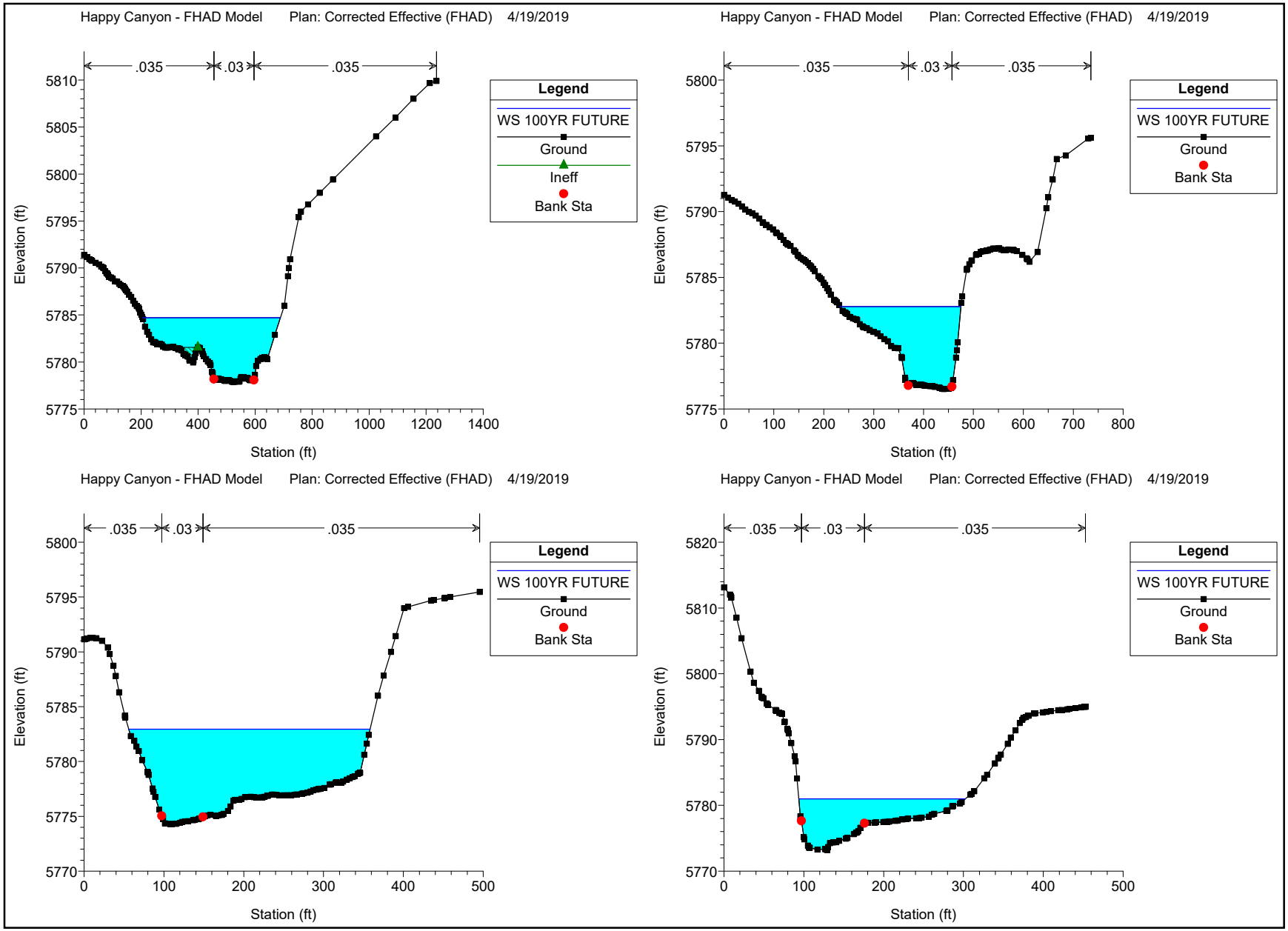

Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10326 Downstream of Crossing 21 / Modified per crossing survey
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10157
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Ineff
Bank Sta
Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
RS = 10111
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100YR FUTURE
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta


Happy Canyon - FHAD Model Plan: FHAD Duplicate Effective 12/28/2017
HCC Mainstem_2
Legend
WS 100YR FUTURE
Ground
Elevation (ft)
5795
5790
5785
5780
5775
5770
5765
5760
5755
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

HEC-RAS Plan: Dup Eff River: HCC Reach: Mainstem_2 Profile: 100YR FUTURE

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)	
Mainstem_2	10111	100YR FUTURE	8475.00	5757.06	5767.37	5767.37	5768.88	0.006080	13.31	1175.37	460.75	0.74
Mainstem_2	10157	100YR FUTURE	8475.00	5757.42	5767.93	5767.93	5770.22	0.007470	14.89	900.59	263.34	0.82
Mainstem_2	10326	100YR FUTURE	8475.00	5757.88	5768.50	5768.05	5771.58	0.004427	15.23	662.20	92.30	0.85
Mainstem_2	10500		Bridge									
Mainstem_2	10548	100YR FUTURE	8475.00	5759.50	5770.41	5769.60	5772.80	0.003288	13.62	781.50	115.79	0.74
Mainstem_2	10595	100YR FUTURE	8475.00	5760.29	5771.30	5771.30	5774.20	0.004959	17.00	719.36	116.92	0.91
Mainstem_2	10679	100YR FUTURE	8475.00	5760.49	5772.12		5774.61	0.003915	15.51	767.67	109.39	0.82
Mainstem_2	10749	100YR FUTURE	8355.00	5764.18	5774.91		5775.33	0.000606	5.89	1758.39	227.81	0.32
Mainstem_2	10842	100YR FUTURE	8303.00	5763.05	5774.97		5775.39	0.000700	6.11	1766.97	488.93	0.34
Mainstem_2	10974	100YR FUTURE	8303.00	5764.90	5774.90		5775.66	0.001946	9.55	1266.70	221.32	0.55
Mainstem_2	11153	100YR FUTURE	8303.00	5766.60	5774.78		5776.43	0.004287	12.84	864.20	148.85	0.81
Mainstem_2	11494	100YR FUTURE	8303.00	5769.44	5776.83	5776.83	5779.55	0.007225	15.63	676.32	124.59	1.03
Mainstem_2	11620	100YR FUTURE	8303.00	5770.49	5779.34		5780.12	0.001764	8.74	1306.82	233.63	0.52
Mainstem_2	11772	100YR FUTURE	8303.00	5771.55	5779.40		5780.57	0.002909	10.16	1054.05	200.27	0.66
Mainstem_2	11959	100YR FUTURE	8303.00	5773.03	5780.09	5780.09	5781.85	0.006149	13.74	884.80	218.85	0.93
Mainstem_2	12129	100YR FUTURE	8303.00	5774.30	5781.63		5782.26	0.001998	8.17	1408.13	290.17	0.54
Mainstem_2	12388	100YR FUTURE	8303.00	5776.52	5782.81	5782.81	5784.62	0.005234	11.95	892.48	242.94	0.85
Mainstem_2	12541	100YR FUTURE	8303.00	5777.84	5784.69		5785.03	0.001004	5.52	2022.16	483.35	0.38

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


Happy Canyon - FHAD Model Plan: Corrected Effective (FHAD) 4/19/2019
.035
.03
.035
Legend
WS 100YR FUTURE
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
Happy Canyon - FHAD Model Plan: Corrected Effective (FHAD) 4/19/2019
.035
.03
.035
Legend
WS 100YR FUTURE
Ground
Bank Sta
Elevation (ft)
Station (ft)
Happy Canyon - FHAD Model Plan: Corrected Effective (FHAD) 4/19/2019
.035
.03
.035
Legend
WS 100YR FUTURE
Ground
Bank Sta
Elevation (ft)
Station (ft)
Happy Canyon - FHAD Model Plan: Corrected Effective (FHAD) 4/19/2019
.035
.03
.035
Legend
WS 100YR FUTURE
Ground
Bank Sta
Elevation (ft)
Station (ft)