DP Application #2300342
NOTE: A newer, final version of this report approved under Grading Permit #2400583.

FINAL DRAINAGE STATEMENT
STARBUCKS COFFEE AND INNOVATION CORPORATE CENTER BLOCK 5
A PORTION OF NEIGHBORHOOD 3
RANCHO VISTOSO, ORO VALLEY
LOCATED WITHIN SECTIONS 31, T11S, R14E, G&SRM
TOWN OF ORO VALLEY, PIMA COUNTY, ARIZONA

PIMA COUNTY TAX ASSESSOR PARCEL: 219-20-9100
TOWN OF ORO VALLEY PROJECT NUMBER: 2300342

February 17, 2023
Revised September 19, 2023
Revised March 7, 2024
Revised April 29, 2024

PREPARED FOR:

VWI/VISTOSO DEVELOPMENT, INC.
6007 E. Grant Road
Tucson, Arizona 85712
Attn: Neil Simon
Tel: (520) 392-8835
Email: nsimon@venturewestaz.com

Registered Professional Engineer (Civil)
Certificate No. 16738
JOHN S. WISE
Date signed 4/29/24
ARIZONA U.S.A.

PREPARED BY:

THE WLB GROUP, INC.
4444 East Broadway Boulevard
Tucson, Arizona 85711
Phone: (520) 881-7480

PRINCIPAL INVESTIGATOR:
Erik Beam, CFM
Hydrologic/Hydraulic Designer

PLANS REVIEWED AND ACCEPTED FOR CODE COMPLIANCE

Stormwater: droberts 06/18/2024

The issuance of a permit shall not be construed to be a permit or approval of any violation of the codes or ordinances of the Town of Oro Valley

WLB Job No. 185050-VW30-0400

Q:\185050\VW-30 Inn Corp Ctr Block 5 Starbucks\03 Hydro\Word Documents185050\ DrnStment_STARBUCKS_APR2024.docx

This Drainage Statement is conditionally approved for the Development Plan. The comments on this drainage report shall be addressed in the drainage statement submitted with the improvement plans.

APPENDICES

APPENDIX	SECTION 1

Appendix A - Hydrologic Data
- NOAA 14 Rainfall
- Pre-Development Rational Worksheets
- Post-Development Rational Worksheets

Appendix B – Hydraulic Data
- Greenway Channel HEC-RAS Model (Existing)
- Greenway Channel HEC-RAS Model (Developed)
- StormCAD Worksheets
- Stormdrain Grate Inlet Worksheets
- Curb Opening Worksheets
- Culvert Worksheets
- Rip-Rap Splash Pad Worksheets

Appendix C – First Flush Filters & Manufacturer Specs.
- Triton First Flush Filters details, sizing, flow rates, and O&M
- Manufacturer Specifications Storm Pipe Installation

Figures
- Figure 1 – Location Map
- Figure 2 – FEMA Map
- Figure 3 – Onsite Pre-Developed Watershed Map
- Figure 4 – Onsite Post-Developed Watershed Map

April 29, 2024

David Laws, P.E.
Town of Oro Valley
11000 N La Canada Drive
Oro Valley, AZ 85737

Re: Drainage Statement for Starbucks Coffee and Innovation Corporate Center Block 5
WLB No. 185050-VW30-0400

Dear Mr. Laws,

This drainage statement has been prepared in support of the proposed design as shown on the Development Plan for Starbucks Coffee located in a portion of Block 5 of the Innovation Corporate Center, and on the mass grading plan for the balance of Block 5. The proposed Starbucks Coffee contains a gross area of approximately 3.35 acres (Phase 1) of the 5.79 acres of block 5 and is currently zoned for Rancho Vistoso P.A.D., Community Commercial C1 Land Use. This site is more specifically described as being a portion of Section 31, Township 11 South, Range 14 East, Gila and Salt River Meridian, Town of Oro Valley, Pima County, Arizona. The *"Drainage Report for a Portion of Neighborhood 3 in Rancho Vistoso (A.K.A. Innovation Corporate Center-East*" prepared by The WLB Group, dated May 11th 2006, revised February 19th 2007 (Oro Valley Case # OV12-13-029) and the "*Addendum #1 Drainage Report for a Portion of Neighborhood 3 in Rancho Vistoso (A.K.A. Vistoso Park Road*)" prepared by The WLB Group Inc., Oro Valley Case No. OV12-06-14, dated November 20, 2007, revised February 6, 2008 were utilized and followed for the Starbucks drainage analysis and design. Specifically, these reports are referenced to provide previous analyses for the Innovation Corporate Center (ICC) and existing Greenway Channel adjacent to the proposed project.

Storm water runoff that exits the Neighborhood 3 site is collected and conveyed south in the Greenway Channel to the 2 - 8'x5' existing RCBC's underneath Tangerine Road. These RCBC's are located at Station 788+39 of the Tangerine Road alignment. This existing structure receives a designed peak discharge for the 100-year event of 536 cfs, provided by The Arizona Department of Transportation (ADOT) Tangerine Road Improvement Plan. In a more recent "*Drainage Report for Lots 2A & 2B; Block 2 of Innovation Corporate Center*" prepared by The WLB Group, dated May 2016, revised date October 2016 states *"The Greenway discharges a peak flow discharge of 479.8* *cfs underneath Vistoso Park Road through 2-8'x5' RCBC's. The channel reaches a peak discharge of 710 cfs adjacent to the project site upstream of the 3-6'x4' RCBC's at Vistoso Park Road*". The 3-6'x4' RCBC's at Vistoso Park Road are located immediately upstream of the Starbucks project site, resulting in the Greenway Channel peak discharge of 710 cfs adjacent to project site, upstream of Tangerine Road. The increased flow results in a split flow of 263 cfs directed to the east while 447 cfs discharges through the existing RCBC (see attached HEC-RAS Models). These culverts discharge directly into Rancho Vistoso Neighborhood 4. The total of these storm water flows are ultimately intercepted by the Big Wash located approximately less than one-half mile to the southeast. Block 5 will be mass graded along with all infrastructure for the site. The Starbucks coffee shop will be the only project constructed for this site. Future building pads will be developed at a later date.

HYDROLOGIC RESULTS

As a result of the grading, the watershed boundaries have been modified. When these watersheds were initially analyzed (May 2012), they were modeled using the Rational Method and rainfall depths accepted by The Town of Oro Valley. The Town of Oro Valley now uses rainfall depths derived from the Upper Bound of the 90% confidence interval from NOAA Atlas 14. This data is available from NOAA's National Weather Service Hydrometeorological design studies center precipitation frequency data server, which relies on the latitude and longitude of the project site.

As shown on Figure 3, there is one existing offsite watershed (CP OS1) discharging onto Block 5 from an existing storm drain. For the purposes of hydraulic design, the existing Offsite (OS1) and existing concentration point 1E (SE corner of Block 5 at Greenway Channel) have been modeled using NOAA 14 rainfall data. Under existing conditions, the site has a vegetative covering of approximately 25 percent of grass and brush. The impervious cover has been estimated to be 10%. The soils of Neighborhood 3 of Rancho Vistoso consist of 100 percent soil series Comoro Sandy Loam. According to the U. S. Soil Conservation Service the Comoro Sandy Loam soil series is a part of Hydrologic Soil Group B. CP 1E includes CP OS1 in the development of the onsite existing discharge values. The estimated watershed areas, with corresponding 2-, 10-, 50- and 100-year peak discharge rates, for each proposed concentration point are summarized in the table on the following page.

Table of Pre-Developed 2-, 10-, 50-, and 100-Year Discharges					
Conc. Point	**Drainage Area (ac)**	**2-Year (cfs)**	**10-Year (cfs)**	**50-Year (cfs)**	**100-Year (cfs)**
1E	8.7	7.3	25.2	44.9	53.9
OS1	1.3	3.7	6.4	9.1	10.3

As shown on Figure 4, there is 1 major watershed located at the southeast corner of Block 5 at Greenway Channel. There are a total of 7 subwatersheds defined by these concentration points and range in size from 0.13 acres to 7.3 acres with corresponding 100-year peak discharge rates ranging from 0.9 cfs to 59.2 cfs. Runoff coefficients ranging from 0.77 to 0.92, imperviousness factors from 20 to 90 percent, and a vegetative cover density of 25 percent were used to model developed conditions. The numbering scheme is built in such a fashion as to designate sub-basins (CP 1.1 is a sub-basin of CP 1.0, etc.). All upstream sub-watershed areas that contribute to the downstream sub-watershed concentration point have been calculated using the combined total area of the sub-watersheds including the remaining areas (See Figure 4 – Development Watershed Map). Any sub-watersheds that require hydraulic structures (i.e. culverts, grates, curb openings, etc.) are defined in greater detail in the Table of Hydraulic Structures which follows in the Hydraulic Results section of this report. The estimated watershed areas, with corresponding 2-, 10-, 50- and 100-year peak discharge rates, for each proposed concentration point are summarized in the table below.

Table of Post Developed 2-, 10-, 50-, and 100-Year Discharges					
Conc. Point	**Drainage Area (ac)**	**2-Year (cfs)**	**10-Year (cfs)**	**50-Year (cfs)**	**100-Year (cfs)**
1.0	7.3	21.8	36.8	52.3	59.2
1.1	1.47	5.6	8.5	11.6	13.0
1.2	0.77	2.3	3.9	5.5	6.3
1.3	1.30	5.0	7.6	10.3	11.5
1.3a	0.50	1.9	2.9	4.0	4.4
1.4	0.13	0.2	0.5	0.7	0.9
1.5	2.17	3.0	7.6	12.5	14.6
1.6	0.77	1.4	3.0	4.7	5.4
1.7	0.15	0.6	0.9	1.2	1.4

HYDRAULIC RESULTS

The following tables are found in this section:

- Table of Hydraulic Structures

See the Post-Developed Watershed Map (Figure 4) for watershed delineations, floodplains, erosion hazard setbacks, concentration points, and hydraulic structure locations.

The project site is located within a critical basin as designated by the Town of Oro Valley; therefore 1 hr-100 yr stormwater detention would typically be required onsite. However, this site resides within a watershed that has a regional detention basin that has been designed for the post developed detention volumes and associated credit for this watershed (Tangerine Road Sta 788+39; 2-8'x5' RCBC's) within Neighborhood 3. This basin was constructed with the first phase (Innovation Corporate Center East Bk. 63 Pg. 16; Vistoso Park Road Bk. 63, Pg 17; and The Greenway Channel) of construction for the proposed development of Neighborhood 3. The basin includes a constructed berm located at the northeast corner of the proposed Innovation Corporate Center-East development adjacent to the Greenway Channel. This basin satisfies the Town's requirement for detention storage and has been constructed per the "*Drainage Report for a Portion of Neighborhood 3 in Rancho Vistoso (A.K.A. Innovation Corporate Center-East*" prepared by The WLB Group, dated May 11th, 2006, revised February 19th, 2007). The remaining areas of Block 5 will be mass graded except the driveway access from Starbucks to Vistoso Park Drive. All Hydraulic structures have been designed for future development discharges (See attached Figure 4).

The post-developed watersheds for this project will consist of several sub-watersheds. A large portion of each sub-watershed's runoff will discharge through catch basins or curb openings and into the stormdrain (Run A) which discharges directly into the Greenway Channel located east of the property boundary (see attached Figure 4). The runoff within the Starbucks Coffee site will discharge through curb openings and to a 24" SRP located under the entrance. This 24" culvert discharges directly into the Greenway Channel. The following table summarizes and further explains the remaining drainage structures for this development:

TABLE OF HYDRAULIC STRUCTURES		
CONC. PT.	**Q100 (cfs)**	**STRUCTURE**
1.1	13.0	Type 4 Catch Basin w/6 EF-1 Grates (rated for 0.5’ depth above grates); 1-36” SRP, 92.46 LF @ 0.59% Slope, HW=3.1’ (SD Run A) Triton First Flush Filter insert in CB (see Appendix C)
1.2	6.3	Type 4 Catch Basin w/2 EF-1 Grates (rated for 0.5’ depth above grates); 1-18” SRP, 35.22 LF @ 0.57% Slope, HW=2.3’ (SD Run A) Triton First Flush Filter insert in CB (see Appendix C)
1.3	11.5	Type 4 Catch Basin w/4 EF-1 Grates (rated for 0.5’ depth above grates); 1-24” SRP, 67.10 LF @ 0.6% Slope, HW=2.2’ (SD Run A) Triton First Flush Filter insert in CB (see Appendix C)
1.3a	4.4	4’ wide Curb Opening w/6” Curb Reveal
1.4	0.9	Type 5 Catch Basin w/1 EF-1 Grates (rated for 0.5’ depth above grates); 1-30” SRP, 220.8 LF @ 0.56% Slope, HW=1.8’ (SD Run A) Triton First Flush Filter insert in CB (see Appendix C)
1.5	14.6	1-24” SRP, 105 LF @ 0.3% Slope, HW=2.06’
1.6	5.4	Type 4 Catch Basin w/2 EF-1 Grates (rated for 1’ depth above grates); 1-18” SRP, 43.1 LF @ 1.0% Slope, HW=2.2’ (SD Run A) Triton First Flush Filter insert in CB (see Appendix C)
1.7	1.4	1’ wide Curb Opening w/6” Curb Reveal

Note: CP 1.5 - SRP will have a smooth interior and adhere to TOV DCM Chapter 6.2 subsections 3 and 4. The revised Culvert Slope has a new slope of 0.3%, and HW depth of 2.06 for 14.6 cfs (Q100). However, the inlet invert is elevated 4" above the bottom for upstream water harvesting. Therefore, the HW can be reduced by 0.25', satisfying TOV DCM 7.1.2.

Storm Drain Design – StormCad is utilized to design storm drain systems, which provides design profiles for each storm drain, and provides hydraulic parameters, such as HGL and EGL.

Floodplain Modeling

The Greenway Channel discharges a portion of Neighborhood 3 to the 2-8'x5' existing RCBC's underneath Tangerine Road. This RCBC is located at Station 788+39 of the Tangerine Road alignment. The intent of this analysis is to evaluate the floodplain boundaries and impacts to the project site as defined by HEC-RAS models. All new buildings and equipment will be elevated at a minimum of 1 foot above the adjacent 100-year water surface elevations. The existing onsite floodplains are incised riverine flows consisting of channel washes and braids. Using these peak flow discharge values, 2021 photogrammetric topography (NAVD), and the cross-sections, the WLB Group Inc. has determined the 100-year water surface elevations (WSEL) and floodplains. Impacts of the proposed development on the floodplains and the associated 50-foot erosion hazard setback boundaries are identified.

Due to the new increased discharge (710 cfs) and topography, a new HEC-RAS model has been prepared modeling flows from Vistoso Park Road to Tangerine Road (See Figures 3 and 4). The increased flows result in a split flow which occurs immediately upstream of the existing RCBC at Tangerine Road. An estimated 263 cfs flows to the east along Tangerine Road to the existing RCBC located near the Securaplane Development, while 447 cfs discharges through the existing RCBC and into Neighborhood 4 (Oro Valley Marketplace). These flows will merge together again in a stormwater management basin located within the Oro Valley Marketplace development, adjacent to the south Tangerine Right-Of-Way Boundary. The headwater elevation of 2686 creates a backwater onto Block 5 to the static elevation, therefore the Block 5 area was modeled as ineffective flow.

<u>First Flush</u>

First flush is being provided in the storm drain systems with the installation of the Triton Catch Basin inserts produced by Revel Environmental Manufacturing Inc. The filter inserts are inserted into a catch basin to remove sediment, oil, and debris from urban runoff.

Each major concentration point location which discharges directly off the parking lot pavement surfaces will require this filter or a similar one to minimize non-point source pollutants that enter into the drainage ways and ultimately into the town's natural watercourses. These filters will capture and eliminate pollutants that adhere to the pavement surface, such as hydrocarbons and other contaminants (metals, sand, silt and litter) from stormwater runoff. The filter is a non-reactive High

Impact Polystyrene plastic construction with U.V. inhibitors. The exterior side of the filter is constructed with Type 304 Stainless Steel and can be easily removed for maintenance. The media is non-hazardous, per EPA and OSHA standards, and is easily installed into new and existing catch basins. These filters also meet Best Available Technology (BAT) for use in stormwater Best Management Practices (BMP). More detailed information on the Triton Filter Inserts is provided in Appendix C.

First flush basin filter inserts are intended to reduce the amount of pavement surface contaminants discharged from the project site during the first half-inch depth of runoff over the entire parking lot paved surface. Regular Maintenance inspection and/or replacement will be required for any storm event exceeding the 10-year event. These first flush devices shall be inspected and maintained according to manufacturers' recommendations. See Appendix C for manufacturer specifications.

Stormdrain Maintenance

Per Section 7.1.9 of the TOV Drainage Criteria Manual stormdrain systems are required to have routine maintenance and inspection to ensure adequate performance for the life of the stormdrain system. The stormdrain will be inspected after every major storm event and cleared of all organic and inorganic debris. The stormdrain shall be cleaned and cleared of any sedimentation accumulated in the stormdrain, or once every 24 months, whichever occurs first. Finally, inspection of the stormdrain and maintenance records is to occur on an annual basis with copies submitted to the Town of Oro Valley for their records.

WATER HARVESTING BASIN MAINTENANCE:

Any onsite water harvesting basins are required to have routine maintenance and inspection to ensure adequate performance for the life of the basin. The basins are required to be inspected after every major storm event and cleared of all organic and inorganic debris. The basins shall be cleaned after 6" of sediment has accumulated on the bottom, or once every 24 months, whichever occurs first. Finally, inspection of the basin and maintenance records is to occur on an annual basis.

Erosion Control

The erosion protection methods and structures proposed include riprap splash pads. The riprap and structure sizing were determined utilizing the AASHTO RDG Manual and the FHWA Hydraulic Toolbox v. 4.2 (HEC-14), 3rd edition Manual. Permanent erosion protection will be installed at the outlet of each hydraulic structure (culvert, channels, etc.). Riprap is required at all curb openings, scupper and culvert outlets, and constructed channel outlets. Some of the approved erosion protection methods and structures used are riprap splash pads and preformed scour holes, concrete and/or gunite lining, revegetation and vegetative lining, stormwater management (detention) basins, and the preservation of natural channels. The riprap splash pads will utilize hand-placed rock based on the applicable D_{50} rock size.

Sedimentation

The impact of erosion and sedimentation is evaluated on the ability of the proposed culvert to function as designed, minimizing culvert maintenance while reducing the impact of culverts on upstream and downstream erosion/sedimentation. To minimize the probability of sediment deposition within the culverts, the design for each culvert/stormdrain headwater elevations will be at or below the existing water-surface elevation on the upstream side of structures. The existing velocity of approach flows will be essentially maintained. During the more frequent flow events, the velocity of flow through structures exceeds the existing velocity of approach flows and the downstream tailwater elevation will be at a minimum; thus, sedimentation in the culvert should not be a significant problem. However, during the less-frequent flow events and during the 100-year event, some sedimentation at the inlet and inside of the culvert can be expected and will need to be addressed as part of regular maintenance.

Stormwater Pollution Prevention Plan (SWPPP)

A Stormwater Pollution Prevention Plan (SWPPP) is a report of Best Management Practices (BMPs) planned for the project and includes: a revegetation and/or soil stabilization plan, an implementation and maintenance plan for the SWPPP, and the location of the BMPs or sediment control devices. The SWPPP guidelines are supplied by the National Pollutant Discharge Elimination System (NPDES) and the Arizona Department of Environmental Quality (ADEQ).

Projects authorized under the Construction General Permit (CGP) will be required to supply a Notice of Intent (NOI) letter and a SWPPP. The SWPPP required under the CGP will be submitted (under separate cover) for this project when the final layout and design has been completed. Projects authorized under the Multi-Sector General Permit (MSGP) will be required to supply portions of the Notice of Intent (NOI) letter and a SWPPP under the MSGP.

CONCLUSIONS

1. The site is a proposed commercial development located in The Town of Oro Valley. The site is largely surrounded by existing commercial and office developments and a hospital.
2. The site is located adjacent to as well as partially within a regulatory floodplain (Greenway Channel) and all new structure Finish Floor Elevations are required to be elevated a minimum of 1 foot above the 100-year WSEL. The 100-year WSEL was determined to be 2686.0. The proposed FFE is 2692.25, thereby providing adequate freeboard and associated FFE.
3. A Floodplain Use Permit is required by the Town of Oro Valley.
4. The onsite runoff is designed to flow away from the proposed building and collected in either proposed onsite water harvesting basins or exit the site through stormdrains and culverts.
5. The Town's detention volume requirement is satisfied per the detention credit available due to the site location within a watershed that has a regional detention basin which is designed to include the post developed detention volumes from the project watershed.

The proposed project has been analyzed within this report and a workable drainage concept has been developed. This concept will provide for the safe and efficient collection and conveyance of all onsite generated runoff. Development of this project, in accordance with the drainage design, will not produce adverse effects for adjacent or downstream property owners. However, deviation in construction from the Development Plan and Improvement Plans, which have been and will be based upon this drainage report, may nullify the conclusions of this report, as may variations in climatic conditions, vegetation and erosion/deposition.

If you should have any further questions or comments, please contact John Wise or me at 881-7480.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
16738
JOHN S.
WISE
4/29/24
Date signed
ARIZONA U.S.A.

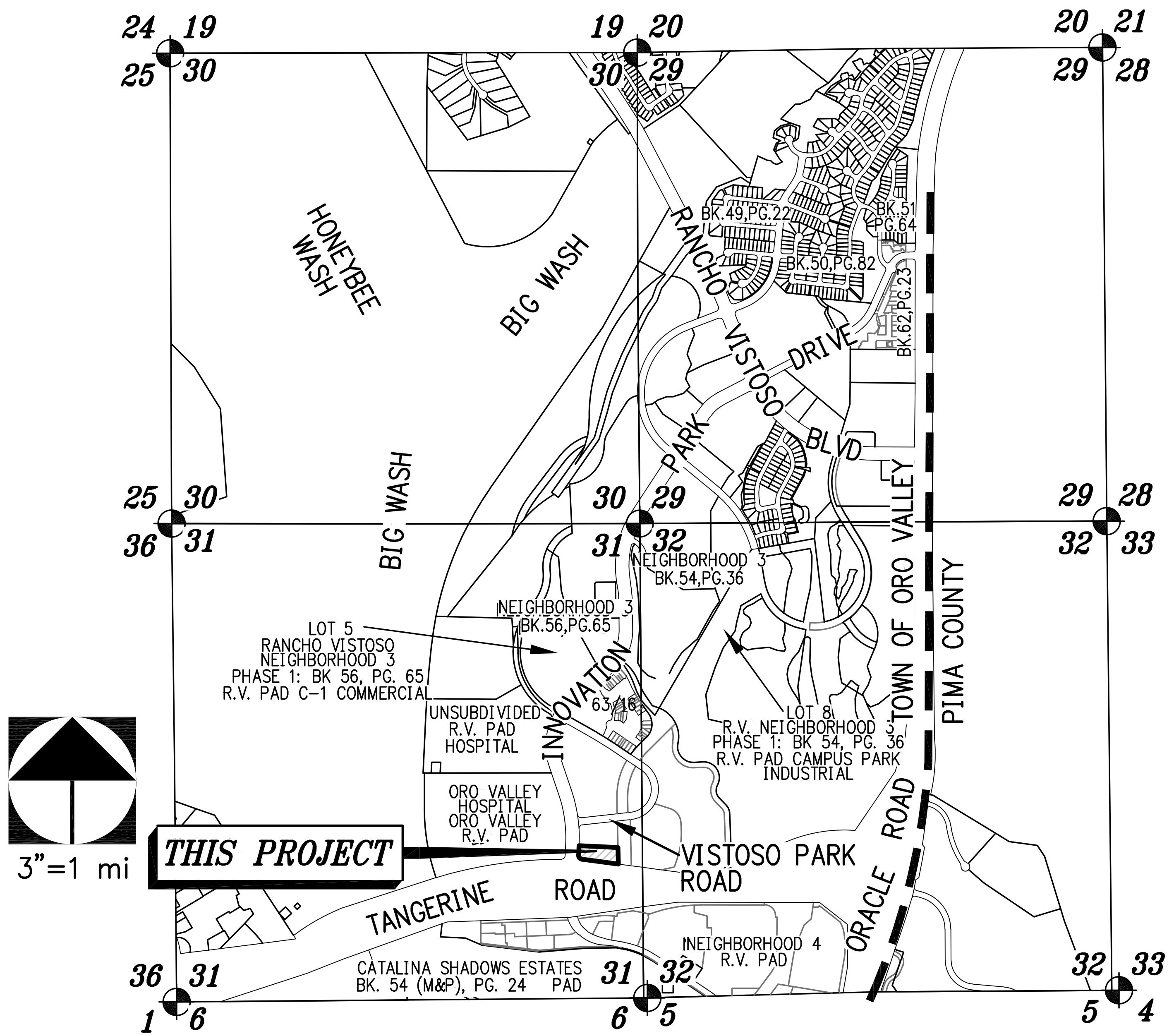
Sincerely,

The WLB Group, Inc.

Erik Beam

Erik Beam, CFM
Hydrologic/Hydraulic Designer

Figure 1: Vicinity Map



LOCATION MAP FOR

A PORTION OF BLOCK 5 OF RANCHO VISTOSO, NEIGHBORHOOD 3 INNOVATION CORPORATE CENTER, BLOCKS 1-6 RECORDED IN BOOK 63, MAPS & PLATS, PAGE 17.

BEING A PORTION OF SECTION 31,
T-11-S, R-14-E, G.&S.R.M.
TOWN OF ORO VALLEY, PIMA COUNTY, ARIZONA

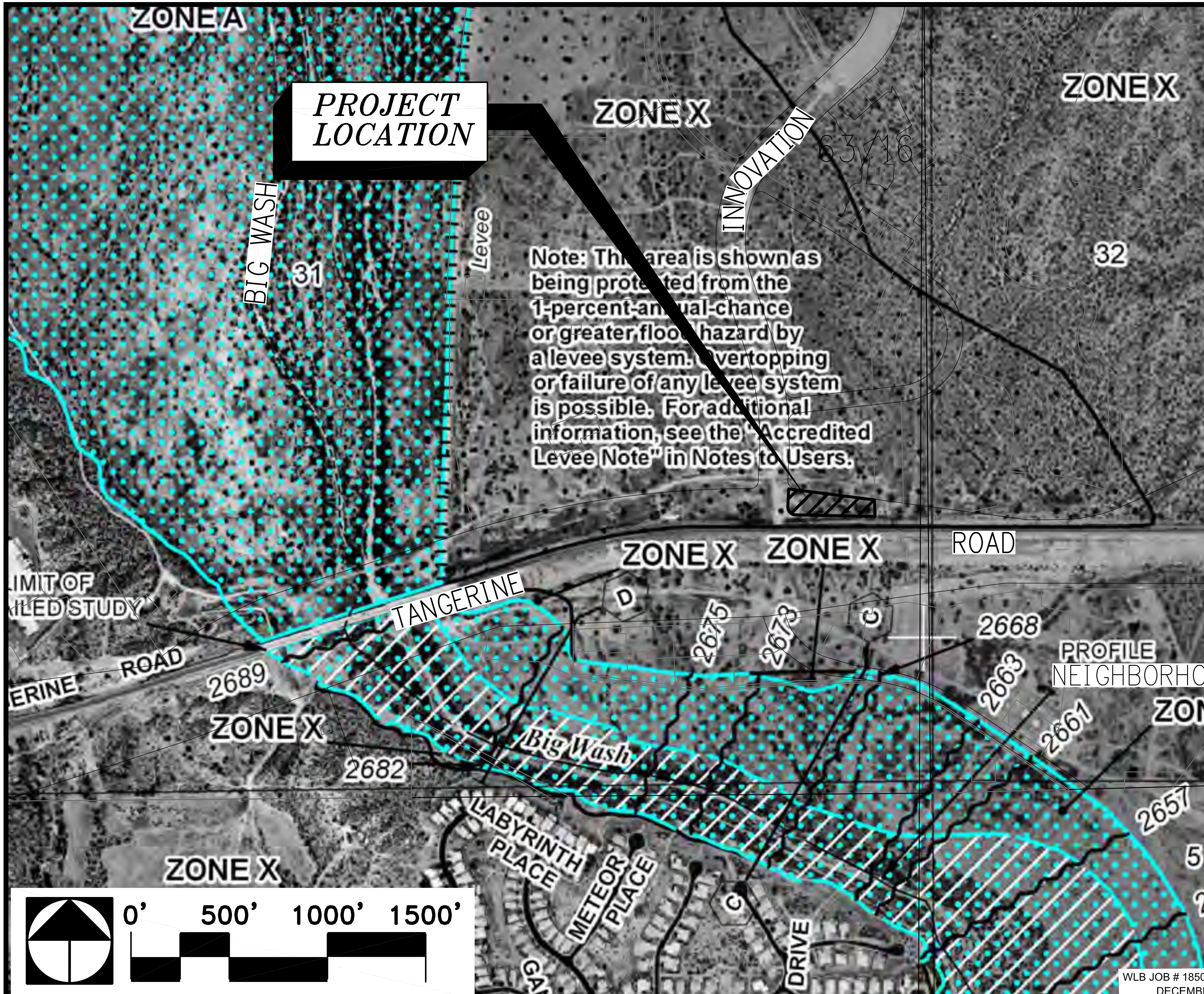
The WLB Group INC.

WLB

Offices located in Tucson, Phoenix,
Flagstaff and Las Vegas, NV
4444 East Broadway
Tucson, Arizona 85711 (520) 881-7480

LOCATION MAP
FIGURE 1

Figure 2: FIRM (Flood Insurance Rate Map)



NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1090L

FIRM

FLOOD INSURANCE RATE MAP

PIMA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 1090 OF 4750

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ORO VALLEY, TOWN OF	040109	1090	L
PIMA COUNTY	040073	1090	L

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
04019C1090L

MAP REVISED
JUNE 16, 2011

Federal Emergency Management Agency

FIRM MAP
BLOCK 5
RANCHO VISTOSO NEIGH. 3
INNOVATION PARK DRIVE
TOWN OF ORO VALLEY,
PIMA COUNTY, ARIZONA
FIGURE 2

WLB JOB # 185050-VW30-0400
DECEMBER 2022

Q:\185050\VW-30 Inn Corp Ctr Block 5 Starbucks\03 Hydro\Exhibits\FIG2-FEMA.dwg Plotted: Dec 12, 2022

Figure 3: Onsite Pre Developed Watershed Map

TABLE OF PRE-DEVELOPED PEAK DISCHARGES					
CONC. PT	DRAINAGE AREA (ac)	Q_2 (cfs)	Q_{10} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
1E	8.7	7.3	25.2	44.9	53.9
OS1	1.3	3.7	6.4	9.1	10.3

LEGEND

- WATERSHED BOUNDARY
- EXISTING MAJOR CONTOUR (2350)
- EXISTING MINOR CONTOUR
- 100-YEAR FLOODPLAIN LIMIT
- 10-YEAR FLOODPLAIN LIMIT
- 25' EROSION HAZARD SETBACK
- HEC-RAS CROSS SECTION (1, WSEL=3008.2)
- PROPERTY BOUNDARY
- CONCENTRATION POINT (1E)
- FLOW DIRECTION

0' 40' 80' 120'

CONTOUR INTERVAL = 1'

The WLB Group INC.

WLB

Engineering Planning Surveying Landscape Architecture Urban Design Offices located in Tucson, Phoenix, and Flagstaff, Arizona, and Las Vegas, Nevada 4444 East Broadway Boulevard, Tucson, Arizona 85711 (520) 881-7480

ONSITE PRE-DEVELOPED WATERSHED MAP

STARBUCKS COFFEE

BLOCK 5 OF INNOVATION CORPORATE CENTER

TOWN OF ORO VALLEY, ARIZONA

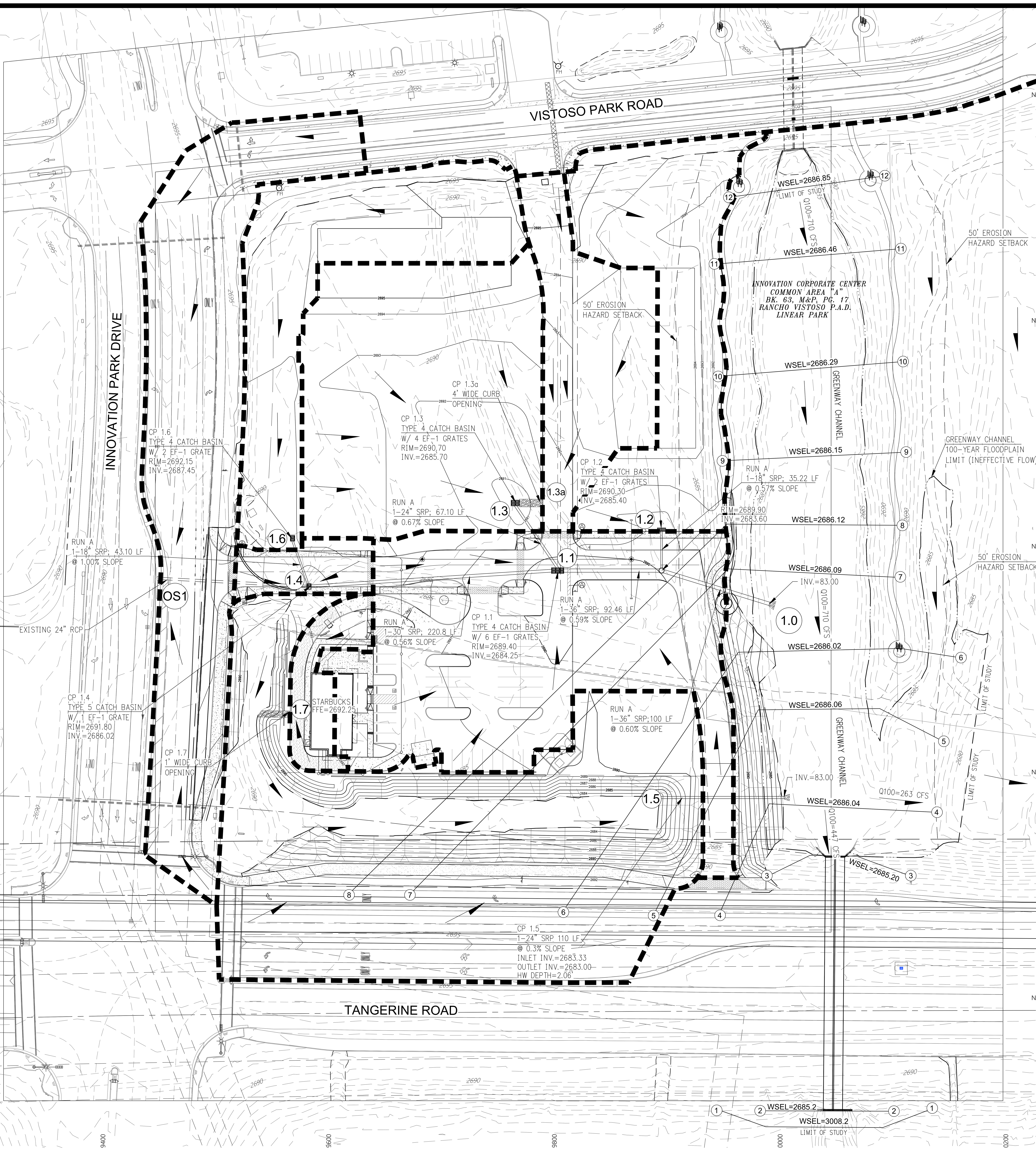
FIGURE 3

WLB JOB # 185050-VW30-0400

JANUARY 2023

Q:\185050\VW-30 Inn Corp Ctr Block 5 Starbucks\03 Hydro\Exhibits\FIG3_EX.dwg Plotted: Mar 06, 2024

Figure 4: Onsite Post Developed Watershed Map



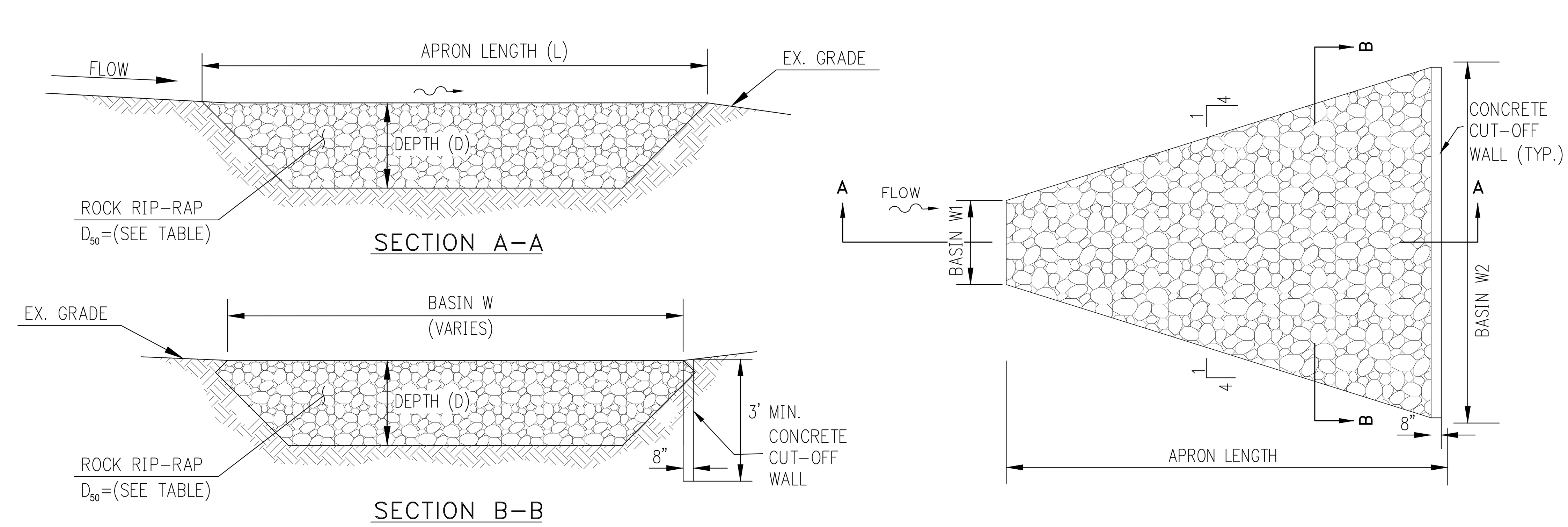


TABLE OF RIP-RAP APRON DIMENSIONS

CP	CULVERT DESCRIPTION	APRON LENGTH(ft) L	APRON WIDTH(ft) W1	APRON WIDTH(ft) W2	APRON DEPTH(in) D	RECOMMENDED D_{50}(in)
1.1	1-36" SRP	19.0	5.0	16.0	18	9.0
1.5	1-24" SRP	5.0	4.0	8.0	18	9.0

RIP-RAP APRON DETAIL

NTS

TABLE OF POST-DEVELOPED PEAK DISCHARGES

CONC. PT	DRAINAGE AREA (ac)	Q_2 (cfs)	Q_{10} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
1.0	7.3	21.8	36.8	52.3	59.2
1.1	1.47	5.6	8.5	11.6	13.0
1.2	0.77	2.3	3.9	5.5	6.3
1.3	1.30	5.0	7.6	10.3	11.5
1.3a	0.5	1.9	2.9	4.0	4.4
1.4	0.13	0.2	0.5	0.7	0.9
1.5	2.17	3.0	7.6	12.5	14.6
1.6	0.77	1.4	3.0	4.7	5.4
1.7	0.15	0.6	0.9	1.2	1.4
OS1	1.3	3.7	6.4	9.1	10.3

LEGEND

- WATERSHED BOUNDARY
- 2350 EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- FINISH GRADE CONTOUR
- 100-YEAR FLOODPLAIN LIMIT
- 10-YEAR FLOODPLAIN LIMIT
- 25' EROSION HAZARD SETBACK
- 1 WSEL=3008.2 HEC-RAS CROSS SECTION
- PROPERTY BOUNDARY
- 1E CONCENTRATION POINT
- FLOW DIRECTION

0' 40' 80' 120'

CONTOUR INTERVAL = 1'

The WLB Group INC.

Engineering Planning Surveying Landscape Architecture Urban Design Offices located in Tucson, Phoenix, and Flagstaff, Arizona, and Las Vegas, Nevada 4444 East Broadway Boulevard, Tucson, Arizona 85711 (520) 881-7480

ONSITE POST-DEVELOPED WATERSHED MAP

STARBUCKS COFFEE

BLOCK 5 OF INNOVATION CORPORATE CENTER

TOWN OF ORO VALLEY, ARIZONA

FIGURE 4

WLB JOB # 185050-VW30-0400

APRIL 2024

Appendix A Hydrologic Analysis

A.1 NOAA 14 Rainfall

A.2 Pre-Development Rational Worksheets

A.3 Post-Development Rational Worksheets

The WLB Group

A.1 NOAA 14 Rainfall

NOAA Atlas 14, Volume 1, Version 5
Location name: Tucson, Arizona, USA*
Latitude: 32.4279°, Longitude: -110.946°
Elevation: 2686.08 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.246** (0.217-0.281)	**0.318** (0.281-0.364)	**0.421** (0.369-0.480)	**0.498** (0.436-0.567)	**0.604** (0.522-0.686)	**0.684** (0.584-0.779)	**0.767** (0.645-0.876)	**0.850** (0.704-0.975)	**0.962** (0.777-1.11)	**1.05** (0.830-1.22)
10-min	**0.374** (0.331-0.428)	**0.484** (0.428-0.554)	**0.640** (0.562-0.730)	**0.758** (0.663-0.863)	**0.920** (0.794-1.04)	**1.04** (0.889-1.19)	**1.17** (0.982-1.33)	**1.29** (1.07-1.48)	**1.46** (1.18-1.69)	**1.59** (1.26-1.86)
15-min	**0.464** (0.410-0.531)	**0.599** (0.530-0.686)	**0.794** (0.697-0.905)	**0.940** (0.822-1.07)	**1.14** (0.984-1.29)	**1.29** (1.10-1.47)	**1.45** (1.22-1.65)	**1.60** (1.33-1.84)	**1.81** (1.47-2.10)	**1.98** (1.57-2.30)
30-min	**0.625** (0.552-0.715)	**0.807** (0.714-0.924)	**1.07** (0.938-1.22)	**1.27** (1.11-1.44)	**1.54** (1.33-1.74)	**1.74** (1.48-1.98)	**1.95** (1.64-2.23)	**2.16** (1.79-2.48)	**2.44** (1.97-2.82)	**2.66** (2.11-3.10)
60-min	**0.773** (0.683-0.885)	**0.999** (0.884-1.14)	**1.32** (1.16-1.51)	**1.57** (1.37-1.78)	**1.90** (1.64-2.15)	**2.15** (1.84-2.45)	**2.41** (2.03-2.75)	**2.67** (2.21-3.07)	**3.02** (2.44-3.49)	**3.29** (2.61-3.83)
2-hr	**0.894** (0.793-1.01)	**1.14** (1.02-1.30)	**1.49** (1.32-1.69)	**1.76** (1.54-1.99)	**2.13** (1.85-2.40)	**2.42** (2.08-2.73)	**2.72** (2.30-3.07)	**3.03** (2.52-3.43)	**3.45** (2.79-3.94)	**3.77** (3.00-4.35)
3-hr	**0.950** (0.848-1.08)	**1.20** (1.07-1.37)	**1.55** (1.38-1.76)	**1.83** (1.61-2.07)	**2.22** (1.93-2.50)	**2.52** (2.17-2.85)	**2.85** (2.41-3.23)	**3.19** (2.65-3.64)	**3.66** (2.95-4.21)	**4.04** (3.18-4.69)
6-hr	**1.10** (0.982-1.24)	**1.38** (1.23-1.56)	**1.74** (1.55-1.97)	**2.04** (1.81-2.30)	**2.46** (2.15-2.76)	**2.79** (2.41-3.14)	**3.15** (2.67-3.55)	**3.51** (2.93-3.98)	**4.03** (3.27-4.60)	**4.45** (3.53-5.11)
12-hr	**1.26** (1.13-1.40)	**1.57** (1.42-1.76)	**1.97** (1.76-2.20)	**2.29** (2.04-2.55)	**2.74** (2.41-3.04)	**3.08** (2.69-3.43)	**3.45** (2.96-3.85)	**3.82** (3.24-4.30)	**4.34** (3.59-4.93)	**4.75** (3.86-5.45)
24-hr	**1.47** (1.35-1.63)	**1.84** (1.68-2.03)	**2.31** (2.10-2.55)	**2.70** (2.44-2.98)	**3.23** (2.90-3.57)	**3.65** (3.25-4.04)	**4.09** (3.61-4.55)	**4.54** (3.97-5.09)	**5.17** (4.44-5.86)	**5.66** (4.80-6.47)
2-day	**1.64** (1.50-1.80)	**2.06** (1.89-2.27)	**2.60** (2.37-2.85)	**3.03** (2.76-3.33)	**3.64** (3.28-4.00)	**4.12** (3.68-4.55)	**4.62** (4.09-5.14)	**5.15** (4.50-5.76)	**5.87** (5.03-6.64)	**6.43** (5.44-7.37)
3-day	**1.75** (1.60-1.92)	**2.19** (2.00-2.41)	**2.78** (2.53-3.05)	**3.26** (2.96-3.59)	**3.95** (3.55-4.35)	**4.51** (4.01-4.98)	**5.10** (4.49-5.67)	**5.73** (4.96-6.42)	**6.62** (5.61-7.52)	**7.34** (6.10-8.43)
4-day	**1.85** (1.70-2.04)	**2.33** (2.12-2.56)	**2.96** (2.69-3.26)	**3.49** (3.16-3.84)	**4.26** (3.82-4.69)	**4.89** (4.34-5.41)	**5.58** (4.88-6.21)	**6.31** (5.43-7.09)	**7.37** (6.18-8.39)	**8.24** (6.77-9.49)
7-day	**2.13** (1.94-2.36)	**2.68** (2.43-2.96)	**3.42** (3.10-3.77)	**4.05** (3.65-4.47)	**4.98** (4.44-5.51)	**5.76** (5.08-6.41)	**6.61** (5.75-7.41)	**7.53** (6.45-8.53)	**8.89** (7.43-10.2)	**10.0** (8.21-11.7)
10-day	**2.39** (2.17-2.63)	**2.99** (2.72-3.30)	**3.80** (3.44-4.19)	**4.48** (4.05-4.95)	**5.48** (4.90-6.06)	**6.31** (5.58-7.00)	**7.21** (6.30-8.06)	**8.19** (7.03-9.23)	**9.60** (8.04-11.0)	**10.8** (8.84-12.5)
20-day	**3.11** (2.84-3.42)	**3.90** (3.56-4.29)	**4.94** (4.50-5.44)	**5.80** (5.26-6.39)	**7.03** (6.31-7.75)	**8.01** (7.12-8.86)	**9.06** (7.97-10.1)	**10.2** (8.83-11.4)	**11.7** (9.96-13.3)	**13.0** (10.8-15.0)
30-day	**3.79** (3.48-4.13)	**4.74** (4.35-5.16)	**5.92** (5.41-6.44)	**6.87** (6.27-7.48)	**8.18** (7.41-8.93)	**9.20** (8.28-10.1)	**10.3** (9.15-11.3)	**11.4** (10.0-12.6)	**12.9** (11.2-14.5)	**14.1** (12.0-16.0)
45-day	**4.60** (4.24-4.99)	**5.75** (5.30-6.25)	**7.11** (6.54-7.73)	**8.16** (7.50-8.88)	**9.54** (8.72-10.4)	**10.6** (9.61-11.6)	**11.6** (10.5-12.8)	**12.7** (11.3-14.0)	**14.0** (12.4-15.6)	**15.0** (13.1-16.9)
60-day	**5.19** (4.78-5.63)	**6.49** (5.97-7.06)	**8.03** (7.38-8.72)	**9.22** (8.45-10.0)	**10.8** (9.85-11.7)	**12.0** (10.9-13.1)	**13.1** (11.9-14.4)	**14.3** (12.8-15.8)	**15.8** (14.0-17.6)	**16.9** (14.9-19.1)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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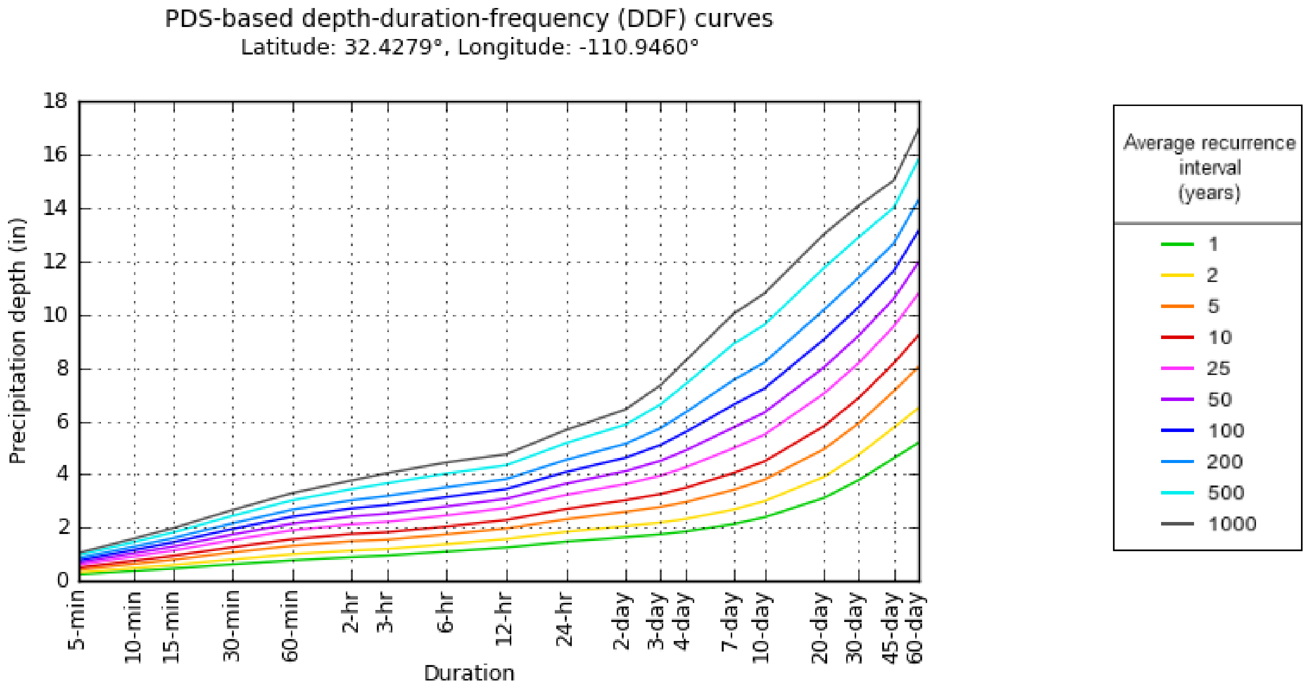
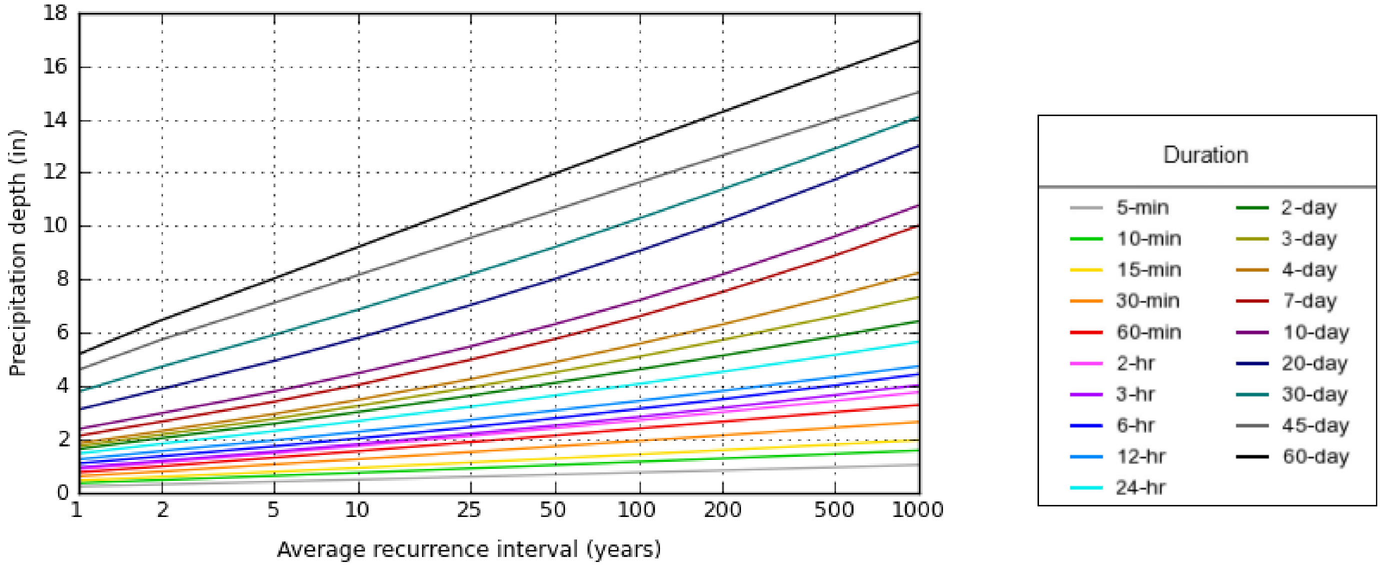
PF graphical





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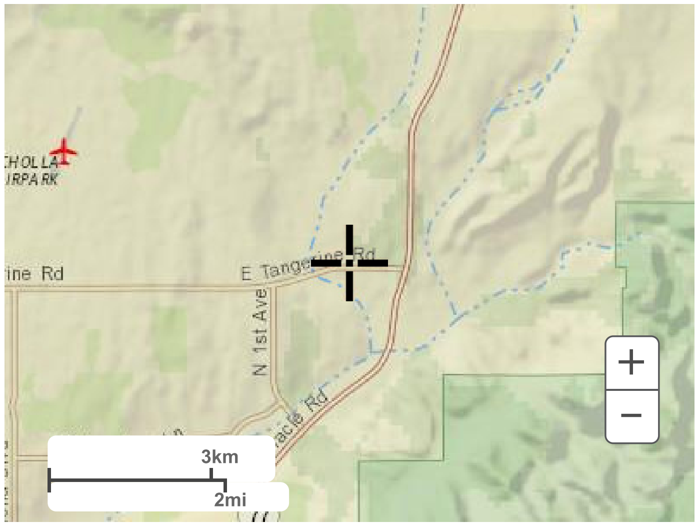
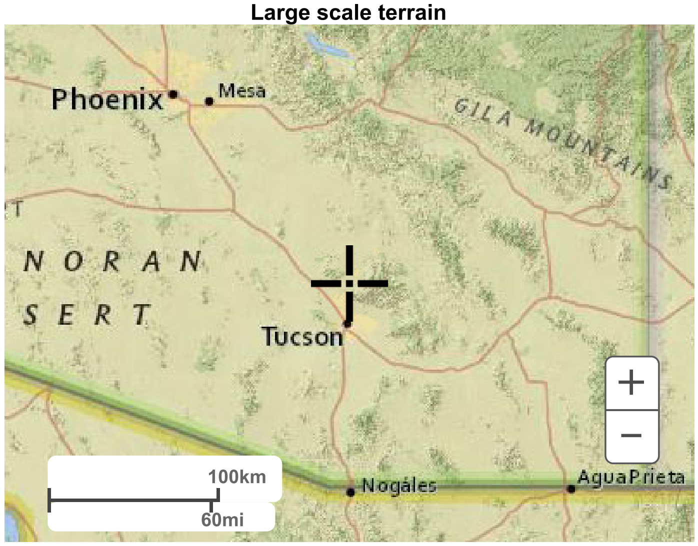
Maps & aerials

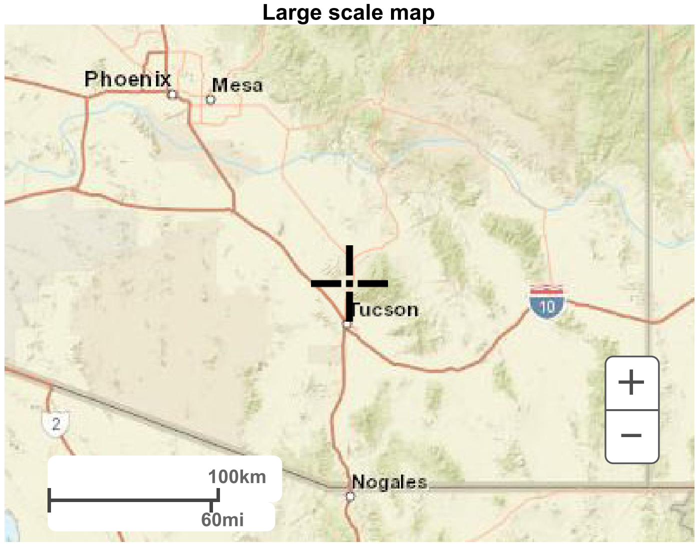
Small scale terrain



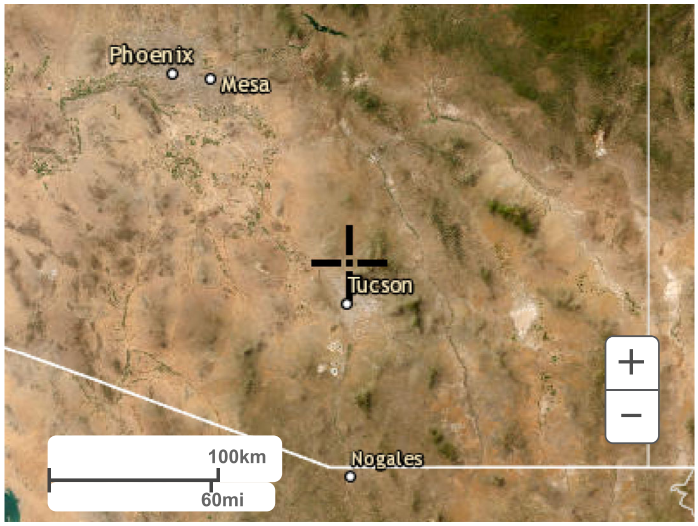
Large scale terrain



Large scale map



Large scale aerial



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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

A.2 Pre-Development Rational Worksheets

The WLB Group	**Rational Method Hydrology**	**WLB Job # 185050-VW-30-0400**
	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed:	EJB
Date:	12/15/2022

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	500.0
D Height, feet =	7.0
Kb =	0.040

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP OS1	2	0.095	0.040	73.9	0.094	4.94	0.094	0.02
	5	0.095	0.040	73.9	0.087	6.09	0.087	0.01
	10	0.095	0.040	73.9	0.083	7.03	0.083	0.02
	50	0.095	0.040	73.9	0.083	9.08	0.075	0.40
	100	0.095	0.040	73.9	0.083	9.97	0.072	0.53

Step 2. Compute Rational Method Discharge Q

Q= C i A

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	1.27		
Soil	B =	40		
Type	C =	0		
Percent	D =	0		
	Imp =	60		

Land Use		Area (acres)
Nat./Rural	A1 =	1.27
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**1.27**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.58	**0.68**	**0.72**	**0.79**	**0.82**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.58	0.68	0.72	0.79	0.82
Rainfall Intensity, i	4.94	6.09	7.03	9.08	9.97
Area, A	1.27	1.27	1.27	1.27	1.27
Discharge, Q	**3.7**	**5.3**	**6.4**	**9.1**	**10.3**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
The WLB Group	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed:	EJB
Date:	12/15/2022

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs

L = Length of the longest flow path, miles

Kb = Watershed resistance coefficient, per ADOT manual [1]

S = Slope of the longest flow path, ft/mile

i = Average rainfall intensity, inches/hour

Length, feet =	1140.0
D Height, feet =	15.0
Kb =	0.025

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1E	2	0.216	0.025	69.5	0.118	4.52	0.118	0.01
	5	0.216	0.025	69.5	0.108	5.66	0.108	0.01
	10	0.216	0.025	69.5	0.103	6.50	0.103	0.02
	50	0.216	0.025	69.5	0.092	8.73	0.092	0.01
	100	0.216	0.025	69.5	0.088	9.73	0.088	0.00

Step 2. Compute Rational Method Discharge Q

Q= C i A

where:

C = Runoff Coefficient

i = Average rainfall intensity, inches/hour

A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	8.68		
Soil	B =	90		
Type	C =	0		
Percent	D =	0		
	Imp =	10		

Land Use	Area (acres)	
Nat./Rural	A1 =	8.68
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**8.68**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.19	**0.37**	**0.45**	**0.59**	**0.64**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.19	0.37	0.45	0.59	0.64
Rainfall Intensity, i	4.52	5.66	6.50	8.73	9.73
Area, A	8.68	8.68	8.68	8.68	8.68
Discharge, Q	**7.3**	**18.3**	**25.2**	**44.9**	**53.9**

[1]ADOT's "Highway Drainage Design Manual - Hydrology", 2014

[2] Town of Oro Valley "Drainage Criteria Manual", 2010

A.3 Post-Development Rational Worksheets

The WLB Group	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed:	EJB
Date:	1/4/2023

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	683.0
D Height, feet =	12.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.0	2	0.129	0.020	92.8	0.083	5.14	0.071	0.62
	5	0.129	0.020	92.8	0.083	6.24	0.066	0.87
	10	0.129	0.020	92.8	0.083	7.03	0.063	1.01
	50	0.129	0.020	92.8	0.083	9.08	0.057	1.30
	100	0.129	0.020	92.8	0.083	9.97	0.055	1.40

Step 2. Compute Rational Method Discharge Q

$Q = C\ i\ A$

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	7.28		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	60		

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.58	**0.68**	**0.72**	**0.79**	**0.82**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

Land Use		Area (acres)
Nat./Rural	A1 =	7.28
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**7.28**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.58	0.68	0.72	0.79	0.82
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	7.28	7.28	7.28	7.28	7.28
Discharge, Q	**21.8**	**30.9**	**36.8**	**52.3**	**59.2**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

The WLB Group	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed:	EJB
Date:	9/13/2023

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	310.0
D Height, feet =	3.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.1	2	0.059	0.020	51.1	0.083	5.14	0.057	1.29
	5	0.059	0.020	51.1	0.083	6.24	0.053	1.49
	10	0.059	0.020	51.1	0.083	7.03	0.051	1.61
	50	0.059	0.020	51.1	0.083	9.08	0.046	1.84
	100	0.059	0.020	51.1	0.083	9.97	0.045	1.92

Step 2. Compute Rational Method Discharge Q

Q= C i A

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	1.47		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	80		

Land Use		Area (acres)
Nat./Rural	A1 =	1.47
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**1.47**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.74	**0.80**	**0.83**	**0.87**	**0.89**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.74	0.80	0.83	0.87	0.89
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	1.47	1.47	1.47	1.47	1.47
Discharge, Q	**5.6**	**7.4**	**8.5**	**11.6**	**13.0**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014

[2] Town of Oro Valley "Drainage Criteria Manual", 2010

The WLB Group	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed:	EJB
Date:	4/29/2024

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	340.0
D Height, feet =	4.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.2	2	0.064	0.020	62.1	0.083	5.14	0.056	1.33
	5	0.064	0.020	62.1	0.083	6.24	0.052	1.53
	10	0.064	0.020	62.1	0.083	7.03	0.050	1.64
	50	0.064	0.020	62.1	0.083	9.08	0.045	1.88
	100	0.064	0.020	62.1	0.083	9.97	0.044	1.96

Step 2. Compute Rational Method Discharge Q

$Q = C\ i\ A$

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	1.08		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	60		

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.58	0.68	0.72	0.79	0.82
0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00

Land Use		Area (acres)
Nat./Rural	A1 =	0.77
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**0.77**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.58	0.68	0.72	0.79	0.82
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	0.77	0.77	0.77	0.77	0.77
Discharge, Q	**2.3**	**3.3**	**3.9**	**5.5**	**6.3**

[1]ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
The WLB Group	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed: EJB
Date: 4/29/2024

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	321.0
D Height, feet =	4.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.3	2	0.061	0.020	65.8	0.083	5.14	0.054	1.46
	5	0.061	0.020	65.8	0.083	6.24	0.050	1.65
	10	0.061	0.020	65.8	0.083	7.03	0.048	1.76
	50	0.061	0.020	65.8	0.083	9.08	0.043	1.98
	100	0.061	0.020	65.8	0.083	9.97	0.042	2.05

Step 2. Compute Rational Method Discharge Q

$Q = C\ i\ A$

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	1.45		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	80		

Land Use		Area (acres)
Nat./Rural	A1 =	1.30
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**1.30**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.74	**0.80**	**0.83**	**0.87**	**0.89**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.74	0.80	0.83	0.87	0.89
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	1.30	1.30	1.30	1.30	1.30
Discharge, Q	**5.0**	**6.5**	**7.6**	**10.3**	**11.5**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

Rational Method Hydrology | **WLB Job # 185050-VW-30-0400**

Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4

Designed: EJB
Date: 4/29/2024

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

- Tc = Time of Concentration, hrs
- L = Length of the longest flow path, miles
- Kb = Watershed resistance coefficient, per ADOT manual [1]
- S = Slope of the longest flow path, ft/mile
- i = Average rainfall intensity, inches/hour

Length, feet = 286.0
D Height, feet = 4.0
Kb = 0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.3a	2	0.054	0.020	73.8	0.083	5.14	0.049	1.70
	5	0.054	0.020	73.8	0.083	6.24	0.046	1.87
	10	0.054	0.020	73.8	0.083	7.03	0.044	1.97
	50	0.054	0.020	73.8	0.083	9.08	0.040	2.17
	100	0.054	0.020	73.8	0.083	9.97	0.038	2.24

Step 2. Compute Rational Method Discharge Q

$Q = C\ i\ A$

where:

- C = Runoff Coefficient
- i = Average rainfall intensity, inches/hour
- A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	0.5		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	80		

Land Use		Area (acres)
Nat./Rural	A1 =	0.50
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**0.50**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.74	**0.80**	**0.83**	**0.87**	**0.89**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.74	0.80	0.83	0.87	0.89
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	0.50	0.50	0.50	0.50	0.50
Discharge, Q	**1.9**	**2.5**	**2.9**	**4.0**	**4.4**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014

[2] Town of Oro Valley "Drainage Criteria Manual", 2010

Rational Method Hydrology	WLB Job # 185050-VW-30-0400
Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed: EJB
Date: 9/13/2023

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	100.0
D Height, feet =	1.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.4	2	0.019	0.020	52.8	0.083	5.14	0.032	2.54
	5	0.019	0.020	52.8	0.083	6.24	0.030	2.65
	10	0.019	0.020	52.8	0.083	7.03	0.029	2.72
	50	0.019	0.020	52.8	0.083	9.08	0.026	2.85
	100	0.019	0.020	52.8	0.083	9.97	0.025	2.90

Step 2. Compute Rational Method Discharge Q

$Q = C\ i\ A$

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	0.13		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	20		

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.27	**0.43**	**0.50**	**0.63**	**0.67**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

Land Use	Area (acres)	
Nat./Rural	A1 =	0.13
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**0.13**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.27	0.43	0.50	0.63	0.67
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	0.13	0.13	0.13	0.13	0.13
Discharge, Q	**0.2**	**0.4**	**0.5**	**0.7**	**0.9**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
The WLB Group	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed: EJB
Date: 9/13/2023

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	618.0
D Height, feet =	8.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.5	2	0.117	0.020	68.3	0.083	5.14	0.074	0.45
	5	0.117	0.020	68.3	0.083	6.24	0.069	0.72
	10	0.117	0.020	68.3	0.083	7.03	0.066	0.87
	50	0.117	0.020	68.3	0.083	9.08	0.060	1.17
	100	0.117	0.020	68.3	0.083	9.97	0.057	1.28

Step 2. Compute Rational Method Discharge Q

$Q = C\ i\ A$

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	2.17		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	20		

Land Use		Area (acres)
Nat./Rural	A1 =	2.17
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**2.17**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.27	**0.43**	**0.50**	**0.63**	**0.67**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.27	0.43	0.50	0.63	0.67
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	2.17	2.17	2.17	2.17	2.17
Discharge, Q	**3.0**	**5.9**	**7.6**	**12.5**	**14.6**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
The WLB Group	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed:	EJB
Date:	9/13/2023

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4\ L^{0.5}\ Kb^{0.52}\ S^{-.31}\ i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	484.0
D Height, feet =	8.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.6	2	0.092	0.020	87.3	0.083	5.14	0.061	1.12
	5	0.092	0.020	87.3	0.083	6.24	0.056	1.33
	10	0.092	0.020	87.3	0.083	7.03	0.054	1.46
	50	0.092	0.020	87.3	0.083	9.08	0.049	1.71
	100	0.092	0.020	87.3	0.083	9.97	0.047	1.79

Step 2. Compute Rational Method Discharge Q

$Q = C\ i\ A$

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	0.11		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	30		

Land Use		Area (acres)
Nat./Rural	A1 =	0.77
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**0.77**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.35	**0.50**	**0.56**	**0.67**	**0.71**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.35	0.50	0.56	0.67	0.71
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	0.77	0.77	0.77	0.77	0.77
Discharge, Q	**1.4**	**2.4**	**3.0**	**4.7**	**5.4**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

The WLB Group	Rational Method Hydrology	WLB Job # 185050-VW-30-0400
	Starbucks; Innovation Corporation Block 5; Rancho Vistoso Neighborhood 4	

Designed:	EJB
Date:	9/13/2023

Step 1. Compute Time of Concentration, Tc

$Tc = 11.4 L^{0.5} Kb^{0.52} S^{-.31} i^{-0.38}$ ADOT Eqn. 2.2

where:

Tc = Time of Concentration, hrs
L = Length of the longest flow path, miles
Kb = Watershed resistance coefficient, per ADOT manual [1]
S = Slope of the longest flow path, ft/mile
i = Average rainfall intensity, inches/hour

Length, feet =	80.0
D Height, feet =	1.0
Kb =	0.020

Concentration Point	Event, year	Length, mi	Kb	S, ft/mi	Trial Tc, hr (estimate)	i, in/hr (from IDF)[2]	Calculated Tc, hr (from equation)	Tc %-ile Difference
CP 1.7	2	0.015	0.020	66.0	0.083	5.14	0.027	2.81
	5	0.015	0.020	66.0	0.083	6.24	0.025	2.90
	10	0.015	0.020	66.0	0.083	7.03	0.024	2.96
	50	0.015	0.020	66.0	0.083	9.08	0.022	3.07
	100	0.015	0.020	66.0	0.083	9.97	0.021	3.11

Step 2. Compute Rational Method Discharge Q

Q= C i A

where:

C = Runoff Coefficient
i = Average rainfall intensity, inches/hour
A = Drainage Area of watershed, acres

		A1	A2	A3
	Area (ac)	0.15		
Soil	B =	100		
Type	C =	0		
Percent	D =	0		
	Imp =	90		

Land Use		Area (acres)
Nat./Rural	A1 =	0.15
Roadway	A2 =	0.00
Mod. Urban	A3 =	0.00
	A, acres =	**0.15**

Q2	Q5	Q10	Q50	Q100
1-hr. Precipitation - P1, (in.)[2]				
1.14	1.51	1.78	2.45	2.75
Runoff Coefficient – C [2]				
0.82	**0.86**	**0.88**	**0.91**	**0.92**
0.00	**0.00**	**0.00**	**0.00**	**0.00**
0.00	**0.00**	**0.00**	**0.00**	**0.00**

	Q2	Q5	Q10	Q50	Q100
Weighted Runoff Coefficient, C	0.82	0.86	0.88	0.91	0.92
Rainfall Intensity, i	5.14	6.24	7.03	9.08	9.97
Area, A	0.15	0.15	0.15	0.15	0.15
Discharge, Q	**0.6**	**0.8**	**0.9**	**1.2**	**1.4**

[1] ADOT's "Highway Drainage Design Manual - Hydrology", 2014
[2] Town of Oro Valley "Drainage Criteria Manual", 2010

Appendix B Hydraulic Analysis

B.1 Greenway Channel HEC-RAS Model (Existing)

B.2 Greenway Channel HEC-RAS Model (Developed)

B.3 StormCAD Worksheets

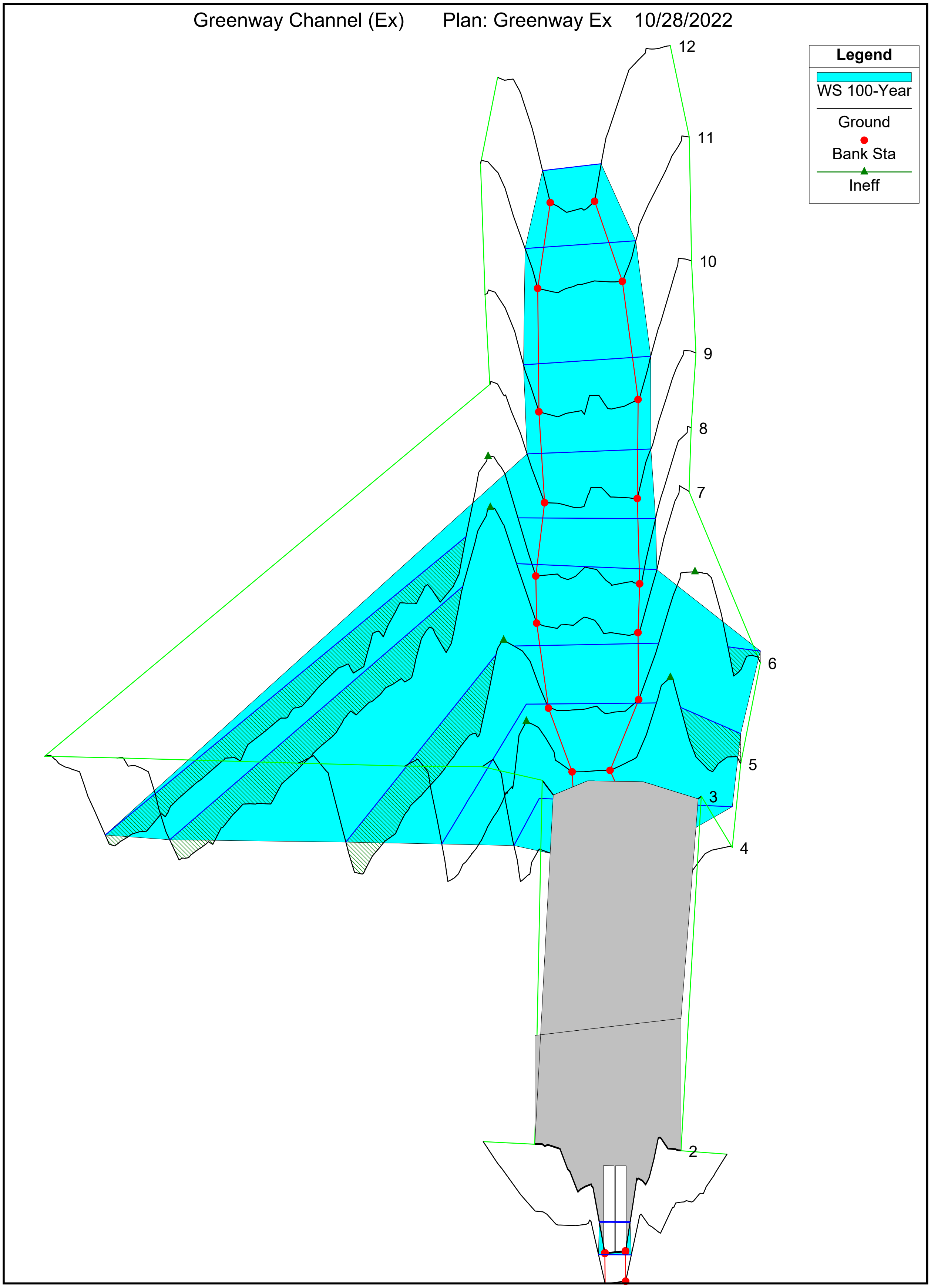
B.4 Stormdrain Grate Inlet Worksheets

B.5 Curb Opening Worksheets

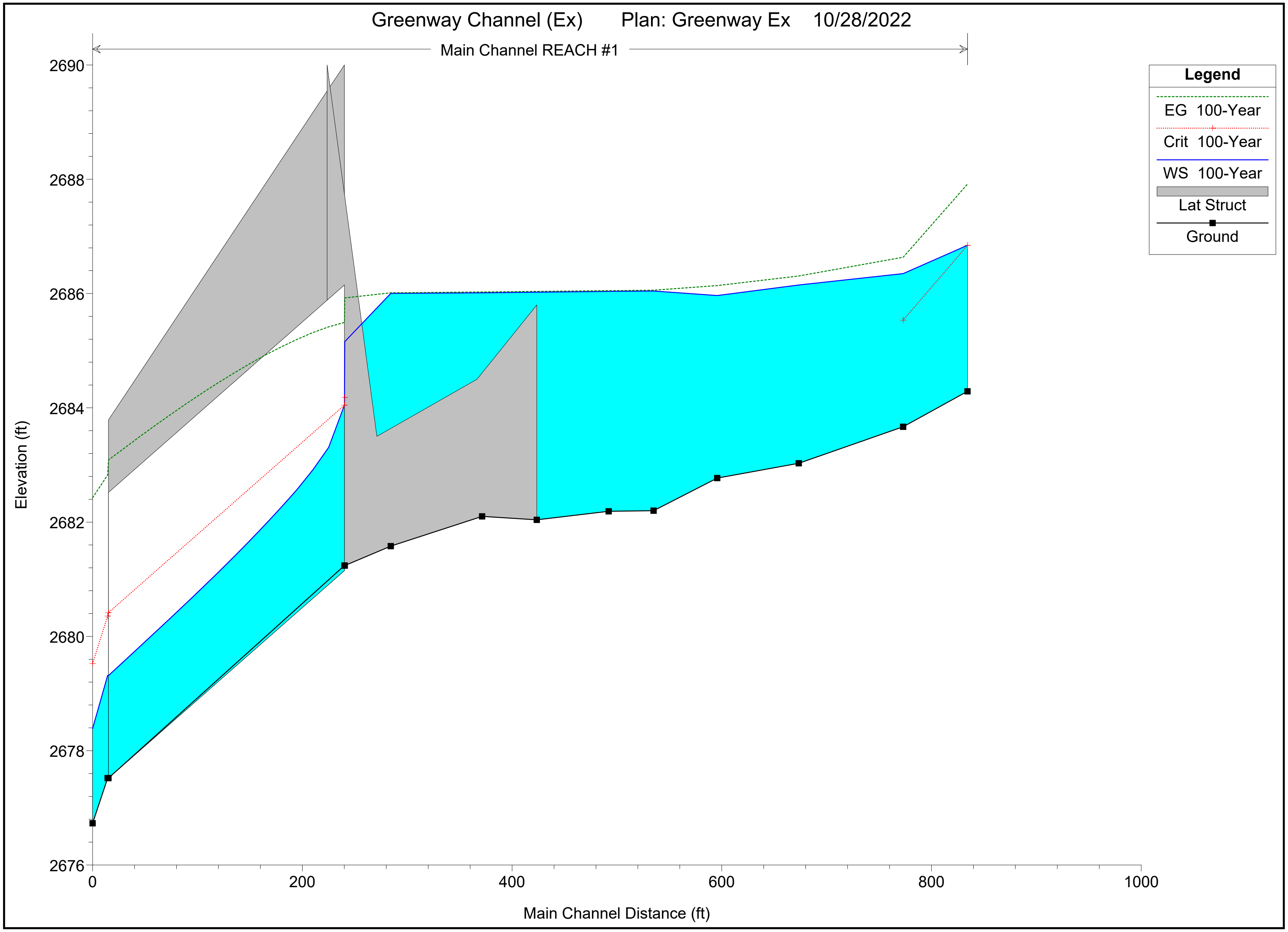
B.6 Culvert Worksheets

B.7 Rip-Rap Splash Pad Worksheets

B.1 Greenway Channel HEC-RAS Model (Existing)



Greenway Channel (Ex) Plan: Greenway Ex 10/28/2022
Legend
WS 100-Year
Ground
Bank Sta
Ineff
12
11
10
9
8
7
6
5
4
3
2



Greenway Channel (Ex) Plan: Greenway Ex 10/28/2022
Main Channel REACH #1
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Lat Struct
Ground
Elevation (ft)
2690
2688
2686
2684
2682
2680
2678
2676
0
200
400
600
800
1000
Main Channel Distance (ft)

Plan: Greenway Ex   Main Channel   REACH #1 RS: 12   Profile: 100-Year

E.G. Elev (ft)	2687.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.07	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.85	Reach Len. (ft)	61.41	61.41	61.41
Crit W.S. (ft)	2686.85	Flow Area (sq ft)	5.15	79.00	5.54
E.G. Slope (ft/ft)	0.016705	Area (sq ft)	5.15	79.00	5.54
Q Total (cfs)	710.00	Flow (cfs)	19.37	670.75	19.88
Top Width (ft)	44.27	Top Width (ft)	4.87	33.56	5.85
Vel Total (ft/s)	7.92	Avg. Vel. (ft/s)	3.76	8.49	3.59
Max Chl Dpth (ft)	2.56	Hydr. Depth (ft)	1.06	2.35	0.95
Conv. Total (cfs)	5493.3	Conv. (cfs)	149.9	5189.7	153.8
Length Wtd. (ft)	61.41	Wetted Per. (ft)	5.31	33.60	6.15
Min Ch El (ft)	2684.29	Shear (lb/sq ft)	1.01	2.45	0.94
Alpha	1.10	Stream Power (lb/ft s)	3.81	20.82	3.37
Frctn Loss (ft)	0.43	Cum Volume (acre-ft)	0.81	2.81	3.59
C & E Loss (ft)	0.24	Cum SA (acres)	0.38	0.92	1.68

Plan: Greenway Ex   Main Channel   REACH #1 RS: 11   Profile: 100-Year

E.G. Elev (ft)	2686.72	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.26	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.46	Reach Len. (ft)	99.55	99.55	99.55
Crit W.S. (ft)	2685.53	Flow Area (sq ft)	13.86	156.20	11.40
E.G. Slope (ft/ft)	0.003868	Area (sq ft)	13.86	156.20	11.40
Q Total (cfs)	710.00	Flow (cfs)	30.38	657.05	22.56
Top Width (ft)	84.01	Top Width (ft)	10.45	63.56	10.00
Vel Total (ft/s)	3.91	Avg. Vel. (ft/s)	2.19	4.21	1.98
Max Chl Dpth (ft)	2.79	Hydr. Depth (ft)	1.33	2.46	1.14
Conv. Total (cfs)	11416.6	Conv. (cfs)	488.6	10565.2	362.8
Length Wtd. (ft)	99.55	Wetted Per. (ft)	10.73	63.57	10.30
Min Ch El (ft)	2683.67	Shear (lb/sq ft)	0.31	0.59	0.27
Alpha	1.09	Stream Power (lb/ft s)	0.68	2.50	0.53
Frctn Loss (ft)	0.24	Cum Volume (acre-ft)	0.80	2.64	3.58
C & E Loss (ft)	0.04	Cum SA (acres)	0.37	0.85	1.66

Plan: Greenway Ex   Main Channel   REACH #1 RS: 10   Profile: 100-Year

E.G. Elev (ft)	2686.44	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.14	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.29	Reach Len. (ft)	77.77	77.77	77.77
Crit W.S. (ft)		Flow Area (sq ft)	14.14	214.06	17.53
E.G. Slope (ft/ft)	0.001700	Area (sq ft)	14.14	214.06	17.53
Q Total (cfs)	710.00	Flow (cfs)	21.43	661.46	27.11
Top Width (ft)	96.43	Top Width (ft)	9.92	74.50	12.01
Vel Total (ft/s)	2.89	Avg. Vel. (ft/s)	1.52	3.09	1.55
Max Chl Dpth (ft)	3.26	Hydr. Depth (ft)	1.42	2.87	1.46
Conv. Total (cfs)	17217.6	Conv. (cfs)	519.8	16040.4	657.4
Length Wtd. (ft)	77.77	Wetted Per. (ft)	10.27	74.72	12.36
Min Ch El (ft)	2683.03	Shear (lb/sq ft)	0.15	0.30	0.15
Alpha	1.08	Stream Power (lb/ft s)	0.22	0.94	0.23
Frctn Loss (ft)	0.14	Cum Volume (acre-ft)	0.77	2.22	3.55
C & E Loss (ft)	0.00	Cum SA (acres)	0.35	0.69	1.64

Plan: Greenway Ex   Main Channel   REACH #1 RS: 9   Profile: 100-Year

E.G. Elev (ft)	2686.30	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.15	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.15	Reach Len. (ft)	60.60	60.60	60.60
Crit W.S. (ft)		Flow Area (sq ft)	14.73	202.71	21.70
E.G. Slope (ft/ft)	0.001800	Area (sq ft)	14.73	202.71	21.70
Q Total (cfs)	710.00	Flow (cfs)	21.71	652.00	36.29
Top Width (ft)	94.51	Top Width (ft)	11.24	69.39	13.88
Vel Total (ft/s)	2.97	Avg. Vel. (ft/s)	1.47	3.22	1.67
Max Chl Dpth (ft)	3.38	Hydr. Depth (ft)	1.31	2.92	1.56
Conv. Total (cfs)	16734.5	Conv. (cfs)	511.7	15367.4	855.4
Length Wtd. (ft)	60.60	Wetted Per. (ft)	11.65	69.53	14.20
Min Ch El (ft)	2682.77	Shear (lb/sq ft)	0.14	0.33	0.17
Alpha	1.10	Stream Power (lb/ft s)	0.21	1.05	0.29
Frctn Loss (ft)	0.07	Cum Volume (acre-ft)	0.74	1.85	3.51
C & E Loss (ft)	0.02	Cum SA (acres)	0.33	0.56	1.62

Plan: Greenway Ex   Main Channel   REACH #1 RS: 8   Profile: 100-Year

E.G. Elev (ft)	2686.21	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.08	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.12	Reach Len. (ft)	42.83	42.83	42.83
Crit W.S. (ft)	2684.00	Flow Area (sq ft)	24.79	268.66	23.86
E.G. Slope (ft/ft)	0.000809	Area (sq ft)	24.79	268.66	635.31
Q Total (cfs)	710.00	Flow (cfs)	32.63	648.70	28.66
Top Width (ft)	481.81	Top Width (ft)	12.11	77.69	392.00
Vel Total (ft/s)	2.24	Avg. Vel. (ft/s)	1.32	2.41	1.20
Max Chl Dpth (ft)	3.92	Hydr. Depth (ft)	2.05	3.46	1.75
Conv. Total (cfs)	24961.7	Conv. (cfs)	1147.3	22806.7	1007.8
Length Wtd. (ft)	42.83	Wetted Per. (ft)	12.75	77.77	14.09
Min Ch El (ft)	2682.20	Shear (lb/sq ft)	0.10	0.17	0.09
Alpha	1.09	Stream Power (lb/ft s)	0.13	0.42	0.10
Frctn Loss (ft)	0.03	Cum Volume (acre-ft)	0.71	1.52	3.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.31	0.46	1.33

Plan: Greenway Ex   Main Channel   REACH #1 RS: 7   Profile: 100-Year

E.G. Elev (ft)	2686.17	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.08	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.09	Reach Len. (ft)	68.67	68.67	68.67
Crit W.S. (ft)	2683.92	Flow Area (sq ft)	28.50	268.49	26.15
E.G. Slope (ft/ft)	0.000772	Area (sq ft)	28.50	268.49	666.13
Q Total (cfs)	710.00	Flow (cfs)	36.44	643.12	30.44
Top Width (ft)	419.63	Top Width (ft)	14.30	75.87	329.46
Vel Total (ft/s)	2.20	Avg. Vel. (ft/s)	1.28	2.40	1.16
Max Chl Dpth (ft)	3.90	Hydr. Depth (ft)	1.99	3.54	1.72
Conv. Total (cfs)	25553.7	Conv. (cfs)	1311.4	23146.6	1095.7
Length Wtd. (ft)	68.67	Wetted Per. (ft)	14.80	75.94	15.62
Min Ch El (ft)	2682.19	Shear (lb/sq ft)	0.09	0.17	0.08
Alpha	1.11	Stream Power (lb/ft s)	0.12	0.41	0.09
Frctn Loss (ft)	0.05	Cum Volume (acre-ft)	0.69	1.26	2.42
C & E Loss (ft)	0.00	Cum SA (acres)	0.30	0.39	0.98

Plan: Greenway Ex Main Channel REACH #1 RS: 6 Profile: 100-Year

E.G. Elev (ft)	2686.12	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.09	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.02	Reach Len. (ft)	52.08	52.08	52.08
Crit W.S. (ft)	2683.79	Flow Area (sq ft)	24.90	251.90	35.88
E.G. Slope (ft/ft)	0.000817	Area (sq ft)	43.72	251.90	556.13
Q Total (cfs)	710.00	Flow (cfs)	29.23	643.06	37.70
Top Width (ft)	333.27	Top Width (ft)	39.57	67.53	226.17
Vel Total (ft/s)	2.27	Avg. Vel. (ft/s)	1.17	2.55	1.05
Max Chl Dpth (ft)	3.98	Hydr. Depth (ft)	1.66	3.73	1.39
Conv. Total (cfs)	24839.9	Conv. (cfs)	1022.7	22498.1	1319.1
Length Wtd. (ft)	52.08	Wetted Per. (ft)	15.32	67.57	26.07
Min Ch El (ft)	2682.04	Shear (lb/sq ft)	0.08	0.19	0.07
Alpha	1.17	Stream Power (lb/ft s)	0.10	0.49	0.07
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.63	0.85	1.45
C & E Loss (ft)	0.02	Cum SA (acres)	0.26	0.27	0.54

Plan: Greenway Ex Main Channel REACH #1 RS: 5 Profile: 100-Year

E.G. Elev (ft)	2686.07	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.02	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.06	Reach Len. (ft)	87.16	87.16	87.16
Crit W.S. (ft)	2684.04	Flow Area (sq ft)	95.81	111.19	493.61
E.G. Slope (ft/ft)	0.000247	Area (sq ft)	198.59	111.19	493.61
Q Total (cfs)	710.00	Flow (cfs)	87.25	161.47	461.28
Top Width (ft)	287.44	Top Width (ft)	85.65	28.34	173.45
Vel Total (ft/s)	1.01	Avg. Vel. (ft/s)	0.91	1.45	0.93
Max Chl Dpth (ft)	3.96	Hydr. Depth (ft)	2.75	3.92	2.85
Conv. Total (cfs)	45180.4	Conv. (cfs)	5552.4	10275.0	29353.0
Length Wtd. (ft)	87.16	Wetted Per. (ft)	35.18	28.34	174.39
Min Ch El (ft)	2682.10	Shear (lb/sq ft)	0.04	0.06	0.04
Alpha	1.12	Stream Power (lb/ft s)	0.04	0.09	0.04
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	0.49	0.63	0.83
C & E Loss (ft)	0.00	Cum SA (acres)	0.18	0.22	0.30

Plan: Greenway Ex Main Channel REACH #1 RS: 4 Profile: 100-Year

E.G. Elev (ft)	2686.06	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.04	Reach Len. (ft)	43.82	43.82	43.82
Crit W.S. (ft)		Flow Area (sq ft)	189.92	261.66	219.51
E.G. Slope (ft/ft)	0.000118	Area (sq ft)	189.92	261.66	219.51
Q Total (cfs)	561.44	Flow (cfs)	135.85	280.48	145.11
Top Width (ft)	190.62	Top Width (ft)	55.29	60.62	74.71
Vel Total (ft/s)	0.84	Avg. Vel. (ft/s)	0.72	1.07	0.66
Max Chl Dpth (ft)	4.46	Hydr. Depth (ft)	3.43	4.32	2.94
Conv. Total (cfs)	51577.2	Conv. (cfs)	12479.8	25766.9	13330.5
Length Wtd. (ft)	43.82	Wetted Per. (ft)	57.76	60.63	75.15
Min Ch El (ft)	2681.58	Shear (lb/sq ft)	0.02	0.03	0.02
Alpha	1.16	Stream Power (lb/ft s)	0.02	0.03	0.01
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.10	0.26	0.11
C & E Loss (ft)	0.08	Cum SA (acres)	0.04	0.13	0.05

Plan: Greenway Ex   Main Channel   REACH #1 RS: 3   Profile: 100-Year

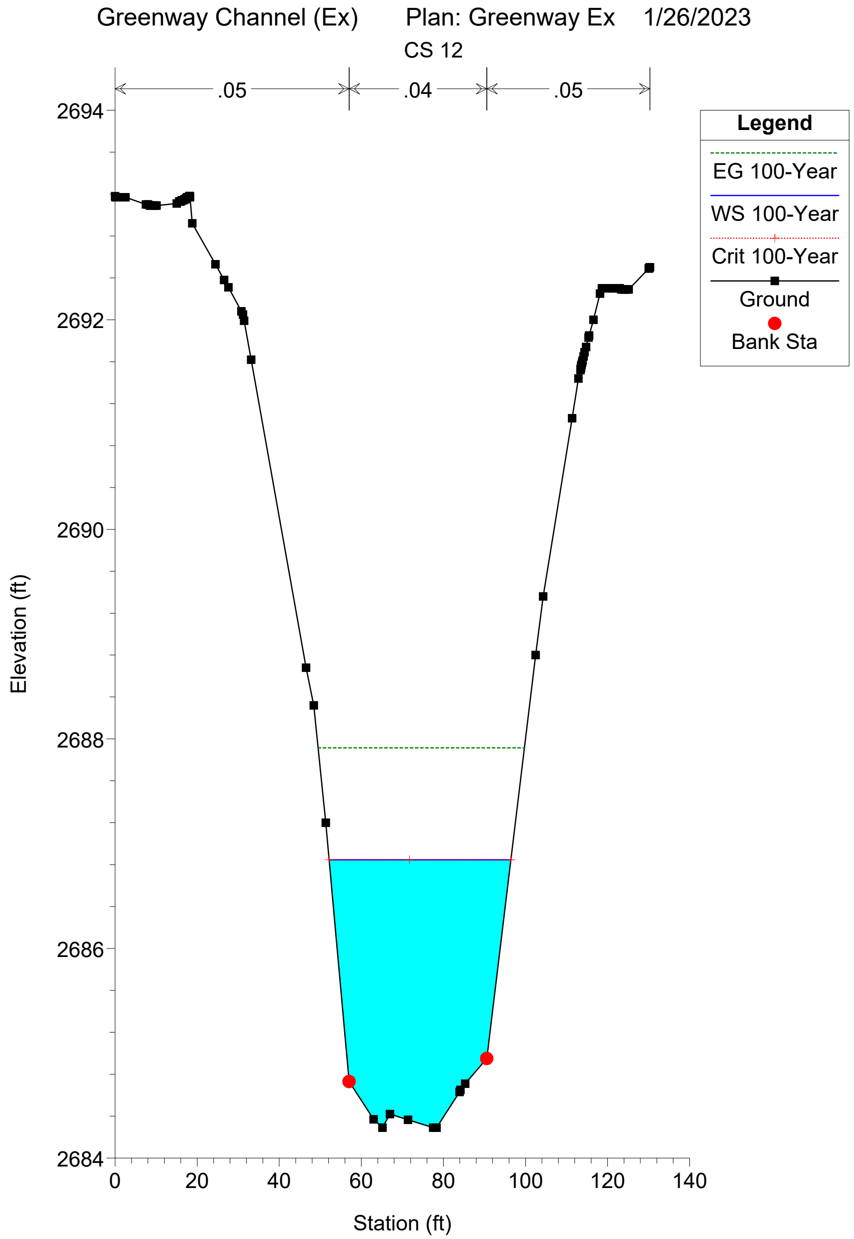
E.G. Elev (ft)	2685.97	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.77	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2685.20	Reach Len. (ft)	226.10	226.10	226.10
Crit W.S. (ft)	2684.21	Flow Area (sq ft)	2.46	62.81	2.14
E.G. Slope (ft/ft)	0.006087	Area (sq ft)	2.46	62.81	2.14
Q Total (cfs)	453.48	Flow (cfs)	4.02	446.08	3.38
Top Width (ft)	18.79	Top Width (ft)	1.24	16.37	1.18
Vel Total (ft/s)	6.73	Avg. Vel. (ft/s)	1.64	7.10	1.57
Max Chl Dpth (ft)	3.96	Hydr. Depth (ft)	1.98	3.84	1.82
Conv. Total (cfs)	5812.3	Conv. (cfs)	51.5	5717.5	43.3
Length Wtd. (ft)	226.10	Wetted Per. (ft)	4.15	16.37	3.83
Min Ch El (ft)	2681.24	Shear (lb/sq ft)	0.23	1.46	0.21
Alpha	1.10	Stream Power (lb/ft s)	0.37	10.35	0.33
Frctn Loss (ft)		Cum Volume (acre-ft)	0.00	0.09	0.00
C & E Loss (ft)		Cum SA (acres)	0.01	0.09	0.02

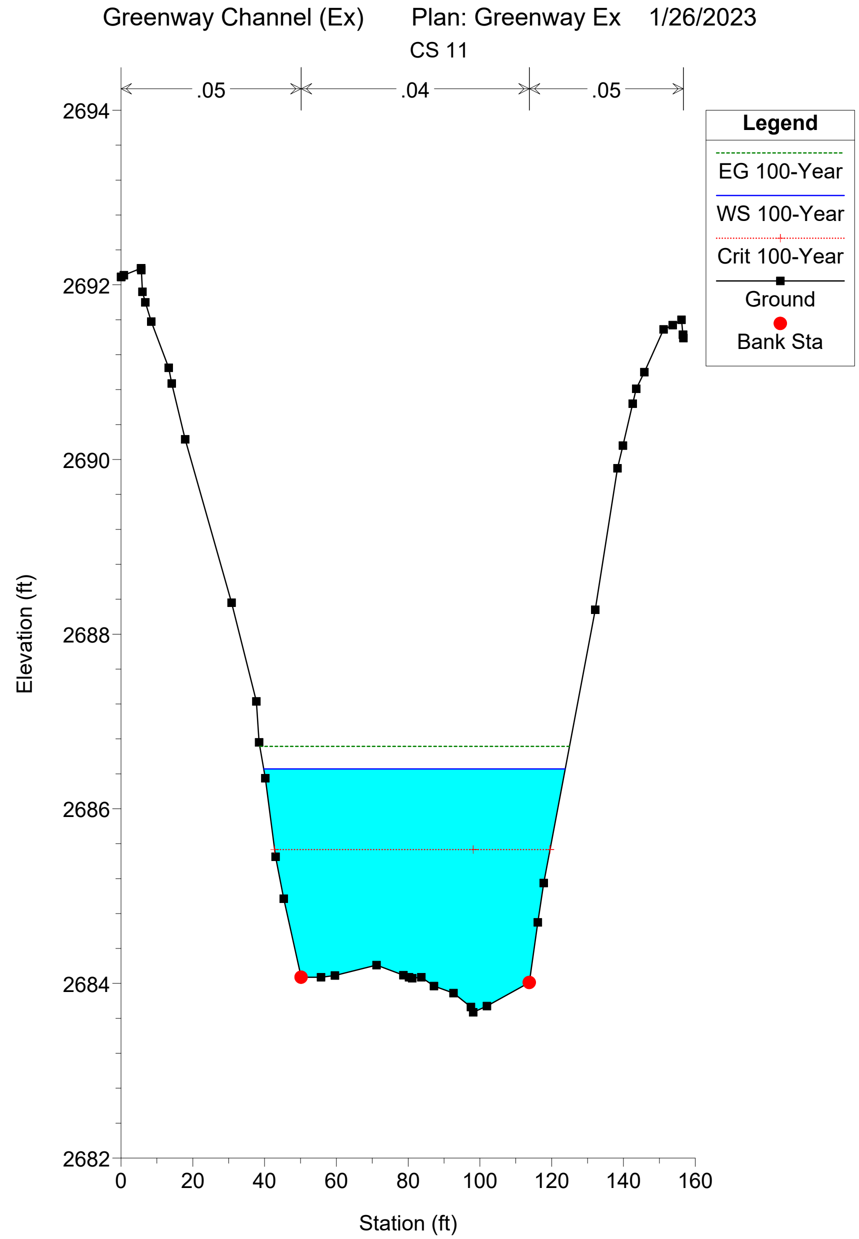
Plan: Greenway Ex   Main Channel   REACH #1 RS: 2   Profile: 100-Year

E.G. Elev (ft)	2682.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.52	Wt. n-Val.	0.040	0.020	0.040
W.S. Elev (ft)	2679.34	Reach Len. (ft)	14.36	14.36	14.36
Crit W.S. (ft)	2680.38	Flow Area (sq ft)	3.02	27.07	3.92
E.G. Slope (ft/ft)	0.020644	Area (sq ft)	3.02	27.07	3.92
Q Total (cfs)	453.48	Flow (cfs)	13.56	421.29	18.63
Top Width (ft)	23.19	Top Width (ft)	3.51	15.38	4.30
Vel Total (ft/s)	13.33	Avg. Vel. (ft/s)	4.50	15.56	4.75
Max Chl Dpth (ft)	1.82	Hydr. Depth (ft)	0.86	1.76	0.91
Conv. Total (cfs)	3156.2	Conv. (cfs)	94.4	2932.2	129.6
Length Wtd. (ft)	14.36	Wetted Per. (ft)	3.90	15.38	4.67
Min Ch El (ft)	2677.52	Shear (lb/sq ft)	1.00	2.27	1.08
Alpha	1.27	Stream Power (lb/ft s)	4.48	35.30	5.14
Frctn Loss (ft)	0.34	Cum Volume (acre-ft)	0.00	0.01	0.00
C & E Loss (ft)	0.05	Cum SA (acres)	0.00	0.01	0.00

Plan: Greenway Ex   Main Channel   REACH #1 RS: 1   Profile: 100-Year

E.G. Elev (ft)	2682.46	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.06	Wt. n-Val.	0.040	0.020	0.040
W.S. Elev (ft)	2678.40	Reach Len. (ft)			
Crit W.S. (ft)	2679.56	Flow Area (sq ft)	3.26	24.73	4.14
E.G. Slope (ft/ft)	0.027270	Area (sq ft)	3.26	24.73	4.14
Q Total (cfs)	453.48	Flow (cfs)	16.10	415.60	21.78
Top Width (ft)	24.63	Top Width (ft)	4.26	15.42	4.95
Vel Total (ft/s)	14.11	Avg. Vel. (ft/s)	4.93	16.81	5.25
Max Chl Dpth (ft)	1.67	Hydr. Depth (ft)	0.77	1.60	0.84
Conv. Total (cfs)	2746.1	Conv. (cfs)	97.5	2516.7	131.9
Length Wtd. (ft)		Wetted Per. (ft)	4.52	15.42	5.23
Min Ch El (ft)	2676.73	Shear (lb/sq ft)	1.23	2.73	1.35
Alpha	1.31	Stream Power (lb/ft s)	6.06	45.88	7.09
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			


Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 12
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
2684
2686
2688
2690
2692
2694
0
20
40
60
80
100
120
140


Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 11
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.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
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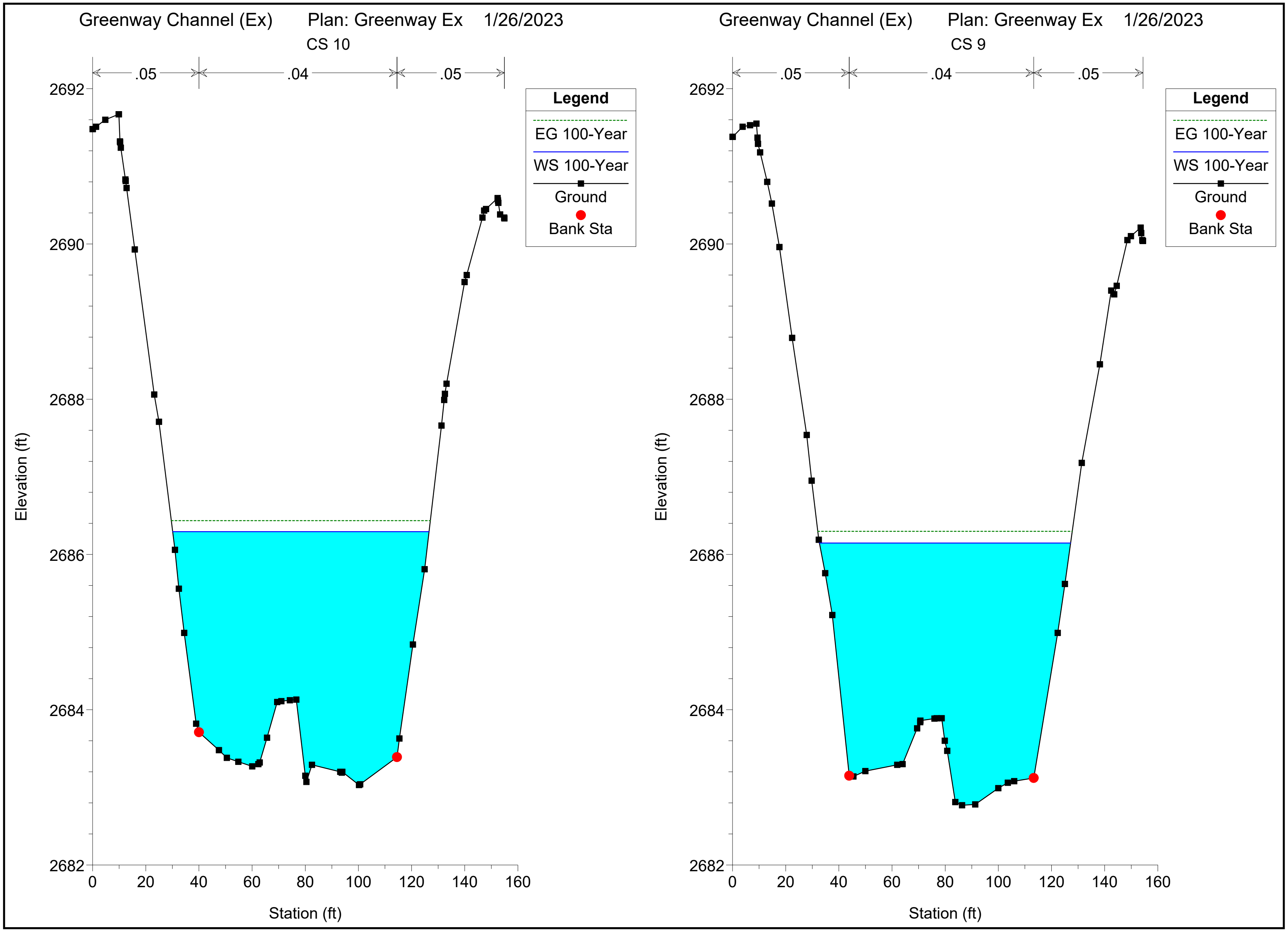
2686
2688
2690
2692
2694
0
20
40
60
80
100
120
140
160



Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 10
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.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2692
2690
2688
2686
2684
2682
0
20
40
60
80
100
120
140
160
Station (ft)
Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 9
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2692
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2688
2686
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2682
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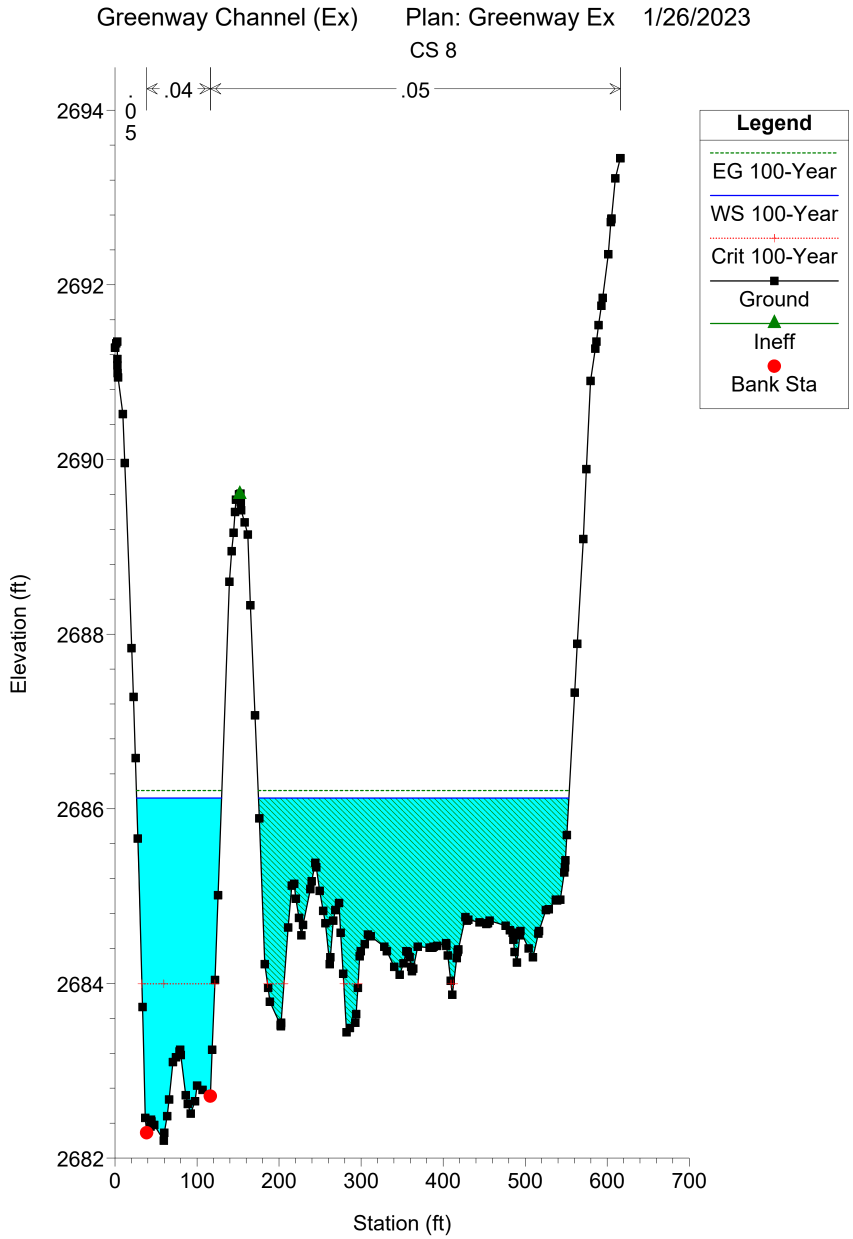
20
40
60
80
100
120
140
160
Station (ft)



Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 8
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Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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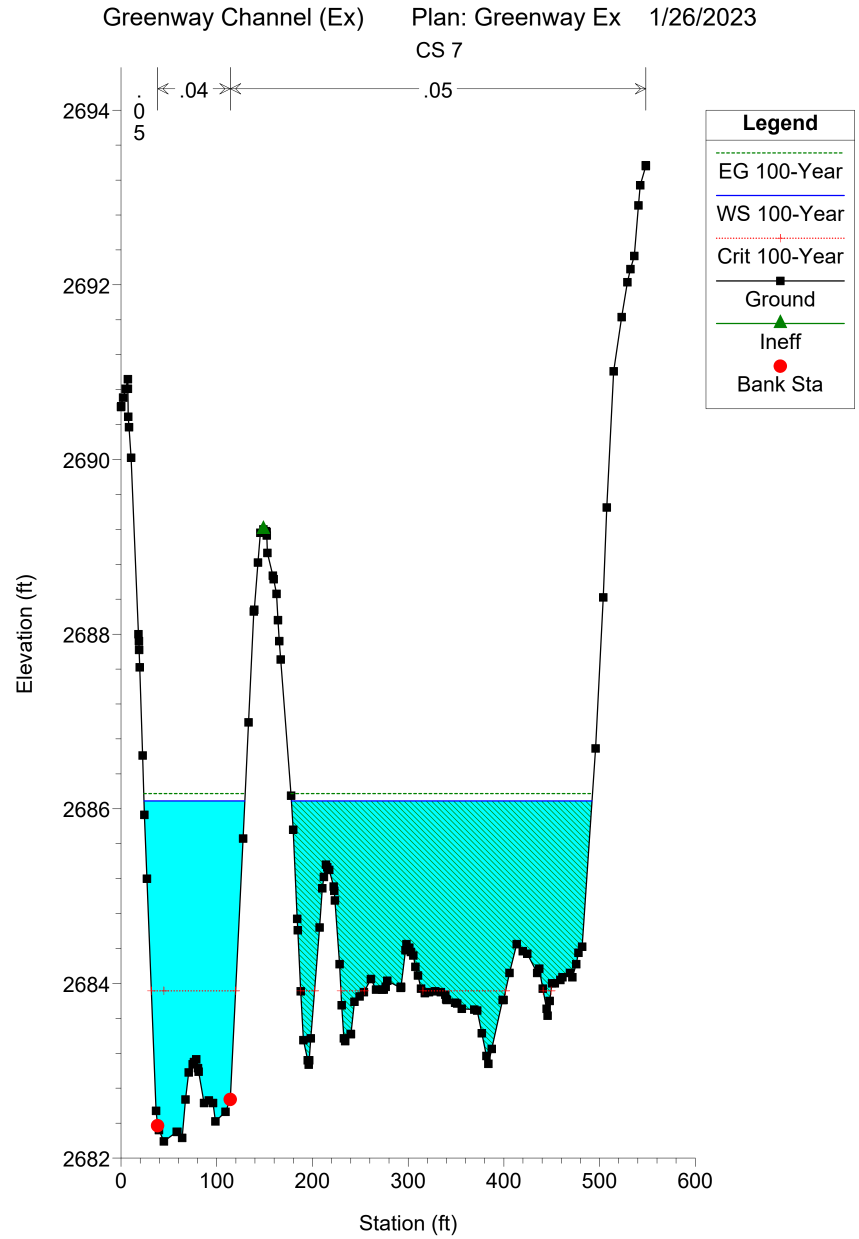
2684
2686
2688
2690
2692
2694
0
100
200
300
400
500
600
700



Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 7
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.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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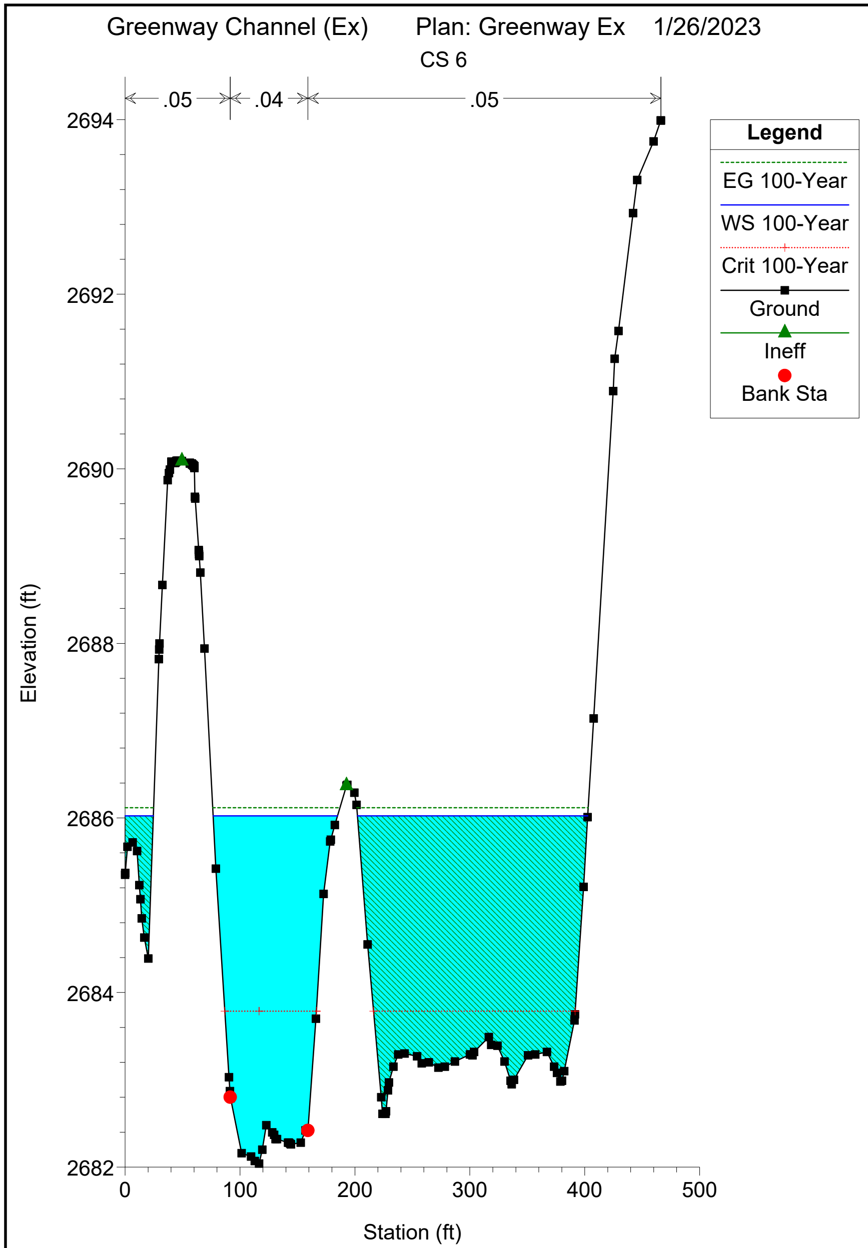
2684
2686
2688
2690
2692
2694
0
100
200
300
400
500
600



Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 6
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.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
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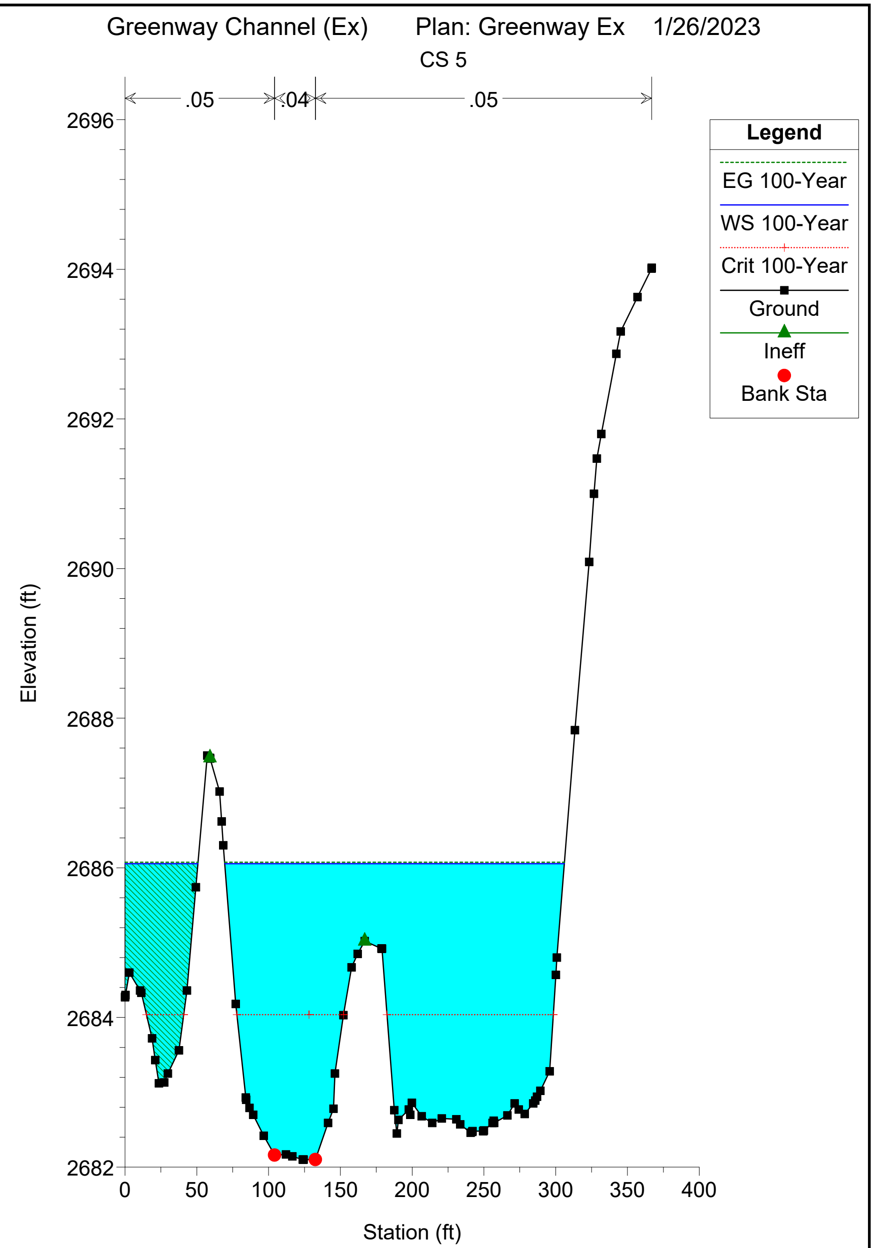
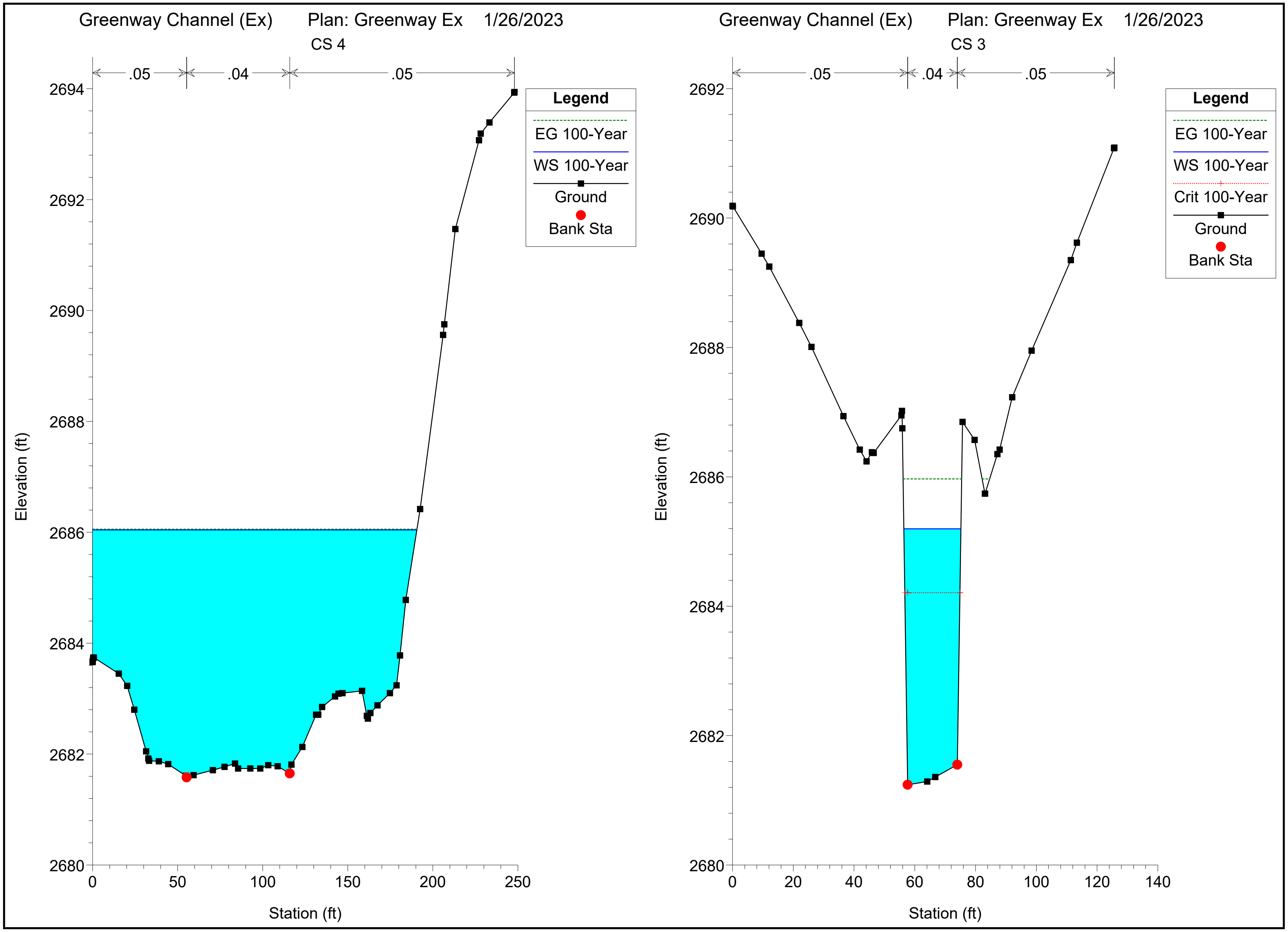
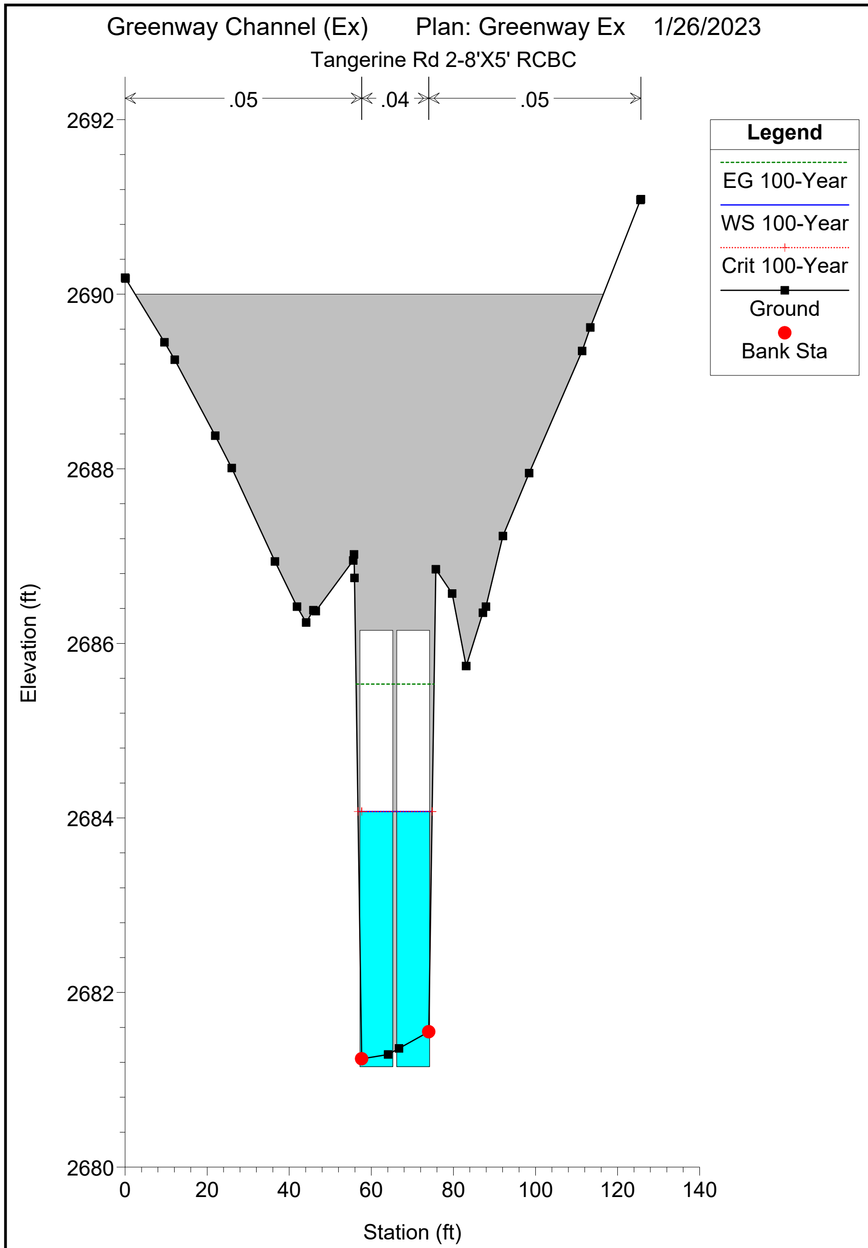
2692
2690
2688
2686
2684
2682
0
100
200
300
400
500
Station (ft)



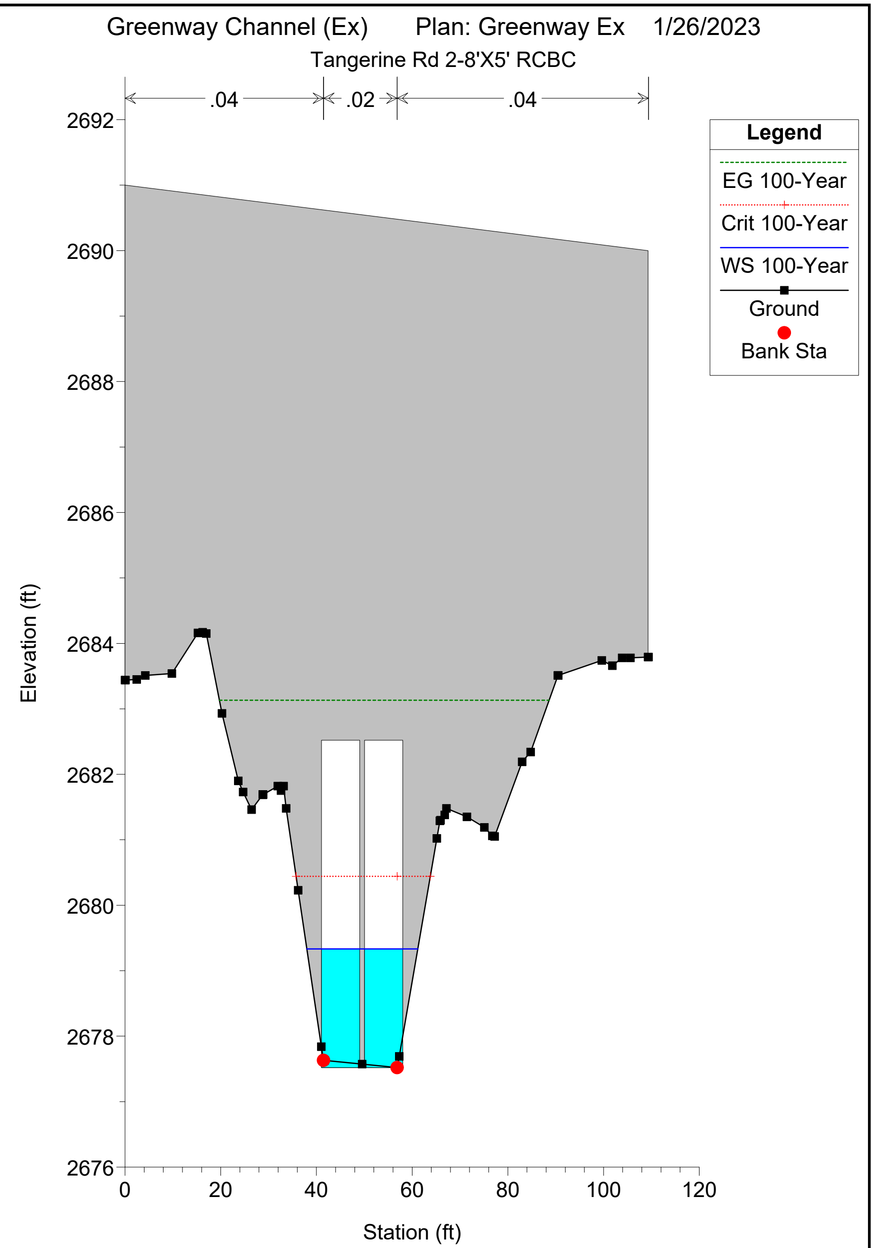
Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 5
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
2696
2694
2692
2690
2688
2686
2684
2682
0
50
100
150
200
250
300
350
400
Station (ft)



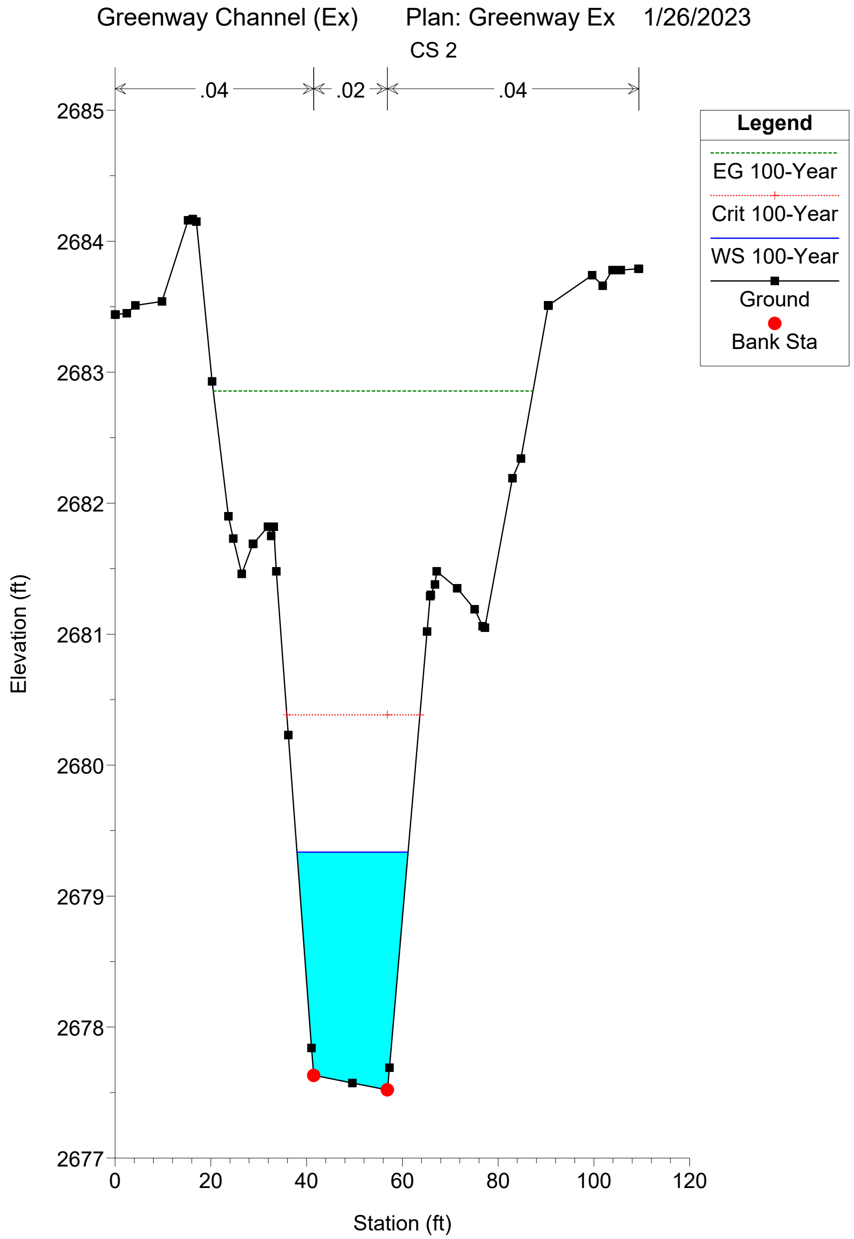
Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 4
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2694
2692
2690
2688
2686
2684
2682
2680
0
50
100
150
200
250
Station (ft)
Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 3
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
2692
2690
2688
2686
2684
2682
2680
0
20
40
60
80
100
120
140
Station (ft)

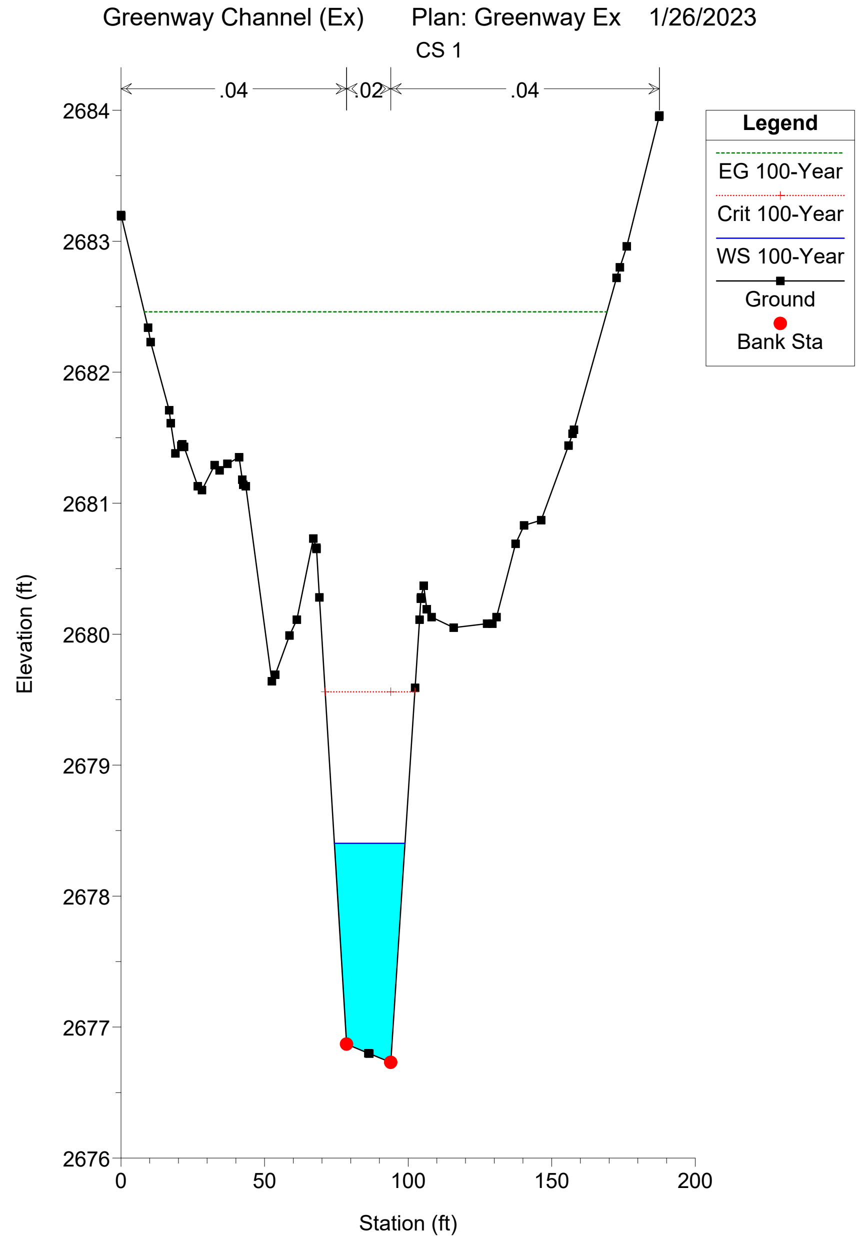


Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
Tangerine Rd 2-8'X5' RCBC
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

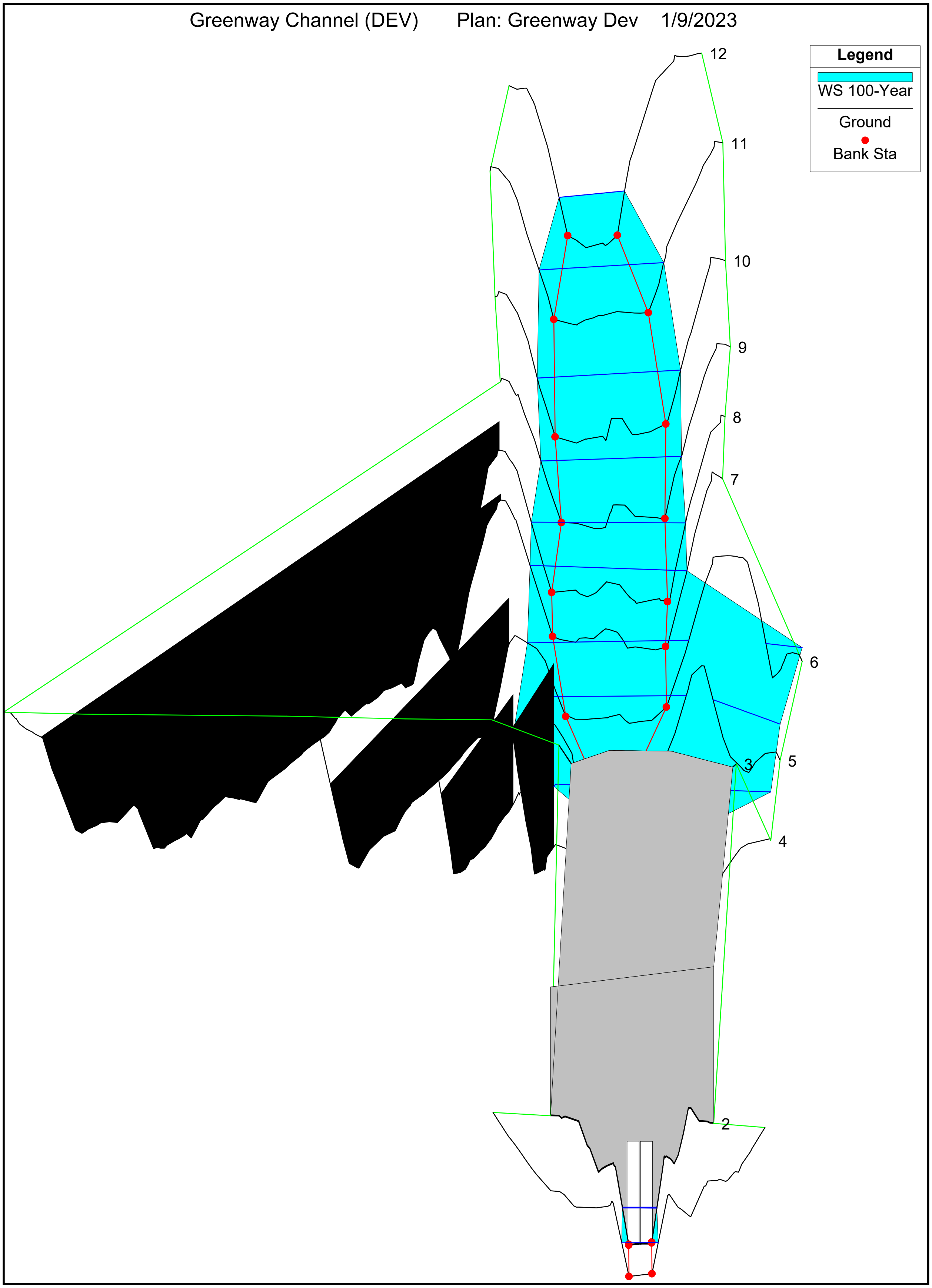


Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
Tangerine Rd 2-8'X5' RCBC
.04
.02
.04
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

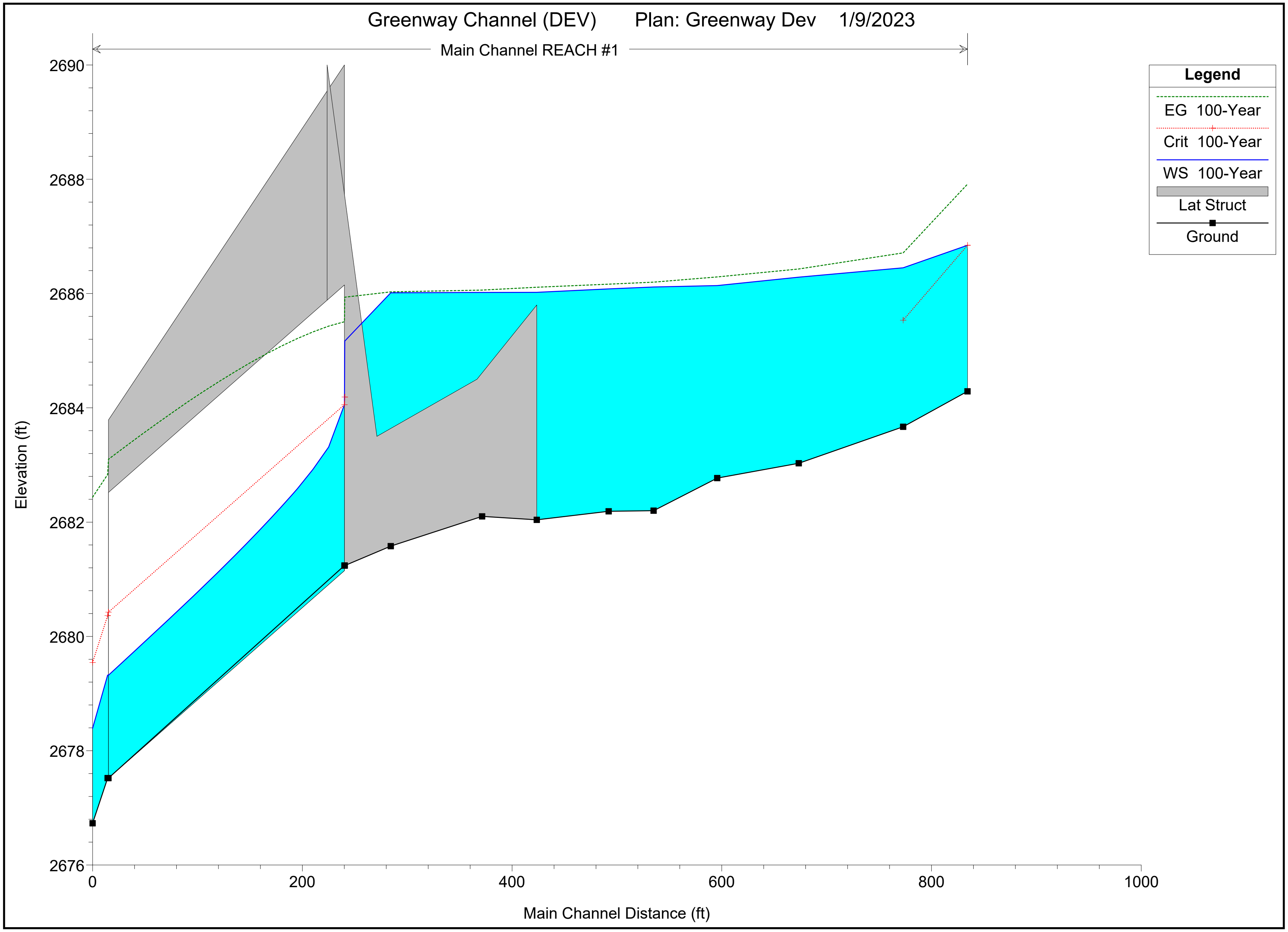

Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 2
.04
.02
.04
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2685
2684
2683
2682
2681
2680
2679
2678
2677
Station (ft)
0
20
40
60
80
100
120


Greenway Channel (Ex) Plan: Greenway Ex 1/26/2023
CS 1
.04
.02
.04
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2684
2683
2682
2681
2680
2679
2678
2677
2676
Station (ft)
0
50
100
150
200

B.2 Greenway Channel HEC-RAS Model (Developed)



Greenway Channel (DEV)
Plan: Greenway Dev
1/9/2023
Legend
WS 100-Year
Ground
Bank Sta
12
11
10
9
8
7
6
5
4
3
2



Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
Main Channel REACH #1
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Lat Struct
Ground
Elevation (ft)
2690
2688
2686
2684
2682
2680
2678
2676
0
200
400
600
800
1000
Main Channel Distance (ft)

Plan: Greenway Ex Main Channel REACH #1 RS: 12 Profile: 100-Year

E.G. Elev (ft)	2687.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.07	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.85	Reach Len. (ft)	61.41	61.41	61.41
Crit W.S. (ft)	2686.85	Flow Area (sq ft)	5.15	79.00	5.54
E.G. Slope (ft/ft)	0.016705	Area (sq ft)	5.15	79.00	5.54
Q Total (cfs)	710.00	Flow (cfs)	19.37	670.75	19.88
Top Width (ft)	44.27	Top Width (ft)	4.87	33.56	5.85
Vel Total (ft/s)	7.92	Avg. Vel. (ft/s)	3.76	8.49	3.59
Max Chl Dpth (ft)	2.56	Hydr. Depth (ft)	1.06	2.35	0.95
Conv. Total (cfs)	5493.3	Conv. (cfs)	149.9	5189.7	153.8
Length Wtd. (ft)	61.41	Wetted Per. (ft)	5.31	33.60	6.15
Min Ch El (ft)	2684.29	Shear (lb/sq ft)	1.01	2.45	0.94
Alpha	1.10	Stream Power (lb/ft s)	3.81	20.82	3.37
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)	0.79	2.74	3.51
C & E Loss (ft)	0.24	Cum SA (acres)	0.38	0.92	1.67

Plan: Greenway Ex Main Channel REACH #1 RS: 11 Profile: 100-Year

E.G. Elev (ft)	2686.64	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.29	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.35	Reach Len. (ft)	99.55	99.55	99.55
Crit W.S. (ft)	2685.53	Flow Area (sq ft)	12.78	149.46	10.37
E.G. Slope (ft/ft)	0.004507	Area (sq ft)	12.78	149.46	10.37
Q Total (cfs)	710.00	Flow (cfs)	29.49	659.02	21.49
Top Width (ft)	83.07	Top Width (ft)	10.00	63.56	9.51
Vel Total (ft/s)	4.11	Avg. Vel. (ft/s)	2.31	4.41	2.07
Max Chl Dpth (ft)	2.68	Hydr. Depth (ft)	1.28	2.35	1.09
Conv. Total (cfs)	10576.3	Conv. (cfs)	439.3	9816.9	320.1
Length Wtd. (ft)	99.55	Wetted Per. (ft)	10.27	63.57	9.80
Min Ch El (ft)	2683.67	Shear (lb/sq ft)	0.35	0.66	0.30
Alpha	1.09	Stream Power (lb/ft s)	0.81	2.92	0.62
Frctn Loss (ft)	0.29	Cum Volume (acre-ft)	0.78	2.57	3.50
C & E Loss (ft)	0.04	Cum SA (acres)	0.37	0.85	1.66

Plan: Greenway Ex Main Channel REACH #1 RS: 10 Profile: 100-Year

E.G. Elev (ft)	2686.31	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.16	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.15	Reach Len. (ft)	77.77	77.77	77.77
Crit W.S. (ft)		Flow Area (sq ft)	12.74	203.28	15.82
E.G. Slope (ft/ft)	0.002035	Area (sq ft)	12.74	203.28	15.82
Q Total (cfs)	710.00	Flow (cfs)	20.44	663.83	25.73
Top Width (ft)	95.41	Top Width (ft)	9.40	74.50	11.51
Vel Total (ft/s)	3.06	Avg. Vel. (ft/s)	1.60	3.27	1.63
Max Chl Dpth (ft)	3.12	Hydr. Depth (ft)	1.36	2.73	1.37
Conv. Total (cfs)	15739.8	Conv. (cfs)	453.2	14716.1	570.5
Length Wtd. (ft)	77.77	Wetted Per. (ft)	9.73	74.72	11.84
Min Ch El (ft)	2683.03	Shear (lb/sq ft)	0.17	0.35	0.17
Alpha	1.08	Stream Power (lb/ft s)	0.27	1.13	0.28
Frctn Loss (ft)	0.17	Cum Volume (acre-ft)	0.75	2.17	3.47
C & E Loss (ft)	0.00	Cum SA (acres)	0.35	0.69	1.63

Plan: Greenway Ex   Main Channel   REACH #1 RS: 9   Profile: 100-Year

E.G. Elev (ft)	2686.14	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.17	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2685.97	Reach Len. (ft)	60.60	60.60	60.60
Crit W.S. (ft)		Flow Area (sq ft)	12.78	190.09	19.24
E.G. Slope (ft/ft)	0.002252	Area (sq ft)	12.78	190.09	19.24
Q Total (cfs)	710.00	Flow (cfs)	20.39	655.14	34.47
Top Width (ft)	92.74	Top Width (ft)	10.22	69.39	13.14
Vel Total (ft/s)	3.20	Avg. Vel. (ft/s)	1.60	3.45	1.79
Max Chl Dpth (ft)	3.20	Hydr. Depth (ft)	1.25	2.74	1.46
Conv. Total (cfs)	14962.1	Conv. (cfs)	429.7	13806.1	726.3
Length Wtd. (ft)	60.60	Wetted Per. (ft)	10.61	69.53	13.44
Min Ch El (ft)	2682.77	Shear (lb/sq ft)	0.17	0.38	0.20
Alpha	1.10	Stream Power (lb/ft s)	0.27	1.32	0.36
Frctn Loss (ft)	0.03	Cum Volume (acre-ft)	0.73	1.82	3.44
C & E Loss (ft)	0.05	Cum SA (acres)	0.33	0.56	1.61

Plan: Greenway Ex   Main Channel   REACH #1 RS: 8   Profile: 100-Year

E.G. Elev (ft)	2686.06	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.04	Reach Len. (ft)	42.83	42.83	42.83
Crit W.S. (ft)		Flow Area (sq ft)	23.84	262.55	604.53
E.G. Slope (ft/ft)	0.000228	Area (sq ft)	23.84	262.55	604.53
Q Total (cfs)	710.00	Flow (cfs)	16.44	331.45	362.10
Top Width (ft)	480.47	Top Width (ft)	11.89	77.69	390.90
Vel Total (ft/s)	0.80	Avg. Vel. (ft/s)	0.69	1.26	0.60
Max Chl Dpth (ft)	3.84	Hydr. Depth (ft)	2.01	3.38	1.55
Conv. Total (cfs)	47017.0	Conv. (cfs)	1089.0	21949.2	23978.9
Length Wtd. (ft)	42.83	Wetted Per. (ft)	12.51	77.77	392.12
Min Ch El (ft)	2682.20	Shear (lb/sq ft)	0.03	0.05	0.02
Alpha	1.48	Stream Power (lb/ft s)	0.02	0.06	0.01
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.70	1.51	3.00
C & E Loss (ft)	0.00	Cum SA (acres)	0.31	0.46	1.33

Plan: Greenway Ex   Main Channel   REACH #1 RS: 7   Profile: 100-Year

E.G. Elev (ft)	2686.05	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.04	Reach Len. (ft)	68.67	68.67	68.67
Crit W.S. (ft)		Flow Area (sq ft)	27.76	264.51	648.86
E.G. Slope (ft/ft)	0.000172	Area (sq ft)	27.76	264.51	648.86
Q Total (cfs)	710.00	Flow (cfs)	16.57	296.10	397.32
Top Width (ft)	418.62	Top Width (ft)	14.15	75.87	328.60
Vel Total (ft/s)	0.75	Avg. Vel. (ft/s)	0.60	1.12	0.61
Max Chl Dpth (ft)	3.85	Hydr. Depth (ft)	1.96	3.49	1.97
Conv. Total (cfs)	54135.6	Conv. (cfs)	1263.7	22577.2	30294.7
Length Wtd. (ft)	68.67	Wetted Per. (ft)	14.64	75.94	329.86
Min Ch El (ft)	2682.19	Shear (lb/sq ft)	0.02	0.04	0.02
Alpha	1.30	Stream Power (lb/ft s)	0.01	0.04	0.01
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.68	1.25	2.39
C & E Loss (ft)	0.00	Cum SA (acres)	0.30	0.39	0.98

Plan: Greenway Ex Main Channel REACH #1 RS: 6 Profile: 100-Year

E.G. Elev (ft)	2686.04	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.02	Reach Len. (ft)	52.08	52.08	52.08
Crit W.S. (ft)		Flow Area (sq ft)	43.72	251.90	556.13
E.G. Slope (ft/ft)	0.000170	Area (sq ft)	43.72	251.90	556.13
Q Total (cfs)	710.00	Flow (cfs)	19.27	293.40	397.33
Top Width (ft)	333.27	Top Width (ft)	39.57	67.53	226.17
Vel Total (ft/s)	0.83	Avg. Vel. (ft/s)	0.44	1.16	0.71
Max Chl Dpth (ft)	3.98	Hydr. Depth (ft)	1.10	3.73	2.46
Conv. Total (cfs)	54443.3	Conv. (cfs)	1477.3	22498.1	30467.9
Length Wtd. (ft)	52.08	Wetted Per. (ft)	41.00	67.57	227.05
Min Ch El (ft)	2682.04	Shear (lb/sq ft)	0.01	0.04	0.03
Alpha	1.23	Stream Power (lb/ft s)	0.00	0.05	0.02
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.62	0.84	1.44
C & E Loss (ft)	0.00	Cum SA (acres)	0.26	0.27	0.54

Plan: Greenway Ex Main Channel REACH #1 RS: 5 Profile: 100-Year

E.G. Elev (ft)	2686.03	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.01	Reach Len. (ft)	87.16	87.16	87.16
Crit W.S. (ft)		Flow Area (sq ft)	194.96	109.99	486.24
E.G. Slope (ft/ft)	0.000212	Area (sq ft)	194.96	109.99	486.24
Q Total (cfs)	710.00	Flow (cfs)	146.05	146.90	417.05
Top Width (ft)	286.90	Top Width (ft)	85.29	28.34	173.27
Vel Total (ft/s)	0.90	Avg. Vel. (ft/s)	0.75	1.34	0.86
Max Chl Dpth (ft)	3.91	Hydr. Depth (ft)	2.29	3.88	2.81
Conv. Total (cfs)	48768.5	Conv. (cfs)	10031.7	10090.3	28646.5
Length Wtd. (ft)	87.16	Wetted Per. (ft)	87.71	28.34	174.21
Min Ch El (ft)	2682.10	Shear (lb/sq ft)	0.03	0.05	0.04
Alpha	1.14	Stream Power (lb/ft s)	0.02	0.07	0.03
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.48	0.62	0.81
C & E Loss (ft)	0.00	Cum SA (acres)	0.18	0.22	0.30

Plan: Greenway Ex Main Channel REACH #1 RS: 4 Profile: 100-Year

E.G. Elev (ft)	2686.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2686.00	Reach Len. (ft)	43.82	43.82	43.82
Crit W.S. (ft)		Flow Area (sq ft)	187.56	259.07	216.33
E.G. Slope (ft/ft)	0.000110	Area (sq ft)	187.56	259.07	216.33
Q Total (cfs)	530.92	Flow (cfs)	128.29	265.88	136.76
Top Width (ft)	190.40	Top Width (ft)	55.29	60.62	74.49
Vel Total (ft/s)	0.80	Avg. Vel. (ft/s)	0.68	1.03	0.63
Max Chl Dpth (ft)	4.42	Hydr. Depth (ft)	3.39	4.27	2.90
Conv. Total (cfs)	50606.9	Conv. (cfs)	12228.2	25343.3	13035.5
Length Wtd. (ft)	43.82	Wetted Per. (ft)	57.72	60.63	74.92
Min Ch El (ft)	2681.58	Shear (lb/sq ft)	0.02	0.03	0.02
Alpha	1.16	Stream Power (lb/ft s)	0.02	0.03	0.01
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.10	0.25	0.11
C & E Loss (ft)	0.08	Cum SA (acres)	0.04	0.13	0.05

Plan: Greenway Ex   Main Channel   REACH #1 RS: 3   Profile: 100-Year

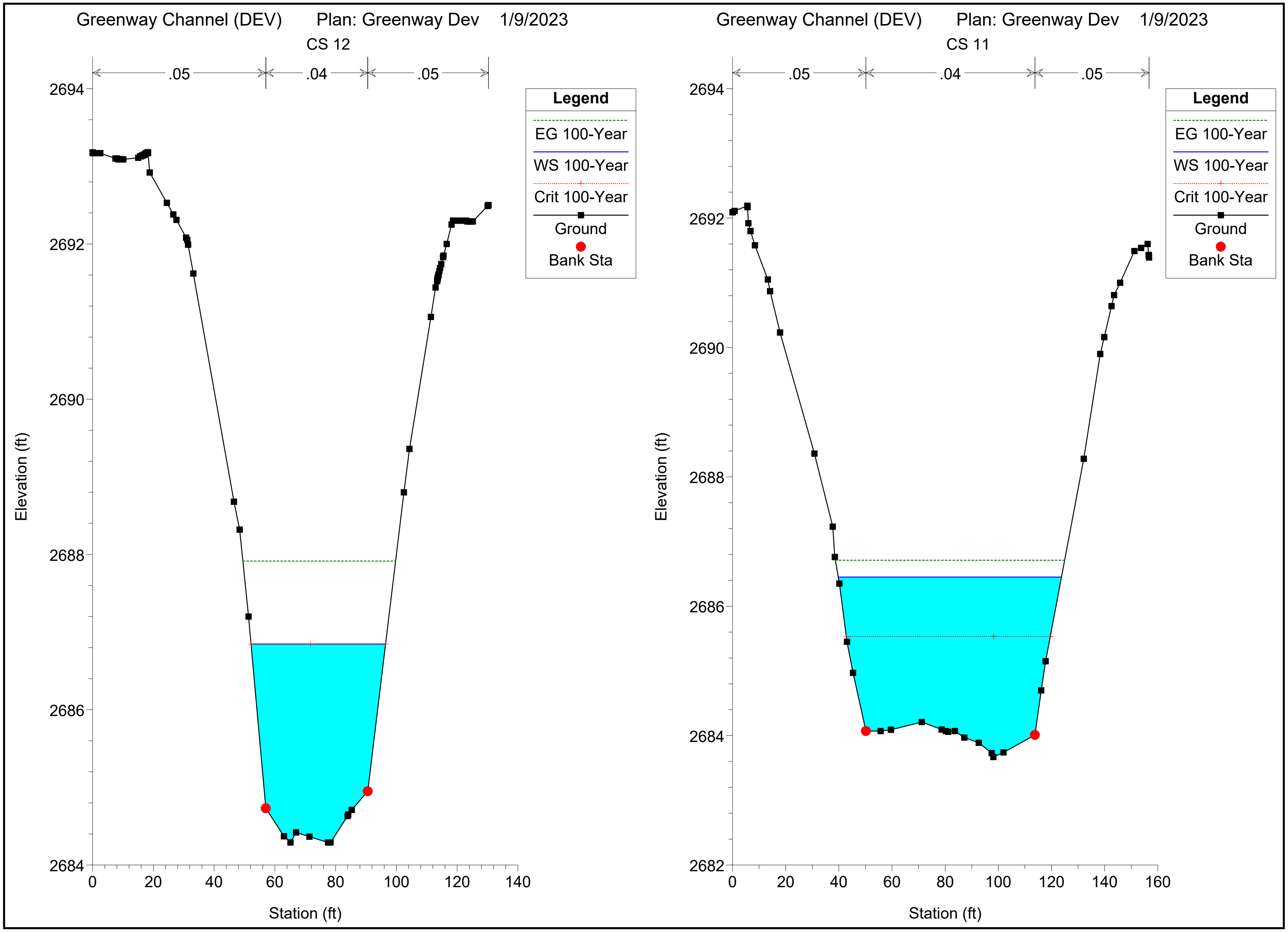
E.G. Elev (ft)	2685.93	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.77	Wt. n-Val.	0.050	0.040	0.050
W.S. Elev (ft)	2685.16	Reach Len. (ft)	226.10	226.10	226.10
Crit W.S. (ft)	2684.18	Flow Area (sq ft)	2.41	62.19	2.10
E.G. Slope (ft/ft)	0.006127	Area (sq ft)	2.41	62.19	2.10
Q Total (cfs)	447.42	Flow (cfs)	3.93	440.20	3.29
Top Width (ft)	18.76	Top Width (ft)	1.23	16.37	1.16
Vel Total (ft/s)	6.71	Avg. Vel. (ft/s)	1.63	7.08	1.57
Max Chl Dpth (ft)	3.92	Hydr. Depth (ft)	1.96	3.80	1.80
Conv. Total (cfs)	5716.1	Conv. (cfs)	50.2	5623.9	42.1
Length Wtd. (ft)	226.10	Wetted Per. (ft)	4.11	16.37	3.79
Min Ch El (ft)	2681.24	Shear (lb/sq ft)	0.22	1.45	0.21
Alpha	1.10	Stream Power (lb/ft s)	0.37	10.28	0.33
Frctn Loss (ft)		Cum Volume (acre-ft)	0.00	0.09	0.00
C & E Loss (ft)		Cum SA (acres)	0.01	0.09	0.02

Plan: Greenway Ex   Main Channel   REACH #1 RS: 2   Profile: 100-Year

E.G. Elev (ft)	2682.82	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.51	Wt. n-Val.	0.040	0.020	0.040
W.S. Elev (ft)	2679.32	Reach Len. (ft)	14.36	14.36	14.36
Crit W.S. (ft)	2680.36	Flow Area (sq ft)	2.95	26.79	3.84
E.G. Slope (ft/ft)	0.020839	Area (sq ft)	2.95	26.79	3.84
Q Total (cfs)	447.42	Flow (cfs)	13.24	415.96	18.22
Top Width (ft)	23.11	Top Width (ft)	3.47	15.38	4.26
Vel Total (ft/s)	13.32	Avg. Vel. (ft/s)	4.49	15.53	4.74
Max Chl Dpth (ft)	1.80	Hydr. Depth (ft)	0.85	1.74	0.90
Conv. Total (cfs)	3099.4	Conv. (cfs)	91.7	2881.5	126.2
Length Wtd. (ft)	14.36	Wetted Per. (ft)	3.86	15.38	4.62
Min Ch El (ft)	2677.52	Shear (lb/sq ft)	1.00	2.27	1.08
Alpha	1.27	Stream Power (lb/ft s)	4.46	35.18	5.13
Frctn Loss (ft)	0.34	Cum Volume (acre-ft)	0.00	0.01	0.00
C & E Loss (ft)	0.05	Cum SA (acres)	0.00	0.01	0.00

Plan: Greenway Ex   Main Channel   REACH #1 RS: 1   Profile: 100-Year

E.G. Elev (ft)	2682.43	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.04	Wt. n-Val.	0.040	0.020	0.040
W.S. Elev (ft)	2678.39	Reach Len. (ft)			
Crit W.S. (ft)	2679.52	Flow Area (sq ft)	3.20	24.48	4.07
E.G. Slope (ft/ft)	0.027486	Area (sq ft)	3.20	24.48	4.07
Q Total (cfs)	447.42	Flow (cfs)	15.72	410.39	21.31
Top Width (ft)	24.54	Top Width (ft)	4.21	15.42	4.91
Vel Total (ft/s)	14.09	Avg. Vel. (ft/s)	4.92	16.76	5.24
Max Chl Dpth (ft)	1.66	Hydr. Depth (ft)	0.76	1.59	0.83
Conv. Total (cfs)	2698.7	Conv. (cfs)	94.8	2475.4	128.6
Length Wtd. (ft)		Wetted Per. (ft)	4.48	15.42	5.18
Min Ch El (ft)	2676.73	Shear (lb/sq ft)	1.22	2.72	1.35
Alpha	1.31	Stream Power (lb/ft s)	6.02	45.67	7.06
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			



Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 12
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
2684
2686
2688
2690
2692
2694
0
20
40
60
80
100
120
140
Station (ft)
Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 11
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
2682
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2692
2694
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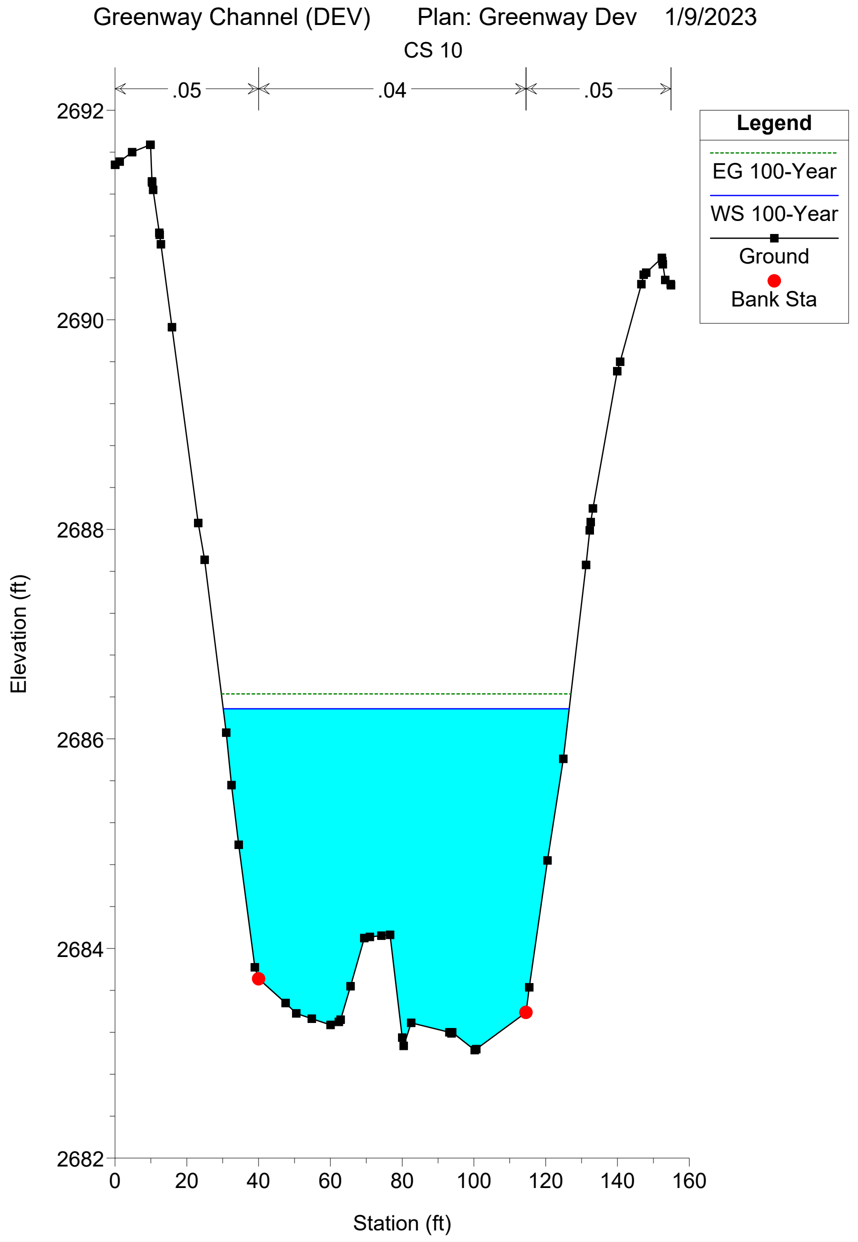
20
40
60
80
100
120
140
160
Station (ft)



Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 10
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
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2688
2686
2684
2682
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20
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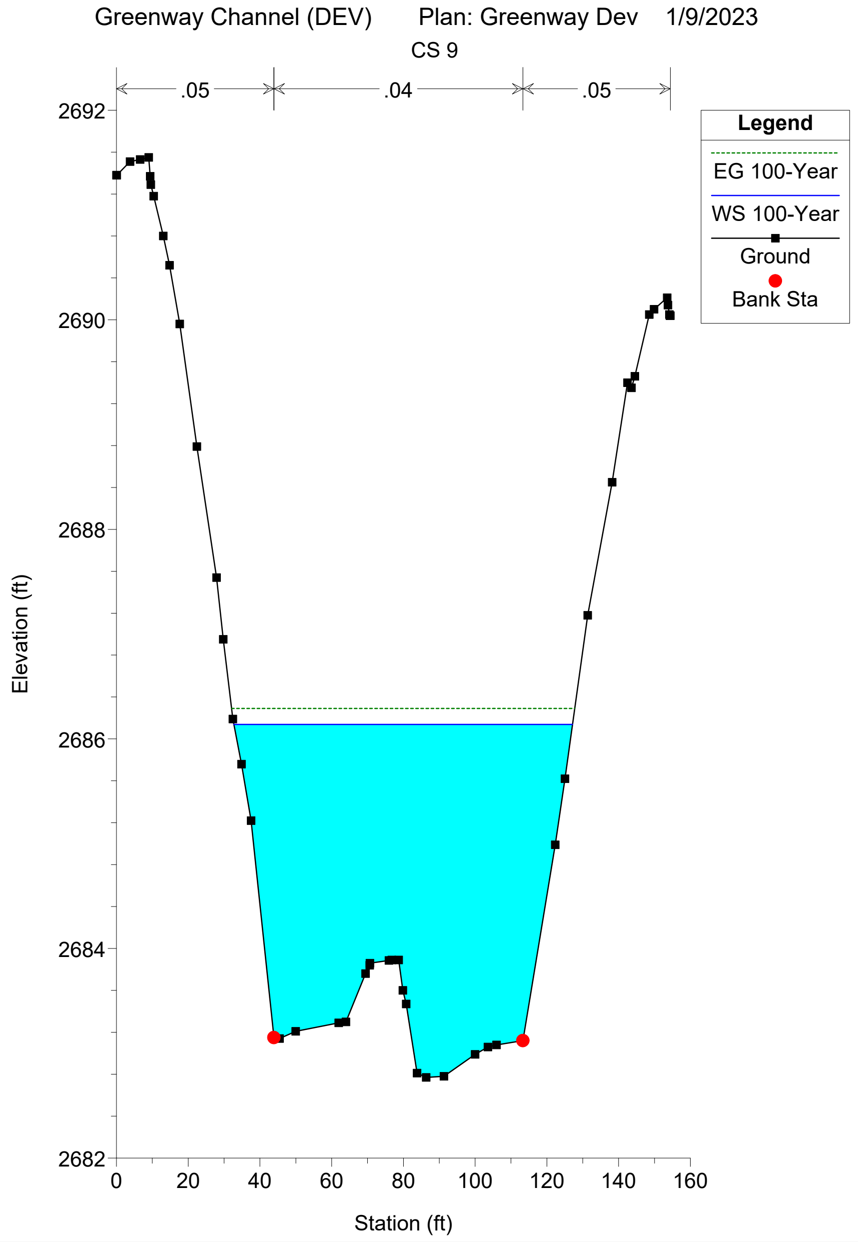
60
80
100
120
140
160
Station (ft)



Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 9
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
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2688
2686
2684
2682
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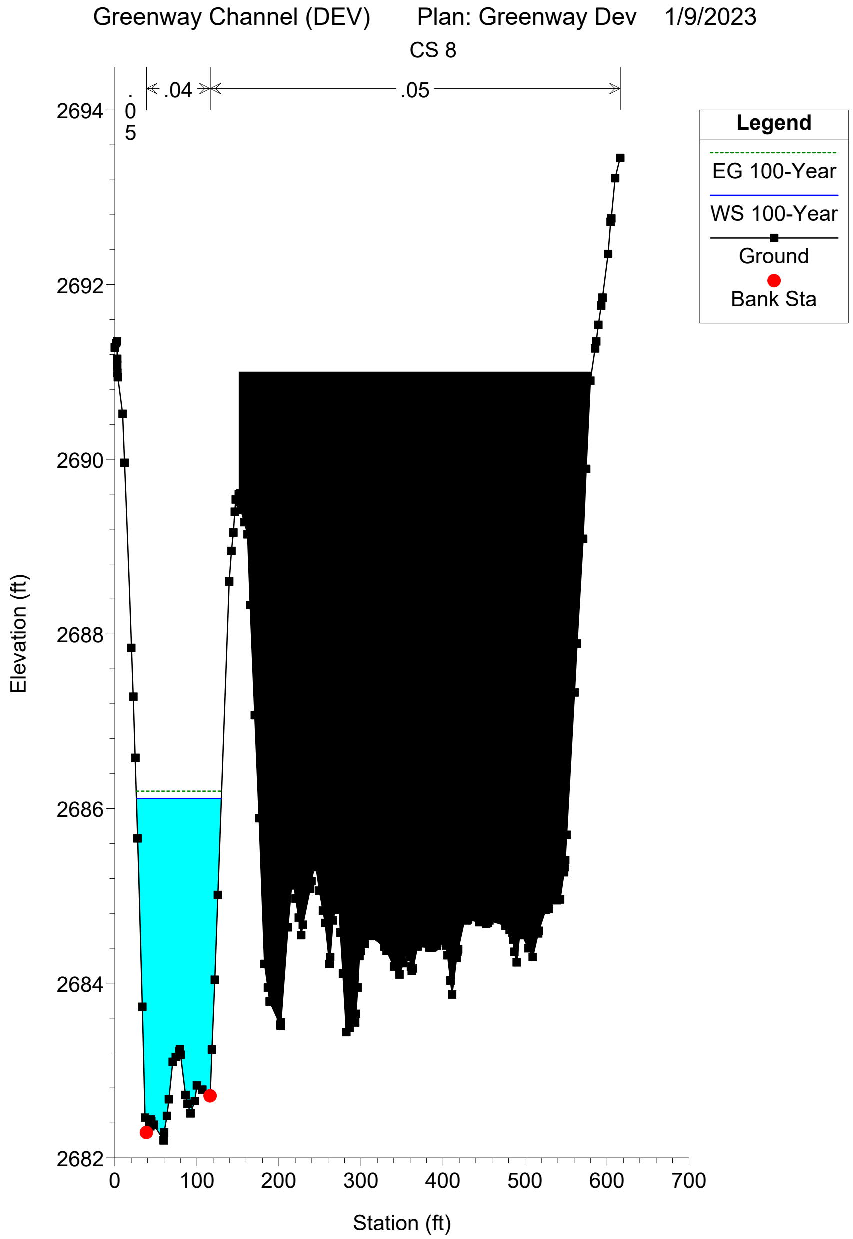
20
40
60
80
100
120
140
160
Station (ft)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CS 8
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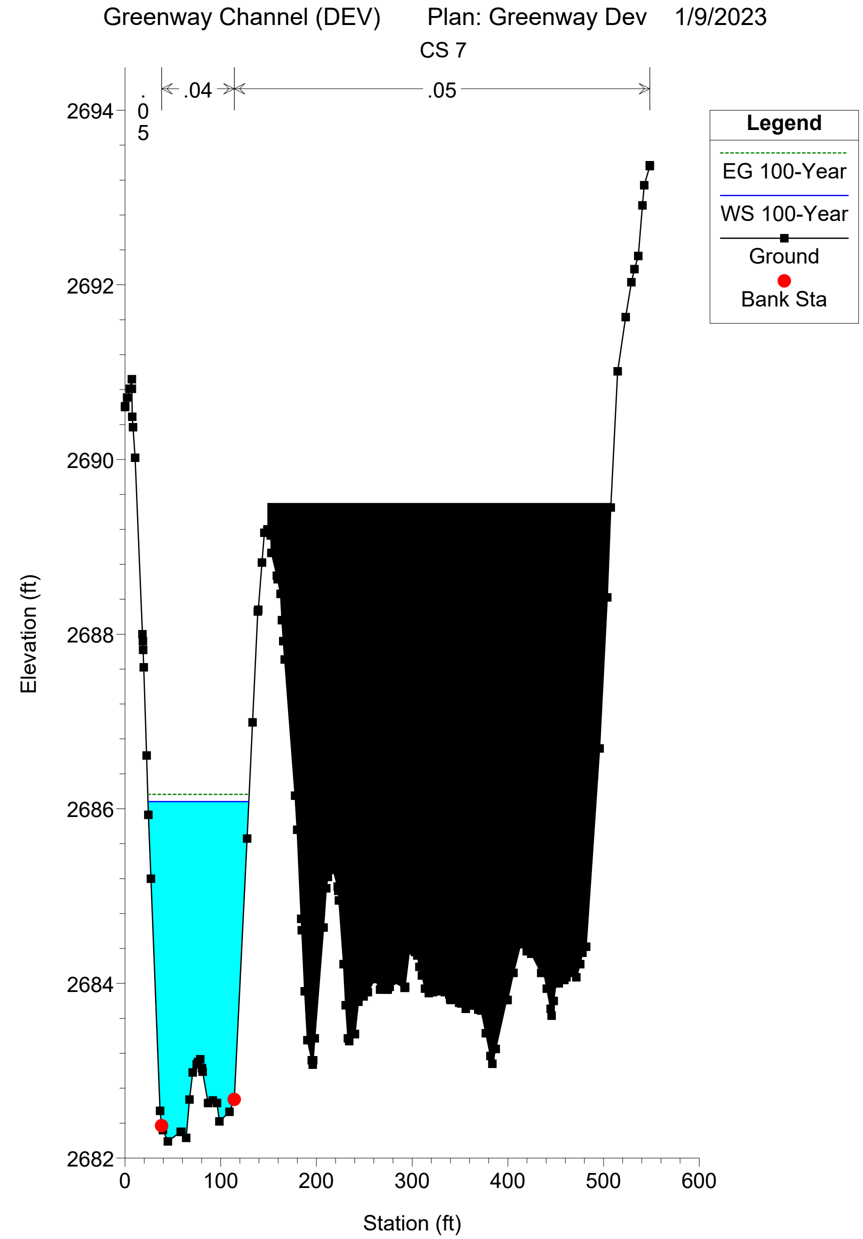
.05
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2694
2692
2690
2688
2686
2684
2682
0
100
200
300
400
500
600
700
Station (ft)


Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 7
.04
.05
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2694
2692
2690
2688
2686
2684
2682
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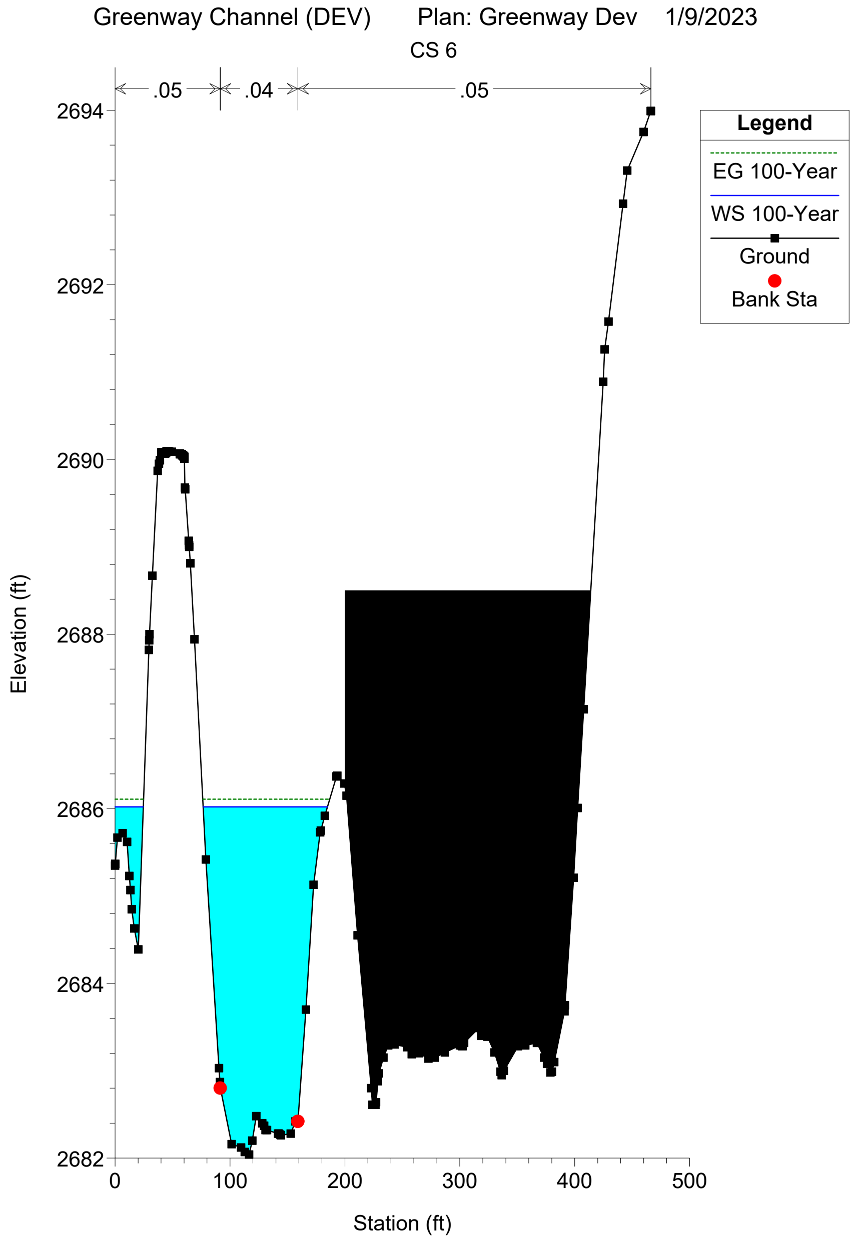
100
200
300
400
500
600
Station (ft)


Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 6
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
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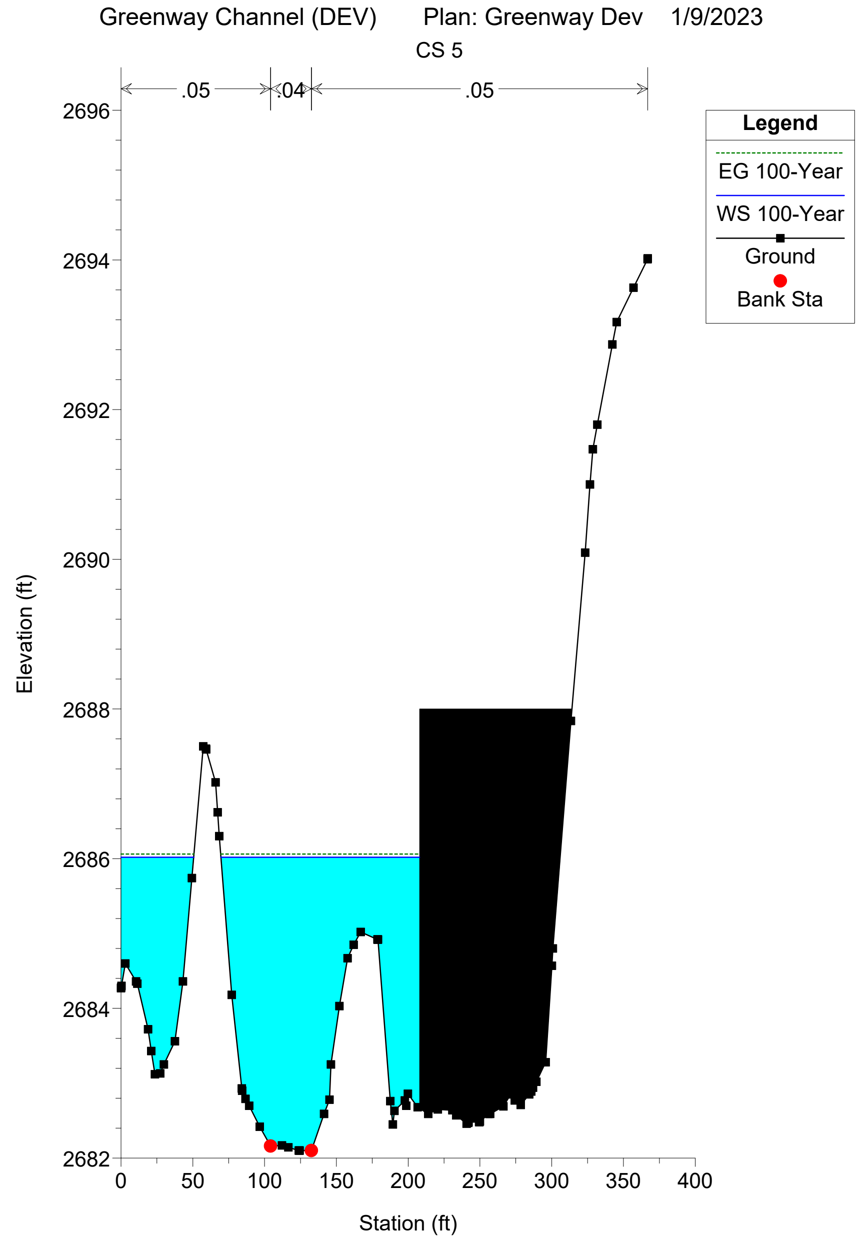
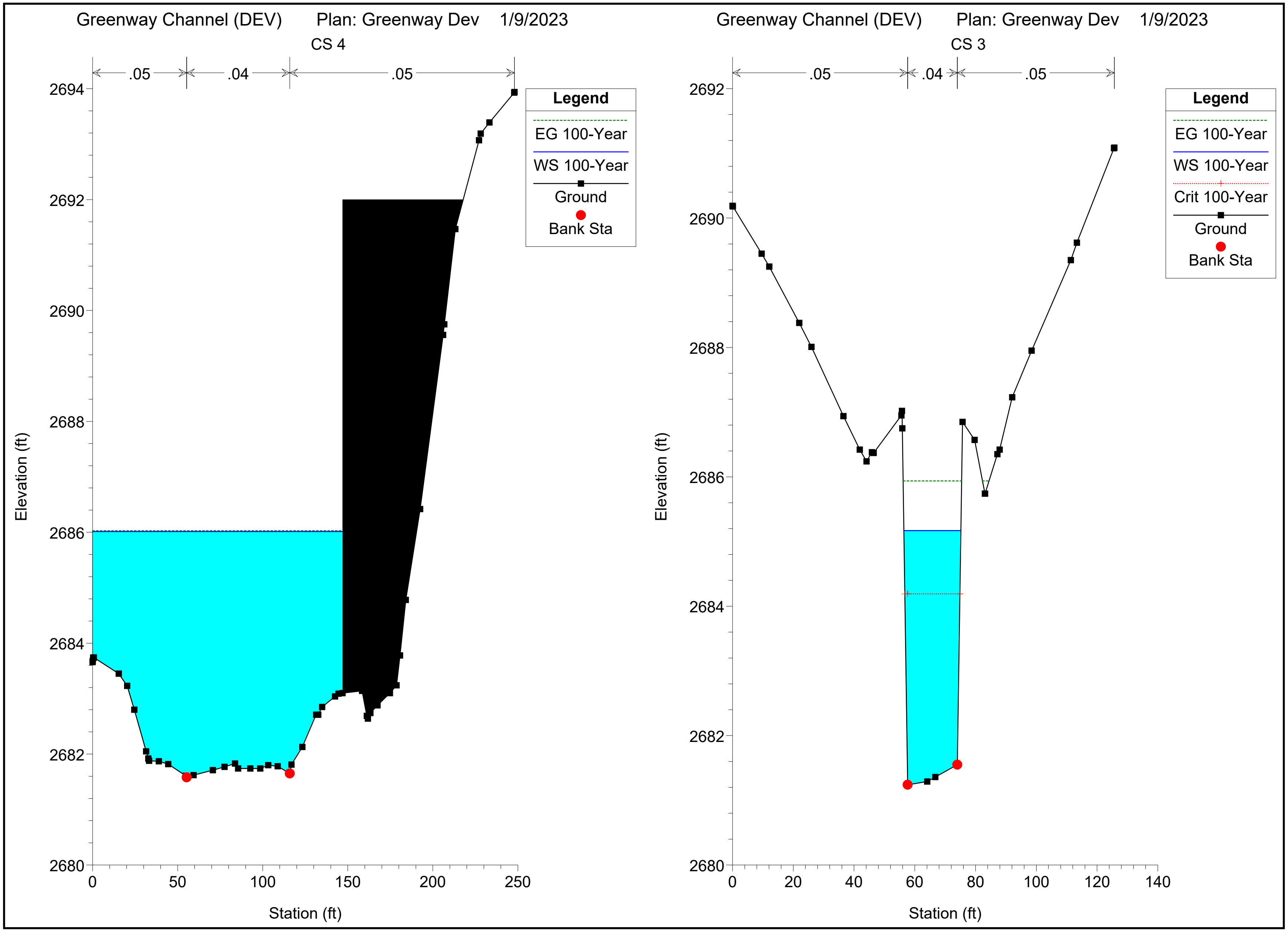
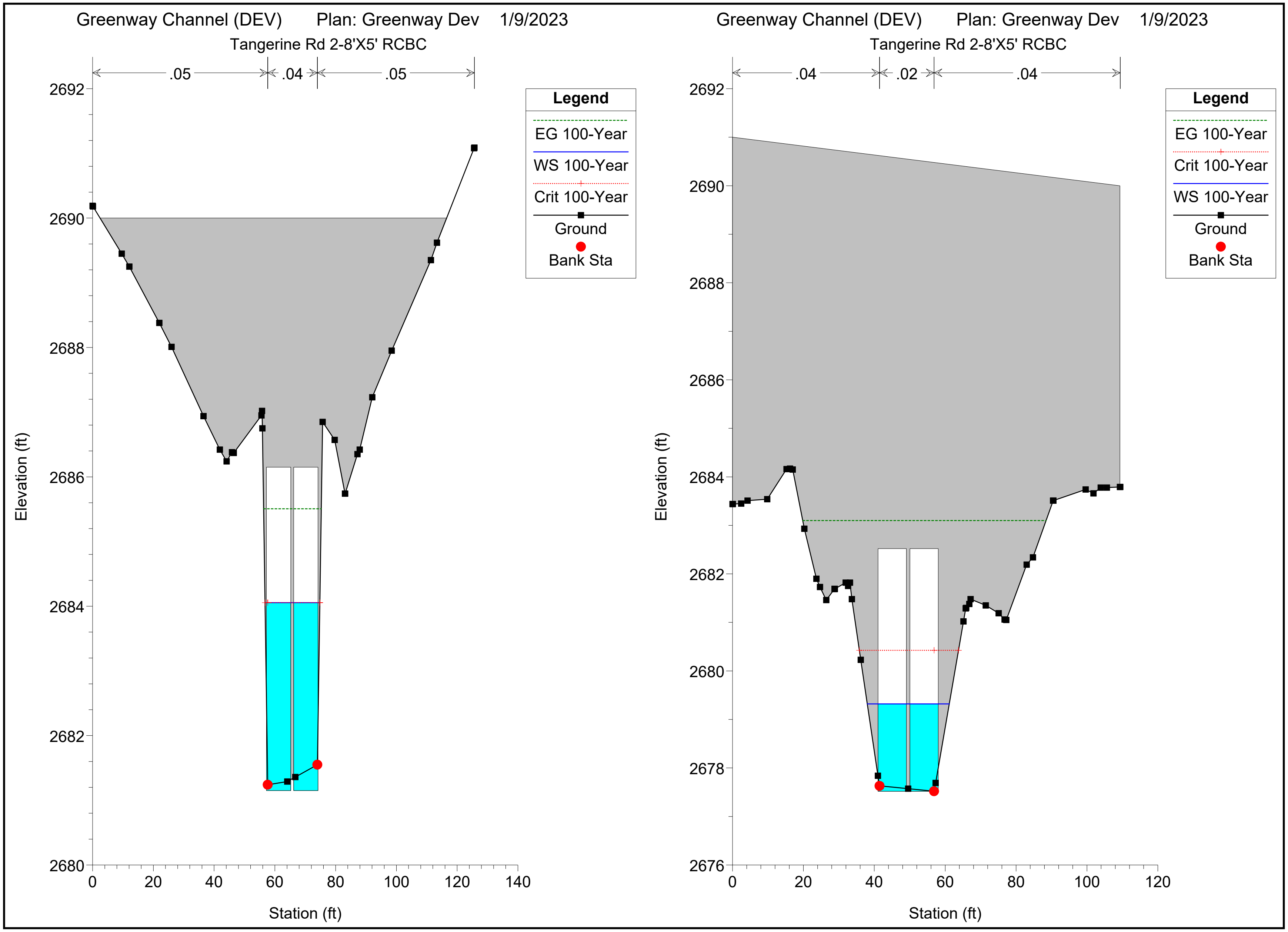
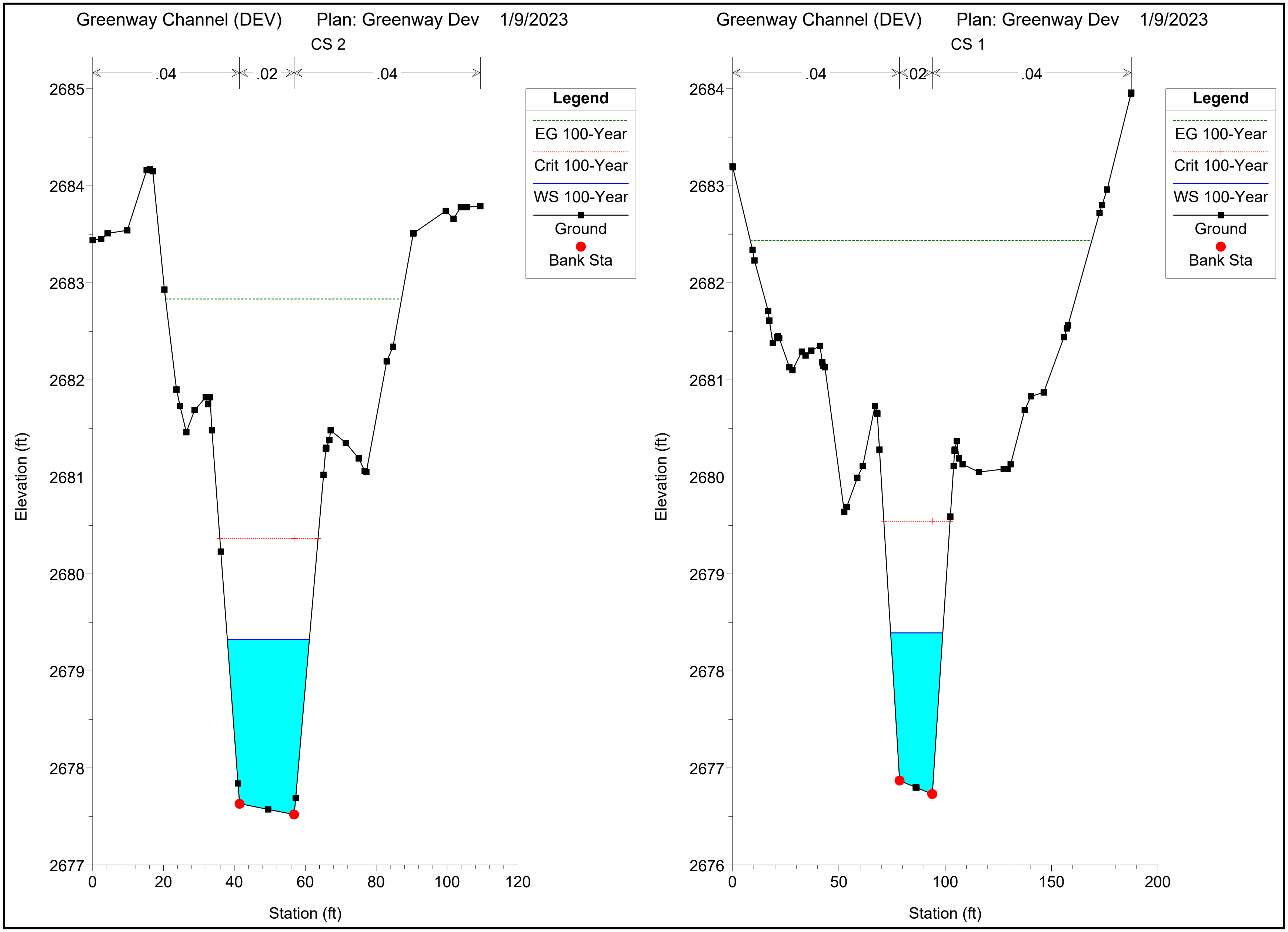
2692
2690
2688
2686
2684
2682
0
100
200
300
400
500
Station (ft)


Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 5
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2696
2694
2692
2690
2688
2686
2684
2682
0
50
100
150
200
250
300
350
400
Station (ft)


Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 4
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2680
2682
2684
2686
2688
2690
2692
2694
Station (ft)
0
50
100
150
200
250
Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 3
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
2680
2682
2684
2686
2688
2690
2692
Station (ft)
0
20
40
60
80
100
120
140

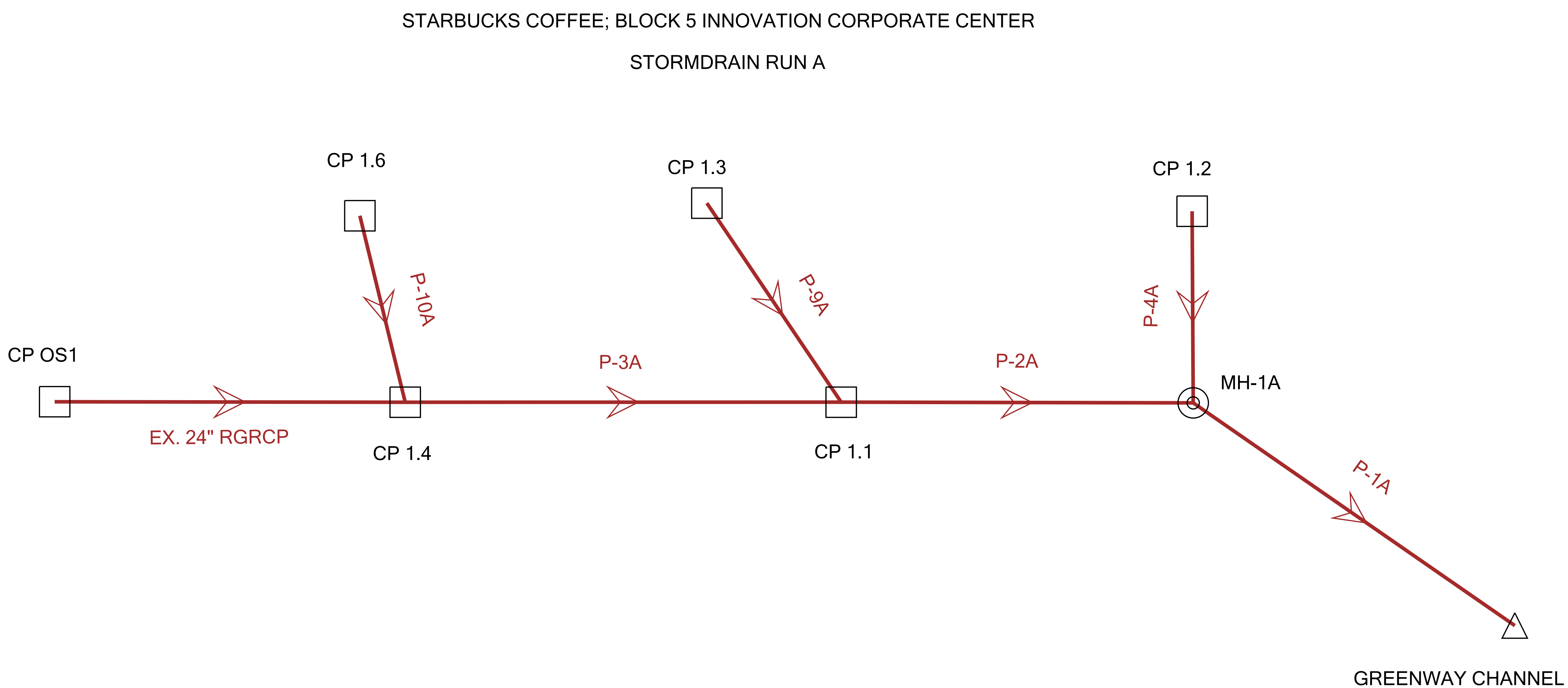

Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
Tangerine Rd 2-8'X5' RCBC
.05
.04
.05
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
2680
2682
2684
2686
2688
2690
2692
0
20
40
60
80
100
120
140
Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
Tangerine Rd 2-8'X5' RCBC
.04
.02
.04
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
2676
2678
2680
2682
2684
2686
2688
2690
2692
0
20
40
60
80
100
120



Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 2
.04
.02
.04
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2685
2684
2683
2682
2681
2680
2679
2678
2677
0
20
40
60
80
100
120
Station (ft)
Greenway Channel (DEV) Plan: Greenway Dev 1/9/2023
CS 1
.04
.02
.04
Legend
EG 100-Year
Crit 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
2684
2683
2682
2681
2680
2679
2678
2677
2676
0
50
100
150
200
Station (ft)

B.3 StormCAD Worksheets

Scenario: Base



Conduit FlexTable: WLB Group Table

Label	Upstream Structure	Flow (cfs)	Length (User Defined) (ft)	Diameter (in)	Material	Number of Barrels	Velocity (ft/s)	Elevation Ground (Start) (ft)	Hydraulic Grade Line (In) (ft)	Energy Grade Line (In) (ft)	Invert (Start) (ft)	Elevation Ground (Stop) (ft)	Hydraulic Grade Line (Out) (ft)	Invert (Stop) (ft)	Energy Grade Line (Out) (ft)
P-3A	CP 1.4	16.60	220.8	30.0	Steel	1	6.44	2,691.80	2,688.05	2,688.29	2,686.02	2,689.40	2,687.76	2,684.75	2,687.93
P-2A	CP 1.1	41.10	92.5	36.0	Steel	1	5.81	2,689.40	2,687.36	2,687.89	2,684.25	2,690.10	2,687.01	2,683.70	2,687.53
P-1A	MH-1A	47.40	100.0	36.0	Steel	1	8.29	2,690.10	2,686.44	2,687.17	2,683.60	2,691.00	2,686.00	2,683.00	2,686.70
P-4A	CP 1.2	6.30	35.2	18.0	Steel	1	3.57	2,690.30	2,687.14	2,687.33	2,685.40	2,690.10	2,687.01	2,685.20	2,687.21
P-9A	CP 1.3	11.50	67.1	24.0	Steel	1	3.66	2,690.70	2,687.93	2,688.14	2,685.70	2,689.40	2,687.76	2,685.25	2,687.96
EX. 24" RGRCP	CP OS1	10.30	102.0	24.0	Concrete	1	7.47	2,690.76	2,688.47	2,688.94	2,687.32	2,691.80	2,688.28	2,686.12	2,688.45
P-10A	CP 1.6	5.40	43.1	18.0	Steel	1	5.98	2,692.15	2,688.35	2,688.72	2,687.45	2,691.80	2,688.28	2,687.02	2,688.46

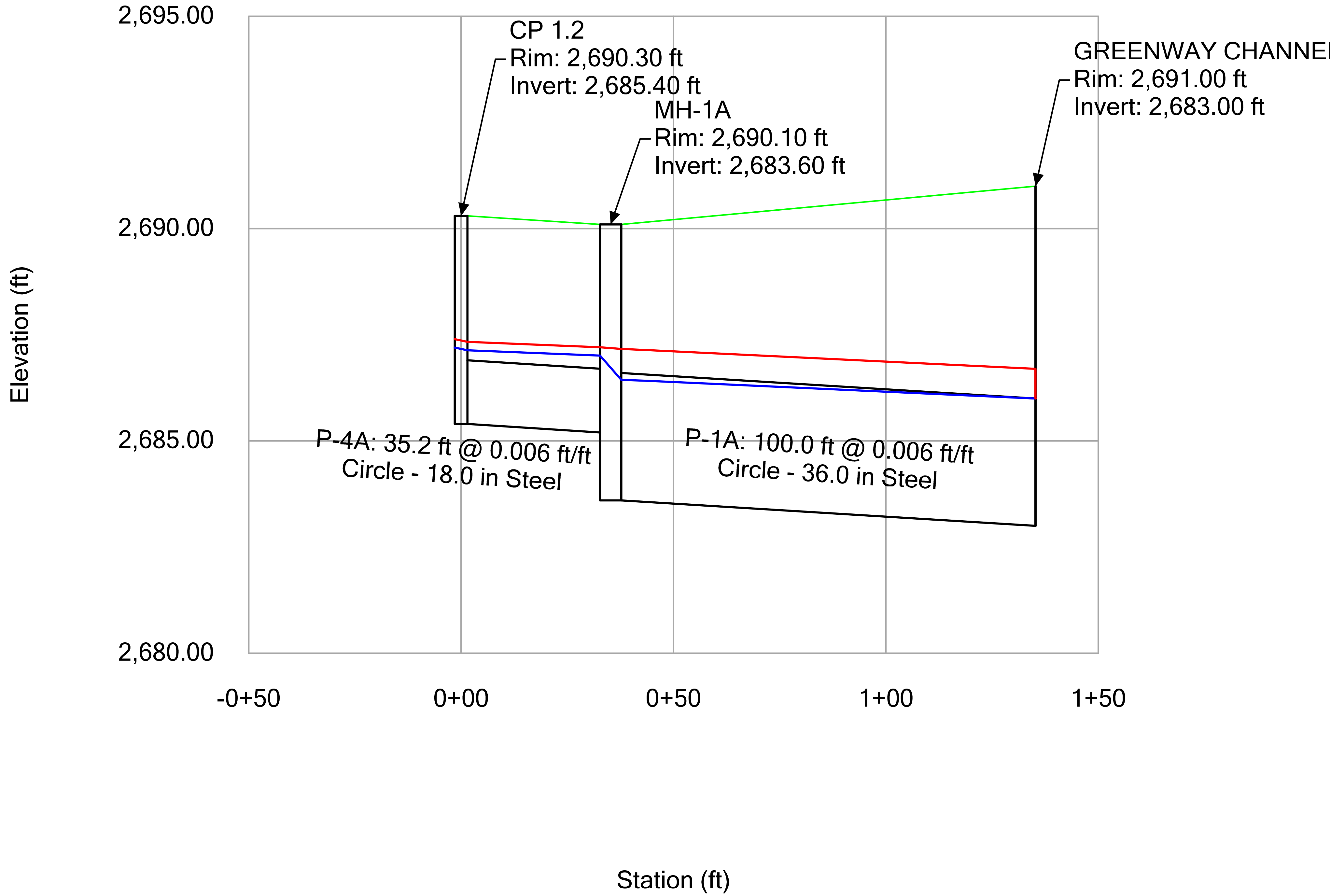
Conduit FlexTable: Culvert Table

Label	Start Node	Stop Node	Length (User Defined) (ft)	Diameter (in)	Slope (Calculated) (ft/ft)	Material	Flow (cfs)	Flow / Capacity (Design) (%)	Velocity (ft/s)	Velocity (In) (ft/s)	Velocity (Out) (ft/s)	Depth (Normal) (ft)	Specific Energy (In) (in)	Specific Energy (Out) (in)	Manning's n	Upstream Structure Headloss (ft)	Headloss (ft)
P-3A	CP 1.4	CP 1.1	220.8	30.0	0.006	Steel	16.60	53.4	6.44	3.89	3.38	1.30	27.2	38.2	0.013	0.23	0.29
P-2A	CP 1.1	MH-1A	92.5	36.0	0.006	Steel	41.10	79.9	5.81	5.81	5.81	2.03	43.6	46.0	0.013	0.40	0.35
P-1A	MH-1A	GREENWAY CHANNEL	100.0	36.0	0.006	Steel	47.40	91.8	8.29	6.85	6.71	2.26	42.8	44.4	0.013	0.57	0.44
P-4A	CP 1.2	MH-1A	35.2	18.0	0.006	Steel	6.30	79.6	3.57	3.57	3.57	1.01	23.2	24.1	0.013	0.06	0.13
P-9A	CP 1.3	CP 1.1	67.1	24.0	0.007	Steel	11.50	62.1	3.66	3.66	3.66	1.14	29.3	32.6	0.013	0.07	0.17
EX. 24" RGRCP	CP OS1	CP 1.4	102.0	24.0	0.012	Concrete	10.30	42.0	7.47	5.51	3.28	0.90	19.5	28.0	0.013	0.15	0.18
P-10A	CP 1.6	CP 1.4	43.1	18.0	0.010	Steel	5.40	51.5	5.98	4.91	3.40	0.76	15.2	17.3	0.013	0.12	0.06

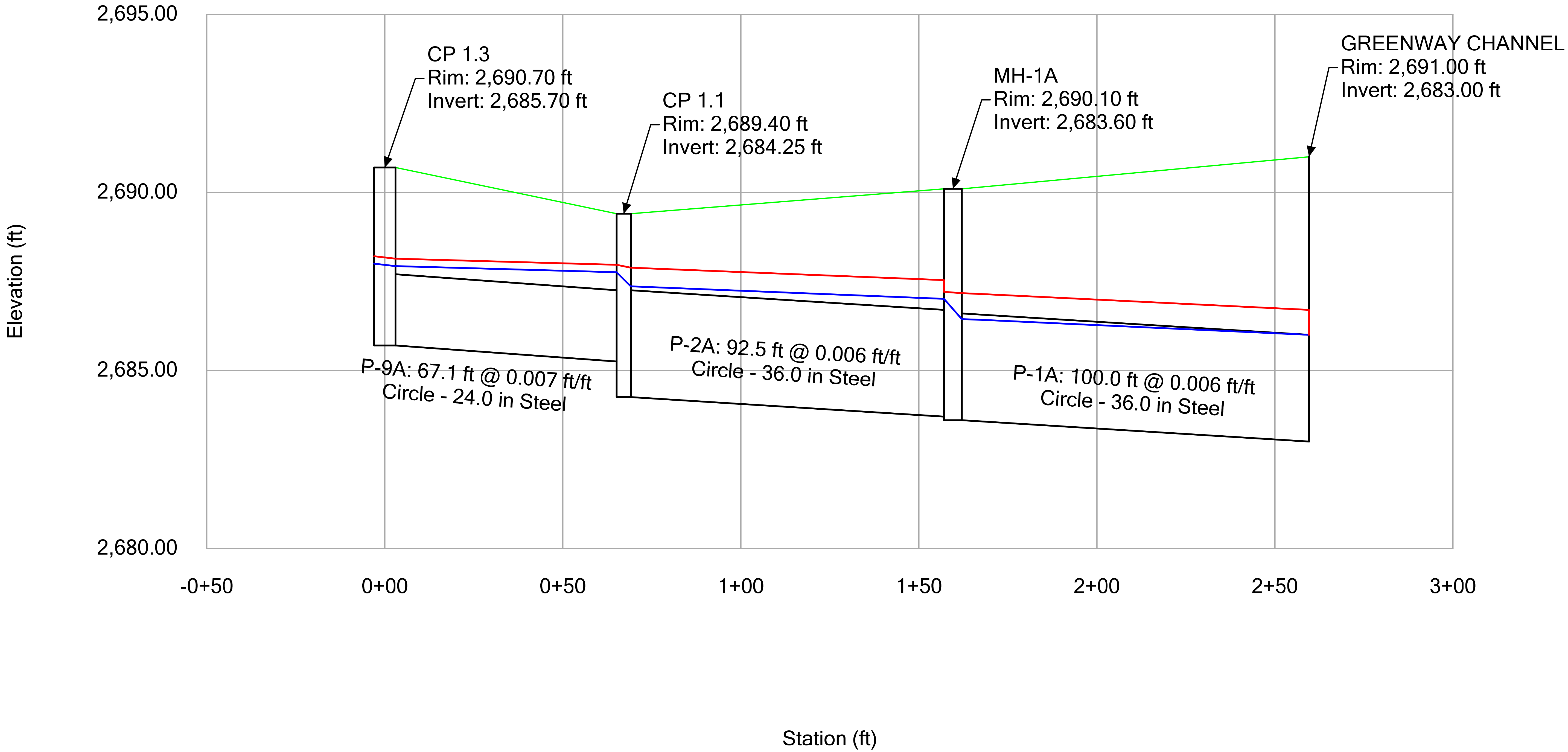
Network Elements FlexTable: AASHTO Headloss Table

Label	Headloss Method	Headloss (ft)	Adjusted Headloss (AASHTO) (ft)	Unadjusted Headloss (AASHTO) (ft)	Velocity Head (In-Governing) (ft)	Velocity Head (Out) (ft)	Bend Angle (Calculated) (degrees)	Bend Loss (AASHTO) (ft)	Bend Loss Coefficient (AASHTO)	Bend Loss Conduit Flow (AASHTO) (cfs)	Bend Loss Pipe Angle (AASHTO) (degrees)	Bend Loss Pipe Velocity (AASHTO) (ft/s)	Bend Loss Pipe Velocity Head (AASHTO) (ft)	Contraction Loss (AASHTO) (ft)	Contraction Loss Coefficient (AASHTO)	Correction factor for shaping (AASHTO)	Expansion Loss (AASHTO) (ft)	Expansion Loss Coefficient (AASHTO)	Expansion Loss Pipe Flow (AASHTO) (cfs)	Expansion Loss Pipe Velocity (AASHTO) (ft/s)	Expansion Loss Pipe Velocity Head (AASHTO) (ft)	Friction Slope (ft/ft)
MH-1A	AASHTO	0.57	0.57	0.57	0.18			0.20	0.387	41.10	34.60	5.81	0.53	0.18	0.250	1.000	0.18	0.350	41.10	5.81	0.53	
CP 1.4	AASHTO	0.23	0.23	0.23	0.18			0.12	0.645	5.40	76.33	3.40	0.18	0.06	0.250	1.000	0.06	0.350	10.30	3.28	0.17	
CP 1.1	AASHTO	0.40	0.40	0.31	0.18			0.11	0.535	11.50	55.89	3.66	0.21	0.13	0.250	1.000	0.06	0.350	16.60	3.38	0.18	
CP 1.3	AASHTO	0.07	0.07	0.05	0.00			0.00	0.000	0.00	0.00	0.00	0.00	0.05	0.250	1.000	0.00	0.000	0.00	0.00	0.00	
CP 1.2	AASHTO	0.06	0.06	0.05	0.00			0.00	0.000	0.00	0.00	0.00	0.00	0.05	0.250	1.000	0.00	0.000	0.00	0.00	0.00	
CP 1.6	AASHTO	0.12	0.12	0.09	0.00			0.00	0.000	0.00	0.00	0.00	0.00	0.09	0.250	1.000	0.00	0.000	0.00	0.00	0.00	
CP OS1	AASHTO	0.15	0.15	0.12	0.00			0.00	0.000	0.00	0.00	0.00	0.00	0.12	0.250	1.000	0.00	0.000	0.00	0.00	0.00	
GREENWAY CHANNEL																						
P-3A		0.29				0.18	0.11															0.002
P-2A		0.35				0.53	34.60															0.004
P-1A		0.44				0.70	0.00															0.005
P-4A		0.13				0.20	54.97															0.004
P-9A		0.17				0.21	55.89															0.003
EX. 24" RGRCP		0.18				0.17	0.08															0.005
P-10A		0.06				0.18	76.33															0.006

Profile Report
Engineering Profile - Profile - CP 1.2 (RUN_A.stsw)

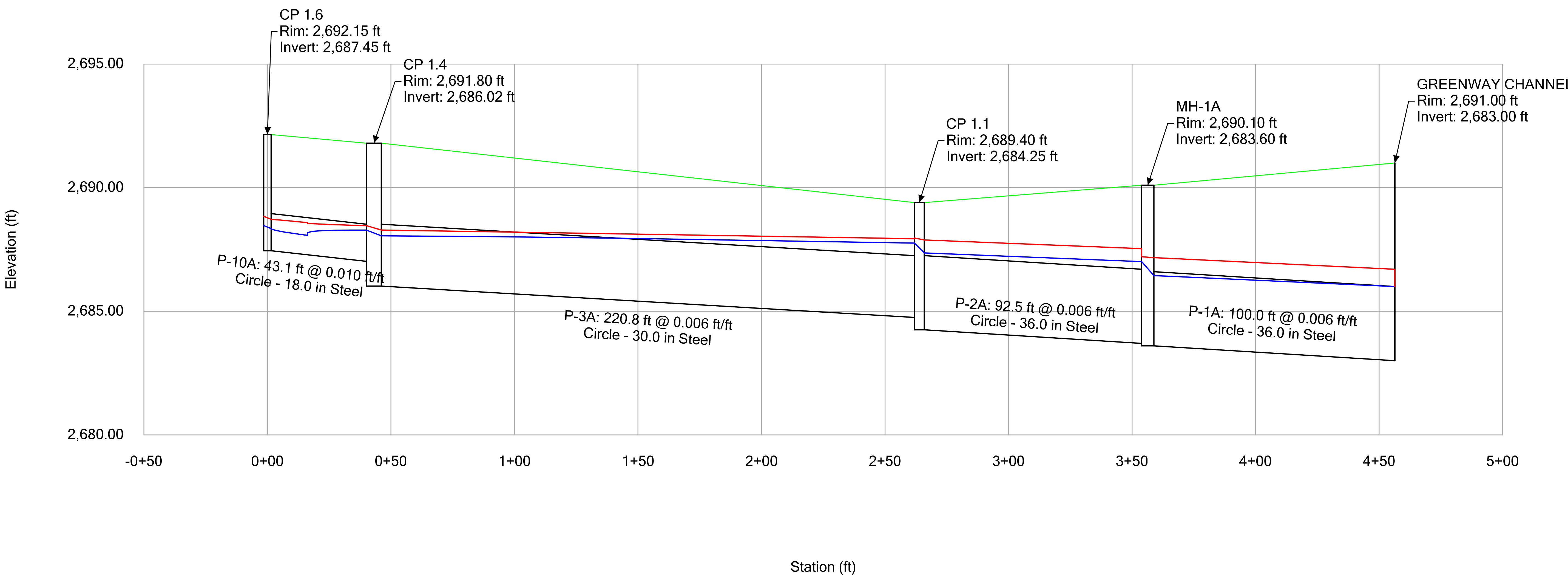


Profile Report
Engineering Profile - Profile - CP 1.3 (RUN_A.stsw)

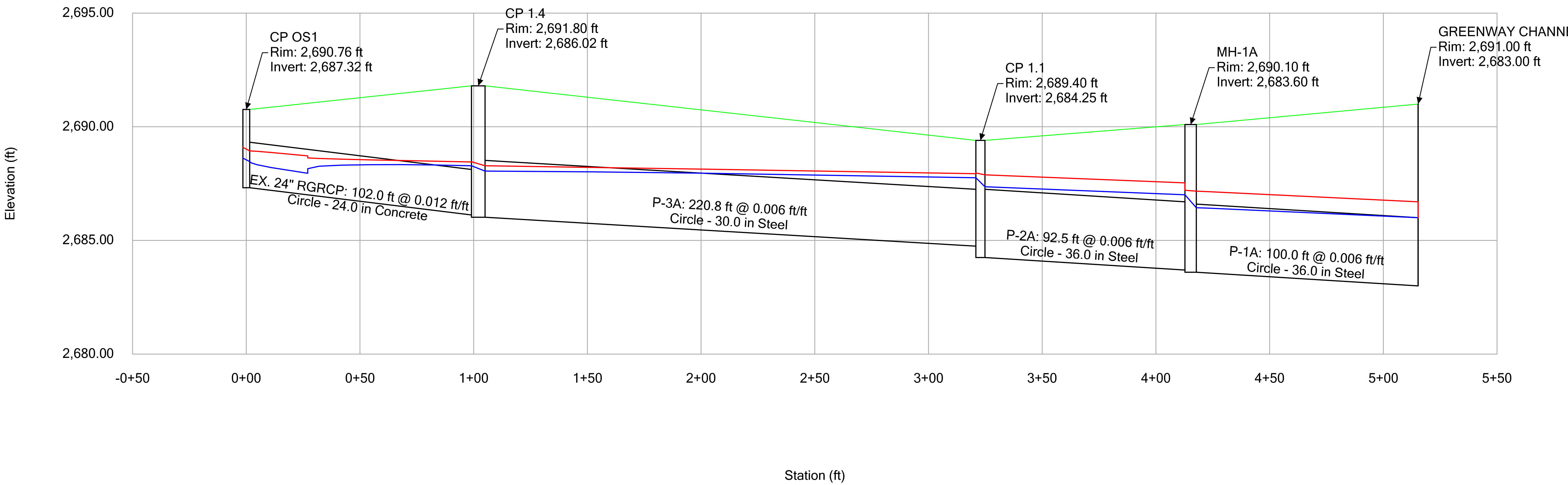


Profile Report

Engineering Profile - Profile - CP 1.6 (RUN_A.stsw)



Profile Report
Engineering Profile - Profile - CP OS1 (RUN_A.stsw)



B.4 Stormdrain Grate Inlet Worksheets

PROJECT: Starbuck's Coffee; Block 5 Innovation Corporate Center
WLB NO: 185050-VW03-0400
DESCRIPTION: CP 1.1 **Q100=** 13.00
DATE: 9/14/2023

Grate Layout

#1	**#2**
#3	**#4**
#5	**#6**

Type of Grate	**EF-1**	**Width, ft**	**1.97**
Number of Grates	**6**	**Length, ft**	**3.33**
Area, ft^2	**28.00**	**Wing, ft**	
Perimeter, ft	**25.14**	**Y, ft**	**0.50**

Required Perimeter,ft (Clogging) **24.51**
Required Area,ft (Clogging) **6.87**

GRATE INLET

DEPTH (FT)	* PERIM. (FT)	AREA (SQ.FT)	DISCHARGE (CFS)		CONTROL (CFS)	DESIGN (CFS)
			[1] WEIR EQ. (CFS)	[2] ORIFICE EQ. (CFS)		
0.05	25.14	28.00	0.84	33.50	0.84	0.42
0.10	25.14	28.00	2.38	47.37	2.38	1.19
0.15	25.14	28.00	4.38	58.02	4.38	2.19
0.20	25.14	28.00	6.75	66.99	6.75	3.37
0.25	25.14	28.00	9.43	74.90	9.43	4.71
0.30	25.14	28.00	12.39	82.05	12.39	6.20
0.35	25.14	28.00	15.62	88.62	15.62	7.81
0.40	25.14	28.00	19.08	94.74	19.08	9.54
0.45	25.14	28.00	22.77	100.49	22.77	11.38
0.50	**25.14**	**28.00**	**26.66**	**105.93**	**26.66**	**13.33**
0.60	25.14	28.00	35.05	116.04	35.05	17.53
0.70	25.14	28.00	44.17	125.33	44.17	22.09
0.80	25.14	28.00	53.97	133.99	53.97	26.98
0.90	25.14	28.00	64.39	142.11	64.39	32.20
1.00	25.14	28.00	75.42	149.80	75.42	37.71
1.10	25.14	28.00	87.01	157.11	87.01	43.51
1.20	25.14	28.00	99.14	164.10	99.14	49.57
1.30	25.14	28.00	111.79	170.80	111.79	55.89
1.40	25.14	28.00	124.93	177.25	124.93	62.47
1.50	25.14	28.00	138.56	183.47	138.56	69.28

1. Weir equation for grate inlet: $Q=3.0P_gY^{3/2}$
2. Orifice equation for grate inlet: $Q=5.35AY^{1/2}$

* Calculated clogging for orfice flow is 200% times the required perimeter.
The required perimeter is one half of a EF-1 grate STD. DTL. 311
Thus, as per the clogging requirements, the grate inlet has been rated for 1 EF-1 grate,
but the ponding depth has been rated for double the discharge

PROJECT: Starbuck's Coffee; Block 5 Innovation Corporate Center
WLB NO: 185050-VW03-0400
DESCRIPTION: CP 1.2 **Q100=** 6.30
DATE: 4/30/2024

Grate Layout

#1	#2

Type of Grate	**EF-1**	**Width, ft**	**1.97**
Number of Grates	**2**	**Length, ft**	**3.33**
Area, ft^2	**9.33**	**Wing, ft**	**8.00**
Perimeter, ft	**17.26**	**Y, ft**	**0.50**

Required Perimeter,ft (Clogging) **11.88**

GRATE INLET

Required Area,ft (Clogging) **3.33**

DEPTH (FT)	* PERIM. (FT)	AREA (SQ.FT)	DISCHARGE (CFS) [1] WEIR EQ. (CFS)	[2] ORIFICE EQ. (CFS)	CONTROL (CFS)	DESIGN (CFS)
0.05	17.26	9.33	0.58	11.17	0.58	0.29
0.10	17.26	9.33	1.64	15.79	1.64	0.82
0.15	17.26	9.33	3.01	19.34	3.01	1.50
0.20	17.26	9.33	4.63	22.33	4.63	2.32
0.25	17.26	9.33	6.47	24.97	6.47	3.24
0.30	17.26	9.33	8.51	27.35	8.51	4.25
0.35	17.26	9.33	10.72	29.54	10.72	5.36
0.40	**17.26**	**9.33**	**13.10**	**31.58**	**13.10**	**6.55**
0.45	17.26	9.33	15.63	33.50	15.63	7.82
0.48	17.26	9.33	17.44	34.74	17.44	8.72
0.50	**17.26**	**9.33**	**18.31**	**35.31**	**18.31**	**9.15**
0.60	17.26	9.33	24.07	38.68	24.07	12.03
0.70	17.26	9.33	30.33	41.78	30.33	15.16
0.80	17.26	9.33	37.05	44.66	37.05	18.53
0.90	17.26	9.33	44.21	47.37	44.21	22.11
1.00	17.26	9.33	51.78	49.93	49.93	24.97
1.10	17.26	9.33	59.74	52.37	52.37	26.19
1.20	17.26	9.33	68.07	54.70	54.70	27.35
1.30	17.26	9.33	76.75	56.93	56.93	28.47
1.40	17.26	9.33	85.77	59.08	59.08	29.54
1.50	17.26	9.33	95.13	61.16	61.16	30.58

1. Weir equation for grate inlet: $Q=3.0P_gY^{3/2}$
2. Orifice equation for grate inlet: $Q=5.35AY^{1/2}$

* Calculated clogging for orfice flow is 200% times the required perimeter.
The required perimeter is one half of a EF-1 grate STD. DTL. 311
Thus, as per the clogging requirements, the grate inlet has been rated for 1 EF-1 grate,
but the ponding depth has been rated for double the discharge

PROJECT: Starbuck's Coffee; Block 5 Innovation Corporate Center
WLB NO: 185050-VW03-0400
DESCRIPTION: CP 1.3 **Q100=** 10.30
DATE: 2/26/2024

Grate Layout

#1	#2
#4	#3

Type of Grate EF-1 **Width, ft** 1.97
Number of Grates 4 **Length, ft** 3.33
Area, ft^2 18.67 **Wing, ft**
Perimeter, ft 21.20 **Y, ft** 0.50

Required Perimeter,ft (Clogging) 19.42
Required Area,ft (Clogging) 5.45

GRATE INLET

DEPTH (FT)	* PERIM. (FT)	AREA (SQ.FT)	DISCHARGE (CFS) [1] WEIR EQ. (CFS)	DISCHARGE (CFS) [2] ORIFICE EQ. (CFS)	CONTROL (CFS)	DESIGN (CFS)
0.05	21.20	18.67	0.71	22.33	0.71	0.36
0.10	21.20	18.67	2.01	31.58	2.01	1.01
0.15	21.20	18.67	3.69	38.68	3.69	1.85
0.20	21.20	18.67	5.69	44.66	5.69	2.84
0.25	21.20	18.67	7.95	49.93	7.95	3.98
0.30	21.20	18.67	10.45	54.70	10.45	5.23
0.35	21.20	18.67	13.17	59.08	13.17	6.58
0.40	21.20	18.67	16.09	63.16	16.09	8.04
0.45	21.20	18.67	19.20	66.99	19.20	9.60
0.47	**21.20**	**18.67**	**20.56**	**68.54**	**20.56**	**10.28**
0.50	**21.20**	**18.67**	**22.49**	**70.62**	**22.49**	**11.24**
0.60	21.20	18.67	29.56	77.36	29.56	14.78
0.70	21.20	18.67	37.25	83.56	37.25	18.62
0.80	21.20	18.67	45.51	89.32	45.51	22.75
0.90	21.20	18.67	54.30	94.74	54.30	27.15
1.00	21.20	18.67	63.60	99.87	63.60	31.80
1.10	21.20	18.67	73.37	104.74	73.37	36.69
1.20	21.20	18.67	83.60	109.40	83.60	41.80
1.30	21.20	18.67	94.27	113.87	94.27	47.13
1.40	21.20	18.67	105.35	118.16	105.35	52.68
1.50	21.20	18.67	116.84	122.31	116.84	58.42

1. Weir equation for grate inlet: $Q=3.0P_gY^{3/2}$
2. Orifice equation for grate inlet: $Q=5.35AY^{1/2}$

* Calculated clogging for orfice flow is 200% times the required perimeter.
The required perimeter is one half of a EF-1 grate STD. DTL. 311
Thus, as per the clogging requirements, the grate inlet has been rated for 1 EF-1 grate, but the ponding depth has been rated for double the discharge

PROJECT: Catalina Springs Apartments
WLB NO: 119014-A001-0400
DESCRIPTION: CP 1.4 **Q100=** 0.90
DATE: 9/14/2023

Type of Grate	**EF-1**	**Width, ft**	**1.97**
Number of Grates	**1**	**Length, ft**	**3.33**
Area, ft^2	**6.56**	**Wing, ft**	
Perimeter, ft	**7.27**		

GRATE INLET

DEPTH (FT)	PERIM. (FT)	AREA (SQ.FT)	DISCHARGE (CFS)		CONTROL (CFS)
			[1] WEIR EQ. (CFS)	[2] ORIFICE EQ. (CFS)	
0.05	7.27	6.56	0.24	7.85	0.24
0.10	7.27	6.56	0.69	11.10	0.69
0.15	7.27	6.56	1.27	13.59	1.27
0.20	7.27	6.56	1.95	15.70	1.95
0.25	7.27	6.56	2.73	17.55	2.73
0.30	7.27	6.56	3.58	19.22	3.58
0.35	7.27	6.56	4.52	20.76	4.52
0.40	7.27	6.56	5.52	22.20	5.52
0.45	7.27	6.56	6.58	23.54	6.58
0.50	**7.27**	**6.56**	**7.71**	**24.82**	**7.71**
0.55	7.27	6.56	8.90	26.03	8.90
0.60	7.27	6.56	10.14	27.19	10.14
0.65	7.27	6.56	11.43	28.30	11.43
0.67	7.27	6.56	11.96	28.73	11.96
0.68	7.27	6.56	12.23	28.94	12.23
0.70	7.27	6.56	12.77	29.36	12.77
0.75	7.27	6.56	14.17	30.39	14.17

Type 5 Catch Basin PC/COT Std. Dtl. 307:

Length of Sump = Total Length of Grates
Length of Wing = 0.00 *(Wing Lengths are 4', 8', 12' or 16')*
Total Length = 3.33 (Effective Opening)

SCUPPER INLET

DEPTH (FT)	* LENGTH (FT)	OPENING (FT)	INCLINED TROAT ANGLE (ϕ)	DISCHARGE (CFS)		CONTROL (CFS)	TOTAL COMBINED CAPACITY (CFS)	
				[3] WEIR EQ.	[4] ORIFICE EQ.			
0.05	3.33	0.50	60.00	0.09	N/A	0.09	0.33	
0.10	3.33	0.50	60.00	0.24	N/A	0.24	0.93	
0.15	3.33	0.50	60.00	0.44	N/A	0.44	1.71	
0.20	3.33	0.50	60.00	0.69	N/A	0.69	2.64	
0.25	3.33	0.50	60.00	0.96	1.63	0.96	3.68	
0.30	3.33	0.50	60.00	1.26	2.57	1.26	4.84	
0.35	3.33	0.50	60.00	1.59	3.25	1.59	6.10	
0.40	3.33	0.50	60.00	1.94	3.82	1.94	7.46	
0.45	3.33	0.50	60.00	2.31	4.30	2.31	8.90	
0.50	**3.33**	**0.50**	**60.00**	**2.71**	**4.74**	**2.71**	**10.42**	**Q100 =0.9 cfs**
0.55	3.33	0.50	60.00	3.12	5.14	3.12	12.02	
0.60	3.33	0.50	60.00	3.56	5.52	3.56	13.70	
0.65	3.33	0.50	60.00	4.01	5.86	4.01	15.44	
0.67	3.33	0.50	60.00	4.20	6.00	4.20	16.16	
0.68	3.33	0.50	60.00	4.29	6.06	4.29	17.07	
0.70	3.33	0.50	60.00	4.49	6.19	4.49	16.72	
0.75	3.33	0.50	60.00	4.97	6.51	4.97	17.75	

1. Weir equation for grate inlet: $Q=3.0P_gY^{3/2}$
2. Orifice equation for grate inlet: $Q=5.35AY^{1/2}$
3. Weir equation for curb inlet without depression: $Q=2.3LY^{3/2}$
4. Orifice equation for curb inlet, inclined throat, no depression: $Q=5.35A(Y-h/2\sin\phi)^{1/2}$

* Calculated length of curb opening equals length of scupper/Safety Factor to account for clogging 10/1.25= 8'

PROJECT: Starbuck's Coffee; Block 5 Innovation Corporate Center
WLB NO: 185050-VW03-0400
DESCRIPTION: CP 1.6 **Q100=** 5.40
DATE: 9/14/2023

Grate Layout

#1

Type of Grate EF-1 **Width, ft** 1.97
Number of Grates 1 **Length, ft** 3.33
Area, ft^2 4.67 **Wing, ft**
Perimeter, ft 10.60 **Y, ft** 0.50
Required Perimeter,ft (Clogging) 10.18
Required Area,ft (Clogging) 2.85

GRATE INLET

DEPTH (FT)	* PERIM. (FT)	AREA (SQ.FT)	DISCHARGE (CFS)		CONTROL (CFS)	DESIGN (CFS)
			[1] WEIR EQ. (CFS)	[2] ORIFICE EQ. (CFS)		
0.05	10.60	4.67	0.36	5.58	0.36	0.18
0.10	10.60	4.67	1.01	7.90	1.01	0.50
0.15	10.60	4.67	1.85	9.67	1.85	0.92
0.20	10.60	4.67	2.84	11.17	2.84	1.42
0.25	10.60	4.67	3.98	12.48	3.98	1.99
0.30	10.60	4.67	5.23	13.67	5.23	2.61
0.35	10.60	4.67	6.58	14.77	6.58	3.29
0.40	10.60	4.67	8.04	15.79	8.04	4.02
0.45	10.60	4.67	9.60	16.75	9.60	4.80
0.50	**10.60**	**4.67**	**11.24**	**17.65**	**11.24**	**5.62**
0.60	10.60	4.67	14.78	19.34	14.78	7.39
0.70	10.60	4.67	18.62	20.89	18.62	9.31
0.80	10.60	4.67	22.75	22.33	22.33	11.17
0.90	10.60	4.67	27.15	23.69	23.69	11.84
1.00	10.60	4.67	31.80	24.97	24.97	12.48
1.10	10.60	4.67	36.69	26.19	26.19	13.09
1.20	10.60	4.67	41.80	27.35	27.35	13.67
1.30	10.60	4.67	47.13	28.47	28.47	14.23
1.40	10.60	4.67	52.68	29.54	29.54	14.77
1.50	10.60	4.67	58.42	30.58	30.58	15.29

1. Weir equation for grate inlet: $Q=3.0P_gY^{3/2}$
2. Orifice equation for grate inlet: $Q=5.35AY^{1/2}$

* Calculated clogging for orfice flow is 200% times the required perimeter.
The required perimeter is one half of a EF-1 grate STD. DTL. 311
Thus, as per the clogging requirements, the grate inlet has been rated for 1 EF-1 grate,
but the ponding depth has been rated for double the discharge

B.5 Curb Opening Worksheets

PROJECT: Starbucks Coffee; Block 5 Innovation Center
WLB NO: 185050-VW-03
DESCRIPTION: **CURB OPENING DATA**

GENERAL TRAPEZOIDAL OR RECTANGULAR WEIR CALCULATION

Equation: $Q = C_{rect}LH^{3/2} + C_{trianagle}(8/15\sqrt{2g}\tan\theta/2)H^{5/2}$

where:
Q = Discharge flow (cfs)
C_{rect} = discharge coefficient for rectangular weir
C_{rect} = 3.3 for sharp crested weir
C_{rect} = 3.1 for broad crested weir
$C_{triangle}$ = discharge coefficient for V-notch weir (Typically $C_{triangle}$ = 0.6)

L = length (ft)
H = distance from top of structure to water surface (ft)

$\tan\theta/2$ = side slopes
for 3H:1V slope $\tan\theta/2$ = 3
for rectangular weir $\tan\theta/2$ = 0

C_{rect} = 3.00
$C_{triangle}$ = 0.60

CONC. POINT	$\tan\theta/2$	LENGTH [L]	HEIGHT [H]	Qcapacity [CFS]
1.3a	3.00	2.0	0.5	2.9

The Q_{100} at concentration point 1.3a is 1.9 cfs

PROJECT: Starbucks Coffee; Block 5 Innovation Center
WLB NO: 185050-VW-03
DESCRIPTION: **CURB OPENING DATA**

GENERAL TRAPEZOIDAL OR RECTANGULAR WEIR CALCULATION

Equation: $Q = C_{rect}LH^{3/2} + C_{trianagle}(8/15\sqrt{2g}\ \tan\theta/2)H^{5/2}$

where:
Q = Discharge flow (cfs)
C_{rect} = discharge coefficient for rectangular weir
C_{rect} = 3.3 for sharp crested weir
C_{rect} = 3.1 for broad crested weir
$C_{triangle}$ = discharge coefficient for V-notch weir (Typically $C_{triangle}$ = 0.6)

L = length (ft)
H = distance from top of structure to water surface (ft)

$\tan\theta/2$ = side slopes
for 3H:1V slope $\tan\theta/2 = 3$
for rectangular weir $\tan\theta/2 = 0$

C_{rect} = 3.00
$C_{triangle}$ = 0.60

CONC.	tanθ/2	LENGTH	HEIGHT	Qcapacity
POINT		[L]	[H]	[CFS]
1.7	3.00	1.0	0.5	1.8

The Q_{100} at concentration point 1.7 is 1.4 cfs

B.6 Culvert Worksheets

Table 1 - Summary of Culvert Flows at Crossing: CP 1.5

Headwater Elevation (ft)	Total Discharge (cfs)	1-24 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2683.33	0.00	0.00	0.00	1
2684.03	2.00	2.00	0.00	1
2684.34	4.00	4.00	0.00	1
2684.59	6.00	6.00	0.00	1
2684.81	8.00	8.00	0.00	1
2685.02	10.00	10.00	0.00	1
2685.23	12.00	12.00	0.00	1
2685.44	14.00	14.00	0.00	1
2685.50	14.60	14.60	0.00	1
2685.95	18.00	18.00	0.00	1
2686.27	20.00	20.00	0.00	1
2691.00	40.22	40.22	0.00	Overtopping

Rating Curve Plot for Crossing: CP 1.5

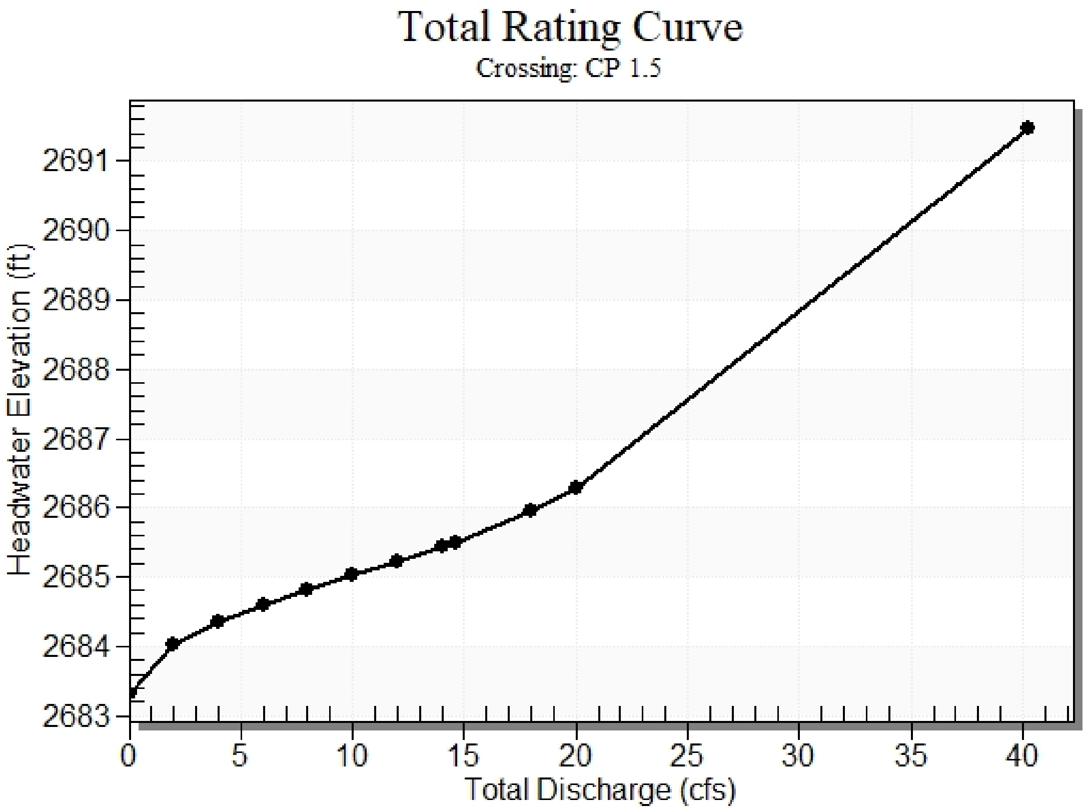


Table 2 - Culvert Summary Table: 1-24

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2683.33	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
2.00	2.00	2684.03	0.666	0.697	2-M2c	0.508	0.485	0.485	0.114	3.400	0.852
4.00	4.00	2684.34	0.961	1.007	2-M2c	0.728	0.697	0.697	0.171	4.103	1.110
6.00	6.00	2684.59	1.218	1.257	2-M2c	0.912	0.865	0.865	0.218	4.609	1.292
8.00	8.00	2684.81	1.438	1.479	2-M2c	1.082	1.006	1.006	0.258	5.052	1.437
10.00	10.00	2685.02	1.634	1.687	2-M2c	1.252	1.126	1.126	0.295	5.487	1.559
12.00	12.00	2685.23	1.819	1.896	2-M2c	1.435	1.239	1.239	0.328	5.870	1.666
14.00	14.00	2685.44	2.006	2.109	7-M2c	2.000	1.344	1.344	0.359	6.235	1.761
14.60	14.60	2685.50	2.064	2.174	7-M2c	2.000	1.373	1.373	0.368	6.351	1.787
18.00	18.00	2685.95	2.420	2.615	7-M2c	2.000	1.526	1.526	0.416	6.997	1.925
20.00	20.00	2686.27	2.659	2.943	7-M2c	2.000	1.604	1.604	0.442	7.404	1.998

****

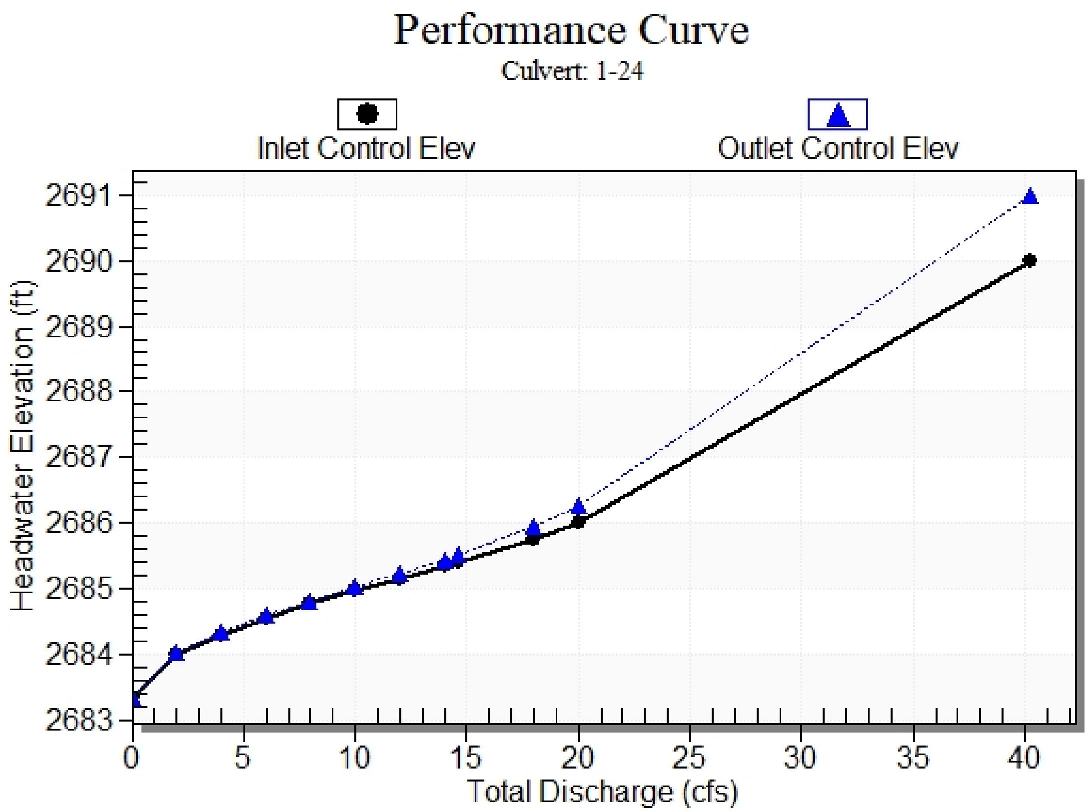
Straight Culvert

Inlet Elevation (invert): 2683.33 ft, Outlet Elevation (invert): 2683.00 ft

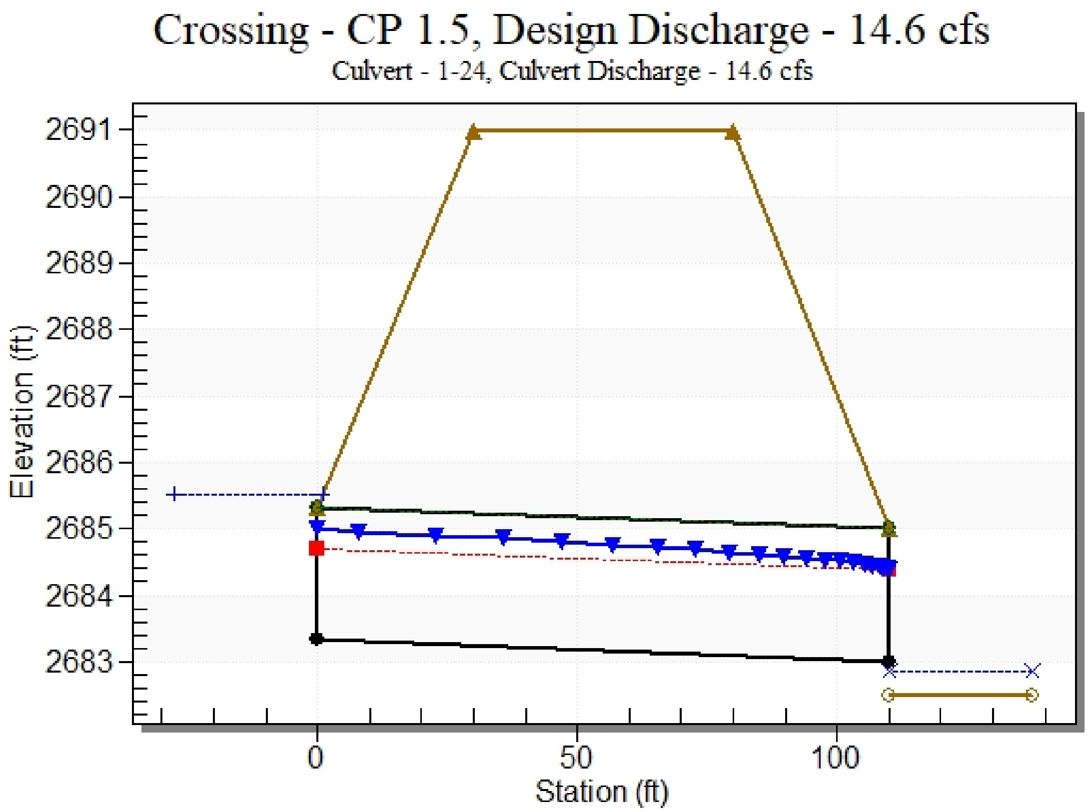
Culvert Length: 110.00 ft, Culvert Slope: 0.0030

****

Culvert Performance Curve Plot: 1-24



Water Surface Profile Plot for Culvert: 1-24



Site Data - 1-24

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 2683.33 ft

Outlet Station: 110.00 ft

Outlet Elevation: 2683.00 ft

Number of Barrels: 1

Culvert Data Summary - 1-24

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Grooved End Projecting

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: CP 1.5)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2682.50	0.00	0.00	0.00	0.00
2.00	2682.61	0.11	0.85	0.07	0.45
4.00	2682.67	0.17	1.11	0.11	0.48
6.00	2682.72	0.22	1.29	0.14	0.50
8.00	2682.76	0.26	1.44	0.16	0.52
10.00	2682.79	0.29	1.56	0.18	0.53
12.00	2682.83	0.33	1.67	0.20	0.54
14.00	2682.86	0.36	1.76	0.22	0.54
14.60	2682.87	0.37	1.79	0.23	0.54
18.00	2682.92	0.42	1.93	0.26	0.55
20.00	2682.94	0.44	2.00	0.28	0.56

Tailwater Channel Data - CP 1.5

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 20.00 ft

Side Slope (H:V): 6.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 2682.50 ft

Roadway Data for Crossing: CP 1.5

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 150.00 ft

Crest Elevation: 2691.00 ft

Roadway Surface: Paved

Roadway Top Width: 50.00 ft

B.7 Rip-Rap Splash Pad Worksheets

The WLB Group WLB	**Riprap Apron Design Spreadsheet**	**WLB Job # 185050-VW03**
	Starbuck's Coffee; Block 5 Innovation Corporate Center	

Riprap Design for Culvert

Description: Riprap Design
Date: 01/26/23
Location: CP 1.1

Designed: EJB
Checked: JSW
Date: 1/26/2023

Riprap Design Spreadsheet

References:

US DOT, FHWA, Highways in the River Environment Hydraulic and Environmental Design Considerations May 1975, pVI-24.

US DOT, FHWA, Hydraulic Design of Energy Dissipators for Culverts and Channel. Sept. 1983, pII-5-II-9.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. January 1996, p5.75-5.77.

1. Riprap Size D50

Max. flow width Wo =	3	ft
Max. culvert flow depth h =	3	ft
Tailwater depth TW =	3	ft
Exit Velocity Ve =	9.01	fps
Tailwater velocity Vd =	6.307	fps
Wash bottom width =	16	ft
Computed Riprap Size D50 =	6.5	in
Design Riprap Size D50 =	**9**	in (Type 1)

2. Riprap Sizes D15 and D85

Design Riprap Size D15 =	**4**	in
Design Riprap Size D85 =	**14**	in

3. Riprap Apron Length

Riprap Apron Length =	**19**	ft

4. Rirap Apron Width

Min. Riprap Apron Width =	**9**	ft
Max. Riprap Apron Width =	**22**	ft

5. Riprap Thickness

Riprap Thickness =	**18**	in

6. Total Riprap Volume

Riprap Rock Volume =	**16.4**	CY

Riprap Design for Culvert

Description: Riprap Design
Date: 01/26/23
Location: CP 1.5

Designed: EJB
Checked: JSW
Date: 1/26/2023

Riprap Design Spreadsheet

References:

US DOT, FHWA, Highways in the River Environment Hydraulic and Environmental Design Considerations May 1975, pVI-24.

US DOT, FHWA, Hydraulic Design of Energy Dissipators for Culverts and Channel. Sept. 1983, pII-5-II-9.

FCDMC, Drainage Design Manual for Maricpa County Arizona, Vol. II - Hydraulics. January 1996, p5.75-5.77.

1. Riprap Size D50

Max. flow width Wo =	2	ft
Max. culvert flow depth h =	2	ft
Tailwater depth TW =	0.409	ft
Exit Velocity Ve =	6.7	fps
Tailwater velocity Vd =	4.69	fps
Wash bottom width =	6	ft
Computed Riprap Size D50 =	3.7	in
Design Riprap Size D50 =	**9**	in (Type 1)

2. Riprap Sizes D15 and D85

Design Riprap Size D15 =	**4**	in
Design Riprap Size D85 =	**14**	in

3. Riprap Apron Length

Riprap Apron Length =	**5**	ft

4. Rirap Apron Width

Min. Riprap Apron Width =	**6**	ft
Max. Riprap Apron Width =	**9**	ft

5. Riprap Thickness

Riprap Thickness =	**18**	in

6. Total Riprap Volume

Riprap Rock Volume =	**2.1**	CY

Appendix C First Flush Filters & Manufacturers Specs.

C.1 Triton First Flush Filters Details, Sizing, Flow Rates, and O&M

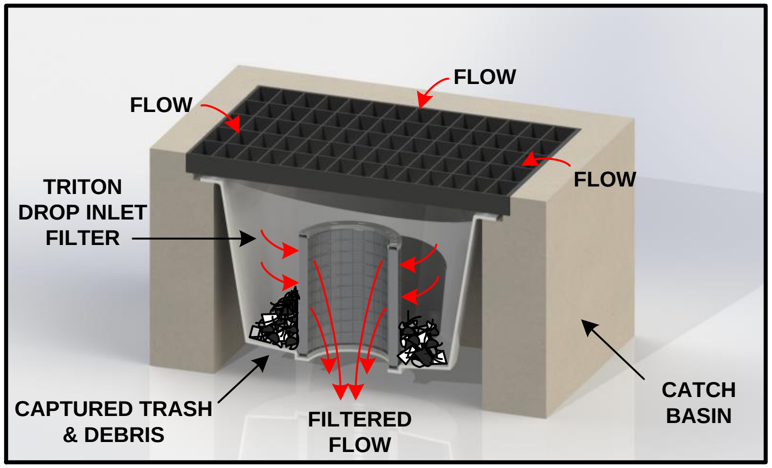
C.2 Manufacturer Specifications Storm Pipe Installation

C.1 Triton First Flush Filters Details, Sizing, Flow Rates, and O&M

REM's TRITON – TR (Drop Inlet) Series

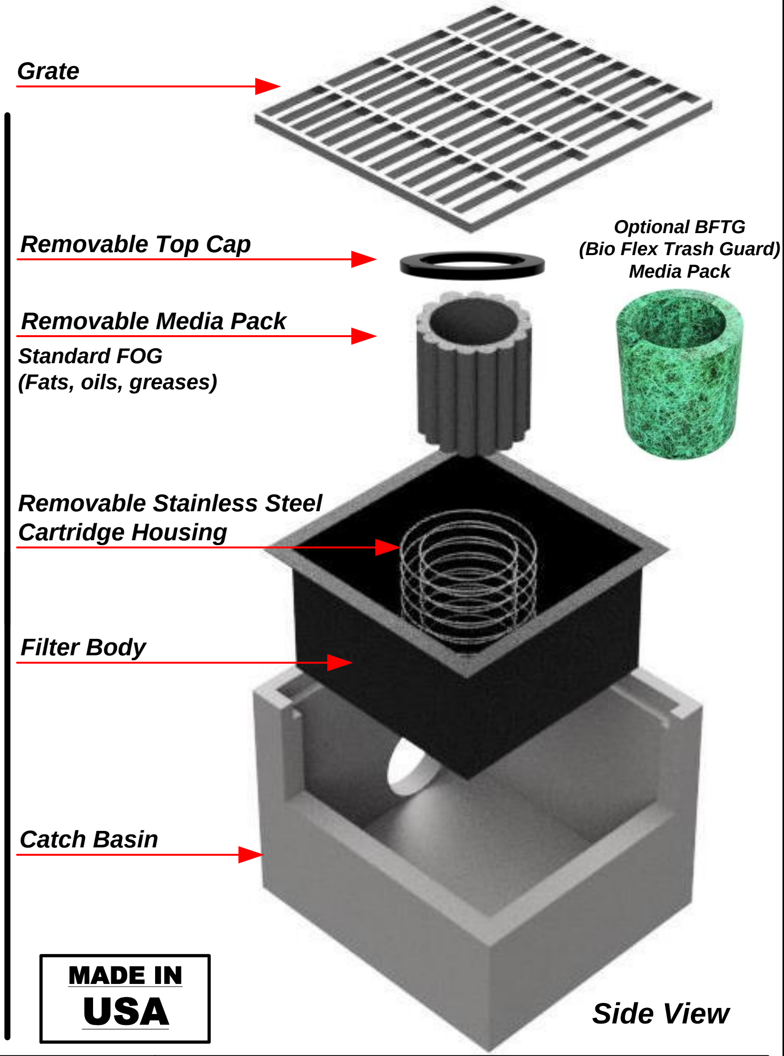
TRITON – TR SERIES FILTER *By REM Inc.*
Ph# (888.526.4736)
Sales@remfilters.com
Remfilters.com

The REM TRITON -TR Filter is a multipurpose catch basin insert designed to capture sediment, trash, debris, suspended solids, oils & grease and other storm water pollutants. TRITON -TR filters may be utilized in new construction or retrofitted in existing catch basin structures. They are sized to spec or modified in the field for drains with unusual dimensions and unique frame and grates. Filter Cartridges may be easily removed when servicing. Media strategy may be optimized for specific pollutant concerns.



Model: TR24SR-D (shown above)

Round Catch Basin Shown



MADE IN USA

Notes:

- *The TRITON - TR Series Filters may be customized in the field to fit catch basins with irregular dimensions or unusual frame and grate types. REM also designs custom filters for unique storm water infrastructures and applications.*
- *Filter bodies are constructed using **100% recycled** High Molecular Weight Polyethylene Plastic (HMWPE) with U.V. inhibitors.*
- *Filter cartridge housings are constructed utilizing Type 304 Stainless Steel, with 2" welded square openings.*
- *Removable cartridge tops are constructed utilizing over 80% recycled ABS Plastic.*
- *REM TRITON replacement Filter Media Packs are charged with REM FOG media an expanded volcanic ash medium treated to be highly hydrophobic housed in a durable geo-textile perforated polypropylene woven fabric. REM FOG media effectively encapsulates liquefied petroleum hydrocarbons (Fats, Oils & Grease including animal fats). The media's hydrophobic characteristic allows for greater polishing of flow resulting in the reduction of Total Suspended Solids (TSS). Suspended solid reduction includes but is not limited to debris, trash, silt sediment and agglomerated heavy metals. (Additional media options are available including mixed blends of granulated carbon [AC] and Zeolite [ZEO].*
- *REM TRITON filter cartridges are removable for ease of cleaning and maintenance.*
- *Filter designs include a high flow overflow bypass to eliminate pooling or flooding during heavy rain events.*
- *See our Specifier Sheet for sizes, models and flow rate information.*
- *Maintenance information and replacement REM Media Packs are available upon request by contacting REM at sales@remfilters.com or (888) 526-4736.*
- ***Made in the USA**.*

Cartridge Diameter size may vary by catch basin. Taller cartridge options provide greater volume capacity and increased treatment rates.

U.S. Patent Number: 6,217,757

PH: (888) 526-4736

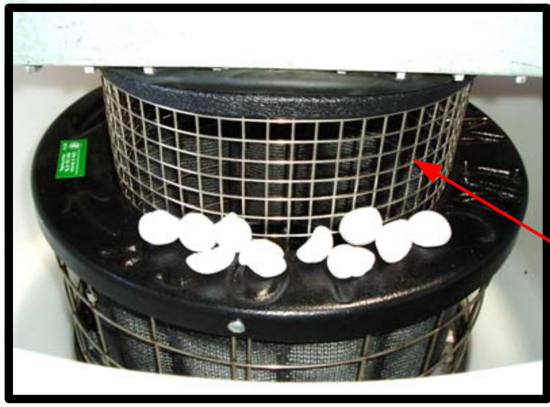
DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED.

REM Inc.

TRITON DROP INLET SERIES
(TRITON Cartridge System)

	DRAWN BY:	FOR:	REV
	D.F.	Drop Inlet Combinations	
SCALE	1/4 : 1	DATE: 9/12/2018	Pg. 1 OF 1

TRITON -Trash & Debris Guard
(TDG-SERIES)



Standard Trash Guard
w/ .5" Sq. Stainless Steel mesh

Trash & Debris Guard
Large
(2" X 2" Mesh)

Trash & Debris Guard
Standard
(.5" X .5" Mesh)

Trash & Debris Guard
Fine
(20 US Sieve Mesh)
(Geo-textile)

TRITON Drop Inlet ***Trash & Debris Guard*****TM**

Designed to help capture trash & debris. The Trash & Debris GuardTM is designed to assist in the removal of trash & debris in compliance with certain TMDL requirements.

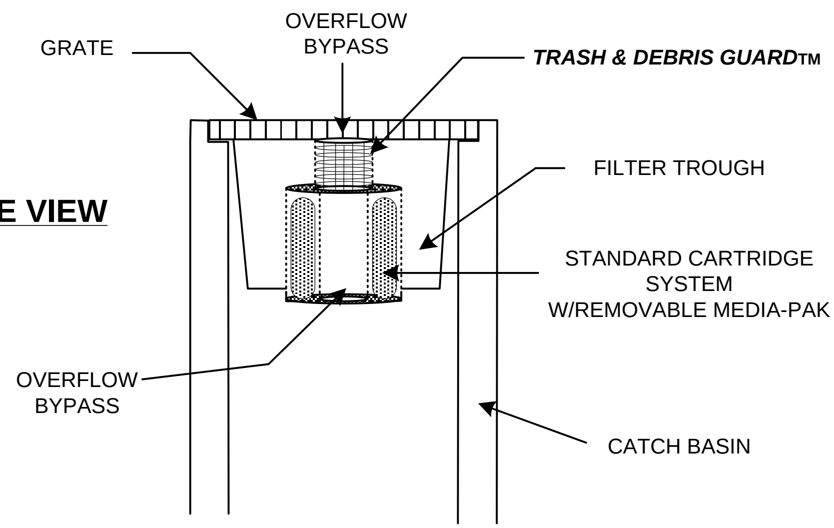
The standard stainless steel Trash & Debris GuardTM mesh size is .5" X .5" (.25 cu. in) or .1968 cm X .1968 cm, (.0387 sq. cm) Optional stainless steel or geo-textile mesh sizes can be supplied depending upon each area's particular needs.

Common trash & debris pollutants captured: Packing material "peanut packing", coffee cups and lids, bottle caps, Styrofoam, paper and plastic bags, candy/food wrappers, aluminum cans and leaves.

As an added feature, the Trash & Debris GuardsTM are equipped with REM's Media-Pak, for the removal of Hydrocarbons and other contaminants.

For more information on this series, please call our office @ (888) 526-4736.

SIDE VIEW



Patent Pending

REM Inc.

TRITON Trash & Debris GuardTM
TDG-Series
(Designed for TRITON Series Drop Inlets)

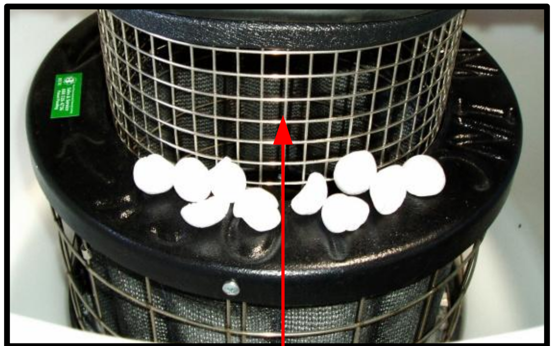
PH: (888) 526-4736

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED.

SIZE	DRAWN BY:	FOR:	REV
	C.F.	Trash & Debris Protection	

SCALE	1/4 : 1	DATE: 5/15/2005	SHEET	1 OF 1

TRITON -Trash & Debris Guard *(TDG-SERIES)*



Standard Trash Guard
w/ .5" Sq. Stainless Steel mesh

Trash & Debris Guard with (.5" X .5" Stainless Steel side mesh and mesh top)

(Attached to a Model: TR14 (16")–FOG-BFTG Cartridge)

Mesh Top Covering Overflow Port

Model: 14TDG (6") – Mesh Top

Note:

TRITON Drop Inlet *Trash & Debris Guard*TM
Designed to help capture trash & debris. The Trash & Debris GuardTM is designed to assist in the removal of trash & debris in compliance with certain TMDL requirements.

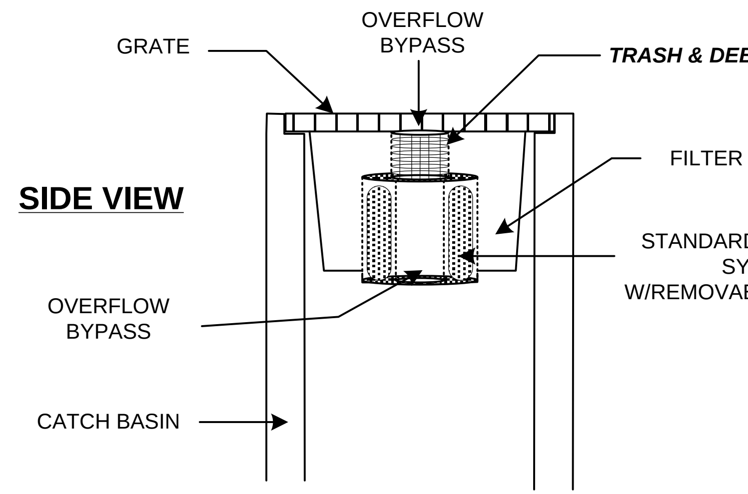
The standard stainless steel Trash & Debris GuardTM mesh size is .5" X .5" (.25 cu. in) or .1968 cm X .1968 cm, (.0387 sq. cm)
Optional stainless steel or geo-textile mesh sizes can be supplied depending upon each area's particular needs.

Common trash & debris pollutants captured: Packing material "peanut packing", coffee cups and lids, bottle caps, Styrofoam, paper and plastic bags, candy/food wrappers, aluminum cans and leaves.

As an added feature, the Trash & Debris GuardsTM are equipped with REM's Media-Pak, for the removal of Hydrocarbons and other contaminants.

Note: Mesh Top option placed over Overflow Port could potentially cause flooding if blinded by debris.

For more information on this series, please call our office @ (888) 526-4736.



MADE IN USA

THE DESIGN AND DETAIL OF THIS DRAWING IS THE PROPERTY OF REM INC. AND IS NOT TO BE USED EXCEPT IN CONNECTION WITH OUR WORK, DESIGN AND INVENTION RIGHTS ARE RESERVED. Patent Pending	**REM Inc.** **TRITON Trash & Debris GuardTM TDG-Series with Mesh Top**			
PH: (888) 526-4736	SIZE	DRAWN BY: C.F.	FOR: TRITON Series Drop Inlets	REV
DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED.	SCALE 1/4 : 1	DATE: 12/8/2011	SHEET 1 OF 1	

Revel Environmental Manufacturing Inc.

REM
www.remfilters.com

sales@remfilters.com (888) 526-4736 Lic. No. 857410

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Concord, California 94518
P: (925) 676-4736
F: (925) 676-8676

Southern California
2110 South Grand Avenue
Santa Ana, California 92705
P: (714) 557-2676
F: (714) 557-2679

REM Media Configuration Options

REM Filters can be customized using different media strategies configured to target site-specific pollutants. A combination of media is often recommended to maximize pollutant removal effectiveness.

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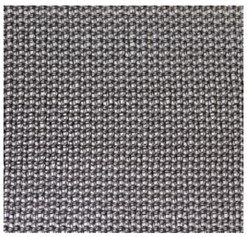


Geotextile Media Pack Housing

Filter media is housed in a mono-filament weaved geotextile containment pack. The filter's vertical cartridge system requires flow to move laterally through the geotextile pack on both sides – once during ingress and again during egress – providing a two stage sieve for fine material removal. The mono-filament geotextile reduces occlusion and blinding allowing for greater treatment flow compared to flat weave fabrics. The design meets "100% Full Trash Capture - 2.4mm" specification.

REM FOG Media (Expanded Hydrophobic Perlite)

REM FOG media is an expanded volcanic ash media treated to be highly hydrophobic. REM FOG media effectively encapsulates liquefied petroleum hydrocarbons (Fats, Oils & Grease including animal fats). The media's hydrophobic characteristic, porous, multi-cellular structure and rough edges allows for greater polishing of flow resulting in the reduction of Total Suspended Solids (TSS). Suspended solid reduction includes but is not limited to debris, trash, silt, sediment, and agglomerated heavy metals. REM FOG Media is an excellent multi-purpose filter media.

REM AC Media (Activated Carbon)

REM AC is a coconut shell granular activated carbon. AC media has a micro-porous structure and large surface area providing high levels of adsorption used for the removal of organics, some metals and other pollutants, such as Chlorine, Chloramine, TCE, PCE, TTHMs, Phenols, Pesticides, Detergents.

REM ZEO Media (Zeolite)

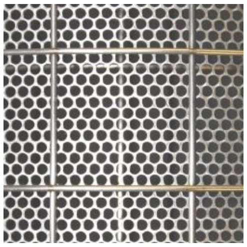
REM ZEO is a group of naturally occurring micro-porous minerals consisting of aluminosilicates of sodium, potassium, calcium and barium. ZEO can be readily dehydrated and rehydrated and used as cation exchangers and molecular sieves to remove soluble metals such as copper, lead, zinc, ammonium and some organics. ZEO medium has a variety of water filtration applications.

REM FOG-AC-ZEO Media Blend

REM FOG-AC-ZEO blend combines the filtration characteristics of all three common media strategies – Hydrophobic Perlite, Granular Activated Carbon and Zeolite.

Bioflex (BFTG)

Bioflex is a three dimensional woven natural fiber media designed to capture debris, trash and sediment. Mesh density of 3.5 ounces per square foot minimizes occlusion and blinding and allows for sustained high volume stormwater treatment rates. The exterior edge of the Bioflex is fitted with a netted polyester fiber configured to capture 100% of trash and debris at 5mm or greater in size. Bioflex is an approved “Full Trash Capture” specification.



Perforated Stainless Steel Screen (SS-PERF-5)

The filter cartridge houses a perforated Type 304 stainless steel screen. Configured to capture 100% of trash and debris no greater than 5mm, the design meets “Full Trash Capture - 5mm” specification.

Perforated Stainless Steel Screen (SS-PERF-2.4)

The filter cartridge houses a perforated Type 304 stainless steel screen. Configured to capture 100% of trash and debris no greater than 2.4mm, the design meets “Full Trash Capture - 2.4mm” specification.

REM TRITON Filter Recommended Maintenance Procedures:

Maintenance and Inspections:

In order to ensure proper operation, REM (Revel Environmental Manufacturing, Inc.) recommends that REM Stormwater filters be serviced and maintained when debris and pollutant accumulations exceed no more than 80% of the filter's capacity. REM recommends that the filters are inspected and serviced at a minimum of three times (3X's) per seasonal cycle year. The frequency and length of duration between inspections and maintenance may fluctuate based on specific site conditions such as local weather conditions, site use, and pollutant type and loading volume.

Filter Media Replacement:

In order to ensure proper operation, REM recommends that the FOG Media, or other specified media (such as Activated Carbon, and/or Zeolite) be replaced when the outer surface of media is no more than 50% coated with contaminants. (The surface area of REM's standard FOG media is stark white in color. The media will blacken with encapsulated contaminants over time.) It is recommended that REM media packs and Bioflex be replaced a minimum of one time (1X) per seasonal cycle year. Sites with higher pollutant loading concentrations may require more frequent service and media replacement. Purchase replacement media packs from REM at (888) 526-4736 or sales@remfilters.com. Custom media configurations are available upon.

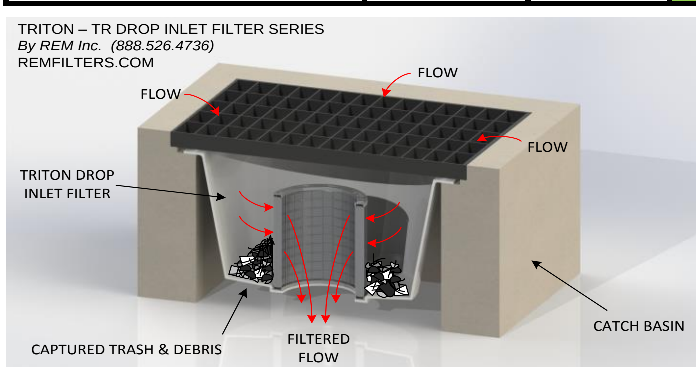
Disposal:

Captured pollutant debris and spent media must be disposed of in accordance with all Federal, State, and Local Laws and Regulations.

On-site Procedures for Triton Catch Basin Filter Inserts:

1. Secure area (proceed with traffic and pedestrian control plan).
2. Clean surface area immediately around each storm drain utilizing a stiff bristled push-broom, flat shovel or industrial vacuum.
3. Proceed with confined space procedures as necessary.
4. Remove grate or manhole cover and set aside.
5. Inspect perimeter filter flange gasket. Confirm media cartridge is secure in the filter basin.
6. Remove debris trapped in grate slot openings.
7. Utilize an industrial vacuum to remove debris from within filter basin.
8. Pressure wash media pack through the stainless steel cartridge. (Avoid discharge by utilizing an industrial vacuum to remove excess water while pressure washing).
9. Inspect media housed inside stainless steel cartridge. REM recommends replacing the filter media a minimum of once a year (see *Filter Media Replacement* above).
10. Place grate or manhole cover back on catch basin grate frame.
11. Secure dated service lock-out tag on grate lid.
12. Identify catch basin on site map for tracking and reporting.
13. Note observations, concerns or recommendation regarding specific filter on maintenance report.
14. Remove pedestrian and/or traffic control barricades.

SPECIFIER CHART TRITON DROP INLET FILTERS	INLET (ID) INSIDE DIMENSION Of Catch Basin	MEDIA REM - BFTG* FILTERED Flow Rate	MEDIA REM - FOG** FILTERED Flow Rate	MEDIA REM - FOG & BFTG*** FILTERED Flow Rate	MEDIA REM - 4.8MM PERF FILTERED Flow Rate	TOTAL FILTER BYPASS Flow Rate	DEBRIS HOLDING CAPACITY
MODEL:	***(inch x inch)***	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CUBIC FEET**
			Standard				
TR12RD *Configured with:*	**12" Dia. RD**						
Cartridge: TR7-CART (4")		0.42	0.17	0.17	1.1	1.61	0.19
Cartridge: TR7-CART (8")		0.91	0.25	0.25	2.21	1.61	0.42
TR1212 *Configured with:*	**12" X 12"**						
Cartridge: TR7-CART (4)		0.42	0.17	0.17	1.1	1.61	0.19
Cartridge: TR7-CART (8)		0.91	0.25	0.25	2.21	1.61	0.45
TR16RD *Configured with:*	**16" Dia. RD**						
Cartridge: TR7-CART (4)		0.42	0.17	0.17	1.1	1.61	0.19
Cartridge: TR7-CART (8)		0.91	0.25	0.25	2.21	1.61	0.45
TR1616 *Configured with:*	**16" X 16"**						
Cartridge: TR7-CART (4)		0.42	0.17	0.17	1.1	1.61	0.19
Cartridge: TR7-CART (8)		0.91	0.25	0.25	2.21	1.61	0.69
TR18RD *Configured with:*	**18" Dia. RD**						
Cartridge: TR7-CART (4)		0.42	0.17	0.17	1.1	1.61	0.19
Cartridge: TR7-CART (8)		0.91	0.25	0.25	2.21	1.61	0.69
TR1818 *Configured with:*	**18" X 18"**						
Cartridge: TR10-CART (4)		0.77	0.19	0.19	1.58	5.14	1.04
Cartridge: TR10-CART (8)		1.63	0.38	0.38	3.11	5.14	2.32
Cartridge: TR10-CART (16)		3.07	0.79	0.79	6.28	5.14	5.03
TR1824 *Configured with:*	**18" X 24"**						
Cartridge: TR10-CART (8)		1.63	0.38	0.38	3.11	5.14	1.04
Cartridge: TR10-CART (16)		3.07	0.79	0.79	6.28	5.14	2.69
TR2024 *Configured with:*	**20" X 24"**						
Cartridge: TR10-CART (8)		1.63	0.38	0.38	3.11	5.14	1.04
Cartridge: TR10-CART (16)		3.07	0.79	0.79	6.28	5.14	2.69
TR2424 *Configured with:*	**24" X 24"**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	2.26
Cartridge: TR14-CART (12)		3.76	1.05	1.05	6.64	13.15	3.4
Cartridge: TR14-CART (16)		4.91	1.43	1.43	8.85	13.15	4.53



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Santa Ana, California 92705
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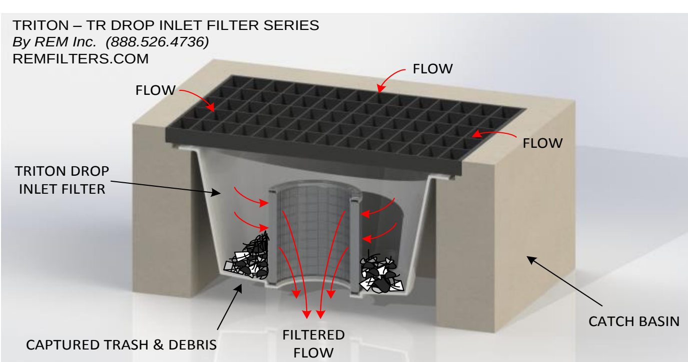
F: (714) 557-2679

SPECIFIER CHART TRITON DROP INLET FILTERS	INLET (ID) INSIDE DIMENSION Of Catch Basin	MEDIA REM - BFTG* FILTERED Flow Rate	MEDIA REM - FOG** FILTERED Flow Rate	MEDIA REM - FOG & BFTG*** FILTERED Flow Rate	MEDIA REM - 4.8MM PERF FILTERED Flow Rate	TOTAL FILTER BYPASS Flow Rate	DEBRIS HOLDING CAPACITY
MODEL:	*(inch x inch)*	CFS	CFS	CFS	CFS	CFS	CUBIC FEET
			Standard				
TR24RD *Configured with:*	**24" Dia. RD**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	2.26
Cartridge: TR14-CART (12)		3.76	1.05	1.05	6.64	13.15	3.4
Cartridge: TR14-CART (16)		4.91	1.43	1.43	8.85	13.15	4.53
TR2436 *Configured with:*	**24" X 36"**						
Cartridge: TR10-CART (8) (Qty 2)		3.26	0.76	0.76	6.28	10.28	1.57
TR2436-14(8) *Configured with:*	**24" X 36"**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	2.5
TR30RD *Configured with:*	**30" Dia. RD**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	2.87
Cartridge: TR14-CART (12)		3.76	1.05	1.05	6.64	13.15	4.31
Cartridge: TR14-CART (16)		4.91	1.43	1.43	8.85	13.15	5.74
TR3030 *Configured with:*	**30" X 30"**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	3.76
Cartridge: TR14-CART (12)		3.76	1.05	1.05	6.64	13.15	5.64
Cartridge: TR14-CART (16)		4.91	1.43	1.43	8.85	13.15	7.52
TR2448 *Configured with:*	**24" X 48"**						
Cartridge: TR14-CART (8) (Qty 2)		5.22	1.38	1.38	4.42	26.3	4.53
Cartridge: TR14-CART (12) (Qty 2)		6.02	2.12	2.12	6.64	26.3	6.8
Cartridge: TR14-CART (16) (Qty 2)		9.82	2.86	2.86	8.85	26.3	9.06
TR3636 *Configured with:*	**36" X 36"**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	5.6
Cartridge: TR14-CART (12)		3.76	1.05	1.05	6.64	13.15	8.4
Cartridge: TR14-CART (16)		4.91	1.43	1.43	8.85	13.15	11.2
TR36RD *Configured with:*	**36" Dia. RD**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	4.71
Cartridge: TR14-CART (12)		3.76	1.05	1.05	6.64	13.15	7.07
Cartridge: TR14-CART (16)		4.91	1.43	1.43	8.85	13.15	9.43



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SPECIFIER CHART TRITON DROP INLET FILTERS	INLET (ID) INSIDE DIMENSION Of Catch Basin	MEDIA REM - BFTG* FILTERED Flow Rate	MEDIA REM - FOG** FILTERED Flow Rate	MEDIA REM - FOG & BFTG*** FILTERED Flow Rate	MEDIA REM - 4.8MM PERF FILTERED Flow Rate	TOTAL FILTER BYPASS Flow Rate	DEBRIS HOLDING CAPACITY
MODEL:	***(inch x inch)***	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CUBIC FEET**
			Standard				
TR42RD *Configured with:*	**42" Dia. RD**						
Cartridge: TR14-CART (8)		2.61	0.69	0.69	4.42	13.15	6
Cartridge: TR14-CART (12)		3.76	1.05	1.05	6.64	13.15	9
Cartridge: TR14-CART (16)		4.91	1.43	1.43	8.85	13.15	12
TR4848 *Configured with:*	**48" X 48"**						
Cartridge: TR24-CART (8)		4.85	1.22	1.22	7.92	51.29	7.24
Cartridge: TR24-CART (16)		10.3	2.42	2.42	15.81	51.29	15.5
TR48RD *Configured with:*	**48" Dia. RD**						
Cartridge: TR24-CART (8)		4.85	1.22	1.22	7.92	51.29	3.37
Cartridge: TR24-CART (16)		10.3	2.42	2.42	15.81	51.29	6.74

Notes:

** Standard cartridge configurations for the TRITON Drop Inlet Series filter. Please specify if larger capacity cartridges are required. The cartridge heights are listed in ( ) next to the model. For shallow catch basins choose the smaller cartridge heights.

** Please see MEDIA OPTIONS page for specific media types and configurations.

** Filter debris capacities can be modified to utilize the maximum dimensions of each specific catch basin. Volumes will either increase or decrease depending upon the size of the catch basin and cartridge used. Volume capacities that are shown, are based on the catch basin filters standard inside wall dimensions for that filter size. Debris holding capacities can be modified to utilize the additional depth of each specific catch basin by adding taller cartridges.

REM Technical Support is available to assist with TRITON Series filter configurations, media strategies, and customization of models.

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Sizing Guide for Square Drop Inlet Catch Basins

REM Inc.

CATCH BASIN SIZING GUIDE

(Designed to help determine what size filters are required for each catch basin on site)

For Curb Inlets or other questions please call (888) 526-4736.

Once you have sized your drains you may either fax or email back your measurements to:

Fax: (925) 676-8676
Or
Email: Sales@remfilters.com

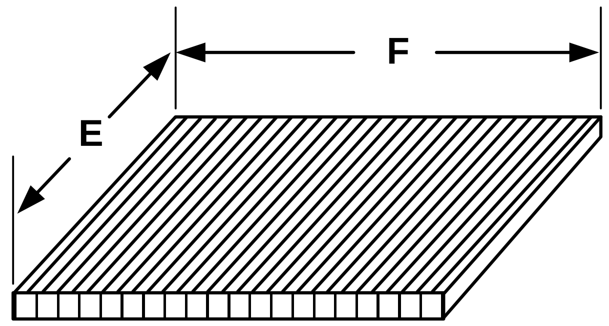
Customer:________________________________ Contact:______________________

Ph: (____)__________________________ Fax: (____)_____________________

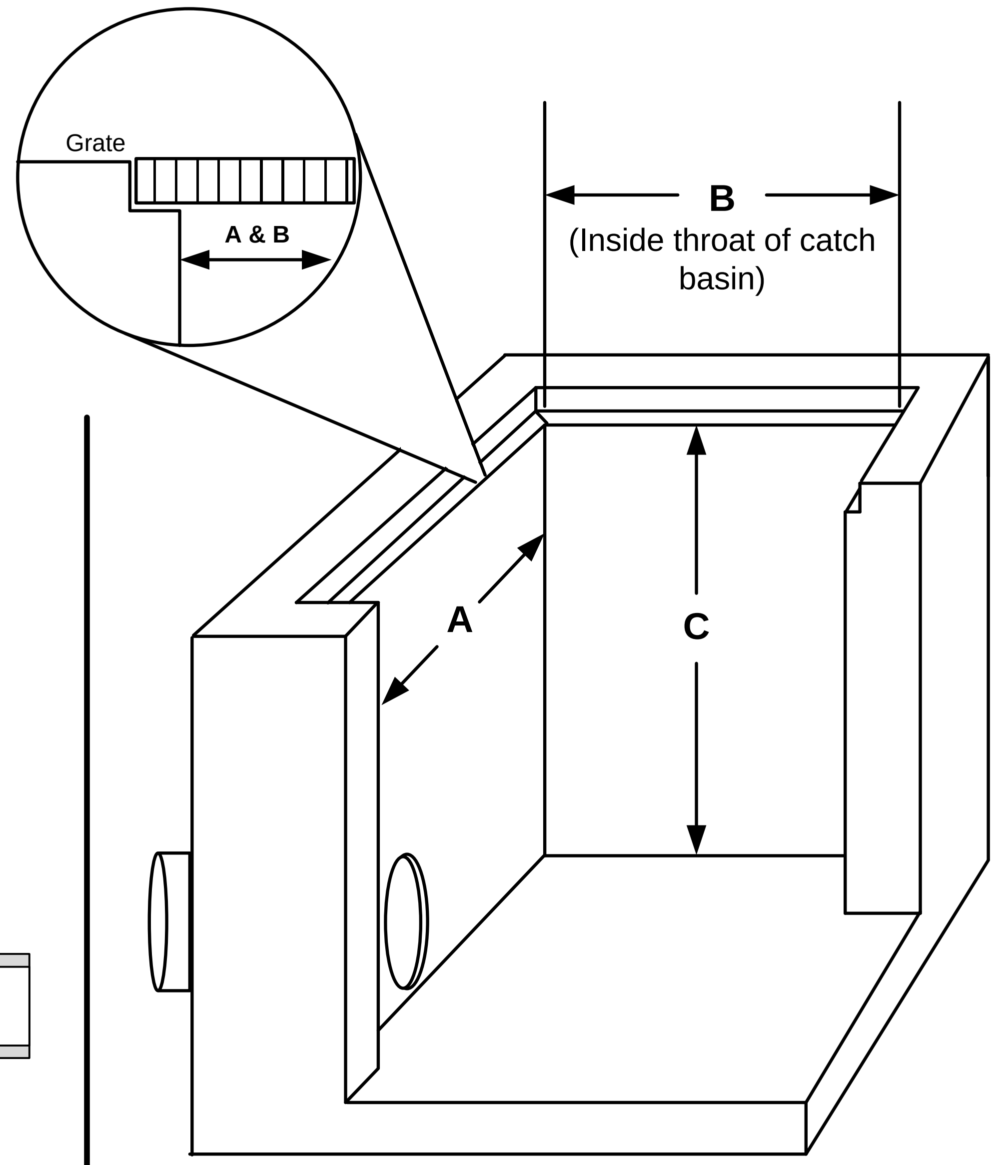
Project/Tract#:____

Location: ____ Page________of__________

Drain #	Quantity	Catch Basin I.D.				Grate Dimensions			
		A	B	C	D	E	F	G	H



NOTES:
1. Please fill in all dimensions that apply within 1/8".
2. Please mark or draw in the location of any obstructions such as pipes, ladder rungs, etc.
3. Dimensions A & B are the clear openings or (inside throat) of the catch basin or the grate frame, whichever is less.
4. Dimension C is measured from the bottom of the grate to the bottom of the catch basin.
5. Dimension D is measured from the bottom of the grate to the top of the outlet pipe.



COMMENTS:

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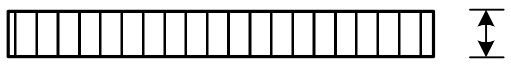
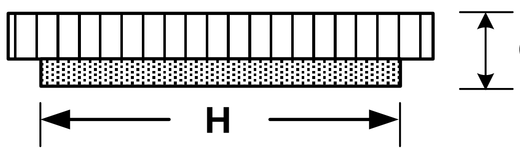
G & H – Dimensions:

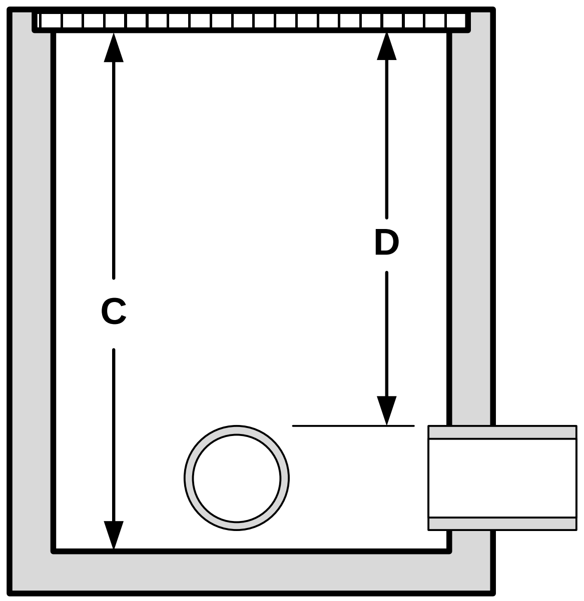
Grate Type, Mark one.

☐ **A** **Flat Bottom (A)** →



☐ **B** **"Keyhole" / Coped Bottom (B)** →





Side View

Sizing Guide for Round Drop Inlet Catch Basins

REM Inc.

CATCH BASIN SIZING GUIDE

(Designed to help determine what size filters are required for each catch basin on site)

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Or
Email: Sales@remfilters.com

Customer:______________________________ Contact:____________________

Ph: (____)_________________________ Fax: (____)__________________

Project/Tract#:____

Location: ______________________________________ Page________of__________

Drain #	Quantity	Catch Basin I.D.				Grate Dimensions			
		A	B	C	D	E	F	G	H
			N/A				N/A		
			N/A				N/A		
			N/A				N/A		
			N/A				N/A		
			N/A				N/A		
			N/A				N/A		

NOTES:

1. Please fill in all dimensions that apply within 1/8".
2. Please mark or draw in the location of any obstructions such as pipes, ladder rungs, etc.
3. Dimensions A is the clear openings or (inside throat) of the catch basin or grate frame, whichever is less.
4. Dimension C is measured from the bottom of the grate to the bottom of the catch basin.
5. Dimension D is measured from the bottom of the grate to the top of the outlet pipe.

COMMENTS:

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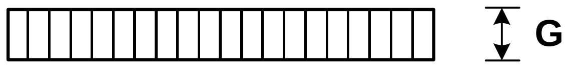
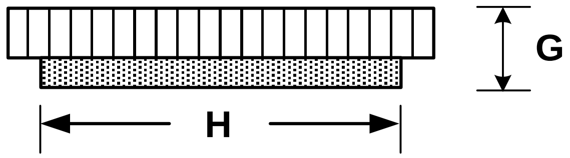
G & H – Dimensions:

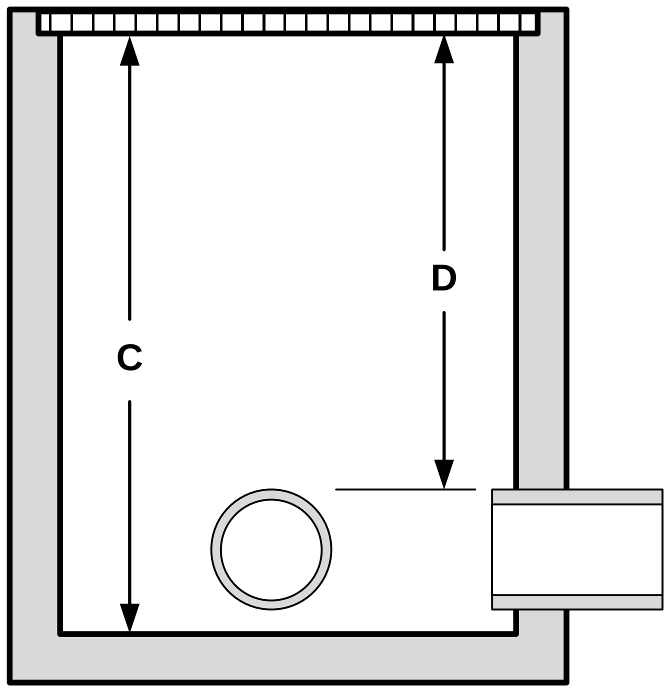
Grate Type, Mark one.

☐ **A** **Flat Bottom (A)** →

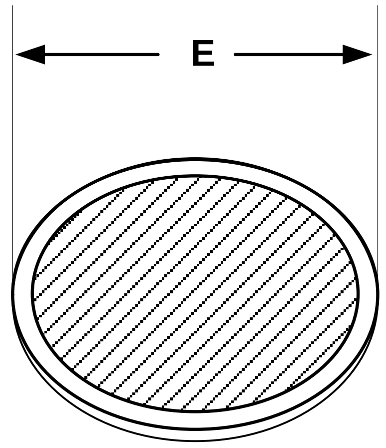


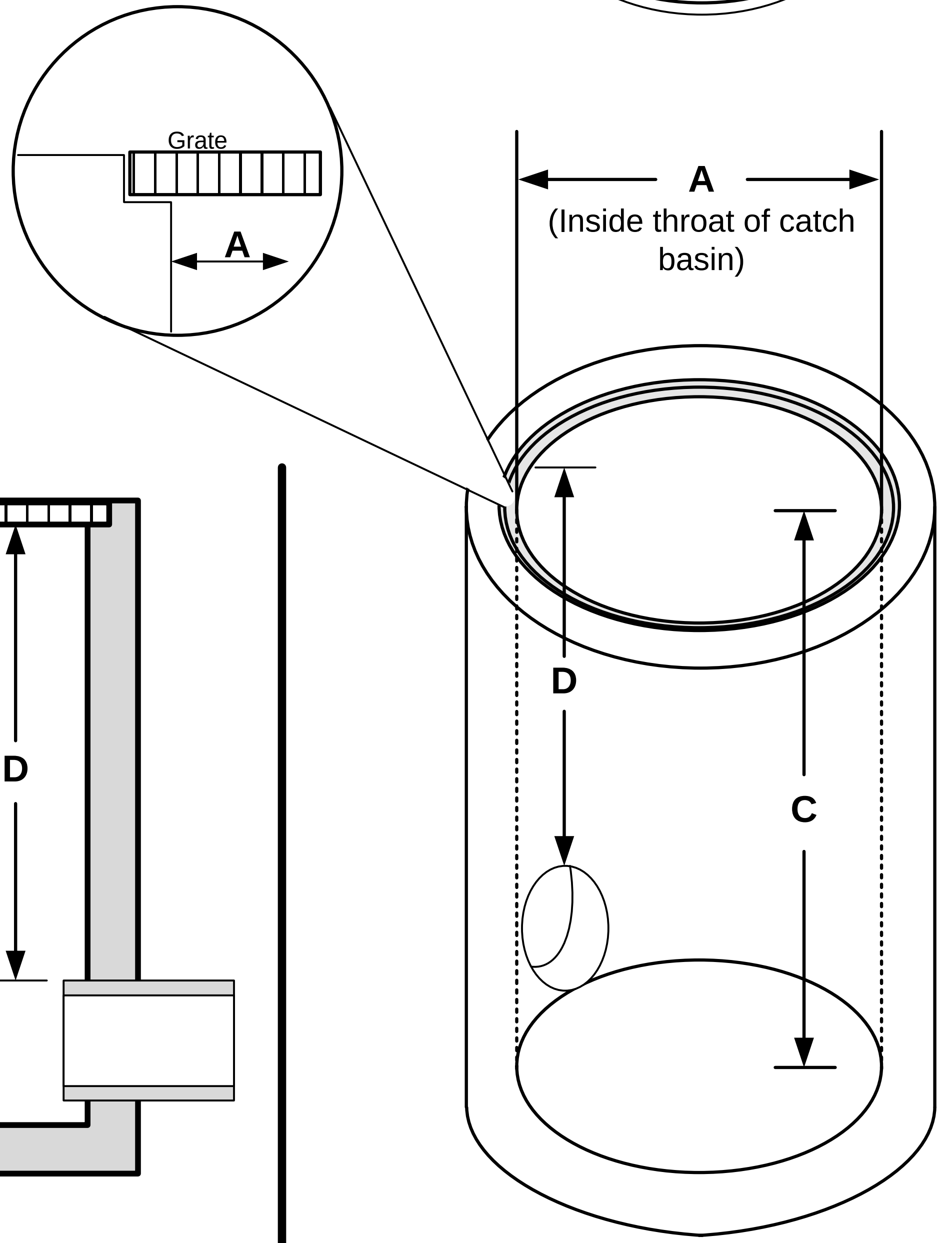
☐ **B** **"Keyhole" / Coped Bottom (B)** →





Side View





Combination Grated Curb Inlet Catch Basin Sizing Guide

REM Inc.

CATCH BASIN SIZING GUIDE

(Designed to help determine what size filters are required for each catch basin on site)

For Curb Inlets or other questions please call (888) 526-4736.

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Or
Email: Sales@remfilters.com

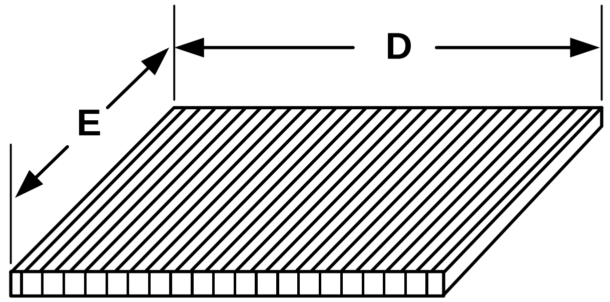
Customer:______________________________ Contact:______________________

Ph: (____)________________________ Fax: (____)__________________

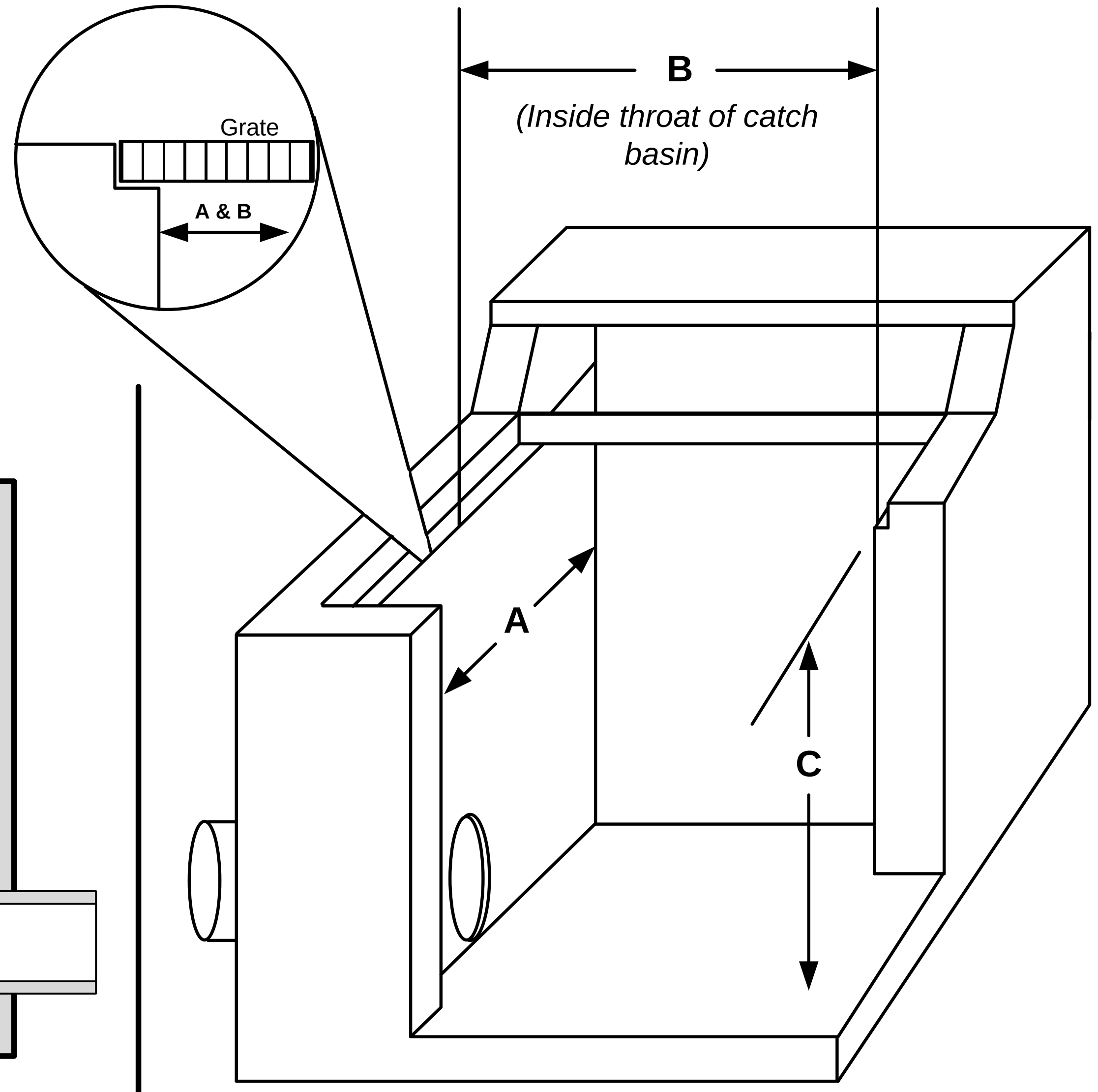
Project/Tract#:____

Location: ____________________________________ Page_______of_________

Drain #	Quantity	Catch Basin I.D.				Grate Dimensions			
		A	B	C	D	E	F	G	H



NOTES:
1. Please fill in all dimensions that apply within 1/8".
2. Please mark or draw in the location of any obstructions such as pipes, ladder rungs, etc.
3. Dimensions A & B are the clear openings or (inside throat) of the catch basin.
4. Dimension C is measured from the bottom of the grate to the bottom of the catch basin.
5. Dimension D is measured from the bottom of the grate to the top of the outlet pipe.



COMMENTS:

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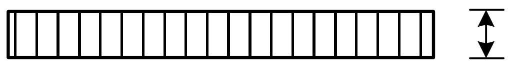
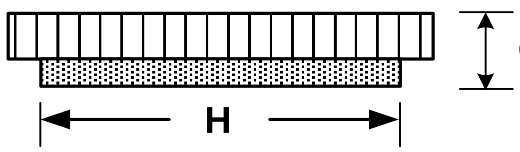
G & H – Dimensions:

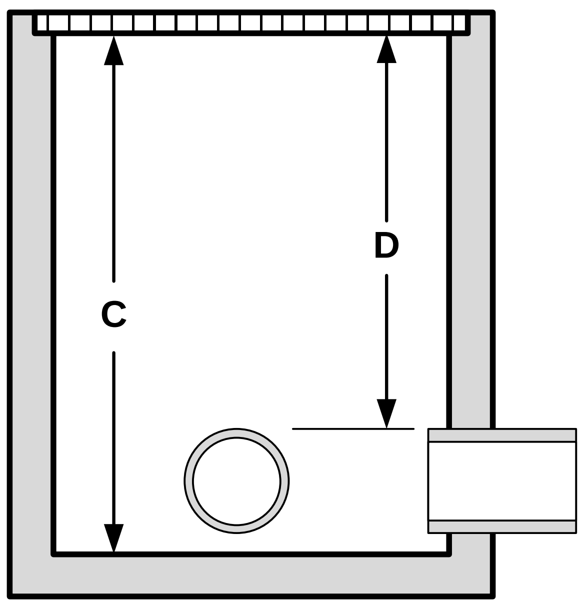
Grate Type, Mark one.

☐ A **Flat Bottom (A)** →



☐ B **"Keyhole" / Coped Bottom (B)** →





Side View

Sizing Guide for Square Drop Inlet Catch Basins
With Oil Stop outlets

REM Inc.

CATCH BASIN SIZING GUIDE

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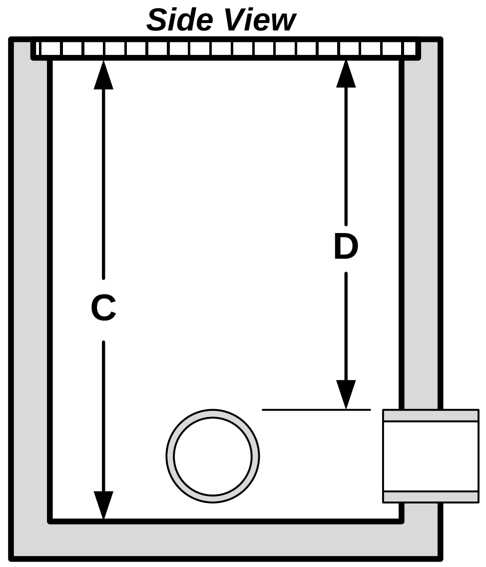
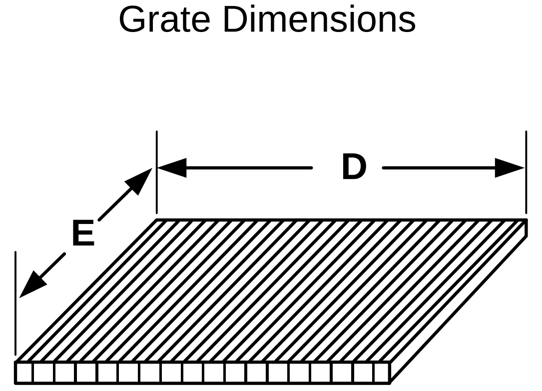
Ph: (____)_________________________ Fax: (____)__________________

Project/Tract#:____

Location: _____________________________________ Page________of__________

Drain #	Quantity	Catch Basin I.D.					Grate Dimensions			
		A	B1	B2	C	D	E	F	G	H





NOTES:
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2. Please mark or draw in the location of any obstructions such as pipes, ladder rungs, etc.
3. Dimensions A & B are the clear openings or (inside throat) of the catch basin.
4. Dimension C is measured from the bottom of the grate to the bottom of the catch basin.
5. Dimension D is measured from the bottom of the grate to the top of the outlet pipe.

COMMENTS:

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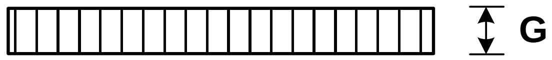
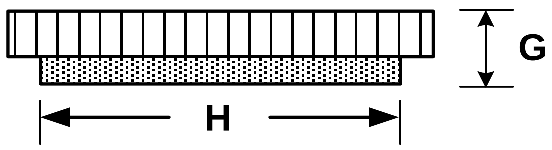
G & H – Dimensions:

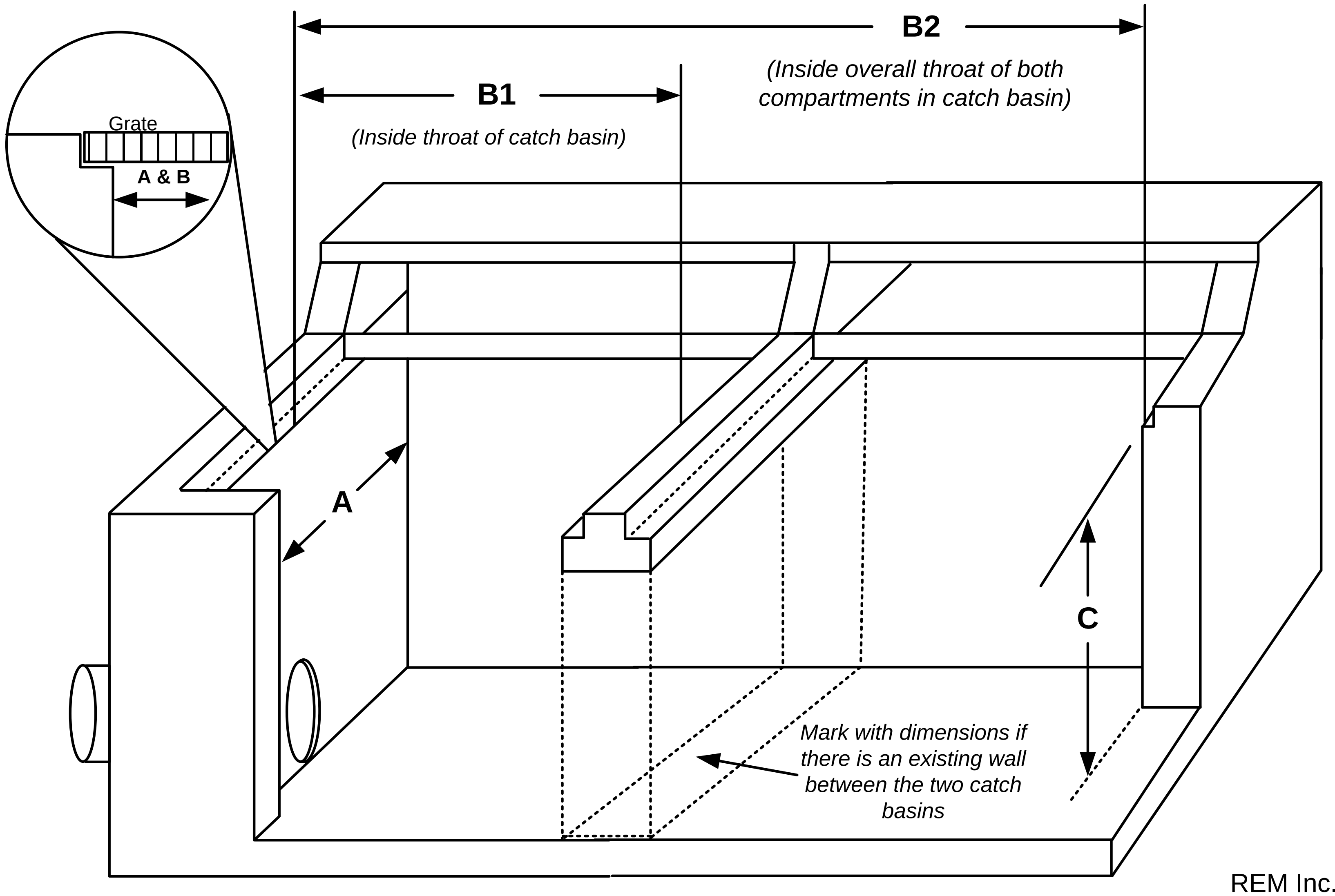
Grate Type, Mark one.

☐ **A** **Flat Bottom (A)** →



☐ **B** **"Keyhole" / Coped Bottom (B)** →





REM Inc.

Sizing Guide to determine type of grate being used.

CATCH BASIN SIZING GUIDE
(Designed to help determine what size filters are required for each catch basin on site)

For Curb Inlets please call (888) 526-4736.

Once you have sized your drains you may either fax or email back your measurements to:

Fax: (925) 676-8676
Or
Email: Sales@remfilters.com

Customer:________________________________ Contact:______________________

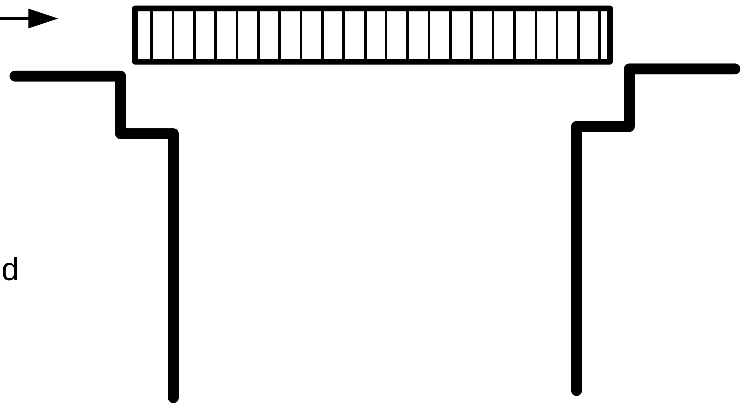
Ph: (____)__________________________ Fax: (____)___________________

Project/Tract#:____

Location: ____ Page________of__________

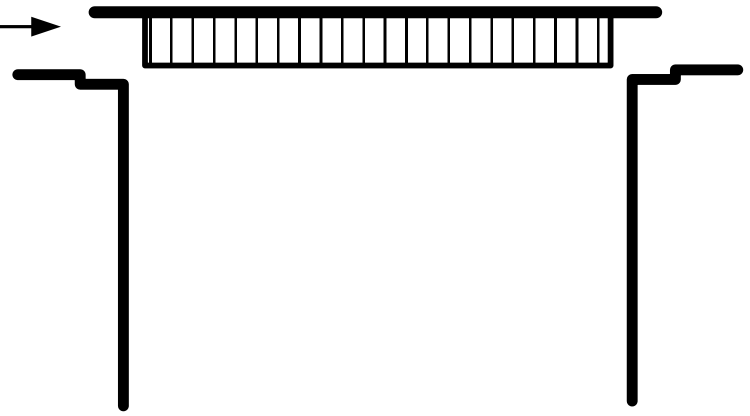
Grate Type, Mark one.

☐ **A** **Flat Bottom (A)** →



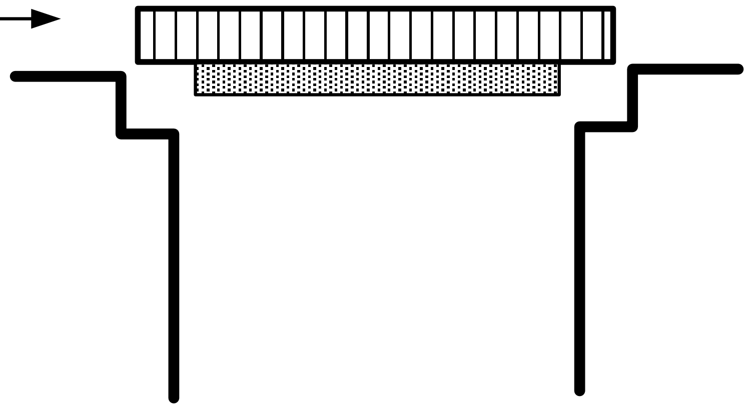
Note: Most commonly found on all sized catch basin grates.

☐ **C** **Flat top "Keyhole" / Coped Bottom (C)** →



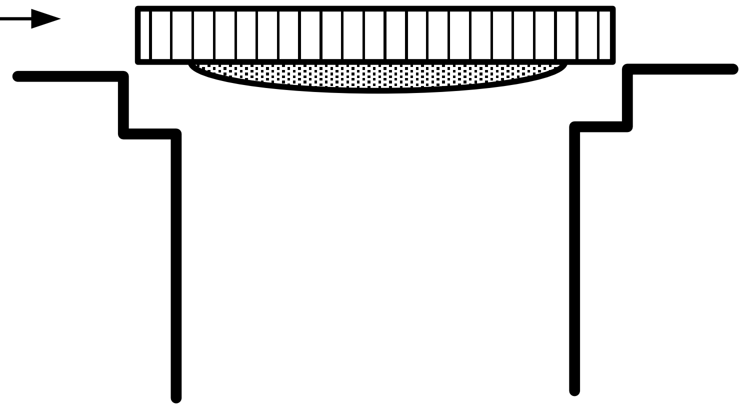
Note: Most commonly found on 24" X 36" ID Catch Basins.

☐ **B** **"Keyhole" / Coped Bottom (B)** →



Note: Most commonly found on 24"X24", 24"X36", 30"X30" ID Catch Basins.

☐ **D** **"Keyhole" / Rounded Bottom (D)** →



Note: Most commonly found on 18" Dia., 24"Dia. and 36"Dia. Round Catch Basins.

COMMENTS:

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Sizing Guide for Catch Basins having Manhole Structures

<u>REM Inc.</u>

MANHOLE SIZING GUIDE

(Designed to help determine what size filters are required for each catch basin on site)

For Curb Inlets or other questions please call (888) 526-4736.

Once you have sized your drains you may either fax or email back your measurements to:

Fax: (925) 676-8676
Or
Email: Sales@remfilters.com

Customer:______________________________ Contact:____________________

Ph: (____)_________________________ Fax: (____)__________________

Project/Tract#:____

Location: _____________________________________ Page________of__________

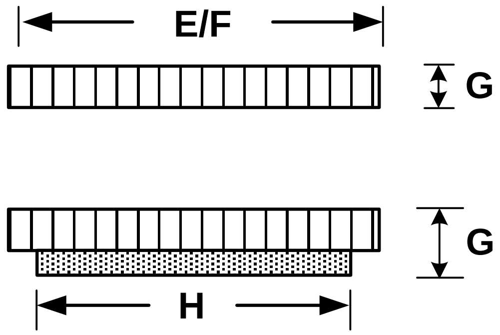
Drain #	Quantity	Manhole / Catch Basin I.D.				Grate Dimensions			
		A	B	C	D	E	F	G	H

G, H & F – Dimensions:

Grate Type, Mark one.

☐ **A** **Flat Bottom (A)**

☐ **B** **"Keyhole" / Coped Bottom (B)**

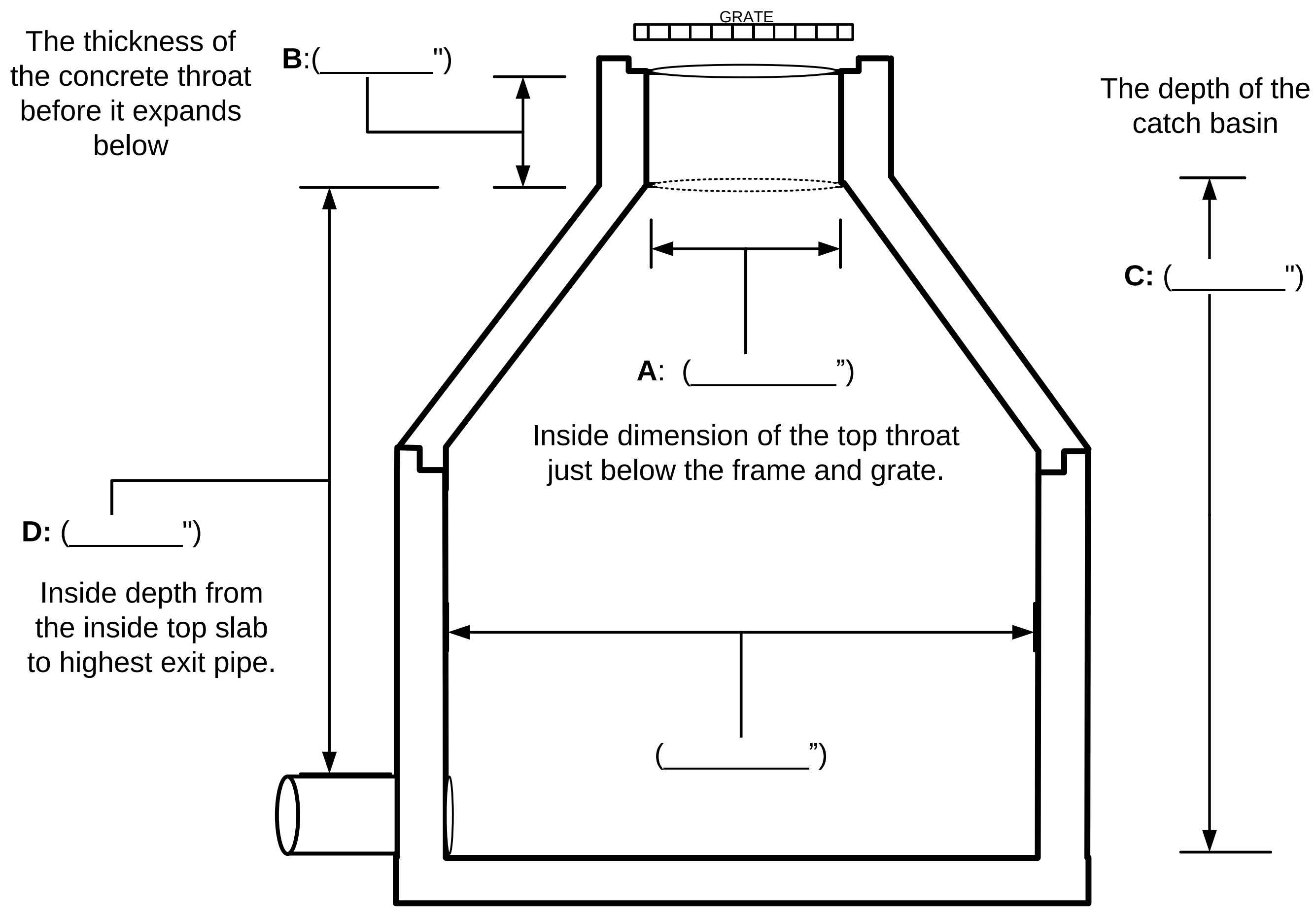


(E/F: If grate is square)

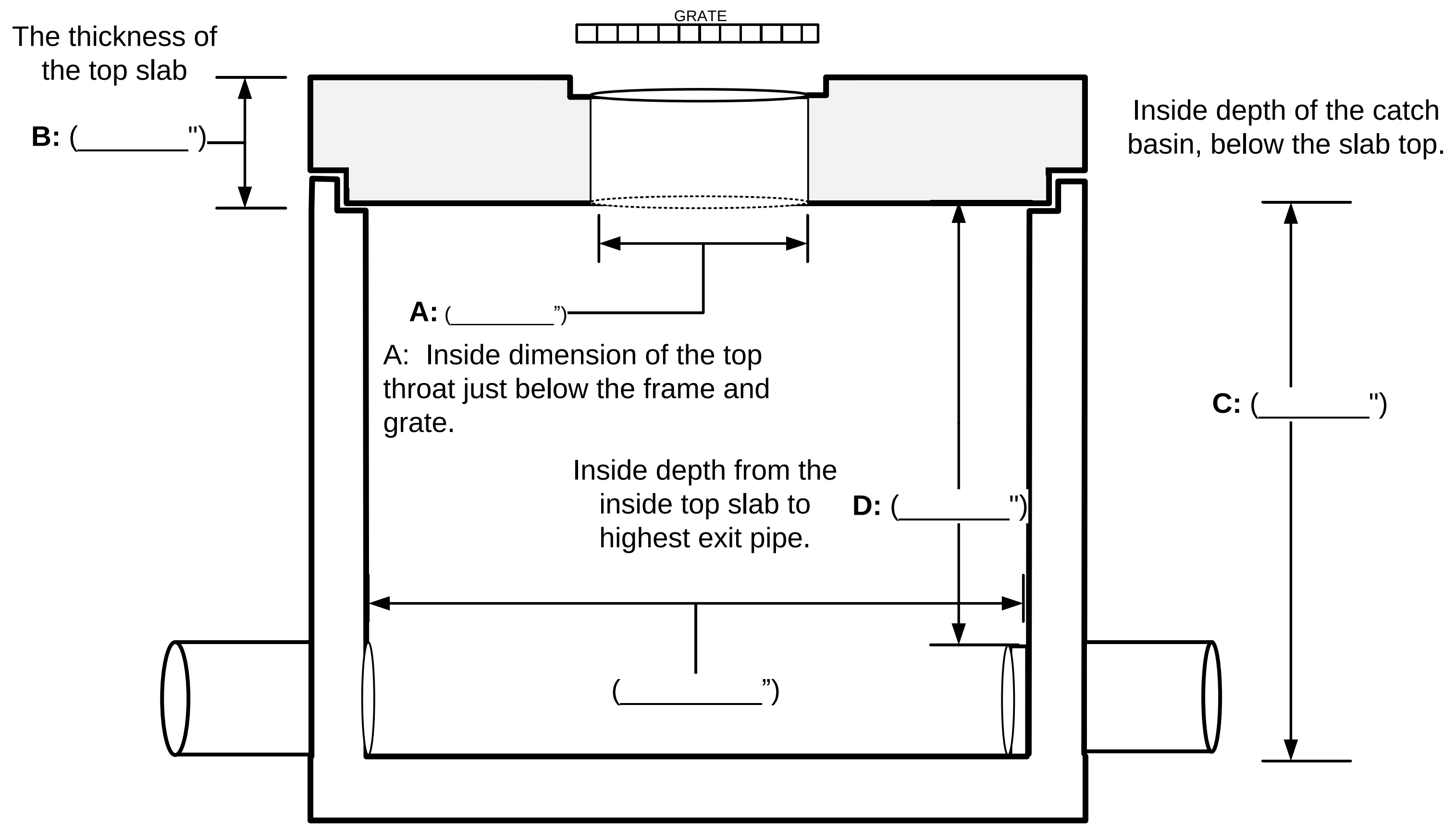
NOTES:
1. Please fill in all dimensions that apply within 1/8".
2. Please mark or draw in the location of any obstructions such as pipes, ladder rungs, etc.
3. Dimensions A is the clear openings or (inside throat) of the catch basin or grate frame, whichever is less.
4. Dimension C is measured from the bottom of the neck or slab to the bottom of the catch basin.
5. Dimension D is measured from the bottom of the grate to the top of the outlet pipe.

COMMENTS:

☐ ***Manhole with a coned top***



☐ ***Manhole with a flat top cap***



Sizing Guide for Square Drop Inlet Catch Basins
With Oil Stop outlets

<u>REM Inc.</u>
CATCH BASIN SIZING GUIDE
(Designed to help determine what size filters are required for each catch basin on site)

For Curb Inlets or other questions please call (888) 526-4736.

Once you have sized your drains you may either fax or email back your measurements to:

Fax: (925) 676-8676
Or
Email: Sales@remfilters.com

Customer:______________________________ Contact:____________________

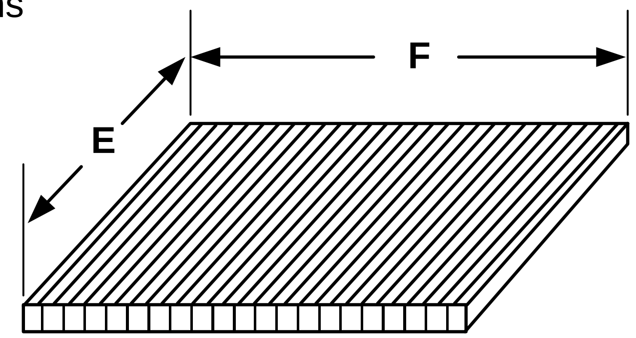
Ph: (____)_________________________ Fax: (____)__________________

Project/Tract#:____

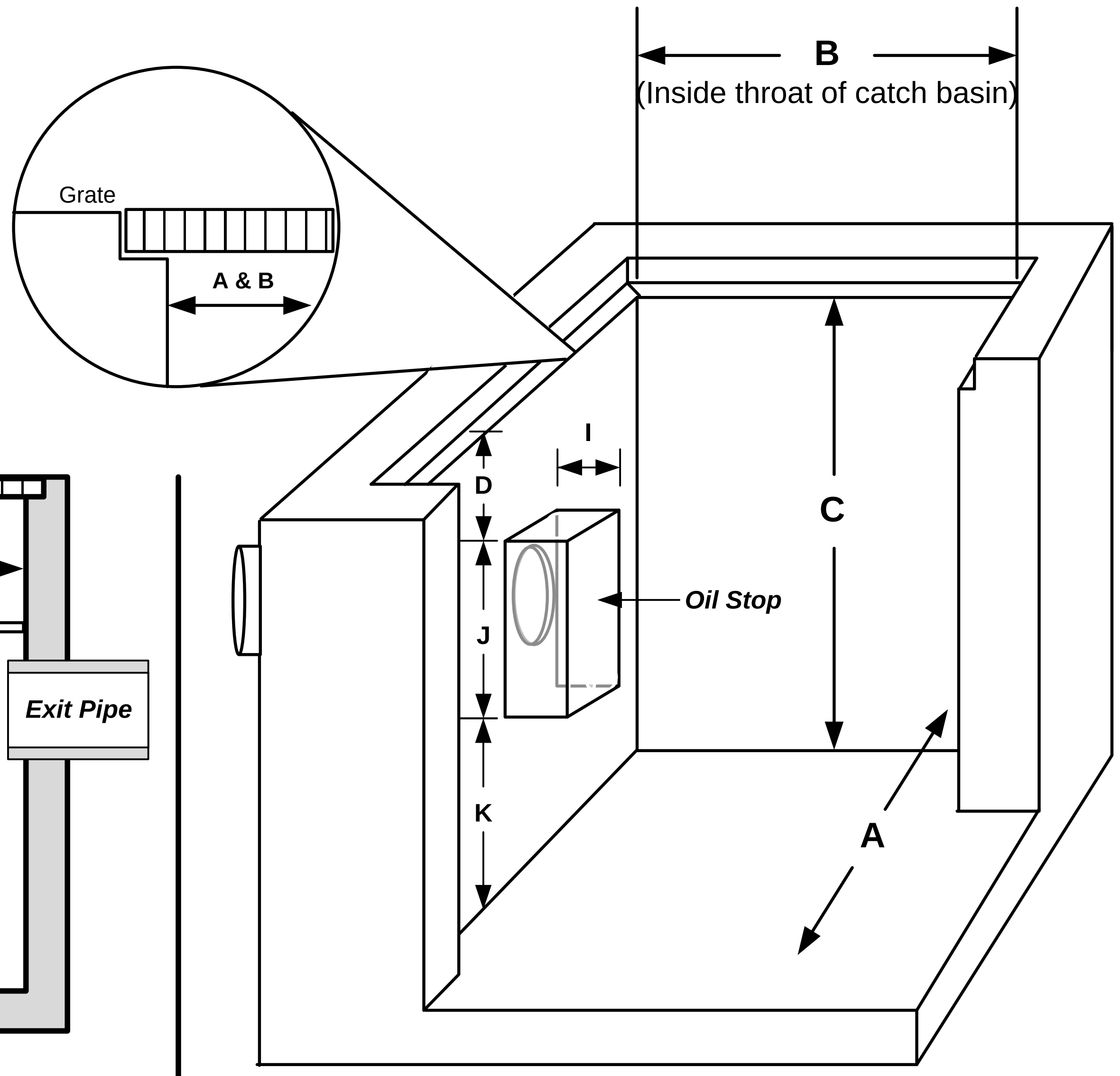
Location: _____________________________________ Page________of__________

Drain #	Quantity	Catch Basin I.D.				Grate Dimensions				Oil Stop		
		A	B	C	D	E	F	G	H	I	J	K

Grate Dimensions



NOTES:
1. Please fill in all dimensions that apply within 1/8".
2. Please mark or draw in the location of any obstructions such as pipes, ladder rungs, etc.
3. Dimensions A & B are the clear openings or (inside throat) of the catch basin or the grate frame, whichever is less.
4. Dimension C is measured from the bottom of the grate to the bottom of the catch basin.
5. Dimension D is measured from the bottom of the grate to the top of the outlet pipe.



COMMENTS:

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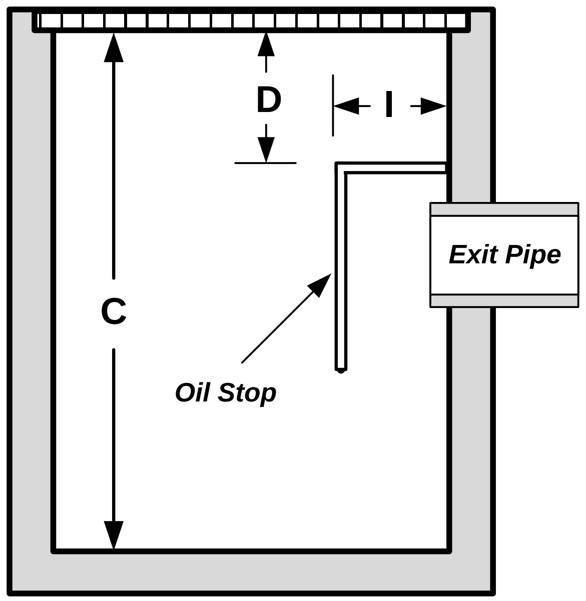
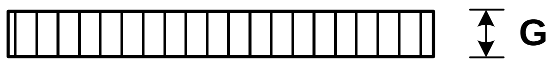


Side View

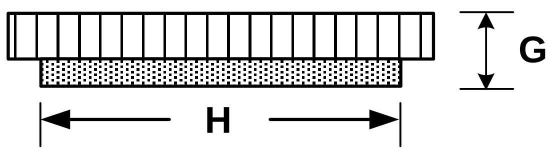
G & H – Dimensions:

Grate Type, Mark one.

☐ **A** **Flat Bottom (A)** →



☐ **B** **"Keyhole" / Coped Bottom (B)** →



C.2 Manufacturer Specifications Storm Pipe Installation

CONTECH ENGINEERED SOLUTIONS

Corrugated Metal Pipe Design Guide

CONTECH PIPE SOLUTIONS

Corrugated Metal Pipe (CMP) Design Guide
Table of Contents

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CORLIX® Corrugated Aluminum Pipe
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CONTECH® ENGINEERED SOLUTIONS

Durability Design Guide

Proper design of culverts and storm sewers requires structural, hydraulic and durability considerations. While most designers are comfortable with structural and hydraulic design, the mechanics of evaluating abrasion, corrosion and water chemistry to perform a durability design are not commonly found in most civil engineering handbooks.

The durability and service life of a drainage pipe installation is directly related to the environmental conditions encountered at the site and the type of materials and coatings from which the culvert is fabricated. Two principle causes of reduced service life in drainage pipe materials are corrosion and abrasion.

Service life can be affected by the corrosive action of the backfill in contact with the outside of a drainage pipe or more commonly by the corrosive and abrasive action of the flow in the invert of the drainage pipe. The design life analysis should include a check for both the water side and soil side environments to determine which is more critical— or which governs service life.

The potential for metal loss in the invert of a drainage pipe due to abrasive flows is often overlooked by designers and its effects are often mistaken for corrosion. An estimate for potential abrasion is required at each pipe location in order to determine the appropriate material and gage.

This manual is intended to guide specifiers through the mechanics of selecting appropriate drainage products to meet service life requirements. The information contained in the following pages is a composite of several national guidelines.

Using the CMP Design Guide

The choice of material, gage and product type can be extremely important to service life. The following steps describe the procedure for selecting the appropriate drainage product, material and gage to meet a specific service life requirement.

Design Sequence

1. Select pipe or structure based on hydraulic and clearance requirements. Use Tables 5 and 6 as reference for size limits and hydraulic properties of all drainage products.

2. Use Height of Cover tables for the chosen pipe or structure to determine the material gage required for the specific loading condition.

3. Use Table 1 to select the appropriate material for the site-specific environmental conditions. Whenever possible, existing installations of drainage structures along the same water course offer the most reliable estimate of long-term performance for specific environment conditions. In many cases, there will be more than one material that is appropriate for the project environmental conditions. Generally speaking, the metal material types increase in price as you move from top down on Table 1. Please contact your local Contech Sales Representative for pricing.

4. Use Table 2 to determine which abrasion level most accurately describes the typical storm event (2 year storm). The expected stream velocity and associated abrasion conditions should be based on a typical flow and not a 10 or 50-year design flood.

5. Use Table 3 to determine whether the structural gage for the selected material is sufficient for the design service life. If the structural gage is greater than or equal to the gage required for a particular abrasion condition and service life, use the structural gage. Conversely, if the structural gage is less than the gage required for a particular abrasion condition and service life, use the gage required by Table 3.

Note:

Both Contech round pipe and pipe-arch are available with either helical or annular corrugations. Contech HEL-COR pipe (helical corrugations) is furnished with continuous lock seams and annular re-rolled ends or non-rerolled ends. For 3″x1″ and 5″x1″ HEL-COR pipe-arch, we recommend non-rerolled ends with flat or dimpled bands and flat gaskets. Contech riveted pipe is furnished with annular corrugations only. The height of cover tables in this guide are helical corrugations only. Consult your Contech representative for Height of Cover tables on riveted pipe.

Table 1 — Recommended Environments											
Material Type	Soil* and Water pH									Resistivity (ohm-cm)	
	3	4	5	6	7	8	9	10	11	12	Minimum	Maximum
Galvanized Steel*				■	■	■	■	■			2,000	10,000
Aluminized Steel Type 2 (ALT2)			■	■	■	■	■				1,500	N/A
Polymer-Coated	■	■	■	■	■	■	■	■	■		250	N/A
Aluminum Alloy		■	■	■	■	■	■				500	N/A

**Appropriate pH range for Galvanized Steel is 6.0 to 10*

Table 2 — FHWA Abrasion Guidelines			
Abrasion Level	Abrasion Condition	Bed Load	Flow Velocity (fps)
1	Non-Abrasive	None	Minimal
2	Low Abrasion	Minor	< 5
3	Moderate Abrasion	Moderate	5 - 15
4	Severe Abrasion	Heavy	> 15

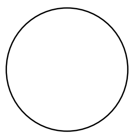
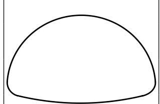
"Interim Direct Guidelines on Drainage Pipe Alternative Selection." FHWA, 2005.

Table 3 – Drainage Product Usage Guide												
Application	Culverts, Storm Drain, Cross Drain, Median Drain, Side Drain											
Roadway Classification	Rural	Minor	Major	Urban	Rural	Minor	Major	Urban	Rural	Minor	Major	Urban
Design Service Life	25	50	75	100	25	50	75	100	25	50	75	100
Abrasion Level	Abrasion Level 1 & 2				Abrasion Level 3				Abrasion Level 4			
CMP (1/2" & 1" deep corrugations), ULTRA FLO® & Smooth Cor™ Minimum gage required to meet design service life, assuming that structural design has been met.												
Galvanized (2 oz.)	16	12	10	8[4]	14	10	8	N/A	14[5]	10[5]	8[5]	N/A
Galvanized and Asphalt Coated	16	14	10	8	14	12	8	N/A	14[5]	12[5]	8[5]	N/A
Galv., Asphalt Coated & Paved Invert	16	16	14	10	16	14	12	8	14	12	10	N/A
Aluminized Type 2 (ALT2)	16	16	16	14	14	14	14	12	14[6]	14[6]	14[6]	12[6]
Polymer-Coated	16	16	16[8]	16[9]	16	16	16[8]	16[9]	14[7]	14[7]	14[7,8]	14[7,9]
Aluminum Alloy	16	16	16	16	14	14	14	14	14[5]	14[5]	14[5]	14[5]

1. *Based on Table 1 - Recommended Environments.*
2. *Smooth Cor™ Steel Pipe combines a corrugated steel exterior shell with a hydraulically smooth interior liner.*
3. *Service life estimates for ULTRA FLO® and Smooth Cor™ Pipe assume a storm sewer application. Storm sewers rarely achieve abrasion levels 3 or 4. For applications other than storm sewers or abrasion conditions above Abrasion Level 2, please contact your Contech Sales Representative for gage and coating recommendations.*
4. *Design service life for 8 GA galvanized is 97 years.*
5. *Invert protection to consist of velocity reduction structures.*
6. *Asphalt coated and paved invert or velocity reduction structures are needed.*
7. *Requires a field applied concrete paved invert with minimum thickness 1" above corrugation crests.*
8. *75 year service life for polymer-coated is based on a pH range of 4-9 and resistivity greater than 750 ohm-cm.*
9. *100 year service life for polymer-coated is based on a pH range of 5-9 and resistivity greater than 1500 ohm-cm.*

Table 4 - AASHTO Reference Specifications					
	Material Type	**Material**	**Pipe**	**Design***	**Installation***
Pipe & Pipe-Arch	**CMP (1/2" or 1" deep corrugations)**				
	Galvanized (2 oz.)	M218	M36	Section 12	Section 26
	Asphalt Coated	M190	M36	Section 12	Section 26
	Asphalt Coated and Paved Invert	M190	M36	Section 12	Section 26
	Aluminized Type 2	M274	M36	Section 12	Section 26
	Polymer-Coated	M246	M36 & M245	Section 12	Section 26
	Aluminum Alloy	M197	M196	Section 12	Section 26
	ULTRA FLO® (3/4" x 3/4" x 7-1/2" corrugation)				
	Galvanized (2 oz.)	M218	M36	Section 12	Section 26
	Aluminized Type 2	M274	M36	Section 12	Section 26
	Polymer-Coated	M246	M36 & M245	Section 12	Section 26
	Aluminum Alloy	M197	M196	Section 12	Section 26
	Smooth Cor™				
	Polymer-Coated	M246	M36 & M245	Section 12	Section 26

* *AASHTO LRFD Bridge Design Specification and AASHTO Standard Specification for Highway Bridges*

Table 5 - Product Dimensions						
		Drainage Product	Common Uses	Size Limits* Minimum	Size Limits* Maximum	Manning's "n" Value
	Round Pipe	Corrugated Steel (1/2" deep corrugation)	Culverts, small bridges, storm water detention/ retention systems, conduits, tunnels, storm sewers.	12"	84"	0.011 - 0.021
		Corrugated Steel with Paved Invert (1/2" deep corrugation)		12"	84"	0.014 - 0.020
		Corrugated Steel (1" deep corrugation)		54"	144"	0.022 - 0.027
		Corrugated Steel with Paved Invert (1" deep corrugation)		54"	144"	0.019 - 0.023
		Corrugated Aluminum (1/2" deep corrugation)		12"	72"	0.011 - 0.021
		Corrugated Aluminum (1" deep corrugation)		30"	120"	0.023 - 0.027
		ULTRA FLO® Steel	Storm sewers, culverts, storm water detention/ retention systems.	18"	102"	0.012
		ULTRA FLO® Aluminum		18"	84"	0.012
		Smooth Cor™ Steel (1/2" deep corrugation)		18"	66"	0.012
		Smooth Cor™ Steel (1" deep corrugation)		48"	126"	0.012
	Pipe-Arch	Corrugated Steel (1/2" deep corrugation)	Culverts, small bridges, storm water detention/ retention systems, conduits, tunnels, storm sewers.	17" x 13"	83" x 57"	0.011 - 0.021
		Corrugated Steel with Paved Invert (1/2" deep corrugation)		17" x 13"	83" x 57"	0.014 - 0.019
		Corrugated Steel (1" deep corrugation)		53" x 41"	142" x 91"	0.023 - 0.027
		Corrugated Steel with Paved Invert (1" deep corrugation)		53" x 41"	142" x 91"	0.019 - 0.022
		Corrugated Aluminum (1/2" deep corrugation)		17" x 13"	71" x 47"	0.011 - 0.021
		Corrugated Aluminum (1" deep corrugation)		60" x 46"	112" x 75"	0.023 - 0.027
		ULTRA FLO® Steel	Storm sewers, culverts, storm water detention/ retention systems.	20" x 16"	66" x 51"	0.012
		ULTRA FLO® Aluminum		20" x 16"	66" x 51"	0.012
		Smooth Cor™ Steel (1/2" deep corrugation)		21" x 15"	77" x 52"	0.012
		Smooth Cor™ Steel (1" deep corrugation)		53" x 41"	137" x 87"	0.012

* *For sizes outside of these limits, please contact your Contech representative.*

Table 6 — Corrugated Steel Pipe—Values of Coefficient of Roughness (Manning's "n")											
	Helical* Corrugation – 2 2/3" x 1/2"								**1-1/2" x 1/4"**		**Annular**
2 2/3" x 1/2"	**12 in.**	**15 in.**	**18 in.**	**24 in.**	**36 in.**	**48 in.**	**60 in. +**		**8 in.**	**10 in.**	**All Diameters**
Unpaved	0.011	0.012	0.013	0.015	0.018	0.020	0.021		0.012	0.014	0.024
Paved Invert				0.014	0.017	0.020	0.019				0.021
Smooth Cor™			0.012	0.012	0.012	0.012	0.012				N/A
	Helical*– 3" x 1"										
3" x 1"	**36 in.**	**42 in.**	**48 in.**	**54 in.**	**60 in.**	**66 in.**	**72 in.**	**78 in. +**			**All Diameters**
Unpaved	0.022	0.022	0.023	0.023	0.024	0.025	0.026	0.027			0.027
Paved Invert	0.019	0.019	0.020	0.020	0.021	0.022	0.022	0.023			0.023
Smooth Cor™			0.012	0.012	0.012	0.012	0.012	0.012			N/A
	Helical* – 5" x 1"										
5" x 1"			**48 in.**	**54 in.**	**60 in.**	**66 in.**	**72 in.**	**78 in. +**			**All Diameters**
Unpaved			0.022	0.022	0.023	0.024	0.024	0.025			N/A
Paved Invert			0.019	0.019	0.020	0.021	0.021	0.022			N/A
ULTRA FLO®	**3/4" x 3/4" x 7-1/2"** All diameters n = 0.012										N/A

* *Tests on helically corrugated pipe demonstrate a lower coefficient of roughness than for annularly corrugated steel pipe. Pipe-arches have approximately the same roughness characteristics as their round equivalent pipes.*

Area and Hydraulic Radius for Corrugated Steel Pipe Flowing Full

Round Pipe – Area & Hydraulic Radius		
Diameter (in.)	Area (Ft^2)	Hydraulic Radius (ft.)
12	0.8	0.250
15	1.2	0.312
18	1.8	0.375
21	2.4	0.437
24	3.1	0.500
30	4.9	0.625
36	7.1	0.750
42	9.6	0.875
48	12.6	1.000
54	15.9	1.125
60	19.6	1.250
66	23.8	1.375
72	28.1	1.500
78	33.2	1.625
84	38.5	1.750
90	44.2	1.875
96	50.3	2.000
102	56.8	2.125
108	63.6	2.250
114	70.9	2.375
120	78.5	2.500
126	86.6	2.625
132	95.0	2.750
138	103.9	2.875
144	113.1	3.000

Notes:

1. *Listed pipe arch dimensions do not include tolerance.*
2. *For additional detail, please reference the hydraulic radius tables (Figure 4.32 and 4.33) found in the NCSPA CSP Design Manual, 2008.*

Pipe-Arch – Area & Hydraulic Radius			
2 2/3″ x 1/2″ Corrugated Steel Pipe			
Diameter (in.)	Pipe-Arch Equivalent Size (in.)	Waterway Area (Ft^2)	Hydraulic Radius A/πD (ft.)
15	17 x 13	1.1	0.280
18	21 x 15	1.6	0.340
21	24 x 18	2.2	0.400
24	28 x 20	2.4	0.462
30	35 x 24	4.5	0.573
36	42 x 29	6.5	0.690
42	49 x 33	8.9	0.810
48	57 x 38	11.6	0.924
54	64 x 43	14.7	1.040
60	71 x 47	18.1	1.153
66	77 x 52	21.9	1.268
72	83 x 57	26.0	1.380

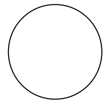
Pipe-Arch – Area & Hydraulic Radius			
3″ x 1″ or 5″ x 1″ Corrugated Steel Pipe			
Diameter (in.)	Pipe-Arch Equivalent Size (in.)	Waterway Area (Ft^2)	Hydraulic Radius A/πD (ft.)
54	60 x 46	15.6	1.104
60	66 x 51	19.3	1.230
66	73 x 55	23.2	1.343
72	81 x 59	27.4	1.454
78	87 x 63	32.1	1.573
84	95 x 67	37.0	1.683
90	103 x 71	42.4	1.800
96	112 x 75	48.0	1.911
102	117 x 79	54.2	2.031
108	128 x 83	60.5	2.141
114	137 x 87	67.4	2.259
120	142 x 91	74.5	2.373

ULTRA FLO® Pipe-Arch – Area & Hydraulic Radius			
2 2/3″ x 1/2 ″ Corrugated Steel Pipe			
Diameter (in.)	Pipe-Arch Equivalent Size (in.)	Waterway Area (Ft^2)	Hydraulic Radius A/πD (ft.)
18	20 x 16	1.7	0.36
21	23 x 19	2.3	0.42
24	27 x 21	3.0	0.48
30	33 x 26	4.7	0.60
36	40 x 31	6.7	0.71
42	46 x 36	9.2	0.84
48	53 x 41	12.1	0.96
54	60 x 46	15.6	1.10
60	66 x 51	19.3	1.23

HEL-COR® Corrugated Steel Pipe

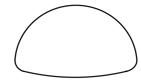
Heights of Cover

2 2/3" x 1/2" Height of Cover Limits for Corrugated Steel Pipe



H 20 and H 25 Live Loads

Diameter (in.)	Minimum Cover (in.)	Maximum Cover[2] (ft.) Specified Thickness (in.) and Gage					
		(0.052) 18	(0.064) 16	(0.079) 14	(0.109) 12	(0.138) 10	(0.168) 8
6[8]	12	388	486				
8[8]	12	291	365				
10[8]	12	233	292				
12	12	197	248	310			
15	12	158	198	248			
18	12	131	165	206			
21	12	113	141	177	248		
24	12	98	124	155	217		
30	12		99	124	173		
36	12		83	103	145	186	
42	12		71	88	124	159	195
48	12		62	77	108	139	171
54	12			67	94	122	150
60	12				80	104	128
66	12				68	88	109
72	12					75	93
78	12						79
84	12						66



H 20 and H 25 Live Loads, Pipe-Arch

Size		Minimum Thickness (in.)	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Span x Rise (in.)			2 Tons/Ft.² Corner Bearing Pressure
15	17 x 13	0.064	12	16
18	21 x 15	0.064	12	15
21	24 x 18	0.064	12	15
24	28 x 20	0.064	12	15
30	35 x 24	0.064	12	15
36	42 x 29	0.064	12	15
42	49 x 33	0.064*	12	15
48	57 x 38	0.064*	12	15
54	64 x 43	0.079*	12	15
60	71 x 47	0.109*	12	15
66	77 x 52	0.109*	12	15
72	83 x 57	0.138*	12	15

E 80 Live Loads

Diameter (in.)	Minimum Cover (in.)	Maximum Cover[2] (ft.) Specified Thickness (in.) and Gage					
		(0.052) 18	(0.064) 16	(0.079) 14	(0.109) 12	(0.138) 10	(0.168) 8
12	12	197	248	310			
15	12	158	198	248			
18	12	131	165	206			
21	12	113	141	177	248		
24	12	98	124	155	217		
30	12		99	124	173		
36	12		83	103	145	186	
42	12		71	88	124	159	195
48	12		62	77	108	139	171
54	18			67	94	122	150
60	18				80	104	128
66	18				68	88	109
72	18					75	93
78	24						79
84	24						66

E 80 Live Loads, Pipe-Arch

Size		Minimum Thickness (in.)	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Span x Rise (in.)			3 Tons/Ft.² Corner Bearing Pressure
15	17 x 13	0.079	24	22
18	21 x 15	0.079	24	22
21	24 x 18	0.109	24	22
24	28 x 20	0.109	24	22
30	35 x 24	0.138	24	22
36	42 x 29	0.138	24	22
42	49 x 33	0.138*	24	22
48	57 x 38	0.138*	24	22
54	64 x 43	0.138*	24	22
60	71 x 47	0.138*	24	22

** These values are based on the AISI Flexibility Factor limit (0.0433 x 1.5) for pipe-arch.*

Heights of Cover Notes:

1. *These tables are for lock-seam or welded-seam construction. They are not for riveted construction. Consult your Contech Sales Representative for Height of Cover tables on riveted pipe.*
2. *These values, where applicable, were calculated using a load factor of K=0.86 as adopted in the NCSPA CSP Design Manual, 2008.*
3. *The haunch areas of a pipe-arch are the most critical zone for backfilling. Extra care should be taken to provide good material and compaction to a point above the spring line.*
4. *E 80 minimum cover is measured from top of pipe to bottom of tie.*
5. *H 20 and H 25 minimum cover is measured from top of pipe to bottom of flexible pavement or top of rigid pavement.*
6. *The pipe-arch tables are based on the corner bearing pressures as shown. These values may increase or decrease with changes in allowable corner bearing pressures. Consider the use of a round pipe in cases where the height of cover exceeds 8'.*
7. *For construction loads, see Page 15.*
8. *1-1/2" x 1/4" corrugation. H 20, H 25 and E 80 loading.*
9. *Smooth Cor™ has same Height of Cover properties as corrugated steel pipe. The exterior shell of Smooth Cor™ is manufactured in either 2 2/3" x 1/2" or 3" x 1" corrugations; maximum exterior shell is 12 GA.*

5” x 1” or 3” x 1” Height of Cover Limits for Corrugated Steel Pipe

H 20 and H 25 Live Loads

Diameter (in.)	Minimum Cover (in.)	Maximum Cover (ft.) Specified Thickness (in.) and Gage				
		(0.064) 16	(0.079) 14	(0.109) 12	(0.138) 10	(0.168) 8
54	12	56	70	98	127	155
60	12	50	63	88	114	139
66	12	46	57	80	103	127
72	12	42	52	74	95	116
78	12	39	48	68	87	107
84	12	36	45	63	81	99
90	12	33	42	59	76	93
96	12	31	39	55	71	87
102	18	29	37	52	67	82
108	18		35	49	63	77
114	18		32	45	58	72
120	18		30	42	54	66
126	18			39	50	61
132	18			36	46	58
138	18			33	43	53
144	18				39	49

Maximum cover heights shown are for 5” x 1”.
To obtain maximum cover for 3” x 1”, increase these values by 12%.

E 80 Live Loads

Diameter or Span (in.)	Minimum Cover (in.)	Maximum Cover (ft.) Specified Thickness (in.) and Gage				
		(0.064) 16	(0.079) 14	(0.109) 12	(0.138) 10	(0.168) 8
54	18	56	70	98	127	155
60	18	50	63	88	114	139
66	18	46	57	80	103	127
72	18	42	52	74	95	116
78	24	39	48	68	87	107
84	24	36	45	63	81	99
90	24	33[1]	42	59	76	93
96	24	31[1]	39	55	71	87
102	30	29[1]	37	52	67	82
108	30		35	49	63	77
114	30		32[1]	45	58	72
120	30		30[1]	42	54	66
126	36			39	50	61
132	36			36	46	58
138	36			33[1]	43	53
144	36				39	49

Maximum cover heights shown are for 5” x 1”.
To obtain maximum cover for 3” x 1”, increase these values by 12%.
(1) These diameters in these gages require additional minimum cover.

5” x 1” Pipe-Arch Height of Cover Limits for Corrugated Steel Pipe

H 20 and H 25 Live Loads

Size			Minimum Thickness (in.)	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Nominal Min. Span (in.)	Nominal Max. Rise (in.)			2 Tons/Ft.^{2} Corner Bearing Pressure
54	60 -2.7	46 +2.7	0.109	18	21
60	66 -3.0	51 +3.0	0.109	18	21
66	73 -3.3	55 +3.3	0.109	18	21
72	81 -3.6	59 +3.6	0.109	18	21
78	87 -4.4	63 +4.4	0.109	18	20
84	95 -4.8	67 +4.8	0.109	18	20
90	103 -5.2	71 +5.2	0.109	18	20
96	112 -5.6	75 +5.6	0.109	21	20
102	117 -5.9	79 +5.9	0.109	21	19
108	128 -6.4	83 +6.4	0.109	24	19
114	137 -6.9	87 +6.9	0.109	24	19
120	142 -7.1	91 +7.1	0.138	24	19

Larger sizes are available in some areas of the United States. Check with your local Contech representative. Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, no tolerance in opposite direction.

E 80 Live Loads, Pipe-Arch

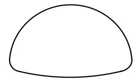
Size			Minimum Thickness (in.)	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Nominal Min. Span (in.)	Nominal Max. Rise (in.)			2 Tons/Ft.^{2} Corner Bearing Pressure
54	60 -2.7	46 +2.7	0.109	30	21
60	66 -3.0	51 +3.0	0.109	30	21
66	73 -3.3	55 +3.3	0.109	30	21
72	81 -3.6	59 +3.6	0.109	30	21
78	87 -4.4	63 +4.4	0.109	30	18
84	95 -4.8	67 +4.8	0.109	30	18
90	103 -5.2	71 +5.2	0.109	36	18
96	112 -5.6	75 +5.6	0.109	36	18
102	117 -5.9	79 +5.9	0.109	36	17
108	128 -6.4	83 +6.4	0.109	42	17
114	137 -6.9	87 +6.9	0.109	42	17
120	142 -7.1	91 +7.1	0.138	42	17

Some 3” x 1” and 5” x 1” minimum gages shown for pipe-arch are due to manufacturing limitations. Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, no tolerance in opposite direction.

Heights of Cover Notes:

1. *These tables are for lock-seam or welded-seam construction. They are not for riveted construction. Consult your Contech Sales Representative for Height of Cover tables on riveted pipe.*
2. *These values, where applicable, were calculated using a load factor of K=0.86 as adopted in the NCSPA CSP Design Manual, 2008.*
3. *The span and rise shown in these tables are nominal. Typically the actual rise that forms is greater than the specified nominal. This actual rise is within the tolerances as allowed by the AASHTO & ASTM specifications. The minimum covers shown are more conservative than required by the AASHTO and ASTM specifications to account for this anticipated increase in rise. Less cover height may be tolerated depending upon actual rise of supplied pipe-arch.*
4. *The haunch areas of a pipe-arch are the most critical zone for backfilling. Extra care should be taken to provide good material and compaction to a point above the spring line.*
5. *E 80 minimum cover is measured from top of pipe to bottom of tie.*
6. *H 20 and H 25 minimum cover is measured from top of pipe to bottom of flexible pavement or top of rigid pavement.*
7. *The pipe-arch tables are based on the corner bearing pressures as shown. These values may increase or decrease with changes in allowable corner bearing pressures. Consider the use of a round pipe in cases where the height of cover exceeds 8’.*
8. *For construction loads, see Page 15.*
9. *Smooth Cor™ has same Height of Cover properties as corrugated steel pipe. The exterior shell of Smooth Cor™ is manufactured in either 2 $^2/_3$” x $^1/_2$” or 3” x 1” corrugations; maximum exterior shell is 12 GA.*

3" x 1" Pipe-Arch Height of Cover Limits for Corrugated Steel Pipe-Arch



H 20 and H 25 Live Loads

Size			Minimum Thickness (in.)	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Nominal				2 Tons/Ft.2 Corner Bearing Pressure
	Min. Span (in.)	Max. Rise (in.)			
48	53 -2.4	41 +2.4	0.079	12	25
54	60 -2.7	46 +2.7	0.079	15	25
60	66 -3.0	51 +3.0	0.079	15	25
66	73 -3.3	55 +3.3	0.079	18	24
72	81 -3.6	59 +3.6	0.079	18	21
78	87 -4.4	63 +4.4	0.079	18	20
84	95 -4.8	67 +4.8	0.079	18	20
90	103 -5.2	71 +5.2	0.079	18	20
96	112 -5.6	75 +5.6	0.079	21	20
102	117 -5.9	79 +5.9	0.109	21	19
108	128 -6.4	83 +6.4	0.109	24	19
114	137 -6.9	87 +6.9	0.109	24	19
120	142 -7.1	91 +7.1	0.138	24	19

Larger sizes are available in some areas of the United States. Check with your local Contech Sales Representative. Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, no tolerance in opposite direction.

E 80 Live Loads, Pipe-Arch

Size			Minimum Thickness (in.)	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Nominal				2 Tons/Ft.2 Corner Bearing Pressure
	Min. Span (in.)	Max. Rise (in.)			
48	53 -2.4	41 +2.4	0.079	24	25
54	60 -2.7	46 +2.7	0.079	24	25
60	66 -3.0	51 +3.0	0.079	24	25
66	73 -3.3	55 +3.3	0.079	30	24
72	81 -3.6	59 +3.6	0.079	30	21
78	87 -4.4	63 +4.4	0.079	30	18
84	95 -4.8	67 +4.8	0.079	30	18
90	103 -5.2	71 +5.2	0.079	36	18
96	112 -5.6	75 +5.6	0.079	36	18
102	117 -5.9	79 +5.9	0.109	36	17
108	128 -6.4	83 +6.4	0.109	42	17
114	137 -6.9	87 +6.9	0.109	42	17
120	142 -7.1	91 +7.1	0.138	42	17

Some 3" x 1" and 5" x 1" minimum gages shown for pipe-arch are due to manufacturing limitations. Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, no tolerance in opposite direction.

Heights of Cover Notes:

1. *These tables are for lock-seam or welded-seam construction. They are not for riveted construction. Consult your Contech Sales Representative for Height of Cover tables on riveted pipe.*
2. *These values, where applicable, were calculated using K=0.86 as adopted in the NCSPA CSP Design Manual, 2008.*
3. *The span and rise shown in these tables are nominal. Typically the actual rise that forms is greater than the specified nominal. This actual rise is within the tolerances as allowed by the AASHTO & ASTM specifications. The minimum covers shown are more conservative than required by the AASHTO and ASTM specifications to account for this anticipated increase in rise. Less cover height may be tolerated depending upon actual rise of supplied pipe-arch.*
4. *The haunch areas of a pipe-arch are the most critical zone for backfilling. Extra care should be taken to provide good material and compaction to a point above the spring line.*
5. *E 80 minimum cover is measured from top of pipe to bottom of tie.*
6. *H 20 and H 25 minimum cover is measured from top of pipe to bottom of flexible pavement or top of rigid pavement.*
7. *The pipe-arch tables are based on the corner bearing pressures as shown. These values may increase or decrease with changes in allowable corner bearing pressures. Consider the use of a round pipe in cases where the height of cover exceeds 8'.*
8. *For construction loads, see Page 15.*
9. *Smooth Cor™ has same Height of Cover properties as corrugated steel pipe. The exterior shell of Smooth Cor™ is manufactured in either 2 ²/₃" x ¹/₂" or 3" x 1" corrugations; maximum exterior shell is 12 GA.*

Approximate Weight (lbs/ft) HEL-COR® Corrugated Steel Pipe

(Estimated Average Weights—Not for Specification Use)

1 1/2" x 1/4" Corrugation			
Inside Diameter (in.)	Specified Thickness (in.)	Galvanized & ALT2	Asphalt Coated
6	0.052	4	5
	0.064	5	6
8	0.052	5	6
	0.064	6	7
10	0.052	6	7
	0.064	7	8

Steel Thicknesses by Gage						
Gage (GA)	18	16	14	12	10	8
Thickness	.052	.064	.079	.109	.138	.168

2 2/3" x 1/2" Corrugation					
Inside Diameter (in.)	Specified Thickness (in.)	Galvanized & ALT2	Asphalt Coated	Asphalt Coated w/ Paved Invert	Smooth Cor™
12	0.052	8	10	13	
	0.064	10	12	15	
	0.079	12	14	17	
15	0.052	10	13	16	
	0.064	12	15	18	
	0.079	15	18	21	
18	0.052	12	16	19	
	0.064	15	19	22	25
	0.079	18	22	25	28
21	0.052	14	18	23	
	0.064	17	21	26	29
	0.079	21	25	30	33
	0.109	29	33	33	41
24	0.052	15	20	26	
	0.064	19	24	30	30
	0.079	24	29	35	38
	0.109	33	38	44	47
30	0.064	24	30	36	42
	0.079	30	36	42	48
	0.109	41	47	53	59
36	0.064	29	36	44	51
	0.079	36	43	51	58
	0.109	49	56	64	71
	0.138	62	69	77	
42	0.064	34	42	51	60
	0.079	42	50	59	68
	0.109	57	65	74	82
	0.138	72	80	89	
	0.168	88	96	105	
48	0.064	38	48	57	67
	0.079	48	58	67	77
	0.109	65	75	84	94
	0.138	82	92	101	
	0.168	100	110	119	
54	0.079	54	65	76	87
	0.109	73	84	95	106
	0.138	92	103	114	
	0.168	112	123	134	
60	0.109	81	92	106	117
	0.138	103	114	128	
	0.168	124	135	149	
66	0.109	89	101	117	129
	0.138	113	125	141	
	0.168	137	149	165	
72	0.138	123	137	154	(2)
	0.168	149	163	180	
78	0.168	161	177	194	(2)
84	0.168	173	190	208	(2)

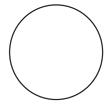
3" x 1" or 5" x 1" Corrugation					
Inside Diameter (in.)	Specified Thickness (in.)	Galvanized & ALT2	Asphalt Coated	Asphalt Coated w/ Paved Invert	Smooth Cor™
54	0.064	50	66	84	84
	0.079	61	77	95	95
	0.109	83	100	118	118
	0.138	106	123	140	
	0.168	129	146	163	
60	0.064	55	73	93	93
	0.079	67	86	105	105
	0.109	92	110	130	130
	0.138	118	136	156	
	0.168	143	161	181	
66	0.064	60	80	102	102
	0.079	74	94	116	116
	0.109	101	121	143	145
	0.138	129	149	171	
	0.168	157	177	199	
72	0.064	66	88	111	112
	0.079	81	102	126	127
	0.109	110	132	156	157
	0.138	140	162	186	
	0.168	171	193	217	
78	0.064	71	95	121	120
	0.079	87	111	137	136
	0.109	119	143	169	168
	0.138	152	176	202	
	0.168	185	209	235	
84	0.064	77	102	130	130
	0.079	94	119	147	147
	0.109	128	154	182	181
	0.138	164	189	217	
	0.168	199	224	253	
90	0.064	82	109	140	139
	0.079	100	127	158	157
	0.109	137	164	195	194
	0.138	175	202	233	
	0.168	213	240	271	
96	0.064	87	116	149	148
	0.079	107	136	169	168
	0.109	147	176	209	208
	0.138	188	217	250	
	0.168	228	257	290	
102	0.064	93	124	158	158
	0.079	114	145	179	179
	0.109	155	186	220	222
	0.138	198	229	263	
	0.168	241	272	306	
108	0.079	120	153	188	189
	0.109	165	198	233	235
	0.138	211	244	279	
	0.168	256	289	324	
114	0.079	127	162	199	200
	0.109	174	209	246	248
	0.138	222	257	294	
	0.168	271	306	343	
120	0.079	134	171	210	211
	0.109	183	220	259	260
	0.138	234	271	310	
	0.168	284	321	360	
126	0.109	195	233	274	276
	0.138	247	285	326	
	0.168	299	338	378	
132	0.109	204	244	287	289
	0.138	259	299	342	
	0.168	314	354	397	
138	0.109	213	255	300	300
	0.138	270	312	357	
	0.168	328	370	415	
144	0.138	282	326	373	
	0.168	344	388	435	(2)

1. *Weights for polymer-coated pipe are 1% to 4% higher, varying by gage.*
2. *Please contact your Contech Sales Representative.*
3. *Weights listed in the 3" x 1" or 5" x 1" table are for 3" x 1" pipe. Weights for 5" x 1" are approximately 12% less than those used in this table, for metallic coated pipe.*

CORLIX® Corrugated Aluminum Pipe

Heights of Cover

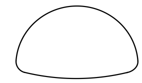
2 2/3" X 1/2" Height of Cover Limits for Corrugated Aluminum Pipe



HL 93 Live Load

Diameter (in.)	Minimum Cover (in.)	Maximum Cover (ft.) Specified Thickness (in.) and Gage					
		(0.048) 18	(0.060) 16	(0.075) 14	(0.105) 12	(0.135) 10	(0.164) 8
6[4]	12	197	247				
8[4]	12	147	185				
10[4]	12	119	148				
12	12		125	157			
15	12		100	125			
18	12		83	104			
21	12		71	89			
24	12		62	78	109		
27	12			69	97		
30	12			62	87		
36	12			51	73	94	
42	12				62	80	
48	12				54	70	85
54	15				48	62	76
60	15					52	64
66	18						52
72	18						43

2 2/3" x 1/2" Height of Cover Limits for Corrugated Aluminum Pipe-Arch



HL 93 Live Load

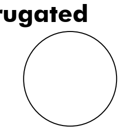
Size		Minimum Gage	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Span x Rise (in.)			2 Tons/Ft.2 for Corner Bearing Pressures
15	17 x 13	16	12	13
18	21 x 15	16	12	12
21	24 x 18	16	12	12
24	28 x 20	14	12	12
30	35 x 24	14	12	12
36	42 x 29	12	12	12
42	49 x 33	12	15	12
48	57 x 38	10	15	12
54	64 x 43	10	18	12
60	71 x 47	8[5]	18	12

Notes:

1. *Height of cover is measured to top of rigid pavement or to bottom of flexible pavement.*
2. *Maximum cover meets AASHTO LRFD design criteria.*
3. *Minimum cover meets AASHTO and ASTM B 790 design criteria.*
4. *1 1/2" x 1/4" corrugation.*
5. *8 GA pipe has limited availability.*
6. *For construction loads, see page 15.*
7. *Consult your Contech Sales Representative for E 80 Live Loads.*

Heights of Cover

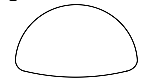
3" x 1" Height of Cover Limits for Corrugated Aluminum Pipe



HL 93 Live Load

Diameter (in.)	Minimum Cover (in.)	Maximum Cover (ft.) Specified Thickness (in.) and Gage				
		(0.060) 16	(0.075) 14	(0.105) 12	(0.135) 10	(0.164) 8
30	12	57	72	101	135	159
36	12	47	60	84	112	132
42	12	40	51	72	96	113
48	12	35	44	62	84	99
54	15	31	39	55	74	88
60	15	28	35	50	67	79
66	18	25	32	45	61	72
72	18	23	29	41	56	66
78	21		27	38	51	61
84	21			35	48	56
90	24			33	44	52
96	24			31	41	49
102	24				39	46
108	24				37	43
114	24					39
120	24					36

3" x 1" Height of Cover Limits for Corrugated Aluminum Pipe-Arch



HL 93 Live Load

Size		Minimum Gage	Minimum Cover (in.)	Maximum Cover (ft.)
Round Equivalent (in.)	Span x Rise (in.)			2 Tons/Ft.^{2} for Corner Bearing Pressures
54	60 x 46	14	15	20
60	66 x 51	14	18	20
66	73 x 55	14	21	20
72	81 x 59	12	21	16
78[4]	87 x 63	12	24	16
84[4]	95 x 67	12	24	16
90[4]	103 x 71	10	24	16
96[4]	112 x 75	8[5]	24	16

Notes:

1. *Height of cover is measured to top of rigid pavement or to bottom of flexible pavement.*
2. *Maximum cover meets AASHTO LRFD design criteria.*
3. *Minimum cover meets ASTM B 790 design criteria.*
4. *Limited availability on these sizes.*
5. *8 GA pipe has limited availability.*
6. *For construction loads, see page 15.*
7. *Consult your Contech Sales Representative for E 80 Live Loads.*

Approximate Weight/Foot
CORLIX® Corrugated Aluminum Pipe

(Estimated Average Weights—Not for Specification Use)

2 2/3" x 1/2" Corrugation Aluminum Pipe						
Diameter (in.)	Weight (Lb./Lineal Ft.)[1] Specified Thickness (in.) and Gage					
	(0.048) 18	(0.060) 16	(0.075) 14	(0.105) 12	(0.135) 10	(0.164) 8
6[(2)]	1.3	1.6				
8[(2)]	1.7	2.1				
10[(2)]	2.1	2.6				
12		3.2	4.0			
15		4.0	4.9			
18		4.8	5.9			
21		5.6	6.9			
24		6.3	7.9	10.8		
27			8.8	12.2		
30			9.8	13.5		
36			11.8	16.3	20.7	
42				19.0	24.2	
48				21.7	27.6	33.5
54				24.4	31.1	37.7
60					34.6	41.9
66						46.0
72						50.1

3" x 1" Corrugation Aluminum Pipe					
Diameter (in.)	Weight (Lb./Lineal Ft.)[1] Specified Thickness (in.) and Gage				
	(0.060) 16	(0.075) 14	(0.105) 12	(0.135) 10	(0.164) 8
30	9.3	11.5	15.8	20.2	24.5
36	11.1	13.7	18.9	24.1	29.3
42	12.9	16.0	22.0	28.0	34.1
48	14.7	18.2	25.1	32.0	38.8
54	16.5	20.5	28.2	35.9	43.6
60	18.3	22.7	31.3	40.0	48.3
66	20.2	24.9	34.3	43.7	53.0
72	22.0	27.1	37.4	47.6	57.8
78		29.3	40.4	51.5	62.5
84			43.5	55.4	67.2
90			46.6	59.3	71.9
96			49.6	63.2	76.7
102				66.6	80.8
108				71.0	86.1
114					90.9
120					95.6

Notes:

1. *Helical lockseam pipe only. Annular riveted pipe weights will be higher.*
2. *1 ½" x ¼" Corrugation.*
3. *8 GA pipe has limited availability.*

ULTRA FLO®

Heights of Cover

Galvanized, ALUMINIZED STEEL Type 2 or
Polymer-Coated Steel** ULTRA FLO® H 20 and H 25 Live Load

Diameter (in.)	Minimum/Maximum Cover (ft.) Specified Thickness (in.) and Gage			
	(0.064) 16	(0.079) 14	(0.109) 12	(0.138) 10
18	1.0 / 108	1.0 / 151		
21	1.0 / 93	1.0 / 130	1.0 / 216	
24	1.0 / 81	1.0 / 113	1.0 / 189	
30	1.0 / 65	1.0 / 91	1.0 / 151	
36	1.0 / 54	1.0 / 75	1.0 / 126	
42	1.0 / 46	1.0 / 65	1.0 / 108	
48	1.0 / 40	1.0 / 56	1.0 / 94	1.0 / 137
54	1.25 / 36	1.25 / 50	1.0 / 84	1.0 / 122
60	1.25*/32*	1.25 / 45	1.0 / 75	1.0 / 109
66		1.5 / 41	1.25 / 68	1.25 / 99
72		1.5*/37*	1.25 / 63	1.25 / 91
78		1.75*/34*	1.5 / 58	1.5 / 84
84			1.75 / 54	1.75 / 78
90			2.0*/50*	2.0 / 73
96			2.0*/47*	2.0 / 68
102			2.5*/43*	2.5 / 61
108				2.5*/54*
114				2.5*/49*
120				2.5*/43*

Galvanized, ALUMINIZED STEEL Type 2 or
Polymer-Coated Steel** ULTRA FLO® E 80 Live Load

Diameter (in.)	Minimum/Maximum Cover (ft.) Specified Thickness (in.) and Gage			
	(0.064) 16	(0.079) 14	(0.109) 12	(0.138) 10
18	1.0 / 93	1.0 / 130		
21	1.0 / 79	1.0 / 111	1.0 / 186	
24	1.0 / 69	1.0 / 97	1.0 / 162	
30	1.0 / 55	1.0 / 78	1.0 / 130	
36	1.5 / 46	1.25 / 65	1.0 / 108	
42	1.5 / 39	1.5 / 55	1.25 / 93	
48	2.0 / 34	1.75 / 48	1.5 / 81	1.5 / 118
54	3.0* / 28*	2.0 / 43	1.5 / 72	1.5 / 104
60		2.0 / 39	1.75 / 65	1.75 / 94
66		2.5* / 35*	2.0 / 58	2.0 / 85
72			2.0 / 49	2.0 / 78
78			2.5 / 42	2.5 / 72
84			2.75* / 35*	2.5 / 67
90				2.5 / 62
96				2.5* / 58*
102				3.0* / 52*

Galvanized, ALUMINIZED STEEL Type 2 or
Polymer-Coated Steel** ULTRA FLO® Pipe-Arch H 20 and H 25 Live Load

Size		Minimum/Maximum Cover (ft.) Specified Thickness (in.) and Gage		
Round Equivalent (in.)	Span x Rise (in.)	(0.064) 16	(0.079) 14	(0.109) 12
18	20 x 16	1.0 / 16		
21	23 x 19	1.0 / 15		
24	27 x 21	1.0 / 13		
30	33 x 26	1.0 / 13	1.0 / 13	
36	40 x 31	1.0 / 13	1.0 / 13	
42	46 x 36	M.L.[7]	M.L.[7]	1.0 / 13
48	53 x 41	M.L.[7]	M.L.[7]	1.25 / 13
54	60 x 46	M.L.[7]	M.L.[7]	1.25 / 13
60	66 x 51	M.L.[7]	M.L.[7]	1.25 / 13

Galvanized, ALUMINIZED STEEL Type 2 or
Polymer-Coated Steel** ULTRA FLO® Pipe-Arch E 80 Live Load

Size		**Minimum/Maximum Cover (ft.) Specified Thickness (in.) and Gage**	
Round Equivalent (in.)	**Span x Rise (in.)**	**(0.064) 16**	**(0.109) 12**
18	20 x 16	2.0 / 22	
21	23 x 19	2.0 / 21	
24	27 x 21	2.0 / 18	
30	33 x 26	2.0 / 18	
36	40 x 31	2.0 / 17	
42	46 x 36		2.0 / 18
48	53 x 41		2.0 / 18
54	60 x 46		2.0 / 18
60	66 x 51		2.0 / 18

Polymer-coated ULTRA FLO® provides added durability.

Notes:

1. *The tables for Steel H 20 and H 25 loading are based on the NCSPA Design Manual, 2008 and were calculated using a load factor of K=0.86. The tables for Steel E 80 loading are based on the AREMA Manual. The tables for Aluminum HL 93 loading are based on AASHTO LRFD Design Criteria.*
2. *The haunch areas of a pipe-arch are the most critical zone for backfilling. Extra care should be taken to provide good material and compaction to a point above the spring line.*
3. *E 80 minimum cover is measured from top of pipe to bottom of tie.*
4. *H 20, H 25 and HL 93 minimum cover is measured from top of pipe to bottom of flexible pavement or top of rigid pavement.*
5. *The pipe-arch tables are based on the corner bearing pressures as shown. These values may increase or decrease with changes in allowable corner bearing pressures. Consider the use of a round pipe in cases where the height of cover exceeds 8'.*
6. *Larger size pipe-arches may be available on special order.*
7. *M.L. (Heavier gage is required to prevent crimping at the haunches.)*
8. *For construction loads, see Page 15.*
9. *Sewer gage (trench conditions) tables for corrugated steel pipe can be found in the AISI book "Modern Sewer Design," 4th Edition, 1999. These tables may reduce the minimum gage (GA) due to a higher flexibility factor allowed for a trench condition.*
10. *All heights of cover are based on trench conditions. If embankment conditions exist, there may be restriction on gages for the large diameters. Your Contech Sales Representative can provide further guidance for a project in embankment conditions.*
11. *All steel ULTRA FLO® is installed in accordance with ASTM A798 "Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications."*

* *These sizes and gage combinations are installed in accordance with ASTM A796 paragraphs 18.2.3 and ASTM A798. For aluminum ULTRA FLO® refer to ASTM B790 and B788.*

** *Contact your local Contech representative for more specific information on Polymer-Coated ULTRA FLO® for 12 GA and 10 GA.*

****Consult your Contech Sales Representative for E 80 Live Loads for Aluminum ULTRA FLO®.*

Heights of Cover

Aluminum ULTRA FLO® HL 93 Live Load

Diameter (in.)	Minimum/Maximum Cover (ft.) Specified Thickness (in.) and Gage			
	(0.060) 16	(0.075) 14	(0.105) 12	(0.135) 10
18	1.0/43	1.0/61		
21	1.0/38	1.0/52	1.0/84	
24	1.0/33	1.0/45	1.0/73	
30	1.25/26	1.25/36	1.25/58	
36	1.5*/21*	1.50/30	1.5/49	1.5/69
42		1.75*/25*	1.75/41	1.75/59
48			2.0/36	2.0/51
54			2.0/32	2.0/46
60			2.0*/29*	2.0/41
66				2.0/37
72				2.5*/34*

Aluminum ULTRA FLO® Pipe-Arch HL 93 Live Load

Size		Minimum/Maximum Cover (ft.) Specified Thickness (in.) and Gage			
Round Equivalent (in.)	Span x Rise (in.)	(0.060) 16	(0.075) 14	(0.105) 12	(0.135) 10
18	20 x 16	1.0/16			
21	23 x 19	1.0/15			
24	27 x 21	1.25/13	1.25/13		
30	33 x 26	1.5/13	1.5/13	1.5/13	
36	40 x 31		1.75/13	1.75/13	
42	46 x 36			2.0/13	2.0/13
48	53 x 41			2.0/13	2.0/13
54	60 x 46			2.0*/13*	2.0/13
60	66 x 51				2.0/13

See previous page for height of cover notes.

Approximate Weight/Foot Contech ULTRA FLO® Pipe

Handling Weight for **ALUMINIZED STEEL Type 2** or **Galvanized Steel** ULTRA FLO®

Diameter (in.)	Weight (Pounds/Lineal Foot) Specified Thickness (in.) and Gage			
	(0.064) 16	(0.079) 14	(0.109) 12	(0.138) 10
18	15	18		
21	17	21	29	
24	19	24	36	
30	24	30	42	
36	29	36	50	
42	33	42	58	
48	38	48	66	80
54	45	54	75	90
60	48	60	83	99
66		66	91	109
72		72	99	119
78		78	108	129
84			116	139
90			124	149
96			132	158
102			141	168
108				175
114				196
120				206

Handling Weight for **ALUMINUM** ULTRA FLO®

Diameter (in.)	Weight (Pounds/Lineal Foot) Specified Thickness (in.) and Gage			
	(0.060) 16	(0.075) 14	(0.105) 12	(0.135) 10
18	5	6		
21	6	8	11	
24	7	9	13	
30	9	11	15	
36	11	13	18	23
42		15	21	26
48			24	30
54			27	34
60			30	37
66				41
72				45

Weights for polymer-coated pipe are 1% to 4% higher, varying by gage.

ULTRA FLO® is available in long lengths, and its light weight allows it to be unloaded and handled with small equipment.

Reduced excavation due to the smaller outside diameter of ULTRA FLO®.

Installation of CMP

Overview

Satisfactory site preparation, trench excavation, bedding and backfill operations are essential to develop the strength of any flexible conduit. In order to obtain proper strength while preventing settlement, it is necessary that the soil envelope around the pipe be of good granular material, properly placed and carefully compacted.

Bedding

Bedding preparation is critical to both pipe performance and service life. The bed should be constructed to uniform line and grade to avoid distortions that may create undesirable stresses in the pipe and/or rapid deterioration of the roadway. The bed should be free of rock formations, protruding stones, frozen lumps, roots and other foreign matter that may cause unequal settlement.

Placing the pipe

Corrugated metal pipe weighs much less than other commonly used drainage structures. This is due to the efficient strength of the metal, further improved with carefully designed and formed corrugations. Even the heaviest sections of Contech pipe can be handled with relatively light equipment compared with equipment required for much heavier reinforced concrete pipe.

Backfill

Satisfactory backfill material, proper placement and compaction are key factors in obtaining maximum strength and stability. Backfill should be a well-graded granular material and should be free of large stones, frozen lumps and other debris.

Backfill materials should be placed in layers about six inches deep, deposited alternately on opposite sides of the pipe. Each layer should be compacted carefully. Select backfill is placed and compacted until minimum cover height is reached, at which point, standard road embankment backfill procedures are used.

Installation References

For more information, see AASHTO Bridge Construction Specification Section 26, the Installation Manual of the National Corrugated Steel Pipe Association, ASTM A798 for steel and ASTM B788 for aluminum ULTRA FLO®.

Additional Considerations for ULTRA FLO® Installations

Bedding and Backfill

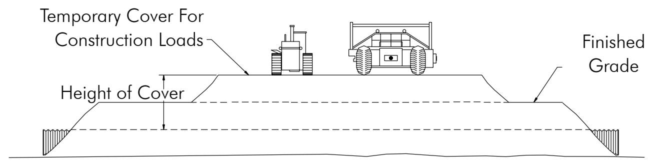
Typical ULTRA FLO® installation requirements are the same as for any other corrugated metal pipe installed in a trench. Bedding and backfill materials for ULTRA FLO® follow the requirements of the CMP installation specifications mentioned above, and must be free from stones, frozen lumps or other debris. When ASTM A796 (steel) or B790 (aluminum) designs are to be followed for condition III requirements, indicated by asterisk (*) in the tables on page 13 and 14, use clean, easily compacted granular backfill materials.

Embankment Conditions

ULTRA FLO® is a superior CMP storm sewer product that is normally installed in a trench condition. In those unusual embankment installation conditions, pipe sizes and gages may be restricted. Your Contech Sales Representative can provide you with further guidance.

Construction Loads

For temporary construction vehicle loads, an extra amount of compacted cover may be required over the top of the pipe. The Height of Cover shall meet minimum requirements shown in the table below. The use of heavy construction equipment necessitates greater protection for the pipe than finished grade cover minimums for normal highway traffic.



Min. Height of Cover Requirements for Construction Loads HEL-COR® Corrugated Steel Pipe*				
Diameter (in.)	Minimum Cover (ft.) for Indicated Axle Loads (kips)			
	18-50	50-75	75-110	110-150
12-42	2.0	2.5	3.0	3.0
48-72	3.0	3.0	3.5	4.0
78-120	3.0	3.5	4.0	4.0
126-144	3.5	4.0	4.5	4.5

Min. Height of Cover Requirements for Construction Loads CORLIX® Corrugated Aluminum Pipe*				
Diameter (in.)	Minimum Cover (ft.) for Indicated Axle Loads (kips)			
	18-50	50-75	75-110	110-150
12-42	3.0	3.5	4.0	4.0
48-72	4.0	4.0	5.0	5.5
78-120	4.0	5.0	5.5	5.5

Min. Height of Cover Requirements for Construction Loads ULTRA FLO® Pipe*				
Diameter (in.)	Minimum Cover (ft.) for Indicated Axle Loads (kips)			
	18-50	50-75	75-110	110-150
	Steel 3/4" x 3/4" x 7-1/2"			
15-42	2.0	2.5	3.0	3.0
48-72	3.0	3.0	3.5	4.0
78-108	3.0	3.5	4.0	4.5
	Aluminum 3/4" x 3/4" x 7-1/2"			
15-42	3.0	3.5	4.0	4.0

* *Minimum cover may vary depending on local conditions. The contractor must provide the additional cover required to avoid damage to the pipe. Minimum cover is measured from the top of the pipe to the top of the maintained construction roadway surface.*

Smooth Cor™ Pipe

Excellent Hydraulics, Long Lengths and Easy Installation

Corrugated Steel Shell

Smooth Cor pipe has a smooth interior steel liner that provides a Manning's "n" of 0.012. Its rugged, corrugated steel shell supplies the structural strength to outperform rigid pipe. Smooth Cor pipe is both the economical and performance alternate to concrete.

Superior hydraulics

Smooth Cor, with its smooth interior surface, is hydraulically superior to conventional corrugated steel pipe and with fewer joints and better interior surface, outperforms reinforced concrete pipe.

Smooth Cor, with its long lengths, light weight and beam strength, is superior to concrete pipe in many difficult situations such as poor soils, poor subsurface drainage conditions, steep slopes and high fills. Smooth Cor should be specified as an alternate under normal site conditions, and specified exclusively under very difficult situations that demand the strength of CSP with positive joints and a hydraulically efficient smooth liner.

Two Pipe Shapes

In addition to full-round pipe, Smooth Cor comes in a pipe-arch shape for limited headroom conditions. The low, wide pipe-arch design distributes the flow area horizontally, enabling it to be installed with lower head room than a round pipe.

Diameters

Smooth Cor is available in diameters ranging from 18 inches to 66 inches in 2 2/3" x 1/2" corrugation. The 3" x 1" corrugation is available in diameters of 48" to 126".

Pipe-arch sizes range from 21" x 15" through 77" x 52" for 2 2/3" x 1/2" corrugations, and 53" x 41" through 137" x 87" for 3" x 1" corrugations.

Materials

Smooth Cor is available with a heavy-gage polymer coating that allows the engineer to design for long service life. This coating is a tough, heavy-gage polymer film laminated to both sides of the steel coil, providing a barrier to corrosion and mild abrasion which is particularly effective for protection in corrosive soils.

Fittings

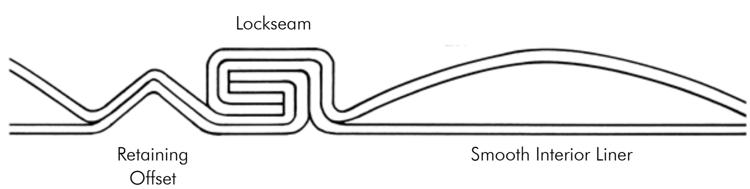
Smooth Cor can be fabricated into any type of structure including tees, elbows, laterals, catch basins, manifolds and reducers. Pre-fabricated fittings are more economical and have superior hydraulic characteristics when compared to concrete structures.

Structural Design

Reference specifications

Material	Polymer-Coated	ASTM A 929 AASHTO M246 ASTM A 742
Pipe	Polymer	AASHTO M245 ASTM A 762 & A 760
Design	Steel Pipe	AASHTO Section 12 ASTM A 796
Installation	Steel Pipe	AASHTO Section 26 ASTM A 798

Smooth Cor is lined with either 18 or 20 gage (GA) steel. Contech has taken a conservative approach to the Height of Cover. The maximum heights of cover are based on the shell thickness with no additional structural allowance for the liner as provided for in the AASHTO and ASTM design specifications. Using this approach, the Height of Cover tables for 2 2/3" x 1/2" and 3" x 1" steel corrugations can be used for Smooth Cor.



QUICK STAB® Joint

Save Time and Money With Faster Pipe Bell and Spigot Coupling

The Contech QUICK STAB Bell and Spigot joint speeds installation of corrugated metal pipe (CMP), reducing your costs. With the QUICK STAB coupling system, installation of CMP storm sewers and culverts has never been easier or faster.

The QUICK STAB joint creates a bell and spigot joining system with the bell only 1-1/2″ larger than the pipe's O.D. Assembled at the factory, the QUICK STAB bell is shipped to the job site ready for installation. The only field operation is placing a special fluted gasket onto the spigot end of the pipe, applying lubricant and pushing it into the bell end of the preceding pipe. Without bands, bolts and wrenches to work and worry with, you can join pipe segments 50% to 90% faster—saving time, money and aggravation.

Soil Tight Joint

Contech's QUICK STAB joint provides the same soil tightness as conventional CMP bands. Each QUICK STAB joint uses a double sealing fluted gasket to seal the spigot against the bell. A flat gasket is installed at the plant between the pipe and the corrugated end of the bell. With the deep bell, you gain maximum soil tightness with minimal installation effort.

Wide Variety of Coatings and Materials

- Plain galvanized
- Aluminized Steel Type 2 (ALT2)
- Aluminum
- Polymeric coated

Four Times Faster Installation Than Concrete

The QUICK STAB's bell and spigot joining system allows pipe segments to be joined quicker than reinforced concrete pipe. Next, add in Contech's corrugated metal pipe's length advantage—each segment is four times longer than standard concrete pipe lengths. That means fewer joints and faster installation—up to four times faster! Plus, with the bell only 1-1/2″ larger than the pipe, trench excavation is considerably less compared with concrete—again, saving time and money.

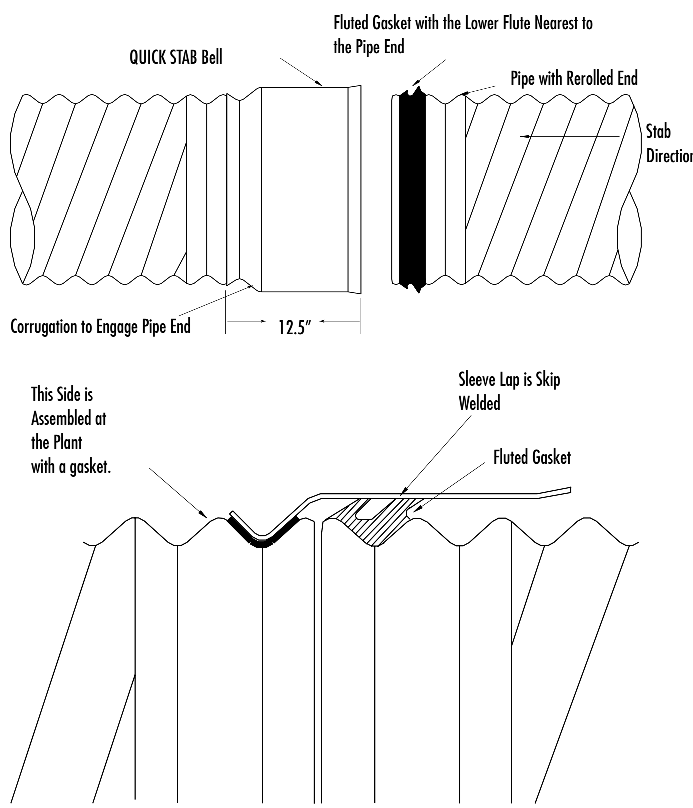
Field Installation Instructions

The spigot and bell ends must be cleaned of any dirt or debris prior to assembly. The fluted gasket shall be placed in the first corrugation with the lower flute nearest the end of the pipe. The bell & gasket shall be thoroughly lubed just before stabbing in the bell. Do not place hands, fingers, or any other body parts between bell and spigot during assembly. If it is necessary to pull the joint apart, the bell, spigot and gasket shall be inspected and cleaned of any dirt or debris prior to re-stabbing.

Corrugated Metal Pipe Bell and Spigot Joint Specification

The joints shall be of such design and the ends of the corrugated metal pipe sections so formed that the pipe can be laid together to make a continuous line of pipe. The joint shall be made from the same material as the pipe and shall prevent infiltration of the fill material.

Bell and Spigot Coupling System for CMP



The Bell and Spigot joint is available on ULTRA FLO® and 2 2/3" x 1/2″ corrugation in 15″ through 60″ diameter.

End Sections

Easily installed, easily maintained culvert end treatments for corrugated metal pipe, reinforced concrete pipe and HDPE Pipe

Contech End Sections provide a practical, economical and hydraulically superior method of finishing a variety of culvert materials.

The lightweight, flexible metal construction of Contech End Sections creates an attractive, durable and erosion-preventing treatment for all sizes of culvert inlets and outlets. They can be used with corrugated metal pipe having either annular or helical corrugations, and both reinforced concrete and plastic pipes. End sections can be salvaged when lengthening or relocating the culvert.

Standard End Sections are fabricated from pregalvanized steel. For added corrosion resistance, Aluminized Type 2 or Aluminum End Sections are available in smaller sizes. Special End Sections for multiple pipe installations may be available on a specific inquiry basis.

Better hydraulics

Flow characteristics are greatly improved by the exacting design of Contech End Sections. Scour and sedimentation conditions are improved, and headwater depth can be better controlled. Culverts aligned with the stream flow and finished with Contech End Sections generally require no additional hydraulic controls.

Improved appearance

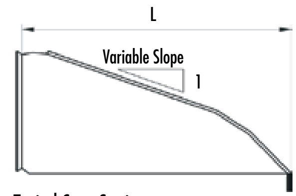
Contech End Sections blend well with the surroundings. The tapered sides of an End Section merge with slope design to improve roadside appearance. Unsightly weeds and debris collection at the culvert end are reduced.

Economical installation

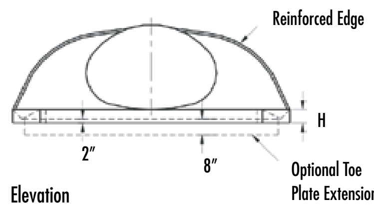
Lightweight equipment and simple crew instructions result in smooth and easy installation. Contech End Sections are easily joined to culvert barrels, forming a continuous, one-piece structure. For easiest installation, End Sections should be installed at the same time as the culvert. Installation is completed by tamping soil around the End Section.

Low maintenance

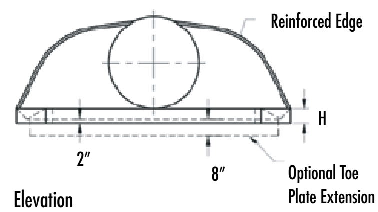
Contech End Sections reduce maintenance expense because their tapered design promotes easier mowing and snow removal. There is no obstruction to hamper weed cutting.



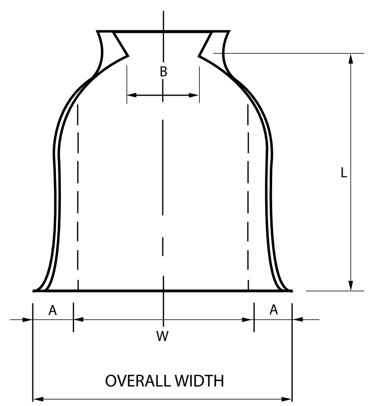
Typical Cross Section



Elevation



Elevation



Plan

Notes for all End Sections:

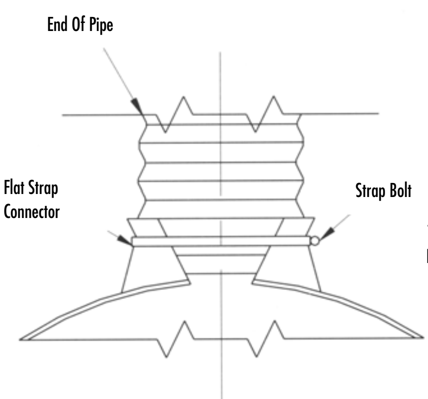
1. All three-piece bodies to have 12 GA sides and 10 GA center panels. Multiple panel bodies to have lap seams which are to be tightly joined by galvanized rivets or bolts.
2. For 60″ through 84″ sizes, reinforced edges are supplemented with stiffener angles. The angles are attached by galvanized nuts and bolts. For the 66″ and 72″ round equivalent pipe-arch sizes, reinforced edges are supplemented by angles. The angles are attached by galvanized nuts and bolts.
3. Angle reinforcements are placed under the center panel seams on the 66″ and 72″ round equivalent pipe-arch sizes.
4. Toe plate is available as an accessory, when specified on the order, and will be same gage (GA) as the End Section.
5. Stiffener angles, angle reinforcement, and toe plates are the same base metal as end section body.
6. **End sections with 6:1 and 4:1 slopes are available in 12″ through 24″ diameters.**
7. Actual dimensions may vary slightly.
8. During manufacturing, a slight invert slope may result along the length of the end section to be accommodated in the field.

End Sections for Round Pipe (2-2/3" x 1/2", 3" x 1" and 5" x 1")							
Approximate Dimensions, Inches (7)							
Pipe Diameter	Gage	A (+/- 1")	B (Max)	H (Min)	L (+/-2")	W (+/- 2")	Overall Width (+/- 4")
12	16	6	6	6	21	24	36
15	16	7	8	6	26	30	44
18	16	8	10	6	31	36	52
21	16	9	12	6	36	42	60
24	16	10	13	6	41	48	68
30	14	12	16	8	51	60	84
36	14	14	19	9	60	72	100
42	12	16	22	11	69	84	116
48	12	18	27	12	78	90	126
54	12	18	30	12	84	102	138
60	12/10	18	33	12	87	114	150
66	12/10	18	36	12	87	120	156
72	12/10	18	39	12	87	126	162
78	12/10	18	42	12	87	132	168
84	12/10	18	45	12	87	138	174

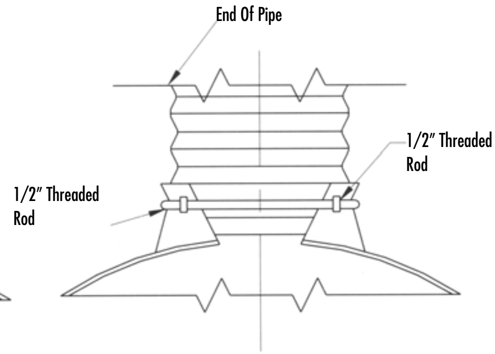
End Sections for Pipe-Arch (2-2/3" x 1/2")								
Approximate Dimensions, Inches (7)								
Round Equivalent	Span x Rise (in.)	Gage	A (+/- 1")	B (Max)	H (+/- 1")	L (+/- 2")	W (+/- 2")	Overall Width (+/- 4")
15	17 x 13	16	7	9	6	19	30	44
18	21 x 15	16	7	10	6	23	36	50
21	24 x 18	16	8	12	6	28	42	58
24	28 x 20	16	9	14	6	32	48	66
30	35 x 24	14	10	16	6	39	60	80
36	42 x 29	14	12	18	8	46	75	99
42	49 x 33	12	13	21	9	53	85	111
48	57 x 38	12	18	26	12	63	90	126
54	64 x 43	12	18	30	12	70	102	138
60	71 x 47	12/10	18	33	12	77	114	150
66	77 x 52	12/10	18	36	12	77	126	162
72	83 x 57	12/10	18	39	12	77	138	174

End Sections for Pipe-Arch (3" x 1" and 5" x 1")								
Approximate Dimensions, Inches (7)								
Round Equivalent	Span x Rise (in.)	Gage	A (+/- 1")	B (Max)	H (+/- 1")	W (+/- 2")	L (+/- 2")	Overall Width (+/- 4")
48	53 x 41	12	18	25	12	90	63	126
54	60 x 46	12	18	34	12	102	70	138
60	66 x 51	12/10	18	33	12	116	77	152
66	73 x 55	12/10	18	36	12	126	77	162
72	81 x 59	12/10	18	39	12	138	77	174
78	87 x 63	12/10	20	38	12	148	77	188
84	95 x 67	12/10	20	34	12	162	87	202
90	103 x 71	12/10	20	38	12	174	87	214
96	112 x 75	12/10	20	40	12	174	87	214

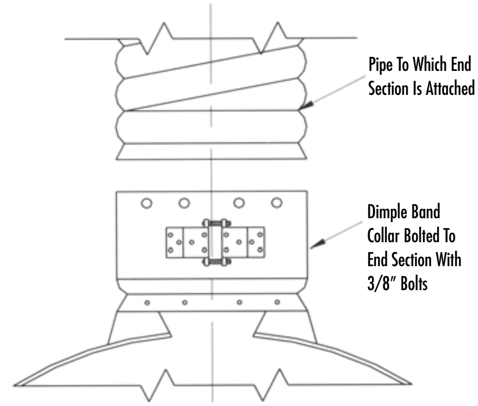
Contech End Sections attach to corrugated metal pipe, reinforced concrete and plastic pipe.



Type 1



Type 2



Type 5

Note: *The Type 3 connection is not illustrated. This connection is a one-foot length of pipe attached to the end section.*

Multiple End Section on Round CSP

End Sections are available for CSP Pipe-Arch

Contech End Sections are often used on concrete pipe. They can be used on both the bell and spigot end.

Low-slope End Sections—Contech manufactures 4:1 and 6:1 low-slope End Sections for corrugated metal pipe. This photo shows the optional field-attached safety bars.

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BRO-CMP-DESIGN 5/3/2022

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