

Phase II Drainage Report

FOR

COSTCO WHOLESALE
TOWN OF CASTLE ROCK, COLORADO
CASE NO. SDP23-0020

Prepared for:

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Engineer's Statement:

I affirm that this report and plan for the Phase II drainage design of Costco Wholesale, was prepared by me (or under my direct supervision) in accordance with the provisions of the Town of Castle Rock Drainage Design and Technical Criteria for the owners thereof. I understand that the Town of Castle Rock does not and will not assume liability for drainage facilities designed by others.

Todd Wolma P.E.
Colorado Professional Engineer
License #59513



OWNER/DEVELOPER'S STATEMENT:

Town of Castle Rock hereby certifies that the drainage facilities for Costco Wholesale shall be constructed according to the design presented in this report. I understand that the Town of Castle Rock does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that The Town of Castle Rock reviews drainage plans pursuant to the Municipal Code; but cannot, on behalf of Costco Wholesale, guarantee that final drainage design review will absolve ACM Dawson Trails VIII JV LLC and/or their successors and/or assigns of future liability for improper design.

Lawrence P. Jacobson

Print Name

Lawrence P. Jacobson

Authorized Signature

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Drainage Maps

I. GENERAL LOCATION AND DESCRIPTION

A. Site Location

This drainage report supports the design of Costco Wholesale, a 161,000 square-foot retail warehouse with onsite fueling station, along with associated vehicle circulation drives and parking.

The project area is approximately centered within Section 22, Township 8 South, Range 67 West of the Sixth Principal Meridian. The property extends into all four quarter-sections of Sections 22.

The proposed Costco Wholesale warehouse is within the Dawson Trails planned development. At present, the site is vacant land and is not accessible by public roads. It is 0.05 miles west of the BNSF railway and 0.10 miles north of Territorial Road. The development parcel lies within Planning Area F-2, which designates single family attached, multifamily, and non-residential as allowable uses. Early phases of infrastructure around the site will construct the following improvements:

- An interchange on Interstate 25 with Crystal Valley Parkway south of the site
- Dawson Trails Boulevard along the west edge of the site
- Collector B along the east edge of the site
- Stabilization of Gambel Ridge Tributary along the south edge of the site
- Regional detention facility C1 on the south side of Crystal Valley Parkway
- Potable water and sanitary sewer improvements to support development of Dawson Trails
- Overlot grading of the portion of Dawson Trails north of Crystal Valley Parkway, including the Costco parcel
- Red Zone Tank and regional detention facility B1 in the Upper Gambel Ridge watershed

The above improvements will be constructed prior to or concurrent with the Costco project, and all are intended to be complete by the conclusion of construction on the Costco site.

B. Description of Property

The area of the development property is 19.58 acres.

Ground cover in the project area is entirely prairie grass, with only a few small, isolated trees on the site. Site topography is generally sloping west to east between 1.5% and 2.5% grade. Gambel Ridge Tributary runs 50 to 80 feet beyond the south property line, with slopes up to 10% along its fringes. Small areas of previous disturbance in the southwest corner of the property have short embankment slopes that approach 4:1. By the time construction commences on the Costco project, it is anticipated that the property will be overlot graded to within 2 feet of ultimate design grades and re-seeded post-grading.

Soils within the project area are detailed on the soils map in Appendix A. The northern $\frac{3}{4}$ of the project site contains hydrologic group A soil, while the southern quarter contains hydrologic group C soil.

Two major drainageways pass near the development site. Gambel Ridge Tributary has a drainage area of about 600 acres and parallels the south property line, 50 to 80 feet beyond the boundary. Gambel Ridge Tributary North has a drainage area of about 300 acres and passes 300 feet north of the northwest property corner. Neither drainageway has a base flow. Both Tributaries flow to East Plum Creek, which passes about 2000 feet east of the site. East Plum Creek is the major receiving drainageway of the area.

Gambel Ridge Tributary and Gambel Ridge Tributary North are analyzed in the FHAD study: *Flood Hazard Area Delineation -- Gambel Ridge and Douglas Lane Tributary Watershed* (Reference F). Gambel Ridge Tributary has recently been subject to a floodplain modification (FD24-0003) that accompanies improvements for the Crystal Valley Interchange. There are no floodplain or floodway encroachments into the Costco development lot with the newly accepted floodplain mapping. There are no floodplain or floodway encroachments into the property from Gambel Ridge Tributary North. The project area is contained within FIRM map panel 08035C0284G. There are no FEMA-designated flood areas from either tributary within the site boundary.

There are no irrigation canals within or near the project area.

There are no notable geologic features within or near the site.

Proposed use of the development site is a 161,000 square-foot retail warehouse with onsite fueling station, along with associated vehicle circulation drives and parking.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Drainage Basins

The Costco property is broken out into three primary on-site drainage basins, and five smaller drainage areas on the site periphery. Each Major basin is further subdivided into Minor Drainage Basins as discussed further below.

Major Basin A Basin covers the east half of the warehouse building, north and east perimeter drive lanes, and the south area of the parking lot. Basin A has an area of 5.87 acres and an overall imperviousness of 93.3%.

Major Basin B Basin covers the west half of the warehouse building, and the west and southwest areas of the parking lot. Basin B also includes the fuel station canopy, fueling area egress drive, and landscape drainage area that is diverted away the fueling area pavement. Basin B has an area of 10.76 acres and an overall imperviousness of 88.2%.

Basin D covers the water quality pond area. Basins E, F and G cover the south, southeast and northeast perimeter daylight slopes, respectively. Basin H covers the fuel area pavement. These small drainage areas are discussed in detail in the next section.

Off-site major drainage basins

There are two areas where offsite flow surface drains toward the northwest part of the site. These areas are conveyed through drainage channels and other storm infrastructure towards the northeast and Costco Way. These areas are described in Section II.B Elsewhere, grade breaks follow the west and north site boundaries to part flows, and high points are designed in the access drives where they cross the property line.

Major Drainageways

Gambel Ridge Tributary is a major drainageway that flows immediately south of the Costco site. Drainageway improvements and a Floodplain Modification Study are separately proposed by the concurrent Crystal Valley Interchange project. The channel improvements and their integration with the Costco site are further discussed in Section III.A of this report. The floodplain modification is discussed in Section IV.B

B. Minor Drainage BasinsOff-site sub-basins

Sub-basin O1 contains 2 acres of undeveloped Tract G area between the site's north property and Costco Way, east of Dawson Trails Boulevard. This area is overlotted graded in a previous work phase (CD22-0056). The Dawson Trails Filing 1 drainage plan anticipates that runoff from O1 will be conveyed to a future pond in the northeast corner of Tract G, ultimately discharging to North Gambel Tributary. A temporary swale and culvert will be installed with the Costco development to convey flows across the proposed eastern access drive from Costco Way.

Sub Basin O2 contains 100 feet of the eastern access from Costco Way, just north of the property boundary. This area drains to the north curb and the perimeter access drive and is captured in Inlet A1.

On-site sub-basins

On-site Basins A, B, and C are further broken out into sub-areas that describes as follows:

Basin A sub-basins

Sub-basins A1, A2, A3 and A4 collectively contain the north service drive. These basins each cover about a quarter of the drive lane's length and drain to curb inlets in local low points on the north side of the drive. Inlets A1, A2, A3 and A4 connect to the upper reaches of Storm Line A.

Sub-basins A5, A7, A9 and A10 collectively contain the east half of the warehouse roof area. Each of these roof areas drain through one or more 10" roof drain pipes that extend away from the building below grade and connect to Storm Line A.

Sub-basin A11 contains the ramp to the loading dock. The ramp drains to a trench drain at the building face that connects to the building's roof drain system.

Sub-basins A6, A8, A12 and A13 contain the eastern service drive, trash compactor pad and loading dock approach. These basins drain to curb inlets in the parking row east of the service drive.

Sub-basin A14 contains the junction area of the east service drive and east access. This area drains away from the building toward the south access drive. Runoff flows are intercepted as much as possible in an on-grade curb inlet on the south edge of the cross-sloped access drive.

Sub-basins A15, A16, A17 and A18 collectively contain the parking lot south of the warehouse building. Each basin covers 1 to 2 drive lanes with adjoining parking. A15, A16, A17 and A18 surface drain to curb inlets that occupy separate low points at the south edge of the lot.

Basin B sub-basins

Sub-basins B1, B3 and B9 collectively contain the parking lot west of the warehouse building. Each basin covers approximately 2 drive lanes with adjoining parking. B1, B3 and B9 surface drain to area inlets in drive lanes west of the building. Because Inlets B1, B3 and B9 are all located in a broad grade break between the warehouse building and Dawson Trails boulevard, they collect runoff from drives on both the east and west sides. Inlet B1 is the upstream end of Storm Line B. Grated manhole covers are used at storm sewer junctions each of Sub-basin B1, B3 and B9, about 25 feet east of each sub-basin's low point. The grated manhole covers assist in flow capture to reduce parking lot ponding in sump locations. They also serve as a redundant capture point in the event of significant clogging at the sump. For the purposes of on-grade interception analysis, sub-basins B1, B3 and B9 are further broken out into areas directly tributary to the grated manholes (B1.1, B3.1 and B9.1) and remaining area tributary to the basin's sump inlet (B1.2, B3.2 and B9.2).

Sub-basins B2, B4 and B10 collectively contain the west half of the warehouse roof area. Each of these roof areas drain through one or more 10" roof drain pipes that extend away from the building below grade and connect to Storm Line B.

Sub-basin B5 contains the western access drive off Dawson Trails Boulevard. The sub-basin drains to an on-grade curb inlet on the south side of the cross-sloped access drive. Drainage from the access drive is intercepted as much as possible to avoid dispersal of concentrated runoff into a high-traffic junction.

Sub-basins B6 and B7 contain the western far west portion of the parking lot, between the west access drive and fueling area. These sub-basins drain to on-grade grate inlets west of the primary north/south drive lane. Runoff from these areas is intercepted as much as possible to avoid dispersal of concentrated flows across into a high-traffic drive lane.

Sub-basins B8, B11, and B15 through B17 collectively contain the parking lot southwest of the warehouse building. B8, B11, B15 and B16 drain to area inlets in the parking area. B17 drains to a curb inlet at the south edge of the lot.

Sub-basin B12 contains a small landscape area between the fueling station and the Dawson Trails Boulevard right-of-way. Runoff from this area is collected in a

shallow swale that drains to a Type C inlet in a landscape area. The swale is designed to intercept stormwater run-on that would otherwise flow onto the fueling station pad.

Sub-basin B13 exclusively contains the canopy over the fueling station. Roof drainage from the canopy is piped below grade into Storm Line C, at Inlet B13. The fueling station pad itself—directly beneath the canopy—is not part of sub-basin B13. Due to the presence of hazardous substances in the fueling area, the fueling station pad drains to a containment pan which routes to the storm sewer system. The fueling pad area is further discussed in this section as Sub-basin C2.

Sub-basin B14 contains the fueling area egress drive. This area is beyond the containment pan that intercepts fueling pad runoff. Runoff from B14 is intercepted in a curb inlet on the south edge of the egress lane.

Basin C sub-basins

Sub-basin C1 contains the fuel tank pad and a small wedge of incidental run-on adjacent to the pad. C1 drains to a curb inlet at the north end of the fueling area. Flows from this inlet are routed to a sand/oil interceptor that connects to the storm sewer system, ultimately routing to Pond C3.

Sub-basin C2 includes the fueling station pad, which is shielded by an overhead canopy. C2 drains to a containment pan which routes to a curb inlet just east of the fueling pad. Flows from this inlet are routed to a sand/oil interceptor that connects to the storm sewer system, ultimately routing to Pond C3. Because the fuel area canopy collects essentially all the rainfall that would otherwise fall on sub-basin C2, the basins minor and major storm flows are set to zero. The function of Inlet C2 is to capture and treat incidental drip water and snowmelt that is brought to the fuel station pad by refueling vehicles.

Basin D

Basin D contains the water quality pond and all areas that are directly tributary via overland flow. The 100-year water surface area is treated as 100% impervious for runoff calculations.

E, F, and G sub-basins

Basin E contains the areas on the southern fringe of the site which cannot be practicably captured by the on-site storm system. These areas sheet flow across the south property line directly into Gambel Ridge Tributary.

Basin F contains the areas on the southeast fringe of the site which cannot be captured by the on-site storm system. These areas sheet flow across the east property line onto the Collector B right-of-way and ultimately to Gambel Ridge Tributary.

Basin G contains the areas on the northeast fringe of the site which cannot be practicably captured by the on-site storm system. These areas sheet flow across the east property line onto Collector B right-of-way and to Gambel Ridge Tributary.

North. Runoff from Basin G1 is conveyed to off-site full spectrum pond B, which is part of the Dawson Trails Filing 1 improvements. The small areas that comprise Basin G are the only parts of the property that drain to Gambel Ridge Tributary North.

The combined area of Basins E, and F is 0.95 acres, which is 4.85% of the 19.58-acre development site. Neither of these areas can be practicably routed to the on-site Pond, as they all contain landscaped daylight slopes that fall away from the site along its perimeter. The site's water quality treatment requirement, with regard to Basins E and F, is documented in Section 3.3.2 of the Town's Permanent Water Quality Determination Worksheet and provided in Appendix C of this report.

Off-site areas

Sub-basin O2 contains a small area of access drive runoff that surface drains onto the property and is accounted for in the site's internal drainage design. There are no other areas of that surface drain onto the site; all boundaries are either high points or drain away from the site.

Areas of the site fringe in Basins E, F and G sheet flow directly onto adjacent curb and gutter or open drainageway. The flow magnitudes are minimal and have negligible impacts.

No irrigation facilities will be impacted by the project.

III. DRAINAGE DESIGN CRITERIA

A. Regulations

The proposed stormwater facilities are designed to be compliant with Town of Castle Rock drainage criteria, specifically: design rainfall, allowable inlet ponding, pipe velocities, pond storage, freeboard and maintenance provisions.

The Urban Storm Drainage Criteria Manual (USDCM) is referenced for principles of Water Quality Capture Volume and 100-year detention where these functions separated out from a typical full-spectrum design.

Runoff analysis in this report references the 2024 (current) revisions of USDCM Chapter 6. In particular, surface imperviousness values reflect the current version of MHFD Criteria Manual Table 6-3.

Design criteria for pond features, such as forebay, low flow channel and outlet structure, reference the 2024 (current) revision of USDCM Volume 3.

All other analysis and design methods the reference portions of the USDCM are based on previous revisions that have not been subject to updates in 2024.

Private drainage improvements within the site are also guided by Costco Wholesale Development Requirements. The roof drainage system, separate fueling area collection system, and loading dock drainage are based on Costco standard templates. However, the hydraulic performance of these systems is still evaluated through methods compliant with Town criteria. Additionally, Costco development standards specify a typical inlet, grate and drainage layout for low points that occur

in the middle of parking areas. A variance is submitted to request use of a Costco-preferred, H-20-rated inlet for the 6 locations that require area drains.

B. Drainage Studies, Master Plans, Site Constraints

Dawson Trails Filing No. 2 Phase III Drainage Report

The Dawson Trails Filing 2 Phase III Drainage Report [Reference J] serves as a guiding document for the broader stormwater management strategies within the Dawson Trails portion of the Gambel Ridge watershed. This site's drainage design relies on other concurrently designed infrastructure, future iterations of this report will reference the Town's case numbers of formally submitted Phase III Drainage Reports as they become available. The Dawson Trails Filing 2 Phase III Drainage Report defines several of the post-development boundary conditions that demonstrate adherence of associated drainage designs to Town regulations and policies.

Integrated drainage plan general concepts:

Several key components of the Filing 2 Phase III plan are critically important to the stormwater management strategy for Costco. These items are summarized below and described in greater detail later in this section:

1. The drainage strategy for the entirety of the Dawson Trails planned development is analyzed and guided by the Filing 2 Phase III Drainage plan. As a result, all areas of the site—including the Costco property—are integrated into a network of planned regional and sub-regional ponds.
2. A CUHP/SWMM model for all of Dawson Trails and tributary offsite area is used to model post-development hydrographs and peak flows exiting the planned development boundary.
3. Channel improvements for major drainageways crossing the site are an integral part of the Dawson Trails Filing 2 Phase III Drainage plan.
4. Existing drainage culverts under the BNSF railway and Interstate 25 are physical constraints between the site's outfall and East Plum Creek, the receiving major drainageway. Combined flows in the Gambel Ridge Tributary—both from on-site releases within the Dawson Trails Planned development and off-site flows from west of the development—must be adequately conveyed through the existing culverts, with consideration to their studied capacities, associated design storms and acceptable performance criteria.
5. Mile High Flood District drainage policy states that the maximum allowable 100-year release rate from detention ponds is 0.9 of the pre-development peak 100-year flows. However, to account for upstream drainageway flows while meeting the constraint described in (4) above, some 100-year detention release rates will need to be further restricted beyond 0.9 of pre-development peak.

The table below summarizes elements of the Costco drainage strategy that are coordinated with off-site improvements.

Off-site Design Coordination Element Summary				
Costco Design Element	Coordinating Off-site Element	Project	Consultant	Latest Reference
100-year Detention	Pond B1	Dawson Trails Filing 2	CORE	Phase III Drainage [Ref. J]
Regulation of total peak Gambel Ridge outflow	Floodplain Modification Study	Crystal Valley Interchange	Jacobs	FMS [Ref. M]
Gambel Floodplain historic encroachment	Floodplain Modification Study	Crystal Valley Interchange	Jacobs	FMS [Ref. M]
South property line match grading	Gambel Tributary Improvements	Crystal Valley Interchange	Jacobs	Phase III Drainage [Ref. I]
WQ Pond Outfall to Gambel Tributary	Floodplain Modification Study	Crystal Valley Interchange	Jacobs	FMS [Ref. M]
N/W property line drainage coordination	Dawson Trails Blvd/Parcel F2	Dawson Trails Filing 1	CORE	Phase III Drainage [Ref. L]
East property fringe runoff/outfall path	Collector B	Dawson Trails Filing 1	CORE	Phase III Drainage [Ref. L]

Outfall considerations

The ultimate outfall where runoff from the Costco site will exit the Dawson Trails development perimeter is the culvert crossing of Gambel Ridge Tributary under the BNSF railroad. There are two sequential culvert crossings in this location:

- A set of three 6' x 9' CMP culverts under the BNSF railway
- A 10' x 6' concrete box culvert under Interstate 25, immediately downstream.

The full analysis of the site outfall and the hydraulic properties of the improved drainageway is included in the Gambel Ridge Tributary Floodplain Modification Study (FD24-0003). The drainage and outfall design for the Costco site adheres to all of the drainageway constraints and boundary conditions set forth in that FMS.

Gambel Ridge Channel Improvements

The runoff analysis in the Dawson Trails Filing 2 Phase III Drainage Plan indicates that Gambel Ridge Tributary will see an increase of flow with anticipated development, and that channel stabilization improvements will be warranted.

The design of the Gambel Ridge Tributary improvements is not within the scope of the Costco project or within the scope of this drainage report.

Improvements to the 1000-foot segment of Gambel Ridge Tributary between the BNSF right-of-way and Dawson Trails boulevard are included in the design of the Crystal Valley Interchange by Jacobs Engineering Group. The Phase III drainage report for the Crystal Valley Interchange project [Ref. I] notes that the Gambel

Ridge improvements are guided by recommendations on the Gambel Ridge Master Plan [Reference G]. Relevant excerpts from that report are referenced Appendix D [G.11].

Regional Pond B1

100-year detention volume for the Costco site is provided in regional Pond B1. The required storage volume in Pond B1 is computed using a combined area of basins that are directly tributary to Pond B1, plus the area of the Costco site, which is also within the watershed but further downstream. A composite imperviousness of those directly tributary basins (B1-B8) and Costco site (C8) is also used to determine storage volumes. 100-year releases are limited to 90% of the combined predevelopment peak flows from both basin components (B1-B8) plus C8.

Regional Pond C1 (CVI West Pond)

Stormwater Management within the lower Gambel Ridge watershed relies on a regional detention facility, designated as Pond C1 and the Dawson Trail Filing 2 Report and as West Pond in the Crystal Valley Interchange Project. Pond C1 is located immediately south of Crystal Valley Parkway, between Dawson Trails Boulevard and Interstate 25. Because Pond C1 is responsible for detention and water quality treatment of the segment of Crystal Valley Parkway between Dawson Trails Boulevard and Interstate 25, its design is programmed with the Crystal Valley Interchange project, by Jacobs Engineering Group. However, Pond C1 also plays an important role in the Filing 2 Phase III Drainage Plan for Dawson Trails because it provides detention and water quality treatment for development parcels in the lower part of the Gambel Ridge watershed. Consequently, the design parameters for Pond C1 have been an item of continued coordination throughout the design process. The key role of Pond C1 in relation to Costco is over-detention to control peak flows exiting the Dawson Trails planned development.

Stormwater Detention and Water Quality

The Costco development site is considered in the Dawson Trails Filing 2 Phase III Drainage plan and is designated as Basin C8.

Regional over-detention will be provided by regional Ponds B1 and C1. The over detention is necessary to ensure that the combined flows in Gambel Ridge Tributary do not exceed the predevelopment 100-year flow rate of 640 cfs through the existing culverts under the BNSF railway and Interstate 25. The total discharge includes flows from the upper watershed and the 100-year release flows from Ponds C1 and C3 (Costco).

The elements of full-spectrum detention for the Costco site and the facilities that accommodate them are summarized below:

Detention Element Summary			
Detention Element	Facility	Designed by	Input parameters
Water Quality Capture Volume (WQCV)	Pond C3	CORE	Costco Site only (Basin C8) Area, %I
Excess Urban Runoff Volume (EURV)	Pond C3	CORE	Costco Site only (Basin C8) Area, %I
100-year detention volume	Pond B1	CORE	Costco Site + Upper Gambel Basins B1 – B8 Combined Area, %I
Q100 exiting Dawson Trails < predevelopment Q100	Ponds B1, C1	CORE/Jacobs	(C1 release + Costco release + B1 release + Gambel Offsite) < Existing Q100 at RR

Specific details on the input parameters, physical design, and outlet hydraulics of Pond B1 are referenced from the Dawson Trails Filing 2 Phase III Drainage Report [Ref. J] and are included in Appendix D.

Specific details on the input parameters, physical design, and outlet hydraulics of Pond C1 are referenced from the Crystal Valley Interchange Project Phase III Drainage Report [Ref. I] and are included in Appendix D.

SWMM

A Stormwater Management Model (SWMM) is used in regional hydrologic analyses to model the hydraulic performance of the developed Gambel Ridge Tributary drainage basin. A stormwater model that routes the watershed flows Gambel Ridge Tributary is not within the scope of this analysis. However, critical design points in the drainageway SWMM are referenced from the Gambel Ridge FMS (FD24-0003) and are adhered to with this design.

Separately, a SWMM for the upper portion of the Gambel Ridge watershed, west of the Twin Oaks Subdivisions, is within the scope of the Dawson Trails Filing 2 drainage design—currently in development. That report will adhere to all of the flow constraints and boundary conditions set forth in the FMS (FD24-0003) and in this report.

Dawson Trails Filing No.1

The perimeter roadways abutting Costco, including Dawson Trails Boulevard on the west and Collector B on the east, will be designed and constructed by the Dawson Trails Filing 1 project. This project is a comprehensive package that encompasses the portion of Dawson Trails development north of Crystal Valley parkway. It includes arterial and collector roads outlined in the preliminary plan, associated utility and drainage infrastructure, and overlot grading of the adjacent development parcels.

The stormwater strategy of the Dawson Trails Filing 1 infrastructure, as it relates to Costco, generally surface drains the Dawson Trails Boulevard right-of-way and most of Collector B right of way to full-spectrum facilities designated as Ponds A, B and C, which are constructed by that project. The overlot grading concept also

defines a linear high point on the Costco property's north boundary to shed runoff from the adjacent site northward, away from Costco. The southernmost leg of Collector B, between Costco's east access and the underpass beneath Crystal Valley Parkway, drains steeply south and cannot be captured for detention. The runoff from this area will discharge directly to Gamble Ridge Tributary and will be included in the 640 cfs allowable maximum. The uncaptured runoff on the eastern property fringe that define sub-basin F and G rely on Collector B's street drainage for conveyance to an outfall.

C. Hydrology

Rational method is used for on-site runoff calculations. Sub-basins range from 0.1 to 1.5 acres in size and are all fully developed. CUHP method is used for calculations of overall Gambel Ridge Tributary watershed flows, as referenced in the Dawson Trails Infrastructure I Phase III Drainage Report. Additionally, a SWMM models the drainageway flows with the consideration of future detention basin and channel improvements within the master plan area.

The 5-year mean recurrence interval is used for the minor drainage system design. The 100-year mean recurrence interval is used for the major drainage system design.

Design 1-hour rainfall amounts are 1.43 in. for the 5-year event and 2.60 in. for the 100-year event. These values are taken from Table 6-1 of the Town's drainage criteria.

Water Quality Capture Volume is determined from the MHFD-Detention_v4-05 spreadsheet, using the methods defined in MHFD Criteria Manual Volume 3. The MHFD-Detention_v4-05 spreadsheet is also used for pond storage and outflow calculations. MHFD-Detention_v4-05 is used to evaluate pond performance during significant storm events and sizing of flow-bypassing components.

D. Hydraulics

Curb/gutter conveyance capacities and curb inlet flow interception is calculated using MHFD-Inlet_v5.03 spreadsheet. A manning's n-value of 0.016 is assumed for all areas of asphalt parking lot paving.

Swale flows and surface drainage depths across parking lots are computed with Hydraflow Express Extension for Autodesk Civil 3D, Version 2022.

Area inlet interception in sump condition is computed using Equation 7-38 and Table 7-8 of the Mile High Flood District Criteria Manual [Reference B].

On-grade grate inlet interception calculations are based on Chapter 7, Section 3.2.1 and Table 7-6 of the Mile High Flood District Criteria Manual [Reference B]. Safety grates used within the project have bar widths, open areas and bar orientations are most similar to a Type 13 valley grate. Therefore, the empirical

splash-over parameters of the Type 13 valley grate are assumed for on-grade interception analysis.

Hydraulic grade lines for on-site, detained storm sewers and pond outfall pipes are computed through StormCAD software, version 10.03.04.53. Headloss coefficients are applied in accordance with the technical publication "Modeling Hydraulic and Energy Gradients in Storm Sewers: A Comparison of Computational Methods" by UDFCD (Urban Drainage & Flood Control District). Hydraulic performance of off-site culverts is evaluated through HY-8 software version 7.80.0.2. Inlet capacity will be evaluated via Mile High Flood District Street and Inlet Hydraulics Workbook. Inlets be designed Type A and comply to Town of Castle Rock's Storm Drainage Design and Technical Criteria Manual tables 7-2 and 7-3.

The MHFD-Detention_v4-06 spreadsheet is used for pond routing and outflow calculations.

E. Storage and Water Quality Enhancement

As described in section III.B, the detention strategy for the Costco site is uniquely integrated into the overall drainage concept for the Dawson Trails development.

Water quality enhancement and excess urban runoff attenuation are provided by an on-site pond sized for the water quality capture volume (WQCV) and excess urban runoff volume (EURV) per MHFD design criteria, as determined by the site's area and imperviousness.

Secondly, the 100-year detention volume is accommodated off-site in regional pond B1 in the Upper Gambel Ridge watershed. The minimum 100-year detention volume is determined from the combined basin area, composite imperviousness, and overall hydrologic characteristics of areas tributary to the pond and Costco, which is not tributary to the pond. The actual volume of the pond will be greater than the minimum required volume due to over-detention that will limit the release rate.

Adherence to the four-step process for water quality control is detailed in Section IV.C of this report.

IV. STORMWATER MANAGEMENT FACILITY DESIGN

A. Stormwater Conveyance Facilities

The stormwater conveyance scheme for the Costco project uses an onsite-storm sewer system to collect parking lot flows and roof drainage and an on-site pond for water quality treatment. Pavement runoff in the fuel station (Sub-basin C1 and C2) is routed to oil/water separators before piping to the on-site storm sewer system.

The site is served by two primary storm sewer runs: Lines A and B collect runoff from the east and west halves of the site. Roof drains connect directly to the storm sewer.

Parking lot runoff is generally allowed to sheet flow away from the building and intercepted by inlets in the parking area. The on-site storm systems convey converge into a single forebay in the water quality/ EURV pond in the southeast corner of the site.

Specific details on surface drainage patterns and interception points are described for each sub-basin and inlet in Section II.B.

A designed swale will be included in Basin B12. Per Mile High Flood District Figure 8-24, there will be a 6" deep designed swale.

B. Stormwater Storage Facilities

The WQCV/EURV pond is in the southeast corner of the site and outfalls to the improved Gambel Ridge Tributary immediately south. A riprap apron will be designed for the pipe outfall with the Phase III report.

An overflow spillway is designed for the south pond berm with capacity to convey 100-year fully developed, unattenuated flows directly to Gambel Ridge Tributary.

The WQCV/EURV Pond has sufficient excess depth to convey the 5-, 10- and 25-year events entirely through the top of the outlet box, with consideration of a 50% clogging factor. For the 50- and 100-year events, the overflow spillway may activate.

The spillway design has at least 1 foot of freeboard from the highest water depth over the spillway crest to the top of berm on the east, north and west sides of the pond. The entire south pond berm directly abuts the Gambel Ridge drainageway and can function as an emergency overflow path. All 50-, 100-, and 500-year routed flows can pass the 60-foot long "active" portions of the spillway (crest elevation 6364.50) with less than 0.50' feet of flow depth. The full, un-attenuated 100-year emergency design flow, which assumes a pond-full condition and complete blockage of the outlet works, passes over the spillway at a maximum depth of 0.50 feet. An additional 0.50 of height is provided between the emergency maximum water surface and the crest on the inactive portion of the overflow berm, which spills into the adjacent drainageway. The downstream face of the spillway is protected by a cutoff wall and armored with riprap, in accordance with Figure 13-7 of the Town's Drainage Criteria.

The pond design is verified to release 97% of runoff from a 5-year or lesser storm within 72 hours, and to release 99% of runoff from a storm greater than a 5-year event within 120 hours.

Maintenance accommodations are designed for the water quality pond constructed with this project. These accommodations include vehicle access paths to the pond's forebay and outlet structure, compliant with Town criteria.

100-year detention volume for the Costco site is provided in regional Pond B1, as detailed under Section III.B of this report.

C. Water Quality Enhancement Control Measures

Implementation of the four-step process of water quality control include the following features:

- 1) Runoff reduction. Efficient utilization of the on-site area the warehouse footprint and associated parking limits the coverage of pervious surfaces on site. However, a significant amount of runoff reduction occurs in the generous open space areas programmed into the greater Dawson Trails development plan.
- 2) The elements of full spectrum detention are collectively provided between the on-site water quality pond (Pond C3) and regional Pond B1. The water quality capture volume based on the Costco parcel's on-site drainage characteristics is treated in the onsite pond. The pond enables settlement of suspended particles within the captured water volume over a design release time of 40 hours. Nearly all precipitation events that will occur at the site will be entirely captured within the onsite pond.

The Costco parcel's required 100-year detention volume is provided in the B1 regional pond.

- 3) Stream stabilization. There are no streams on the property. However, the drainageway immediately south of the site will be stabilized through a separate project supporting regional development of Dawson Trails. The outfall of the Costco water quality pond C3 to the drainageway will be designed in a manner that will avoid bank erosion and adverse hydraulics.
- 4) Source Controls: The use of source control as a water quality enhancement measure is an important element of the site's design. Multiple locations on the site—the fueling area, the fuel tank filling area, the tire center, and the loading dock—are all designed with separate stormwater collection structures that route to sand/oil separators and ultimately to the on-site water quality pond. Additionally, a canopy structure above the fueling area prevents falling rainwater from mixing with substances that may have been incidentally spilled on the fueling pad.

The on-site water quality pond outfalls directly to the Gambel Ridge Tributary major drainageway. The design details of this connection are described in Section IV.B

D. Floodplain Modification

A separately prepared floodplain modification study (FMS), by Jacobs Engineering Group [FD24-0003; Reference M] accompanies the channel improvement for Gambel Ridge Tributary adjacent to the site. It is anticipated that the channel improvements and floodplain modification will be in place before substantial completion of the Costco project.

The floodplain modification eliminates the previously mapped encroachments into the Costco property by the 100-year in 500-year flood that were delineated of the

2014 Gambel Ridge FHAD. Linework shown on the drainage plan is defined by the FMS (FD24-0003). Once complete, the channel improvements will confine the floodplain limits to the drainage tract immediately south of the Costco lot. The finished floor elevation for the Costco warehouse (6381.4') will be at least 7' higher than the developed 100-year water surface elevation on Gambel Ridge Tributary, which descends from 6374 to 6355 feet in elevation along the south property boundary. Since there is no flood hazard area shown along Gambel Ridge Tributary on the FIRM, there is no need for a map revision.

E. Geotechnical Investigation and Sub-surface Collection System Design

The site has no observed history of shallow groundwater or other sub-surface drainage issues. A geotechnical investigation has been initiated and its findings will be incorporated into the Phase III report.

F. Operation and Maintenance

The proposed stormwater conveyance and treatment facilities, including Pond C3, are private improvements that will be owned and maintained by Costco Wholesale.

Vehicle access to Pond C3's forebay and outlet structure are compliant with maintenance requirements in Section 13.6 of the Town's storm drainage criteria.

Recommended maintenance practices for extended detention basins in the Denver region are detailed in MHFD Criteria Manual Volume 3, Chapter 6, Section 7.

Regular maintenance of the stormwater facilities will include:

- Inspection and debris removal – twice annually
- Aeration – annually
- Sediment removal from forebay and trickle channel – annually

Occasional or as-needed maintenance activities will include:

- Sediment removal from basin bottom—when sediment volume reaches 20% WQCV (~15 to 25 years)
- Repair of eroded areas—as determined by inspection

Separately designed Pond B1 is a regional detention facility, with ownership and ongoing maintenance by the Town of Castle Rock.

G. Additional Permitting Requirements

There are no attributes of this project, associated disturbance areas, or impacted drainages that are expected to trigger additional permitting requirements.

H. General

The following published tables and charts have been used in the drainage design and are referenced in the Appendices:

- a. *Castle Rock Storm Drainage Design and Technical Criteria*, Figure 13-7, Embankment Protection Details and Rock Sizing Chart: This chart is used to determine appropriate riprap protection on pond embankments below spillways.
- b. *Mile High Flood District Criteria Manual Volume 1*, Figure 8-24, Swale Stability Chart: greater than 4-foot bottom width and side slopes between 5:1 and 10:1. This graph is used to determine the size of designed swales.
- c. *Castle Rock Storm Drainage and Technical Criteria*, Table 7-2, Minor Storm Allowable Flow Depth and Roadway Encroachment For Streets with Curb and Gutter. This chart classifies the maximum roadway encroachment for different drainage classifications.
- d. *Castle Rock Storm Drainage and Technical Criteria*, Table 7-3, Major Storm Allowable Flow Depth For Streets with Curb and Gutter. This table is used to specify allowable flow depth for different drainage calculations.

V. CONCLUSIONS

A. Compliance with Standards

The drainage infrastructure for the Costco Wholesale project has been designed to adhere to Town of Castle Rock criteria and standards. Some elements of the site's internal drainage design are also guided by published Costco development requirements.

A variance request is submitted to permit part of the site's required full-spectrum detention obligations to be fulfilled in an off-site facility. A second variance request is submitted to use H-20 rated area inlets in parking areas.

Stormwater conveyance and storage elements have been coordinated with currently proposed adjacent infrastructure projects in accordance with the overall vision of the Dawson Trails Infrastructure I Phase III Drainage Plan. This drainage plan also coordinates with the separately proposed improvements to the Gambel Ridge Tributary and the resulting elimination of floodplain encroachment into the site.

The project area and associated drainage areas lie within the Chatfield Reservoir Watershed. To date, the project has not been subjected to specific requirements regarding Regulation No. 73.

B. Variances

A variance request for section 13.1.1 of TOCR Storm Drainage Design and Technical Criteria Manual is submitted with this report. This project requires a variance from criteria to permit the site's 100-year detention responsibilities to be provided by regional Pond B1. From section 3B of Drainage Design Criteria of this report, the 100-year detention will be accounted for in the regional pond. The variance

request and supporting documentation will be submitted with the Phase III report after technical details of the off-site facility have been more thoroughly developed.

The project requires a second variance from the TOCR Storm Drainage Design and Technical Criteria Manual sections 8.2.2, Table 8-1 list of acceptable inlets to use an H-20 rated area inlet design from Costco's development standards that is regularly used by Costco in parking areas.

C. Drainage Concept

This drainage design detailed in this report effectively implements the stormwater management principles described below:

- a. Adherence to the regional drainage strategy outlined in the Dawson Trails Filing 2 Phase III Drainage Report
- b. Source control and a separate collection system for areas with high contaminant risk to protect downstream drainage ways
- c. Conveyance, capture and water quality treatment of on-site runoff
- d. Capture and controlled release of the site's excess urban runoff volume
- e. Fulfillment of the site's 100-year detention volume obligation by an off-site regional facility

VI. REFERENCES

- A. Town of Castle Rock Storm Drainage Design and Technical Criteria Manual, June 2019.
- B. Mile High Flood District Urban Storm Drainage Criteria Manual, January 2021.
- C. Web Soil Survey, Soil Survey Staff (Natural Resources Conservation Service), United States Department of Agriculture. Available online at the following link:
<https://websoilsurvey.sc.egov.usda.gov/>. Accessed May 15, 2023.
- D. Flood Insurance Rate Map (FIRM) No. 08035C0284G, Federal Emergency Management Agency, Revised March 16, 2016. Available online at the following link:
<https://msc.fema.gov/portal/home>. Accessed May 15, 2023.
- E. Modeling Hydraulic and Energy Gradients in Storm Sewers: A Comparison of Computational Methods by AMEC, October 2009
- F. Flood Hazard Area – Delineation Gambel Ridge and Douglas Lane Tributary Watersheds by Respec Consulting and Service, July 2014
- G. Gambel Ridge and Douglas Lane Tributary Watersheds – Master Plan by Respec Consulting and Service, July 2014.
- H. Dawson Trails Planned Development Plan and Zoning Regulations by Norris Design, June 9, 2022 (PDP-05)
- I. Crystal Valley Interchange Project Package 2: Phase III Drainage Report, by Jacobs Engineering Group, October 2023
- J. Phase III Drainage Report for Dawson Trails Filing 2 by CORE Consultants, October 13, 2023
- K. Interstate 25 South Express Lanes: Castle Rock to Monument (The Gap) Hydrology and Hydraulics Report by ch2m, December 2020.
- L. Phase III Drainage Report for Dawson Trails Filing 1 by CORE Consultants, August 22, 2023
- M. Crystal Valley Interchange Project Packages 1 and 2 - Floodplain Modification Study - Gambel Ridge – E Plum Creek to Dawson Trails Boulevard, by Jacobs Engineering Group, April 2024 (FD24-0003)

Computer Modeling Programs:

- A. StormCAD by Bentley Systems, Inc., Version 10.03.04.53.
- B. Hydraflow Express Extension for Autodesk Civil 3D by Autodesk, Version 2022.
- C. Detention Basin Design Workbook (MHFD-Detention v4.04.xlsm) by Mile High Flood District, Version 4.04, February 2021.
- D. Street and Inlet Hydraulics Workbook (MHFD-Inlet v5.03.xlsm) by Mile High Flood District, Version 5.03, August 2023.
- E. HY-8 by Federal Highway Administration, Version 7.80.0.2, November 2022. APPENDICES

APPENDIX A

HYDROLOGIC COMPUTATIONS

set of one hour design point rainfall values, indicated in Table 6-1, apply to the Town.

TABLE 6-1
1-HOUR POINT RAINFALL VALUES FOR
THE TOWN OF CASTLE ROCK (INCHES)

2- YR	5-YR	10-YR	50-YR	100-YR
1.06	1.43	1.66	2.26	2.60

The one-hour rainfall depths are the basis of the Town's intensity-duration rainfall curves and are used to formulate design storm distributions.

6.1.2 Intensity-Duration Curves. Rainfall intensity based on storm duration for a variety of storm return periods can be found on Figure 6-1 at the end of this chapter. These curves were developed using distribution factors provided in the NOAA Atlas and also provided in Table RA-4 of the UDFCD Manual. These Intensity-Duration curves are based on Equation RA-3 in the Rainfall Section of the UDFCD Manual.

6.1.3 Six-hour Rainfall. In order to use the Colorado Urban Hydrograph Procedure (CUHP), two, three or six-hour rainfall distributions are required, depending on watershed area. Table RA-1 in the UDFCD Manual summarizes storm durations, area adjustments, and incremental rainfall depths to be used in CUHP based on watershed area. The UD-Raincurve Spreadsheet included in the UDFCD Manual shall be used to generate the rainfall distribution curves necessary for a CUHP model. In order to generate these distribution curves, the one-hour and six-hour rainfall depths for the design return periods are necessary. Since the Town of Castle Rock is not located within UDFCD boundaries, the rainfall depth-duration-frequency curves provided in the UDFCD Manual do not provide rainfall values for the entire Town. Therefore these values are provided in these Criteria. The 1-hour point values can be found in Table 6-1 of this chapter. The six-hour point values are as follows:

TABLE 6-2
6-HOUR POINT RAINFALL VALUES FOR
THE TOWN OF CASTLE ROCK (INCHES)

2- YR	5-YR	10-YR	50-YR	100-YR
1.5	2.0	2.2	3.0	3.4

The UD-Raincurve spreadsheet shall be used for all portions of the Town. Once the rainfall distribution curves are generated using the UDFCD UD-Raincurve Spreadsheet, the CUHP model is to be set up following the procedures provided in the Runoff chapter in Volume 1 of the UDFCD Manual.

Costco Wholesale, Castle Rock, CO

CORE Project #: 20-224-05

Prepared By: LCC

IMPERVIOUS CALCULATIONS**-REFERENCE UDFCD Vol.1 RUNOFF Table 6-3**

		Residential & Commercial												Soil Type		
		Single Family			Multi-Family											
		0.25 acres or less	0.25 - 0.75 acres	2.5 acres or larger	Attached	Roof/ Concrete	Asphalt/ Ponded Water	Extended Detention Basin	Newly Graded/ Gravel	Landscape Area	Historic			Soil Type A Area	Soil Type B Area	Soil Type C/D Area
% Imperv.		45.00%	30.00%	12.00%	75.00%	95.00%	95.00%	25.00%	65.00%	20.00%	5.00%					
BASIN	Design Point											Total Area (ac)	Percent Impervious			
		Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)			Area (ac)	Area (ac)	Area (ac)
O1	O1	-	-	-	-	-	-	-	1.98	-	-	1.98	65.0%	-	-	1.98
O2	O2	-	-	-	-	-	0.06	-	-	-	-	0.06	95.0%	-	-	0.06
		-	-	-	-	-	-	-	-	-	-	-		-	-	-
A1	A1	-	-	-	-	-	0.15	-	-	-	-	0.15	95.0%	-	-	0.15
A2	A2	-	-	-	-	-	0.13	-	-	-	-	0.13	95.0%	-	-	0.13
A3	A3	-	-	-	-	-	0.12	-	-	-	-	0.12	95.0%	-	-	0.12
A4	A4	-	-	-	-	-	0.12	-	-	-	-	0.12	95.0%	-	-	0.12
A5	A5	-	-	-	-	0.29	-	-	-	-	-	0.29	95.0%	-	-	0.29
A6	A6	-	-	-	-	-	0.20	-	-	-	-	0.20	95.0%	-	-	0.20
A7	A7	-	-	-	-	0.57	-	-	-	-	-	0.57	95.0%	-	-	0.57
A8	A8	-	-	-	-	-	0.27	-	-	-	-	0.27	95.0%	-	-	0.27
A9	A9	-	-	-	-	0.57	-	-	-	-	-	0.57	95.0%	-	-	0.57
A10	A10	-	-	-	-	0.30	-	-	-	-	-	0.30	95.0%	-	-	0.30
A11	A11	-	-	-	-	-	0.12	-	-	-	-	0.12	95.0%	-	-	0.12
A12	A12	-	-	-	-	-	0.16	-	-	-	-	0.16	95.0%	-	-	0.16
A13	A13	-	-	-	-	-	0.15	-	-	-	-	0.15	95.0%	-	-	0.15
A14	A14	-	-	-	-	-	0.28	-	-	-	-	0.28	95.0%	-	-	0.28
A15	A15	-	-	-	-	-	0.35	-	-	-	-	0.35	95.0%	-	-	0.35
A16	A16	-	-	-	-	-	0.88	-	-	0.06	-	0.93	90.4%	-	-	0.93
A17	A17	-	-	-	-	-	1.01	-	-	0.04	-	1.05	92.4%	-	-	1.05
A18	A18	-	-	-	-	-	0.48	-	-	0.05	-	0.53	88.5%	-	-	0.53

		Residential & Commercial													Soil Type		
		Single Family			Multi-Family										Soil Type A Area	Soil Type B Area	Soil Type C/D Area
		0.25 acres or less	0.25 - 0.75 acres	2.5 acres or larger	Attached	Roof/ Concrete	Asphalt/ Ponded Water	Extended Detention Basin	Newly Graded/ Gravel	Landscape Area	Historic						
		% Imperv.	Design Point	45.00%	30.00%	12.00%	75.00%	95.00%	95.00%	25.00%	65.00%	20.00%	5.00%	Total Area (ac)	Percent Impervious		
BASIN		Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)	Area (ac)			Area (ac)	Area (ac)	Area (ac)	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
B1.1	B1.1	-	-	-	-	-	0.36	-	-	-	-	0.36	95.0%	-	-	0.36	
B1.2	B1.2	-	-	-	-	-	0.78	-	-	0.24	-	1.01	77.4%	-	-	1.01	
B2	B2	-	-	-	-	0.57	-	-	-	-	-	0.57	95.0%	-	-	0.57	
B3.1	B3.1	-	-	-	-	0.35	-	-	-	-	-	0.35	95.0%	-	-	0.35	
B3.2	B3.2	-	-	-	-	-	0.88	-	-	0.24	-	1.12	79.0%	-	-	1.12	
B4	B4	-	-	-	-	0.57	-	-	-	-	-	0.57	95.0%	-	-	0.57	
B5	B5	-	-	-	-	-	0.13	-	-	-	-	0.13	95.0%	-	-	0.13	
B6	B6	-	-	-	-	-	0.95	-	-	0.02	-	0.97	93.6%	-	-	0.97	
B7	B7	-	-	-	-	-	0.25	-	-	0.13	-	0.38	68.8%	-	-	0.38	
B8	B8	-	-	-	-	-	0.52	-	-	0.03	-	0.55	90.9%	-	-	0.55	
B9.1	B9.1	-	-	-	-	-	0.36	-	-	-	-	0.36	95.0%	-	-	0.36	
B9.2	B9.2	-	-	-	-	-	0.48	-	-	0.03	-	0.51	90.1%	-	-	0.51	
B10	B10	-	-	-	-	0.82	-	-	-	-	-	0.82	95.0%	-	-	0.82	
B11	B11	-	-	-	-	-	0.64	-	-	0.05	-	0.69	90.1%	-	-	0.69	
B12	B12	-	-	-	-	-	-	-	-	0.17	-	0.17	20.0%	-	-	0.17	
B13	B13	-	-	-	-	0.34	-	-	-	-	-	0.34	95.0%	-	-	0.34	
B14	B14	-	-	-	-	-	0.23	-	-	-	-	0.23	95.0%	-	-	0.23	
B15	B15	-	-	-	-	-	0.42	-	-	0.03	-	0.45	89.9%	-	-	0.45	
B16	B16	-	-	-	-	-	0.45	-	-	0.01	-	0.46	94.0%	-	-	0.46	
B17	B17	-	-	-	-	-	0.69	-	-	0.03	-	0.72	91.9%	-	-	0.72	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
C1	C1	-	-	-	-	-	0.35	-	-	-	-	0.35	95.0%	-	-	0.35	
C2	C2	-	-	-	-	-	0.34	-	-	-	-	0.34	95.0%	-	-	0.34	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pond Forebay	B	-	-	-	-	4.39	11.96	-	-	1.11	-	17.46	90.2%	-	-	17.46	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
D	D	-	-	-	-	-	-	0.49	0.16	0.48	-	1.12	28.4%	-	-	1.12	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
EURV Pond (C3)	D0	-	-	-	-	4.39	11.96	0.49	0.16	1.59	-	18.58	86.5%	-	-	18.58	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
E	E	-	-	-	-	-	-	-	-	0.64	-	0.64	20.0%	-	-	0.64	
F	F	-	-	-	-	-	0.03	-	-	0.27	-	0.31	28.0%	-	-	0.31	
G	G	-	-	-	-	-	-	-	-	0.43	-	0.43	20.0%	-	-	0.43	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Total Site		-	-	-	-	4.39	11.93	0.49	0.16	2.93	-	19.89	82.0%	-	-	19.89	

Basin ID	% Imperv.	i	Soil Type	Runoff Coefficients, C				Basin Area	Total Area	Weighted Runoff Coefficients, C			
				2-Year	5-Year	10-Year	100-Year			2-Year	5-Year	10-Year	100-Year
O1	65.0%	0.65	A	0.48	0.50	0.51	0.62	1.98	1.98	0.51	0.57	0.61	0.75
			B	0.51	0.54	0.58	0.73						
			C or D	0.51	0.57	0.61	0.75						
O2	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.06	0.06	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
									-	-	-	-	
A1	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.15	0.15	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A2	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.13	0.13	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A3	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.12	0.12	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A4	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.12	0.12	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A5	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.29	0.29	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A6	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.20	0.20	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A7	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.57	0.57	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A8	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.27	0.27	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A9	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.57	0.57	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A10	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.30	0.30	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A11	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.12	0.12	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A12	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.16	0.16	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A13	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.15	0.15	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A14	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.28	0.28	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A15	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.35	0.35	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
A16	90.4%	0.90	A	0.74	0.76	0.77	0.82	0.93	0.93	0.74	0.78	0.80	0.85
			B	0.75	0.77	0.79	0.85						
			C or D	0.74	0.78	0.80	0.85						
A17	92.4%	0.92	A	0.76	0.78	0.79	0.83	1.05	1.05	0.76	0.79	0.82	0.86
			B	0.77	0.79	0.81	0.86						
			C or D	0.76	0.79	0.82	0.86						
A18	88.5%	0.88	A	0.72	0.74	0.75	0.80	0.53	0.53	0.72	0.76	0.79	0.85
			B	0.73	0.75	0.77	0.84						
			C or D	0.72	0.76	0.79	0.85						

Basin ID	% Imperv.	i	Soil Type	Runoff Coefficients, C				Basin Area	Total Area	Weighted Runoff Coefficients, C			
				2-Year	5-Year	10-Year	100-Year			2-Year	5-Year	10-Year	100-Year
B1.1	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.36	0.36	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B1.2	77.4%	0.77	A	0.60	0.62	0.63	0.71	1.01	1.01	0.62	0.67	0.70	0.80
			B	0.62	0.65	0.68	0.79						
			C or D	0.62	0.67	0.70	0.80						
B2	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.57	0.57	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B3.1	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.35	0.35	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B3.2	79.0%	0.79	A	0.62	0.64	0.65	0.73	1.12	1.12	0.64	0.68	0.72	0.81
			B	0.64	0.67	0.70	0.80						
			C or D	0.64	0.68	0.72	0.81						
B4	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.57	0.57	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B5	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.13	0.13	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B6	93.6%	0.94	A	0.77	0.79	0.80	0.84	0.97	0.97	0.77	0.80	0.82	0.87
			B	0.78	0.80	0.82	0.87						
			C or D	0.77	0.80	0.82	0.87						
B7	68.8%	0.69	A	0.52	0.53	0.55	0.65	0.38	0.38	0.55	0.60	0.64	0.77
			B	0.54	0.57	0.61	0.75						
			C or D	0.55	0.60	0.64	0.77						
B8	90.9%	0.91	A	0.74	0.76	0.77	0.82	0.55	0.55	0.75	0.78	0.80	0.86
			B	0.75	0.78	0.79	0.85						
			C or D	0.75	0.78	0.80	0.86						
B9.1	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.36	0.36	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B9.2	90.1%	0.90	A	0.73	0.75	0.77	0.81	0.51	0.51	0.74	0.77	0.80	0.85
			B	0.74	0.77	0.79	0.85						
			C or D	0.74	0.77	0.80	0.85						
B10	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.82	0.82	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B11	90.1%	0.90	A	0.73	0.75	0.77	0.81	0.69	0.69	0.74	0.77	0.80	0.85
			B	0.74	0.77	0.79	0.85						
			C or D	0.74	0.77	0.80	0.85						
B12	20.0%	0.20	A	0.10	0.11	0.12	0.27	0.17	0.17	0.14	0.20	0.28	0.57
			B	0.13	0.15	0.22	0.52						
			C or D	0.14	0.20	0.28	0.57						
B13	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.34	0.34	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B14	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.23	0.23	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
B15	89.9%	0.90	A	0.73	0.75	0.76	0.81	0.45	0.45	0.74	0.77	0.80	0.85
			B	0.74	0.77	0.79	0.85						
			C or D	0.74	0.77	0.80	0.85						
B16	94.0%	0.94	A	0.78	0.79	0.81	0.84	0.46	0.46	0.77	0.81	0.83	0.87
			B	0.78	0.80	0.82	0.87						
			C or D	0.77	0.81	0.83	0.87						
B17	91.9%	0.92	A	0.75	0.77	0.78	0.83	0.72	0.72	0.75	0.79	0.81	0.86
			B	0.76	0.78	0.80	0.86						
			C or D	0.75	0.79	0.81	0.86						
C1	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.35	0.35	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
C2	95.0%	0.95	A	0.79	0.81	0.82	0.85	0.34	0.34	0.78	0.81	0.84	0.87
			B	0.79	0.81	0.83	0.87						
			C or D	0.78	0.81	0.84	0.87						
D	28.4%	0.28	A	0.16	0.17	0.18	0.33	1.12	1.12	0.20	0.27	0.34	0.60
			B	0.19	0.22	0.29	0.56						
			C or D	0.20	0.27	0.34	0.60						
E	20.0%	0.20	A	0.10	0.11	0.12	0.27	0.64	0.64	0.14	0.20	0.28	0.57
			B	0.13	0.15	0.22	0.52						
			C or D	0.14	0.20	0.28	0.57						
F	28.0%	0.28	A	0.16	0.17	0.18	0.33	0.31	0.31	0.20	0.26	0.34	0.60
			B	0.19	0.22	0.28	0.56						
			C or D	0.20	0.26	0.34	0.60						
G	20.0%	0.20	A	0.10	0.11	0.12	0.27	0.43	0.43	0.14	0.20	0.28	0.57
			B	0.13	0.15	0.22	0.52						
			C or D	0.14	0.20	0.28	0.57						

CORE Project #: 20-224-05
Prepared By: LCC

Prepared By: LCC

-REFERENCE UDFCD Vol.1 Section 2.4

NRCS Conveyance factors, K -REFERENCE UDFCD Vol.1 RUNOFF Table 6-2

Heavy Meadow	3	Short Grass Pasture & Lawns	7	Grassed Waterway	15
Tillage/field	5	Nearly Bare Ground	10	Paved Area & Shallow Gutter	20

[illegible]

SUB-BASIN DATA			INITIAL / OVERLAND TIME			CHANNEL / TRAVEL TIME T(t)						T(c) CHECK (URBANIZED BASINS)		FINAL T(c)
DRAIN BASIN	AREA ac.	C(5)	Length ft.	Slope %	T(i) min	Length ft.	Slope %	Coeff.	Velocity fps	T(t) min.	COMP. T(c)	% IMPERVIOUS	USDCM Eq . 6-5	min.
B1.1	0.36	0.81	80	1.3	4.3	100	1.2	20	2.2	0.8	5.1	95.0%	10.5	5.1
B1.2	1.01	0.67	100	1.8	6.4	150	1.7	20	2.6	1.0	7.4	77.4%	13.8	7.4
B2	0.57	0.81	50	1.0	3.7	200	0.5	20	1.4	2.4	6.0	95.0%	12.0	6.0
B3.1	0.35	0.81	80	1.3	4.3	100	1.2	20	2.2	0.8	5.1	95.0%	10.5	5.1
B3.2	1.12	0.68	100	1.8	6.2	150	1.7	20	2.6	1.0	7.2	79.0%	13.5	7.2
B4	0.57	0.81	50	1.0	3.7	200	0.5	20	1.4	2.4	6.0	95.0%	12.0	6.0
B5	0.13	0.81	40	2.5	2.4	180	3.3	20	3.7	0.8	3.2	95.0%	10.6	5.0
B6	0.97	0.80	100	1.2	5.1	150	1.2	20	2.2	1.1	6.2	93.6%	11.1	6.2
B7	0.38	0.60	80	1.5	7.1	100	1.0	20	2.0	0.8	7.9	68.8%	15.2	7.9
B8	0.55	0.78	80	1.3	4.8	100	1.2	20	2.2	0.8	5.6	90.9%	11.2	5.6
B9.1	0.36	0.81	80	1.3	4.3	100	1.2	20	2.2	0.8	5.1	95.0%	10.5	5.1
B9.2	0.51	0.77	80	1.5	4.6	150	1.2	20	2.2	1.1	5.7	90.1%	11.7	5.7
B10	0.82	0.81	50	1.0	3.7	200	0.5	20	1.4	2.4	6.0	95.0%	12.0	6.0
B11	0.69	0.77	50	1.6	3.6	100	1.6	20	2.5	0.7	4.2	90.1%	11.3	5.0
B12	0.17	0.20	10	10.0	2.4	120	1.7	7	0.9	2.2	4.6	20.0%		5.0
B13	0.34	0.81	20	2.0	1.8	30	2.0	20	2.8	0.2	2.0	95.0%	10.0	5.0
B14	0.23	0.81	40	1.3	3.0	130	0.9	20	1.9	1.1	4.2	95.0%	10.9	5.0
B15	0.45	0.77	50	1.6	3.6	100	1.6	20	2.5	0.7	4.2	89.9%	11.3	5.0
B16	0.46	0.81	40	1.3	3.1	120	1.0	20	2.0	1.0	4.1	94.0%	10.9	5.0
B17	0.72	0.79	50	1.8	3.3	160	1.5	20	2.4	1.1	4.4	91.9%	11.4	5.0
C1	0.35	0.81	100	1.2	4.9	100	0.9	20	1.9	0.9	5.7	95.0%	10.6	5.7
C2	0.34	0.81	100	1.2	4.9	60	1.0	20	2.0	0.5	5.4	95.0%	10.3	5.4
D	1.12	0.27	80	17.5	5.2						5.2	28.4%		5.2
E	0.64	0.20	30	16.7	3.5						3.5	20.0%		5.0
F	0.31	0.26	40	20.0	3.5						3.5	28.0%		5.0
G	0.43	0.20	70	14.3	5.7						5.7	20.0%		5.7

Costco Wholesale, Castle Rock, CO

CORE Project #: 20-224-05

Prepared By: LCC

RATIONAL METHOD PEAK RUNOFF

5-Year STORM

Rainfall Depth-Duration-Frequency (1-hr) = 1.43

SF-3

-REFERENCE UDFCD Vol.1 EQ 5-1 & EQ 6-1

BASIN INFORMATION				DIRECT RUNOFF			
DESIGN POINT	DRAIN BASIN	AREA ac.	5yr Runoff COEFF	T(c) min	C x A	I in/hr	Q cfs
O1	O1	1.98	0.57	10.4	1.13	3.80	4.28
O2	O2	0.06	0.81	5.0	0.05	4.85	0.24
A1	A1	0.15	0.81	5.0	0.12	4.85	0.58
A2	A2	0.13	0.81	5.0	0.10	4.85	0.50
A3	A3	0.12	0.81	5.0	0.10	4.85	0.49
A4	A4	0.12	0.81	5.0	0.10	4.85	0.48
A5	A5	0.29	0.81	6.0	0.23	4.61	1.07
A6	A6	0.20	0.81	5.1	0.16	4.81	0.78
A7	A7	0.57	0.81	6.0	0.46	4.61	2.14
A8	A8	0.27	0.81	5.1	0.22	4.81	1.07
A9	A9	0.57	0.81	6.0	0.47	4.61	2.15
A10	A10	0.30	0.81	6.0	0.25	4.61	1.14
A11	A11	0.12	0.81	5.0	0.10	4.85	0.47
A12	A12	0.16	0.81	5.0	0.13	4.85	0.62
A13	A13	0.15	0.81	5.0	0.12	4.85	0.59
A14	A14	0.28	0.81	5.0	0.22	4.85	1.09
A15	A15	0.35	0.81	5.1	0.29	4.83	1.38
A16	A16	0.98	0.78	7.6	0.76	4.28	3.26
A17	A17	1.08	0.79	6.7	0.86	4.47	3.84
A18	A18	0.54	0.76	7.2	0.41	4.36	1.81
B1	B1	1.37	0.71	6.8	0.97	4.43	4.30
B2	B2	0.57	0.81	6.0	0.47	4.61	2.15
B3	B3	1.47	0.71	6.7	1.05	4.46	4.69
B4	B4	0.57	0.81	6.0	0.46	4.61	2.13
B5	B5	0.13	0.81	5.0	0.11	4.85	0.53
B6	B6	0.97	0.80	6.2	0.78	4.57	3.54
B7	B7	0.38	0.60	7.9	0.23	4.22	0.96
B8	B8	0.55	0.78	5.6	0.43	4.71	2.03
B9	B9	0.87	0.79	5.5	0.69	4.72	3.24
B10	B10	0.82	0.81	6.0	0.67	4.61	3.07
B11	B11	0.69	0.77	5.0	0.53	4.85	2.59
B12	B12	0.17	0.20	5.0	0.03	4.85	0.17
B13	B13	0.34	0.81	5.0	0.28	4.85	1.36
B14	B14	0.23	0.81	5.0	0.18	4.85	0.89
B15	B15	0.45	0.77	5.0	0.34	4.85	1.67
B16	B16	0.26	0.80	5.0	0.20	0.00	
B17	B17	0.93	0.79	5.0	0.74	4.85	3.58
C1	C1	0.35	0.81	5.7	0.28	4.67	1.33
C2	C2	0.34	0.81	5.4	0.28	4.76	1.33
D	D	1.03	0.27	5.2	0.28	4.80	1.36
E	E	0.64	0.20	5.0	0.13	4.85	0.61
F	F	0.30	0.27	5.0	0.08	4.85	0.39
G	G	0.43	0.20	5.7	0.09	4.69	0.40

Costco Wholesale, Castle Rock, CO

CORE Project #: 20-224-05

Prepared By: LCC

RATIONAL METHOD PEAK RUNOFF

100-YR STORM

SF-3

Rainfall Depth-Duration-Frequency (1-hr) = 2.60

-REFERENCE UDFCD Vol.1 EQ 5-1 & EQ 6-1

BASIN INFORMATION				DIRECT RUNOFF			
DESIGN POINT	DRAIN BASIN	AREA ac.	100YR RUNOFF COEFF	T(c) min	C x A	I in/hr	Q cfs
O1	O1	1.98	0.75	10.4	1.49	6.91	10.28
O2	O2	0.06	0.87	5.0	0.05	8.82	0.46
A1	A1	0.15	0.87	5.0	0.13	8.82	1.14
A2	A2	0.13	0.87	5.0	0.11	8.82	0.97
A3	A3	0.12	0.87	5.0	0.11	8.82	0.96
A4	A4	0.12	0.87	5.0	0.11	8.82	0.94
A5	A5	0.29	0.87	6.0	0.25	8.38	2.09
A6	A6	0.20	0.87	5.1	0.17	8.75	1.52
A7	A7	0.57	0.87	6.0	0.50	8.38	4.17
A8	A8	0.27	0.87	5.1	0.24	8.75	2.09
A9	A9	0.57	0.87	6.0	0.50	8.38	4.20
A10	A10	0.30	0.87	6.0	0.27	8.38	2.23
A11	A11	0.12	0.87	5.0	0.10	8.82	0.91
A12	A12	0.16	0.87	5.0	0.14	8.82	1.22
A13	A13	0.15	0.87	5.0	0.13	8.82	1.16
A14	A14	0.28	0.87	5.0	0.24	8.82	2.12
A15	A15	0.35	0.87	5.1	0.31	8.77	2.69
A16	A16	0.98	0.86	7.6	0.84	7.78	6.51
A17	A17	1.08	0.86	6.7	0.93	8.12	7.59
A18	A18	0.54	0.85	7.2	0.46	7.93	3.65
B1	B1	1.37	0.82	6.8	1.12	8.06	9.06
B2	B2	0.57	0.87	6.0	0.50	8.38	4.19
B3	B3	1.47	0.82	6.7	1.21	8.10	9.83
B4	B4	0.57	0.87	6.0	0.50	8.38	4.16
B5	B5	0.13	0.87	5.0	0.12	8.82	1.02
B6	B6	0.97	0.87	6.2	0.84	8.30	6.97
B7	B7	0.38	0.77	7.9	0.29	7.67	2.23
B8	B8	0.55	0.86	5.6	0.47	8.57	4.06
B9	B9	0.87	0.86	5.5	0.75	8.59	6.42
B10	B10	0.82	0.87	6.0	0.72	8.38	5.99
B11	B11	0.69	0.85	5.0	0.59	8.82	5.19
B12	B12	0.17	0.57	5.0	0.10	8.82	0.85
B13	B13	0.34	0.87	5.0	0.30	8.82	2.65
B14	B14	0.23	0.87	5.0	0.20	8.82	1.73
B15	B15	0.45	0.85	5.0	0.38	8.82	3.35
B16	B16	0.26	0.87	5.0	0.22	0.00	
B17	B17	0.93	0.86	5.0	0.80	8.82	7.07
C1	C1	0.35	0.87	5.7	0.31	8.49	2.60
C2	C2	0.34	0.87	5.4	0.30	8.65	2.60
D	D	1.03	0.60	5.2	0.62	8.73	5.43
E	E	0.64	0.57	5.0	0.36	8.82	3.18
F	F	0.30	0.60	5.0	0.18	8.82	1.60
G	G	0.43	0.57	5.7	0.24	8.53	2.08

APPENDIX B

HYDRAULIC COMPUTATIONS

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0.00 cfs

Design Flow: 485.00 cfs

Maximum Flow: 640.00 cfs

Table 1 - Summary of Culvert Flows at Crossing: Culvert 7.5 (Ex. 10' x 6' CBC)

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 7.5 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6343.00	0.00	0.00	0.00	1
6344.56	64.00	64.00	0.00	1
6345.48	128.00	128.00	0.00	1
6346.28	192.00	192.00	0.00	1
6347.04	256.00	256.00	0.00	1
6347.76	320.00	320.00	0.00	1
6348.46	384.00	384.00	0.00	1
6349.14	448.00	448.00	0.00	1
6349.55	485.00	485.00	0.00	1
6350.57	576.00	576.00	0.00	1
6351.33	640.00	640.00	0.00	1
6353.00	768.33	768.33	0.00	Overtopping

Culvert Data: Culvert 7.5

Table 1 - Culvert Summary Table: Culvert 7.5

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 cfs	0.00 cfs	6343.00	0.00	0.000	0-NF	0.00	0.00	0.41	0.00	0.00	0.00
64.00 cfs	64.00 cfs	6344.56	1.56	0.0*	1-S2n	0.43	1.08	0.43	0.44	15.05	4.00
128.00 cfs	128.00 cfs	6345.48	2.48	0.0*	1-S2n	0.66	1.72	0.66	0.66	19.45	5.18
192.00 cfs	192.00 cfs	6346.28	3.28	0.0*	1-S2n	0.85	2.25	0.86	0.84	22.38	6.01
256.00 cfs	256.00 cfs	6347.04	4.04	0.0*	1-S2n	1.02	2.73	1.05	0.99	24.35	6.66
320.00 cfs	320.00 cfs	6347.76	4.76	0.0*	1-S2n	1.18	3.17	1.22	1.13	26.20	7.20
384.00 cfs	384.00 cfs	6348.46	5.46	0.0*	1-S2n	1.33	3.58	1.40	1.25	27.50	7.68
448.00 cfs	448.00 cfs	6349.14	6.14	0.0*	5-S2n	1.48	3.96	1.56	1.37	28.68	8.10
485.00 cfs	485.00 cfs	6349.55	6.55	0.0*	5-S2n	1.56	4.18	1.66	1.43	29.22	8.32
576.00 cfs	576.00 cfs	6350.57	7.57	0.0*	5-S2n	1.75	4.69	1.89	1.58	30.50	8.82
640.00 cfs	640.00 cfs	6351.33	8.33	0.0*	5-S2n	1.87	5.03	2.05	1.68	31.20	9.14

* Full Flow Headwater elevation is below inlet invert.

Culvert Barrel Data

Culvert Barrel Type Straight Culvert

Inlet Elevation (invert): 6343.00 ft,

Outlet Elevation (invert): 6324.00 ft

Culvert Length: 323.56 ft,

Culvert Slope: 0.0588

Culvert Data Summary - Culvert 7.5

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0130

Culvert Type: Straight

Inlet Configuration: 1:1 Bevel (45° flare) Wingwall (Ke=0.2)

Inlet Depression: None

Roadway Data for Crossing: Culvert 7.5 (Ex. 10' x 6' CBC)

Roadway Profile Shape: Constant Roadway Elevation

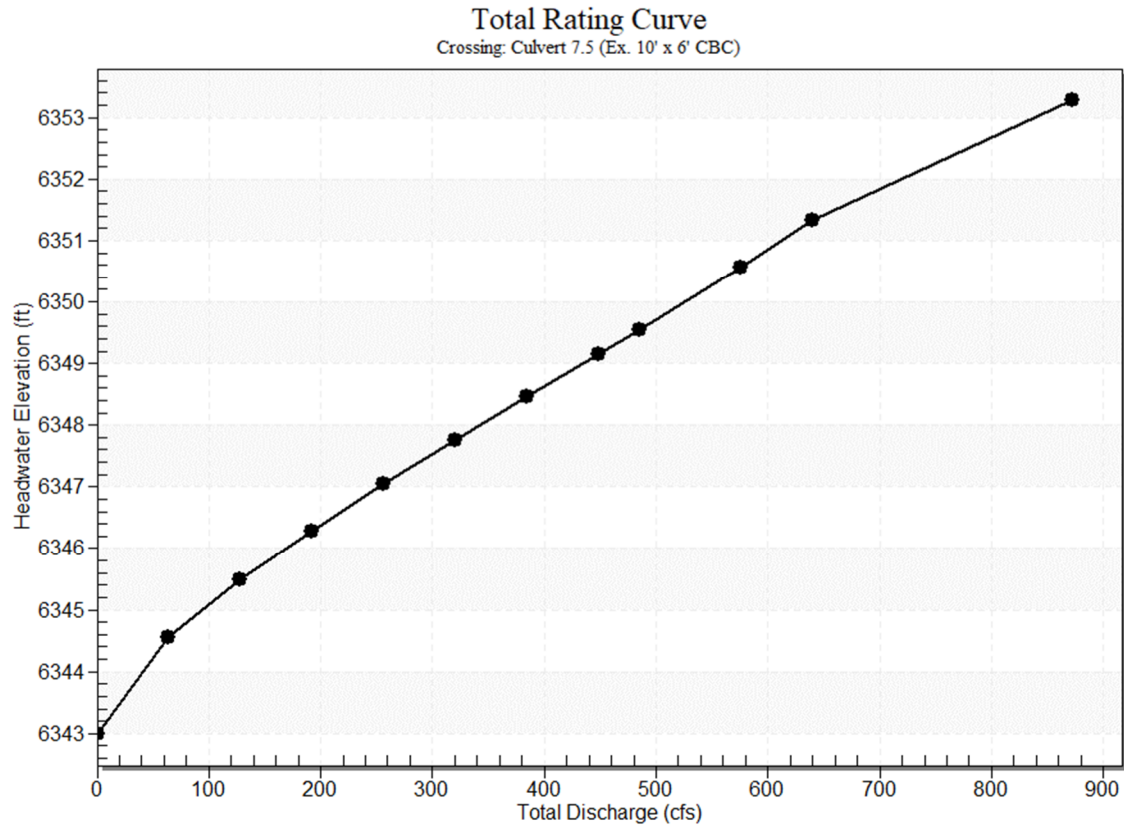
Crest Length: 290.00 ft

Crest Elevation: 6353.00 ft

Roadway Surface: Paved

Roadway Top Width: 125.00 ft

Rating Curve Plot for Crossing: Culvert 7.5 (Ex. 10' x 6' CBC)



Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0.00 cfs

Design Flow: 485.00 cfs

Maximum Flow: 640.00 cfs

Table 2 - Summary of Culvert Flows at Crossing: Culvert 7 (Triple 6' x 9' CMP)

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 7 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6345.06	0.00	0.00	0.00	1
6346.33	64.00	64.00	0.00	1
6346.93	128.00	128.00	0.00	1
6347.43	192.00	192.00	0.00	1
6347.87	256.00	256.00	0.00	1
6348.26	320.00	320.00	0.00	1
6348.60	384.00	384.00	0.00	1
6348.92	448.00	448.00	0.00	1
6349.09	485.00	485.00	0.00	1
6349.50	576.00	576.00	0.00	1
6349.80	640.00	640.00	0.00	1
6356.50	1598.64	1598.64	0.00	Overtopping

Culvert Data: Culvert 7

Table 2 - Culvert Summary Table: Culvert 7

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 cfs	0.00 cfs	6345.06	0.00	0.000	0-NF	0.00	0.00	0.00	0.00	0.00	0.00

64.00 cfs	64.00 cfs	6346.33	1.27	0.158	1-S2n	0.73	0.80	0.73	0.44	4.96	4.00
128.00 cfs	128.00 cfs	6346.93	1.87	0.543	1-S2n	1.04	1.16	1.04	0.66	6.30	5.18
192.00 cfs	192.00 cfs	6347.43	2.37	0.873	1-S2n	1.28	1.45	1.28	0.84	7.22	6.01
256.00 cfs	256.00 cfs	6347.87	2.81	1.181	1-S2n	1.50	1.71	1.50	0.99	7.90	6.66
320.00 cfs	320.00 cfs	6348.26	3.20	1.481	1-S2n	1.69	1.94	1.71	1.13	8.48	7.20
384.00 cfs	384.00 cfs	6348.60	3.54	1.779	1-S2n	1.88	2.15	1.90	1.25	8.98	7.68
448.00 cfs	448.00 cfs	6348.92	3.86	2.079	1-S2n	2.06	2.35	2.08	1.37	9.41	8.10
485.00 cfs	485.00 cfs	6349.09	4.03	2.255	1-S2n	2.16	2.46	2.18	1.43	9.64	8.32
576.00 cfs	576.00 cfs	6349.50	4.44	2.697	1-S2n	2.40	2.72	2.43	1.58	10.15	8.82
640.00 cfs	640.00 cfs	6349.80	4.74	3.018	1-S2n	2.57	2.89	2.60	1.68	10.47	9.14

Culvert Barrel Data

Culvert Barrel Type Straight Culvert

Inlet Elevation (invert): 6345.06 ft,

Outlet Elevation (invert): 6344.41 ft

Culvert Length: 52.26 ft,

Culvert Slope: 0.0124

Culvert Data Summary - Culvert 7

Barrel Shape: Pipe Arch

Barrel Span: 106.00 in

Barrel Rise: 73.30 in

Barrel Material: Steel Structural Plate

Embedment: 0.00 in

Barrel Manning's n: 0.0220

Culvert Type: Straight

Inlet Configuration: Mitered ($K_e=0.7$)

Inlet Depression: None

Roadway Data for Crossing: Culvert 7 (Triple 6' x 9' CMP)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

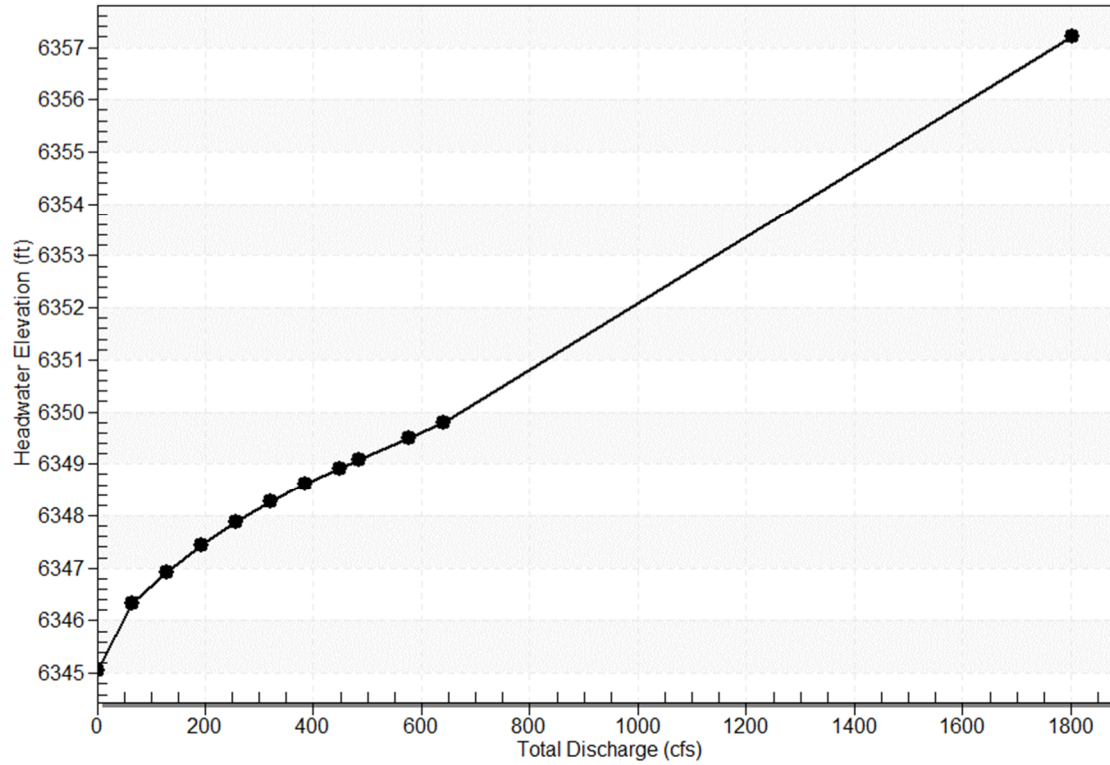
Crest Elevation: 6356.50 ft

Roadway Surface: Gravel

Roadway Top Width: 5.00 ft

Rating Curve Plot for Crossing: Culvert 7 (Triple 6' x 9' CMP)

Total Rating Curve
Crossing: Culvert 7 (Triple 6' x 9' CMP)



Costco Wholesale, Castle Rock, CO

CORE Project #: 20-224-05
Prepared By: LCC

SURFACE CONVEYANCE AND INLET CAPTURE SUMMARY

-REFERENCE Town of Castle Rock Storm Drainage Design and Technical Criteria Sections 7.3-7.5, 8.4-8.5

SUB-BASIN DATA					SURFACE CONVEYANCE						INLET CAPTURE							
Tributary Basins	Design Pt.	Area ac	Q5 cfs	Q100 cfs	Conveyance Element	Longitudinal Grade	Transverse Grade	Allow. Depth	Capacity	Calc. Method	Inlet Type	Inlet Size	Inlet Grade	Allow. Depth	Max Capture	Inlet Elevation	Max Pond Elevation	Calc. Method
A1	A1	0.15	0.58	1.14	Curb	1.0%	1.0%	0.50	5.7	MHFD-Inlet	Type R	5'	Sump	0.50	5.4	6380.40	6380.90	MHFD-Inlet
A2	A2	0.13	0.50	0.97	Curb	1.0%	1.0%	0.50	5.7	MHFD-Inlet	Type R	5'	Sump	0.50	5.4	6380.40	6380.90	MHFD-Inlet
A3	A3	0.12	0.49	0.96	Curb	1.0%	1.0%	0.50	5.7	MHFD-Inlet	Type R	5'	Sump	0.50	5.4	6380.40	6380.90	MHFD-Inlet
A4	A4	0.12	0.48	0.94	Curb	1.0%	1.0%	0.50	5.7	MHFD-Inlet	Type R	5'	Sump	0.50	5.4	6380.40	6380.90	MHFD-Inlet
A5	A5	0.29	1.07	2.09	Roof Drain													
A6	A6	0.20	0.78	1.52	Curb	1.0%	1.2%	0.50	3.3	MHFD-Inlet	Type R	5'	Sump	0.50	5.4	6380.10	6380.60	MHFD-Inlet
A7	A7	0.57	2.14	4.17	Roof Drain													
A8	A8	0.27	1.07	2.09	Curb	1.5%	1.8%	0.50	3.3	MHFD-Inlet	Type R	5'	Sump	0.50	5.4	6379.21	6379.71	MHFD-Inlet
A9	A9	0.57	2.15	4.20	Roof Drain													
A10	A10	0.30	1.14	2.23	Roof Drain													
A11	A11	0.12	0.47	0.91	Loading Dock Drain													
A12	A12	0.16	0.62	1.22	Curb	2.3%	2.2%	0.50	3.3	MHFD-Inlet	Type R	5'	Sump	0.41	5.4	6377.92	6378.33	MHFD-Inlet
A13	A13	0.15	0.59	1.16	Curb	1.9%	2.0%	0.50	3.3	MHFD-Inlet	Type R	5'	Sump	0.24	5.4	6377.60	6377.84	MHFD-Inlet
A14	A14	0.28	1.09	2.12	Curb	2.3%	4.0%	0.50	12.6	MHFD-Inlet	Type R	5'	On-Grade		2.2	6375.64	On-Grade	MHFD-Inlet
A15	A15	0.35	1.38	2.69	Curb	1.7%	1.0%	0.50	5.8	MHFD-Inlet	Type R	5'	On-Grade		2.8	6375.38	On-Grade	MHFD-Inlet
A16	A16	0.93	3.10	6.20	Curb	0.8%	1.4%	0.50	12.2	MHFD-Inlet	Type R	15'	Sump	0.50	9.7	6374.71	6375.21	MHFD-Inlet
A17	A17	1.05	3.72	7.36	Curb	0.8%	1.4%	0.50	15.9	MHFD-Inlet	Type R	10'	On-Grade		8.0	6375.81	On-Grade	MHFD-Inlet
A18	A18	0.53	1.74	3.52	Curb	0.9%	1.4%	0.50	13.0	MHFD-Inlet	Type R	10'	On-Grade		4.0	6376.86	On-Grade	MHFD-Inlet
B1.1	B1.1	0.36	1.40	2.73	Valley	1.0%	1.2%	0.25	11.6	Hydraflow	Area	2' Dia.	On-Grade		11.5	6378.89	On-Grade	Ch. 7, Sec 3.2.1
B1.2	B1.2	1.01	2.94	6.39	Valley	1.0%	1.2%	0.25	11.6	Hydraflow	Area	(4) 2' x 2'	Sump	0.43	11.5	6378.89	6379.32	Ch. 7, Sec 3.2.7
B2	B2	0.57	2.15	4.19	Roof Drain													
B3.1	B3.1	0.35	1.39	2.70	Valley	1.4%	1.4%	0.25	11.6	Hydraflow	Area	2' Dia.	On-Grade		5.7	6378.36	On-Grade	Ch. 7, Sec 3.2.1
B3.2	B3.2	1.12	3.34	7.19	Valley	1.4%	1.4%	0.25	11.6	Hydraflow	Area	(4) 2' x 2'	Sump	0.65	5.7	6378.36	6379.01	Ch. 7, Sec 3.2.7
B4	B4	0.57	2.13	4.16	Roof Drain													
B5	B5	0.13	0.53	1.02	Curb	4.8%	1.0%	0.50	4.2	MHFD-Inlet	Type R	5'	On-Grade		1.1	6380.00	On-Grade	MHFD-Inlet
B6	B6	0.97	3.54	6.97	Valley	1.5%	0.9%	0.25	13.6	Hydraflow	Area	(2) 2' x 2'	On-Grade		7.8	6379.06	On-Grade	Ch. 7, Sec 3.2.1
B7	B7	0.38	0.96	2.23	Valley	1.6%	0.9%	0.25	13.6	Hydraflow	Area	(2) 2' x 2'	On-Grade		2.5	6379.34	On-Grade	Ch. 7, Sec 3.2.1
B8	B8	0.55	2.03	4.06	Valley	1.0%	1.0%	0.25	11.6	Hydraflow	Area	(2) 2' x 2'	Sump	0.85	6.5	6378.12	6378.97	Ch. 7, Sec 3.2.7
B9.1	B9.1	0.36	1.42	2.77	Valley	1.6%	1.0%	0.25	11.6	Hydraflow	Area	2' Dia.	On-Grade		5.6	6377.99	On-Grade	Ch. 7, Sec 3.2.1
B9.2	B9.2	0.51	1.84	3.68	Valley	1.6%	1.0%	0.25	11.6	Hydraflow	Area	(4) 2' x 2'	Sump	0.63	5.6	6377.99	6378.62	Ch. 7, Sec 3.2.7
B10	B10	0.82	3.07	5.99	Roof Drain													
B11	B11	0.69	2.59	5.19	Valley	0.8%	1.8%	0.25	6.1	Hydraflow	Area	(4) 2' x 2'	Sump	0.46	6.3	6378.00	6378.46	Ch. 7, Sec 3.2.7
B12	B12	0.17	0.17	0.85	Swale	2.0%	10.0%	0.50	5.2	Hydraflow	Area	(2) 2' x 2'	Sump	0.50	1.5	6376.50	6377.00	MHFD-Inlet
B13	B13	0.34	1.36	2.65	Fuel Canopy Drain													
B14	B14	0.23	0.89	1.73	Curb	1.1%	1.0%	0.50	13.6	MHFD-Inlet	Type R	5'	Sump	0.50	5.4	6379.71	6380.21	MHFD-Inlet
B15	B15	0.45	1.67	3.35	Valley	0.8%	1.8%	0.25	6.1	Hydraflow	Area	(2) 2' x 2'	Sump	0.39	4.9	6377.85	6378.24	Ch. 7, Sec 3.2.7
B16	B16	0.46	1.80	3.53	Valley	0.9%	0.6%	0.50	11.6	Hydraflow	Area	(2) 2' x 2'	Sump	0.23	9.7	6377.98	6378.21	Ch. 7, Sec 3.2.1
B17	B17	0.72	2.76	5.49	Curb	1.0%	1.2%	0.50	11.6	MHFD-Inlet	Type R	15'	Sump	0.50	9.7	6376.80	6377.30	MHFD-Inlet
C1	C1	0.35	1.33	2.60	Curb	1.0%	1.0%	0.50	3.3	MHFD-Inlet	Type R	5'	On-Grade		1.8	6380.20	On-Grade	MHFD-Inlet
C2	C2	0.34	1.33	2.60	Curb	1.0%	1.0%	0.50	3.3	MHFD-Inlet	Type R	5'	On-Grade		1.8	6379.40	On-Grade	MHFD-Inlet

Shading Key

- 100-year design flow
- Capacity > design flow
- Ponding depth limited by local grading
- On-Grade Inlet: Allowable depth N/A

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlet A1 Curb	Inlet A1 Sump	Inlets A2-A4 Curb	Inlets A2-A4 Sump
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade	In Sump	On Grade	In Sump
Inlet Type		CDOT Type R Curb Opening		CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	0.6	0.6	0.5	0.5
Major Q_{Known} (cfs)	1.1	1.1	1.0	1.0

Bypass (Carry-Over) Flow from Upstream Inlets must be organized from upstream (left) to downstream (right) in order for bypass flows to be linked.

Receive Bypass Flow from:	User-Defined	User-Defined	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.2	0.2	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.5	0.5	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)				
Percent Impervious				
NRCS Soil Type				

Watershed Profile

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

Minor Storm Rainfall Input

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

Major Storm Rainfall Input

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

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.8	0.8	0.5	0.5
Major Total Design Peak Flow, Q (cfs)	1.6	1.6	1.0	1.0
Minor Flow Bypassed Downstream, Q_b (cfs)		N/A		N/A
Major Flow Bypassed Downstream, Q_b (cfs)		N/A		N/A

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlets A6, 8, 12-13 Curb	Inlets A6 A8 A12-13 Sump	Inlet A14	Inlet A15
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade	In Sump	On Grade	On Grade
Inlet Type		CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	1.1	1.1	1.1	1.4
Major Q_{Known} (cfs)	2.2	2.2	2.2	2.7

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)				
Percent Impervious				
NRCS Soil Type				

Watershed Profile

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

Minor Storm Rainfall Input

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

Major Storm Rainfall Input

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

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	1.1	1.1	1.1	1.4
Major Total Design Peak Flow, Q (cfs)	2.2	2.2	2.2	2.7
Minor Flow Bypassed Downstream, Q_b (cfs)		N/A	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)		N/A	0.0	0.0

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlet A18	Inlet A17	Inlet A16 Gutter	Inlet A16 Sump
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade	On Grade	On Grade	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening		CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	1.7	3.7	3.1	3.1
Major Q_{Known} (cfs)	3.5	7.4	6.2	6.2

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	Inlet A18	User-Defined	Inlet A17
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.3	0.3

Watershed Characteristics

Subcatchment Area (acres)				
Percent Impervious				
NRCS Soil Type				

Watershed Profile

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

Minor Storm Rainfall Input

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

Major Storm Rainfall Input

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

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	1.7	3.7	3.1	3.1
Major Total Design Peak Flow, Q (cfs)	3.5	7.4	6.5	6.5
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0		N/A
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.3		N/A

Inlet A1: Surface Conveyance (1/1)

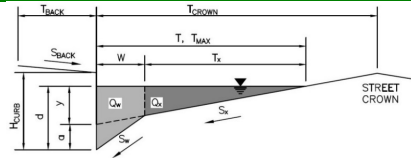
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A1 Curb



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_X = 0.010$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.010$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	10.0	20.0	ft
$d_{MAX} =$	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	1.20	2.40	inches
$d_c =$	2.0	2.0	inches
$a =$	1.75	1.75	inches
$d =$	2.95	4.15	inches
$T_X =$	8.0	18.0	ft
$E_o =$	0.696	0.362	
$Q_X =$	0.4	3.6	cfs
$Q_W =$	1.0	2.1	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	1.4	5.7	cfs
$V =$	2.9	3.9	fps
$V*d =$	0.7	1.4	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	35.4	35.4	ft
$T_{X TH} =$	33.4	33.4	ft
$E_o =$	0.189	0.189	
$Q_{X TH} =$	18.8	18.8	cfs
$Q_X =$	18.6	18.6	cfs
$Q_W =$	4.4	4.4	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	23.0	23.0	cfs
$V =$	5.2	5.2	fps
$V*d =$	2.6	2.6	
$R =$	1.00	1.00	
$Q_d =$	23.0	23.0	cfs
$d =$	6.00	6.00	inches
$d_{CROWN} =$	0.65	0.65	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	1.4	5.7	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.82 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.60 cfs on sheet 'Inlet Management'

Inlet A1: Inlet Capture (1/2)

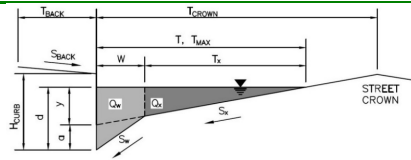
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A1 Sump



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_x = 0.010$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.000$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
$T_{MAX} =$	10.0	10.0	ft
$d_{MAX} =$	6.0	6.0	inches

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_x * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_w * 12$)
Gutter Depression ($d_c - (W * S_x * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_x
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	1.20	1.20	inches
$d_c =$	2.0	2.0	inches
$a =$	1.75	1.75	inches
$d =$	2.95	2.95	inches
$T_x =$	8.0	8.0	ft
$E_o =$	0.696	0.696	
$Q_X =$	0.0	0.0	cfs
$Q_W =$	0.0	0.0	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	SUMP	SUMP	cfs
$V =$	0.0	0.0	fps
$V*d =$	0.0	0.0	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_x$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	35.4	35.4	ft
$T_{X TH} =$	33.4	33.4	ft
$E_o =$	0.189	0.189	
$Q_{X TH} =$	0.0	0.0	cfs
$Q_X =$	0.0	0.0	cfs
$Q_W =$	0.0	0.0	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	SUMP	SUMP	cfs
$V =$	0.0	0.0	fps
$V*d =$	0.0	0.0	
$R =$	SUMP	SUMP	
$Q_d =$	SUMP	SUMP	cfs
$d =$			inches
$d_{CROWN} =$			inches

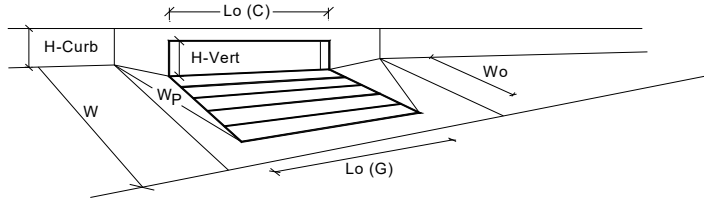
MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
$Q_{allow} =$	SUMP	SUMP	cfs

Inlet A1: Inlet Capture (2/2)

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information			MINOR	MAJOR	☒ Override Depths
Length of a Unit Grate		L _o (G) =	N/A	N/A	feet
Width of a Unit Grate		W _o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L _o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.67	0.67	
Grate Flow Analysis (Calculated)			MINOR	MAJOR	
Clogging Coefficient for Multiple Units		Coef =	N/A	N/A	
Clogging Factor for Multiple Units		Clog =	N/A	N/A	
Grate Capacity as a Weir (based on MHFD - CSU 2010 Study)			MINOR	MAJOR	
Interception without Clogging		Q _{wi} =	N/A	N/A	cfs
Interception with Clogging		Q _{wa} =	N/A	N/A	cfs
Grate Capacity as an Orifice (based on MHFD - CSU 2010 Study)			MINOR	MAJOR	
Interception without Clogging		Q _{oi} =	N/A	N/A	cfs
Interception with Clogging		Q _{oa} =	N/A	N/A	cfs
Grate Capacity as Mixed Flow			MINOR	MAJOR	
Interception without Clogging		Q _{mi} =	N/A	N/A	cfs
Interception with Clogging		Q _{ma} =	N/A	N/A	cfs
Resulting Grate Capacity (assumes clogged condition)		Q_{Grate} =	N/A	N/A	cfs
Curb Opening Flow Analysis (Calculated)			MINOR	MAJOR	
Clogging Coefficient for Multiple Units		Coef =	1.00	1.00	
Clogging Factor for Multiple Units		Clog =	0.10	0.10	
Curb Capacity as a Weir (based on MHFD - CSU 2010 Study)			MINOR	MAJOR	
Interception without Clogging		Q _{wi} =	6.0	6.0	cfs
Interception with Clogging		Q _{wa} =	5.4	5.4	cfs
Curb Capacity as an Orifice (based on MHFD - CSU 2010 Study)			MINOR	MAJOR	
Interception without Clogging		Q _{oi} =	9.8	9.8	cfs
Interception with Clogging		Q _{oa} =	8.8	8.8	cfs
Curb Opening Capacity as Mixed Flow			MINOR	MAJOR	
Interception without Clogging		Q _{mi} =	7.1	7.1	cfs
Interception with Clogging		Q _{ma} =	6.4	6.4	cfs
Resulting Curb Opening Capacity (assumes clogged condition)		Q_{Curb} =	5.4	5.4	cfs
Resultant Street Conditions			MINOR	MAJOR	
Total Inlet Length		L =	5.00	5.00	feet
Resultant Street Flow Spread (based on street geometry from above)		T =	35.4	35.4	ft. >T-Crown
Resultant Flow Depth at Street Crown		d _{CROWN} =	0.6	0.6	inches
Low Head Performance Reduction (Calculated)			MINOR	MAJOR	
Depth for Grate Midwidth		d _{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.33	0.33	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	1.00	1.00	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)			MINOR	MAJOR	
		Q_s =	5.4	5.4	cfs
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _{PEAK REQUIRED} =	0.8	1.6	cfs

Inlets A2-A4: Surface Conveyance (1/1)

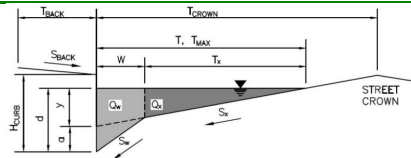
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlets A2-A4 Curb



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_X = 0.010$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.010$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	10.0	20.0	ft
$d_{MAX} =$	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	1.20	2.40	inches
$d_c =$	2.0	2.0	inches
$a =$	1.75	1.75	inches
$d =$	2.95	4.15	inches
$T_X =$	8.0	18.0	ft
$E_o =$	0.696	0.362	
$Q_X =$	0.4	3.6	cfs
$Q_W =$	1.0	2.1	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	1.4	5.7	cfs
$V =$	2.9	3.9	fps
$V*d =$	0.7	1.4	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	35.4	35.4	ft
$T_{X TH} =$	33.4	33.4	ft
$E_o =$	0.189	0.189	
$Q_{X TH} =$	18.8	18.8	cfs
$Q_X =$	18.6	18.6	cfs
$Q_W =$	4.4	4.4	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	23.0	23.0	cfs
$V =$	5.2	5.2	fps
$V*d =$	2.6	2.6	
$R =$	1.00	1.00	
$Q_d =$	23.0	23.0	cfs
$d =$	6.00	6.00	inches
$d_{CROWN} =$	0.65	0.65	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Spread Criterion

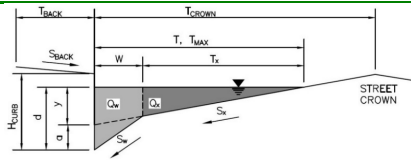
	Minor Storm	Major Storm	
$Q_{allow} =$	1.4	5.7	cfs

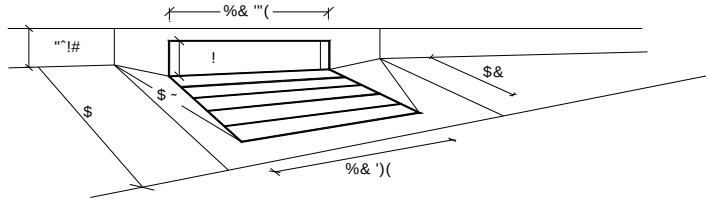
Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.52 cfs on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design peak flow of 0.99 cfs on sheet 'Inlet Management'

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

Project: Costco Dawson Trails
Inlet ID: Inlets A2-A4 Sump

[illegible]
$$\begin{array}{l} 143^* \quad 3^* \\ J3^* \quad 3^* \end{array} \quad \begin{array}{l} \cdot \quad \cdot \quad \$ \quad) \quad ^ \quad \cdot \quad \$ \\ \cdot \quad \cdot \quad \$ \quad) \quad ^ \quad \cdot \quad \$ \end{array}$$

$$14/:' 14 \quad 0 = 3^* \quad /3:' 134$$
[illegible]

Inlets A6, A8, A12-A13: Inlet Capture (1/2)
 Controlling max flows: Q5 = 1.1; Q100=2.2 (Inlet A8)
 Controlling grades: S0 = 1.0% Sx = 1.2%

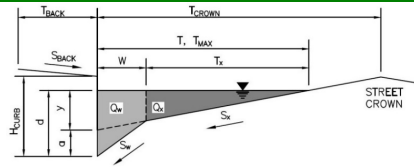
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlets A6, 8, 12-13 Curb



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
 Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
 Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

T_{BACK} = 0.0 ft
 S_{BACK} = ft/ft
 n_{BACK} =

Height of Curb at Gutter Flow Line
 Distance from Curb Face to Street Crown
 Gutter Width
 Street Transverse Slope
 Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
 Street Longitudinal Slope - Enter 0 for sump condition
 Manning's Roughness for Street Section (typically between 0.012 and 0.020)

H_{CURB} = 6.00 inches
 T_{CROWN} = 30.0 ft
 W = 2.00 ft
 S_x = 0.012 ft/ft
 S_w = 0.083 ft/ft
 S₀ = 0.010 ft/ft
 n_{STREET} = 0.016

Max. Allowable Spread for Minor & Major Storm
 Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
 Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
T _{MAX}	18.0	30.0	ft
d _{MAX}	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression (T * S_x * 12)
 Vertical Depth between Gutter Lip and Gutter Flowline (W * S_w * 12)
 Gutter Depression (d_c - (W * S_x * 12))
 Water Depth at Gutter Flowline (y + a)
 Allowable Spread for Discharge outside the Gutter Section (T - W)
 Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
 Discharge outside the Gutter Section, carried in Section T_x
 Discharge within the Gutter Section (Q_T - Q_X - Q_{BACK})
 Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
 Maximum Flow Based On Allowable Spread
 Flow Velocity within the Gutter Section
 V*d Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
y	2.59	4.32	inches
d _c	2.0	2.0	inches
a	1.70	1.70	inches
d	4.30	6.02	inches
T _x	16.0	28.0	ft
E ₀	0.382	0.217	
Q _X	3.6	15.9	cfs
Q _W	2.2	4.4	cfs
Q _{BACK}	0.0	0.0	cfs
Q _T	5.8	20.3	cfs
V	4.0	5.3	fps
V*d	1.4	2.6	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
 Theoretical Spread for Discharge outside the Gutter Section (T - W)
 Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
 Theoretical Discharge outside the Gutter Section, carried in Section T_x
 Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
 Discharge within the Gutter Section (Q_d - Q_X)
 Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
 Total Discharge for Major & Minor Storm (Pre-Safety Factor)
 Average Flow Velocity Within the Gutter Section
 V*d Product: Flow Velocity Times Gutter Flowline Depth
 Slope-Based Safety Factor for Minor/Major Storm depth reduction, d ≥ 6"
 Max Flow based on Allowable Depth (Safety Factor Applied)
 Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
 Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
T _{TH}	29.8	29.8	ft
T _X TH	27.8	27.8	ft
E ₀	0.218	0.218	
Q _X TH	15.7	15.7	cfs
Q _X	15.7	15.7	cfs
Q _W	4.4	4.4	cfs
Q _{BACK}	0.0	0.0	cfs
Q	20.0	20.0	cfs
V	5.2	5.2	fps
V*d	2.6	2.6	
R	1.00	1.00	
Q _d	20.0	20.0	cfs
d	6.00	6.00	inches
d _{CROWN}	0.00	0.00	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q _{allow}	5.8	20.0	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 1.13 cfs on sheet 'Inlet Management'
 Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.15 cfs on sheet 'Inlet Management'

Inlets A6, A8, A12-A13: Inlet Capture (1/2)
Controlling max flows: Q5 = 1.1; Q100=2.2 (Inlet A8)

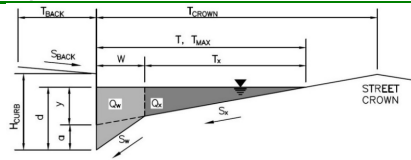
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlets A6 A8 A12-13 Sump



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

T_{BACK} = 0.0 ft
S_{BACK} = ft/ft
n_{BACK} =

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

H_{CURB} = 6.00 inches
T_{CROWN} = 30.0 ft
W = 2.00 ft
S_x = 0.012 ft/ft
S_w = 0.083 ft/ft
S_o = 0.000 ft/ft
n_{STREET} = 0.016

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
T _{MAX}	18.0	30.0	ft
d _{MAX}	6.0	6.0	inches

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression (T * S_x * 12)
Vertical Depth between Gutter Lip and Gutter Flowline (W * S_w * 12)
Gutter Depression (d_c - (W * S_x * 12))
Water Depth at Gutter Flowline (y + a)
Allowable Spread for Discharge outside the Gutter Section (T - W)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_x
Discharge within the Gutter Section (Q_T - Q_x - Q_{BACK})
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
V*d Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
y	2.59	4.32	inches
d _c	2.0	2.0	inches
a	1.70	1.70	inches
d	4.30	6.02	inches
T _x	16.0	28.0	ft
E _O	0.382	0.217	
Q _x	0.0	0.0	cfs
Q _w	0.0	0.0	cfs
Q _{BACK}	0.0	0.0	cfs
Q _T	SUMP	SUMP	cfs
V	0.0	0.0	fps
V*d	0.0	0.0	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section (T - W)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section T_{x TH}
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section (Q_d - Q_x)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
V*d Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, d ≥ 6"
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
T _{TH}	29.8	29.8	ft
T _{x TH}	27.8	27.8	ft
E _O	0.218	0.218	
Q _{x TH}	0.0	0.0	cfs
Q _x	0.0	0.0	cfs
Q _w	0.0	0.0	cfs
Q _{BACK}	0.0	0.0	cfs
Q	SUMP	SUMP	cfs
V	0.0	0.0	fps
V*d	0.0	0.0	
R	SUMP	SUMP	
Q _d	SUMP	SUMP	cfs
d			inches
d _{CROWN}			inches

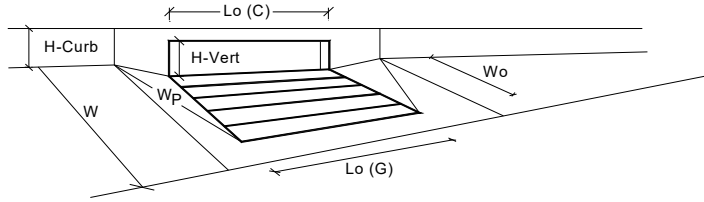
MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
Q _{allow}	SUMP	SUMP	cfs

Inlets A6, A8, A12-A13: Inlet Capture (2/2)
Controlling max flows: Q5 = 1.1; Q100=2.2 (Inlet A8)

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Inputs)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information		MINOR		MAJOR	
Length of a Unit Grate		L _o (G) =	N/A	N/A	feet
Width of a Unit Grate		W _o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	N/A	N/A	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		L _o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.67	0.67	
Grate Flow Analysis (Calculated)		MINOR		MAJOR	
Clogging Coefficient for Multiple Units		Coef =	N/A	N/A	
Clogging Factor for Multiple Units		Clog =	N/A	N/A	
Grate Capacity as a Weir (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q _{wi} =	N/A	N/A	cfs
Interception with Clogging		Q _{wa} =	N/A	N/A	cfs
Grate Capacity as an Orifice (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q _{oi} =	N/A	N/A	cfs
Interception with Clogging		Q _{oa} =	N/A	N/A	cfs
Grate Capacity as Mixed Flow		MINOR		MAJOR	
Interception without Clogging		Q _{mi} =	N/A	N/A	cfs
Interception with Clogging		Q _{ma} =	N/A	N/A	cfs
Resulting Grate Capacity (assumes clogged condition)		Q _{Grate} =	N/A	N/A	cfs
Curb Opening Flow Analysis (Calculated)		MINOR		MAJOR	
Clogging Coefficient for Multiple Units		Coef =	1.00	1.00	
Clogging Factor for Multiple Units		Clog =	0.10	0.10	
Curb Capacity as a Weir (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q _{wi} =	6.0	6.0	cfs
Interception with Clogging		Q _{wa} =	5.4	5.4	cfs
Curb Capacity as an Orifice (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q _{oi} =	9.8	9.8	cfs
Interception with Clogging		Q _{oa} =	8.8	8.8	cfs
Curb Opening Capacity as Mixed Flow		MINOR		MAJOR	
Interception without Clogging		Q _{mi} =	7.1	7.1	cfs
Interception with Clogging		Q _{ma} =	6.4	6.4	cfs
Resulting Curb Opening Capacity (assumes clogged condition)		Q _{Curb} =	5.4	5.4	cfs
Resultant Street Conditions		MINOR		MAJOR	
Total Inlet Length		L =	5.00	5.00	feet
Resultant Street Flow Spread (based on street geometry from above)		T =	29.8	29.8	ft
Resultant Flow Depth at Street Crown		d _{CROWN} =	0.0	0.0	inches
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		d _{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.33	0.33	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	1.00	1.00	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _s =	5.4	5.4	cfs
Q _{PEAK REQUIRED} =			1.1	2.2	cfs

Inlet A14: Surface Conveyance & Inlet Capture (1/2)

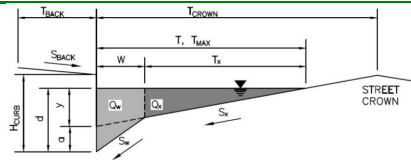
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A14



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 10.0$ ft
 $W = 2.00$ ft
 $S_X = 0.040$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.023$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	10.0	10.0	ft
$d_{MAX} =$	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	4.80	4.80	inches
$d_c =$	2.0	2.0	inches
$a =$	1.03	1.03	inches
$d =$	5.83	5.83	inches
$T_X =$	8.0	8.0	ft
$E_o =$	0.497	0.497	
$Q_X =$	6.4	6.4	cfs
$Q_W =$	6.3	6.3	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	12.6	12.6	cfs
$V =$	7.8	7.8	fps
$V*d =$	3.8	3.8	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	10.4	10.4	ft
$T_{X TH} =$	8.4	8.4	ft
$E_o =$	0.482	0.482	
$Q_{X TH} =$	7.1	7.1	cfs
$Q_X =$	7.1	7.1	cfs
$Q_W =$	6.6	6.6	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	13.8	13.8	cfs
$V =$	8.0	8.0	fps
$V*d =$	4.0	4.0	
$R =$	0.92	0.92	
$Q_d =$	12.7	12.7	cfs
$d =$	5.84	5.84	inches
$d_{CROWN} =$	0.01	0.01	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	12.6	12.6	cfs

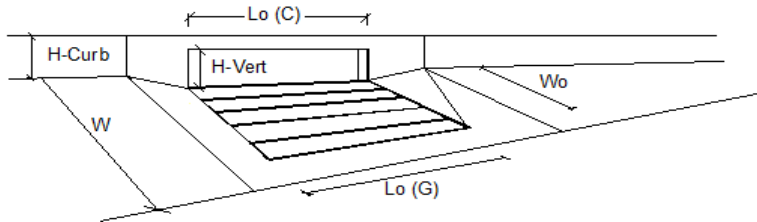
Minor storm max. allowable capacity GOOD - greater than the design peak flow of 1.14 cfs on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.17 cfs on sheet 'Inlet Management'

Inlet A14: Surface Conveyance & Inlet Capture (2/2)

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR	
Design Discharge for Half of Street (from Inlet Management)		Q _o =	1.1	2.2	cfs
Water Spread Width		T =	3.3	4.7	ft
Water Depth at Flowline (outside of local depression)		d =	2.6	3.3	inches
Water Depth at Street Crown (or at T _{MAX})		d _{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E _o =	0.953	0.843	
Discharge outside the Gutter Section W, carried in Section T _x		Q _x =	0.1	0.3	cfs
Discharge within the Gutter Section W		Q _w =	1.1	1.8	cfs
Discharge Behind the Curb Face		Q _{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A _W =	0.27	0.38	sq ft
Velocity within the Gutter Section W		V _W =	4.0	4.8	fps
Water Depth for Design Condition		d _{LOCAL} =	5.6	6.3	inches
Grate Analysis (Calculated)		MINOR		MAJOR	
Total Length of Inlet Grate Opening		L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow		E _{o-GRATE} =	N/A	N/A	
Under No-Clogging Condition		MINOR		MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V _o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R _f =	N/A	N/A	
Interception Rate of Side Flow		R _s =	N/A	N/A	
Interception Capacity		Q _i =	N/A	N/A	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoeff =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L _e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins		V _o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R _f =	N/A	N/A	
Interception Rate of Side Flow		R _s =	N/A	N/A	
Actual Interception Capacity		Q _a =	N/A	N/A	cfs
Carry-Over Flow = Q _o - Q _a (to be applied to curb opening or next d/s inlet)		Q _b =	N/A	N/A	cfs
Curb Opening or Slotted Inlet Analysis (Calculated)		MINOR		MAJOR	
Equivalent Slope S _e		S _e =	0.200	0.182	ft/ft
Required Length L _T to Have 100% Interception		L _T =	4.58	6.66	ft
Under No-Clogging Condition		MINOR		MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L _T)		L =	4.58	6.66	ft
Interception Capacity		Q _i =	1.1	2.2	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient		CurbCoeff =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	0.06	0.06	
Effective (Unclogged) Length		L _e =	4.58	6.66	ft
Actual Interception Capacity		Q _a =	1.1	2.2	cfs
Carry-Over Flow = Q _o (GRATE) - Q _a		Q _b =	0.0	0.0	cfs
Summary		MINOR		MAJOR	
Total Inlet Interception Capacity		Q =	1.1	2.2	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	0.0	cfs
Capture Percentage = Q _a /Q _o		C% =	100	100	%

Inlet A15: Surface Conveyance & Inlet Capture (1/2)

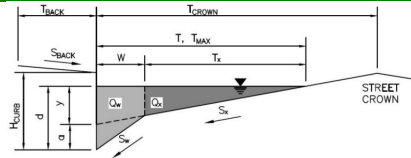
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A15



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 18.0$ ft
 $W = 2.00$ ft
 $S_x = 0.010$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.017$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	18.0	18.0	ft
$d_{MAX} =$	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_x * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_w * 12$)
Gutter Depression ($d_c - (W * S_x * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_x
Discharge within the Gutter Section ($Q_T - Q_x - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	2.16	2.16	inches
$d_c =$	2.0	2.0	inches
$a =$	1.75	1.75	inches
$d =$	3.91	3.91	inches
$T_x =$	16.0	16.0	ft
$E_o =$	0.406	0.406	
$Q_x =$	3.4	3.4	cfs
$Q_w =$	2.4	2.4	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	5.8	5.8	cfs
$V =$	4.8	4.8	fps
$V*d =$	1.6	1.6	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section T_{XTH}
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_x$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	35.4	35.4	ft
$T_{XTH} =$	33.4	33.4	ft
$E_o =$	0.189	0.189	
$Q_{XTH} =$	24.5	24.5	cfs
$Q_x =$	20.2	20.2	cfs
$Q_w =$	5.7	5.7	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	25.9	25.9	cfs
$V =$	6.8	6.8	fps
$V*d =$	3.4	3.4	
$R =$	1.00	1.00	
$Q_d =$	25.9	25.9	cfs
$d =$	6.00	6.00	inches
$d_{CROWN} =$	2.09	2.09	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	5.8	5.8	cfs

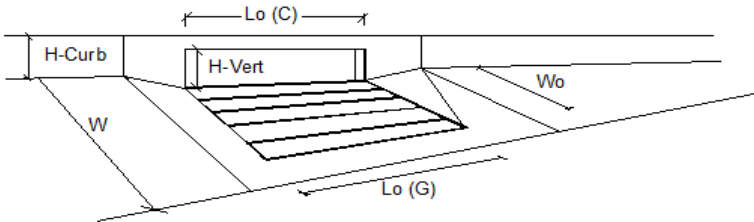
Minor storm max. allowable capacity GOOD - greater than the design peak flow of 1.40 cfs on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design peak flow of 2.70 cfs on sheet 'Inlet Management'

Inlet A15: Surface Conveyance & Inlet Capture (2/2)

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR	
Design Discharge for Half of Street (from <i>Inlet Management</i>)		Q _o =	1.4	2.7	cfs
Water Spread Width		T =	8.6	12.6	ft
Water Depth at Flowline (outside of local depression)		d =	2.8	3.3	inches
Water Depth at Street Crown (or at T _{MAX})		d _{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E _o =	0.769	0.579	
Discharge outside the Gutter Section W, carried in Section T _x		Q _x =	0.3	1.1	cfs
Discharge within the Gutter Section W		Q _w =	1.1	1.6	cfs
Discharge Behind the Curb Face		Q _{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A _W =	0.30	0.38	sq ft
Velocity within the Gutter Section W		V _W =	3.6	4.1	fps
Water Depth for Design Condition		d _{LOCAL} =	5.8	6.3	inches
Grate Analysis (Calculated)		MINOR		MAJOR	
Total Length of Inlet Grate Opening		L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow		E _{G-GRATE} =	N/A	N/A	
Under No-Clogging Condition		MINOR		MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V _o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R _f =	N/A	N/A	
Interception Rate of Side Flow		R _s =	N/A	N/A	
Interception Capacity		Q _i =	N/A	N/A	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoeff =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L _e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins		V _o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R _f =	N/A	N/A	
Interception Rate of Side Flow		R _s =	N/A	N/A	
Actual Interception Capacity		Q _a =	N/A	N/A	cfs
Carry-Over Flow = Q _o - Q _a (to be applied to curb opening or next d/s inlet)		Q _b =	N/A	N/A	cfs
Curb Opening or Slotted Inlet Analysis (Calculated)		MINOR		MAJOR	
Equivalent Slope S _e		S _e =	0.162	0.125	ft/ft
Required Length L _T to Have 100% Interception		L _T =	5.51	8.70	ft
Under No-Clogging Condition		MINOR		MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L _T)		L =	5.51	8.70	ft
Interception Capacity		Q _i =	1.4	2.7	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient		CurbCoeff =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	0.06	0.06	
Effective (Unclogged) Length		L _e =	5.51	8.70	ft
Actual Interception Capacity		Q _a =	1.4	2.7	cfs
Carry-Over Flow = Q _o (GRATE) - Q _a		Q _b =	0.0	0.0	cfs
Summary		MINOR		MAJOR	
Total Inlet Interception Capacity		Q =	1.4	2.7	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	0.0	cfs
Capture Percentage = Q _a /Q _o		C% =	100	100	%

Inlet A18: Surface Conveyance & Inlet Capture (1/2)

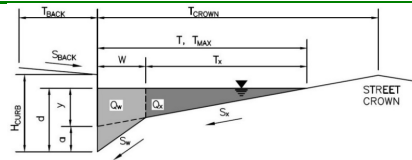
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A18



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_X = 0.014$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.009$ ft/ft
 $n_{STREET} = 0.020$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	18.0	30.0	ft
$d_{MAX} =$	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	3.02	5.04	inches
$d_c =$	2.0	2.0	inches
$a =$	1.66	1.66	inches
$d =$	4.68	6.70	inches
$T_X =$	16.0	28.0	ft
$E_o =$	0.364	0.209	
$Q_X =$	3.5	15.6	cfs
$Q_W =$	2.0	4.1	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	5.5	19.7	cfs
$V =$	3.3	4.3	fps
$V*d =$	1.3	2.4	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section T_{XTH}
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	25.9	25.9	ft
$T_{XTH} =$	23.9	23.9	ft
$E_o =$	0.246	0.246	
$Q_{XTH} =$	10.2	10.2	cfs
$Q_X =$	10.2	10.2	cfs
$Q_W =$	3.3	3.3	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	13.5	13.5	cfs
$V =$	4.0	4.0	fps
$V*d =$	2.0	2.0	
$R =$	1.00	1.00	
$Q_d =$	13.5	13.5	cfs
$d =$	6.00	6.00	inches
$d_{CROWN} =$	0.00	0.00	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

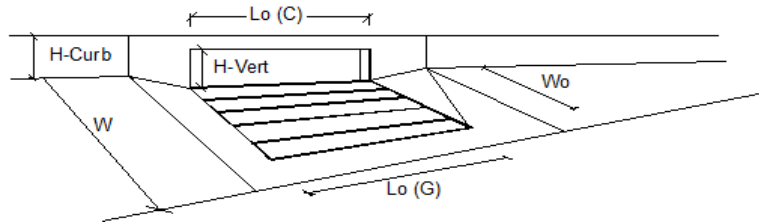
	Minor Storm	Major Storm	
$Q_{allow} =$	5.5	13.5	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 1.74 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 3.52 cfs on sheet 'Inlet Management'

Inlet A18: Surface Conveyance & Inlet Capture (2/2)

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR	
Design Discharge for Half of Street (from Inlet Management)		Q _o =	1.7	3.5	cfs
Water Spread Width		T =	10.7	14.9	ft
Water Depth at Flowline (outside of local depression)		d =	3.5	4.2	inches
Water Depth at Street Crown (or at T _{MAX})		d _{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E _o =	0.599	0.442	
Discharge outside the Gutter Section W, carried in Section T _x		Q _x =	0.7	2.0	cfs
Discharge within the Gutter Section W		Q _w =	1.0	1.6	cfs
Discharge Behind the Curb Face		Q _{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A _w =	0.41	0.53	sq ft
Velocity within the Gutter Section W		V _w =	2.5	3.0	fps
Water Depth for Design Condition		d _{LOCAL} =	6.5	7.2	inches
Grate Analysis (Calculated)		MINOR		MAJOR	
Total Length of Inlet Grate Opening		L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow		E _{o-GRATE} =	N/A	N/A	
Under No-Clogging Condition		MINOR		MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V _o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R _f =	N/A	N/A	
Interception Rate of Side Flow		R _s =	N/A	N/A	
Interception Capacity		Q _i =	N/A	N/A	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoeff =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L _e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins		V _o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R _f =	N/A	N/A	
Interception Rate of Side Flow		R _s =	N/A	N/A	
Actual Interception Capacity		Q _a =	N/A	N/A	cfs
Carry-Over Flow = Q _o - Q _a (to be applied to curb opening or next d/s inlet)		Q _b =	N/A	N/A	cfs
Curb Opening or Slotted Inlet Analysis (Calculated)		MINOR		MAJOR	
Equivalent Slope S _e		S _e =	0.130	0.100	ft/ft
Required Length L _T to Have 100% Interception		L _T =	5.92	9.59	ft
Under No-Clogging Condition		MINOR		MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L _T)		L =	5.92	9.59	ft
Interception Capacity		Q _i =	1.7	3.5	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient		CurbCoeff =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	0.06	0.06	
Effective (Unclogged) Length		L _e =	5.92	9.38	ft
Actual Interception Capacity		Q _a =	1.7	3.5	cfs
Carry-Over Flow = Q _o (GRATE) - Q _a		Q _b =	0.0	0.0	cfs
Summary		MINOR		MAJOR	
Total Inlet Interception Capacity		Q =	1.7	3.5	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.0	0.0	cfs
Capture Percentage = Q _a /Q _o		C% =	100	100	%

Inlet A17: Surface Conveyance & Inlet Capture (1/2)

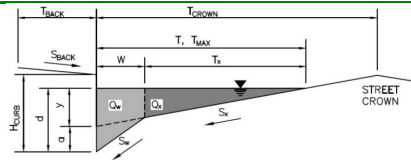
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A17



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_x = 0.014$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.008$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	18.0	30.0	ft
$d_{MAX} =$	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_x * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_w * 12$)
Gutter Depression ($d_c - (W * S_x * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_x
Discharge within the Gutter Section ($Q_T - Q_x - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	3.02	5.04	inches
$d_c =$	2.0	2.0	inches
$a =$	1.66	1.66	inches
$d =$	4.68	6.70	inches
$T_x =$	16.0	28.0	ft
$E_o =$	0.364	0.209	
$Q_x =$	4.1	18.4	cfs
$Q_w =$	2.4	4.9	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	6.5	23.3	cfs
$V =$	3.9	5.1	fps
$V*d =$	1.5	2.9	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section T_{XTH}
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_x$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	25.9	25.9	ft
$T_{XTH} =$	23.9	23.9	ft
$E_o =$	0.246	0.246	
$Q_{XTH} =$	12.0	12.0	cfs
$Q_x =$	12.0	12.0	cfs
$Q_w =$	3.9	3.9	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	15.9	15.9	cfs
$V =$	4.7	4.7	fps
$V*d =$	2.3	2.3	
$R =$	1.00	1.00	
$Q_d =$	15.9	15.9	cfs
$d =$	6.00	6.00	inches
$d_{CROWN} =$	0.00	0.00	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

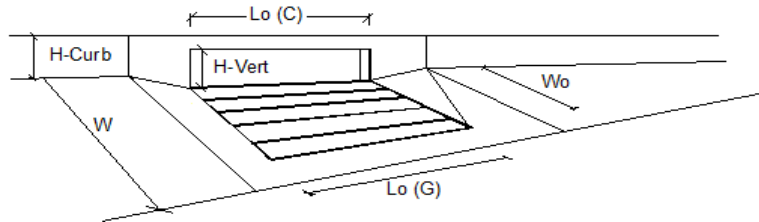
	Minor Storm	Major Storm	
$Q_{allow} =$	6.5	15.9	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 3.72 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 7.36 cfs on sheet 'Inlet Management'

Inlet A17: Surface Conveyance & Inlet Capture (2/2)

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		N_o =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	15.00	15.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR	
Design Discharge for Half of Street (from <i>Inlet Management</i>)		Q_o =	3.7	7.4	cfs
Water Spread Width		T =	14.2	19.0	ft
Water Depth at Flowline (outside of local depression)		d =	4.0	4.8	inches
Water Depth at Street Crown (or at T_{MAX})		d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E_o =	0.464	0.344	
Discharge outside the Gutter Section W, carried in Section T_x		Q_x =	2.0	4.8	cfs
Discharge within the Gutter Section W		Q_w =	1.7	2.5	cfs
Discharge Behind the Curb Face		Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A_w =	0.51	0.64	sq ft
Velocity within the Gutter Section W		V_w =	3.4	3.9	fps
Water Depth for Design Condition		d_{LOCAL} =	7.0	7.8	inches
Grate Analysis (Calculated)		MINOR		MAJOR	
Total Length of Inlet Grate Opening		L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow		$E_{O-GRATE}$ =	N/A	N/A	
Under No-Clogging Condition		MINOR		MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R_f =	N/A	N/A	
Interception Rate of Side Flow		R_s =	N/A	N/A	
Interception Capacity		Q_i =	N/A	N/A	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoeff =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L_e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins		V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R_f =	N/A	N/A	
Interception Rate of Side Flow		R_s =	N/A	N/A	
Actual Interception Capacity		Q_a =	N/A	N/A	cfs
Carry-Over Flow = $Q_o - Q_a$ (to be applied to curb opening or next d/s inlet)		Q_b =	N/A	N/A	cfs
Curb Opening or Slotted Inlet Analysis (Calculated)		MINOR		MAJOR	
Equivalent Slope S_e		S_e =	0.104	0.081	ft/ft
Required Length L_T to Have 100% Interception		L_T =	10.65	16.96	ft
Under No-Clogging Condition		MINOR		MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L , L_T)		L =	10.65	15.00	ft
Interception Capacity		Q_i =	3.7	7.2	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient		CurbCoeff =	1.31	1.31	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	0.04	0.04	
Effective (Unclogged) Length		L_e =	10.65	14.35	ft
Actual Interception Capacity		Q_a =	3.7	7.1	cfs
Carry-Over Flow = $Q_o - Q_a$		Q_b =	0.0	0.3	cfs
Summary		MINOR		MAJOR	
Total Inlet Interception Capacity		Q =	3.7	7.1	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.3	cfs
Capture Percentage = Q_o/Q_o		C% =	100	97	%

Inlet A16: Surface Conveyance (1/1)

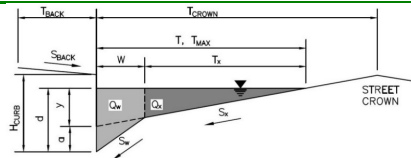
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A16 Gutter



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_X = 0.020$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.008$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
T_{MAX}	30.0	30.0	ft
d_{MAX}	6.0	6.0	inches
	☐	☒	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
y	7.20	7.20	inches
d_c	2.0	2.0	inches
a	1.51	1.51	inches
d	8.71	8.71	inches
T_X	28.0	28.0	ft
E_O	0.194	0.194	
Q_X	33.3	33.3	cfs
Q_W	8.0	8.0	cfs
Q_{BACK}	0.0	0.0	cfs
Q_T	41.4	41.4	cfs
V	6.2	6.2	fps
$V*d$	4.5	4.5	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
T_{TH}	18.7	18.7	ft
$T_{X TH}$	16.7	16.7	ft
E_O	0.318	0.318	
$Q_{X TH}$	8.4	8.4	cfs
Q_X	8.4	8.4	cfs
Q_W	3.9	3.9	cfs
Q_{BACK}	0.0	0.0	cfs
Q	12.3	12.3	cfs
V	4.7	4.7	fps
$V*d$	2.3	2.3	
R	1.00	1.00	
Q_d	12.3	12.3	cfs
d	6.00	6.00	inches
d_{CROWN}	0.00	0.00	inches

MINOR STORM Allowable Capacity is based on Depth Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q_{allow}	12.3	12.3	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 3.10 cfs on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design peak flow of 6.50 cfs on sheet 'Inlet Management'

Inlet A16: Inlet Capture (1/2)

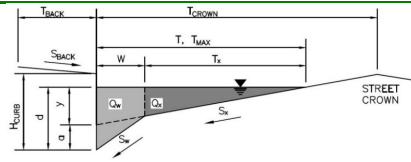
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet A16 Sump



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_x = 0.014$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.000$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
$T_{MAX} =$	18.0	30.0	ft
$d_{MAX} =$	6.0	6.0	inches

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_x * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_w * 12$)
Gutter Depression ($d_c - (W * S_x * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_x
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	3.02	5.04	inches
$d_c =$	2.0	2.0	inches
$a =$	1.66	1.66	inches
$d =$	4.68	6.70	inches
$T_x =$	16.0	28.0	ft
$E_o =$	0.364	0.209	
$Q_X =$	0.0	0.0	cfs
$Q_W =$	0.0	0.0	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	SUMP	SUMP	cfs
$V =$	0.0	0.0	fps
$V*d =$	0.0	0.0	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_x$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	25.9	25.9	ft
$T_{X TH} =$	23.9	23.9	ft
$E_o =$	0.246	0.246	
$Q_{X TH} =$	0.0	0.0	cfs
$Q_X =$	0.0	0.0	cfs
$Q_W =$	0.0	0.0	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	SUMP	SUMP	cfs
$V =$	0.0	0.0	fps
$V*d =$	0.0	0.0	
$R =$	SUMP	SUMP	
$Q_d =$	SUMP	SUMP	cfs
$d =$			inches
$d_{CROWN} =$			inches

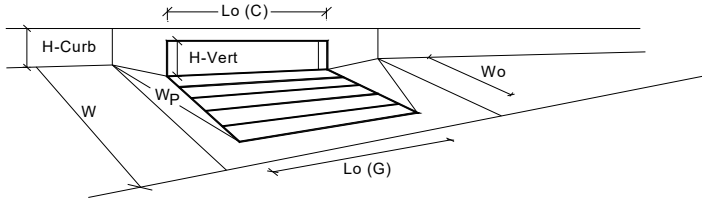
MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
$Q_{allow} =$	SUMP	SUMP	cfs

Inlet A16: Inlet Capture (2/2)

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Inputs)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information		MINOR		MAJOR	
Length of a Unit Grate		$L_o (G)$ =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		$C_f (G)$ =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		$C_w (G)$ =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		$C_o (G)$ =	N/A	N/A	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		$L_o (C)$ =	15.00	15.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		$C_f (C)$ =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		$C_w (C)$ =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		$C_o (C)$ =	0.67	0.67	
Grate Flow Analysis (Calculated)		MINOR		MAJOR	
Clogging Coefficient for Multiple Units		Coef =	N/A	N/A	
Clogging Factor for Multiple Units		Clog =	N/A	N/A	
Grate Capacity as a Weir (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q_{wi} =	N/A	N/A	cfs
Interception with Clogging		Q_{wa} =	N/A	N/A	cfs
Grate Capacity as an Orifice (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q_{oi} =	N/A	N/A	cfs
Interception with Clogging		Q_{oa} =	N/A	N/A	cfs
Grate Capacity as Mixed Flow		MINOR		MAJOR	
Interception without Clogging		Q_{mi} =	N/A	N/A	cfs
Interception with Clogging		Q_{ma} =	N/A	N/A	cfs
Resulting Grate Capacity (assumes clogged condition)		Q_{Grate} =	N/A	N/A	cfs
Curb Opening Flow Analysis (Calculated)		MINOR		MAJOR	
Clogging Coefficient for Multiple Units		Coef =	1.31	1.31	
Clogging Factor for Multiple Units		Clog =	0.04	0.04	
Curb Capacity as a Weir (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q_{wi} =	10.2	10.2	cfs
Interception with Clogging		Q_{wa} =	9.7	9.7	cfs
Curb Capacity as an Orifice (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging		Q_{oi} =	29.3	29.3	cfs
Interception with Clogging		Q_{oa} =	28.0	28.0	cfs
Curb Opening Capacity as Mixed Flow		MINOR		MAJOR	
Interception without Clogging		Q_{mi} =	16.0	16.0	cfs
Interception with Clogging		Q_{ma} =	15.3	15.3	cfs
Resulting Curb Opening Capacity (assumes clogged condition)		Q_{Curb} =	9.7	9.7	cfs
Resultant Street Conditions		MINOR		MAJOR	
Total Inlet Length		L =	15.00	15.00	feet
Resultant Street Flow Spread (based on street geometry from above)		T =	25.9	25.9	ft
Resultant Flow Depth at Street Crown		d_{CROWN} =	0.0	0.0	inches
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.33	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	0.79	0.79	
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q_s =	9.7	9.7	cfs
		$Q_{PEAK REQUIRED}$ =	3.1	6.5	cfs

Inlets B5, B12, B14, B17 Capture & Bypass Summary (1/1)

MHFD-Inlet, Version 5.03 (August 2023)

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlet B5	Inlet B12	Inlet B14-Gutter	Inlet B14-Sump	Inlet B17-Gutter	Inlet B17 Sump
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	AREA	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade	Swale	On Grade	In Sump	On Grade	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type C		CDOT Type R Curb Opening		CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	0.5	0.2	0.9	0.9	2.8	2.8
Major Q_{Known} (cfs)	1.0	0.9	1.7	1.7	5.5	5.5

Bypass (Carry-Over) Flow from Upstream

Inlets must be organized from upstream (left) to downstream (right) in order for bypass flows to be linked.

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)						
Percent Impervious						
NRCS Soil Type						

Watershed Profile

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

Minor Storm Rainfall Input

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

Major Storm Rainfall Input

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

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.5	0.2	0.9	0.9	2.8	2.8
Major Total Design Peak Flow, Q (cfs)	1.0	0.9	1.7	1.7	5.5	5.5
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0		N/A		N/A
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0		N/A		N/A

Inlet B5: Surface Conveyance & Inlet Capture (1/2)

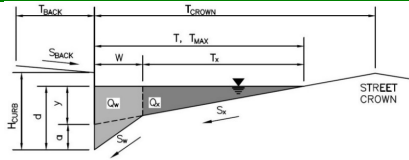
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet B5



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 12.0$ ft
 $W = 2.00$ ft
 $S_X = 0.010$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.048$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
T_{MAX}	12.0	12.0	ft
d_{MAX}	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
y	1.44	1.44	inches
d_c	2.0	2.0	inches
a	1.75	1.75	inches
d	3.19	3.19	inches
T_X	10.0	10.0	ft
E_o	0.603	0.603	
Q_X	1.7	1.7	cfs
Q_W	2.5	2.5	cfs
Q_{BACK}	0.0	0.0	cfs
Q_T	4.2	4.2	cfs
V	6.8	6.8	fps
$V*d$	1.8	1.8	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
T_{TH}	35.4	35.4	ft
$T_{X TH}$	33.4	33.4	ft
E_o	0.189	0.189	
$Q_{X TH}$	41.2	41.2	cfs
Q_X	25.2	25.2	cfs
Q_W	9.6	9.6	cfs
Q_{BACK}	0.0	0.0	cfs
Q	34.8	34.8	cfs
V	11.5	11.5	fps
$V*d$	5.7	5.7	
R	0.51	0.51	
Q_d	17.8	17.8	cfs
d	4.74	4.74	inches
d_{CROWN}	1.55	1.55	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Spread Criterion

	Minor Storm	Major Storm	
Q_{allow}	4.2	4.2	cfs

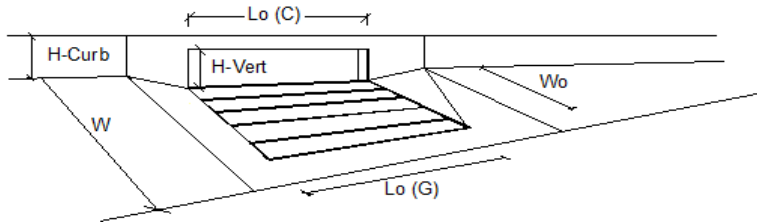
Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.53 cfs on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.02 cfs on sheet 'Inlet Management'

Inlet B5: Surface Conveyance & Inlet Capture (2/2)

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.03 (August 2023)



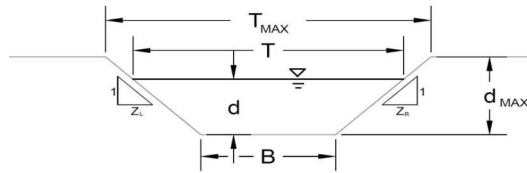
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')		a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		N_o =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L_o =	10.00	10.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		$C_f (G)$ =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		$C_f (C)$ =	0.10	0.10	
Street Hydraulics: OK - $Q < \text{Allowable Street Capacity}$		MINOR		MAJOR	
Design Discharge for Half of Street (from <i>Inlet Management</i>)		Q_o =	0.5	1.0	cfs
Water Spread Width		T =	1.7	2.2	ft
Water Depth at Flowline (outside of local depression)		d =	2.0	2.0	inches
Water Depth at Street Crown (or at T_{MAX})		d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow		E_o =	1.000	1.000	
Discharge outside the Gutter Section W, carried in Section T_x		Q_x =	0.0	0.0	cfs
Discharge within the Gutter Section W		Q_w =	0.5	1.0	cfs
Discharge Behind the Curb Face		Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W		A_W =	0.00	0.17	sq ft
Velocity within the Gutter Section W		V_W =	0.0	6.0	fps
Water Depth for Design Condition		d_{LOCAL} =	5.0	5.0	inches
Grate Analysis (Calculated)		MINOR		MAJOR	
Total Length of Inlet Grate Opening		L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow		$E_{O-GRATE}$ =	N/A	N/A	
Under No-Clogging Condition		MINOR		MAJOR	
Minimum Velocity Where Grate Splash-Over Begins		V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R_f =	N/A	N/A	
Interception Rate of Side Flow		R_s =	N/A	N/A	
Interception Capacity		Q_i =	N/A	N/A	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet		GrateCoeff =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet		GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet		L_e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins		V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow		R_f =	N/A	N/A	
Interception Rate of Side Flow		R_s =	N/A	N/A	
Actual Interception Capacity		Q_a =	N/A	N/A	cfs
Carry-Over Flow = $Q_o - Q_a$ (to be applied to curb opening or next d/s inlet)		Q_b =	N/A	N/A	cfs
Curb Opening or Slotted Inlet Analysis (Calculated)		MINOR		MAJOR	
Equivalent Slope S_e		S_e =	0.208	0.208	ft/ft
Required Length L_T to Have 100% Interception		L_T =	3.18	4.44	ft
Under No-Clogging Condition		MINOR		MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L , L_T)		L =	3.18	4.44	ft
Interception Capacity		Q_i =	0.5	1.0	cfs
Under Clogging Condition		MINOR		MAJOR	
Clogging Coefficient		CurbCoeff =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet		CurbClog =	0.06	0.06	
Effective (Unclogged) Length		L_e =	3.18	4.44	ft
Actual Interception Capacity		Q_a =	0.5	1.0	cfs
Carry-Over Flow = $Q_o - Q_a$		Q_b =	0.0	0.0	cfs
Summary		MINOR		MAJOR	
Total Inlet Interception Capacity		Q =	0.5	1.0	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q_b =	0.0	0.0	cfs
Capture Percentage = Q_o/Q_o		$C\%$ =	100	100	%

Inlet B12: Surface Conveyance & Inlet Capture (1/2)

MHFD-Inlet, Version 5.03 (August 2023)

AREA INLET IN A SWALE

Costco Dawson Trails
Inlet B12



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)

Manning's n (Leave cell D16 blank to manually enter an n value)

Channel Invert Slope

Bottom Width

Left Side Slope

Right Side Slope

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

A, B, C, D, or E =

n =	0.030	
S_0 =	0.0100	ft/ft
B =	2.00	ft
Z1 =	5.00	ft/ft
Z2 =	5.00	ft/ft

Choose One:

- ☒ Non-Cohesive
☒ Cohesive
☒ Paved

Maximum Allowable Top Width of Channel for Minor & Major Storm

Maximum Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
T_{MAX} =	10.00	10.00	ft
d_{MAX} =	0.50	0.50	ft

Maximum Channel Capacity Based On Allowable Top Width

Maximum Allowable Top Width

Water Depth

Flow Area

Wetted Perimeter

Hydraulic Radius

Manning's n

Flow Velocity

Velocity-Depth Product

Hydraulic Depth

Froude Number

Maximum Flow Based on Allowable Water Depth

	Minor Storm	Major Storm	
T_{MAX} =	10.00	10.00	ft
d =	0.80	0.80	ft
A =	4.80	4.80	sq ft
P =	10.16	10.16	ft
R =	0.47	0.47	ft
n =	0.030	0.030	
V =	3.01	3.01	fps
VR =	1.42	1.42	ft ² /s
D =	0.48	0.48	ft
Fr =	0.77	0.77	
Q_T =	14.5	14.5	cfs

Maximum Channel Capacity Based On Allowable Water Depth

Maximum Allowable Water Depth

Top Width

Flow Area

Wetted Perimeter

Hydraulic Radius

Manning's n

Flow Velocity

Velocity-Depth Product

Hydraulic Depth

Froude Number

Maximum Flow Based On Allowable Water Depth

	Minor Storm	Major Storm	
d_{MAX} =	0.50	0.50	ft
T =	7.00	7.00	ft
A =	2.25	2.25	sq ft
P =	7.10	7.10	ft
R =	0.32	0.32	ft
n =	0.030	0.030	
V =	2.31	2.31	fps
VR =	0.73	0.73	ft ² /s
D =	0.32	0.32	ft
Fr =	0.72	0.72	
Q_d =	5.2	5.2	cfs

Allowable Channel Capacity Based On Channel Geometry

MINOR STORM Allowable Capacity is based on Depth Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q_{allow} =	5.2	5.2	cfs
d_{allow} =	0.50	0.50	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow

Water Depth

Top Width

Flow Area

Wetted Perimeter

Hydraulic Radius

Manning's n

Flow Velocity

Velocity-Depth Product

Hydraulic Depth

Froude Number

	Minor Storm	Major Storm	
Q_o =	0.2	0.9	cfs
d =	0.08	0.20	ft
T =	2.83	4.02	ft
A =	0.20	0.61	sq ft
P =	2.85	4.06	ft
R =	0.07	0.15	ft
n =	0.030	0.030	
V =	0.85	1.40	fps
VR =	0.06	0.21	ft ² /s
D =	0.07	0.15	ft
Fr =	0.56	0.63	

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

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

Inlet B12: Surface Conveyance & Inlet Capture (2/2)

MHFD-Inlet, Version 5.03 (August 2023)

AREA INLET IN A SWALE

Costco Dawson Trails

Inlet B12

Inlet Design Information (Input)

Type of Inlet

CDOT Type C

Inlet Type =

CDOT Type C

Angle of Inclined Grate (must be ≤ 30 degrees)

Width of Grate

Length of Grate

Open Area Ratio

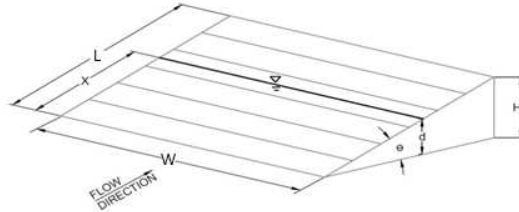
Height of Inclined Grate

Clogging Factor

Grate Discharge Coefficient

Orifice Coefficient

Weir Coefficient



$\theta =$ 0.00 degrees

W = 3.00 ft

L = 3.00 ft

A_{RATIO} = 0.70

H_B = 0.00 ft

C_f = 0.50

C_g = 0.96

C_o = 0.64

C_w = 2.05

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

d =

MINOR	MAJOR
0.08	0.20

Grate Capacity as a Weir

Submerged Side Weir Length

Inclined Side Weir Flow

Base Weir Flow

Interception Without Clogging

Interception With Clogging

	MINOR	MAJOR	
X =	3.00	3.00	ft
Q _{ws} =	0.3	1.0	cfs
Q _{wb} =	0.4	1.4	cfs
Q _{wi} =	0.9	3.3	cfs
Q _{wa} =	0.4	1.7	cfs

Grate Capacity as an Orifice

Interception Without Clogging

Interception With Clogging

Q _{oi} =	9.3	14.5	cfs
Q _{oa} =	4.7	7.3	cfs

Total Inlet Interception Capacity (assumes clogged condition)

Bypassed Flow

Capture Percentage = Q_a/Q_o

Q _a =	0.4	1.7	cfs
Q _b =	0.0	0.0	cfs
C% =	100	100	%

Inlet B14: Surface Conveyance (1/1)

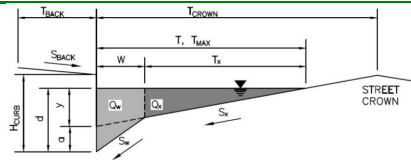
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet B14-Gutter



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 24.0$ ft
 $W = 2.00$ ft
 $S_x = 0.010$ ft/ft
 $S_w = 0.083$ ft/ft
 $S_o = 0.011$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
T_{MAX}	24.0	24.0	ft
d_{MAX}	6.0	6.0	inches
	☐	☒	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_x * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_w * 12$)
Gutter Depression ($d_c - (W * S_x * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_x
Discharge within the Gutter Section ($Q_T - Q_x - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
y	2.88	2.88	inches
d_c	2.0	2.0	inches
a	1.75	1.75	inches
d	4.63	4.63	inches
T_x	22.0	22.0	ft
E_o	0.295	0.295	
Q_x	6.5	6.5	cfs
Q_w	2.7	2.7	cfs
Q_{BACK}	0.0	0.0	cfs
Q_T	9.2	9.2	cfs
V	4.5	4.5	fps
$V*d$	1.7	1.7	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section T_{XTH}
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_x$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
T_{TH}	35.4	35.4	ft
T_{XTH}	33.4	33.4	ft
E_o	0.189	0.189	
Q_{XTH}	19.7	19.7	cfs
Q_x	18.6	18.6	cfs
Q_w	4.6	4.6	cfs
Q_{BACK}	0.0	0.0	cfs
Q	23.2	23.2	cfs
V	5.5	5.5	fps
$V*d$	2.8	2.8	
R	1.00	1.00	
Q_d	23.2	23.2	cfs
d	6.00	6.00	inches
d_{CROWN}	1.37	1.37	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q_{allow}	9.2	23.2	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 0.89 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 1.73 cfs on sheet 'Inlet Management'

Inlet B14: Inlet Capture (1/2)

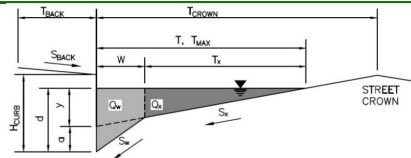
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet B14-Sump



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 12.0$ ft
 $W = 2.00$ ft
 $S_X = 0.010$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.000$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
T_{MAX}	12.0	12.0	ft
d_{MAX}	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
y	1.44	1.44	inches
d_c	2.0	2.0	inches
a	1.75	1.75	inches
d	3.19	3.19	inches
T_X	10.0	10.0	ft
E_O	0.603	0.603	
Q_X	0.0	0.0	cfs
Q_W	0.0	0.0	cfs
Q_{BACK}	0.0	0.0	cfs
Q_T	SUMP	SUMP	cfs
V	0.0	0.0	fps
$V*d$	0.0	0.0	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section $T_{X TH}$
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
T_{TH}	35.4	35.4	ft
$T_{X TH}$	33.4	33.4	ft
E_O	0.189	0.189	
$Q_{X TH}$	0.0	0.0	cfs
Q_X	0.0	0.0	cfs
Q_W	0.0	0.0	cfs
Q_{BACK}	0.0	0.0	cfs
Q	SUMP	SUMP	cfs
V	0.0	0.0	fps
$V*d$	0.0	0.0	
R	SUMP	SUMP	
Q_d	SUMP	SUMP	cfs
d			inches
d_{CROWN}			inches

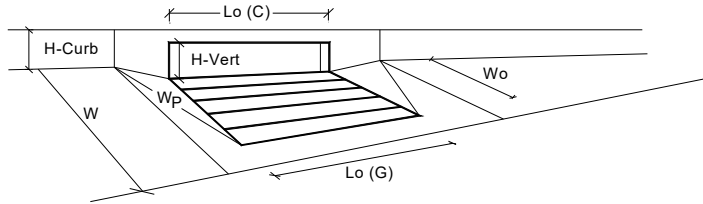
MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
Q_{allow}	SUMP	SUMP	cfs

Inlet B14: Inlet Capture (2/2)

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information			MINOR	MAJOR	☒ Override Depths
Length of a Unit Grate		L _o (G) =	N/A	N/A	feet
Width of a Unit Grate		W _o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L _o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)			MINOR	MAJOR	
Depth for Grate Midwidth		d _{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.33	0.33	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	1.00	1.00	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)			MINOR	MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _a =	5.4	5.4	cfs
		Q _{PEAK REQUIRED} =	0.9	1.7	cfs

Inlet B17: Surface Conveyance (1/1)

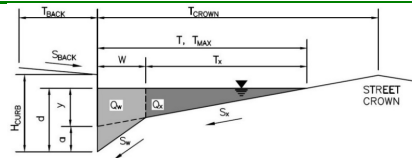
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet B17-Gutter



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_X = 0.012$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.010$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
$T_{MAX} =$	18.0	30.0	ft
$d_{MAX} =$	6.0	6.0	inches
	☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	2.59	4.32	inches
$d_c =$	2.0	2.0	inches
$a =$	1.70	1.70	inches
$d =$	4.30	6.02	inches
$T_X =$	16.0	28.0	ft
$E_o =$	0.382	0.217	
$Q_X =$	3.6	15.9	cfs
$Q_W =$	2.2	4.4	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	5.8	20.3	cfs
$V =$	4.0	5.3	fps
$V*d =$	1.4	2.6	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section T_{XTH}
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	29.8	29.8	ft
$T_{XTH} =$	27.8	27.8	ft
$E_o =$	0.218	0.218	
$Q_{XTH} =$	15.7	15.7	cfs
$Q_X =$	15.7	15.7	cfs
$Q_W =$	4.4	4.4	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	20.0	20.0	cfs
$V =$	5.2	5.2	fps
$V*d =$	2.6	2.6	
$R =$	1.00	1.00	
$Q_d =$	20.0	20.0	cfs
$d =$	6.00	6.00	inches
$d_{CROWN} =$	0.00	0.00	inches

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
$Q_{allow} =$	5.8	20.0	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 2.76 cfs on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design peak flow of 5.49 cfs on sheet 'Inlet Management'

Inlet B17: Inlet Capture (1/2)

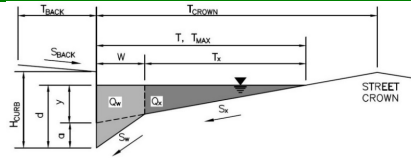
MHFD-Inlet, Version 5.03 (August 2023)

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

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

Project: Costco Dawson Trails

Inlet ID: Inlet B17 Sump



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

$T_{BACK} = 0.0$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

Height of Curb at Gutter Flow Line
Distance from Curb Face to Street Crown
Gutter Width
Street Transverse Slope
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)
Street Longitudinal Slope - Enter 0 for sump condition
Manning's Roughness for Street Section (typically between 0.012 and 0.020)

$H_{CURB} = 6.00$ inches
 $T_{CROWN} = 30.0$ ft
 $W = 2.00$ ft
 $S_X = 0.012$ ft/ft
 $S_W = 0.083$ ft/ft
 $S_D = 0.000$ ft/ft
 $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm
Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
$T_{MAX} =$	18.0	30.0	ft
$d_{MAX} =$	6.0	6.0	inches

Maximum Capacity for 1/2 Street based On Allowable Spread

Water Depth without Gutter Depression ($T * S_X * 12$)
Vertical Depth between Gutter Lip and Gutter Flowline ($W * S_W * 12$)
Gutter Depression ($d_c - (W * S_X * 12)$)
Water Depth at Gutter Flowline ($y + a$)
Allowable Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Discharge outside the Gutter Section, carried in Section T_X
Discharge within the Gutter Section ($Q_T - Q_X - Q_{BACK}$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Maximum Flow Based On Allowable Spread
Flow Velocity within the Gutter Section
 $V*d$ Product: Flow Velocity times Gutter Flowline Depth

	Minor Storm	Major Storm	
$y =$	2.59	4.32	inches
$d_c =$	2.0	2.0	inches
$a =$	1.70	1.70	inches
$d =$	4.30	6.02	inches
$T_X =$	16.0	28.0	ft
$E_D =$	0.382	0.217	
$Q_X =$	0.0	0.0	cfs
$Q_W =$	0.0	0.0	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q_T =$	SUMP	SUMP	cfs
$V =$	0.0	0.0	fps
$V*d =$	0.0	0.0	

Maximum Capacity for 1/2 Street based on Allowable Depth

Theoretical Water Spread
Theoretical Spread for Discharge outside the Gutter Section ($T - W$)
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. 7-7)
Theoretical Discharge outside the Gutter Section, carried in Section T_X
Actual Discharge outside the Gutter Section, (limited by distance T_{CROWN})
Discharge within the Gutter Section ($Q_d - Q_X$)
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)
Total Discharge for Major & Minor Storm (Pre-Safety Factor)
Average Flow Velocity Within the Gutter Section
 $V*d$ Product: Flow Velocity Times Gutter Flowline Depth
Slope-Based Safety Factor for Minor/Major Storm depth reduction, $d \geq 6"$
Max Flow based on Allowable Depth (Safety Factor Applied)
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)
Resultant Flow Depth at Street Crown (Safety Factor Applied)

	Minor Storm	Major Storm	
$T_{TH} =$	29.8	29.8	ft
$T_{X TH} =$	27.8	27.8	ft
$E_D =$	0.218	0.218	
$Q_{X TH} =$	0.0	0.0	cfs
$Q_X =$	0.0	0.0	cfs
$Q_W =$	0.0	0.0	cfs
$Q_{BACK} =$	0.0	0.0	cfs
$Q =$	SUMP	SUMP	cfs
$V =$	0.0	0.0	fps
$V*d =$	0.0	0.0	
$R =$	SUMP	SUMP	
$Q_d =$	SUMP	SUMP	cfs
$d =$			inches
$d_{CROWN} =$			inches

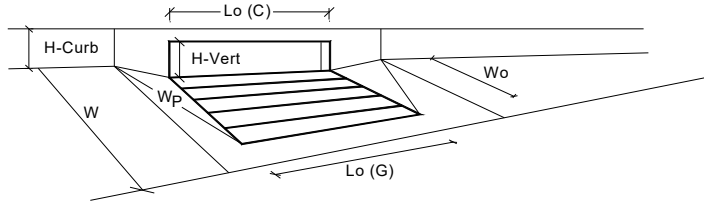
MINOR STORM Allowable Capacity is not applicable to Sump Condition
MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
$Q_{allow} =$	SUMP	SUMP	cfs

Inlet B17: Inlet Capture (2/2)

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening			
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches	
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1		
Water Depth at Flowline (outside of local depression)	Ponding Depth =	6.0	6.0	inches	
Grate Information		MINOR		MAJOR	
Length of a Unit Grate	$L_o (G)$ =	N/A	N/A	feet	
Width of a Unit Grate	W_o =	N/A	N/A	feet	
Open Area Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A		
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	$C_f (G)$ =	N/A	N/A		
Grate Weir Coefficient (typical value 2.15 - 3.60)	$C_w (G)$ =	N/A	N/A		
Grate Orifice Coefficient (typical value 0.60 - 0.80)	$C_o (G)$ =	N/A	N/A		
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening	$L_o (C)$ =	15.00	15.00	feet	
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches	
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches	
Angle of Throat	Theta =	63.40	63.40	degrees	
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	2.00	2.00	feet	
Clogging Factor for a Single Curb Opening (typical value 0.10)	$C_f (C)$ =	0.10	0.10		
Curb Opening Weir Coefficient (typical value 2.3-3.7)	$C_w (C)$ =	3.60	3.60		
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	$C_o (C)$ =	0.67	0.67		
Grate Flow Analysis (Calculated)		MINOR		MAJOR	
Clogging Coefficient for Multiple Units	Coef =	N/A	N/A		
Clogging Factor for Multiple Units	Clog =	N/A	N/A		
Grate Capacity as a Weir (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging	Q_{wi} =	N/A	N/A	cfs	
Interception with Clogging	Q_{wa} =	N/A	N/A	cfs	
Grate Capacity as an Orifice (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging	Q_{oi} =	N/A	N/A	cfs	
Interception with Clogging	Q_{oa} =	N/A	N/A	cfs	
Grate Capacity as Mixed Flow		MINOR		MAJOR	
Interception without Clogging	Q_{mi} =	N/A	N/A	cfs	
Interception with Clogging	Q_{ma} =	N/A	N/A	cfs	
Resulting Grate Capacity (assumes clogged condition)	Q_{Grate} =	N/A	N/A	cfs	
Curb Opening Flow Analysis (Calculated)		MINOR		MAJOR	
Clogging Coefficient for Multiple Units	Coef =	1.31	1.31		
Clogging Factor for Multiple Units	Clog =	0.04	0.04		
Curb Capacity as a Weir (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging	Q_{wi} =	10.2	10.2	cfs	
Interception with Clogging	Q_{wa} =	9.7	9.7	cfs	
Curb Capacity as an Orifice (based on MHFD - CSU 2010 Study)		MINOR		MAJOR	
Interception without Clogging	Q_{oi} =	29.3	29.3	cfs	
Interception with Clogging	Q_{oa} =	28.0	28.0	cfs	
Curb Opening Capacity as Mixed Flow		MINOR		MAJOR	
Interception without Clogging	Q_{mi} =	16.0	16.0	cfs	
Interception with Clogging	Q_{ma} =	15.3	15.3	cfs	
Resulting Curb Opening Capacity (assumes clogged condition)	Q_{Curb} =	9.7	9.7	cfs	
Resultant Street Conditions		MINOR		MAJOR	
Total Inlet Length	L =	15.00	15.00	feet	
Resultant Street Flow Spread (based on street geometry from above)	T =	29.8	29.8	ft	
Resultant Flow Depth at Street Crown	d_{CROWN} =	0.0	0.0	inches	
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft	
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.33	ft	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A		
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.79	0.79		
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	N/A	N/A		
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
	Q_s =	9.7	9.7	cfs	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	$Q_{PEAK REQUIRED}$ =	2.8	5.5	cfs	

Area inlets: R-3563-HB grate

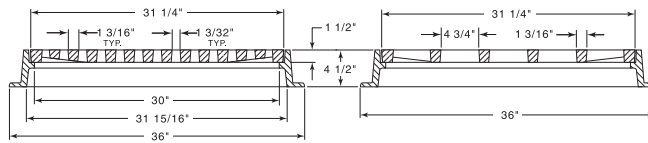
■ Note: When specifying/ordering grates, refer to "Choosing the Proper Inlet Grate" on pages 125-126.

For a complete listing of FREE OPEN AREAS and WEIR PERIMETERS of all NEENAH grates, refer to pages 327-332.

R-3561

Gutter Inlet Frame, Grate

Heavy Duty



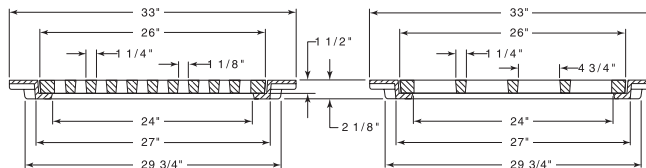
Solid Type C lid available.

CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET
R-3561	A or C	2.3	10.4

R-3562

Gutter Inlet Frame, Grate

Heavy Duty



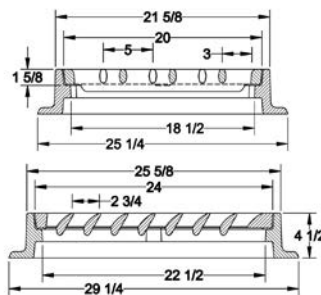
Top surface of frame and grate have Perma-grip texture.

CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET
R-3562	C	1.5	8.7

R-3563-L

Gutter Inlet Frames, Grate

Heavy Duty

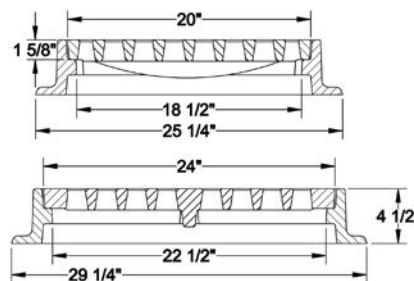


CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET
R-3563-L	L	1.4	7.3

R-3563-HB

Gutter Inlet Frames, Grate

Heavy Duty



CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET
R-3563-HB	K	1.3	7.3

FREE OPEN AREAS OF NEENAH GRATES (Continued)

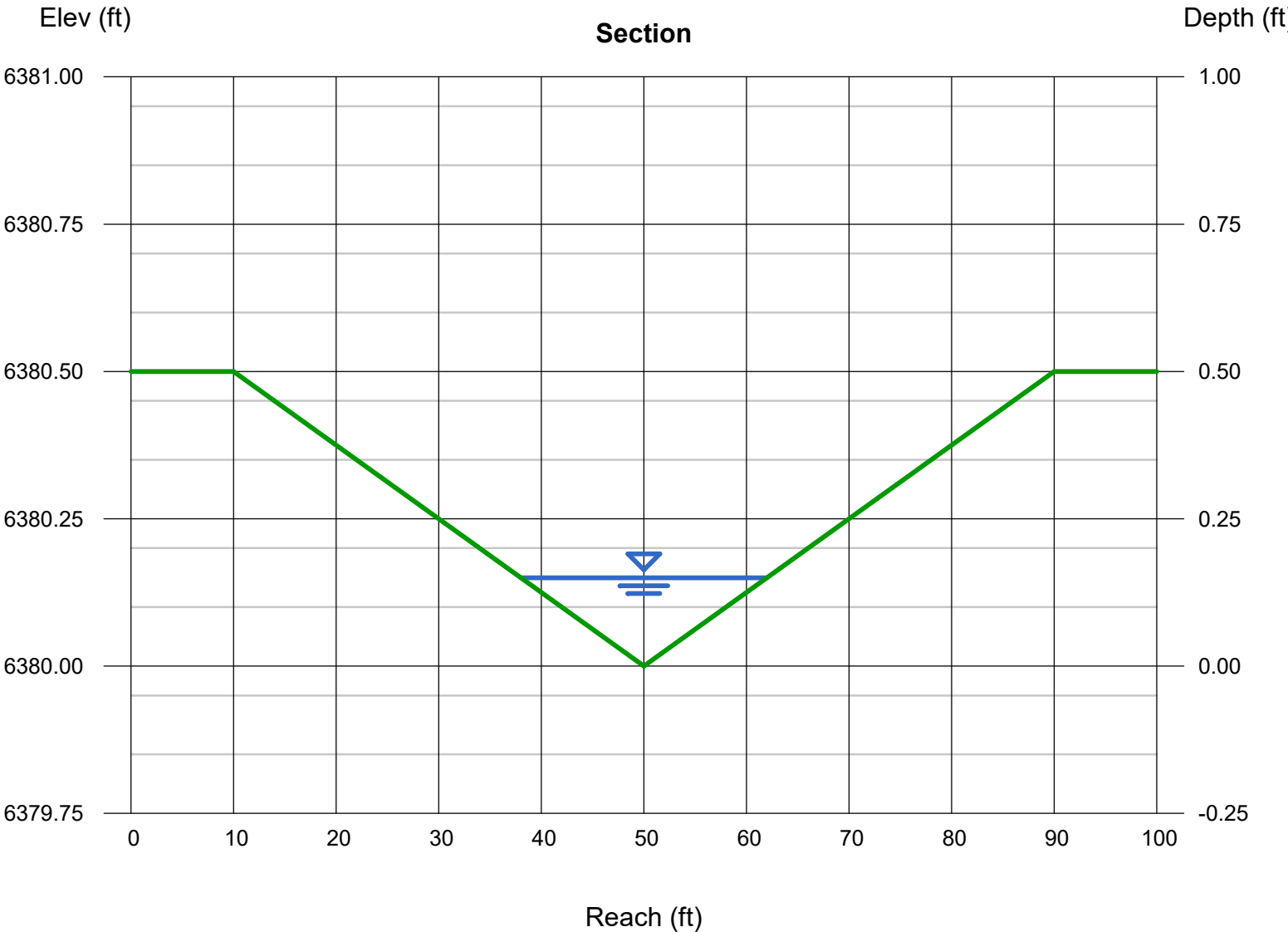
CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET	CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET	CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET	CATALOG NUMBER	GRATE TYPE	SQ. FT. OPEN	WEIR PERIMETER LINEAL FEET
R-3541	L	1.6	7.3	R-3921-B1	B	0.7	4.5	R-4015-A	P	0.1	3.6	R-4352	Beehive	1.3	5.8
R-3541-2	L	3.2	11.3	R-3921-L1	L	0.3	4.1	R-4015-A1	B	0.2	3.6	R-4353	Beehive	1.8	6.7
R-3550-2	C	5.8	15.2	R-3921-V1	V	0.5	4.1	R-4015-B	C	0.4	3.6	R-4360-A	Beehive	0.6	4.3
R-3555	B	0.5	5.3	R-3922	V	1.0	5.9	R-4015-C	B	0.3	3.6	R-4360-B	Beehive	0.8	4.7
R-3560	A or C	1.5	8.4	R-3922-A	V	1.0	5.9	R-4015-D	B	0.2	3.6	R-4360-C	Beehive	1.4	4.5
R-3561	A or C	2.3	10.4	R-3923	V	1.6	5.6	R-4015-P	P	0.1	3.6	R-4360-D	Beehive	0.7	6.3
R-3562	L	1.5	8.7	R-3924	A	2.3	8.4	R-4016-B	C	0.5	4.8	R-4370-1	C	0.1	1.7
R-3563-HB	K	1.3	7.3	R-3927	B	2.3	8.5	R-4016-H1	A	0.6	5.3	R-4370-2	G	0.2	2.5
R-3563-L	L	1.4	7.3	R-3927-A	B	2.3	8.5	R-4016-K	B or D	1.0	6.3	R-4370-3	E	0.4	3.9
R-3570	A	2.4	7.4	R-3928	B	0.5	1.9	R-4018	B	0.2	3.8	R-4370-4	G	0.6	3.9
R-3570-A	A	2.4	7.4	R-3930	B or D	0.3	3.0	R-4030-4	H	0.1	1.5	R-4370-5	G	0.8	4.7
R-3571	A	2.4	7.4	R-3935	A or C	0.6	5.3	R-4030-6	H	0.1	2.1	R-4370-6	G	0.8	5.1
R-3571-A	A	2.4	7.4	R-3935	V	1.5	5.3	R-4030-8	H	0.2	2.7	R-4370-7	G	0.8	5.2
R-3572-A	R	4.4	12.3	R-3936-A	C	1.0	6.5	R-4030-10	H	0.3	3.3	R-4370-8	E	1.0	5.5
R-3572-2D	R	3.8	12.3	R-3940	A	1.0	6.1	R-4030-12	H	0.4	3.9	R-4370-9	C	1.3	5.8
R-3572-2L	L	4.7	12.3	R-3942	V	0.8	5.1	R-4030-15	H	0.8	4.8	R-4370-10	A	1.1	5.8
R-3572-2Q	Q	1.8	12.3	R-3943	V	1.2	6.9	R-4030-18	B	1.1	5.8	R-4370-12	F	0.9	5.8
R-3573-2D	R	3.8	12.3	R-3945	L	2.4	13.0	R-4030-21	B	1.3	6.7	R-4370-13	G	1.3	5.8
R-3573-2L	L	4.7	12.3	R-3945-A	L	2.4	13.0	R-4030-24	B	2.1	7.6	R-4370-15	D	1.0	5.9
R-3573-2Q	Q	1.8	12.3	R-3945-2	L	2.4	13.0	R-4030-27	G	2.8	8.6	R-4370-17	D	1.0	6.0
R-3574-2D	R	3.8	12.3	R-3945-8	L	2.4	13.0	R-4030-30	G	3.4	9.4	R-4370-18	E	1.3	6.0
R-3574-2L	L	4.6	12.3	R-3946	L	2.9	13.5	R-4040-6	E	0.1	2.1	R-4370-21	D	0.9	6.0
R-3574-2Q	Q	1.8	12.3	R-3946-A	L	9.2	15.0	R-4040-8	E	0.2	2.7	R-4370-22	D	1.1	6.0
R-3575	B	2.6	9.5	R-3948-A	C	1.1	5.1	R-4040-10	E	0.3	3.3	R-4370-23	H	0.9	6.3
R-3576	R	2.4	9.3	R-3948-V	V	1.5	5.1	R-4040-12	E	0.5	3.9	R-4370-25	G	1.9	7.6
R-3577	D	1.8	9.2	R-3949-A	L	2.5	8.9	R-4040-15	E	0.7	4.8	R-4370-26	G	2.8	8.6
R-3578	L	2.3	10.9	R-3949-B	L	2.5	8.9	R-4040-18	E	0.9	5.8	R-4370-27A	G	2.4	9.9
R-3580	L	1.4	7.9	R-3951	L	1.6	9.0	R-4040-21	G	1.4	6.7	R-4380-AA1	E	2.8 sq. in.	1.0
R-3580-1	L	2.8	12.9	R-3952	B or D	1.1	6.3	R-4040-24	G	1.6	7.6	R-4380-A	E	3.7 sq. in.	1.1
R-3581	V	2.2	9.3	R-3954	B	1.8	8.1	R-4040-27	G	2.3	8.6	R-4380-A1	E	6.0 sq. in.	1.2
R-3588	D	1.8	7.9	R-3955	C	2.6	8.9	R-4040-30	G	2.9	9.4	R-4380-B1	E	4.8 sq. in.	1.3
R-3588-A	H	1.2	7.9	R-3956	Q	1.2	6.9	R-4215-A	Beehive	2.0	9.0	R-4380-1	E	5.4 sq. in.	1.4
R-3588-LL	L	1.5	7.9	R-3961	D	0.7	5.2	R-4215-C	Beehive	3.3	11.3	R-4380-3	E	5.0 sq. in.	1.6
R-3588-LL4	L	1.5	7.9	R-3976	B	0.2	3.3	R-4216-B	Beehive	2.2	4.1	R-4380-4	E	0.1	2.1
R-3588-LR	L	1.5	7.9	R-3977	B	0.1	2.6	R-4217	Beehive	4.9	7.1	R-4380-4A1	E	0.1	2.2
R-3588-LR4	L	1.5	7.9	R-3978	D	1.0	4.0	R-4340-A	Beehive	1.5	6.2	R-4380-4A	E	0.2	2.6
R-3589	D	1.8	7.9					R-4340-B	Beehive	1.1	6.0	R-4380-6	G	0.2	2.8
R-3589-A	H	1.2	7.9	R-4001-B	C	0.3	2.5	R-4340-C	Beehive	1.2	6.0	R-4380-7	G	0.3	3.1
R-3589-LL	L	1.5	7.9	R-4001-B	P	0.1	2.5	R-4340-F	Beehive	1.6	6.5	R-4380-8	E	0.3	3.3
R-3589-LL4	L	1.5	7.9	R-4003-A	A	0.9	6.1	R-4340-F1	Beehive	0.7	4.5	R-4380-9	E	0.4	3.7
R-3589-LR	L	1.5	7.9	R-4003-B	A	0.9	6.1	R-4340-G	Beehive	0.6	5.0	R-4380-10	E	0.5	3.9
R-3589-LR4	L	1.5	7.9	R-4003-C	A	0.9	6.1	R-4340-H	Beehive	0.5	4.5	R-4380-11	E	0.5	3.9
R-3591	A	1.5	8.0	R-4004-A	C	1.3	6.8	R-4341-A	Beehive	2.5	6.0	R-4380-12	E	0.6	4.0
R-3593	C	2.5	12.3	R-4004-B	B	1.5	7.4	R-4342	Beehive	2.0	6.0	R-4380-13	G	0.7	4.2
R-3599-A	L	0.2 per ft.	2 per ft.	R-4004-C	B	1.5	7.4	R-4343	Beehive	2.4	8.4	R-4380-13A	E	0.9	4.7
R-3599-B	L	0.2 per ft.	2 per ft.	R-4004-G1	B or D	1.9	7.3	R-4344	Beehive	0.2	2.9	R-4380-14	E	0.7	4.7
R-3801	C	34.6	42.5	R-4005-A2	B	0.4	4.3	R-4345	Beehive	2.0	8.6	R-4380-15	E	0.6	4.7
R-3805	C	11.6	21.8	R-4006	D	0.3	3.1	R-4346	Beehive	2.0	8.6	R-4380-16	E	0.8	5.0
R-3806	C	17.5	29.8	R-4007	B	0.4	4.3	R-4347	Beehive	2.0	8.6	R-4380-17	E	0.8	5.0
R-3807	D	6.0	13.4	R-4007-A6	B	0.4	4.3	R-4349-C	Beehive	2.4	6.9	R-4380-18	G	0.7	5.2
R-3808-1	C	5.2	12.3	R-4014-B1	A	2.8	9.7	R-4349-D	Beehive	5.4	10.2	R-4380-21	G	1.3	6.3
R-3808-2	C	10.3	19.9	R-4014-B1	C	1.3	9.7	R-4350-1	Beehive	0.3	2.7	R-4380-22	G	1.5	7.0
R-3900-B	L	1.9	7.7	R-4014-C1	A	2.3	8.4	R-4350-A	Beehive	0.3	3.1	R-4380-23	G	1.1	7.3
R-3900-C	L	3.8	11.8	R-4014-C2	A	2.4	8.4	R-4350-B	Beehive	0.4	3.9	R-4380-24	G	1.7	7.9
R-3900-D	L	5.7	16.0	R-4014-T	B	1.2	7.3	R-4350-C	Beehive	0.6	4.8	R-4380-25	G	2.5	8.4
R-3910-V	V	0.3	3.1	R-4014-TL	L	0.5	7.3	R-4350-D	Beehive	1.0	5.8	R-4380-26	G	2.7	8.8
R-3918	V	1.9	7.8	R-4014-T2	B	0.7	4.5	R-4350-E	Beehive	1.7	7.6	R-4385-B	E	0.1	2.1
R-3919	Q	0.9	6.9	R-4014-T2L	L	0.3	4.1	R-4351-B	Beehive	0.5	3.9	R-4385-C	E	0.3	2.7
R-3919	R	1.4	6.9	R-4014-T2V	V	0.3	4.1	R-4351-C	Beehive	1.2	5.2	R-4385-E	E	0.5	3.9
R-3920-V	V	0.9	4.2	R-4015-A	B	0.2	3.6	R-4351-D	Beehive	1.6	5.8	R-4385-F	E	0.5	4.8

• NOTE: On catalog #'s R-4990-AA thru R-4999-L9, SQ.FT. OPEN and WEIR PERIMETER are per lineal foot.
Type K indicates "Special" grate style and is not among standard types illustrated.
** Roll-type or mountable curb

Channel Report

Inlet B1A

Triangular		Highlighted	
Side Slopes (z:1)	= 80.00, 80.00	Depth (ft)	= 0.15
Total Depth (ft)	= 0.50	Q (cfs)	= 2.730
		Area (sqft)	= 1.80
Invert Elev (ft)	= 6380.00	Velocity (ft/s)	= 1.52
Slope (%)	= 1.01	Wetted Perim (ft)	= 24.00
N-Value	= 0.016	Crit Depth, Yc (ft)	= 0.15
		Top Width (ft)	= 24.00
		EGL (ft)	= 0.19
Calculations			
Compute by:	Known Q		
Known Q (cfs)	= 2.73		



FLOW INTERCEPTION OF ON-GRADE GRATE INLET CALCULATION

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.1 & Table 7-6;

Inlet B1.1

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

Surface flow properties

Q =	2.73	cfs	Surface flow to inlet
S _o =	0.01		Drive Lane Longitudinal Grade
S _x =	0.012		Drive Lane Reverse Crown Grade
d =	0.15	ft	Flow Depth (from Hydraflow Express)
V =	1.52		Flow Velocity (from Hydraflow Express)
T =	12.0	ft	1/2 Flow Spread (from Hydraflow Express)

Grate inlet properties

			Model 24" dia. Grate as 16" front X 18" side
W =	16.0	in	Length of inlet grate
	1.33	ft	
L =	18.0	in	Width of inlet grate
	1.50	ft	
N =	1		Number of inlet grates

Flow Interception Calculation

V _o =	a+bVL-c(L) ² +n(L) ³		Splash-over velocity [Equation 7-20]
a =	0		
b =	0.68		Splash-over constants; Table 7-6
c =	0.06		Use parameters for Type 13 Valley Grate
n =	0.0023		
V _o =	1.16		
Q _w =	Q*(1-(1-(W/T)) ^{2.67})		Frontal flow to Grate Inlet [Equation 7-17]
Q _w =	0.74	cfs	
Q _x =	Q-Q _w		Side flow to grate inlet (per side)
Q _x =	1.00	cfs	[Equation 7-18]
R _f =	1.0-0.09*(V-V _o)		Interception rate of frontal flow
R _f =	0.97		[Equation 7-19]
Q _{wi} =	R _f *Q _w		Intercepted frontal flow by grate inlet
Q _{wi} =	0.71	cfs	[Equation 7-19]
R _x =	1/(1+(0.015*V ^{1.8})/(S _x *(N*L) ^{2.3}))		Interception rate of side flow (each side)
R _x =	0.49		[Equation 7-21]
Q _{xi} =	R _x *Q _x		Intercepted side flow by grate inlet (each side)
Q _{xi} =	0.49	cfs	
Q _i =	<input type="text" value="1.69"/>	cfs	Total flow intercepted flow by grate inlet
Q _b =	<input type="text" value="1.04"/>	cfs	Total bypassed flow to <input type="text" value="Inlet B1"/>

HYDRAULIC CAPACITY OF AREA INLETS IN SUMP CALCULATIONS

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.7 & Table 7-8;

Inlet B1

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

$$Q_i = C_o A_o (2gd)^{0.5} \quad \text{hydraulic capacity of grate inlet operating as an orifice (cfs); Equation 7-38}$$

$$C_o = 0.67 \quad \text{orifice discharge coefficient; Table 7-8}$$

$$g = 32.2 \quad \text{acceleration of gravity (ft/sec}^2\text{)}$$

$$A_o = A_g A_{\text{RATIO}} C_f / 100^2 \quad \text{orifice area}$$

$$A_g = 3.34 \text{ ft}^2 \quad \text{grate area (L x W)}$$

$$A_{\text{RATIO}} = 39 \% \quad \text{open area ratio (70% for CDOT Type C standard grate)}$$

$$C_f = 50 \% \quad \text{clogging factor (50% typical per MHFD recommendation)}$$

$$A_o = 0.65 \text{ ft}^2 \quad \text{grate clear opening area}$$

$$d = 0.43 \text{ ft} \quad \text{available ponding depth of water over grate}$$

$$Q_R = 7.43 \text{ cfs} \quad \text{surface flow to inlet}$$

$$Q_B = 1.04 \quad \text{bypassed flow to inlet}$$

$$Q_T = 8.47 \quad \text{total flow to inlet}$$

$$Q_i = 2.30 \text{ cfs} \quad \text{calculated single grate inlet capacity}$$

$$N = 4 \quad \text{number of grates}$$

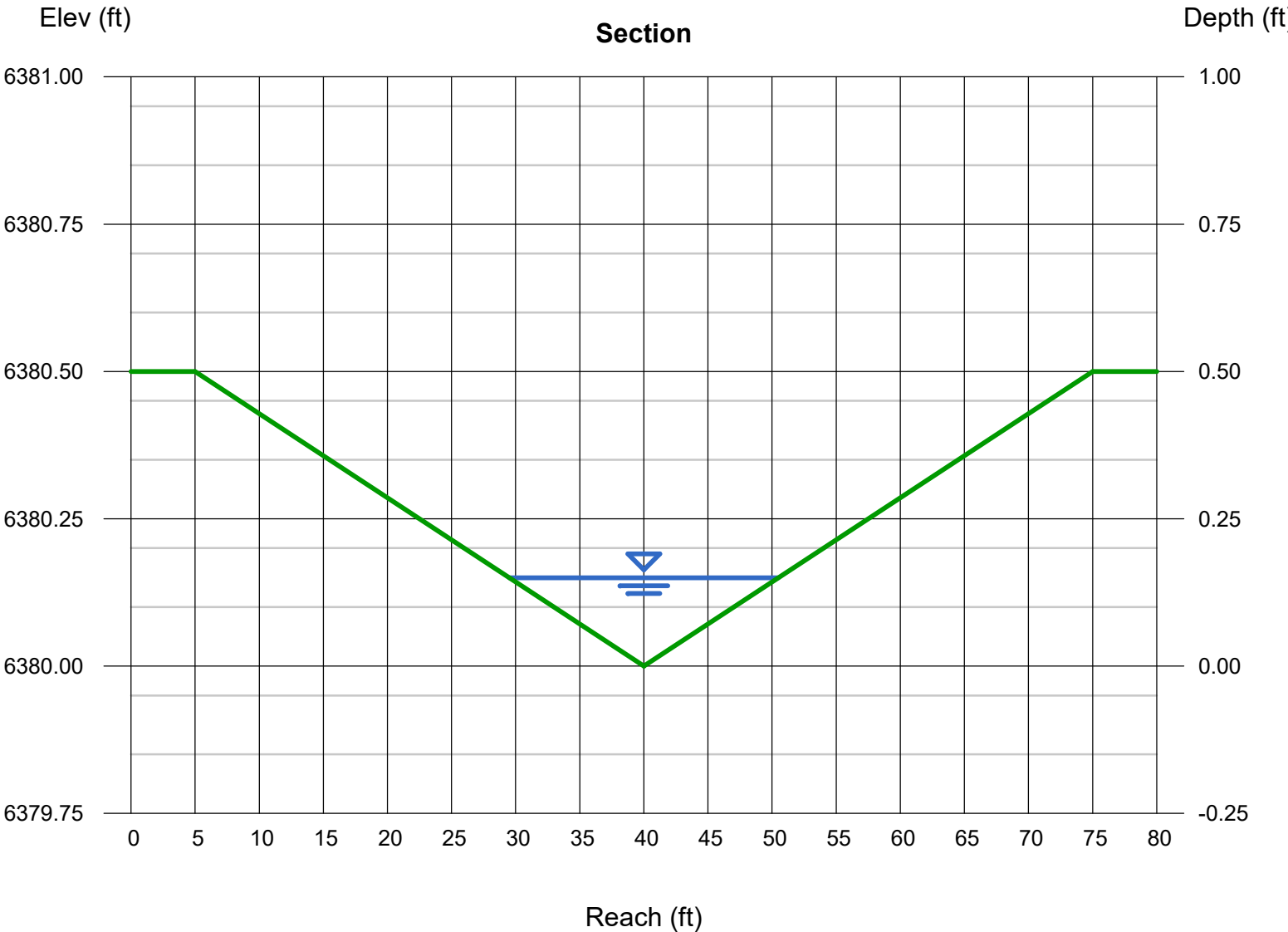
$$Q_{\text{cap}} = 9.19 \text{ cfs} \quad \text{total calculated inlet capacity}$$

Inlet capacity is GOOD for the given ponding depth.

Channel Report

Inlet B3A

Triangular		Highlighted	
Side Slopes (z:1)	= 70.00, 70.00	Depth (ft)	= 0.15
Total Depth (ft)	= 0.50	Q (cfs)	= 2.700
		Area (sqft)	= 1.58
Invert Elev (ft)	= 6380.00	Velocity (ft/s)	= 1.71
Slope (%)	= 1.40	Wetted Perim (ft)	= 21.00
N-Value	= 0.016	Crit Depth, Yc (ft)	= 0.16
		Top Width (ft)	= 21.00
		EGL (ft)	= 0.20
Calculations			
Compute by:	Known Q		
Known Q (cfs)	= 2.70		



FLOW INTERCEPTION OF ON-GRADE GRATE INLET CALCULATION

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.1 & Table 7-6;

Inlet B3.1

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

Surface flow properties

Q =	2.70	cfs	Surface flow to inlet
S _o =	0.01		Drive Lane Longitudinal Grade
S _x =	0.012		Drive Lane Reverse Crown Grade
d =	0.15	ft	Flow Depth (from Hydraflow Express)
V =	1.71		Flow Velocity (from Hydraflow Express)
T =	10.5	ft	1/2 Flow Spread (from Hydraflow Express)

Grate inlet properties

			Model 24" dia. Grate as 16" front X 18" side
W =	16.0	in	Length of inlet grate
	1.33	ft	
L =	18.0	in	Width of inlet grate
	1.50	ft	
N =	1		Number of inlet grates

Flow Interception Calculation

$V_o = a + bVL - c(L)^2 + n(L)^3$	Splash-over velocity [Equation 7-20]
a = 0	
b = 0.68	Splash-over constants; Table 7-6
c = 0.06	Use parameters for Type 13 Valley Grate
n = 0.0023	
$V_o = 1.16$	
$Q_w = Q * (1 - (1 - (W/T))^2.67)$	Frontal flow to Grate Inlet [Equation 7-17]
$Q_w = 0.82$	cfs
$Q_x = Q - Q_w$	Side flow to grate inlet (per side)
$Q_x = 0.94$	cfs [Equation 7-18]
$R_f = 1.0 - 0.09 * (V - V_o)$	Interception rate of frontal flow
$R_f = 0.95$	[Equation 7-19]
$Q_{wi} = R_f * Q_w$	Intercepted frontal flow by grate inlet
$Q_{wi} = 0.78$	cfs [Equation 7-19]
$R_x = 1 / (1 + (0.015 * V^{1.8}) / (S_x * (N * L)^{2.3}))$	Interception rate of side flow (each side)
$R_x = 0.44$	[Equation 7-21]
$Q_{xi} = R_x * Q_x$	Intercepted side flow by grate inlet (each side)
$Q_{xi} = 0.41$	cfs
$Q_i = 1.60$	cfs Total flow intercepted flow by grate inlet
$Q_b = 1.10$	cfs Total bypassed flow to Inlet B3

HYDRAULIC CAPACITY OF AREA INLETS IN SUMP CALCULATIONS

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.7 & Table 7-8;

Inlet B3

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

$$Q_i = C_o A_o (2gd)^{0.5} \quad \text{hydraulic capacity of grate inlet operating as an orifice (cfs); Equation 7-38}$$

$$C_o = 0.67 \quad \text{orifice discharge coefficient; Table 7-8}$$

$$g = 32.2 \quad \text{acceleration of gravity (ft/sec}^2\text{)}$$

$$A_o = A_g A_{\text{RATIO}} C_f / 100^2 \quad \text{orifice area}$$

$$A_g = 3.34 \text{ ft}^2 \quad \text{grate area (L x W)}$$

$$A_{\text{RATIO}} = 39 \% \quad \text{open area ratio (70% for CDOT Type C standard grate)}$$

$$C_f = 50 \% \quad \text{clogging factor (50% typical per MHFD recommendation)}$$

$$A_o = 0.65 \text{ ft}^2 \quad \text{grate clear opening area}$$

$$d = 0.50 \text{ ft} \quad \text{available ponding depth of water over grate}$$

$$Q_R = 3.96 \text{ cfs} \quad \text{direct flow to inlet}$$

$$Q_B = 1.10 \quad \text{bypassed flow to inlet}$$

$$Q_T = 5.06 \quad \text{total flow to inlet}$$

$$Q_i = 2.48 \text{ cfs} \quad \text{calculated single grate inlet capacity}$$

$$N = 4 \quad \text{number of grates}$$

$$Q_{\text{cap}} = 9.90 \text{ cfs} \quad \text{total calculated inlet capacity}$$

Inlet capacity is GOOD for the given ponding depth.

Channel Report

Inlet B6

Triangular

Side Slopes (z:1) = 110.00, 110.00
Total Depth (ft) = 0.50

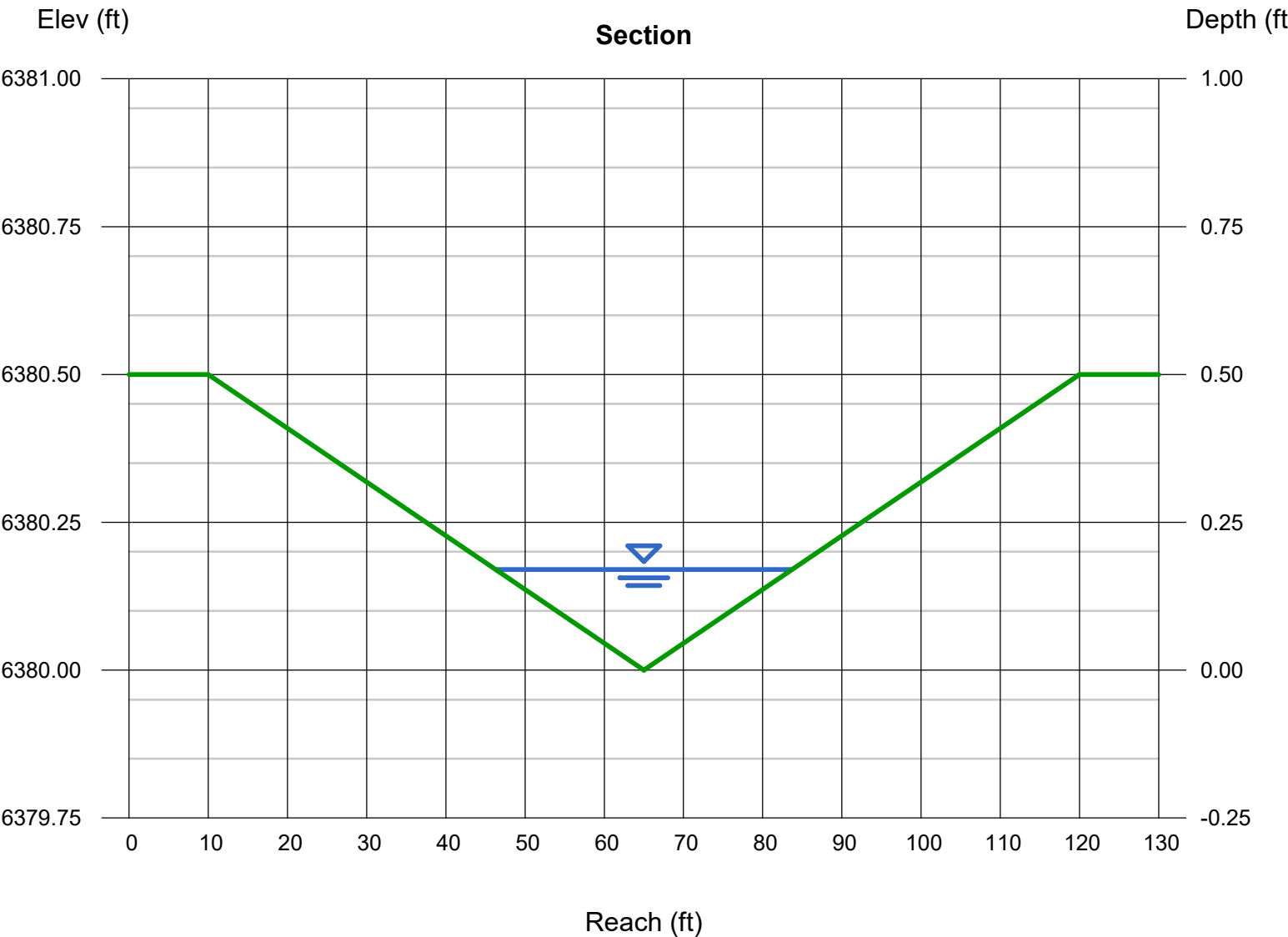
Invert Elev (ft) = 6380.00
Slope (%) = 1.50
N-Value = 0.016

Calculations

Compute by: Known Q
Known Q (cfs) = 6.97

Highlighted

Depth (ft) = 0.17
Q (cfs) = 6.970
Area (sqft) = 3.18
Velocity (ft/s) = 2.19
Wetted Perim (ft) = 37.40
Crit Depth, Yc (ft) = 0.20
Top Width (ft) = 37.40
EGL (ft) = 0.24



FLOW INTERCEPTION OF ON-GRADE GRATE INLET CALCULATION

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.1 & Table 7-6;

Inlet B6

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

Surface flow properties

Q =	6.97	cfs	Surface flow to inlet
S _o =	0.015		Drive Lane Longitudinal Grade
S _x =	0.009		Drive Lane Reverse Crown Grade
d =	0.17	ft	Flow Depth (from Hydraflow Express)
V =	2.19		Flow Velocity (from Hydraflow Express)
T =	18.7	ft	1/2 Flow Spread (from Hydraflow Express)

Grate inlet properties

W =	24.0	in	Length of inlet grate
	2.00	ft	
L =	20.0	in	Width of inlet grate
	1.67	ft	
N =	2		Number of inlet grates

Flow Interception Calculation

V _o =	a+bVL-c(L) ² +n(L) ³	Splash-over velocity
		[Equation 7-20]
a =	0	
b =	0.68	Splash-over constants; Table 7-6
c =	0.06	Use parameters for Type 13 Valley Grate
n =	0.0023	
V _o =	3.02	
Q _w =	Q*(1-(1-(W/T)) ^{2.67})	Frontal flow to Grate Inlet
Q _w =	1.82	cfs
		[Equation 7-17]
Q _x =	Q-Q _w	Side flow to grate inlet (per side)
Q _x =	2.58	cfs
		[Equation 7-18]
R _f =	1.0-0.09*(V-V _o)	Interception rate of frontal flow
R _f =	1.00	
		[Equation 7-19]
Q _{wi} =	R _f *Q _w	Intercepted frontal flow by grate inlet
Q _{wi} =	1.82	cfs
		[Equation 7-19]
R _x =	1/(1+(0.015*V ^{1.8})/(S _x *(N*L) ^{2.3}))	Interception rate of side flow (each side)
R _x =	0.70	
		[Equation 7-21]
Q _{xi} =	R _x *Q _x	Intercepted side flow by grate inlet (each side)
Q _{xi} =	1.80	cfs
Q _i =	<input type="text" value="5.42"/>	cfs
		Total flow intercepted flow by grate inlet
Q _b =	<input type="text" value="1.55"/>	cfs
		Total bypassed flow to <input type="text" value="Inlet B8"/>

Channel Report

Inlet B7

Triangular

Side Slopes (z:1) = 110.00, 110.00
Total Depth (ft) = 0.50

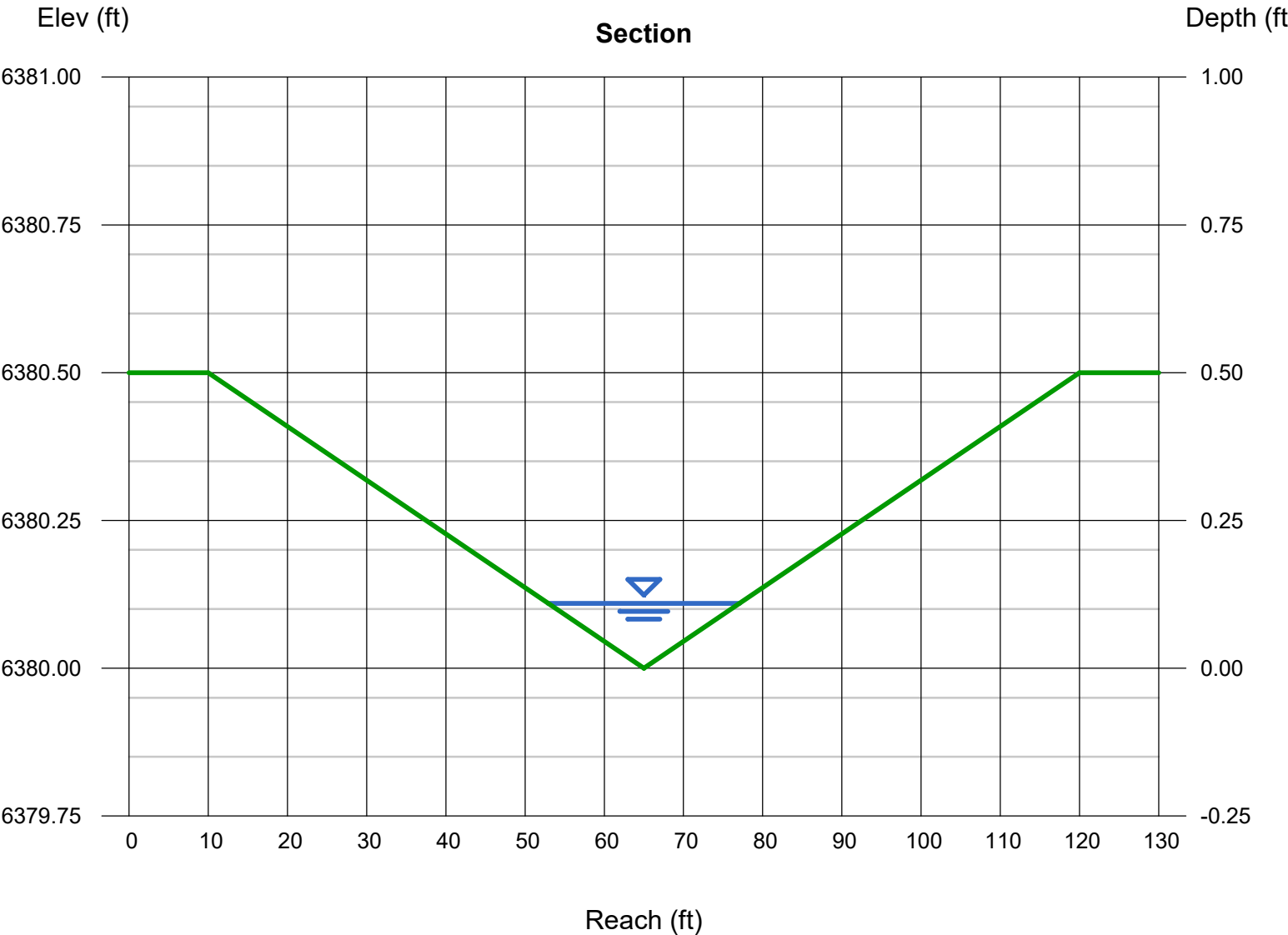
Invert Elev (ft) = 6380.00
Slope (%) = 1.60
N-Value = 0.016

Calculations

Compute by: Known Q
Known Q (cfs) = 2.23

Highlighted

Depth (ft) = 0.11
Q (cfs) = 2.230
Area (sqft) = 1.33
Velocity (ft/s) = 1.68
Wetted Perim (ft) = 24.20
Crit Depth, Yc (ft) = 0.13
Top Width (ft) = 24.20
EGL (ft) = 0.15



FLOW INTERCEPTION OF ON-GRADE GRATE INLET CALCULATION

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.1 & Table 7-6;

Inlet B7

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

Surface flow properties

Q =	2.23	cfs	Surface flow to inlet
S _o =	0.016		Drive Lane Longitudinal Grade
S _x =	0.009		Drive Lane Reverse Crown Grade
d =	0.11	ft	Flow Depth (from Hydraflow Express)
V =	1.68		Flow Velocity (from Hydraflow Express)
T =	12.1	ft	1/2 Flow Spread (from Hydraflow Express)

Grate inlet properties

W =	24.0	in	Length of inlet grate
	2.00	ft	
L =	20.0	in	Width of inlet grate
	1.67	ft	
N =	2		Number of inlet grates

Flow Interception Calculation

$V_o = a + bVL - c(L)^2 + n(L)^3$	Splash-over velocity [Equation 7-20]
a = 0	
b = 0.68	Splash-over constants; Table 7-6
c = 0.06	Use parameters for Type 13 Valley Grate
n = 0.0023	
$V_o = 3.02$	
$Q_w = Q * (1 - (1 - (W/T))^2.67)$	Frontal flow to Grate Inlet [Equation 7-17]
$Q_w = 0.85$	cfs
$Q_x = Q - Q_w$	Side flow to grate inlet (per side) [Equation 7-18]
$Q_x = 0.69$	cfs
$R_f = 1.0 - 0.09 * (V - V_o)$	Interception rate of frontal flow [Equation 7-19]
$R_f = 1.00$	
$Q_{wi} = R_f * Q_w$	Intercepted frontal flow by grate inlet [Equation 7-19]
$Q_{wi} = 0.85$	cfs
$R_x = 1 / (1 + (0.015 * V^{0.8}) / (S_x * (N * L)^{2.3}))$	Interception rate of side flow (each side) [Equation 7-21]
$R_x = 0.79$	
$Q_{xi} = R_x * Q_x$	Intercepted side flow by grate inlet (each side)
$Q_{xi} = 0.54$	cfs
$Q_i = 1.94$	cfs
	Total flow intercepted flow by grate inlet
$Q_b = 0.29$	cfs
	Total bypassed flow to Inlet B9

HYDRAULIC CAPACITY OF AREA INLETS IN SUMP CALCULATIONS

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.7 & Table 7-8;

Inlet B8

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

$$Q_i = C_o A_o (2gd)^{0.5} \quad \text{hydraulic capacity of grate inlet operating as an orifice (cfs); Equation 7-38}$$

$$C_o = 0.67 \quad \text{orifice discharge coefficient; Table 7-8}$$

$$g = 32.2 \quad \text{acceleration of gravity (ft/sec}^2\text{)}$$

$$A_o = A_g A_{\text{RATIO}} C_f / 100^2 \quad \text{orifice area}$$

$$A_g = 3.34 \text{ ft}^2 \quad \text{grate area (L x W)}$$

$$A_{\text{RATIO}} = 39 \% \quad \text{open area ratio (70% for CDOT Type C standard grate)}$$

$$C_f = 50 \% \quad \text{clogging factor (50% typical per MHFD recommendation)}$$

$$A_o = 0.65 \text{ ft}^2 \quad \text{grate clear opening area}$$

$$d = 0.50 \text{ ft} \quad \text{available ponding depth of water over grate}$$

$$Q_R = 4.36 \text{ cfs} \quad \text{surface flow to inlet}$$

$$Q_B = 1.55 \quad \text{bypassed flow to inlet}$$

$$Q_T = 5.91 \quad \text{total flow to inlet}$$

$$Q_i = 2.48 \text{ cfs} \quad \text{calculated single grate inlet capacity}$$

$$N = 4 \quad \text{number of grates}$$

$$Q_{\text{cap}} = 9.90 \text{ cfs} \quad \text{total calculated inlet capacity}$$

Inlet capacity is GOOD for the given ponding depth.

Channel Report

Inlet B9A

Triangular

Side Slopes (z:1) = 100.00, 100.00
Total Depth (ft) = 0.50

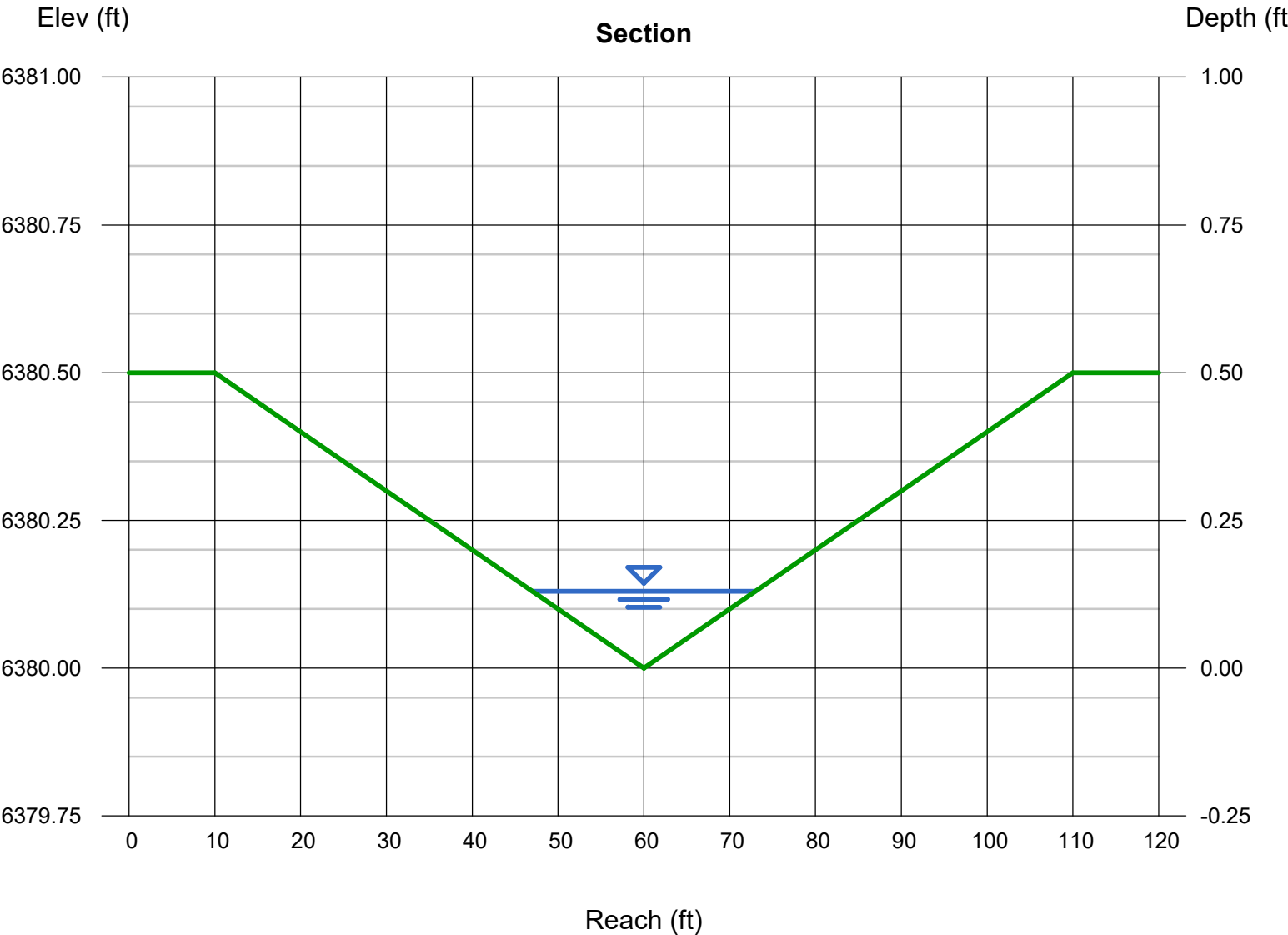
Invert Elev (ft) = 6380.00
Slope (%) = 1.60
N-Value = 0.016

Calculations

Compute by: Known Q
Known Q (cfs) = 2.77

Highlighted

Depth (ft) = 0.13
Q (cfs) = 2.770
Area (sqft) = 1.69
Velocity (ft/s) = 1.64
Wetted Perim (ft) = 26.00
Crit Depth, Yc (ft) = 0.14
Top Width (ft) = 26.00
EGL (ft) = 0.17



FLOW INTERCEPTION OF ON-GRADE GRATE INLET CALCULATION

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.1 & Table 7-6;

Inlet B9.1

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

Surface flow properties

Q =	2.77	cfs	Surface flow to inlet
S _o =	0.016		Drive Lane Longitudinal Grade
S _x =	0.01		Drive Lane Reverse Crown Grade
d =	0.13	ft	Flow Depth (from Hydraflow Express)
V =	1.64		Flow Velocity (from Hydraflow Express)
T =	13.0	ft	1/2 Flow Spread (from Hydraflow Express)

Grate inlet properties

			Model 24" dia. Grate as 16" front X 18" side
W =	16.0	in	Length of inlet grate
	1.33	ft	
L =	18.0	in	Width of inlet grate
	1.50	ft	
N =	1		Number of inlet grates

Flow Interception Calculation

V _o =	a+bVL-c(L)^2+n(L)^3	Splash-over velocity [Equation 7-20]
a =	0	
b =	0.68	Splash-over constants; Table 7-6
c =	0.06	Use parameters for Type 13 Valley Grate
n =	0.0023	
V _o =	1.16	
Q _w =	Q*(1-(1-(W/T))^2.67)	Frontal flow to Grate Inlet [Equation 7-17]
Q _w =	0.70	cfs
Q _x =	Q-Q _w	Side flow to grate inlet (per side)
Q _x =	1.04	cfs [Equation 7-18]
R _f =	1.0-0.09*(V-V _o)	Interception rate of frontal flow
R _f =	0.96	[Equation 7-19]
Q _{wi} =	R _f *Q _w	Intercepted frontal flow by grate inlet
Q _{wi} =	0.67	cfs [Equation 7-19]
R _x =	1/(1+(0.015*V^1.8)/(S _x *(N*L)^2.3))	Interception rate of side flow (each side)
R _x =	0.41	[Equation 7-21]
Q _{xi} =	R _x *Q _x	Intercepted side flow by grate inlet (each side)
Q _{xi} =	0.43	cfs
Q _i =	<input type="text" value="1.52"/>	cfs Total flow intercepted flow by grate inlet
Q _b =	<input type="text" value="1.25"/>	cfs Total bypassed flow to <input type="text" value="Inlet B9"/>

HYDRAULIC CAPACITY OF AREA INLETS IN SUMP CALCULATIONS

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.7 & Table 7-8;

Inlet B9

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

$$Q_i = C_o A_o (2gd)^{0.5}$$

hydraulic capacity of grate inlet operating as an orifice (cfs); Equation 7-38

$$C_o = 0.67$$

orifice discharge coefficient; Table 7-8

$$g = 32.2$$

acceleration of gravity (ft/sec²)

$$A_o = A_g A_{\text{RATIO}} C_f / 100^2$$

orifice area

$$A_g = 3.34 \text{ ft}^2$$

grate area (L x W)

$$A_{\text{RATIO}} = 39 \%$$

open area ratio (70% for CDOT Type C standard grate)

$$C_f = 50 \%$$

clogging factor (50% typical per MHFD recommendation)

$$A_o = 0.65 \text{ ft}^2$$

grate clear opening area

$$d = 0.50 \text{ ft}$$

available ponding depth of water over grate

$$Q_R = 5.31 \text{ cfs}$$

surface flow to inlet

$$Q_B = 1.54$$

bypassed flow to inlet

$$Q_T = 6.85$$

total flow to inlet

$$Q_i = 2.48 \text{ cfs}$$

calculated single grate inlet capacity

$$N = 4$$

number of grates

$$Q_{\text{cap}} = 9.90 \text{ cfs}$$

total calculated inlet capacity

Inlet capacity is GOOD for the given ponding depth.

HYDRAULIC CAPACITY OF AREA INLETS IN SUMP CALCULATIONS

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.7 & Table 7-8;

Inlet B11

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

$$Q_i = C_o A_o (2gd)^{0.5} \quad \text{hydraulic capacity of grate inlet operating as an orifice (cfs); Equation 7-38}$$

$$C_o = 0.67 \quad \text{orifice discharge coefficient; Table 7-8}$$

$$g = 32.2 \quad \text{acceleration of gravity (ft/sec}^2\text{)}$$

$$A_o = A_g A_{\text{RATIO}} C_f / 100^2 \quad \text{orifice area}$$

$$A_g = 3.34 \text{ ft}^2 \quad \text{grate area (L x W)}$$

$$A_{\text{RATIO}} = 39 \% \quad \text{open area ratio (70% for CDOT Type C standard grate)}$$

$$C_f = 50 \% \quad \text{clogging factor (50% typical per MHFD recommendation)}$$

$$A_o = 0.65 \text{ ft}^2 \quad \text{grate clear opening area}$$

$$d = 0.46 \text{ ft} \quad \text{available ponding depth of water over grate}$$

$$Q_R = 5.43 \text{ cfs} \quad \text{surface flow to inlet}$$

$$Q_B = 0.00 \quad \text{bypassed flow to inlet}$$

$$Q_T = 5.43 \quad \text{total flow to inlet}$$

$$Q_i = 2.38 \text{ cfs} \quad \text{calculated single grate inlet capacity}$$

$$N = 4 \quad \text{number of grates}$$

$$Q_{\text{cap}} = 9.50 \text{ cfs} \quad \text{total calculated inlet capacity}$$

Inlet capacity is GOOD for the given ponding depth.

HYDRAULIC CAPACITY OF AREA INLETS IN SUMP CALCULATIONS

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.7 & Table 7-8;

Inlet B15

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

$$Q_i = C_o A_o (2gd)^{0.5} \quad \text{hydraulic capacity of grate inlet operating as an orifice (cfs); Equation 7-38}$$

$$C_o = 0.67 \quad \text{orifice discharge coefficient; Table 7-8}$$

$$g = 32.2 \quad \text{acceleration of gravity (ft/sec}^2\text{)}$$

$$A_o = A_g A_{\text{RATIO}} C_f / 100^2 \quad \text{orifice area}$$

$$A_g = 3.34 \text{ ft}^2 \quad \text{grate area (L x W)}$$

$$A_{\text{RATIO}} = 39 \% \quad \text{open area ratio (70% for CDOT Type C standard grate)}$$

$$C_f = 50 \% \quad \text{clogging factor (50% typical per MHFD recommendation)}$$

$$A_o = 0.65 \text{ ft}^2 \quad \text{grate clear opening area}$$

$$d = 0.39 \text{ ft} \quad \text{available ponding depth of water over grate}$$

$$Q_R = 3.51 \text{ cfs} \quad \text{surface flow to inlet}$$

$$Q_B = 0.00 \quad \text{bypassed flow to inlet}$$

$$Q_T = 3.51 \quad \text{total flow to inlet}$$

$$Q_i = 2.19 \text{ cfs} \quad \text{calculated single grate inlet capacity}$$

$$N = 2 \quad \text{number of grates}$$

$$Q_{\text{cap}} = 4.37 \text{ cfs} \quad \text{total calculated inlet capacity}$$

Inlet capacity is GOOD for the given ponding depth.

HYDRAULIC CAPACITY OF AREA INLETS IN SUMP CALCULATIONS

Project Name: Costco Wholesale

Project No.: 20-224-005

Per MHFD USDCM Vol. 1, Ch. 7, S. 3.2.7 & Table 7-8;

Inlet B16

Inlet Type : Neenah R-3563-HB Grate (Costco Standard Detail 07_05 equivalent)

$$Q_i = C_o A_o (2gd)^{0.5} \quad \text{hydraulic capacity of grate inlet operating as an orifice (cfs); Equation 7-38}$$

$$C_o = 0.67 \quad \text{orifice discharge coefficient; Table 7-8}$$

$$g = 32.2 \quad \text{acceleration of gravity (ft/sec}^2\text{)}$$

$$A_o = A_g A_{\text{RATIO}} C_f / 100^2 \quad \text{orifice area}$$

$$A_g = 3.34 \text{ ft}^2 \quad \text{grate area (L x W)}$$

$$A_{\text{RATIO}} = 39 \% \quad \text{open area ratio (70% for CDOT Type C standard grate)}$$

$$C_f = 50 \% \quad \text{clogging factor (50% typical per MHFD recommendation)}$$

$$A_o = 0.65 \text{ ft}^2 \quad \text{grate clear opening area}$$

$$d = 0.25 \text{ ft} \quad \text{available ponding depth of water over grate}$$

$$Q_R = 3.35 \text{ cfs} \quad \text{surface flow to inlet}$$

$$Q_B = 0.00 \quad \text{bypassed flow to inlet}$$

$$Q_T = 3.35 \quad \text{total flow to inlet}$$

$$Q_i = 1.75 \text{ cfs} \quad \text{calculated single grate inlet capacity}$$

$$N = 2 \quad \text{number of grates}$$

$$Q_{\text{cap}} = 3.50 \text{ cfs} \quad \text{total calculated inlet capacity}$$

Inlet capacity is GOOD for the given ponding depth.

Channel Report

O2 Swale

Triangular

Side Slopes (z:1) = 4.00, 4.00
Total Depth (ft) = 1.50

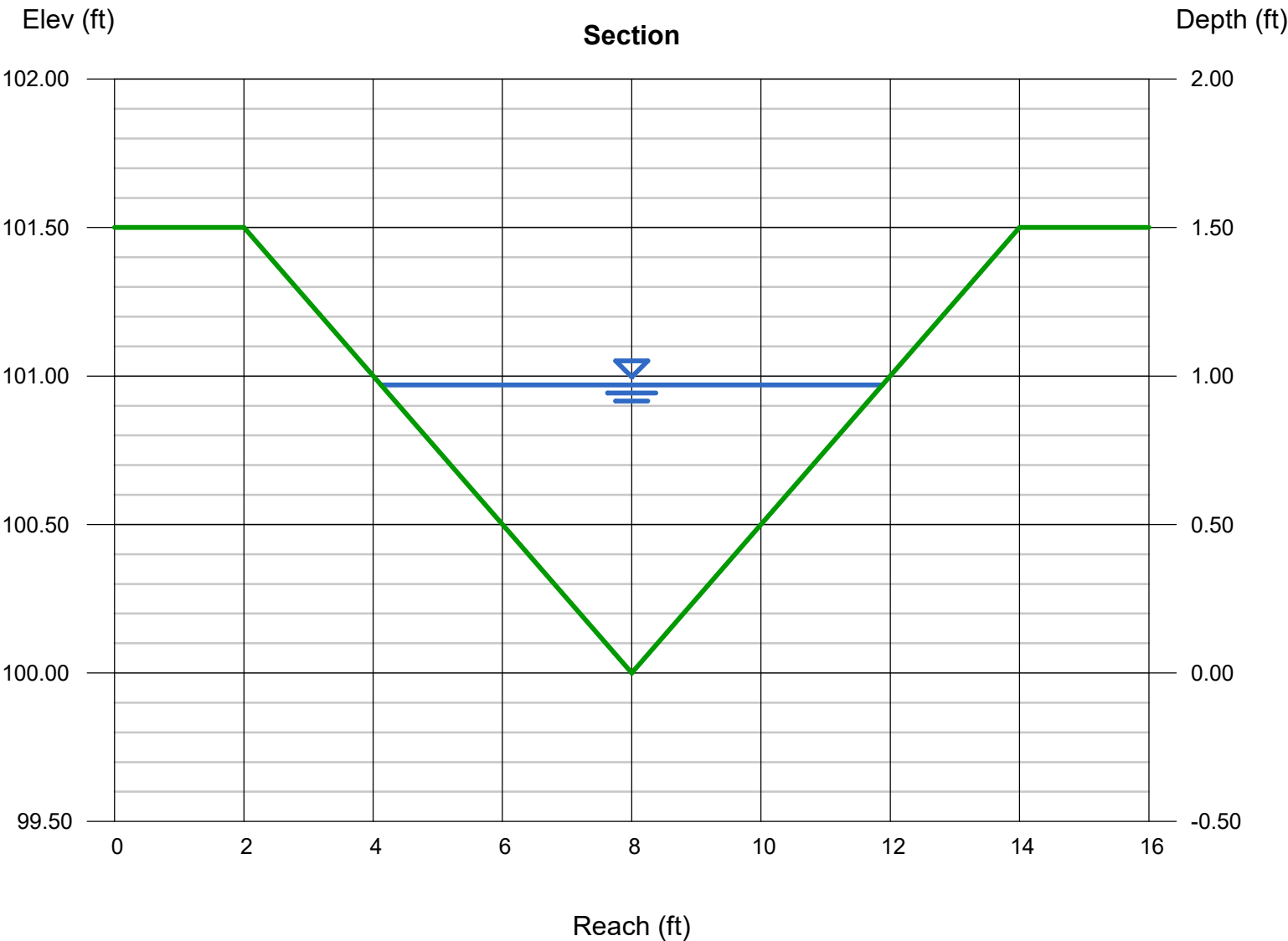
Invert Elev (ft) = 100.00
Slope (%) = 1.00
N-Value = 0.032

Calculations

Compute by: Known Q
Known Q (cfs) = 10.52

Highlighted

Depth (ft) = 0.97
Q (cfs) = 10.52
Area (sqft) = 3.76
Velocity (ft/s) = 2.80
Wetted Perim (ft) = 8.00
Crit Depth, Yc (ft) = 0.85
Top Width (ft) = 7.76
EGL (ft) = 1.09



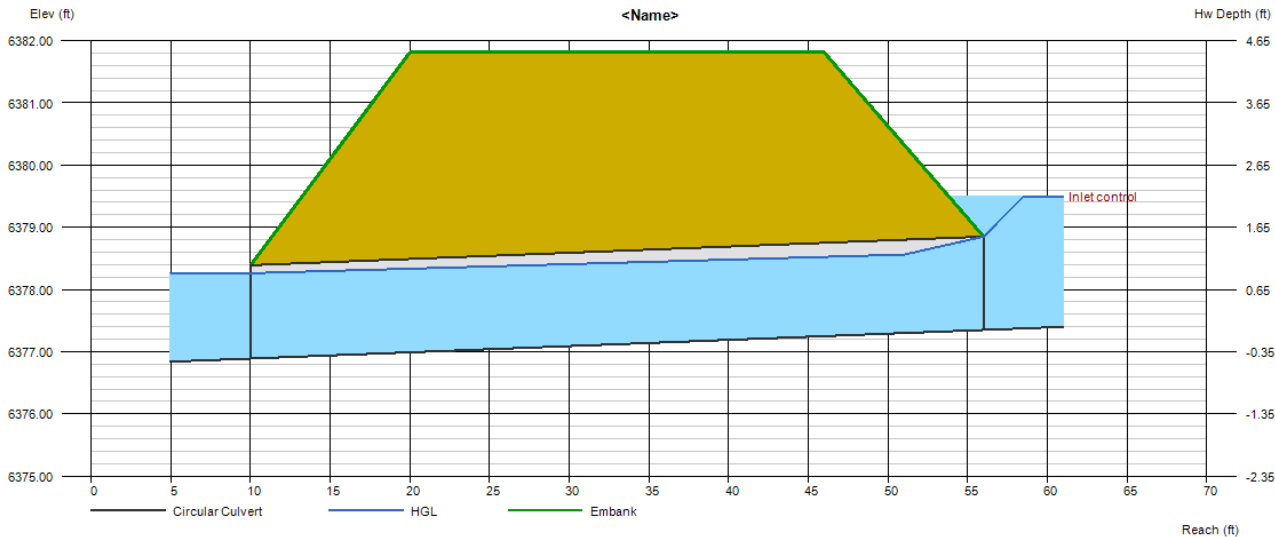
Culvert Report

Circular Culvert

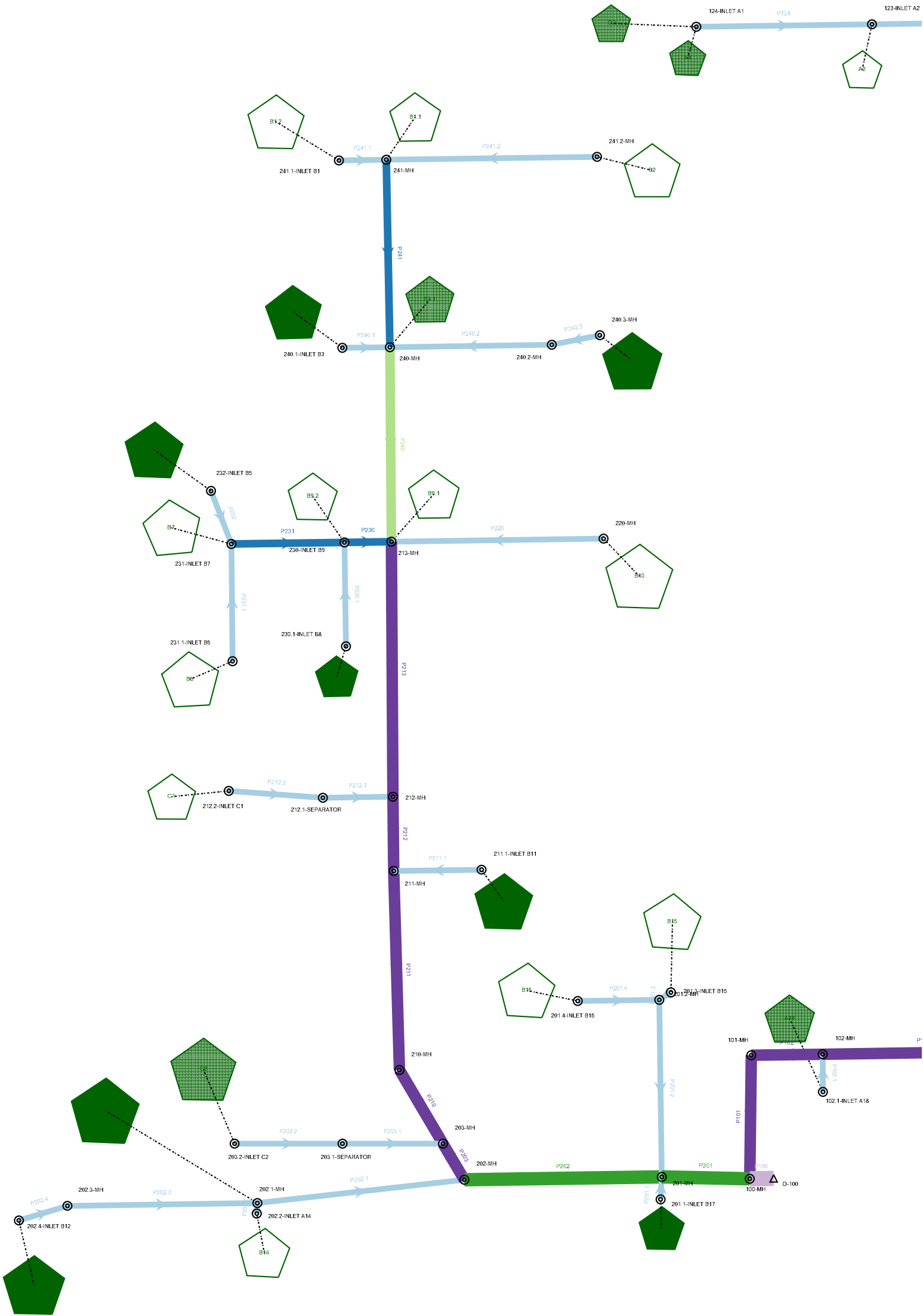
Invert Elev Dn (ft)	= 6376.89
Pipe Length (ft)	= 46.00
Slope (%)	= 1.00
Invert Elev Up (ft)	= 6377.35
Rise (in)	= 18.0
Shape	= Circular
Span (in)	= 18.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Groove end projecting (C)
Coeff. K,M,c,Y,k	= 0.0045, 2, 0.0317, 0.69, 0.2

Embankment	
Top Elevation (ft)	= 6381.81
Top Width (ft)	= 26.00
Crest Width (ft)	= 10.00

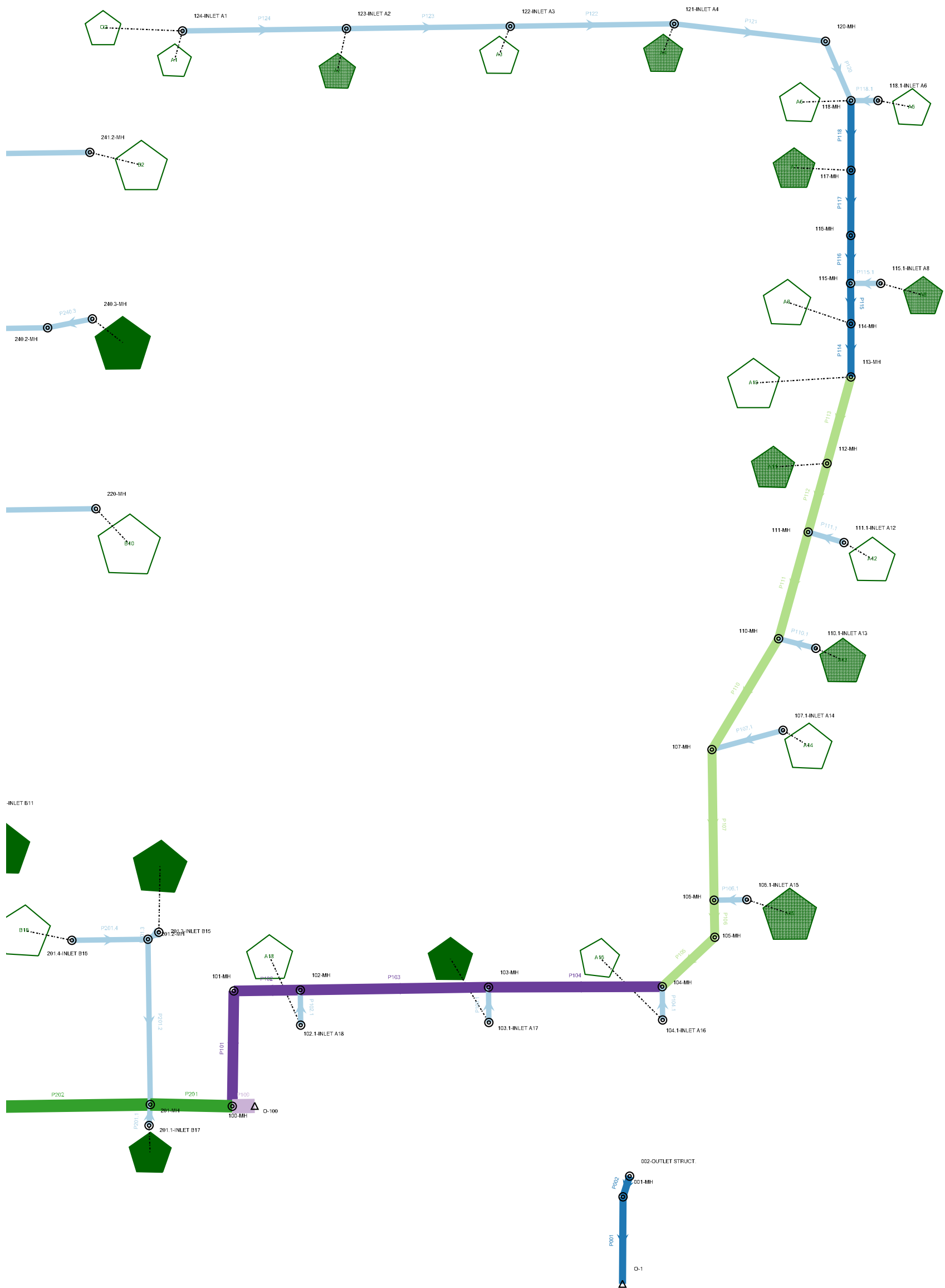
Calculations	
Qmin (cfs)	= 0.00
Qmax (cfs)	= 10.52
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 10.50
Qpipe (cfs)	= 10.50
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 6.20
Veloc Up (ft/s)	= 6.69
HGL Dn (ft)	= 6378.26
HGL Up (ft)	= 6378.60
Hw Elev (ft)	= 6379.50
Hw/D (ft)	= 1.43
Flow Regime	= Inlet Control



Scenario: Major



Scenario: Major



Minor Storm: Hydrology Summary (1/1)

FlexTable: Catchment Table

Label	Outflow Element	Area (User Defined) (acres)	Runoff Coefficient (Rational)	Time of Concentration (min)
O2	124-INLET A1	0.060	0.810	5.000
A1	124-INLET A1	0.150	0.810	5.000
A2	123-INLET A2	0.130	0.810	5.000
A3	122-INLET A3	0.120	0.810	5.000
A4	121-INLET A4	0.120	0.810	5.000
A5	118-MH	0.290	0.810	6.000
A6	118.1-INLET A6	0.200	0.810	5.100
A7	117-MH	0.570	0.810	6.000
A8	115.1-INLET A8	0.270	0.810	5.100
A9	114-MH	0.570	0.810	6.000
A10	113-MH	0.300	0.810	6.000
A11	112-MH	0.120	0.810	5.000
A12	111.1-INLET A12	0.160	0.810	5.000
A13	110.1-INLET A13	0.150	0.810	5.000
A14	107.1-INLET A14	0.280	0.810	5.000
A15	106.1-INLET A15	0.350	0.810	5.100
A16	104.1-INLET A16	0.930	0.780	7.600
A17	103.1-INLET A17	1.050	0.790	6.700
A18	102.1-INLET A18	0.530	0.760	7.200
B1.1	241-MH	0.360	0.810	5.100
B1.2	241.1-INLET B1	1.010	0.670	7.400
B2	241.2-MH	0.570	0.810	6.000
B3.1	240-MH	0.350	0.810	5.100
B3.2	240.1-INLET B3	1.120	0.680	7.200
B4	240.3-MH	0.570	0.810	6.000
B5	232-INLET B5	0.130	0.810	5.000
B6	231.1-INLET B6	0.970	0.800	6.200
B7	231-INLET B7	0.380	0.600	7.900
B8	230.1-INLET B8	0.550	0.780	5.600
B9.1	213-MH	0.360	0.810	5.100
B9.2	230-INLET B9	0.510	0.770	5.700
B10	220-MH	0.820	0.810	6.000
B11	211.1-INLET B11	0.690	0.770	5.000
B12	202.4-INLET B12	0.170	0.200	5.000
B13	202.1-MH	0.340	0.810	5.000
B14	202.2-INLET A14	0.230	0.810	5.000
B15	201.3-INLET B15	0.450	0.770	5.000
B16	201.4-INLET B16	0.460	0.810	5.000
B17	201.1-INLET B17	0.720	0.790	5.000
C1	212.2-INLET C1	0.350	0.810	5.700
C2	203.2-INLET C2	0.340	0.810	5.400

FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)	Diameter (in)	Material	Manning's n	Flow (cfs)	Velocity (ft/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Capacity (Full Flow) (cfs)	Flow / Capacity (Design) (%)
P241.2	241.2-MH	6,375.01	241-MH	6,374.15	144.0	0.006	18.0	Concrete	0.013	2.15	3.88	6,375.57	6,375.04	8.14	26.4
P241.1	241.1-INLET B1	6,374.35	241-MH	6,374.15	32.4	0.006	18.0	Concrete	0.013	2.94	4.23	6,375.01	6,375.04	8.14	36.2
P241	241-MH	6,373.65	240-MH	6,372.88	128.1	0.006	24.0	Concrete	0.013	6.19	5.10	6,374.53	6,374.27	17.52	35.3
P240.3	240.3-MH	6,375.01	240.2-MH	6,374.81	33.4	0.006	18.0	Concrete	0.013	2.15	3.88	6,375.57	6,375.34	8.14	26.4
P240.2	240.2-MH	6,374.61	240-MH	6,373.29	110.6	0.012	18.0	Concrete	0.013	2.13	4.97	6,375.16	6,374.27	11.49	18.5
P240.1	240.1-INLET B3	6,373.88	240-MH	6,373.31	32.5	0.017	18.0	Concrete	0.013	3.34	6.46	6,374.58	6,374.27	13.89	24.1
P240	240-MH	6,372.38	213-MH	6,371.59	133.0	0.006	30.0	Concrete	0.013	12.47	6.08	6,373.57	6,373.14	31.77	39.3
P232	232-INLET B5	6,374.99	231-INLET B7	6,374.35	38.8	0.019	18.0	Concrete	0.013	0.51	3.84	6,375.26	6,375.12	14.38	3.6
P231.1	231.1-INLET B6	6,375.07	231-INLET B7	6,374.35	80.1	0.009	18.0	Concrete	0.013	3.57	5.17	6,375.79	6,375.12	9.96	35.9
P231	231-INLET B7	6,373.85	230-INLET B9	6,372.70	77.3	0.015	24.0	Concrete	0.013	4.72	6.56	6,374.62	6,374.23	27.58	17.1
P230.1	230.1-INLET B8	6,373.73	230-INLET B9	6,373.20	71.0	0.007	18.0	Concrete	0.013	2.03	4.14	6,374.27	6,374.23	9.07	22.4
P230	230-INLET B9	6,372.50	213-MH	6,372.09	32.1	0.013	24.0	Concrete	0.013	8.15	7.28	6,373.52	6,373.14	25.80	31.6
P220	220-MH	6,374.51	213-MH	6,372.59	145.0	0.013	18.0	Concrete	0.013	3.09	5.72	6,375.18	6,373.11	12.09	25.5
P213	213-MH	6,370.59	212-MH	6,369.42	174.3	0.007	36.0	Concrete	0.013	24.34	7.49	6,372.18	6,371.17	54.49	44.7
P212.2	212.2-INLET C1	6,376.97	212.1- SEPARATOR	6,376.21	64.5	0.012	18.0	Concrete	0.013	1.34	4.32	6,377.40	6,376.75	11.40	11.7
P212.1	212.1-SEPARATOR	6,376.01	212-MH	6,375.64	47.9	0.008	18.0	Concrete	0.013	1.32	3.69	6,376.44	6,376.03	9.18	14.4
P212	212-MH	6,369.42	211-MH	6,369.10	50.7	0.006	36.0	Concrete	0.013	25.11	7.42	6,371.04	6,370.56	53.21	47.2
P211.1	211.1-INLET B11	6,373.66	211-MH	6,371.24	60.0	0.040	18.0	Concrete	0.013	2.60	8.10	6,374.27	6,371.60	21.08	12.3
P211	211-MH	6,368.70	210-MH	6,367.41	136.1	0.009	36.0	Concrete	0.013	27.16	8.78	6,370.39	6,368.77	64.94	41.8
P210	210-MH	6,366.73	203-MH	6,366.01	58.5	0.012	36.0	Concrete	0.013	26.87	9.63	6,368.41	6,367.33	73.98	36.3
P203.2	203.2-INLET C2	6,376.76	203.1- SEPARATOR	6,376.01	73.7	0.010	18.0	Concrete	0.013	1.32	4.08	6,377.19	6,376.54	10.59	12.4
P203.1	203.1-SEPARATOR	6,375.81	203-MH	6,375.13	68.7	0.010	18.0	Concrete	0.013	1.30	4.04	6,376.24	6,375.48	10.50	12.4
P203	203-MH	6,365.81	202-MH	6,365.47	28.7	0.012	36.0	Concrete	0.013	27.87	9.62	6,367.52	6,367.35	72.90	38.2
P202.4	202.4-INLET B12	6,373.06	202.3-MH	6,372.71	34.7	0.010	18.0	Concrete	0.013	0.17	2.20	6,373.21	6,372.84	10.50	1.6
P202.3	202.3-MH	6,372.51	202.1-MH	6,371.54	129.8	0.007	18.0	Concrete	0.013	0.16	1.97	6,372.66	6,372.48	9.09	1.8
P202.2	202.2-INLET A14	6,372.06	202.1-MH	6,371.99	7.1	0.010	18.0	Concrete	0.013	0.91	3.62	6,372.46	6,372.48	10.42	8.7
P202.1	202.1-MH	6,371.54	202-MH	6,369.50	142.4	0.014	18.0	Concrete	0.013	2.26	5.40	6,372.11	6,369.93	12.59	18.0
P202	202-MH	6,365.01	201-MH	6,362.51	135.0	0.019	42.0	Concrete	0.013	29.81	11.38	6,366.70	6,365.15	136.91	21.8
P201.4	201.4-INLET B16	6,373.08	201.2-MH	6,370.70	55.7	0.043	18.0	Concrete	0.013	1.82	7.46	6,373.59	6,370.99	21.71	8.4
P201.3	201.3-INLET B15	6,374.47	201.2-MH	6,373.28	9.5	0.125	18.0	Concrete	0.013	1.69	10.66	6,374.96	6,373.53	37.17	4.6
P201.2	201.2-MH	6,369.03	201-MH	6,368.64	121.0	0.003	18.0	Concrete	0.013	3.49	3.48	6,369.86	6,369.36	5.90	59.2
P201.1	201.1-INLET B17	6,371.01	201-MH	6,370.70	15.3	0.020	18.0	Concrete	0.013	2.78	6.44	6,371.64	6,371.18	14.85	18.7
P201	201-MH	6,362.02	100-MH	6,361.72	60.1	0.005	42.0	Concrete	0.013	34.71	7.35	6,364.54	6,364.53	71.14	48.8
P124	124-INLET A1	6,378.02	123-INLET A2	6,377.44	120.0	0.005	18.0	Concrete	0.013	0.83	2.78	6,378.36	6,377.78	7.43	11.2
P123	123-INLET A2	6,377.18	122-INLET A3	6,376.61	120.0	0.005	18.0	Concrete	0.013	1.30	3.16	6,377.61	6,377.03	7.43	17.5
P122	122-INLET A3	6,376.16	121-INLET A4	6,375.59	120.0	0.005	18.0	Concrete	0.013	1.71	3.41	6,376.65	6,376.08	7.43	23.0
P121	121-INLET A4	6,372.17	120-MH	6,371.62	111.6	0.005	18.0	Concrete	0.013	2.10	3.61	6,372.71	6,372.17	7.41	28.3
P120	120-MH	6,371.37	118-MH	6,371.14	47.2	0.005	18.0	Concrete	0.013	2.05	3.59	6,371.91	6,371.82	7.43	27.6
P118.1	118.1-INLET A6	6,375.46	118-MH	6,374.67	19.8	0.040	18.0	Concrete	0.013	0.79	5.69	6,375.79	6,374.87	21.00	3.8
P118	118-MH	6,370.89	117-MH	6,370.63	51.1	0.005	24.0	Concrete	0.013	3.74	4.15	6,371.56	6,371.29	16.00	23.4
P117	117-MH	6,370.38	116-MH	6,370.14	47.7	0.005	24.0	Concrete	0.013	5.68	4.66	6,371.22	6,370.97	16.00	35.5
P116	116-MH	6,369.89	115-MH	6,369.72	35.0	0.005	24.0	Concrete	0.013	5.64	4.65	6,370.73	6,370.73	16.00	35.2
P115.1	115.1-INLET A8	6,374.56	115-MH	6,373.68	22.0	0.040	18.0	Concrete	0.013	1.06	6.21	6,374.94	6,373.91	20.98	5.1
P115	115-MH	6,369.47	114-MH	6,369.32	29.6	0.005	24.0	Concrete	0.013	6.53	4.83	6,370.37	6,370.21	16.00	40.8
P114	114-MH	6,369.07	113-MH	6,368.87	38.9	0.005	24.0	Concrete	0.013	8.44	5.16	6,370.10	6,369.91	16.00	52.8
P113	113-MH	6,368.62	112-MH	6,368.30	65.7	0.005	30.0	Concrete	0.013	9.41	5.28	6,369.65	6,369.28	29.00	32.5

Minor Storm: Pipe Summary (2/2)

FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)	Diameter (in)	Material	Manning's n	Flow (cfs)	Velocity (ft/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Capacity (Full Flow) (cfs)	Flow / Capacity (Design) (%)
P112	112-MH	6,368.05	111-MH	6,367.79	52.1	0.005	30.0	Concrete	0.013	9.73	5.32	6,369.09	6,369.01	29.00	33.6
P111.1	111.1-INLET A12	6,373.38	111-MH	6,372.29	27.4	0.040	18.0	Concrete	0.013	0.63	5.31	6,373.68	6,372.47	20.95	3.0
P111	111-MH	6,367.54	110-MH	6,367.13	81.0	0.005	30.0	Concrete	0.013	10.20	5.39	6,368.60	6,368.39	29.00	35.2
P110.1	110.1-INLET A13	6,373.04	110-MH	6,371.92	28.2	0.040	18.0	Concrete	0.013	0.59	5.20	6,373.33	6,372.09	20.91	2.8
P110	110-MH	6,366.88	107-MH	6,366.41	94.7	0.005	30.0	Concrete	0.013	10.59	5.44	6,367.97	6,367.73	29.00	36.5
P107.1	107.1-INLET A14	6,371.16	107-MH	6,370.89	54.0	0.005	18.0	Concrete	0.013	1.11	3.05	6,371.55	6,371.28	7.53	14.7
P107	107-MH	6,366.16	106-MH	6,365.61	110.3	0.005	30.0	Concrete	0.013	11.37	5.55	6,367.29	6,367.00	29.00	39.2
P106.1	106.1-INLET A15	6,370.83	106-MH	6,369.87	24.0	0.040	18.0	Concrete	0.013	1.38	6.72	6,371.27	6,370.13	20.99	6.6
P106	106-MH	6,365.36	105-MH	6,365.18	27.2	0.006	30.0	Concrete	0.013	12.35	6.22	6,366.53	6,366.26	32.88	37.5
P105	105-MH	6,364.93	104-MH	6,364.67	52.7	0.005	30.0	Concrete	0.013	12.31	5.67	6,366.11	6,366.13	29.06	42.4
P104.1	104.1-INLET A16	6,369.85	104-MH	6,369.73	24.4	0.005	18.0	Concrete	0.013	3.13	4.06	6,370.53	6,370.41	7.51	41.6
P104	104-MH	6,364.42	103-MH	6,363.78	127.2	0.005	36.0	Concrete	0.013	15.09	5.94	6,365.65	6,365.43	47.19	32.0
P103.1	103.1-INLET A17	6,370.94	103-MH	6,370.71	25.9	0.010	18.0	Concrete	0.013	3.73	5.44	6,371.68	6,371.33	10.50	35.5
P103	103-MH	6,363.53	102-MH	6,362.84	137.8	0.005	36.0	Concrete	0.013	18.09	6.23	6,364.94	6,364.99	47.16	38.4
P102.1	102.1-INLET A18	6,372.10	102-MH	6,371.87	25.7	0.010	18.0	Concrete	0.013	1.77	4.42	6,372.60	6,372.29	10.50	16.8
P102	102-MH	6,362.59	101-MH	6,362.34	48.8	0.005	36.0	Concrete	0.013	19.38	6.35	6,364.80	6,364.79	47.19	41.1
P101	101-MH	6,362.10	100-MH	6,361.72	84.4	0.004	36.0	Concrete	0.013	19.28	6.05	6,364.56	6,364.53	44.30	43.5
P100	100-MH	6,361.47	O-100	6,361.39	16.4	0.005	48.0	Concrete	0.013	51.92	8.13	6,363.64	6,363.46	101.56	51.1
P002	002-OUTLET STRUCT.	6,353.11	001-MH	6,352.58	15.9	0.034	24.0	Concrete	0.013	4.00	8.35	6,353.82	6,353.05	41.49	9.6
P001	001-MH	6,349.72	O-1	6,347.95	63.7	0.028	24.0	Concrete	0.013	4.00	1.27	6,351.81	6,351.79	37.76	10.6

Minor Storm: Junction Summary (1/2)

FlexTable: Manhole Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Local Additional Flow (cfs)	Local Known Flow (cfs)	Flow (Total Out) (cfs)	Headloss Coefficient (Standard)	Headloss (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Headloss Method
241.2-MH	6,381.13	6,375.01	0.00	0.00	2.15	0.050	0.01	6,375.58	6,375.57	Standard
241.1-INLET B1	6,378.90	6,374.35	0.00	0.00	2.94	0.050	0.01	6,375.02	6,375.01	Standard
241-MH	6,379.21	6,373.65	0.00	0.00	6.19	1.520	0.51	6,375.04	6,374.53	Standard
240.3-MH	6,381.03	6,375.01	0.00	0.00	2.15	0.050	0.01	6,375.58	6,375.57	Standard
240.2-MH	6,380.44	6,374.61	0.00	0.00	2.13	0.100	0.02	6,375.18	6,375.16	Standard
240.1-INLET B3	6,378.38	6,373.88	0.00	0.00	3.34	0.050	0.01	6,374.59	6,374.58	Standard
240-MH	6,378.83	6,372.38	0.00	0.00	12.47	1.520	0.70	6,374.27	6,373.57	Standard
232-INLET B5	6,380.49	6,374.99	0.00	0.00	0.51	0.050	0.00	6,375.26	6,375.26	Standard
231.1-INLET B6	6,379.07	6,375.07	0.00	0.00	3.57	0.050	0.01	6,375.81	6,375.79	Standard
231-INLET B7	6,379.35	6,373.85	0.00	0.00	4.72	1.770	0.50	6,375.12	6,374.62	Standard
230.1-INLET B8	6,378.13	6,373.73	0.00	0.00	2.03	0.050	0.01	6,374.28	6,374.27	Standard
230-INLET B9	6,378.00	6,372.50	0.00	0.00	8.15	1.770	0.71	6,374.23	6,373.52	Standard
220-MH	6,380.93	6,374.51	0.00	0.00	3.09	0.050	0.01	6,375.19	6,375.18	Standard
213-MH	6,378.49	6,370.59	0.00	0.00	24.34	1.520	0.97	6,373.14	6,372.18	Standard
212.2-INLET C1	6,379.99	6,376.97	0.00	0.00	1.34	0.050	0.01	6,377.41	6,377.40	Standard
212.1-SEPARATOR	6,379.25	6,376.01	0.00	0.00	1.32	2.000	0.31	6,376.75	6,376.44	Standard
212-MH	6,379.19	6,369.42	0.00	0.00	25.11	0.200	0.13	6,371.17	6,371.04	Standard
211.1-INLET B11	6,378.00	6,373.66	0.00	0.00	2.60	0.050	0.01	6,374.28	6,374.27	Standard
211-MH	6,378.99	6,368.70	0.00	0.00	27.16	0.200	0.14	6,370.52	6,370.39	Standard
210-MH	6,380.11	6,366.73	0.00	0.00	26.87	0.200	0.14	6,368.54	6,368.41	Standard
203.2-INLET C2	6,381.01	6,376.76	0.00	0.00	1.32	0.050	0.01	6,377.20	6,377.19	Standard
203.1-SEPARATOR	6,379.97	6,375.81	0.00	0.00	1.30	2.000	0.31	6,376.54	6,376.24	Standard
203-MH	6,379.14	6,365.81	0.00	0.00	27.87	0.050	0.03	6,367.56	6,367.52	Standard
202.4-INLET B12	6,378.01	6,373.06	0.00	0.00	0.17	0.200	0.01	6,373.22	6,373.21	Standard
202.3-MH	6,381.32	6,372.51	0.00	0.00	0.16	0.200	0.01	6,372.67	6,372.66	Standard
202.2-INLET A14	6,379.87	6,372.06	0.00	0.00	0.91	0.050	0.00	6,372.46	6,372.46	Standard
202.1-MH	6,380.01	6,371.54	0.00	0.00	2.26	1.770	0.37	6,372.48	6,372.11	Standard
202-MH	6,378.53	6,365.01	0.00	0.00	29.81	1.000	0.66	6,367.35	6,366.70	Standard
201.4-INLET B16	6,377.85	6,373.08	0.00	0.00	1.82	0.050	0.01	6,373.60	6,373.59	Standard
201.3-INLET B15	6,377.98	6,374.47	0.00	0.00	1.69	0.050	0.01	6,374.97	6,374.96	Standard
201.2-MH	6,378.44	6,369.03	0.00	0.00	3.49	0.050	0.01	6,369.87	6,369.86	Standard
201.1-INLET B17	6,377.15	6,371.01	0.00	0.00	2.78	0.050	0.01	6,371.66	6,371.64	Standard
201-MH	6,377.14	6,362.02	0.00	0.00	34.71	1.770	0.60	6,365.15	6,364.54	Standard
124-INLET A1	6,381.00	6,378.02	0.00	0.00	0.83	0.050	0.01	6,378.36	6,378.36	Standard
123-INLET A2	6,380.69	6,377.18	0.00	0.00	1.30	0.050	0.01	6,377.62	6,377.61	Standard
122-INLET A3	6,380.30	6,376.16	0.00	0.00	1.71	0.050	0.01	6,376.66	6,376.65	Standard
121-INLET A4	6,379.80	6,372.17	0.00	0.00	2.10	0.050	0.01	6,372.72	6,372.71	Standard
120-MH	6,380.86	6,371.37	0.00	0.00	2.05	0.500	0.10	6,372.01	6,371.91	Standard
118.1-INLET A6	6,380.46	6,375.46	0.00	0.00	0.79	0.050	0.01	6,375.80	6,375.79	Standard
118-MH	6,380.25	6,370.89	0.00	0.00	3.74	1.020	0.25	6,371.82	6,371.56	Standard
117-MH	6,380.75	6,370.38	0.00	0.00	5.68	0.050	0.02	6,371.24	6,371.22	Standard
116-MH	6,380.28	6,369.89	0.00	0.00	5.64	0.050	0.02	6,370.75	6,370.73	Standard
115.1-INLET A8	6,379.56	6,374.56	0.00	0.00	1.06	0.050	0.01	6,374.95	6,374.94	Standard
115-MH	6,379.44	6,369.47	0.00	0.00	6.53	1.020	0.35	6,370.73	6,370.37	Standard
114-MH	6,380.16	6,369.07	0.00	0.00	8.44	0.050	0.02	6,370.13	6,370.10	Standard
113-MH	6,380.73	6,368.62	0.00	0.00	9.41	0.050	0.02	6,369.67	6,369.65	Standard
112-MH	6,379.94	6,368.05	0.00	0.00	9.73	0.100	0.04	6,369.13	6,369.09	Standard
111.1-INLET A12	6,378.38	6,373.38	0.00	0.00	0.63	0.050	0.01	6,373.68	6,373.68	Standard
111-MH	6,378.63	6,367.54	0.00	0.00	10.20	1.020	0.41	6,369.01	6,368.60	Standard

FlexTable: Manhole Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Local Additional Flow (cfs)	Local Known Flow (cfs)	Flow (Total Out) (cfs)	Headloss Coefficient (Standard)	Headloss (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Headloss Method
110.1-INLET A13	6,378.11	6,373.04	0.00	0.00	0.59	0.050	0.00	6,373.33	6,373.33	Standard
110-MH	6,378.19	6,366.88	0.00	0.00	10.59	1.020	0.42	6,368.39	6,367.97	Standard
107.1-INLET A14	6,376.17	6,371.16	0.00	0.00	1.11	0.050	0.01	6,371.56	6,371.55	Standard
107-MH	6,377.08	6,366.16	0.00	0.00	11.37	1.020	0.44	6,367.73	6,367.29	Standard
106.1-INLET A15	6,375.83	6,370.83	0.00	0.00	1.38	0.050	0.01	6,371.28	6,371.27	Standard
106-MH	6,375.55	6,365.36	0.00	0.00	12.35	1.020	0.47	6,367.00	6,366.53	Standard
105-MH	6,375.28	6,364.93	0.00	0.00	12.31	0.050	0.02	6,366.13	6,366.11	Standard
104.1-INLET A16	6,375.10	6,369.85	0.00	0.00	3.13	0.050	0.01	6,370.54	6,370.53	Standard
104-MH	6,375.06	6,364.42	0.00	0.00	15.09	1.020	0.48	6,366.13	6,365.65	Standard
103.1-INLET A17	6,375.95	6,370.94	0.00	0.00	3.73	0.050	0.01	6,371.69	6,371.68	Standard
103-MH	6,376.25	6,363.53	0.00	0.00	18.09	1.020	0.49	6,365.43	6,364.94	Standard
102.1-INLET A18	6,377.21	6,372.10	0.00	0.00	1.77	0.050	0.01	6,372.61	6,372.60	Standard
102-MH	6,377.09	6,362.59	0.00	0.00	19.38	1.020	0.19	6,364.99	6,364.80	Standard
101-MH	6,377.49	6,362.10	0.00	0.00	19.28	1.520	0.23	6,364.79	6,364.56	Standard
100-MH	6,370.05	6,361.47	0.00	0.00	51.92	1.020	0.89	6,364.53	6,363.64	Standard
002-OUTLET STRUCT.	6,357.03	6,353.11	0.00	4.00	4.00	0.050	0.01	6,353.83	6,353.82	Standard
001-MH	6,366.02	6,349.72	0.00	0.00	4.00	0.050	0.00	6,351.81	6,351.81	Standard

Minor Storm: Outfall Summary (1/1)

FlexTable: Outfall Table

Label	Elevation (Invert) (ft)	Flow (Total Out) (cfs)	Boundary Condition Type	Elevation (User Defined Tailwater) (ft)	Depth (Node) (ft)	Hydraulic Grade (ft)
O-1	6,347.95	4.00	User Defined Tailwater	6,351.79	3.84	6,351.79
O-100	6,361.39	51.85	User Defined Tailwater	6,354.75	2.07	6,363.46

6354.75 =
Pond C3
5-yr WSE

6351.79 ~
Gamble Ridge
Tributary
100-yr WSE

Major Storm: Hydrology Summary (1/1)

FlexTable: Catchment Table

Label	Outflow Element	Area (User Defined) (acres)	Runoff Coefficient (Rational)	Time of Concentration (min)
O2	124-INLET A1	0.060	0.870	5.000
A1	124-INLET A1	0.150	0.870	5.000
A2	123-INLET A2	0.130	0.870	5.000
A3	122-INLET A3	0.120	0.870	5.000
A4	121-INLET A4	0.120	0.870	5.000
A5	118-MH	0.290	0.870	6.000
A6	118.1-INLET A6	0.200	0.870	5.100
A7	117-MH	0.570	0.870	6.000
A8	115.1-INLET A8	0.270	0.870	5.100
A9	114-MH	0.570	0.870	6.000
A10	113-MH	0.300	0.870	6.000
A11	112-MH	0.120	0.870	5.000
A12	111.1-INLET A12	0.160	0.870	5.000
A13	110.1-INLET A13	0.150	0.870	5.000
A14	107.1-INLET A14	0.280	0.870	5.000
A15	106.1-INLET A15	0.350	0.870	5.100
A16	104.1-INLET A16	0.930	0.850	7.600
A17	103.1-INLET A17	1.050	0.860	6.700
A18	102.1-INLET A18	0.530	0.850	7.200
B1.1	241-MH	0.360	0.870	5.100
B1.2	241.1-INLET B1	1.010	0.800	7.400
B2	241.2-MH	0.570	0.870	6.000
B3.1	240-MH	0.350	0.870	5.100
B3.2	240.1-INLET B3	1.120	0.810	7.200
B4	240.3-MH	0.570	0.870	6.000
B5	232-INLET B5	0.130	0.870	5.000
B6	231.1-INLET B6	0.970	0.870	6.200
B7	231-INLET B7	0.380	0.770	7.900
B8	230.1-INLET B8	0.550	0.860	5.600
B9.1	213-MH	0.360	0.870	5.100
B9.2	230-INLET B9	0.510	0.850	5.700
B10	220-MH	0.820	0.870	6.000
B11	211.1-INLET B11	0.690	0.850	5.000
B12	202.4-INLET B12	0.170	0.570	5.000
B13	202.1-MH	0.340	0.870	5.000
B14	202.2-INLET A14	0.230	0.870	5.000
B15	201.3-INLET B15	0.450	0.850	5.000
B16	201.4-INLET B16	0.460	0.870	5.000
B17	201.1-INLET B17	0.720	0.860	5.000
C1	212.2-INLET C1	0.350	0.870	5.700
C2	203.2-INLET C2	0.340	0.870	5.400

FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)	Diameter (in)	Material	Manning's n	Flow (cfs)	Velocity (ft/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Capacity (Full Flow) (cfs)	Flow / Capacity (Design) (%)
P241.2	241.2-MH	6,375.01	241-MH	6,374.15	144.0	0.006	18.0	Concrete	0.013	4.19	2.37	6,376.75	6,376.52	8.14	51.5
P241.1	241.1-INLET B1	6,374.35	241-MH	6,374.15	32.4	0.006	18.0	Concrete	0.013	6.39	3.62	6,376.64	6,376.52	8.14	78.6
P241	241-MH	6,373.65	240-MH	6,372.88	128.1	0.006	24.0	Concrete	0.013	12.71	4.04	6,376.13	6,375.73	17.52	72.5
P240.3	240.3-MH	6,375.01	240.2-MH	6,374.81	33.4	0.006	18.0	Concrete	0.013	4.19	4.64	6,375.90	6,375.89	8.14	51.5
P240.2	240.2-MH	6,374.61	240-MH	6,373.29	110.6	0.012	18.0	Concrete	0.013	4.17	5.98	6,375.88	6,375.73	11.49	36.3
P240.1	240.1-INLET B3	6,373.88	240-MH	6,373.31	32.5	0.017	18.0	Concrete	0.013	7.24	4.10	6,375.88	6,375.73	13.89	52.1
P240	240-MH	6,372.38	213-MH	6,371.59	133.0	0.006	30.0	Concrete	0.013	25.52	5.20	6,375.09	6,374.58	31.77	80.3
P232	232-INLET B5	6,374.99	231-INLET B7	6,374.35	38.8	0.019	18.0	Concrete	0.013	1.01	4.69	6,375.92	6,375.93	14.38	7.0
P231.1	231.1-INLET B6	6,375.07	231-INLET B7	6,374.35	80.1	0.009	18.0	Concrete	0.013	7.06	6.11	6,376.10	6,375.93	9.96	70.9
P231	231-INLET B7	6,373.85	230-INLET B9	6,372.70	77.3	0.015	24.0	Concrete	0.013	9.67	8.01	6,375.63	6,375.51	27.58	35.0
P230.1	230.1-INLET B8	6,373.73	230-INLET B9	6,373.20	71.0	0.007	18.0	Concrete	0.013	4.08	2.31	6,375.62	6,375.51	9.07	44.9
P230	230-INLET B9	6,372.50	213-MH	6,372.09	32.1	0.013	24.0	Concrete	0.013	16.56	5.27	6,374.75	6,374.58	25.80	64.2
P220	220-MH	6,374.51	213-MH	6,372.59	145.0	0.013	18.0	Concrete	0.013	6.03	6.84	6,375.46	6,374.58	12.09	49.9
P213	213-MH	6,370.59	212-MH	6,369.42	174.3	0.007	36.0	Concrete	0.013	49.05	8.72	6,372.87	6,371.99	54.49	90.0
P212.2	212.2-INLET C1	6,376.97	212.1- SEPARATOR	6,376.21	64.5	0.012	18.0	Concrete	0.013	2.61	5.24	6,377.58	6,377.08	11.40	22.9
P212.1	212.1-SEPARATOR	6,376.01	212-MH	6,375.64	47.9	0.008	18.0	Concrete	0.013	2.58	4.46	6,376.62	6,376.19	9.18	28.2
P212	212-MH	6,369.42	211-MH	6,369.10	50.7	0.006	36.0	Concrete	0.013	50.63	8.57	6,371.76	6,371.42	53.21	95.1
P211.1	211.1-INLET B11	6,373.66	211-MH	6,371.24	60.0	0.040	18.0	Concrete	0.013	5.21	9.89	6,374.54	6,371.75	21.08	24.7
P211	211-MH	6,368.70	210-MH	6,367.41	136.1	0.009	36.0	Concrete	0.013	54.76	10.30	6,371.10	6,370.08	64.94	84.3
P210	210-MH	6,366.73	203-MH	6,366.01	58.5	0.012	36.0	Concrete	0.013	54.27	7.68	6,369.90	6,369.51	73.98	73.4
P203.2	203.2-INLET C2	6,376.76	203.1- SEPARATOR	6,376.01	73.7	0.010	18.0	Concrete	0.013	2.58	4.94	6,377.37	6,376.87	10.59	24.3
P203.1	203.1-SEPARATOR	6,375.81	203-MH	6,375.13	68.7	0.010	18.0	Concrete	0.013	2.54	4.90	6,376.42	6,375.63	10.50	24.2
P203	203-MH	6,365.81	202-MH	6,365.47	28.7	0.012	36.0	Concrete	0.013	56.15	7.94	6,369.46	6,369.26	72.90	77.0
P202.4	202.4-INLET B12	6,373.06	202.3-MH	6,372.71	34.7	0.010	18.0	Concrete	0.013	0.86	3.59	6,373.41	6,373.00	10.50	8.2
P202.3	202.3-MH	6,372.51	202.1-MH	6,371.54	129.8	0.007	18.0	Concrete	0.013	0.85	3.23	6,373.03	6,373.04	9.09	9.4
P202.2	202.2-INLET A14	6,372.06	202.1-MH	6,371.99	7.1	0.010	18.0	Concrete	0.013	1.78	4.40	6,373.03	6,373.04	10.42	17.1
P202.1	202.1-MH	6,371.54	202-MH	6,369.50	142.4	0.014	18.0	Concrete	0.013	5.05	6.73	6,372.41	6,370.16	12.59	40.1
P202	202-MH	6,365.01	201-MH	6,362.51	135.0	0.019	42.0	Concrete	0.013	60.32	6.27	6,368.65	6,368.16	136.91	44.1
P201.4	201.4-INLET B16	6,373.08	201.2-MH	6,370.70	55.7	0.043	18.0	Concrete	0.013	3.56	9.06	6,373.80	6,371.11	21.71	16.4
P201.3	201.3-INLET B15	6,374.47	201.2-MH	6,373.28	9.5	0.125	18.0	Concrete	0.013	3.40	13.10	6,375.18	6,373.66	37.17	9.1
P201.2	201.2-MH	6,369.03	201-MH	6,368.64	121.0	0.003	18.0	Concrete	0.013	6.92	3.92	6,370.38	6,369.66	5.90	117.3
P201.1	201.1-INLET B17	6,371.01	201-MH	6,370.70	15.3	0.020	18.0	Concrete	0.013	5.50	7.78	6,371.92	6,371.40	14.85	37.1
P201	201-MH	6,362.02	100-MH	6,361.72	60.1	0.005	42.0	Concrete	0.013	69.52	7.23	6,366.72	6,366.44	71.14	97.7
P124	124-INLET A1	6,378.02	123-INLET A2	6,377.44	120.0	0.005	18.0	Concrete	0.013	1.62	3.37	6,378.50	6,377.92	7.43	21.9
P123	123-INLET A2	6,377.18	122-INLET A3	6,376.61	120.0	0.005	18.0	Concrete	0.013	2.55	3.81	6,377.79	6,377.21	7.43	34.4
P122	122-INLET A3	6,376.16	121-INLET A4	6,375.59	120.0	0.005	18.0	Concrete	0.013	3.37	4.10	6,376.87	6,376.29	7.43	45.4
P121	121-INLET A4	6,372.17	120-MH	6,371.62	111.6	0.005	18.0	Concrete	0.013	4.15	4.31	6,373.07	6,372.97	7.41	56.1
P120	120-MH	6,371.37	118-MH	6,371.14	47.2	0.005	18.0	Concrete	0.013	4.07	2.30	6,372.92	6,372.85	7.43	54.8
P118.1	118.1-INLET A6	6,375.46	118-MH	6,374.67	19.8	0.040	18.0	Concrete	0.013	1.54	6.93	6,375.93	6,374.96	21.00	7.3
P118	118-MH	6,370.89	117-MH	6,370.63	51.1	0.005	24.0	Concrete	0.013	7.40	4.99	6,372.76	6,372.71	16.00	46.2
P117	117-MH	6,370.38	116-MH	6,370.14	47.7	0.005	24.0	Concrete	0.013	11.25	3.58	6,372.70	6,372.58	16.00	70.3
P116	116-MH	6,369.89	115-MH	6,369.72	35.0	0.005	24.0	Concrete	0.013	11.14	3.55	6,372.57	6,372.49	16.00	69.6
P115.1	115.1-INLET A8	6,374.56	115-MH	6,373.68	22.0	0.040	18.0	Concrete	0.013	2.08	7.57	6,375.10	6,374.01	20.98	9.9
P115	115-MH	6,369.47	114-MH	6,369.32	29.6	0.005	24.0	Concrete	0.013	12.88	4.10	6,372.22	6,372.12	16.00	80.5
P114	114-MH	6,369.07	113-MH	6,368.87	38.9	0.005	24.0	Concrete	0.013	16.63	5.29	6,372.10	6,371.88	16.00	104.0
P113	113-MH	6,368.62	112-MH	6,368.30	65.7	0.005	30.0	Concrete	0.013	18.55	3.78	6,371.87	6,371.73	29.00	63.9

Major Storm: Pipe Summary (2/2)

FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)	Diameter (in)	Material	Manning's n	Flow (cfs)	Velocity (ft/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Capacity (Full Flow) (cfs)	Flow / Capacity (Design) (%)
P112	112-MH	6,368.05	111-MH	6,367.79	52.1	0.005	30.0	Concrete	0.013	19.11	3.89	6,371.71	6,371.60	29.00	65.9
P111.1	111.1-INLET A12	6,373.38	111-MH	6,372.29	27.4	0.040	18.0	Concrete	0.013	1.24	6.49	6,373.80	6,372.54	20.95	5.9
P111	111-MH	6,367.54	110-MH	6,367.13	81.0	0.005	30.0	Concrete	0.013	19.97	4.07	6,371.33	6,371.14	29.00	68.9
P110.1	110.1-INLET A13	6,373.04	110-MH	6,371.92	28.2	0.040	18.0	Concrete	0.013	1.16	6.36	6,373.44	6,372.16	20.91	5.5
P110	110-MH	6,366.88	107-MH	6,366.41	94.7	0.005	30.0	Concrete	0.013	20.66	4.21	6,370.85	6,370.61	29.00	71.2
P107.1	107.1-INLET A14	6,371.16	107-MH	6,370.89	54.0	0.005	18.0	Concrete	0.013	2.17	3.68	6,371.72	6,371.44	7.53	28.8
P107	107-MH	6,366.16	106-MH	6,365.61	110.3	0.005	30.0	Concrete	0.013	22.12	4.51	6,370.28	6,369.96	29.00	76.3
P106.1	106.1-INLET A15	6,370.83	106-MH	6,369.87	24.0	0.040	18.0	Concrete	0.013	2.69	8.17	6,371.45	6,370.25	20.99	12.8
P106	106-MH	6,365.36	105-MH	6,365.18	27.2	0.006	30.0	Concrete	0.013	23.94	4.88	6,369.57	6,369.48	32.88	72.8
P105	105-MH	6,364.93	104-MH	6,364.67	52.7	0.005	30.0	Concrete	0.013	23.85	4.86	6,369.46	6,369.28	29.06	82.1
P104.1	104.1-INLET A16	6,369.85	104-MH	6,369.73	24.4	0.005	18.0	Concrete	0.013	6.20	4.75	6,370.88	6,370.70	7.51	82.5
P104	104-MH	6,364.42	103-MH	6,363.78	127.2	0.005	36.0	Concrete	0.013	29.29	4.14	6,369.00	6,368.75	47.19	62.1
P103.1	103.1-INLET A17	6,370.94	103-MH	6,370.71	25.9	0.010	18.0	Concrete	0.013	7.38	6.43	6,372.00	6,371.65	10.50	70.2
P103	103-MH	6,363.53	102-MH	6,362.84	137.8	0.005	36.0	Concrete	0.013	34.99	4.95	6,368.36	6,367.98	47.16	74.2
P102.1	102.1-INLET A18	6,372.10	102-MH	6,371.87	25.7	0.010	18.0	Concrete	0.013	3.60	5.39	6,372.83	6,372.48	10.50	34.2
P102	102-MH	6,362.59	101-MH	6,362.34	48.8	0.005	36.0	Concrete	0.013	37.45	5.30	6,367.53	6,367.37	47.19	79.4
P101	101-MH	6,362.10	100-MH	6,361.72	84.4	0.004	36.0	Concrete	0.013	37.24	5.27	6,366.70	6,366.44	44.30	84.1
P100	100-MH	6,361.47	O-100	6,361.39	16.4	0.005	48.0	Concrete	0.013	102.01	9.21	6,365.36	6,365.29	101.56	100.4
P002	002-OUTLET STRUCT.	6,353.11	001-MH	6,352.58	15.9	0.034	24.0	Concrete	0.013	28.00	14.18	6,354.94	6,354.06	41.49	67.5
P001	001-MH	6,349.72	O-1	6,347.95	63.7	0.028	24.0	Concrete	0.013	28.00	8.91	6,352.77	6,351.79	37.76	74.1

Major Storm: Junction Summary (1/2)

FlexTable: Manhole Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Local Additional Flow (cfs)	Local Known Flow (cfs)	Flow (Total Out) (cfs)	Headloss Coefficient (Standard)	Headloss (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Headloss Method
241.2-MH	6,381.13	6,375.01	0.00	0.00	4.19	0.050	0.00	6,376.75	6,376.75	Standard
241.1-INLET B1	6,378.90	6,374.35	0.00	0.00	6.39	0.050	0.01	6,376.65	6,376.64	Standard
241-MH	6,379.21	6,373.65	0.00	0.00	12.71	1.520	0.39	6,376.52	6,376.13	Standard
240.3-MH	6,381.03	6,375.01	0.00	0.00	4.19	0.050	0.01	6,375.91	6,375.90	Standard
240.2-MH	6,380.44	6,374.61	0.00	0.00	4.17	0.100	0.01	6,375.89	6,375.88	Standard
240.1-INLET B3	6,378.38	6,373.88	0.00	0.00	7.24	0.050	0.01	6,375.90	6,375.88	Standard
240-MH	6,378.83	6,372.38	0.00	0.00	25.52	1.520	0.64	6,375.73	6,375.09	Standard
232-INLET B5	6,380.49	6,374.99	0.00	0.00	1.01	0.050	0.00	6,375.92	6,375.92	Standard
231.1-INLET B6	6,379.07	6,375.07	0.00	0.00	7.06	0.050	0.02	6,376.13	6,376.10	Standard
231-INLET B7	6,379.35	6,373.85	0.00	0.00	9.67	1.770	0.29	6,375.93	6,375.63	Standard
230.1-INLET B8	6,378.13	6,373.73	0.00	0.00	4.08	0.050	0.00	6,375.62	6,375.62	Standard
230-INLET B9	6,378.00	6,372.50	0.00	0.00	16.56	1.770	0.76	6,375.51	6,374.75	Standard
220-MH	6,380.93	6,374.51	0.00	0.00	6.03	0.050	0.02	6,375.48	6,375.46	Standard
213-MH	6,378.49	6,370.59	0.00	0.00	49.05	1.520	1.71	6,374.58	6,372.87	Standard
212.2-INLET C1	6,379.99	6,376.97	0.00	0.00	2.61	0.050	0.01	6,377.59	6,377.58	Standard
212.1-SEPARATOR	6,379.25	6,376.01	0.00	0.00	2.58	2.000	0.46	6,377.08	6,376.62	Standard
212-MH	6,379.19	6,369.42	0.00	0.00	50.63	0.200	0.23	6,371.99	6,371.76	Standard
211.1-INLET B11	6,378.00	6,373.66	0.00	0.00	5.21	0.050	0.02	6,374.56	6,374.54	Standard
211-MH	6,378.99	6,368.70	0.00	0.00	54.76	0.200	0.25	6,371.36	6,371.10	Standard
210-MH	6,380.11	6,366.73	0.00	0.00	54.27	0.200	0.18	6,370.08	6,369.90	Standard
203.2-INLET C2	6,381.01	6,376.76	0.00	0.00	2.58	0.050	0.01	6,377.38	6,377.37	Standard
203.1-SEPARATOR	6,379.97	6,375.81	0.00	0.00	2.54	2.000	0.45	6,376.87	6,376.42	Standard
203-MH	6,379.14	6,365.81	0.00	0.00	56.15	0.050	0.05	6,369.51	6,369.46	Standard
202.4-INLET B12	6,378.01	6,373.06	0.00	0.00	0.86	0.200	0.02	6,373.43	6,373.41	Standard
202.3-MH	6,381.32	6,372.51	0.00	0.00	0.85	0.200	0.01	6,373.04	6,373.03	Standard
202.2-INLET A14	6,379.87	6,372.06	0.00	0.00	1.78	0.050	0.00	6,373.04	6,373.03	Standard
202.1-MH	6,380.01	6,371.54	0.00	0.00	5.05	1.770	0.63	6,373.04	6,372.41	Standard
202-MH	6,378.53	6,365.01	0.00	0.00	60.32	1.000	0.61	6,369.26	6,368.65	Standard
201.4-INLET B16	6,377.85	6,373.08	0.00	0.00	3.56	0.050	0.01	6,373.81	6,373.80	Standard
201.3-INLET B15	6,377.98	6,374.47	0.00	0.00	3.40	0.050	0.01	6,375.19	6,375.18	Standard
201.2-MH	6,378.44	6,369.03	0.00	0.00	6.92	0.050	0.01	6,370.39	6,370.38	Standard
201.1-INLET B17	6,377.15	6,371.01	0.00	0.00	5.50	0.050	0.02	6,371.93	6,371.92	Standard
201-MH	6,377.14	6,362.02	0.00	0.00	69.52	1.770	1.44	6,368.16	6,366.72	Standard
124-INLET A1	6,381.00	6,378.02	0.00	0.00	1.62	0.050	0.01	6,378.50	6,378.50	Standard
123-INLET A2	6,380.69	6,377.18	0.00	0.00	2.55	0.050	0.01	6,377.80	6,377.79	Standard
122-INLET A3	6,380.30	6,376.16	0.00	0.00	3.37	0.050	0.01	6,376.88	6,376.87	Standard
121-INLET A4	6,379.80	6,372.17	0.00	0.00	4.15	0.050	0.01	6,373.09	6,373.07	Standard
120-MH	6,380.86	6,371.37	0.00	0.00	4.07	0.500	0.04	6,372.97	6,372.92	Standard
118.1-INLET A6	6,380.46	6,375.46	0.00	0.00	1.54	0.050	0.01	6,375.93	6,375.93	Standard
118-MH	6,380.25	6,370.89	0.00	0.00	7.40	1.020	0.09	6,372.85	6,372.76	Standard
117-MH	6,380.75	6,370.38	0.00	0.00	11.25	0.050	0.01	6,372.71	6,372.70	Standard
116-MH	6,380.28	6,369.89	0.00	0.00	11.14	0.050	0.01	6,372.58	6,372.57	Standard
115.1-INLET A8	6,379.56	6,374.56	0.00	0.00	2.08	0.050	0.01	6,375.11	6,375.10	Standard
115-MH	6,379.44	6,369.47	0.00	0.00	12.88	1.020	0.27	6,372.49	6,372.22	Standard
114-MH	6,380.16	6,369.07	0.00	0.00	16.63	0.050	0.02	6,372.12	6,372.10	Standard
113-MH	6,380.73	6,368.62	0.00	0.00	18.55	0.050	0.01	6,371.88	6,371.87	Standard
112-MH	6,379.94	6,368.05	0.00	0.00	19.11	0.100	0.02	6,371.73	6,371.71	Standard
111.1-INLET A12	6,378.38	6,373.38	0.00	0.00	1.24	0.050	0.01	6,373.80	6,373.80	Standard
111-MH	6,378.63	6,367.54	0.00	0.00	19.97	1.020	0.27	6,371.60	6,371.33	Standard

Major Storm: Junction Summary (2/2)

FlexTable: Manhole Table

Label	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Local Additional Flow (cfs)	Local Known Flow (cfs)	Flow (Total Out) (cfs)	Headloss Coefficient (Standard)	Headloss (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Headloss Method
110.1-INLET A13	6,378.11	6,373.04	0.00	0.00	1.16	0.050	0.01	6,373.45	6,373.44	Standard
110-MH	6,378.19	6,366.88	0.00	0.00	20.66	1.020	0.28	6,371.14	6,370.85	Standard
107.1-INLET A14	6,376.17	6,371.16	0.00	0.00	2.17	0.050	0.01	6,371.73	6,371.72	Standard
107-MH	6,377.08	6,366.16	0.00	0.00	22.12	1.020	0.33	6,370.61	6,370.28	Standard
106.1-INLET A15	6,375.83	6,370.83	0.00	0.00	2.69	0.050	0.01	6,371.46	6,371.45	Standard
106-MH	6,375.55	6,365.36	0.00	0.00	23.94	1.020	0.38	6,369.96	6,369.57	Standard
105-MH	6,375.28	6,364.93	0.00	0.00	23.85	0.050	0.02	6,369.48	6,369.46	Standard
104.1-INLET A16	6,375.10	6,369.85	0.00	0.00	6.20	0.050	0.02	6,370.90	6,370.88	Standard
104-MH	6,375.06	6,364.42	0.00	0.00	29.29	1.020	0.28	6,369.28	6,369.00	Standard
103.1-INLET A17	6,375.95	6,370.94	0.00	0.00	7.38	0.050	0.02	6,372.02	6,372.00	Standard
103-MH	6,376.25	6,363.53	0.00	0.00	34.99	1.020	0.39	6,368.75	6,368.36	Standard
102.1-INLET A18	6,377.21	6,372.10	0.00	0.00	3.60	0.050	0.01	6,372.84	6,372.83	Standard
102-MH	6,377.09	6,362.59	0.00	0.00	37.45	1.020	0.45	6,367.98	6,367.53	Standard
101-MH	6,377.49	6,362.10	0.00	0.00	37.24	1.520	0.66	6,367.37	6,366.70	Standard
100-MH	6,370.05	6,361.47	0.00	0.00	102.01	1.020	1.08	6,366.44	6,365.36	Standard
002-OUTLET STRUCT.	6,357.03	6,353.11	0.00	28.00	28.00	0.050	0.07	6,355.01	6,354.94	Standard
001-MH	6,366.02	6,349.72	0.00	0.00	28.00	0.050	0.06	6,352.83	6,352.77	Standard

Major Storm: Outfall Summary (1/1)

FlexTable: Outfall Table

Label	Elevation (Invert) (ft)	Flow (Total Out) (cfs)	Boundary Condition Type	Elevation (User Defined Tailwater) (ft)	Depth (Node) (ft)	Hydraulic Grade (ft)
O-1	6,347.95	28.00	User Defined Tailwater	6,351.79	3.84	6,351.79
O-100	6,361.39	101.89	User Defined Tailwater	6,365.29	3.90	6,365.29

6365.29 =
Pond C3
100-yr WSE

6351.79 ~
Gamble Ridge
Tributary
100-yr WSE

APPENDIX C

WATER QUALITY ENHANCEMENT CONTROL MEASURES

Permanent Water Quality Determination Worksheet (Taken from 2019 SDDTCM Sections 13.1.4 and 13.1.5)

Project: Dawson Trails - Costco

CRW# CD23-0020

Applicant: ACM Dawson Trails VIII JV LLC

Section	Questions	Response	Check those that apply	Instructions
1	Non-applicable Sites			
	Will the project result in a temporary disturbance of greater than one acre?	No	☐	Proceed to next line.
		Yes	☒	Proceed to section 2.
	Is the project part of a larger common plan of development or sale where multiple separate and distinct construction activities may be taking place at different times on different schedules, but remain related and are within 1/4 mile of each other? (A common plan of development will generally be documented on a site development plan, master plan, or equivalent, for the property/project)	No	☐	Proceed to next line.
		Yes	☐	Proceed to section 2.
	Is the project within the Cherry Creek Watershed?	Yes	☐	Exclusions do not apply. Permanent water quality is required per Control Regulation 72.7.
		No	☐	Permanent water quality is not required. No further action is required.
2	Applicable Site Types and Exclusions by Variance			
	Does the project have more than 35% impervious area on the existing site?	No	☒	Project is an applicable Development Site. Proceed to section 3.
		Yes	☐	Proceed to next line.
	Does the project have greater than 75% impervious area on the existing site?	No	☐	Project is an applicable Redevelopment Site. Proceed to section 3.
		Yes	☐	Proceed to next line.
	Will 100% of the runoff from the existing and proposed site be captured and treated for permanent water quality?	Yes	☐	Document in drainage report. No further action required.
		No	☐	Proceed to next line.
	Do any other water quality exclusions apply to the site?	No	☐	Portions of the project are excluded. Proceed with design in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> .
		Yes	☐	Proceed to next section. Following approval of other variances, design remaining site in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> .
3	Applicable Sites with Other Exclusions by Variance			
3.1	Category 1: Roadways, bridges and trails only			
3.1.1	Is the project a bike or pedestrian trail?	Yes	☐	Proceed to next line.
		No	☒	Proceed to 3.1.2.
	Is the trail for a roadway?	Yes	☐	Proceed to 3.1.2.
		No	☐	Project is excluded. Submit variance for <u>Trails Excluded from Permanent Water Quality Requirements</u> .
3.1.2	Is the project primarily used for parking or access to parking?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to 3.1.3.
3.1.3	Does the project add impervious area?	No	☐	Project is excluded. Submit variance for <u>Pavement Management Sites Excluded from Permanent Water Quality Requirements</u> .
		Yes	☒	Proceed to 3.1.4.

3.1.4	Does the project add more than 8.25 feet of paved width at any location to the existing roadway?	No	☐	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
		Yes	☐	
	Does the project add more than one acre of paved area per mile to an existing roadway?	No	☐	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
		Yes	☐	
	Does the project increase the width by two times or more, on average, of the original roadway area?	No	☐	Existing areas of site are excluded only. Submit variance for <u>Existing Roadway Surfaces Only Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	This exclusion does not apply. Permanent water quality is required.
3.2	Category 2: Non-residential and non-commercial projects only			
3.2.1	Is the project associated with oil and gas exploration, production, processing, or treatment operations or transmission facilities, including activities necessary to prepare a site for drilling and the movement and placement of drilling equipment?	Yes	☐	Project is excluded. Submit variance for <u>Oil and Gas Exploration Sites Excluded from Permanent Water Quality Requirements</u> .
		No	☐	Proceed to 3.2.2.
3.2.2	Is the project for stream stabilization?	Yes	☐	Project is excluded. Submit variance for <u>Stream Stabilization Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.3.
		No	☐	
3.2.3	Is the project for installation or maintenance of underground utilities or infrastructure that does not permanently alter the terrain, ground cover, or drainage patterns from those present prior to the construction activity including activities to install, replace or maintain utilities under roadways or other paved areas that return the surface to the same condition?	Yes	☐	Project is excluded. Submit variance for <u>Aboveground and Underground Utilities Excluded from Permanent Water Quality Requirements</u> .
		No	☐	Proceed to 3.2.4.
3.2.4	Is the project on undeveloped land (land with no human-made structures such as buildings or pavement) that will remain undeveloped after the project?	Yes	☐	Project is excluded. Submit variance for <u>Sites with Land Disturbances to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.5.
		No	☐	
3.2.5	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No	☐	Project is excluded. Submit study along with variance for <u>Non-residential and Non-commercial Infiltration Conditions Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	This exclusion does not apply. Permanent water quality is required.
3.3	Category 3: Residential and Commercial projects			
3.3.1	Is the project a single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling unit?	Yes	☐	Proceed to next line.
		No	☒	Proceed to 3.3.2.
	Is the project site greater than 10% impervious?	No	☐	Project is excluded. Submit variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
		Yes	☐	
	Is the project site greater than 20% impervious?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☐	Proceed to next line.
	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No	☐	Project is excluded. Submit study along with variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	This exclusion does not apply. Permanent water quality is required.

3.3.2	Will 100% of the runoff from the residential or commercial site be captured?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is all or a portion of the site undeveloped or will it remain undeveloped after construction?	Yes	☐	This portion of the project is excluded. Submit variance for <u>Sites with Land Disturbance to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
		No	☒	Proceed to next line.
	Is the remaining untreated impervious area greater than 20% of the site?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is the remaining untreated impervious area greater than one acre?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is it practicable to capture runoff from portions of the site that will not drain to a control measure?	No	☒	Document justification demonstrating that it is not practicable to capture runoff from this portion of the site in the drainage report . No further action is needed.
		Yes	☐	This exclusion does not apply. Permanent water quality is required.



Summary of Water Quality Conformance to MS4 Permit

The purpose of this worksheet is to document conformance with the Town of Castle Rock's MS4 permit with regard to permanent water quality on land disturbance projects.

Project Name Dawson Trails -Costco

Project Owner ACM Dawson Trails VIII JV LLC

Project Location West side of I-25 just North of Territorial Rd, Castle Rock, CO

ToCR Project Number CD23-0020

Total Site Area 19.8 +/- acres

Total Size of Common Plan of Development N/A acres

Check all that apply:

☒ **Project within Plum Creek Basin**

☐ **Project within Cherry Creek Basin**

Estimated construction completion date June 2023

1. The water quality control measure(s) for applicable development sites shall meet one of the following base design standards as per the SDDTCM Section 14.4. Please select all design standards that were applied to meet conformance with the MS4 on this site.

☒ WQCV standard

☐ Pollutant removal standard

☐ Runoff reduction standard

☐ Applicable site draining to regional WQVC control measure (accepts drainage prior to discharging to WOTS)

☐ Applicable site draining to regional WQVC control facility (with receiving pervious area control measure upstream of WOTS)

☐ Constrained redevelopment sites standard

• Imperviousness of existing site _____/_____ (Imp. Ac/Site Ac) = ____%

• Variance required TCV No. _____

☐ Existing control measure with WQCV per previous criteria standards

• Reference Construction Permit No. _____

☐ Cherry Creek Basin only, choose one: ☐ Tier 1 ☐ Tier 2 ☐ Tier 3

☐ No control measures provided (See Permanent WQ Worksheet for applicability)

Summary of Water Quality Conformance to MS4 Permit

2. Was an exclusion to water quality applied as per SDDTCM Section 13.1.5? ☐ Yes ☒ No

i. If yes, please select all that apply, provide total excluded impervious area(s) and submit variance, as applicable: TCV No. _____

- ☐ Pavement management site
Excluded impervious area: _____ acres
- ☐ Excluded roadway redevelopment
Excluded impervious area: _____ acres
- ☐ Excluded existing roadway areas
Excluded impervious area: _____ acres
- ☐ Above ground and below ground utilities
- ☐ Large lot single family home
- ☐ Non-residential and non-commercial infiltration
Excluded impervious area: _____ acres
- ☐ Land disturbance for land to remain undeveloped
Excluded impervious area: _____ acres
- ☐ Stream Stabilization Sites
Excluded impervious area: _____ acres
- ☐ Trails
Excluded impervious area: _____ acres
- ☐ Oil and Gas Exploration

3. For Development and Redevelopment sites, following any exclusions claimed above, was any portion of the site excluded up to 20% of the site and not to exceed one acre? ☒ Yes ☐ No

If yes, complete the following:

Excluded area: 0.95 acres
Total Site area: 19.58 acres, 4.85 % site excluded

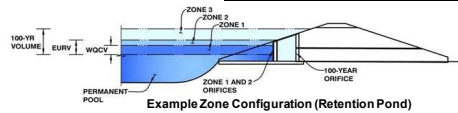
4. For Constrained sites, was any portion of the site excluded up to 50% of the site and not to exceed 50% of the impervious area? ☐ Yes ☒ No

If yes, complete the following:

Excluded area: _____ acres
Excluded impervious area: _____ acres
Total Site area: _____ acres, _____ % site excluded
Total Impervious area: _____ acres, _____ % impervious excluded

MHFD-Detention, Version 4.06 (July 2022)

Basin ID: Pond C3



Selected BMP Type =	EDB	
Watershed Area =	18.58	acres
Watershed Length =	1,050	ft
Watershed Length to Centroid =	500	ft
Watershed Slope =	0.007	ft/ft
Watershed Imperviousness =	86.90%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Group C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths = Castle Pines - City Office		

Optional User Overrides

Water Quality Capture Volume (WQCV) =	0.583	acre-feet	acre-feet
Excess Urban Runoff Volume (EURV) =	1.597	acre-feet	acre-feet
2-yr Runoff Volume ($P1 = 1.06$ in.) =	1.384	acre-feet	1.06 inches
5-yr Runoff Volume ($P1 = 1.43$ in.) =	1.967	acre-feet	1.43 inches
10-yr Runoff Volume ($P1 = 1.66$ in.) =	2.336	acre-feet	1.66 inches
25-yr Runoff Volume ($P1 = 1.72$ in.) =	2.443	acre-feet	1.72 inches
50-yr Runoff Volume ($P1 = 2.26$ in.) =	3.317	acre-feet	2.26 inches
100-yr Runoff Volume ($P1 = 2.6$ in.) =	3.882	acre-feet	2.60 inches
500-yr Runoff Volume ($P1 = 3.07$ in.) =	4.645	acre-feet	inches
Approximate 2-yr Detention Volume =	1.293	acre-feet	
Approximate 5-yr Detention Volume =	1.857	acre-feet	
Approximate 10-yr Detention Volume =	2.138	acre-feet	
Approximate 25-yr Detention Volume =	2.051	acre-feet	
Approximate 50-yr Detention Volume =	2.448	acre-feet	
Approximate 100-yr Detention Volume =	2.622	acre-feet	

Zone 1 Volume (WQCV) =	0.583	acre-feet
Zone 2 Volume (EURV - Zone 1) =	1.014	acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =	1.597	acre-feet
Initial Surcharge Volume (ISV) =	user	ft ³
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio (R_{LW}) =	user	

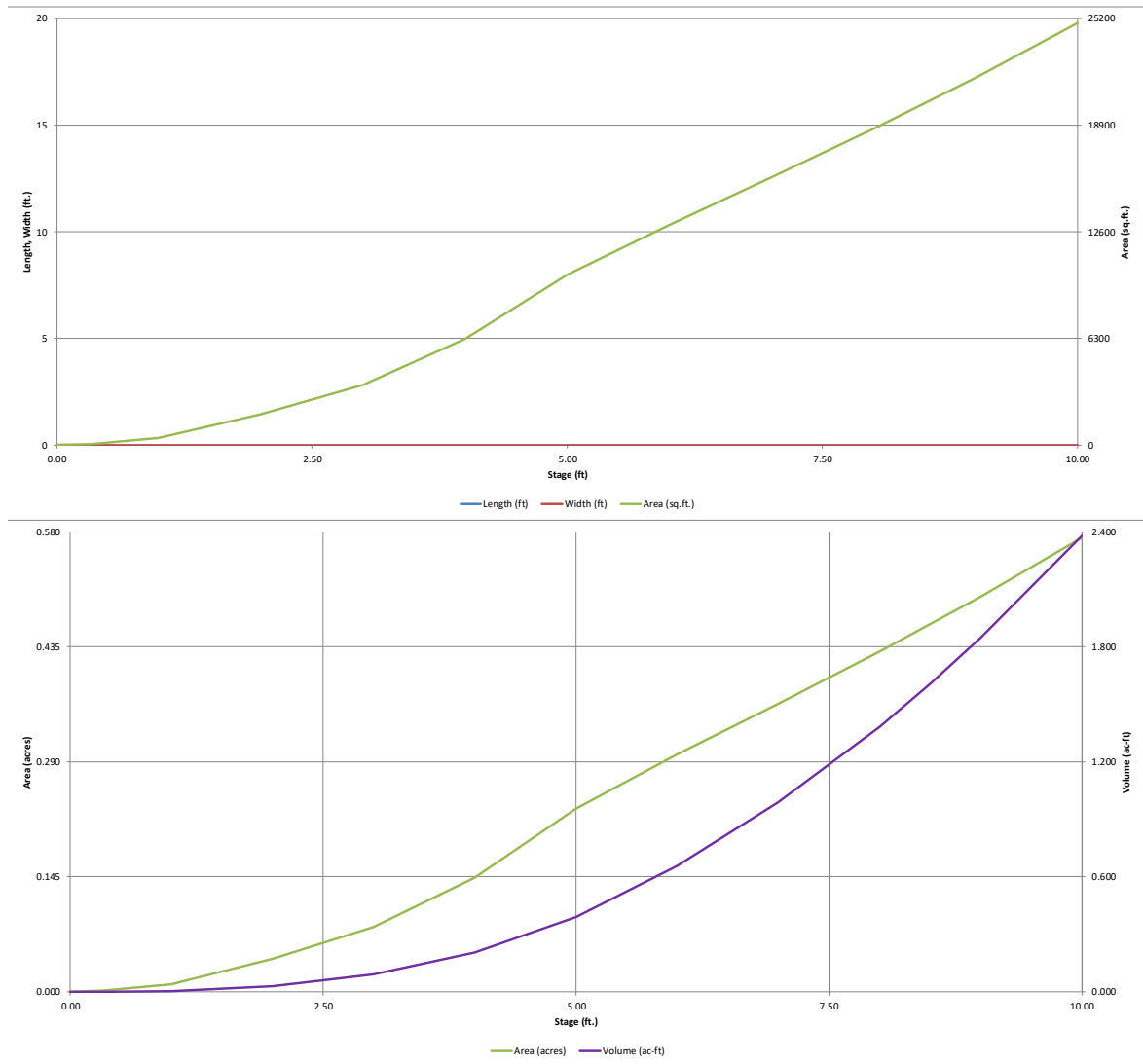
Total detention volume is less than 100-year volume.

Initial Surcharge Area (A_{SV})	=	user	ft ²
Surcharge Volume Length (L_{SV})	=	user	ft
Surcharge Volume Width (W_{SV})	=	user	ft
Depth of Basin Floor ($H_{1,COR}$)	=	user	ft
Length of Basin Floor ($L_{1,COR}$)	=	user	ft
Width of Basin Floor ($W_{1,COR}$)	=	user	ft
Area of Basin Floor ($A_{1,COR}$)	=	user	ft ²
Volume of Basin Floor ($V_{1,COR}$)	=	user	ft ³
Depth of Main Basin (H_{MA})	=	user	ft
Length of Main Basin (L_{MA})	=	user	ft
Width of Main Basin (W_{MA})	=	user	ft
Area of Main Basin (A_{MA})	=	user	ft ²
Volume of Main Basin (V_{MA})	=	user	ft ³
Calculated Total Basin Volume (V_{TBA})	=	user	acre-feet

[illegible]

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

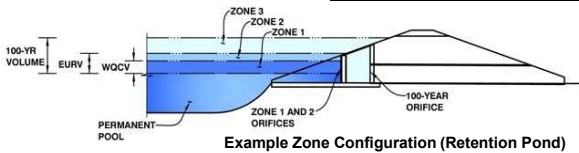


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: **Costco WQ Pond - Dawson Trails**

Basin ID: **Pond C3**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	6.07	0.670	Orifice Plate
Zone 2			Weir&Pipe (Circular)
Zone 3			Not Utilized
Total (all zones)		0.670	

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

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain
Underdrain Orifice Area = ft²
Underdrain Orifice Centroid = feet

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

Centroid of Lowest Orifice = 0.00 ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = 6.10 ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = 27.00 inches
Orifice Plate: Orifice Area per Row = 1.68 sq. inches (diameter = 1-7/16 inches)

Calculated Parameters for Plate
WQ Orifice Area per Row = 1.167E-02 ft²
Elliptical Half-Width = N/A feet
Elliptical Slot Centroid = N/A feet
Elliptical Slot Area = N/A ft²

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	2.20	4.40					
Orifice Area (sq. inches)	1.68	1.68	1.68					

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

User Input: Vertical Orifice (Circular or Rectangular)

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

Calculated Parameters for Vertical Orifice
Vertical Orifice Area = Not Selected Not Selected ft²
Vertical Orifice Centroid = N/A N/A feet

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

Overflow Weir Front Edge Height, H_o = Zone 2 Weir Not Selected ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length = 6.10 N/A feet
Overflow Weir Grate Slope = 18.00 N/A H:V
Horiz. Length of Weir Sides = 0.00 N/A feet
Overflow Grate Type = 3.00 N/A Type C Grate
Debris Clogging % = Type C Grate N/A %

Calculated Parameters for Overflow Weir
Height of Grate Upper Edge, H_u = Zone 2 Weir Not Selected feet
Overflow Weir Slope Length = 6.10 N/A feet
Grate Open Area / 100-yr Orifice Area = 3.00 N/A
Overflow Grate Open Area w/o Debris = 0.00 N/A ft²
Overflow Grate Open Area w/ Debris = 37.58 N/A ft²

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

Depth to Invert of Outlet Pipe = Zone 2 Circular Not Selected ft (distance below basin bottom at Stage = 0 ft)
Circular Orifice Diameter = N/A N/A inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate
Outlet Orifice Area = Zone 2 Circular Not Selected ft²
Outlet Orifice Centroid = N/A N/A feet
Half-Central Angle of Restrictor Plate on Pipe = N/A N/A radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage = 7.15 ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length = 35.00 feet
Spillway End Slopes = 4.00 H:V
Freeboard above Max Water Surface = 1.00 feet

Calculated Parameters for Spillway
Spillway Design Flow Depth = 0.73 feet
Stage at Top of Freeboard = 8.88 feet
Basin Area at Top of Freeboard = 0.48 acres
Basin Volume at Top of Freeboard = 1.74 acre-ft

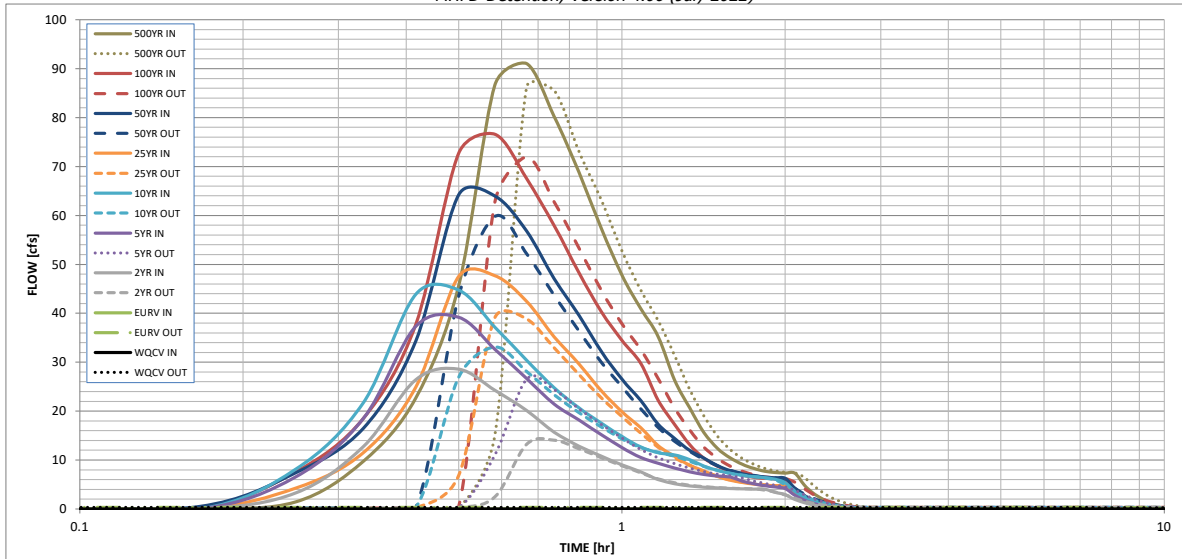
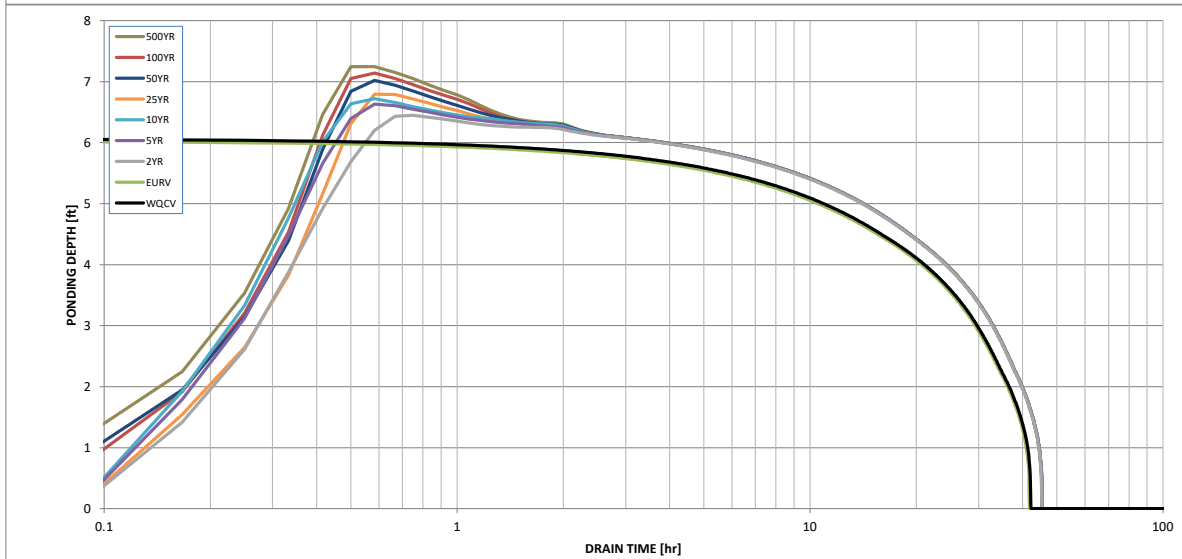
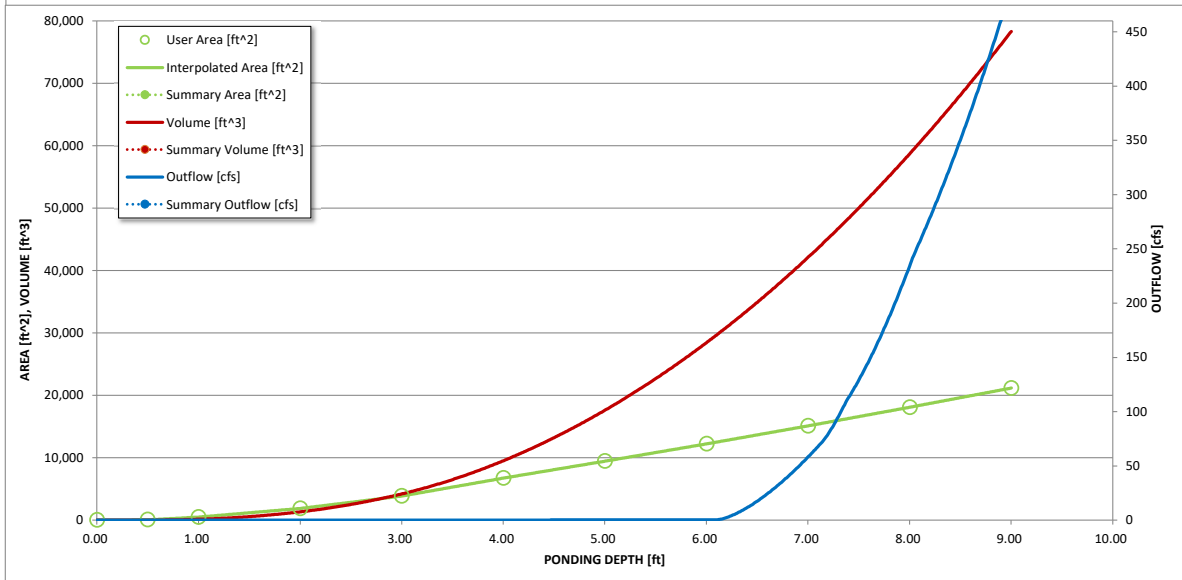
Routed Hydrograph Results

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

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =	N/A	N/A	1.06	1.43	1.66	1.72	2.26	2.60	3.07
One-Hour Rainfall Depth (in) =	0.670	1.785	1.541	2.175	2.573	2.685	3.626	4.230	5.051
CUHP Runoff Volume (acre-ft) =	N/A	N/A	1.541	2.175	2.573	2.685	3.626	4.230	5.051
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	2.0	7.3	10.3	13.5	22.5	29.5	37.5
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A							
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.10	0.37	0.51	0.68	1.13	1.48	1.88
Peak Inflow Q (cfs) =	N/A	N/A	28.6	39.1	44.7	47.7	64.3	76.6	91.1
Peak Outflow Q (cfs) =	0.3	163.7	14.0	26.5	33.1	39.1	59.8	72.0	86.2
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	3.6	3.2	2.9	2.7	2.4	2.3
Structure Controlling Flow =	Plate	Spillway	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	-0.01	-0.01	0.0	0.0	0.0	0.0	0.0	0.0
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	35	38	36	35	34	32	31	29
Time to Drain 99% of Inflow Volume (hours) =	41	39	42	41	41	41	39	38	37
Maximum Ponding Depth (ft) =	6.07	8.98	6.44	6.63	6.72	6.79	7.02	7.14	7.24
Area at Maximum Ponding Depth (acres) =	0.29	0.48	0.31	0.32	0.33	0.33	0.35	0.36	0.36
Maximum Volume Stored (acre-ft) =	0.673	1.789	0.783	0.843	0.869	0.895	0.970	1.012	1.052

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)



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

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.25	1.41
	0:15:00	0.00	0.00	3.25	6.54	8.07	4.23	7.35	7.57	9.73
	0:20:00	0.00	0.00	12.77	18.48	21.70	11.51	16.50	18.52	22.67
	0:25:00	0.00	0.00	26.42	37.31	43.88	24.91	34.36	37.74	45.65
	0:30:00	0.00	0.00	28.55	39.15	44.72	47.51	64.25	72.72	86.67
	0:35:00	0.00	0.00	24.23	32.64	37.16	47.68	63.98	76.59	91.08
	0:40:00	0.00	0.00	20.14	26.67	30.41	42.48	56.86	67.56	80.28
	0:45:00	0.00	0.00	15.69	21.44	24.77	35.21	47.07	57.93	68.78
	0:50:00	0.00	0.00	12.84	18.18	20.63	29.65	39.57	48.27	57.28
	0:55:00	0.00	0.00	10.80	15.15	17.52	24.10	32.14	40.29	47.81
	1:00:00	0.00	0.00	9.00	12.56	14.82	19.89	26.53	34.47	40.91
	1:05:00	0.00	0.00	7.58	10.53	12.66	16.59	22.14	29.72	35.27
	1:10:00	0.00	0.00	6.02	9.33	11.47	12.96	17.33	22.21	26.40
	1:15:00	0.00	0.00	5.18	8.39	11.05	10.77	14.44	17.34	20.64
	1:20:00	0.00	0.00	4.73	7.59	10.08	8.92	11.95	13.13	15.64
	1:25:00	0.00	0.00	4.45	7.07	8.76	7.77	10.40	10.41	12.40
	1:30:00	0.00	0.00	4.31	6.72	7.87	6.63	8.87	8.78	10.46
	1:35:00	0.00	0.00	4.20	6.51	7.27	5.87	7.85	7.66	9.13
	1:40:00	0.00	0.00	4.12	5.71	6.86	5.39	7.22	6.95	8.28
	1:45:00	0.00	0.00	4.07	5.13	6.60	5.06	6.77	6.48	7.72
	1:50:00	0.00	0.00	4.06	4.75	6.40	4.87	6.51	6.25	7.44
	1:55:00	0.00	0.00	3.40	4.49	6.05	4.75	6.35	6.15	7.33
	2:00:00	0.00	0.00	2.94	4.17	5.38	4.69	6.27	6.13	7.30
	2:05:00	0.00	0.00	1.97	2.79	3.62	3.16	4.22	4.15	4.94
	2:10:00	0.00	0.00	1.28	1.81	2.38	2.08	2.78	2.74	3.26
	2:15:00	0.00	0.00	0.83	1.15	1.54	1.36	1.82	1.79	2.13
	2:20:00	0.00	0.00	0.50	0.71	0.95	0.84	1.12	1.11	1.32
	2:25:00	0.00	0.00	0.29	0.44	0.58	0.53	0.71	0.70	0.83
	2:30:00	0.00	0.00	0.14	0.24	0.30	0.29	0.39	0.39	0.46
	2:35:00	0.00	0.00	0.06	0.10	0.12	0.13	0.17	0.17	0.20
	2:40:00	0.00	0.00	0.01	0.02	0.03	0.03	0.04	0.04	0.05
	2:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

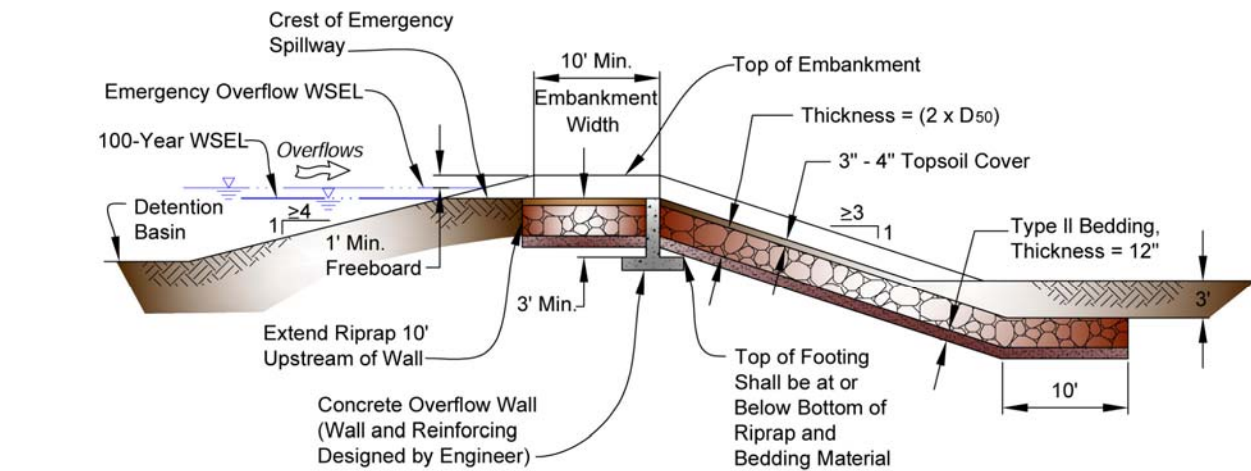
The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

[illegible]

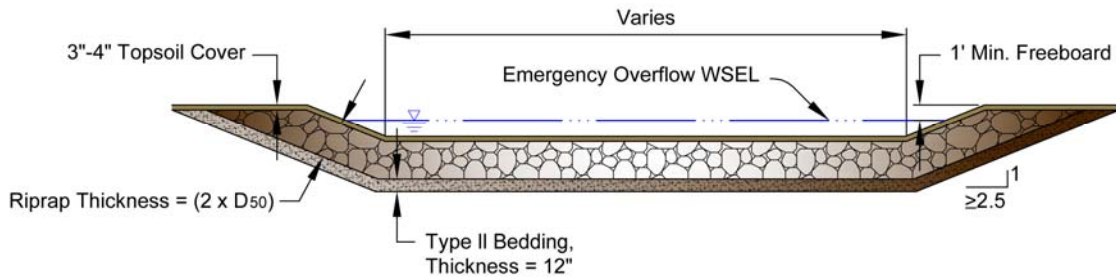
POND C3 SPILLWAY RIPRAP CALCULATION

Chapter 13. Storage

**FIGURE 13-7
EMBANKMENT PROTECTION DETAILS AND ROCK SIZING CHART**



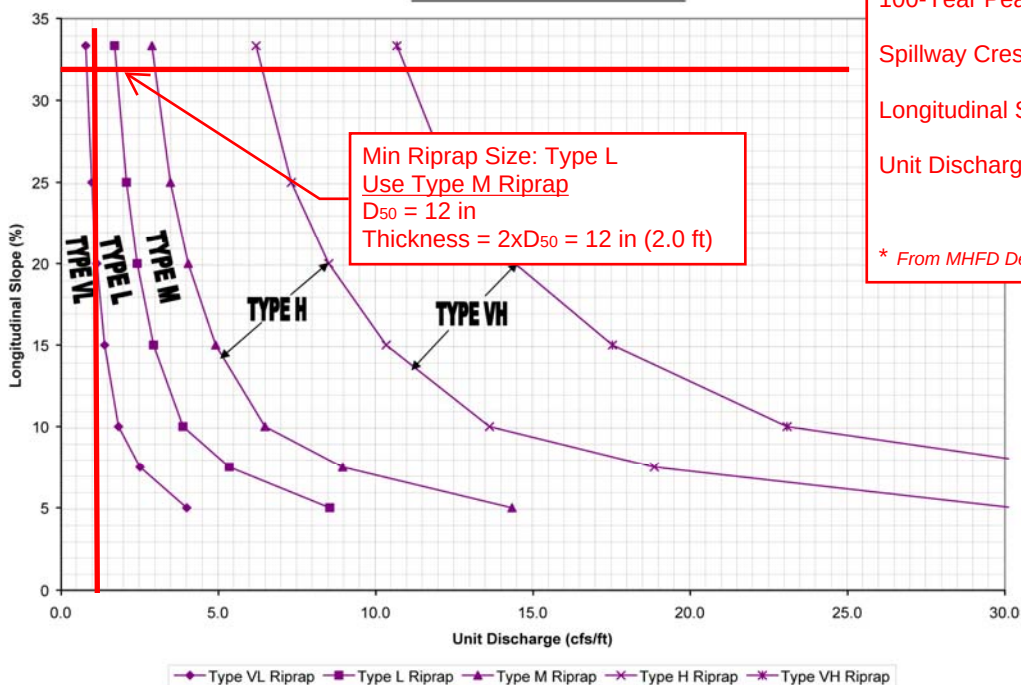
EMERGENCY SPILLWAY PROFILE



RIPRAP DESIGNATION

VL ($D_{50} = 6$ IN)
L ($D_{50} = 9$ IN)
M ($D_{50} = 12$ IN)
H ($D_{50} = 18$ IN)
VH ($D_{50} = 24$ IN)

SPILLWAY CHANNEL AT CREST AND DOWNSTREAM SIDE OF EMBANKMENT



100-Year Peak Inflow* = 68.9 CFS

Spillway Crest Length* = 60 FT

Longitudinal Slope = 32%

Unit Discharge = $68.9/35 = 1.2$ CFS/FT

* From MHFD Detention Workbook

Notes:

- 1) Place and compact 12" Type II Granular Bedding only under Void-Filled Riprap (typical per USDCM Vol. 1, Ch. 8, Figure 8-34).
- 2) If Type VL Riprap is calculated, use Type L (typical per USDCM Vol. 2, Ch. 9, Figure 9-38).

POND C3 OUTFALL

SHEET 1 OF 5

Project: Costco Wholesale

Per USDCM Vol. 2, Ch. 9, S. 3.1 & 3.2

Riprap Sizing per Section 3.2.3

$$L_p = (1/2 \tan \theta) [(A_t/Y_t) - W]$$

Length of protection; Equation 9-11

$$D = \begin{matrix} 24.00 & \text{in} \\ 2.00 & \text{ft} \end{matrix}$$

Pipe diameter

$$Y_n = 1.28 \text{ ft}$$

Normal depth of flow at culvert outlet

$$V = 8.9 \text{ ft/s}$$

Flow velocity at culvert outlet

$$FR = 1.39$$

Froude Number

Y

Supercritical flow?

$$Y_t = 4.23 \text{ ft}$$

Tailwater depth

$$D_a = 1.64$$

D parameter for supercritical flow

$$A_t = Q/V \text{ ft}^2$$

Required area of flow at allowable velocity; Equation 9-12

$$Q = 28 \text{ cfs}$$

100-year discharge

$$V = 5 \text{ ft/sec}$$

Max velocity allowed by UDFCD for non-cohesive soils

$$A_t = 5.60 \text{ ft}^2$$

$$Q/D^{1.5} = 9.90$$

Froude Parameter (for Rock Sizing figure 9-38)

$$Y_t/D = 2.12$$

Tailwater Depth/Conduit Height

$$Y_t/D_a = 2.58$$

(use 0.40 if unknown or hydraulic jump is suspected downstream)

Use Type M Riprap per Figure 9-38	$D_{50} = 24 \text{ in}$
-----------------------------------	--------------------------

See Figure 9-38

Thickness of Riprap Layer = $2D_{50} = 4.0 \text{ ft}$
--

See Figure 9-34

$$Q/D^{2.5} = 8.13$$

Froude Parameter (for Extent of Protection figure 9-35)
(must be ≤ 6.0)

$$1/2 \tan \theta = 4.3$$

 (F_E) Expansion factor; Figure 9-35

$L_p = 6 \text{ ft}$

See Figure 9-34; min $3 \cdot D$

$$T = 2(L_p \tan \theta) + W$$

Width of riprap at furthest downstream point; Equation 9-13

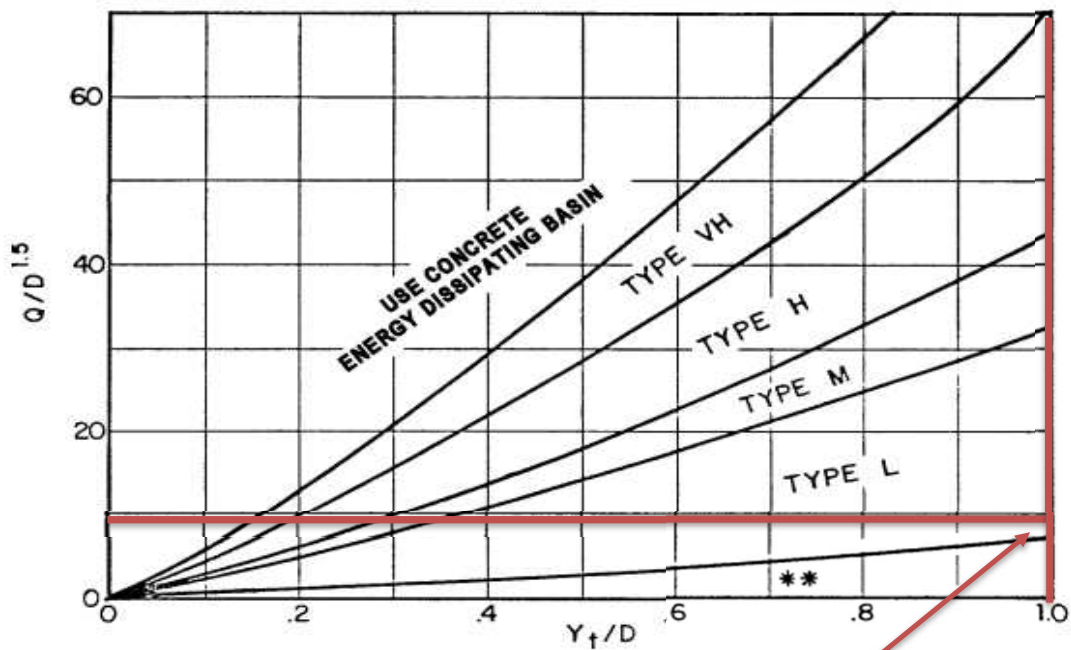
$$\theta = \tan^{-1} [1/(2 \cdot F_E)]$$

Equation 9-13

$$\theta = 0.12^\circ$$

$T = 3 \text{ ft}$

See Figure 9-34



Use D_a instead of D whenever flow is supercritical in the barrel.
 ** Use Type L for a distance of $3D$ downstream.

Use Type L ($D_{50}=9"$)

Figure 9-38. Riprap erosion protection at circular conduit outlet (valid for $Q/D^{2.5} \leq 6.0$)

THICKNESS REQUIREMENTS FOR GRANULAR BEDDING			
RIPRAP DESIGNATION	MINIMUM BEDDING THICKNESS (INCHES)		
	FINE-GRAINED SOILS ¹		COARSE-GRAINED SOILS ²
	TYPE I (LOWER LAYER)	TYPE II (UPPER LAYER)	TYPE II
VL ($D_{50} = 6$ IN)	4	4	6
L ($D_{50} = 9$ IN)	4	4	6
M ($D_{50} = 12$ IN)	4	4	6
H ($D_{50} = 18$ IN)	4	6	8
VH ($D_{50} = 24$ IN)	4	6	8

NOTES:-

1. MAY SUBSTITUTE ONE 12-INCH LAYER OF TYPE II BEDDING. THE SUBSTITUTION OF ONE LAYER OF TYPE II BEDDING SHALL NOT BE PERMITTED AT DROP STRUCTURES. THE USE OF A COMBINATION OF FILTER FABRIC AND TYPE II BEDDING AT DROP STRUCTURES IS ACCEPTABLE.
2. FIFTY PERCENT OR MORE BY WEIGHT RETAINED ON THE #40 SIEVE.

Figure 8-34. Riprap and soil riprap placement and gradation (part 3 of 3)

Project: Costco Wholesale

Per USDCM Vol. 2, Ch. 9, S. 3.2.1

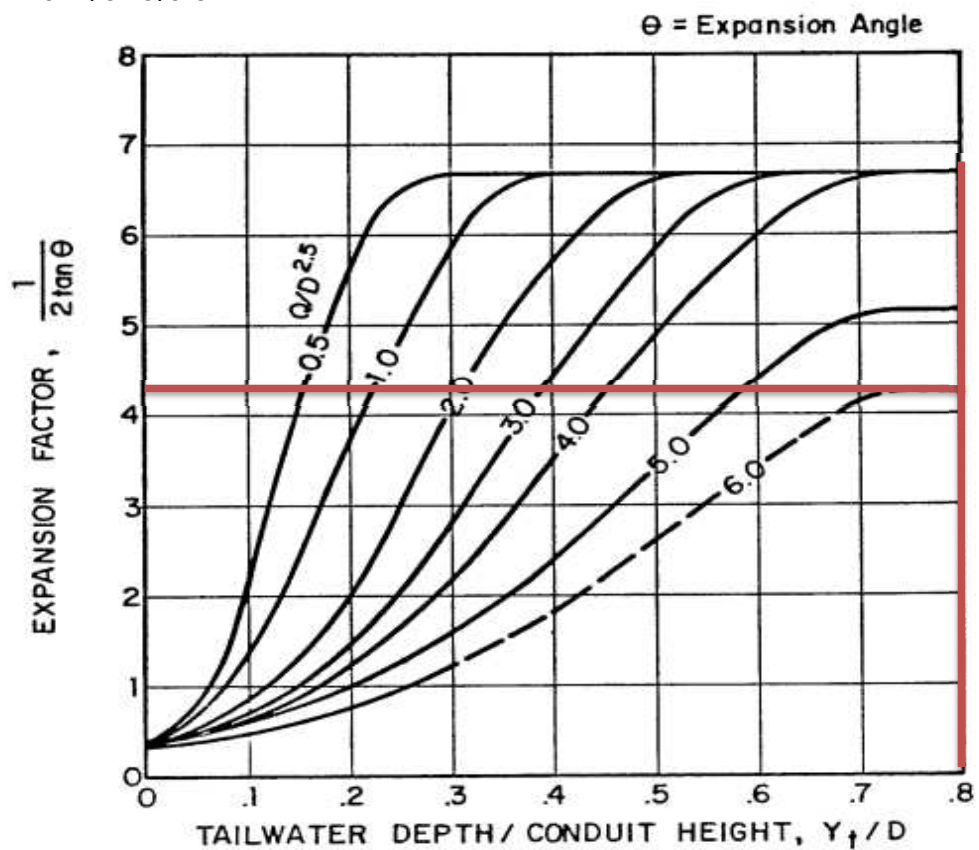


Figure 9-35. Expansion factor for circular conduits

POND C3 OUTFALL

SHEET 4 OF 5

Project: Costco Wholesale

Per USDCM Vol. 2, Ch. 9, S. 3.2.1

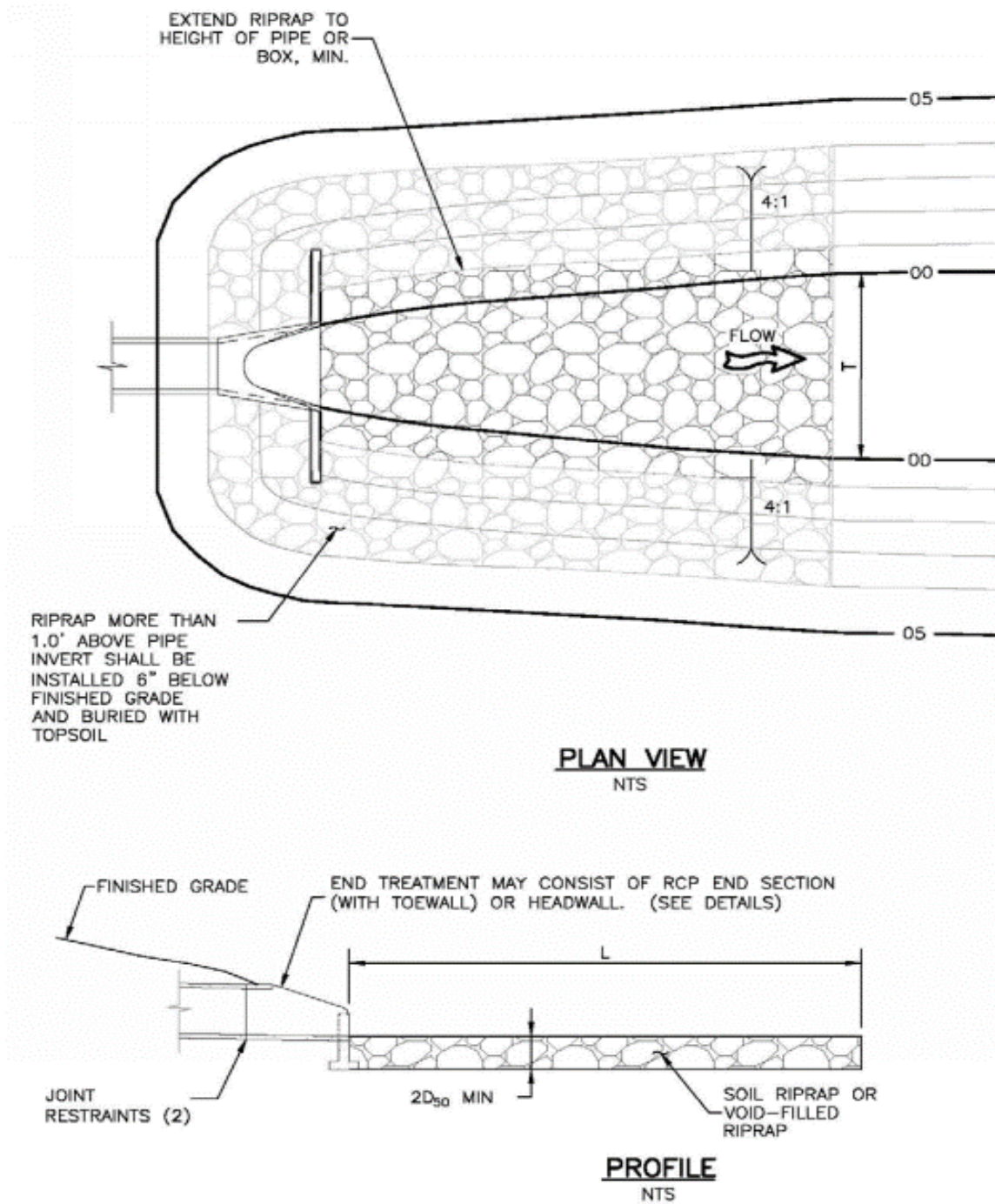


Figure 9-34. Riprap apron detail for culverts in-line with the channel

POND C3 OUTFALL

SHEET 5 OF 5

Project: Costco Wholesale

Per USDCM Vol. 2, Ch. 9, S. 3.1.2

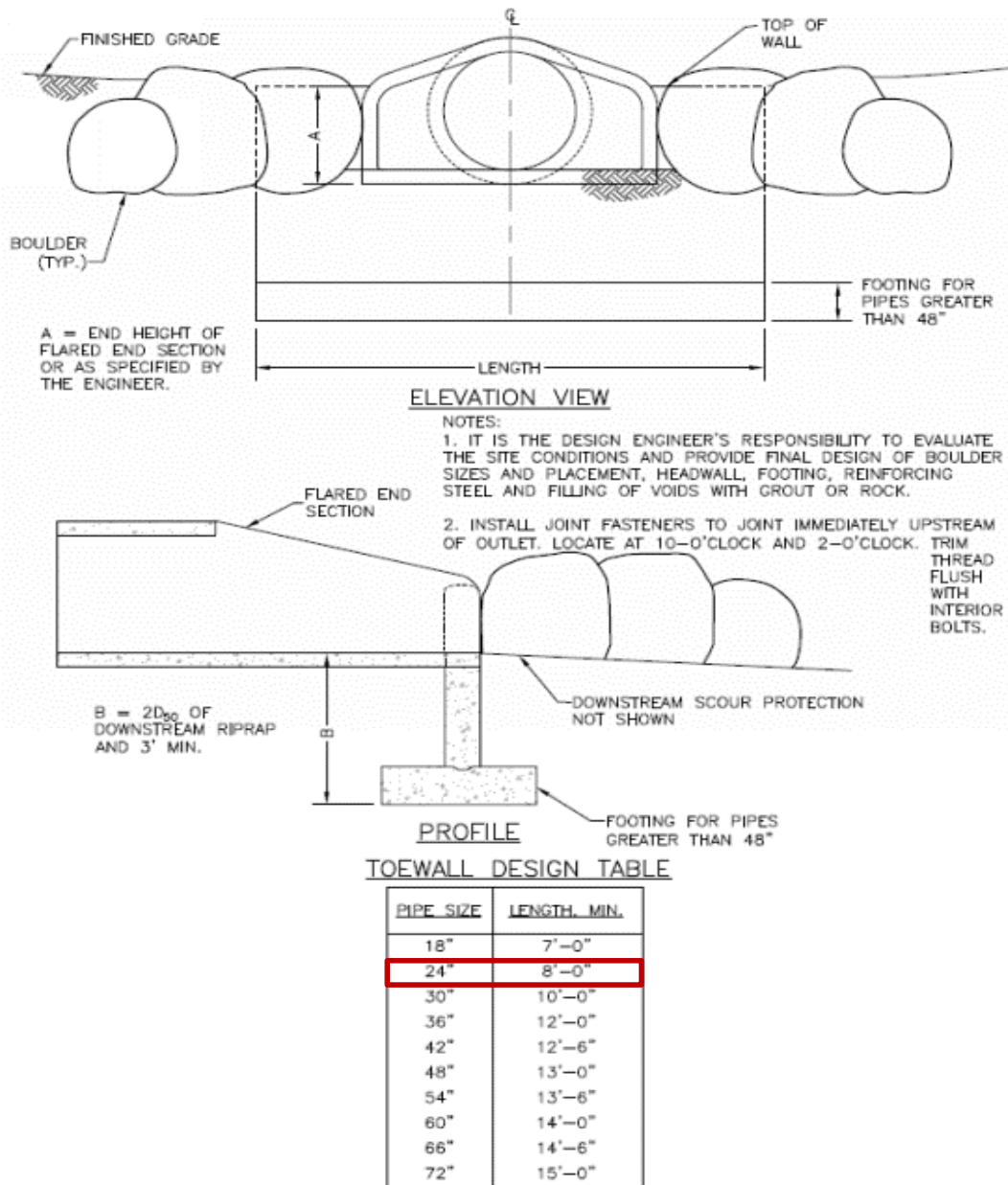


Figure 9-30. Flared end section (FES) headwall concept

Toe wall Dimensions		
Length =	12	ft
Depth (B) =	3.0	ft
Footing Required =	N	

APPENDIX C

WATER QUALITY ENHANCEMENT CONTROL MEASURES

Permanent Water Quality Determination Worksheet (Taken from 2019 SDDTCM Sections 13.1.4 and 13.1.5)

Project: Dawson Trails - Costco

CRW# CD23-0020

Applicant: ACM Dawson Trails VIII JV LLC

Section	Questions	Response	Check those that apply	Instructions
1	Non-applicable Sites			
	Will the project result in a temporary disturbance of greater than one acre?	No	☐	Proceed to next line.
		Yes	☒	Proceed to section 2.
	Is the project part of a larger common plan of development or sale where multiple separate and distinct construction activities may be taking place at different times on different schedules, but remain related and are within 1/4 mile of each other? (A common plan of development will generally be documented on a site development plan, master plan, or equivalent, for the property/project)	No	☐	Proceed to next line.
		Yes	☐	Proceed to section 2.
	Is the project within the Cherry Creek Watershed?	Yes	☐	Exclusions do not apply. Permanent water quality is required per Control Regulation 72.7.
		No	☐	Permanent water quality is not required. No further action is required.
2	Applicable Site Types and Exclusions by Variance			
	Does the project have more than 35% impervious area on the existing site?	No	☒	Project is an applicable Development Site. Proceed to section 3.
		Yes	☐	Proceed to next line.
	Does the project have greater than 75% impervious area on the existing site?	No	☐	Project is an applicable Redevelopment Site. Proceed to section 3.
		Yes	☐	Proceed to next line.
	Will 100% of the runoff from the existing and proposed site be captured and treated for permanent water quality?	Yes	☐	Document in drainage report. No further action required.
		No	☐	Proceed to next line.
	Do any other water quality exclusions apply to the site?	No	☐	Portions of the project are excluded. Proceed with design in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> .
		Yes	☐	Proceed to next section. Following approval of other variances, design remaining site in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> .
3	Applicable Sites with Other Exclusions by Variance			
3.1	Category 1: Roadways, bridges and trails only			
3.1.1	Is the project a bike or pedestrian trail?	Yes	☐	Proceed to next line.
		No	☒	Proceed to 3.1.2.
	Is the trail for a roadway?	Yes	☐	Proceed to 3.1.2.
		No	☐	Project is excluded. Submit variance for <u>Trails Excluded from Permanent Water Quality Requirements</u> .
3.1.2	Is the project primarily used for parking or access to parking?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to 3.1.3.
3.1.3	Does the project add impervious area?	No	☐	Project is excluded. Submit variance for <u>Pavement Management Sites Excluded from Permanent Water Quality Requirements</u> .
		Yes	☒	Proceed to 3.1.4.

3.1.4	Does the project add more than 8.25 feet of paved width at any location to the existing roadway?	No	☐	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	Proceed to next line.
	Does the project add more than one acre of paved area per mile to an existing roadway?	No	☐	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	Proceed to next line.
	Does the project increase the width by two times or more, on average, of the original roadway area?	No	☐	Existing areas of site are excluded only. Submit variance for <u>Existing Roadway Surfaces Only Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	This exclusion does not apply. Permanent water quality is required.
3.2	Category 2: Non-residential and non-commercial projects only			
3.2.1	Is the project associated with oil and gas exploration, production, processing, or treatment operations or transmission facilities, including activities necessary to prepare a site for drilling and the movement and placement of drilling equipment?	Yes	☐	Project is excluded. Submit variance for <u>Oil and Gas Exploration Sites Excluded from Permanent Water Quality Requirements</u> .
		No	☐	Proceed to 3.2.2.
3.2.2	Is the project for stream stabilization?	Yes	☐	Project is excluded. Submit variance for <u>Stream Stabilization Sites Excluded from Permanent Water Quality Requirements</u> .
		No	☐	Proceed to 3.2.3.
3.2.3	Is the project for installation or maintenance of underground utilities or infrastructure that does not permanently alter the terrain, ground cover, or drainage patterns from those present prior to the construction activity including activities to install, replace or maintain utilities under roadways or other paved areas that return the surface to the same condition?	Yes	☐	Project is excluded. Submit variance for <u>Aboveground and Underground Utilities Excluded from Permanent Water Quality Requirements</u> .
		No	☐	Proceed to 3.2.4.
3.2.4	Is the project on undeveloped land (land with no human-made structures such as buildings or pavement) that will remain undeveloped after the project?	Yes	☐	Project is excluded. Submit variance for <u>Sites with Land Disturbances to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> .
		No	☐	Proceed to 3.2.5.
3.2.5	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No	☐	Project is excluded. Submit study along with variance for <u>Non-residential and Non-commercial Infiltration Conditions Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	This exclusion does not apply. Permanent water quality is required.
3.3	Category 3: Residential and Commercial projects			
3.3.1	Is the project a single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling unit?	Yes	☐	Proceed to next line.
		No	☒	Proceed to 3.3.2.
	Is the project site greater than 10% impervious?	No	☐	Project is excluded. Submit variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	Proceed to next line.
	Is the project site greater than 20% impervious?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☐	Proceed to next line.
	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No	☐	Project is excluded. Submit study along with variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> .
		Yes	☐	This exclusion does not apply. Permanent water quality is required.

3.3.2	Will 100% of the runoff from the residential or commercial site be captured?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is all or a portion of the site undeveloped or will it remain undeveloped after construction?	Yes	☐	This portion of the project is excluded. Submit variance for <u>Sites with Land Disturbance to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
		No	☒	Proceed to next line.
	Is the remaining untreated impervious area greater than 20% of the site?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is the remaining untreated impervious area greater than one acre?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is it practicable to capture runoff from portions of the site that will not drain to a control measure?	No	☒	Document justification demonstrating that it is not practicable to capture runoff from this portion of the site in the drainage report . No further action is needed.
		Yes	☐	This exclusion does not apply. Permanent water quality is required.



Summary of Water Quality Conformance to MS4 Permit

The purpose of this worksheet is to document conformance with the Town of Castle Rock's MS4 permit with regard to permanent water quality on land disturbance projects.

Project Name Dawson Trails -Costco

Project Owner ACM Dawson Trails VIII JV LLC

Project Location West side of I-25 just North of Territorial Rd, Castle Rock, CO

ToCR Project Number CD23-0020

Total Site Area 19.8 +/- acres

Total Size of Common Plan of Development N/A acres

Check all that apply:

☒ **Project within Plum Creek Basin**

☐ **Project within Cherry Creek Basin**

Estimated construction completion date June 2023

1. The water quality control measure(s) for applicable development sites shall meet one of the following base design standards as per the SDDTCM Section 14.4. Please select all design standards that were applied to meet conformance with the MS4 on this site.

☒ WQCV standard

☐ Pollutant removal standard

☐ Runoff reduction standard

☐ Applicable site draining to regional WQVC control measure (accepts drainage prior to discharging to WOTS)

☐ Applicable site draining to regional WQVC control facility (with receiving pervious area control measure upstream of WOTS)

☐ Constrained redevelopment sites standard

• Imperviousness of existing site _____/_____ (Imp. Ac/Site Ac) = ____%

• Variance required TCV No. _____

☐ Existing control measure with WQCV per previous criteria standards

• Reference Construction Permit No. _____

☐ Cherry Creek Basin only, choose one: ☐ Tier 1 ☐ Tier 2 ☐ Tier 3

☐ No control measures provided (See Permanent WQ Worksheet for applicability)

Summary of Water Quality Conformance to MS4 Permit

2. Was an exclusion to water quality applied as per SDDTCM Section 13.1.5? ☐ Yes ☒ No

i. If yes, please select all that apply, provide total excluded impervious area(s) and submit variance, as applicable: TCV No. _____

- ☐ Pavement management site
Excluded impervious area: _____ acres
- ☐ Excluded roadway redevelopment
Excluded impervious area: _____ acres
- ☐ Excluded existing roadway areas
Excluded impervious area: _____ acres
- ☐ Above ground and below ground utilities
- ☐ Large lot single family home
- ☐ Non-residential and non-commercial infiltration
Excluded impervious area: _____ acres
- ☐ Land disturbance for land to remain undeveloped
Excluded impervious area: _____ acres
- ☐ Stream Stabilization Sites
Excluded impervious area: _____ acres
- ☐ Trails
Excluded impervious area: _____ acres
- ☐ Oil and Gas Exploration

3. For Development and Redevelopment sites, following any exclusions claimed above, was any portion of the site excluded up to 20% of the site and not to exceed one acre? ☒ Yes ☐ No

If yes, complete the following:

Excluded area: 0.94 acres
Total Site area: 19.58 acres, 4.8 % site excluded

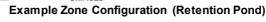
4. For Constrained sites, was any portion of the site excluded up to 50% of the site and not to exceed 50% of the impervious area? ☐ Yes ☒ No

If yes, complete the following:

Excluded area: _____ acres
Excluded impervious area: _____ acres
Total Site area: _____ acres, _____ % site excluded
Total Impervious area: _____ acres, _____ % impervious excluded

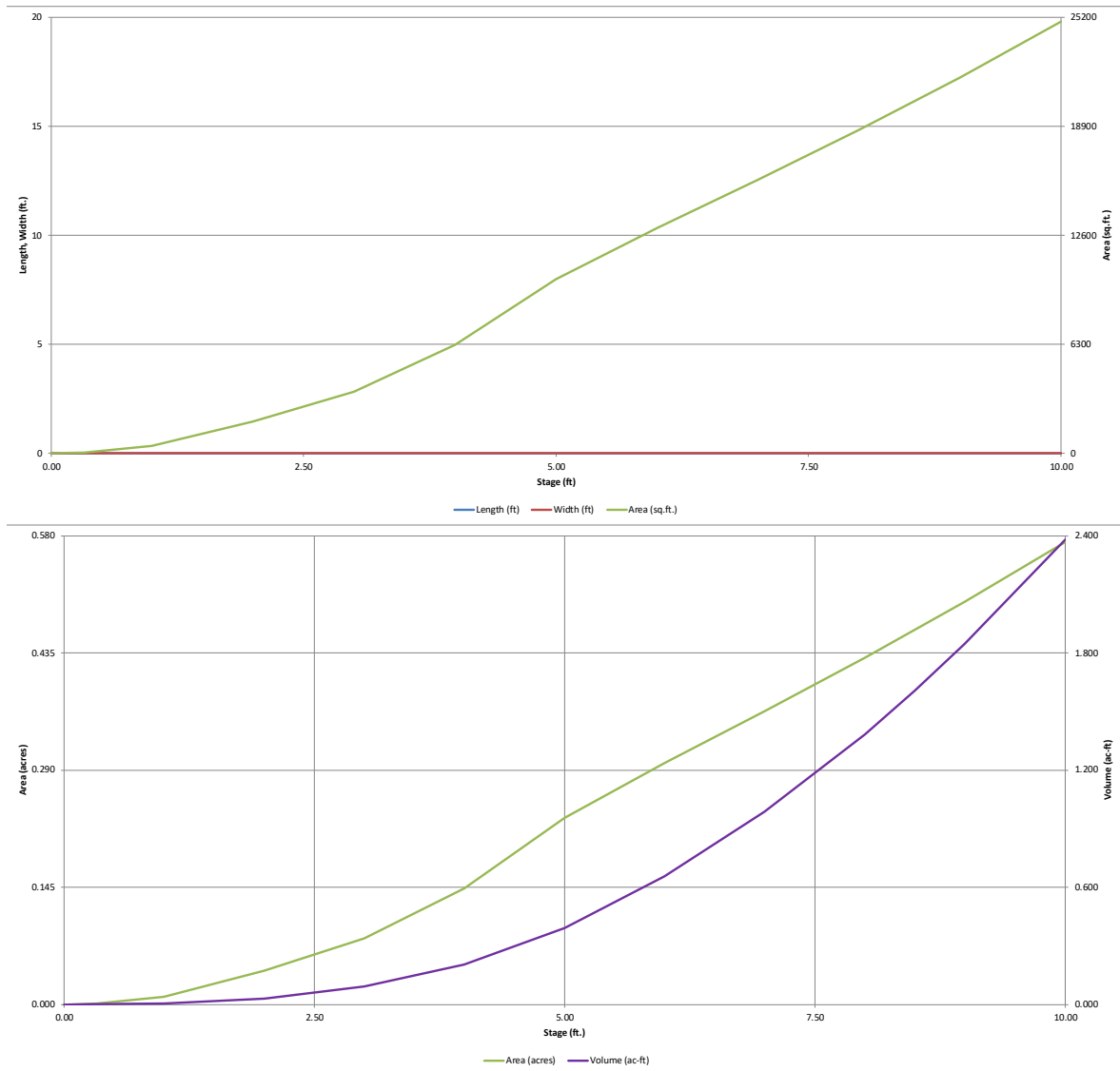
MHFD-Detention, Version 4.06 (July 2022)

Basin ID: Pond C3



DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

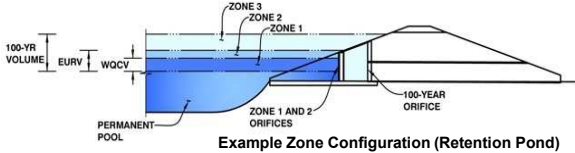


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: Costco WQ Pond - Dawson Trails

Basin ID: Pond C3



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	5.73	0.578	Orifice Plate
Zone 2 (EURV)	8.47	1.011	Orifice Plate
Zone 3			Weir&Pipe (Circular)
Total (all zones)		1.589	

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

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain

Underdrain Orifice Area = ft²
Underdrain Orifice Centroid = feet

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

Calculated Parameters for Plate

Centroid of Lowest Orifice = 0.00 ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = 8.48 ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = 30.20 inches
Orifice Plate: Orifice Area per Row = 1.82 sq. inches (diameter = 1-1/2 inches)

WQ Orifice Area per Row = 1.264E-02 ft²
Elliptical Half-Width = N/A feet
Elliptical Slot Centroid = N/A feet
Elliptical Slot Area = N/A ft²

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	2.83	5.65					
Orifice Area (sq. inches)	1.82	1.82	1.82					

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

User Input: Vertical Orifice (Circular or Rectangular)

Calculated Parameters for Vertical Orifice

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

Vertical Orifice Area = Not Selected Not Selected ft²
Vertical Orifice Centroid = N/A N/A feet

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

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, H _o =	8.50	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Gate Upper Edge, H _g =	8.50	N/A	feet
Overflow Weir Front Edge Length =	5.67	N/A	feet	Overflow Weir Slope Length =	2.92	N/A	feet
Overflow Weir Gate Slope =	0.00	N/A	H:V	Gate Open Area / 100-yr Orifice Area =	6.52	N/A	
Horiz. Length of Weir Sides =	2.92	N/A	feet	Overflow Gate Open Area w/o Debris =	11.52	N/A	ft ²
Overflow Gate Type =	Type C Gate	N/A		Overflow Gate Open Area w/ Debris =	5.76	N/A	ft ²
Debris Clogging % =	50%	N/A	%				

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

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Circular	Not Selected			Zone 3 Circular	Not Selected	
Depth to Invert of Outlet Pipe =	2.00	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	1.77	N/A	ft ²
Circular Orifice Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.75	N/A	feet
				Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Calculated Parameters for Spillway

Spillway Invert Stage = 9.00 ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length = 60.00 feet
Spillway End Slopes = 10.00 H:V
Freeboard above Max Water Surface = 0.50 feet

Spillway Design Flow Depth = 0.50 feet
Stage at Top of Freeboard = 10.00 feet
Basin Area at Top of Freeboard = 0.57 acres
Basin Volume at Top of Freeboard = 2.38 acre-ft

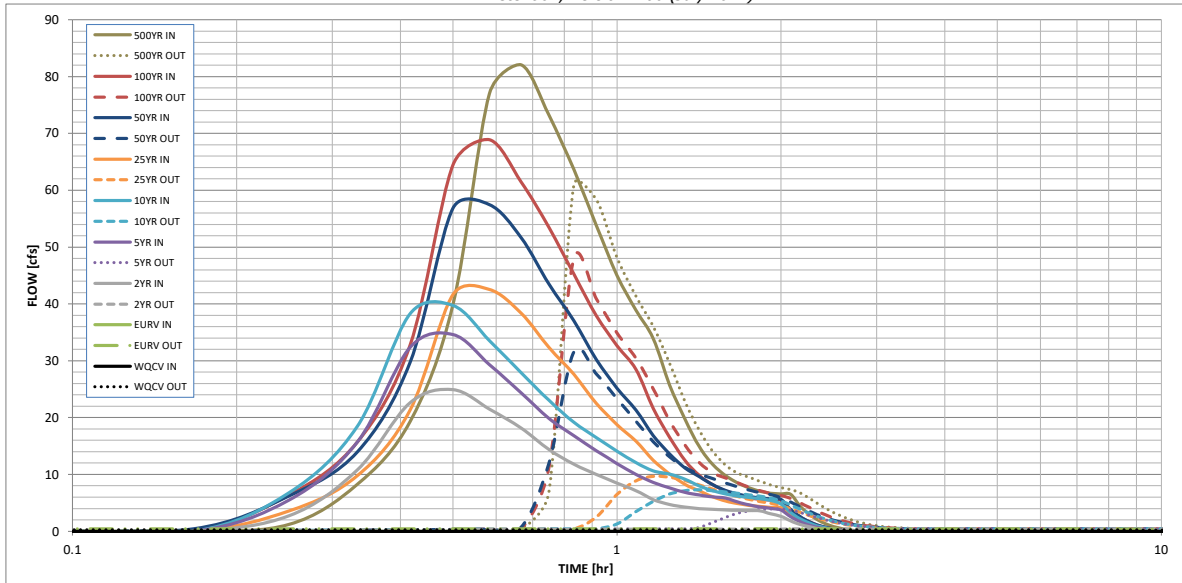
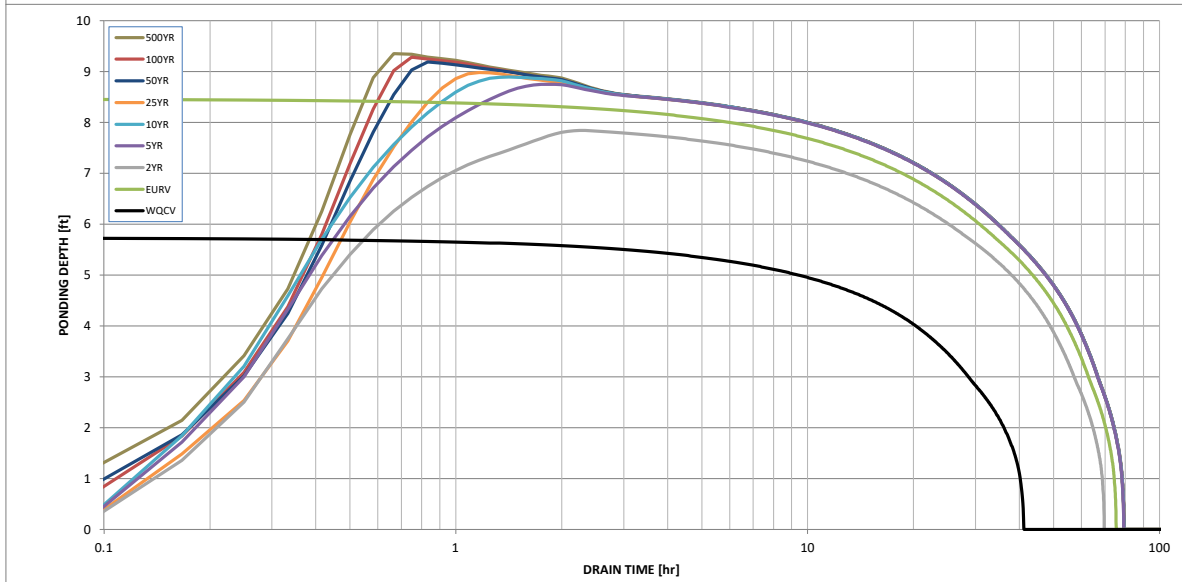
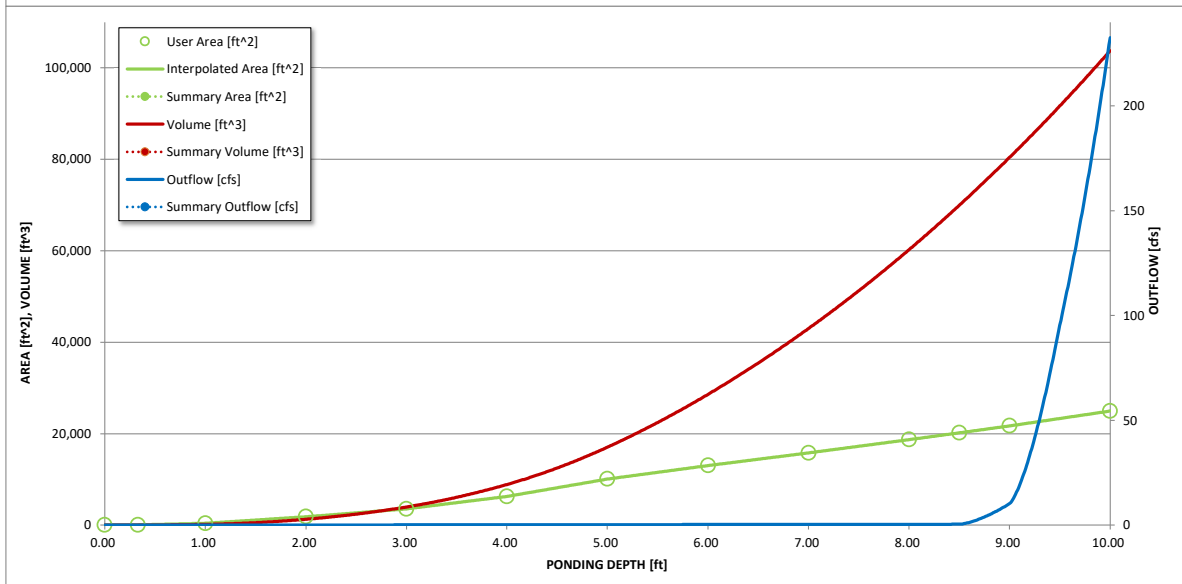
Routed Hydrograph Results

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

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =									
One-Hour Rainfall Depth (in) =	N/A	N/A	1.06	1.43	1.66	1.72	2.26	2.60	3.07
CUHP Runoff Volume (acre-ft) =	0.578	1.589	1.378	1.960	2.329	2.436	3.309	3.874	4.638
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	1.378	1.960	2.329	2.436	3.309	3.874	4.638
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	1.8	6.6	9.3	12.3	20.5	26.8	34.1
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.10	0.36	0.50	0.66	1.10	1.44	1.84
Peak Inflow Q (cfs) =	N/A	N/A	24.9	34.6	39.7	42.5	57.5	68.9	82.1
Peak Outflow Q (cfs) =	0.3	0.4	0.4	3.9	7.3	9.7	31.6	48.1	61.0
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.6	0.8	0.8	1.5	1.8	1.8
Structure Controlling Flow =	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Spillway	Spillway	Spillway
Max Velocity through Gate 1 (fps) =	N/A	N/A	N/A	0.3	0.6	0.8	1.4	1.7	1.9
Max Velocity through Gate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	68	63	70	69	69	66	65	63
Time to Drain 99% of Inflow Volume (hours) =	40	72	67	76	75	75	74	73	72
Maximum Ponding Depth (ft) =	5.73	8.47	7.84	8.75	8.89	8.98	9.19	9.28	9.35
Area at Maximum Ponding Depth (acres) =	0.28	0.46	0.42	0.48	0.49	0.50	0.51	0.52	0.52
Maximum Volume Stored (acre-ft) =	0.578	1.592	1.311	1.719	1.792	1.836	1.937	1.989	2.020

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)



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

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

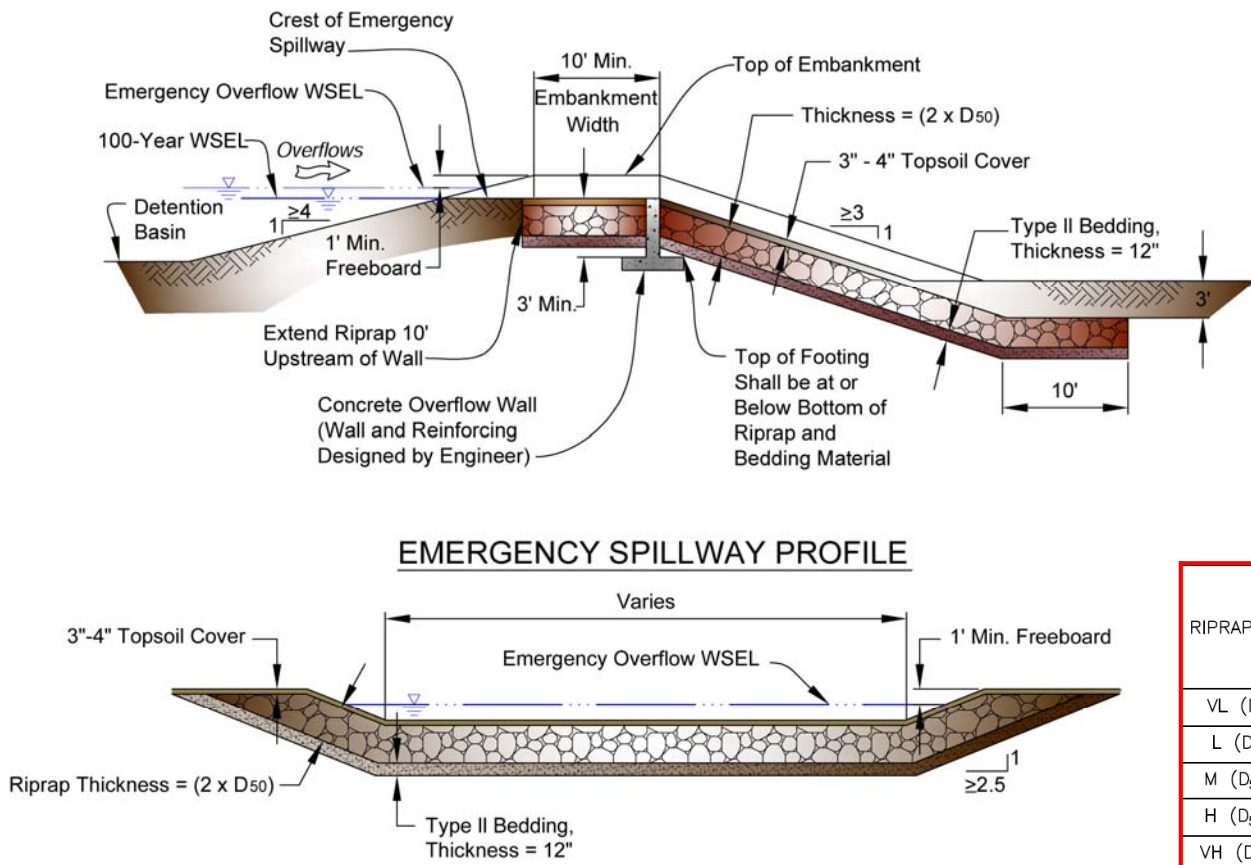
The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.21	1.19
	0:15:00	0.00	0.00	2.73	5.51	6.80	3.57	6.21	6.38	8.22
	0:20:00	0.00	0.00	10.80	15.65	18.45	9.76	13.95	15.70	19.31
	0:25:00	0.00	0.00	22.62	32.38	38.28	21.29	29.68	32.74	39.88
	0:30:00	0.00	0.00	24.89	34.61	39.71	41.66	56.82	64.42	77.02
	0:35:00	0.00	0.00	21.47	29.31	33.51	42.54	57.48	68.87	82.06
	0:40:00	0.00	0.00	18.15	24.35	27.87	38.37	51.67	61.48	73.21
	0:45:00	0.00	0.00	14.39	19.87	23.04	32.34	43.49	53.49	63.64
	0:50:00	0.00	0.00	11.79	16.83	19.18	27.59	37.05	45.23	53.79
	0:55:00	0.00	0.00	10.01	14.18	16.47	22.51	30.23	37.90	45.07
	1:00:00	0.00	0.00	8.48	11.92	14.11	18.78	25.21	32.68	38.87
	1:05:00	0.00	0.00	7.15	10.01	12.07	15.84	21.29	28.46	33.85
	1:10:00	0.00	0.00	5.57	8.60	10.59	12.49	16.81	21.58	25.70
	1:15:00	0.00	0.00	4.70	7.60	10.05	10.06	13.60	16.53	19.74
	1:20:00	0.00	0.00	4.26	6.85	9.14	8.26	11.15	12.45	14.88
	1:25:00	0.00	0.00	3.99	6.37	7.95	7.12	9.61	9.82	11.74
	1:30:00	0.00	0.00	3.85	6.04	7.14	6.06	8.17	8.19	9.79
	1:35:00	0.00	0.00	3.75	5.83	6.58	5.32	7.17	7.09	8.48
	1:40:00	0.00	0.00	3.67	5.13	6.19	4.87	6.56	6.37	7.62
	1:45:00	0.00	0.00	3.62	4.62	5.93	4.55	6.13	5.89	7.04
	1:50:00	0.00	0.00	3.59	4.27	5.74	4.34	5.85	5.60	6.69
	1:55:00	0.00	0.00	3.04	4.02	5.41	4.22	5.69	5.49	6.56
	2:00:00	0.00	0.00	2.64	3.73	4.82	4.15	5.59	5.44	6.50
	2:05:00	0.00	0.00	1.82	2.56	3.31	2.86	3.85	3.77	4.51
	2:10:00	0.00	0.00	1.21	1.70	2.23	1.93	2.59	2.55	3.05
	2:15:00	0.00	0.00	0.80	1.12	1.48	1.30	1.74	1.72	2.05
	2:20:00	0.00	0.00	0.50	0.70	0.95	0.83	1.12	1.10	1.31
	2:25:00	0.00	0.00	0.30	0.44	0.59	0.53	0.71	0.70	0.84
	2:30:00	0.00	0.00	0.16	0.26	0.33	0.31	0.42	0.42	0.50
	2:35:00	0.00	0.00	0.07	0.13	0.15	0.16	0.21	0.20	0.24
	2:40:00	0.00	0.00	0.02	0.04	0.04	0.05	0.07	0.07	0.08
	2:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

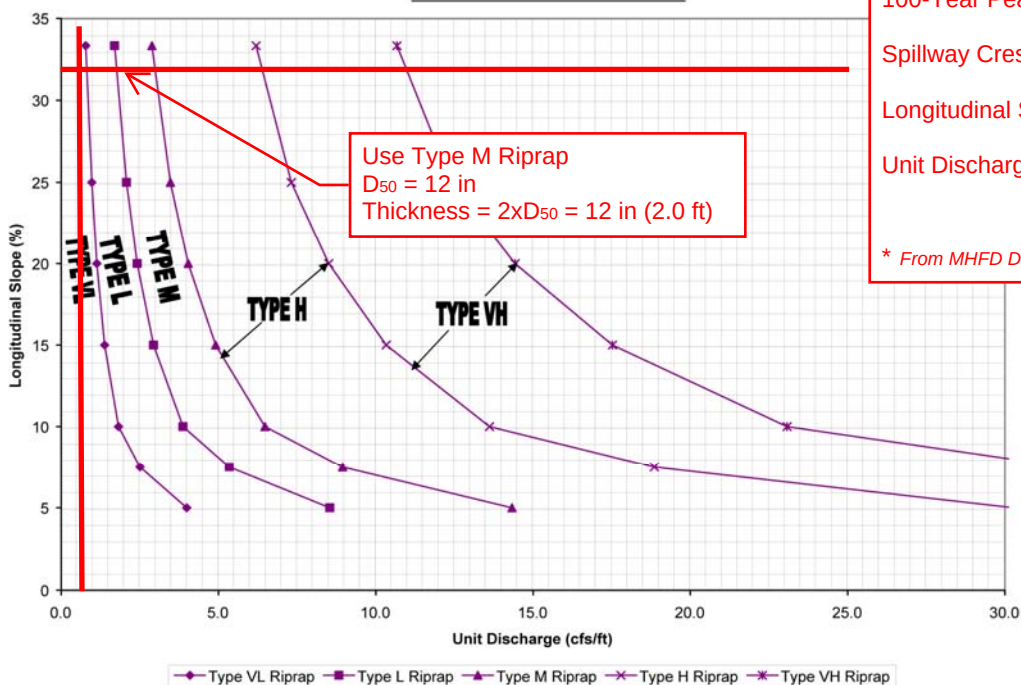
POND C3 SPILLWAY RIPRAP CALCULATION

Chapter 13. Storage

**FIGURE 13-7
EMBANKMENT PROTECTION DETAILS AND ROCK SIZING CHART**



SPILLWAY CHANNEL AT CREST AND DOWNSTREAM SIDE OF EMBANKMENT



100-Year Peak Inflow* = 69.0 CFS
Spillway Crest Length* = 60 FT
Longitudinal Slope = 32%
Unit Discharge = 69.0/60 = 1.15 CFS/FT

* From MHFD Detention Workbook

Notes:

- 1) Place and compact 12\" Type II Granular Bedding only under Void-Filled Riprap (typical per USDCM Vol. 1, Ch. 8, Figure 8-34).
- 2) If Type VL Riprap is calculated, use Type L (typical per USDCM Vol. 2, Ch. 9, Figure 9-38).

POND C3 OUTFALL

SHEET 1 OF 5

Project: Costco Wholesale

Per USDCM Vol. 2, Ch. 9, S. 3.1 & 3.2

Riprap Sizing per Section 3.2.3

$$L_p = (1/2 \tan \Theta) [(A_t/Y_t) - W]$$

Length of protection; Equation 9-11

$$D = \frac{36.00}{3.00} \text{ in}$$

Pipe diameter

$$Y_n = 2.00 \text{ ft}$$

Normal depth of flow at culvert outlet

$$V = 9.8 \text{ ft/s}$$

Flow velocity at culvert outlet

$$FR = \frac{1.22}{Y}$$

Froude Number

Supercritical flow?

$$Y_t = 1.00 \text{ ft}$$

Tailwater depth

$$D_a = 2.50$$

D parameter for supercritical flow

$$A_t = Q/V \text{ ft}^2$$

Required area of flow at allowable velocity; Equation 9-12

$$Q = 64.9 \text{ cfs}$$

100-year discharge

$$V = 5 \text{ ft/sec}$$

Max velocity allowed by UDFCD for non-cohesive soils

$$A_t = 12.98 \text{ ft}^2$$

$$Q/D^{1.5} = 12.49$$

Froude Parameter (for Rock Sizing figure 9-38)

$$Y_t/D = 0.33$$

Tailwater Depth/Conduit Height

$$Y_t/D_a = 0.40$$

(use 0.40 if unknown or hydraulic jump is suspected downstream)

Use Type M Riprap per Figure 9-38	$D_{50} = 24 \text{ in}$
--	--------------------------

See Figure 9-38

Thickness of Riprap Layer = $2D_{50} = 4.0 \text{ ft}$
--

See Figure 9-34

$$Q/D^{2.5} = 6.57$$

Froude Parameter (for Extent of Protection figure 9-35)
(must be ≤ 6.0)

$$1/2 \tan \Theta = 1.6$$

 (F_E) Expansion factor; Figure 9-35

$L_p = 16 \text{ ft}$

See Figure 9-34

$$T = 2(L_p \tan \Theta) + W$$

Width of riprap at furthest downstream point; Equation 9-13

$$\Theta = \tan^{-1} [1/(2 * F_E)]$$

Equation 9-13

$$\Theta = 0.30^\circ$$

$T = 13 \text{ ft}$

See Figure 9-34

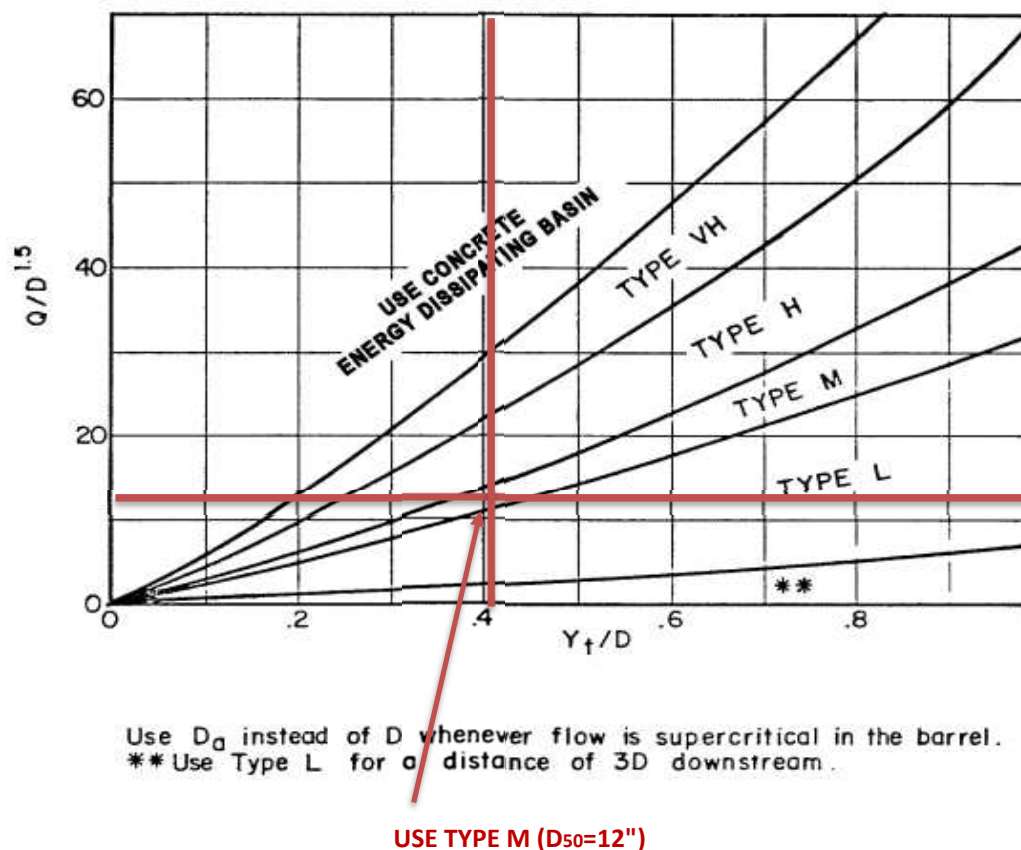


Figure 9-38. Riprap erosion protection at circular conduit outlet (valid for $Q/D^{2.5}$:

THICKNESS REQUIREMENTS FOR GRANULAR BEDDING			
RIPRAP DESIGNATION	MINIMUM BEDDING THICKNESS (INCHES)		
	FINE-GRAINED SOILS ¹		COARSE-GRAINED SOILS
	TYPE I (LOWER LAYER)	TYPE II (UPPER LAYER)	TYPE II
VL ($D_{50} = 6$ IN)	4	4	6
L ($D_{50} = 9$ IN)	4	4	6
M ($D_{50} = 12$ IN)	4	4	6
H ($D_{50} = 18$ IN)	4	6	8
VH ($D_{50} = 24$ IN)	4	6	8

NOTES:

1. MAY SUBSTITUTE ONE 12-INCH LAYER OF TYPE II BEDDING. THE SUBSTITUTION OF ONE LAY OF TYPE II BEDDING SHALL NOT BE PERMITTED AT DROP STRUCTURES. THE USE OF A COMBINATION OF FILTER FABRIC AND TYPE II BEDDING AT DROP STRUCTURES IS ACCEPTABLE.
2. FIFTY PERCENT OR MORE BY WEIGHT RETAINED ON THE #40 SIEVE.

Figure 8-34. Riprap and soil riprap placement and gradation (part 3 of 3)

Project: Costco Wholesale

Per USDCM Vol. 2, Ch. 9, S. 3.2.1

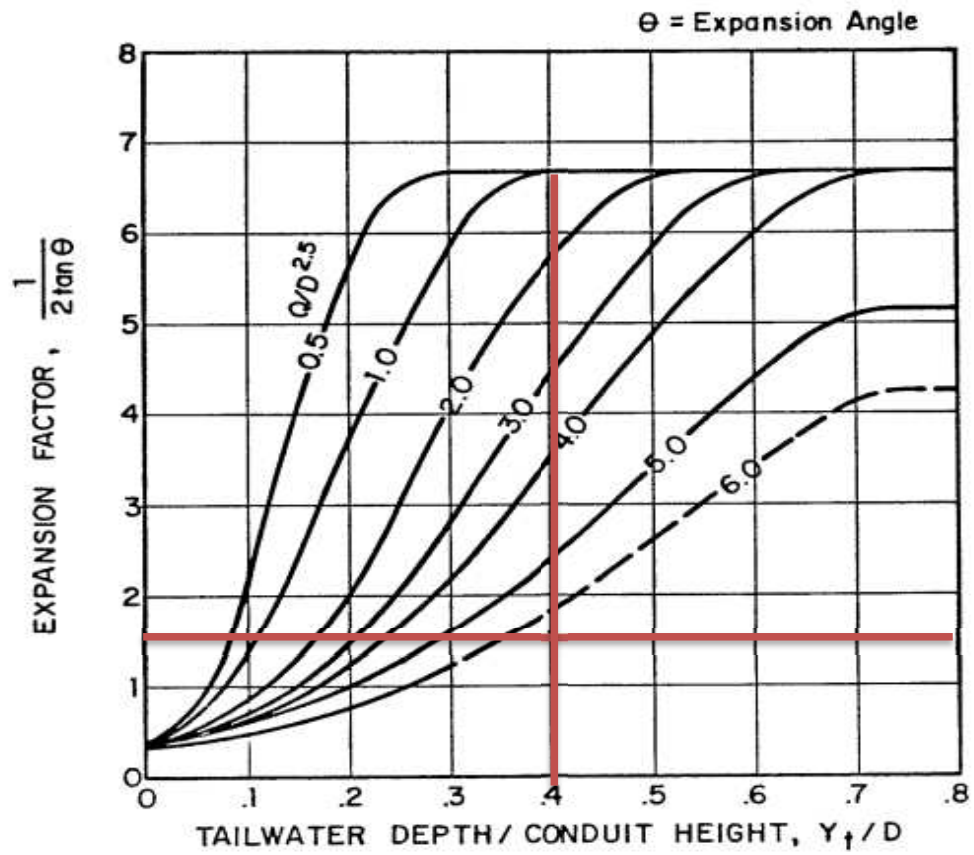


Figure 9-35. Expansion factor for circular conduits

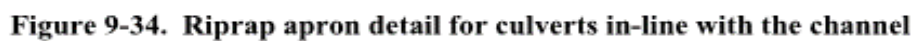
≤ 6.0)



ER

SHEET 4 OF 5

Per USDCM Vol. 2, Ch. 9, S. 3.2.1



POND C3 OUTFALL

SHEET 5 OF 5

Project: Costco Wholesale

Per USDCM Vol. 2, Ch. 9, S. 3.1.2

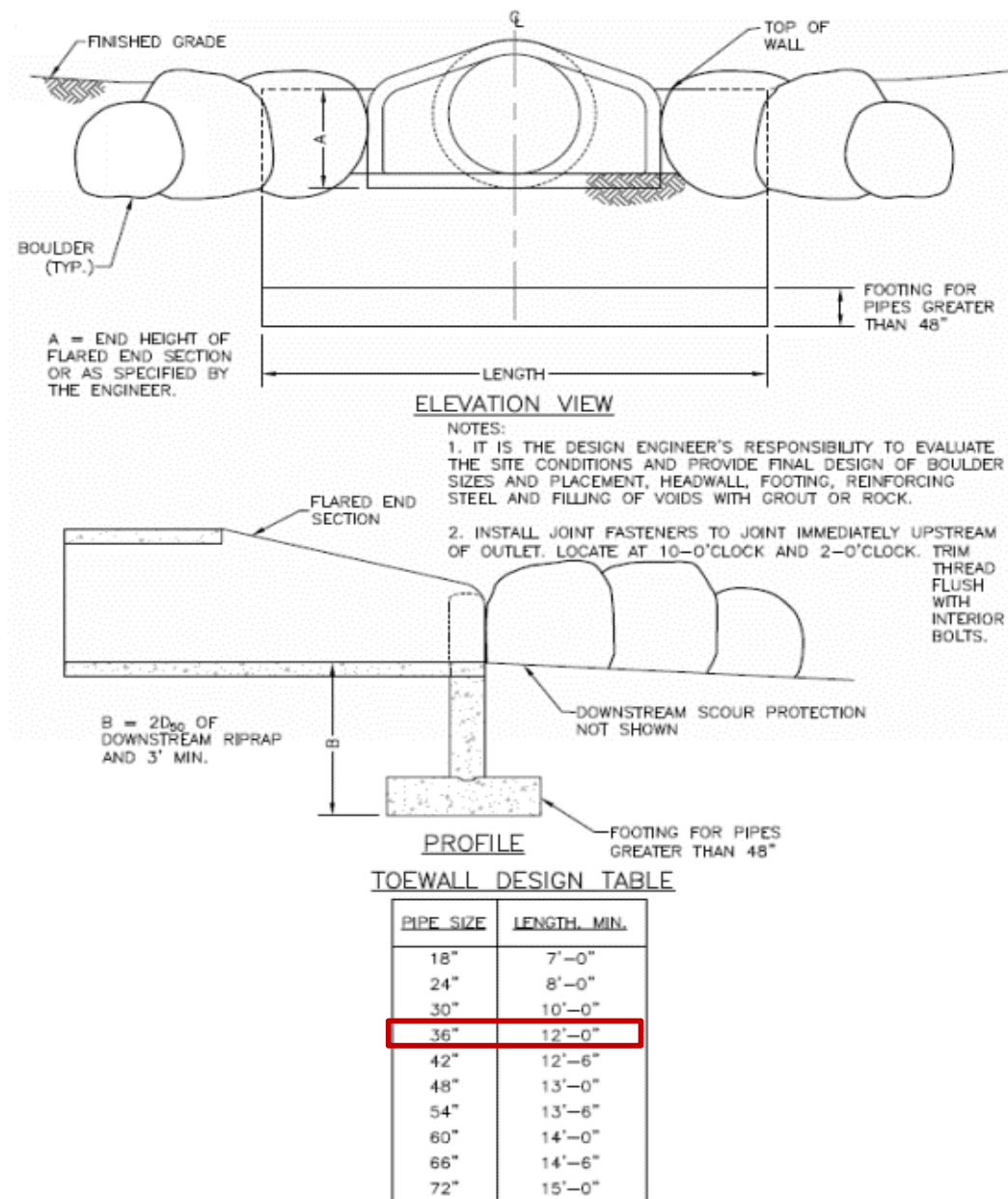


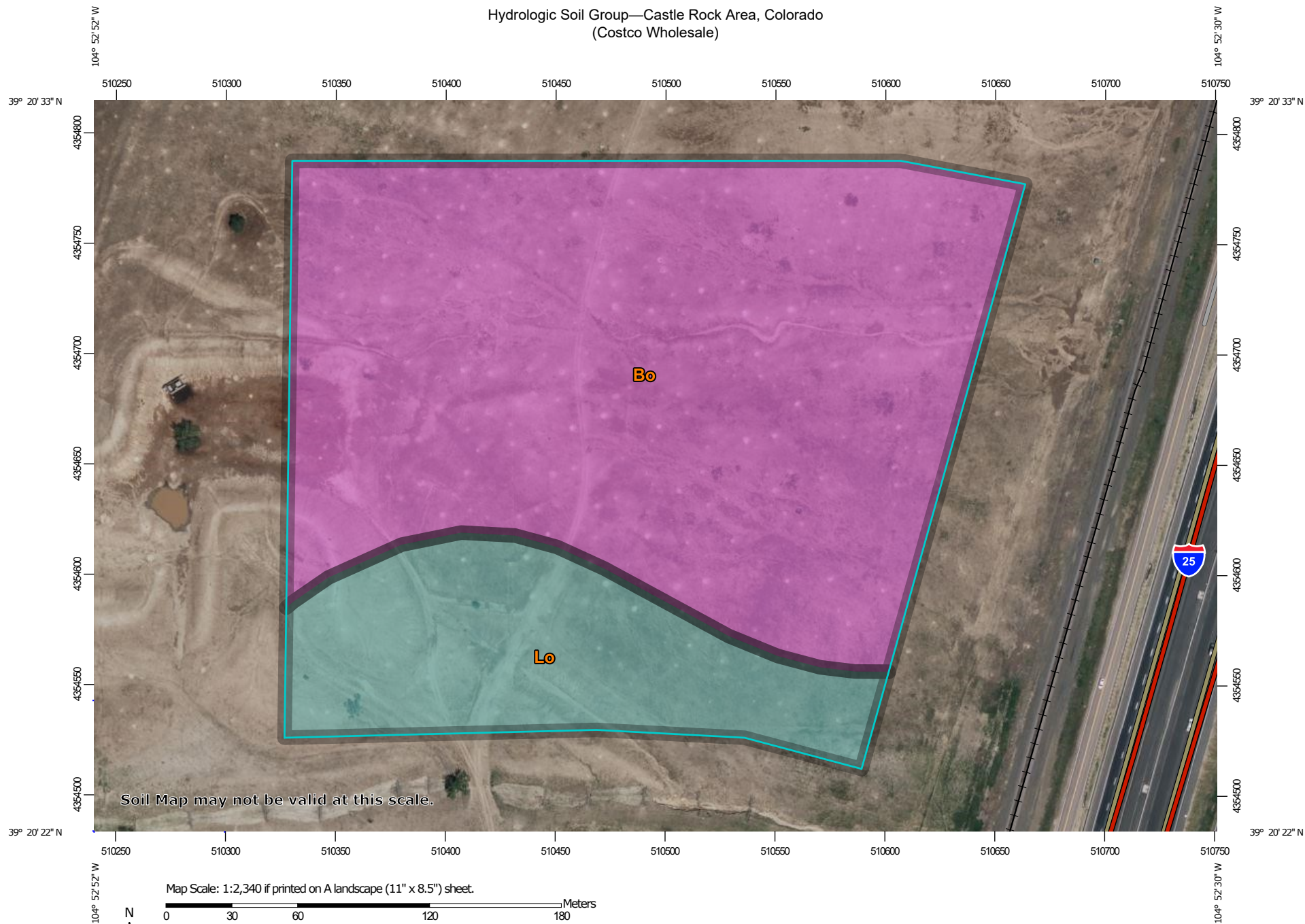
Figure 9-30. Flared end section (FES) headwall concept

Toe wall Dimensions		
Length =	12	ft
Depth (B) =	4.0	ft
Footing Required =	N	

APPENDIX D

REFERENCE EXCERPTS

Hydrologic Soil Group—Castle Rock Area, Colorado (Costco Wholesale)



Hydrologic Soil Group—Castle Rock Area, Colorado (Costco Wholesale)

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

Soil Rating Polygons

 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Lines

 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Points

 A
 A/D
 B
 B/D

 C
 C/D
 D
 Not rated or not available

Water Features

 Streams and Canals

Transportation

 Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Background

 Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Castle Rock Area, Colorado
 Survey Area Data: Version 15, Sep 1, 2022

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Bo	Blakeland-Orsa association, 1 to 4 percent slopes	A	15.0	77.0%
Lo	Loamy alluvial land	C	4.5	23.0%
Totals for Area of Interest			19.5	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations (BFEs)** and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables shown on this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Floodway Data table shown on this FIRM.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov> or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, NNGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at <http://www.ngs.noaa.gov>.

Base map information shown on this FIRM was provided by the Douglas County GIS Department and the Town of Castle Rock GIS Department. Additional input was provided by the City of Lone Tree and Town of Parker. These data are current as of 2010.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

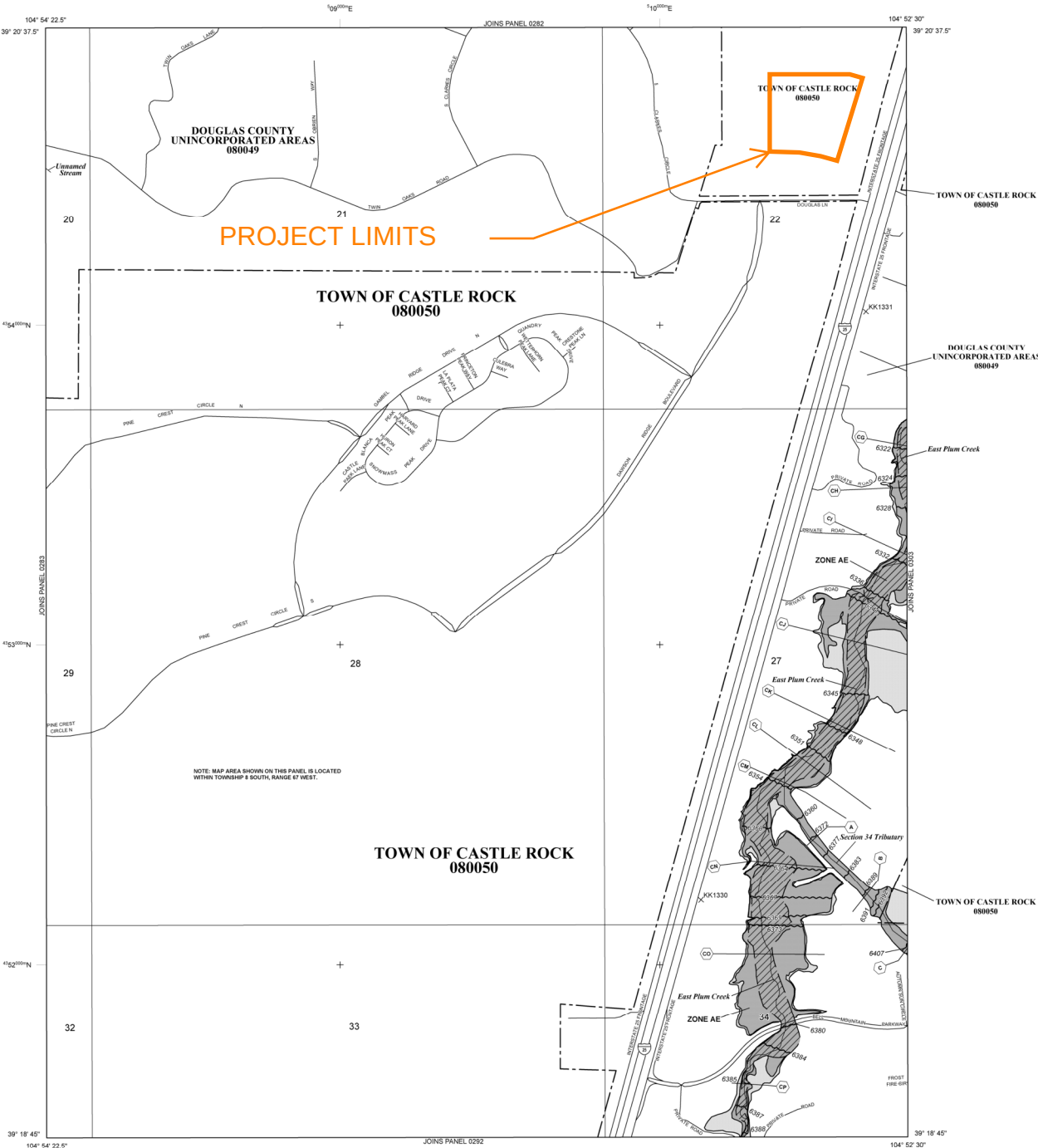
Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations** and **floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for multiple streams in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on the map. Also, the ratio to floodplain relationships for unreviewed streams may have been shown on previous maps.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses, and a listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov/businessinfo>.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD
The 1% annual chance flood (100-year flood), also known as the **base flood**, is the flood that has a 1% chance of being equaled or exceeded in any given year. Flood depths, velocities, and wave heights are determined for areas of special flood hazard. Areas of special flood hazard include Zone A, AE, AH, AO, AR, AV, and VE. The **Base Flood Elevation** is the water-surface elevation of the 1% annual chance flood.

- ZONE A** No Base Flood Elevations determined.
- ZONE AE** Base Flood Elevations determined.
- ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
- ZONE AO** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined; for areas of elevated fill, velocities also determined.
- ZONE AR** The 1% annual chance flood is the flood that has a 1% annual chance of being equaled or exceeded in any given year. Flood depths, velocities, and wave heights are determined for areas of special flood hazard. Areas of special flood hazard include Zone A, AE, AH, AO, AR, AV, and VE. The **Base Flood Elevation** is the water-surface elevation of the 1% annual chance flood.
- ZONE AV** Areas to be protected from the 1% annual chance flood by Federal flood protection system under construction; no Base Flood Elevations determined.
- ZONE VE** Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
- FLOODWAY AREAS IN ZONE AE**

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

- OTHER FLOOD AREAS**
- ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.
- OTHER AREAS**
- ZONE X** Areas determined to be outside the 0.2% annual chance floodplain.
- ZONE D** Areas in which flood hazards are undetermined, but possible.
- COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**
- OTHERWISE PROTECTED AREAS (OPAs)**

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% Annual Chance Floodplain Boundary**
- Floodway boundary**
- Zone D boundary**
- CBRS and OPA boundary**
- Boundary dividing Special Flood Hazard Areas and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.**
- Base Flood Elevation line and value: elevation in feet**
- Base Flood Elevation value where uniform within zone; elevation in feet**

*Referenced to the North American Vertical Datum of 1988

- Cross section line**
- Traverse line**
- Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere**
- 1000-meter Universal Transverse Mercator grid values, zone 13**
- Bench mark (see explanation in Notes to Users section of this FIRM panel)**
- Map title**

MAP REPOSITORIES
Refer to Map Repositories list on Map Index.
EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
SEPTEMBER 30, 2005

EFFECTIVE DATES OF REVISIONS TO THIS PANEL

MARCH 16, 2016: To update corporate limits, to change base flood elevations, to add base flood elevations, to add special flood hazard areas, to update map format, to add roads and road names, to reflect updated topographic information, to incorporate previously issued letters of map revision.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-435-6620.



MAP SCALE 1" = 500'

PANEL 0284G

FIRM

FLOOD INSURANCE RATE MAP

DOUGLAS COUNTY, COLORADO

AND INCORPORATED AREAS

PANEL 284 OF 495
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CASTLE ROCK, TOWN OF	080050	0284	G
DOUGLAS COUNTY	080049	0284	G

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 0803C0284G

MAP REVISED MARCH 16, 2016

Federal Emergency Management Agency

Chapter 6. Hydrology

set of one hour design point rainfall values, indicated in Table 6-1, apply to the Town.

TABLE 6-1
1-HOUR POINT RAINFALL VALUES FOR
THE TOWN OF CASTLE ROCK (INCHES)

2- YR	5-YR	10-YR	50-YR	100-YR
1.06	1.43	1.66	2.26	2.60

The one-hour rainfall depths are the basis of the Town's intensity-duration rainfall curves and are used to formulate design storm distributions.

6.1.2 Intensity-Duration Curves. Rainfall intensity based on storm duration for a variety of storm return periods can be found on Figure 6-1 at the end of this chapter. These curves were developed using distribution factors provided in the NOAA Atlas and also provided in Table RA-4 of the UDFCD Manual. These Intensity-Duration curves are based on Equation RA-3 in the Rainfall Section of the UDFCD Manual.

6.1.3 Six-hour Rainfall. In order to use the Colorado Urban Hydrograph Procedure (CUHP), two, three or six-hour rainfall distributions are required, depending on watershed area. Table RA-1 in the UDFCD Manual summarizes storm durations, area adjustments, and incremental rainfall depths to be used in CUHP based on watershed area. The UD-Raincurve Spreadsheet included in the UDFCD Manual shall be used to generate the rainfall distribution curves necessary for a CUHP model. In order to generate these distribution curves, the one-hour and six-hour rainfall depths for the design return periods are necessary. Since the Town of Castle Rock is not located within UDFCD boundaries, the rainfall depth-duration-frequency curves provided in the UDFCD Manual do not provide rainfall values for the entire Town. Therefore these values are provided in these Criteria. The 1-hour point values can be found in Table 6-1 of this chapter. The six-hour point values are as follows:

TABLE 6-2
6-HOUR POINT RAINFALL VALUES FOR
THE TOWN OF CASTLE ROCK (INCHES)

2- YR	5-YR	10-YR	50-YR	100-YR
1.5	2.0	2.2	3.0	3.4

The UD-Raincurve spreadsheet shall be used for all portions of the Town. Once the rainfall distribution curves are generated using the UDFCD UD-Raincurve Spreadsheet, the CUHP model is to be set up following the procedures provided in the Runoff chapter in Volume 1 of the UDFCD Manual.

6.3 Combined Junction Loss Equation

$$H_j = H_s = k_{bT} \cdot \left(\frac{V_{fT}^2}{2g} \right) + \left[\left(\frac{V_{fo}^2}{2g} \right) - k_m \cdot \left(\frac{V_{fi}^2}{2g} \right) \right] + k_{bL} \cdot \left(\frac{V_{fi}^2}{2g} \right) = k \cdot \left(\frac{V_o^2}{2g} \right) \quad \text{Equation (13)}$$

where, H_j = UD-Sewer junction loss

H_s = Standard method junction loss

k_{bT} = Bend loss coefficient at truckling

k_{bL} = Bend loss coefficient at lateral

V_{fT} = Full flow velocity of trunk line at manhole

V_{fi} = Full flow velocity of incoming lateral at manhole

V_o = Full flow velocity of trunk line at manhole

k = Head Loss Coefficient

g = Acceleration due to Gravity

Table 2 - StormCAD Standard Method Conversions

StormCAD Conversion Table			
Bend Loss	Bend Angle	K coefficient Conversion	
	0	0.05	
	22.5	0.1	
	45	0.4	
	60	0.64	
	90	1.32	
Lateral Loss	1 Lateral K coefficient Conversion		
	Bend Angle	Non Surcharged	Surcharged
	45	0.27	0.47
	60	0.52	0.9
	90	1.02	1.77
	2 Laterals K coefficient Conversion		
	45	0.96	
	60	1.16	
	90	1.52	

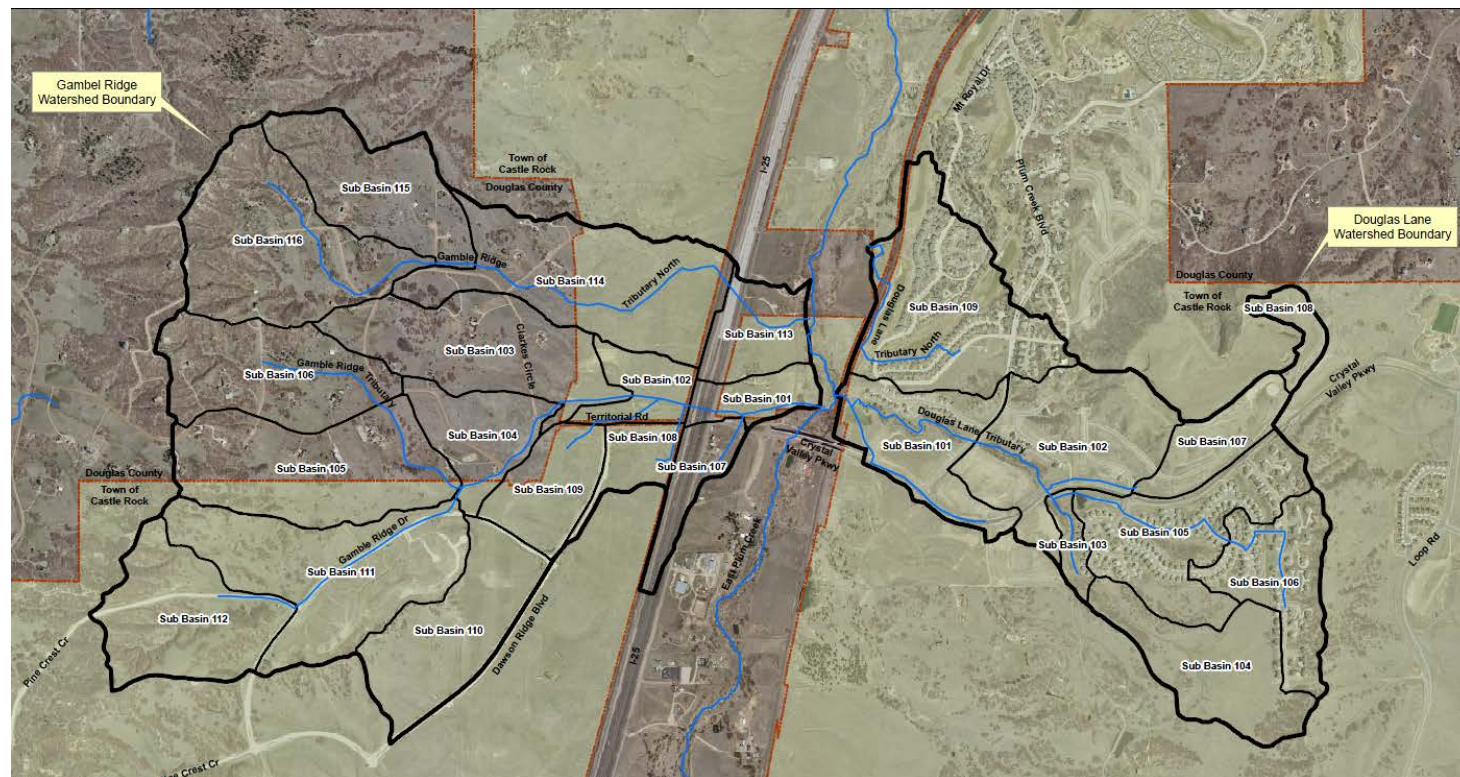
The engineering guidelines from this study provide the methodology needed to reach an HGL analysis result using StormCAD which replicates that of UD-Sewer. However, the following limitations apply:

- The full pipe velocity should not exceed 18 fps
- The conversion only applies for the storm sewer pipe sizes 42" or less
- A regional storm sewer system should use UD-Sewer only

FLOOD HAZARD AREA DELINEATION

GAMBEL RIDGE AND DOUGLAS LANE

TRIBUTARY WATERSHEDS



Project Sponsor:



TOWN OF CASTLE ROCK

Prepared by:



July 2014

720 South Colorado Boulevard
Suite 410 S
Denver, Colorado 80246
phone (303) 757-3655
fax (303) 300-1635

SECTION 3 – HYDROLOGIC ANALYSIS

ponds that are modeled. All storage elements in EPA SWMM are a unique four-digit number that ends in 8 (ie. XXX8).

The stage-area and stage-discharge curves were obtained from the available drainage reports for each detention pond. The water quality storage volume and release rates were not included in the development of the baseline hydrology (unless specified otherwise by the drainage report). The detention pond rating curves can be located in Appendix B Table B-8 Detention Pond Characteristics.

DIVERSION ANALYSIS

There are several dividers included within the EPA SWMM model so that the existing infrastructure can be accurately modeled and provide representative peak flows to all downstream design points. At locations where the pipe capacity was exceeded, trapezoidal sections were added as overflows to prevent inadvertent detention. The “cutoff” pipe capacity was set at 90% of the maximum pipe capacity generated by EPA SWMM using the “overflow” function. This approach minimizes the instabilities in the model that often reports inaccurate peak flows and provides a conservative approach. Each overflow consists of the routing element number with an “o” at the end (ie. XXXXo).

3.5 RESULTS OF ANALYSIS

Peak flows were developed using the rainfall information, subwatershed hydrologic parameters and drainage system conveyance characteristics. The peak flows were calculated for the 2-, 5-, 10-, 25-, 50-, 100- and 500-year return period storm events and for the existing and future land use conditions.

The Gambel Ridge and Douglas Lane Tributary watersheds peak flows are included in Appendix B, Table B-9, CUHP Subwatershed Peak Flows - Gambel Ridge Tributary and Table B-10, CUHP Subwatershed Peak Flows - Douglas Lane Tributary. The routed peak flows at each design point are summarized for each watershed and can be located in Appendix B, Table B-11 Peak Flow Summary Table - Gambel Ridge Tributary and Table B-12 Peak Flow Summary Table - Douglas Lane Tributary.

The Peak Flow Summary Tables at Key Design Points, Tables 3-5 and 3-6 below, illustrate the peak flows at several key locations in the drainageways for the Gambel Ridge and Douglas Lane Tributaries.

Table 3-6 Douglas Lane Peak Flow Summary Table at Key Design Points

Design Point	Location	Drainage Area		10-Year		50-Year		100-Year		500-Year	
				Existing	Future	Existing	Future	Existing	Future	Existing	Future
		(acres)	(sq.mi.)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
1010	Outfall to East Plum Creek D/S Study Limits	530.6	0.83	127	150	393	478	612	707	870	988
1012	Heckendorf Detention Basin Outflow	530.6	0.83	127	150	393	478	612	707	870	988
1014	Heckendorf Detention Basin Inflow	530.6	0.83	232	292	465	564	720	849	1051	1225
1018	Heckendorf Detention Basin	530.6	0.83	232	292	465	564	720	849	1051	1225
1020	Plum Creek Boulevard	468.3	0.73	173	207	368	466	620	734	904	1046
1030	Crystal Valley Parkway	279.0	0.44	72	97	231	308	390	478	552	671
1050	Crystal Valley Detention Basin Out	197.0	0.31	50	56	160	205	286	331	418	476
1052	Crystal Valley Detention Basin In	197.0	0.31	157	187	292	335	368	419	473	534
1058	Crystal Valley Detention Basin	197.0	0.31	157	187	292	335	368	419	473	534
1090	Outfall to East Plum Creek D/S Study Limits	113.1	0.18	113	141	213	255	265	314	341	400

Several hydrographs at key locations for the 100-year existing and future land use conditions can be found in Appendix B, Table B-13 Gambel Ridge Tributary Hydrographs and Table B-14 Douglas Lane Tributary Hydrographs. A majority of the hydrographs were found to have sharp peaks which could be greatly reduced by implementing detention ponds.

3.6 PREVIOUS STUDIES

Numerous drainage studies have been performed as development has occurred in each watershed. However, there has not been a recent comprehensive drainage study that incorporates the entire Gambel Ridge Tributary. A comprehensive study was completed for Douglas Lane Tributary for the design of the Heckendorf Detention Pond that was constructed as part of the Heckendorf Ranch Filing 2 development. The peak flow comparison tables below summarize the peak flows from this baseline hydrology and selected drainage reports.

Table 3-7 below presents a 100-year peak flow comparison between the Gambel Ridge Tributary baseline hydrology results to the Dawson Ridge Filing No. 2 and No. 11 drainage reports at key design points.

Table 3-7 Gambel Ridge Tributary 100-Year Peak Flow Comparison Table

Design Point	Location	RESPEC 2013		Dawson Ridge Filing No. II	Final Drainage Study for Dawson Ridge Filing No. 2
		Existing	Future	Future	Historic
		(cfs)	(cfs)	(cfs)	(cfs)
1110	Gamble Ridge Drive North	290	639	192	
1050		531	874		499

Overall, the Gambel Ridge Tributary peak flows for this study vary considerably from existing studies. The percentage differences range from 6% to 232%. Several potential reasons for the wide range in peak flows are presented below.

- Differences in drainage areas between the existing reports and this baseline hydrology report.
- Difficulty in locating similarly developed peak flows in the drainage reports. Many reports have similar design points but there are no downstream peak flows reported.
- Poor or missing routing maps in the existing drainage reports to enable comparisons at similar locations.

Table 3-5 Gambel Ridge and Gambel Ridge North Tributary Peak Flow Summary Table at Key Design Points

Design Point	Location	Drainage Area		10-Year		50-Year		100-Year		500-Year	
				Existing	Future	Existing	Future	Existing	Future	Existing	Future
		(acres)	(sq.mi.)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
1010	Outfall to East Plum Creek D/S Study Limits (Gambel Outfall)	727.9	1.14	305	757	741	1378	977	1720	1324	2243
1110	Gamble Ridge Drive North	197.4	0.31	100	296	224	517	290	639	390	826
1130	Outfall to East Plum Creek D/S Study Limits (North Outfall)	336.1	0.53	87	185	273	378	380	504	533	693
1020	Upstream of Railroad and I-25 Crossing	681.3	1.06	278	708	682	1286	901	1604	1224	2092
1140	Upstream of Railroad and I-25 Crossing	300.8	0.47	77	143	241	332	334	444	467	608
1150	Upstream of Clarkes Circle and Briscoe Lane	184.2	0.29	69	69	177	177	234	234	317	317
1040	Downstream of Territorial Road and Clarkes Circle	427.6	0.67	186	383	443	733	581	921	785	1212
1120	Gamble Ridge Drive North and Pine Crest Circle	79.8	0.12	42	127	95	224	123	272	166	353
1100	Gamble Ridge Drive North and Dawson Ridge Boulevard	76.1	0.12	43	206	92	308	119	362	159	451

SECTION 4 – HYDRAULIC ANALYSIS

4.1 INTRODUCTION

A hydraulic analysis was performed for the tributaries to estimate the hydraulic capacities of the existing waterways and drainage structures. The hydraulics of the drainageways were analyzed using the United States Army Corps of Engineers (USACE) HEC-RAS 4.1.0 modeling program. The post-development land-use condition peak discharges were modeled for the 10-, 50, 100-, and 500-year events. The geometry and physical condition of the existing drainage conveyance system were modeled.

4.2 EVALUATION OF EXISTING FACILITIES

Detailed field survey was obtained of all existing drainage structures on the Gambel Ridge and Douglas Lane Tributaries. The survey information was then used to define the structure types and geometries in the HEC-RAS program. Table 4-1 describes drainage structures included in the hydraulic analysis. Photographs of all structures are included in Appendix C.

Table 4-1 Major Crossing Structure Inventory

Tributary	Street Name	Roadway Classification	HEC-RAS Station	Size	Type
Douglas Lane	Railroad Bridge	Railroad	87.2212	22' (w) opening	Concrete Bridge
Douglas Lane	Plum Creek Boulevard	Collector	2428.302	2-72"	RCP
Douglas Lane	Crystal Valley Parkway	Collector	3697.874	2-72"	RCP
Gambel Ridge North	I-25	Arterial	1142.626	10' (w) x 8' (h)	RCPA
Gambel Ridge North	Railroad	Railroad	1289.289	11' (w) x 7' (h)	CMPA
Gambel Ridge	I-25	Arterial	1706.496	10' (w) x 6' (h)	CBC
Gambel Ridge	Railroad	Railroad	1830.03	3 - 9' (w) x 6' (h)	CMPA
Gambel Ridge	Clarkes Circle	Collector	3943.826	4.5' (w) x 2.8' (h)	CMPA
Gambel Ridge	Twin Oaks Road	Collector	4768.087	2 - 4.3' (w) x 3' (h)	CMPA

All crossings on the Gambel Ridge Tributary are subject to overtopping during the 10-, 50-, 100-, and 500-year flood events, while all crossings on the Douglas Lane Tributary have sufficient capacity to convey flows during the 10-, 50-, 100-, and 500-year flood events.

Table 4-2, Existing Facilities tabulates each culvert crossing, the capacity and expected flows tributary upstream of each location.

Table 4-2 Existing Facilities

Tributary	Street Name	HEC-RAS Station	Size	Type	Pipe Capacity (cfs)	Source	Design Point	100-Year (cfs)	
								Existing	Future
Douglas Lane	Railroad Bridge	87.2212	22' (w) opening	Concrete Bridge	988	HEC-RAS	1020	620.3	733.9
Douglas Lane	Plum Creek Boulevard	2428.302	2-72"	RCP	1046	HEC-RAS	1020	620.3	733.9
Douglas Lane	Crystal Valley Parkway	3697.874	2-72"	RCP	671	HEC-RAS	1030	389.6	477.7
Gambel Ridge North	I-25	1142.626	10' (w) x 8' (h)	RCPA	467	HEC-RAS	1140	333.8	444.2
Gambel Ridge North	Railroad	1289.289	11' (w) x 7' (h)	CMPA	467	HEC-RAS	1140	333.8	444.2
Gambel Ridge	I-25	1706.496	10' (w) x 6' (h)	CBC	650-700	HEC-RAS	1020	901.3	1604.2
Gambel Ridge	Railroad	1830.03	3 - 9' (w) x 6' (h)	CMPA	650-700	HEC-RAS	1020	901.3	1604.2
Gambel Ridge	Clarkes Circle	3943.826	4.5' (w) x 2.8' (h)	CMPA	80	HEC-RAS	1040	580.6	921.2
Gambel Ridge	Twin Oaks Road	4768.087	2 - 4.3' (w) x 3' (h)	CMPA	80	HEC-RAS	1050	530.5	874.3

When the pipe capacity was equal to or greater than the 500-year future flows, the pipe capacity was set to that event.

HEC-RAS was used to determine the capacity of each crossing in the Gambel Ridge and Douglas Lane Tributary watersheds.

Douglas Lane culverts appear to be in good condition and have adequate capacity to convey the 500-year future event. The capacities of the culverts in Gambel Ridge are inadequate to convey the 100-year event and as you can see in Table 4-2 in many cases cannot convey the 10-year event.

4.3 HYDRAULIC PARAMETERS

Hydraulic cross sections were developed using the Town's 2-foot contour interval topographic data supplemented by Town field survey and design and as-built information. The cross sections developed for input into the HEC-RAS model were obtained from the project topographic mapping using Autodesk Civil Design software. All cross sections were stationed left to right looking downstream. Cross section spacing was established to adequately define the drainageway hydraulic conditions along with the floodplain boundary. Cross sections were included in the model at locations of all substantial vertical or horizontal changes in the channel shape, geometry, or slope. In addition, hydraulic cross sections were included near the entrance and exit of all drainage structures.

The following Manning's "n" roughness coefficient parameters used in the hydraulic model were determined based on guidelines in the HEC-RAS Hydraulic Reference Manual and visual inspection during site visits:

	<u>CHANNEL</u>	<u>"n" VALUES</u>	<u>OVERBANKS</u>
Gambel Ridge	0.040-0.045		0.040-0.045
Gambel Ridge North	0.040-0.045		0.040-0.045
Douglas Lane	0.040		0.060

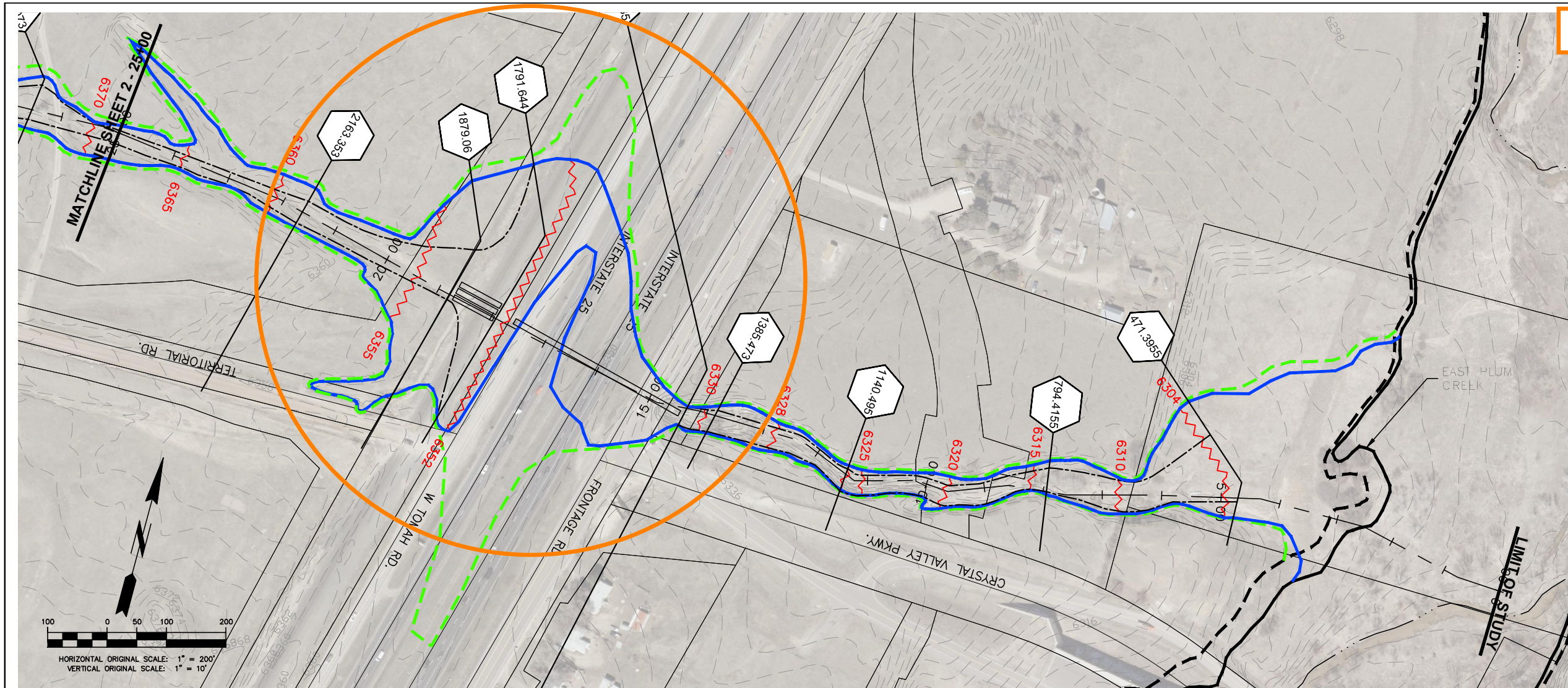
Contraction and expansion coefficients of 0.1 and 0.3 respectively were used for all cross sections except for at the entrance and exit of drainage structures where 0.3 and 0.5 were used. Using the project mapping, the hydraulic length between cross sections was established for the main channel along with the left and right over-banks.

The following photos illustrate our justification on Manning' n values used.

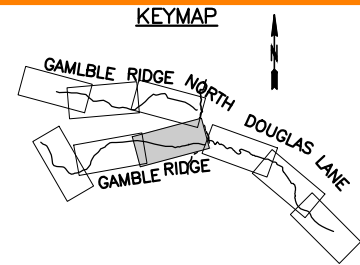
HEC-RAS OUTPUT SUMMARY TABLE											
Gambel Ridge											
River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
471.3955	10-yr	757	6301.3	6302.76	6302.76	6303.13	0.023441	6.01	166.25	210.18	0.93
471.3955	50-yr	1378	6301.3	6303.12	6303.12	6303.66	0.023663	7.12	244.79	219.89	0.97
471.3955	100-yr	1720	6301.3	6303.29	6303.29	6303.91	0.023985	7.64	281.31	223.94	1
471.3955	500-yr	2243	6301.3	6303.54	6303.54	6304.26	0.023104	8.17	338.04	229.88	1
471.3955	Culv Cap	757	6301.3	6302.76	6302.76	6303.13	0.023441	6.01	166.25	210.18	0.93
794.4155	10-yr	757	6309.07	6312.36	6312.36	6313.47	0.019022	9.58	94.76	43.88	0.96
794.4155	50-yr	1378	6309.07	6313.52	6313.52	6314.98	0.01713	11.28	151.31	52.84	0.97
794.4155	100-yr	1720	6309.07	6314.04	6314.04	6315.66	0.016585	11.98	179.58	56.53	0.97
794.4155	500-yr	2243	6309.07	6314.75	6314.75	6316.56	0.015802	12.83	221.52	61.6	0.97
794.4155	Culv Cap	757	6309.07	6312.36	6312.36	6313.47	0.019022	9.58	94.76	43.88	0.96
1140.495	10-yr	757	6320.76	6324.3	6324.3	6325.45	0.016973	9.73	95.52	42.39	0.93
1140.495	50-yr	1378	6320.76	6325.5	6325.5	6327.02	0.015926	11.52	152.3	52.32	0.94
1140.495	100-yr	1720	6320.76	6326.06	6326.06	6327.71	0.015306	12.19	183.06	57.71	0.94
1140.495	500-yr	2243	6320.76	6326.82	6326.82	6328.61	0.014407	12.95	229.46	65	0.94
1140.495	Culv Cap	757	6320.76	6324.3	6324.3	6325.45	0.016973	9.73	95.52	42.39	0.93
1385.473	10-yr	757	6323.27	6327.62		6328.28	0.008222	7.44	122.85	44.65	0.66
1385.473	50-yr	1378	6323.27	6328.9		6329.88	0.00874	9.26	185.32	52.87	0.71
1385.473	100-yr	1720	6323.27	6329.44		6330.58	0.009065	10.07	214.94	56.3	0.74
1385.473	500-yr	2243	6323.27	6330.12		6331.51	0.0097	11.21	254.66	60.58	0.78
1385.473	Culv Cap	757	6323.27	6327.62		6328.28	0.008222	7.44	122.85	44.65	0.66
1434.485	10-yr	708	6324.11	6328.47	6328.47	6329.97	0.023797	9.84	71.94	24.23	1.01
1434.485	50-yr	1286	6324.11	6330.12	6330.12	6331.98	0.022138	10.93	117.7	32.21	1.01
1434.485	100-yr	1604	6324.11	6330.87	6330.87	6332.8	0.021523	11.14	143.94	37.77	1.01
1434.485	500-yr	2092	6324.11	6331.78	6331.78	6333.85	0.020287	11.56	181.26	44.87	1
1434.485	Culv Cap	650	6324.11	6328.27	6328.27	6329.72	0.02415	9.68	67.16	23.48	1.01
1706.496	Culvert										
1791.644	10-yr	708	6342.8	6352.22	6346.3	6352.26	0.000196	1.57	510.29	383.86	0.12
1791.644	50-yr	1286	6342.8	6352.93	6347.51	6352.99	0.000328	2.2	814.01	471.24	0.16
1791.644	100-yr	1604	6342.8	6353.04	6348.02	6353.13	0.000456	2.63	866.49	479.96	0.19
1791.644	500-yr	2092	6342.8	6353.32	6348.71	6353.44	0.000583	3.06	1005.18	500.69	0.21
1791.644	Culv Cap	650	6342.8	6351.82	6346.17	6351.86	0.000218	1.59	409.13	80.74	0.12
1830.031	Culvert										
1879.06	10-yr	708	6344.67	6353.01	6346.89	6353.04	0.000122	1.69	579.72	163.33	0.1
1879.06	50-yr	1286	6344.67	6353.84	6347.85	6353.93	0.000312	2.88	759.64	318.8	0.17
1879.06	100-yr	1604	6344.67	6354.02	6348.3	6354.16	0.000445	3.48	826.91	397.13	0.2
1879.06	500-yr	2092	6344.67	6354.29	6348.91	6354.47	0.000603	4.13	938.01	425.93	0.23
1879.06	Culv Cap	650	6344.67	6352.55	6346.77	6352.58	0.000109	1.54	521.52	98.85	0.1
2163.353	10-yr	708	6354.02	6356.92	6356.92	6357.88	0.015331	9.19	96.85	52.64	0.96
2163.353	50-yr	1286	6354.02	6357.9	6357.9	6359.15	0.01421	10.8	155.42	66.27	0.97
2163.353	100-yr	1604	6354.02	6358.38	6358.38	6359.71	0.013355	11.33	189.53	75.29	0.96
2163.353	500-yr	2092	6354.02	6358.99	6358.99	6360.45	0.012869	12.14	239.06	89.24	0.97
2163.353	Culv Cap	650	6354.02	6356.8	6356.8	6357.72	0.015287	8.93	90.98	51.02	0.95
2652.073	10-yr	708	6369.23	6371.86	6371.86	6372.71	0.016441	8.79	102.5	63.07	0.98
2652.073	50-yr	1286	6369.23	6372.78	6372.78	6373.84	0.014603	10.2	168.52	82.45	0.97
2652.073	100-yr	1604	6369.23	6373.15	6373.15	6374.33	0.014768	10.98	200.97	93.94	0.99
2652.073	500-yr	2092	6369.23	6373.67	6373.67	6374.98	0.014536	11.87	255.51	116.94	1.01
2652.073	Culv Cap	650	6369.23	6371.76	6371.76	6372.57	0.016599	8.58	95.89	61.1	0.98
3000	10-yr	414	6377.69	6379.58	6379.58	6380.21	0.018474	7.45	68.26	55.69	0.98
3000	50-yr	815	6377.69	6380.33	6380.33	6381.2	0.017291	9.11	116.92	74.08	1.01
3000	100-yr	1030	6377.69	6380.7	6380.7	6381.61	0.016074	9.61	146.76	88.02	0.99
3000	500-yr	1361	6377.69	6381.47	6381.47	6382.16	0.011045	9.32	259.31	206.54	0.85
3000	Culv Cap	414	6377.69	6379.58	6379.58	6380.21	0.018474	7.45	68.26	55.69	0.98
3500	10-yr	414	6387.62	6389.49	6389.49	6390.11	0.018446	7.4	68.75	55.94	0.98
3500	50-yr	815	6387.62	6390.24	6390.24	6391.09	0.016832	8.95	115.91	69.62	0.99
3500	100-yr	1030	6387.62	6390.56	6390.56	6391.51	0.016381	9.55	138.98	75.54	1
3500	500-yr	1361	6387.62	6391	6391	6392.07	0.015886	10.37	175.18	87.37	1.01
3500	Culv Cap	414	6387.62	6389.49	6389.49	6390.11	0.018446	7.4	68.75	55.94	0.98

HEC-RAS OUTPUT SUMMARY TABLE											
Gambel Ridge											
River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
3906.503	10-yr	414	6400.38	6402.99	6402.99	6403.62	0.014403	6.75	71.23	61.31	0.87
3906.503	50-yr	815	6400.38	6403.83	6403.83	6404.56	0.01163	7.76	138.25	101.93	0.83
3906.503	100-yr	1030	6400.38	6404.12	6404.12	6404.91	0.011416	8.23	170.82	118.63	0.83
3906.503	500-yr	1361	6400.38	6404.59	6404.59	6405.37	0.010045	8.49	234.14	156.42	0.8
3906.503	Culv Cap	414	6400.38	6402.99	6402.99	6403.62	0.014403	6.75	71.23	61.31	0.87
3943.826	Culvert										
3996.147	10-yr	414	6400.59	6405.88	6403.6	6405.95	0.000827	2.39	222.47	151.41	0.23
3996.147	50-yr	815	6400.59	6406.4	6404.66	6406.56	0.001553	3.6	310.35	184.14	0.32
3996.147	100-yr	1030	6400.59	6406.62	6405.43	6406.82	0.00184	4.07	353.12	195.47	0.35
3996.147	500-yr	1361	6400.59	6406.93	6405.87	6407.17	0.002194	4.65	413.92	208.69	0.39
3996.147	Culv Cap	414	6400.59	6405.88	6403.6	6405.95	0.000827	2.39	222.47	151.41	0.23
4428.602	10-yr	383	6415.07	6416.27	6416.27	6416.62	0.021633	6.07	85.83	123.33	0.99
4428.602	50-yr	733	6415.07	6416.67	6416.67	6417.14	0.021183	7.28	139.84	153.53	1.03
4428.602	100-yr	921	6415.07	6416.85	6416.85	6417.36	0.020215	7.65	169.22	169.24	1.02
4428.602	500-yr	1212	6415.07	6417.09	6417.09	6417.65	0.019491	8.19	212.97	193.61	1.02
4428.602	Culv Cap	80	6415.07	6415.69	6415.69	6415.86	0.022653	3.93	26.61	79.4	0.9
4711.959	10-yr	383	6419.43	6421.77	6421.77	6422.57	0.017935	7.18	54.58	39.72	0.95
4711.959	50-yr	733	6419.43	6422.83	6422.83	6423.58	0.010162	7.4	122.55	88.6	0.78
4711.959	100-yr	921	6419.43	6423.12	6423.12	6423.93	0.010146	7.89	149.33	98.07	0.79
4711.959	500-yr	1212	6419.43	6423.39	6423.39	6424.4	0.01181	8.99	177.23	109.36	0.86
4711.959	Culv Cap	80	6419.43	6420.57	6420.38	6420.82	0.013474	3.97	20.17	22.6	0.74
4768.087	Culvert										
4822.813	10-yr	373	6420.5	6424.27	6422.85	6424.47	0.0029	3.6	114.34	99.11	0.4
4822.813	50-yr	698	6420.5	6425.4	6423.75	6425.55	0.001742	3.44	270.78	178.91	0.33
4822.813	100-yr	874	6420.5	6425.77	6424.59	6425.92	0.001605	3.54	343.32	211.3	0.32
4822.813	500-yr	1148	6420.5	6426.18	6424.93	6426.33	0.001576	3.76	434.82	237.32	0.32
4822.813	Culv Cap	80	6420.5	6421.74	6421.46	6421.96	0.010498	3.72	21.51	21.95	0.66
5154.495	10-yr	373	6428.9	6430.42	6430.42	6430.92	0.02023	6.78	68.54	68.75	0.99
5154.495	50-yr	698	6428.9	6430.96	6430.96	6431.65	0.018568	8.04	109.22	80.11	1
5154.495	100-yr	874	6428.9	6431.19	6431.19	6431.97	0.018259	8.57	128.27	84.18	1.01
5154.495	500-yr	1148	6428.9	6431.54	6431.54	6432.41	0.01711	9.14	158.39	89.93	1
5154.495	Culv Cap	80	6428.9	6429.62	6429.62	6429.85	0.025498	4.47	21.51	46.42	0.97
5483.639	10-yr	373	6441.54	6442.6	6442.6	6442.98	0.024034	5.98	77.59	104.17	1.02
5483.639	50-yr	698	6441.54	6443.01	6443.01	6443.53	0.021611	7.05	123.59	119.99	1.03
5483.639	100-yr	874	6441.54	6443.19	6443.19	6443.78	0.021219	7.54	145.4	126.79	1.04
5483.639	500-yr	1148	6441.54	6443.45	6443.45	6444.11	0.020156	8.09	179.16	136.59	1.03
5483.639	Culv Cap	80	6441.54	6442.03	6442.03	6442.2	0.028947	3.91	25.6	76.71	0.99
5983.639	10-yr	35	6459.05	6459.63	6459.63	6459.83	0.028101	3.76	10.12	26.6	0.97
5983.639	50-yr	89	6459.05	6459.99	6459.99	6460.3	0.022197	4.88	21.07	34.61	0.94
5983.639	100-yr	117	6459.05	6460.12	6460.12	6460.48	0.021942	5.33	25.57	36.83	0.96
5983.639	500-yr	158	6459.05	6460.3	6460.3	6460.71	0.020337	5.75	32.39	39.98	0.95
5983.639	Culv Cap	35	6459.05	6459.63	6459.63	6459.83	0.028101	3.76	10.12	26.6	0.97
6483.639	10-yr	35	6476.88	6477.41	6477.41	6477.58	0.026667	3.62	11.3	34.12	0.94
6483.639	50-yr	89	6476.88	6477.71	6477.71	6477.97	0.022806	4.67	23.12	44.32	0.94
6483.639	100-yr	117	6476.88	6477.82	6477.82	6478.12	0.02228	5.06	28.24	47.29	0.96
6483.639	500-yr	158	6476.88	6477.97	6477.97	6478.31	0.021237	5.48	35.5	51.2	0.96
6483.639	Culv Cap	35	6476.88	6477.41	6477.41	6477.58	0.026667	3.62	11.3	34.12	0.94
6983.639	10-yr	35	6493.33	6493.7	6493.7	6493.81	0.029956	3.17	13.68	58.12	0.95
6983.639	50-yr	89	6493.33	6493.9	6493.9	6494.08	0.027662	4.15	27.23	74.65	0.99
6983.639	100-yr	117	6493.33	6493.99	6493.99	6494.19	0.026173	4.43	33.74	80.98	0.98
6983.639	500-yr	158	6493.33	6494.09	6494.09	6494.32	0.025339	4.81	42.24	88.15	0.99
6983.639	Culv Cap	35	6493.33	6493.7	6493.7	6493.81	0.029956	3.17	13.68	58.12	0.95

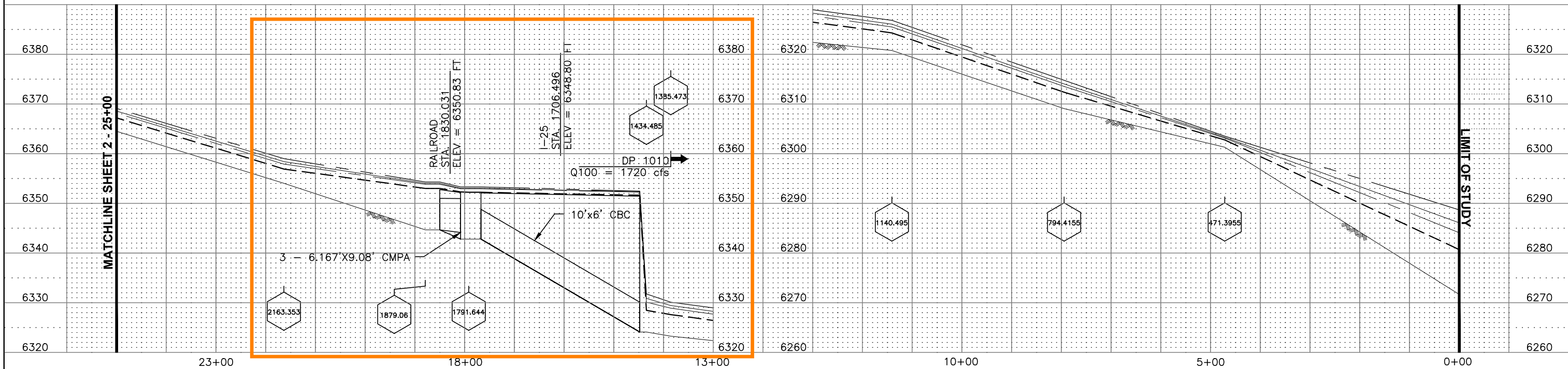
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PLOT DATE: Jul 25, 2014 1:12pm



Reference F - p79

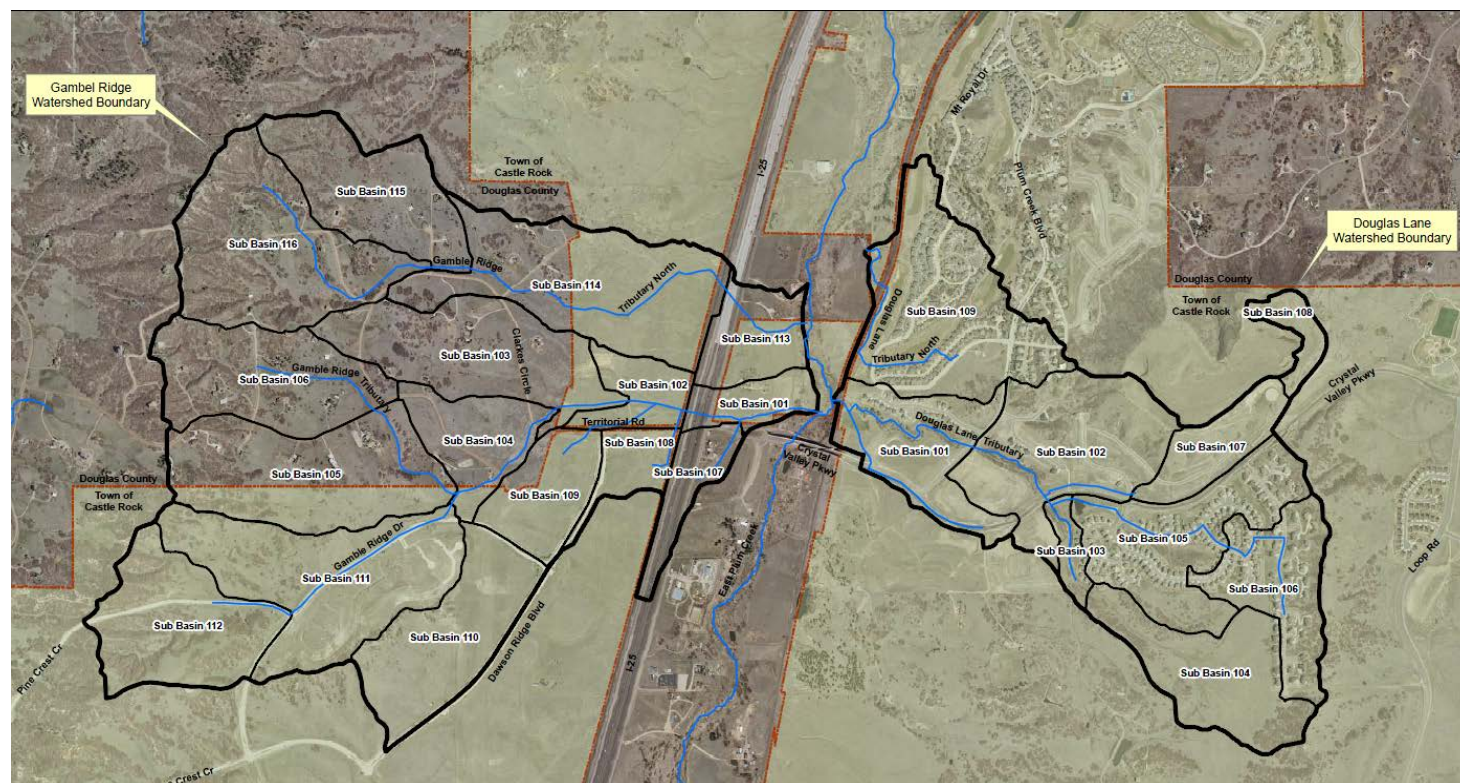


PLAN LEGEND	
	CROSS SECTION
	100-YEAR FLOODPLAIN
	500-YEAR FLOODPLAIN
	FLOODWAY
	BFE
	EXISTING CONTOURS
PROFILE LEGEND	
	CROSS SECTION
	500-YEAR FLOODPLAIN
	100-YEAR FLOODPLAIN
	50-YEAR FLOODPLAIN
	10-YEAR FLOODPLAIN
	EXISTING GROUND



				DESIGNED <u>WPF</u> DATE <u>7/8/13</u>	 <div>720 S. COLORADO BLVD. SUITE 410S DENVER, CO 80246 PH: (303) 757-3655</div>	 <div>TOWN OF CASTLE ROCK COLORADO</div>	TOWN OF CASTLE ROCK	GAMBEL RIDGE FLOOD HAZARD AREA DELINEATION	PLAN AND PROFILE 0+00 TO 25+00	FIGURE 1 OF 6
			DRAWN <u>ACT</u> DATE <u>7/8/13</u>							
			CHECKED <u>RCO</u> DATE <u>7/8/13</u>							
NO.	DATE	DESCRIPTION	BY	PROJECT NO. _____						

GAMBEL RIDGE AND DOUGLAS LANE TRIBUTARY WATERSHEDS MASTER PLAN



Project Sponsor:



TOWN OF CASTLE ROCK

Prepared by:



July 2014

720 South Colorado Boulevard
Suite 410 S
Denver, Colorado 80246
phone (303) 757-3655
fax (303) 300-1635

1. PLEASE SEE ALTERNATIVES PLAN COVER SHEET FOR LEGEND AND GENERAL NOTES.
2. SEE DETAIL SHEET FOR ENGINEERED CHANNEL GEOMETRY AND DROPS DETAILS.
3. BUFFER ZONE AREA SHOWN IS DEFINED BY A 20' OFFSET OF THE 100-YEAR FLOODPLAIN BOUNDARY.
4. PROPOSED ALIGNMENT AS SHOWN HAS THE LEAST AMOUNT OF IMPACT. FINAL CHANNEL ALIGNMENT WILL BE DETERMINED BASED ON FUTURE ZONING DEVELOPMENT AND MAY CHANGE FROM SHOWN.

Project Limits

REACH 1 - PRIORITY 2
ENGINEERED CHANNEL-A (SEE NOTE 2, 4)
(PROPOSED)
L = 1410 FEET
6 GROUDED SLOPING BOULDER
DROP STRUCTURES 5 FEET HIGH (PROPOSED)
DP1010, Q100 (ALT1) = 1720 CFS
Q100 (ALT1) = 702 CFS

REACH 1 - PRIORITY 1
REMOVE DEBRIS IN EXISTING CHANNEL

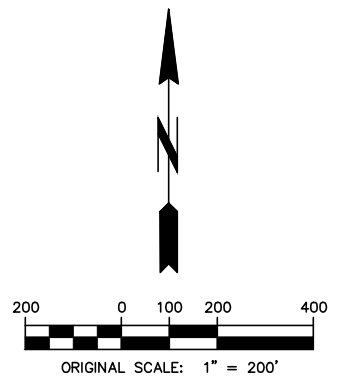
REACH 3 - PRIORITY 2
ENGINEERED CHANNEL-C (1)
L = 250 FEET (PROPOSED)
ROW = 27 FEET

REACH 2
NO IMPROVEMENTS REQUIRED
10'x6' CBC (EXISTING)
CAPACITY 650-700 CFS
3-9'x6' CMPA (EXISTING)
CAPACITY 650-700 CFS
DP1020, Q100 (FUT) = 1604 CFS
Q100 (ALT 1) = 630 CFS

REACH 4 - PRIORITY 1
14'X6' CBC (PROPOSED)
L = 50 FEET
DP1050, Q100 (FUT) = 874 CFS

REACH 3 - PRIORITY 1
PROPOSED ON-LINE FULL SPECTRUM
SUBREGIONAL DETENTION POND
ROAD OVERTOPPING (EXISTING)
72" RCP OUTLET STRUCTURE (PROPOSED)
L = 100 FEET
V100 = 13.4 ACRE- FEET (PROPOSED)
APPROXIMATE SURFACE AREA = 2.0 ACRE
DEPTH = 8 FEET
DP1090, Q100 (FUT) = 469 CFS
QOUT (ALT1) = 180 CFS

No improvements to BNSF/I-25 crossing identified in master plan; existing capacity remains



				DESIGNED <u>WPF</u> DATE <u>7/8/13</u>	 720 S. COLORADO BLVD. SUITE 410S DENVER, CO 80246 PH: (303) 757-3655	 TOWN OF CASTLE ROCK	GAMBEL RIDGE	ES-3 ALTERNATIVE 1 TWO DETENTION PONDS (RECOMMENDED IMPROVEMENT)	FIGURE 1 OF 1
				DRAWN <u>ACT</u> DATE <u>7/8/13</u>					
				CHECKED <u>RCO</u> DATE <u>7/8/13</u>					
NO.	DATE	DESCRIPTION	BY	PROJECT NO. _____					

NAME: Z:\Castle Rock\TCR Planning Studies\CAD\Dwg-Alternatives\Gambel Ridge Alternatives.dwg
PLOT DATE: Jul 28, 2014 11:15am



Crystal Valley Interchange Project
Package 2:
Phase III Drainage Report
NHPP M185-016
CIP23-0004
October 2023

Prepare For:
Town of Castle Rock – Public Works
4175 North Castleton Court
Castle Rock, Colorado 80104

Prepared By:
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Denver, Colorado 80111
T +1 719.477.4942

Contact:
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2. Drainage Basins and Sub-Basins

2.1 Major Drainage Basins

The major drainage basins in the Project limits are rural and mostly undeveloped. The existing drainage pattern generally runs west to east and existing flow is conveyed by ditches and drainage structures until it is ultimately discharged into East Plum Creek. Existing drainage patterns will remain largely unchanged in the proposed condition. Existing drainage patterns will remain the same in the proposed condition and will not be altered as a part of this project.

The existing Gambel Ridge Drainageway flows through the project west of I-25 and to the existing triple barrel Corrugated Metal Pipe - Arch (CMPA) culvert under the railroad. The triple barrel CMPA is used as the downstream design point for the portion of the project West of I-25. Gambel Ridge then is conveyed under I-25 and to the Package 1 portion of the project through the existing 10' x 6' CBC under I-25. See **Appendix A** for the Drainage Basin Map. At the west end of Package 2, the Gambel Ridge Drainageway will flow through a proposed 12' x 6' CBC under the proposed Dawson Trails Boulevard. Gambel Ridge Drainageway will be improved with the proposed drop structures and stable slope described in the *Gambel Ridge and Douglas Lane Tributary Watersheds Master Plan*. The existing downstream end of Gambel Ridge Drainageway East of I-25 was re-aligned in Package 1 with proposed drop structures and stable slope as described in the *Gambel Ridge and Douglas Lane Tributary Watersheds Master Plan*.

East Plum Creek is located in the Package 1 area of the project and is a designated FEMA Flood Zone AE floodplain and runs parallel to the project on the east side of I-25. See **Appendix A** for FEMA FIRM Map Number 08035C0303G, revision date March 16, 2016, and Map Number 08035C0284G, revision date March 16, 2016.

2.2 Regional Major Basins

The CVI Package 2 project is located at the downstream end of the future development to the west of I-25. Based on the discussion with the Town, the Package 2 drainage system has been designed to accommodate the drainage flows from future development. The project team has coordinated with the development team and the Town to determine the type of development planned and the approach to detention and water quality requirements. The Developer and CORE Consultants have provided anticipated flow rates from the future development based on the planned development used in this design. To identify the flows coming from the future development to CVI Package 2 project, CORE Consultants prepared a Gambel Ridge Tributary Regional Basin Map (which includes the overall future development drainage basins), analyzed the proposed condition in SWMM, and determined overall site discharge at the upstream end of the triple barrel culvert under the railroad to ensure flow rates do not exceed the culvert capacity or the *Gambel Ridge and Douglas Lane Tributary Watersheds Master Plan*. See **Appendix A** for Regional Proposed Drainage Basin Map prepared by CORE Consultants for the major drainage basin which includes the overall future development drainage basins. The proposed developed conditions were analyzed by CORE Consultants using SWMM to determine the overall site discharge at the upstream of the existing culvert under the railroad. The proposed development includes additional detention ponds upstream of the project to meet the detention and water quality requirement of the development. Based on the information provided by CORE Consultants, the maximum existing flow at the design point (upstream end of the existing triple barrel CMPA culvert under the railroad) is 570.61 cfs. The proposed flows at that same point will be equal to or less than the existing as described in this report.

To maintain maximum allowable flow at the existing culvert under the railroad, a full spectrum detention pond, referred to as "West Pond", is proposed at the SE corner of the project. CORE Consultants are designing other detention ponds upstream of the project as part of the development project. The West Pond is sized to accommodate flows at the ultimate future condition (post-development) and requires approximately 7 acres of land at the top of the berm. See **Appendix A** for the overall proposed pond

Crystal Valley Interchange: Phase III Drainage Report

footprint. Since the West Pond is sized for the ultimate future conditions and works in conjunction with other ponds in the development, the total watershed area and % imperviousness of the development area to size the pond were provided by CORE Consultants. A total watershed area of 185.18 acres with 76.90% imperviousness was used to size the West Pond. Note that the total CVI Package 2 proposed drainage basin area west of I-25 of 28.4 acres is included within the total watershed area used to size the West Pond.

The developer will be responsible for any changes to the development plan including changes to development densities or approach to meeting the water quality and detention requirements that would result in changes to flow rates provided during the project design. This may include additional FSD Ponds or modification to the pond constructed by this project west of I-25 to ensure the flow rate at the existing culvert under the railroad does not increase.

2.3 Minor Drainage Basins

Minor drainage basins were delineated using existing and proposed topography. The overall existing drainage patterns will remain the same; however, new storm drainage structures will be sized and placed to accommodate proposed roadway modifications.

Regional Minor Basins

CORE Consultants provided a Regional Proposed Drainage Basin Map (**Appendix A**), which states the maximum existing flow through the existing triple barrel CMPA culvert under the railroad was 570.61 cfs. The Regional Proposed Drainage Basin Map (**Appendix A**) was prepared by CORE Consultants, which includes future proposed sub-basins and is only used to size West Pond within the CVI Package 2 project. In the Overall Proposed Gambel Ridge Pond Analysis Basin Map provided by CORE Consultants, Pond C1 (called West Pond in the CVI project) accepts flow from the future proposed sub-basins. Basin areas from Basin C-1 to Basin C-6 were used to size Pond C1. The detention for future private Water Quality (WQ) Pond located west of north DTB is also added to Pond C1. Therefore, Basin C-7 was added to the tributary area to size Pond C1. Flows from basins C-1 & C-2, and C-3 will be conveyed to Pond C1 through a future proposed open channel. Basin C-4, C-5, and C-6 will carry flows from future proposed roadways/development and will be conveyed to Pond C1 through the proposed underground storm sewer system, which will be tied into the proposed storm sewer system within the CVI Package 2 project. All flows at tie-in points coming to the CVI Project were provided by CORE Consultants and used for the analysis.

CVI Project Minor Basins

The proposed construction area has been split into minor basins as identified in the Basin Map (**Appendix A**). Stormwater generated in the project will be collected and conveyed to FSD ponds or sand filter basins located south of the proposed Crystal Valley Parkway and southbound ramps before outfalling to Gambel Ridge and ultimately into East Plum Creek.

See **Appendix A** for the Drainage Basin Map.

Crystal Valley Interchange: Phase III Drainage Report

exceed 12-inches for the major storm. Bentley's OpenRoads Drainage and Utilities and Autodesk Storm & Sanitary Sewer Analysis were used for hydraulic analysis of allowable street flow. See **Appendix B** for analysis.

Per Table EBD-4 from Urban Storm Drainage Criteria Manual (USDCM) Volume 3, Pond Forebays were designed to release 2% of undetained 100-year peak discharge using a rectangular notch. The minimum forebay volume was designed to be 3% of the Water Quality Capture Volume (WQCV). See **Appendix B** for forebay and trickle channel calculations.

The ponds were designed with 4:1 side slopes and maintenance access as outlined in Section 13.6 of the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual.

At the Town's direction, the West Pond outlet pipe was designed to carry approximately 345 cfs (3 times the release rate from West Pond), and riprap outlet erosion protection was designed to carry 345 cfs, which is more than a 100-year storm coming from the outlet pipe. MHFD-Culvert_v4.0 spreadsheet was used to design the length and width of riprap outfall protection. However, the calculations show the Type of Riprap is very large and requires excessive excavation due to the large amount of flow coming from the outfall pipe. The CM/GC project delivery approach was leveraged to gain input from both the Town and the Contractor to provide a functional and constructable outfall. After discussion with the CM/GC Team, it is determined that use of the same 36" In-Channel Grouted Boulders used for the Gambel Ridge drop structures is sufficient to handle 345 cfs and is proposed as outfall protection and protection for the opposite channel bank. Additionally, a concrete headwall with wing walls was designed at the downstream end of the 84" RCP pond outfall pipe as per CDOT Standard Detail M-601-10 and M-601-20. See **Appendix B** for analysis of outfall pipe and riprap protection calculations.

4.2 Stormwater Storage Facilities and Water Quality Enhancement Control Measures

The FSD ponds outfall to Gambel Ridge and into East Plum Creek. The ponds are designed with 4:1 side slopes and maintenance access as outlined in Section 13.6 of the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual.

MHFD's UD-Detention was used to design the FSD pond, including the outlet structure design and emergency spillway design, based on the 100-year storm event and a 40-hour drain time. The pond has been designed with a minimum freeboard of 1 foot measured from the 100-year water surface elevation to the top of the embankment.

The ponds were designed to detain the 100-year storm event for 40 hours; therefore, there is no need for a water right exemption.

The West Pond was developed to meet additional requirements by the Town and is sized for the Project as well as the ultimate future conditions in the upstream development, CORE Consultants provided the overall watershed area with the percent imperviousness required to design the west pond based on the planned development approach. The provided total watershed area of 185.18 acres with 76.90% imperviousness was used to size the west pond. This total watershed area includes CVI Package 2 project and planned future development sites. Based on Storm Water Management Model (SWMM) analysis performed by CORE Consultants to develop the water quality and detention approach of the development, a maximum allowable release rate of 115 cfs was used for west pond. This flow, combined with the Gambel Ridge Drainageway flows, will not increase the flowrate at the design point (upstream end of the existing culvert under the railroad) from the predeveloped conditions. As directed by the Town, the west pond was sized to handle flows in addition to 100-year storm event. A total of 3.32 acre-feet of extra storage was provided to mitigate flooding after 100-year storm events. A third chamber was also designed in the outlet structure to provide an additional flow path, without engaging the spillway, for storm events beyond the 100-year storm. As part of the planned development approach upstream of the Project, the west pond was sized to include the required detention for parcels planned to treat water quality only at developed parcel site. The detention requirements for those parcels have been captured by the west pond.

Crystal Valley Interchange: Phase III Drainage Report

A future Collector B Road is proposed by CORE Consultants east of the west pond where the west pond emergency spillway is located. The town has concerns regarding emergency flows coming from west pond and outfalls directly to future Collector B Road, causing inundation on Collector B Road in an emergency storm. To mitigate inundation on future Collector B Road, west pond was oversized by 3.32 acre-feet to accommodate flows of more than 100-year storm events, and an extra third chamber was added to the outlet structure as described below as described previously. Additionally, the minimum requirement of a 1-foot freeboard at the emergency spillway was reduced to 6 inches to detain more water in west pond. Therefore, a freeboard variance is required for the pond and spillway. The goal of these accommodations was to direct more water through the west pond's outlet structure, not from the emergency spillway, to mitigate the inundation on future Collector B Road.

To reduce the possible inundation of future Collector B Road, the third chamber at west pond the outlet structure was designed to carry additional flows beyond a 100-year storm event without engaging the emergency spillway. First, a 100-year water surface elevation was calculated for the pond under normal analysis conditions, and the third chamber's rim was set to this elevation. Then, a second water surface elevation was calculated for the 100-year storm assuming the second chamber (traditional outlet structure inlet box) was in 100% clogged condition. The crest of the emergency spillway was set above that second elevation. The third chamber was designed to carry this additional storage between the second chamber and the spillway crest. This additional water depth between the top of the second chamber and the spillway crest was 0.57 feet. The second water surface elevation was also used to calculate the discharge going through the third chamber (assumed 25% clogging through the third chamber grate) using the orifice flow equation. The flow through the third chamber was calculated to be 229 cfs, and the total flow through the second (restrictor plate) and third chambers combined was calculated to be 344 cfs which is approximately three times the restricted outflow (115 cfs) from the second chamber.

As noted above, the West pond outfall pipe is designed to handle a discharge of three times the 100-year restricted release rate (115 cfs) from the outlet structure. An 84" Reinforced Concrete Pipe (RCP) outfall pipe was designed and will convey 411.50 cfs. This flow includes 115 cfs restricted flow from the second chamber of the outlet structure and the additional flow captured by the third chamber in excess of a 100-year storm event. The outfall pipe was oversized to allow future maintenance such as slip-lining in the future and still provide the 345 cfs requested. It was determined that the pipe's maximum flow rate would be 351 cfs after potential future slip lining.

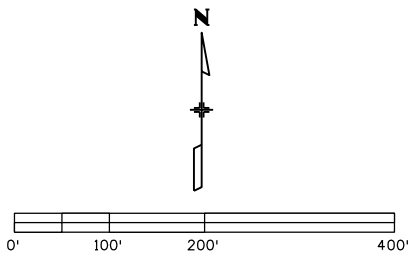
A variance will be required for the West Pond freeboard. A freeboard of 0.5' is provided and required to meet the constraints and additional requirements.

Release rates, storage volumes, and water surface elevations can be found in the UD-Detention worksheets included in **Appendix B**.

4.3 Floodplain Modification

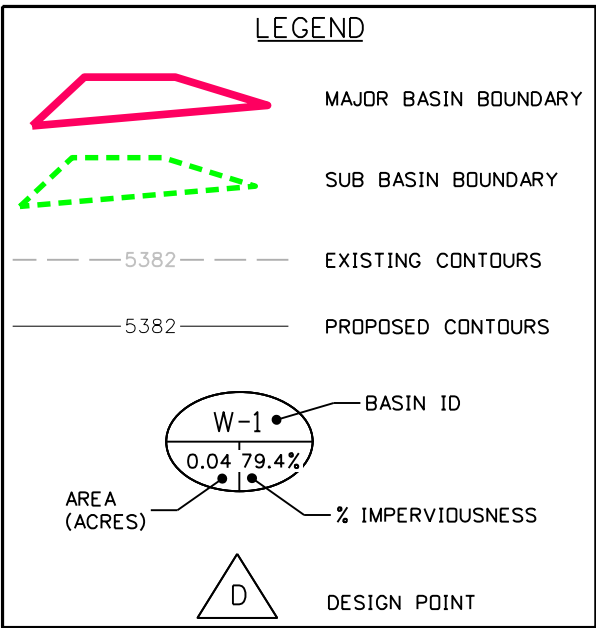
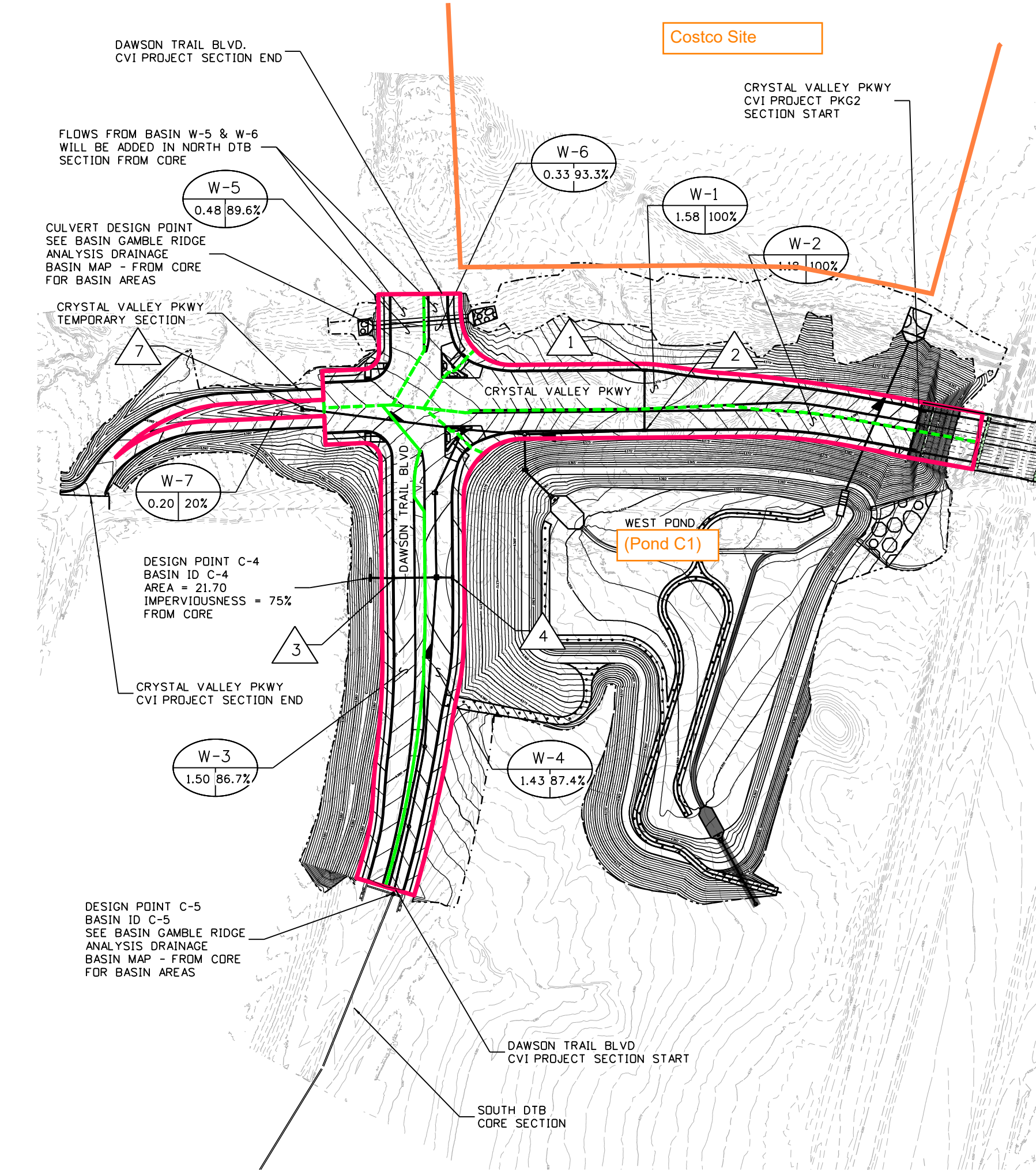
A Town of Castle Rock Floodplain Development Permit is required for the Gambel Ridge Tributary modifications, which includes realigning the stretch of Gambel Ridge from the railroad ROW upstream to Dawson Trails Blvd. The HEC-RAS analysis includes a future 2 cell 13'x5' CBC to be constructed near the railroad ROW as part of the development to provide access across Gambel Ridge. The proposed improvements also include grouted boulder drop structures to achieve the stable slope described in the Master Plan. The lower section of Gambel Ridge improvements East of I-25 will take place in Package 1 of the project.

The portion of Gambel Ridge in Package 1 East of I-25 is eroded with deep channel walls as it flows to East Plum Creek. The existing channel West of I-25 has experienced less erosion than the downstream section. The proposed improvements will contain the Gambel Ridge Drainageway within a confined channel, and the grouted drop structures will help stabilize the channel by establishing the stable slope and reducing water velocity to limit erosion.



NOTES

1. ALL PROPOSED BASIN & FLOWS AT ROAD TIE IN POINTS ARE TAKEN FROM GAMBLE RIDGE ANALYSIS DRAINAGE MAP PROVIDED BY CORE CONSULTANT.



hbbise 4/24/23, PM 0:00:00, Jacobs-US-V-A-PW-Bentley.com:jacobs-us-v-a-pw-02-Documents\WXZ8300 - Crystal Valley Interchange\NHPP M185-016-24262\4. Delivery\Project_WIP\Package 2\Hydraulics (Shrewsberry)\Drawings\Reference_Files\24262-HYD-DRNBASIN01-PKG2-SHR.dgn

Print Date: 9/28/2023	
File Name: 24262_HYD-DRNBASIN01_PKG2_SHR.dgn	
Horiz. Scale: 1:202.181	Vert. Scale: As Noted
Unit Information	Unit Leader Initials

	PUBLIC WORKS DEPT.
	4175 NORTH CASTLETON CT.
	CASTLE ROCK, CO 80109
	PHONE 303 660-1020 FAX 303 660-1025

CRYSTAL VALLEY INTERCHANGE PACKAGE 2 PROPOSED DRAINAGE BASIN MAP	Project No./Code
	NHPP M185-0116
	25846
	Exhibit Number 01

PRLIMINARY DESIGN - NOT FOR CONSTRUCTION

Reference I - p121

Appendix B.5c

Basin ID: Public Regional Extended Detention Basin C-1



Location for 1-hr Rainfall Depths = User Input

Optional User Overrides

Define Zones and Basin Geometry

Initial Surcharge Area (A_{SV})	=	user	ft ²
Surcharge Volume Length (L_{SV})	=	user	ft
Surcharge Volume Width (W_{SV})	=	user	ft
Depth of Basin Floor ($H_{1,LOC}$)	=	user	ft
Length of Basin Floor ($L_{1,LOC}$)	=	user	ft
Width of Basin Floor ($W_{1,LOC}$)	=	user	ft
Area of Basin Floor ($A_{1,LOC}$)	=	user	ft ²
Volume of Basin Floor ($V_{1,LOC}$)	=	user	ft ³
Depth of Main Basin (H_{MA})	=	user	ft
Length of Main Basin (L_{MA})	=	user	ft
Width of Main Basin (W_{MA})	=	user	ft
Area of Main Basin (A_{MA})	=	user	ft ²
Volume of Main Basin (V_{MA})	=	user	ft ³
Calculated Total Basin Volume (V_{TBA})	=	user	acre-feet

2_EDB C1 - MHFD-Detention v4-06 SHR Trial 9 New Iteration 71 feet Spillway.xlsm, Basin

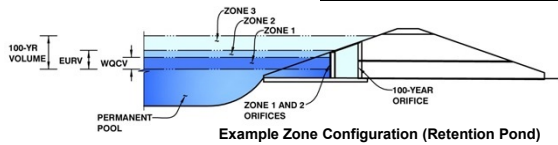
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DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: CVI Package 2 - West of I-25

Basin ID: Public Regional Extended Detention Basin C-1



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.67	4.783	Orifice Plate
Zone 2 (EURV)	6.02	10.135	Orifice Plate
Zone 3 (100+1/2WQCV)	8.26	11.894	Weir&Pipe (Restrict)
Total (all zones)		26.811	

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

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
 Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain
 Underdrain Orifice Area = ft²
 Underdrain Orifice Centroid = feet

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

Centroid of Lowest Orifice = ft (relative to basin bottom at Stage = 0 ft)
 Depth at top of Zone using Orifice Plate = ft (relative to basin bottom at Stage = 0 ft)
 Orifice Plate: Orifice Vertical Spacing = inches
 Orifice Plate: Orifice Area per Row = sq. inches

Calculated Parameters for Plate
 WQ Orifice Area per Row = ft²
 Elliptical Half-Width = feet
 Elliptical Slot Centroid = feet
 Elliptical Slot Area = ft²

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	2.01	4.01					
Orifice Area (sq. inches)	20.55	20.55	42.60					

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

User Input: Vertical Orifice (Circular or Rectangular)

Invert of Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
 Depth at top of Zone using Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
 Vertical Orifice Diameter = inches

Calculated Parameters for Vertical Orifice
 Vertical Orifice Area = ft²
 Vertical Orifice Centroid = feet

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

Overflow Weir Front Edge Height, H_o = ft (relative to basin bottom at Stage = 0 ft)
 Overflow Weir Front Edge Length = feet
 Overflow Weir Grate Slope = H:V
 Horiz. Length of Weir Sides = feet
 Overflow Grate Type =
 Debris Clogging % = %

Calculated Parameters for Overflow Weir
 Height of Grate Upper Edge, H_u = feet
 Overflow Weir Slope Length = feet
 Grate Open Area / 100-yr Orifice Area =
 Overflow Grate Open Area w/o Debris = ft²
 Overflow Grate Open Area w/ Debris = ft²

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

Depth to Invert of Outlet Pipe = ft (distance below basin bottom at Stage = 0 ft)
 Outlet Pipe Diameter = inches
 Restrictor Plate Height Above Pipe Invert = inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate
 Outlet Orifice Area = ft²
 Outlet Orifice Centroid = feet
 Half-Central Angle of Restrictor Plate on Pipe = radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage = ft (relative to basin bottom at Stage = 0 ft)
 Spillway Crest Length = feet
 Spillway End Slopes = H:V
 Freeboard above Max Water Surface = feet

Calculated Parameters for Spillway
 Spillway Design Flow Depth = feet
 Stage at Top of Freeboard = feet
 Basin Area at Top of Freeboard = acres
 Basin Volume at Top of Freeboard = acre-ft

Routed Hydrograph Results

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

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period	N/A	N/A	1.06	1.43	1.66	1.69	2.26	2.60	3.14
One-Hour Rainfall Depth (in)	N/A	N/A	1.06	1.43	1.66	1.69	2.26	2.60	3.14
CUHP Runoff Volume (acre-ft)	4.783	14.917	12.378	18.026	21.644	22.485	31.745	37.598	46.569
Inflow Hydrograph Volume (acre-ft)	N/A	N/A	12.378	18.026	21.644	22.485	31.745	37.598	46.569
CUHP Predevelopment Peak Q (cfs)	N/A	N/A	5.4	45.5	70.5	98.1	177.4	233.8	312.1
OPTIONAL Override Predevelopment Peak Q (cfs)	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre)	N/A	N/A	0.03	0.25	0.38	0.53	0.96	1.26	1.69
Peak Inflow Q (cfs)	N/A	N/A	201.0	293.3	346.1	370.5	525.9	620.9	765.9
Peak Outflow Q (cfs)	2.2	5.1	4.5	8.7	21.7	24.9	74.1	115.0	172.1
Ratio Peak Outflow to Predevelopment Q	N/A	N/A	N/A	0.2	0.3	0.3	0.4	0.5	0.6
Structure Controlling Flow	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps)	N/A	N/A	N/A	0.0	0.1	0.1	0.5	0.8	0.8
Max Velocity through Grate 2 (fps)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours)	38	67	62	72	73	73	70	69	67
Time to Drain 99% of Inflow Volume (hours)	40	71	66	78	79	79	79	78	78
Maximum Ponding Depth (ft)	3.67	6.02	5.36	6.43	6.95	7.04	8.00	8.65	9.60
Area at Maximum Ponding Depth (acres)	3.24	5.06	4.75	5.15	5.27	5.29	5.50	5.65	5.88
Maximum Volume Stored (acre-ft)	4.806	14.920	11.671	17.013	19.722	20.196	25.375	28.945	34.422

Storage and Release Rate
 parameters coordinated
 with 04/19/2023
 Correspondence between
 CORE and Jacobs

CVI - Package 2

8/10/2023

West Pond Analysis Results

	New Iteration
Watershed Area (acres)	185.18
% Imperviousness	76.90
100 Year Inflow (cfs)	620.90
Release Rate (cfs)	115.00
Total 100-Year Detention Volume Required with restriction (acre-feet)	28.945
Total Detention Volume Provided (acre-feet)	32.263
Extra Storage Provided (acre-feet)	3.318
RCP Outfall Pipe Size (inches)	84.00
Emergency Spillway Crest Elevation (ft)	6360.22
Emergency Spillway Length (ft)	71.00
Spillway Freeboard Used (ft) - See Note 4	0.50
Minimum depth required for the spillway (including freeboard) based on inflow	1.78
100 Year WSEL stage (ft)	8.65
WSEL at 100% clogging factor (required spillway invert stage)	9.08
Provided spillway invert stage (ft)	9.22
Extra-depth provided between crest of spillway & top of third chamber (ft)	0.57
Extra-depth between crest of spillway & top of third chamber (inches)	6.84
Third chamber size (B feet x W feet)	12 x 10
Outfall pipe capacity at 100 yr storm requested by Town (cfs)	345.00
Third chamber inflow calculated using Orifice Discharge Equation - See Note 5 & Reference	229.02
Total incoming flow in outfall pipe from 3rd chamber & restriction plate	344.02
Outfall Pipe (84" RCP) Capacity Provided - Includes 115 cfs restricted flow (cfs) - See Note 7	411.50
Slip-Lined Outfall Pipe Capacity (76") Provided - Includes 115 cfs restricted flow (cfs) - See Note 6 & 7	396.96

Notes:

1. Overall pond grading/footprint remained same based on a meeting with Jacobs/Developer/Town/CORE on April 17th.
2. Pond Top Elevation = 6362.00
3. Pond Bottom Elevation = 6351.00
4. Need variance from Town for 0.5 feet freeboard requirement
5. Assumed 25% Clogging, 0.7 open area factor for 3rd chamber
6. Assumed 2" (1" walls) of slip lining for the pipe
7. Outfall pipe analysis performed in HY-8 for the pressure condition flow using depth (9.22) above 3rd chamber

PHASE III DRAINAGE REPORT FOR

DAWSON TRAILS INFRASTRUCTURE 1
TOWN OF CASTLE ROCK, COLORADO
PROJECT NO. 23-00XX

Prepared for:

ACM Dawson Trails JV LLC
4100 Mississippi Ave, Ste 500
Glendale, CO 80246
Contact: Lawrence Jacobson
Phone: 303-984-9800

Prepared by:



CORE Consultants, Inc.
3473 South Broadway
Englewood, CO 80113
Contact: Joseph Ferris, PE
Phone: 303-730-5975
CORE Project Number: 20-224

October 13, 2023

development parcel, with a specific anticipation of commercial oriented use. The area is assigned a build-out imperviousness of 75% for hydrologic analysis. This basin is tributary to the Regional Pond C1 and has been accounted for in its sizing.

Basin C-5 (24.2 acres | 80% Impervious | Q100 = 50 cfs)

Major Basin C-5 includes the road rights-of-way for Arterial A, Dawson Trails Boulevard, Crystal Valley Parkway and the western segment of Collector D. Specific sub-areas of Basin C-5 are further detailed in Section II.B of this report, along with the proposed drainage improvements for the included roadways. The area is assigned a build-out imperviousness of 80% for hydrologic analysis. This basin is tributary to the Regional Pond C1 and has been accounted for in its sizing.

Basin C-6 (8.4 acres | 80% Impervious | Q100 = 15 cfs)

Major Basin C-6 includes the road rights-of-way for Collector E and the eastern segment of Collector D. Specific sub-areas of Basin C6 are further detailed in Section II.B of this report, along with the proposed drainage improvements for the included roadways. The area is assigned a build-out imperviousness of 80% for hydrologic analysis. This basin is tributary to the Regional Pond C1 and has been accounted for in its sizing.

Lower Gambel Watershed: Offsite basins

Basin C-7 (13.5 acres | 89% Impervious | Q100 = 41 cfs)

Major Basin C-7 is bounded by Dawson Trails Boulevard to the east, Gambel Ridge Tributary to the south, Town of Castle Rock park space to the north and the Twin Oaks subdivision to the west. Major Basin C7 contains development parcels north of Crystal Valley Parkway. It is designated within Planning area E1 in the development plan. A specific use of commercial land type is anticipated in this basin. The area is assigned a build-out imperviousness of 87% for hydrologic analysis. This basin is not tributary to the Regional Pond C1 but has been considered in the sizing of Pond C1 for detention purposes.

Basin C-8 (19.3 acres | 95% Impervious | Q100 = 70 cfs)

Major Basin C-8 is bounded by Dawson Trails Boulevard to the west, Gambel Ridge Tributary to the south, a collector road to the north and the BNSF railroad to the west. Major Basins C-8 contains development parcels north of Crystal Valley Parkway. It is designated within Planning area F2 in the development plan. A specific use of commercial land type is anticipated in this basin. The area is assigned a build-out imperviousness of 95% for hydrologic analysis. This basin is not tributary to the Regional Pond C1 but has been considered in the sizing of Pond C1 for detention purposes.

Basin C-9 (4.2 acres | 2% Impervious | Q100 = 4 cfs)

Basin C-9 contains the Gambel Ridge major drainageway and associated open space tracts. Basin C9's area and imperviousness is factored into the sizing of Pond C1 and its flow component is modeled in the SWMM evaluate total flows leaving the development. The area is assigned a build-out imperviousness of 2% for hydrologic analysis. Flows from this basin will exit the project site via existing storm conveyance elements beneath the BNSF Railroad and eventually drain to East Plum Creek.

North Dawson Tributary Watershed: On-site Basins used in CUHP/SWMM Analysis

Basin A-1 (13.4 acre | 12% Impervious | Q100 = 28 cfs)

3. Culvert performance under proposed release rates

Since the release rate from Pond A1 is set to match the existing 100-year flow rate, the performance of Culverts 10 (under BNSF railway) and Culvert 10.5 (under I-25) is not expected to vary from existing conditions. Additionally, the split flow condition that produces the flows through Culverts 11 and 11.5 will be eliminated.

Gamble Ridge Outfall

The ultimate outfall for the northern part of the project area is the culvert crossing of Gambel Ridge Tributary under the BNSF railroad. There are two culvert crossings in series in this location:

- A set of three 6' x 9' CMP culverts under the BNSF railway
- A 10' x 6' concrete box culvert under Interstate 25, immediately downstream.

The Gambel Ridge culverts and their respective capacities are critical to the drainage design of this area of Dawson Trails. The culverts were analyzed in the Gambel Ridge FHAD [Reference F] and are re-evaluated with this study.. The culvert under Interstate 25 was also analyzed in the 2020 South Interstate 25 Express Lanes Hydrology and Hydraulics Report [Reference K].

All three of these studies included hydrologic analyses of the Gambel Ridge Tributary Basin to determine existing peak flows for various recurrence intervals. The conclusions of these studies are summarized below:

Culvert Hydrologic Analysis Summary for Gambel Ridge Outfall					
Source	Crossing	Culvert Size	Existing Q50 [cfs]	Existing Q100 [cfs]	Capacity [cfs]
Gambel Ridge FHAD (Respec; Ref. F)]	BNSF RR (DP 1020)	Triple 9' x 6' CMP Arch	682	901	650-700
Gambel Ridge FHAD (Respec; Ref. F)]	I-25 (DP 1020)	10' x 6' CBC	682	901	650-700
I-25 Gap Hydrology/Hydraulics Report [ch2m; Ref. K]	I-25 (MP 178.94)	10' x 6' CBC	533	698	726
CUHP Analysis (this report)	BNSF RR (Culvert 7)	Triple 9' x 6' CMP Arch	485	640 *	1698
CUHP Analysis (this report)	I-25 (Culvert 7.5)	10' x 6' CBC	485	640 *	768

* Controlling outfall capacity

1. Outfall assessment

The Gambel Ridge FHAD [Ref. F] estimates an overall capacity of 650-700 cfs through the culvert crossing under the BNSF railway and Interstate 25. The I-25 Gap study determined the capacity of the I-25 culvert to be 726 cfs. A separate analysis included herein—which is based on independent survey, field observations and hydraulic assumptions—computes a resultant crossing capacity of 768 cfs, with the Interstate 25 culvert controlling. The separate hydraulic analyses are reasonably consistent in their conclusions.

2. Release rate determination

All three studies also estimate a peak 100-year flow at the upstream end of the BNSF culvert. This location is designated as Design Point 1020 in the FHAD study, MP 178.94 in the I-25 study, and Culvert 7 in the Existing Conditions Drainage Map. The existing basin CUHP analysis determines an existing 100-year flow rate of 640 cfs at this point. While this result is reasonably close to the 698 cfs identified in the I-25 Study, the flowrate from the FHAD study is somewhat of an outlier. A more in-depth analysis of the input parameters of each study's hydrologic models shows that FHAD study assumes a greater residential density than what is used in the other studies or observed in the field.

The pre-development peak of 640 cfs is lesser than the values presented in the other 2 studies and thus more conservative from an allowable release rate standpoint. 640 cfs is also less than the crossing capacities determined by all 3 studies and is therefore selected as the maximum allowable discharge rate from Gambel Ridge Tributary where it enters the BNSF right-of-way.

3. Culvert performance under proposed release rates

The I-25 hydrology and hydraulics report identifies 50 years as the design recurrence interval for its assessment of the existing culverts within the study area. Hydraulic evaluations of the existing culverts are done for both 100-year and 50-year event to verify acceptable performance under the design recurrence intervals of both the drainageway and the crossing infrastructure.

BNSF Culvert Hydraulic Performance for Gambel Ridge Outfall					
Design Storm	Culvert Size	Allowable HW/D	Flow	Depth at Inlet	Actual HW/D
50-year	Triple 9' x 6' Arch	1.2 *	485	4.03	0.67
100-year	Triple 9' x 6' Arch	1.2 *	640	4.74	0.79

* 1.2 Headwater to depth ratio taken from most restrictive value stated in TOCR Drainage Criteria, Section 11.2.3

I-25 Culvert Hydraulic Performance for Gambel Ridge Outfall					
Design Storm	Culvert Size	Allowable HW/D	Flow	Depth at Inlet	Actual HW/D
50-year	10' x 6' CBC	1.5	485	6.55	1.09
100-year	10' x 6' CBC	N/A	640	8.33	1.38

The Gamble Ridge Tributary culverts are identified on the drainage plan. HY-8 culvert performance calculations are included in Appendix B (B.1)

The summary of hydrologic results from the CUHP calculations can be found in the Culvert Summary Table below. Culverts crossings 8, 9, and 11 will not be utilized as outfalls by the Dawson Trails development. They will continue to convey runoff from the BNSF right-of-way and immediately adjacent areas with no increase in flows. Culverts 7 and Culvert 10 will have full spectrum detention facilities included, where the ultimate outfall location and flowrate will be at or below that of the historic condition. The

Report Output files, Link flow, Storage Volume, and outfall loading results have been provided in **Appendix B**.

Gambel Ridge Tributary:

The Gambel Ridge SWMM model is made up of two major drainage basin drainage systems, which together form the Gambel Ridge Tributary. The area in the upper watershed has been designated as "H" basins and the area in the lower water shed has been designated as "C" basins. "C" basins are, by and in large, associated with the Crystal Valley Interchange (CVI) project that is anticipated to be in construction prior to the build out of Infrastructure 1. These drainage systems are built of junction nodes which coincide with their assigned basins. Pipe links, which are primarily used to ensure the maximum flow is conveyed through the system with minimal routing error, dummy links, and storage nodes to represent the proposed flood control facilities. Junctions, links, and storage nodes have been named in accordance with what drainage system they are considered within.

Manning N values are consistent with those used in the North Dawson Tributary SWMM analysis. Please see **Appendix D** for relevant excerpts.

The overall drainage concept of the Gambel Ridge Tributary is to use proposed and existing off-site channels as the main flow conveyance with three full spectrum Extended Detention Basins (EDB) utilized to attenuate flows during major storm events. These ponds are identified as Pond B1, Pond B2, and Pond C1. Several parcels within the Gambel Ridge Tributary will have private Water Quality (WQ) ponds which will accomplish Water Quality Capture Volume (WQCV) and Excess Urban Runoff Volume (EURV) treatment before releasing into the Gambel Ridge proposed channel. All WQ ponds have been modeled as junctions.

Within the "H" basins, two in-line EDB's were considered in the SWMM model. These Ponds are identified as Pond B2 and Pond B1. Pond B1's proposed location is on the northern property line, in the northeast corner of Basin B7 of the Proposed Drainage Map. This location also corresponds to Basin H-7 of the Proposed Overall SWMM Map provided in **Appendix D**. Pond B1's proposed location coincides with the "Regional Pond Location A" from the approved PDP. Pond B2's proposed location is on the northeast corner of Basin B1 of the Proposed Drainage Map. This location also corresponds to Basin H-1 of the Proposed Overall SWMM Map provided in **Appendix D**. Pond B2's proposed location will be within the northern portion of PL-1.03 of the approved PDP. Pond B1 is part of the Phase I construction process and will be required as part of the Infrastructure 1 construction efforts. No flooding concerns of Pond B1 were immediately present during the interim condition analysis and therefore, Pond B2 will be built as part of the future Phase II construction process and is not required until Parcel B – Phase II begins development. Both the ultimate and interim conditions were analyzed to ensure no adverse effects to downstream storm infrastructure. Inflow hydrograph data was extracted from SWMM and routed through the MHFD Detention workbook for Pond B-1. The outflow of Pond B1 will exit the Dawson Trail Development on the north property line before reentering the site on the west side of the Crystal Valley Interchange and into the "C" basins.

"C" basins within this model largely represent the CVI project area and outfall from Gambel Ride Tributary. Within the "C" basin, one regional EDB was considered in the

SWMM model. This pond is identified as Pond C1. Pond C1's proposed location will be at the intersection of Dawson Trails Boulevard and Crystal Valley Parkway within Basin C3 of the Proposed Drainage Basin Map and will be required as construction begins on and around the Crystal Valley Interchange. This location also corresponds to Basin C-3 of the Proposed Overall SWMM Map provided in **Appendix D**. CORE Consultants collaborated and shared anticipated tributary areas and impervious percentages with others to help facilitate the most efficient and accurate design of this regional facility. Pond C1's design, construction, and certification will ultimately be the responsibility of the consultants and engineers associated with the CVI project. Basins C-7 and C-8 are anticipated to only require WQ and EURV ponds within their basins. Pond C1 will be designed to over detain to account for those basins lack of detention within the Gambel Ridge Tributary system.

The storage curve and rating curves for Ponds B-1 and B-2 were developed using the MHFD detention workbook version 4.06. The storage curves in SWMM reflect the most up to date proposed topography available and release rates were developed in coordination with Shrewsberry and Jacob's Engineering to best ensure proposed flow rates do not exceed historic flow conditions. The upstream Pond B2 saw a maximum percent full of 80% with a maximum release of 49 CFS during the 100-year storm event. The downstream Pond B1 saw a maximum percent full of 97.3% with a maximum release of 147 CFS during the 100-year storm event. With the most up to date information available through coordination with the consultants involved in the CVI project, Pond C1 saw a maximum percent full of 93.9% with a maximum release of 115 CFS during the 100-year storm event.

A significant amount of un-detained offsite flow will enter the Gambel Ridge at several points along the main tributary. These offsite basins have been identified as OS-1, OS-2, OS-3, and OS-4. Offsite flow which enters the site will not be treated or detained within the proposed EDBs and will instead be conveyed along their historic drainage routes to Gambel Ridge, entering the tributary at different locations along its reach.

Report Output files, Link flow, Storage Volume, and outfall loading results have been provided in **Appendix B**.

The combined release rates from Pond B1 and Pond C1, in addition to un-detained off-site flow, is below both the existing CUHP analysis completed by CORE consultants and the Flood Hazard Area Delineation – Gambel Ridge and Douglas Lane Tributary Watersheds completed by RESPEC Consulting & Services. Please see the table on the following page for a results summary of the SWMM model.

SWMM Key Design Pont Summary				
Key Flow Location	Model Node	Tributary Basins	100-year Peak Flow	Peak Flow Modeled Time
Future Pond B2 Release	EDB-B2	H-1	48.5	1:05
Pond B1 Release	EDB-B1	H2-H7	146.6	1:45
Gambel Ridge Offsite + Pond B1 Release	J_6	H1-H7, OS1-OS4	470.9	1:05
Pond C1 Release	EDB-C1	C1-C6	110.1	1:35
Total Basin Release at BNSF Culvert	OUT-1	All	631	1:10
Max Allowable at Outfall	OUT-1	All	640 (Existing)	N/A

C. Hydrology

Colorado Urban Hydrograph Procedure (CUHP) Method

The Colorado Urban Hydrograph Procedure (CUHP) is a hydrologic analysis method based upon the Snyder's Unit Hydrograph. It has been calibrated by the Mile High Flood District (MHFD) for the front range region using local simulations of rainfall-runoff data. CUHP considers physical characteristics of each watershed basin including shape, slope, impervious area, and soil conditions. CUHP is able to produce hydrographs based on these characteristics for each basin and route them together using EPA SWMM. This results in a more accurate representation of peak flow times throughout the drainage systems. The Rational Method is a simpler hydrologic approach and is only able to produce peak flows from each subject basin. For this reason, CUHP was chosen as the preferred methodology when analyzing each major tributary on a holistic scale. Please see **Section III.B** of this report for further discussion on EPA SWMM.

Per the TOCR SDDTCM, Chapter 6, Section 6.2; Table 6-3, CUHP is an appropriate methodology to determine runoff values for basins ranging from 5-3,000 or more acres. For basins less than 5 acres, flows from the rational method will be used to determine peak flow values. CUHP method is used for calculations of major basin flows, offsite flows, and future development area flows.

Runoff calculations use CUHP 2005v_2.0.1 for the minor (5-year) and the major (100-year) storm events. The workbook utilizes rainfall data found in Table 6-1 of the TOCR Criteria Manual as well as imperviousness values for the various land uses per Table 6-3 of the MHFD Criteria Manual Volume 1. Tables 6-1 & 6-3 are included in **Appendix D**.

Maximum Depression Storage, Horton's infiltration Parameters and Disconnected Impervious Areas (DCIA) standard values were determined by using recommended values from Table B-1 & B-2 within the *CUHP 2005 User Manual, Version 2.0.0* dated September 9, 2016, prepared by the MHFD.

- 100-year pond volume of approximately 27.7 acre-feet

The design parameters listed above are critical to ensuring that the Pond C1 can integrate with the ultimate development conditions of the watershed, hydrograph routing of upstream Regional Pond B1, and total anticipated discharge from Gambel Ridge Tributary across the eastern Dawson Trails Planned Development boundary.

The proposed, existing, and future storage facilities with the Gambel Ridge and North Dawson watersheds are listed below. Detention ponds and water quality ponds are listed separately, with full-spectrum ponds shown in both tables:

Gambel & North Dawson Watersheds: Regional Detention Pond Summary (100-year Detention)					
Pond	Tributary Basins (CUHP)	Tributary Area (ac)	% Imp.	Req. 100-year Volume (ac-ft)	Design/ Const
B1	B2-B7	170.8	40.0%	13.74	Proposed; Infra 1 by CORE
B2	B1	46.4	7.8%	1.58	Future; P.A. B1, Phase 2
C1	C1-C7	185.2	76.9%	24.42 *	Proposed; CVI by Jacobs
A1	A1-A8	277.5	63.9%	31.39 **	Proposed; Infra 1 by CORE
E1	E1-E3	133.8	32.6%	9.49 **	Future; Planning Area C1

* Basins C7 and C8 are not directly tributary to Pond C1; 100-year volume for C7 is accounted for in Pond C1

** Ponds A1 and E1 are in direct series and accommodate combined required volume between both ponds

Gambel & North Dawson Watersheds: Water Quality / EURV Pond Summary					
Pond	Tributary Basins (CUHP)	Tributary Area (ac)	% Imp.	WQCV / EURV (ac-ft)	Design/ Const
B1	H2-H8	170.8	40.0%	2.56	Proposed; Infra 1 by CORE
B2	H1	46.4	7.8%	0.21	Future; Planning Area B1
C1	C1-C6	185.2	76.9%	4.78	Proposed; CVI by Jacobs
E1	C7	9.1	90.8%	0.31	Proposed; DTB North by CORE
C3	C8	20.5	90.8%	0.70 (WQCV only)	Proposed; Costco by CORE
D3	A4	91.9	66.9%		Proposed; Infra 1 by CORE
D4	D4(minor basin)	2.77	100%		Proposed; Infra 1 by CORE

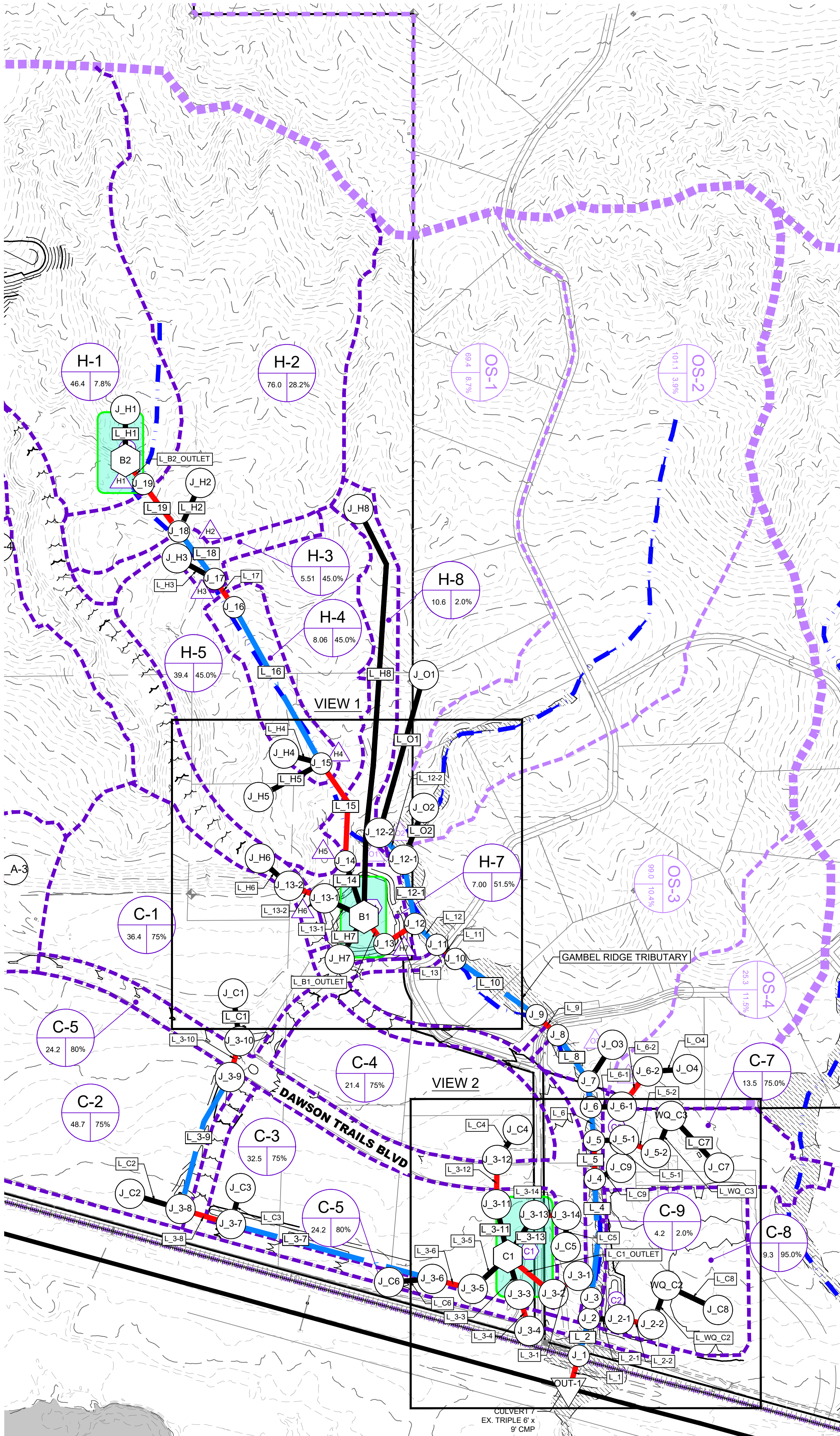
ULTIMATE BUILDOUT CONDITION

CUHP SUBCATCHMENTS

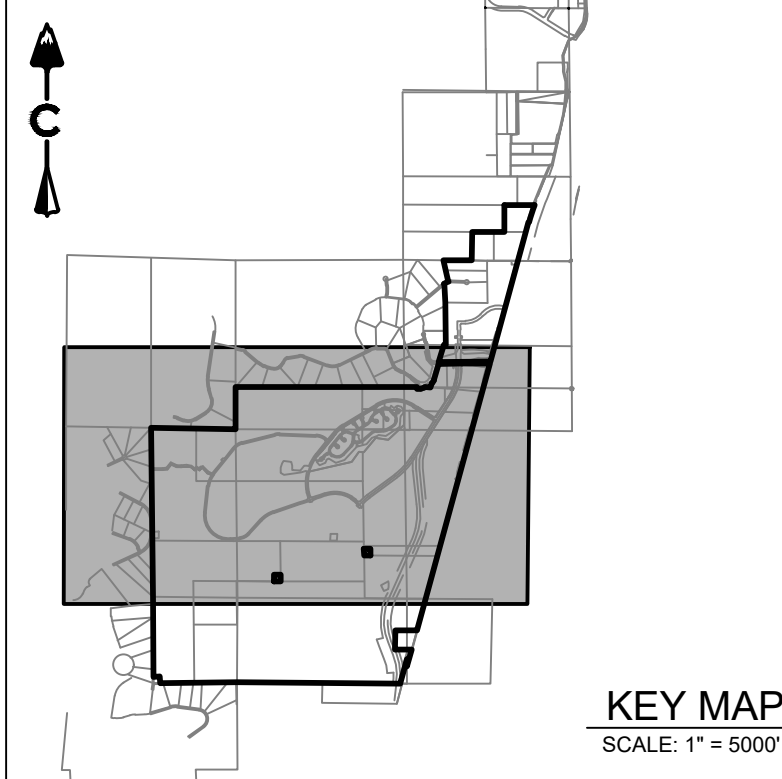
Columns with this color heading are for required user-input
 Columns with this color heading are for optional override values
 Columns with this color heading are for program-calculated values

Subcatchment Name	EPA SWMM Target Node	Raingage	Area (mi ²)	Length to Centroid (mi)	Length (mi)	Slope (ft/ft)	Percent Imperviousness	Maximum Depression Storage (Watershed inches)		Horton's Infiltration Parameters			DCIA Level 0, 1, or 2
								Pervious	Impervious	Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)	
H-1	H1	2-Year	0.0725514	0.221212121	0.5210227	0.058	7.8	0.4	0.1	3.7	0.0018	0.5	0
H-2	H2	2-Year	0.1187964	0.357386364	0.7441288	0.045	28.2	0.35	0.05	3.5	0.0018	0.5	0
H-3	H3	2-Year	0.0086165	0.098863636	0.1977273	0.033	45	0.35	0.05	3	0.0018	0.5	0
H-4	H4	2-Year	0.0126001	0.131439394	0.2606061	0.045	45	0.35	0.05	3	0.0018	0.5	0
H-5	H5	2-Year	0.0614924	0.2	0.4005682	0.036	45	0.35	0.05	3.1	0.0018	0.5	0
H-6	H6	2-Year	0.0394709	0.359469697	0.7189394	0.045	32.6	0.35	0.1	3	0.0018	0.5	0
H-7	H7	2-Year	0.0100076	0.052840909	0.1988636	0.031	51.5	0.35	0.05	4.2	0.0018	0.6	0
H-8	H8	2-Year	0.0165493	0.225776932	0.4346471	0.0533	2	0.4	0.01	3	0.0018	0.5	0
C-1	C1	2-Year	0.0570767	0.16969697	0.4077652	0.06321412	75	0.35	0.1	4	0.0018	0.6	0
C-2	C2	2-Year	0.0760191	0.226704545	0.4401515	0.022934596	75	0.35	0.1	3.3	0.001745	0.5	0
C-3	C3	2-Year	0.0508346	0.219128788	0.4765152	0.019475358	75	0.35	0.1	3.4	0.0018	0.5	0
C-4	C4	2-Year	0.033502	0.130681818	0.3314394	0.024257143	75	0.35	0.1	3.7	0.0018	0.5	0
C-5	C5	2-Year	0.0377594	0.358522727	0.7168561	0.018124174	80.4	0.35	0.1	3.7	0.0018	0.5	0
C-6	C6	2-Year	0.0130523	0.21969697	0.5893939	0.01722365	80.4	0.35	0.1	4.2	0.001714589	0.6	0
C-7	C7	2-Year	0.0210999	0.148674242	0.2666667	0.011576705	88.6	0.35	0.1	4.4	0.001010314	0.9	0
C-8	C8	2-Year	0.030106	0.130492424	0.2907197	0.015	95	0.35	0.1	4.5	0.001	0.9	0
C-9	C9	2-Year	0.0066354	0.131439394	0.2712121	0.02	2	0.35	0.05	3	0.0018	0.5	0
OS-1	O1	2-Year	0.1084434	0.422916667	0.7518939	0.066	8.7	0.4	0.05	4.1	0.0018	0.6	0
OS-2	O2	2-Year	0.1579448	0.522727273	0.9541667	0.059	3.9	0.4	0.05	4.2	0.0018	0.6	0
OS-3	O3	2-Year	0.1543167	0.297727273	0.8047348	0.059	10.4	0.4	0.05	3	0.0018	0.5	0
OS-4	O4	2-Year	0.0394811	0.148106061	0.4035985	0.057	11.5	0.4	0.05	3	0.0018	0.5	0

0.0301 sq. mi. = 19.26 ac



Reference J -
Appendix D, p19



LEGEND

- OUTFALL DESIGNATION
- DESIGN POINT/JUNCTION DESIGNATION
- POND DESIGNATION
- PIPE/CHANNEL DESIGNATION
- JUNCTION/NODE DESIGNATION

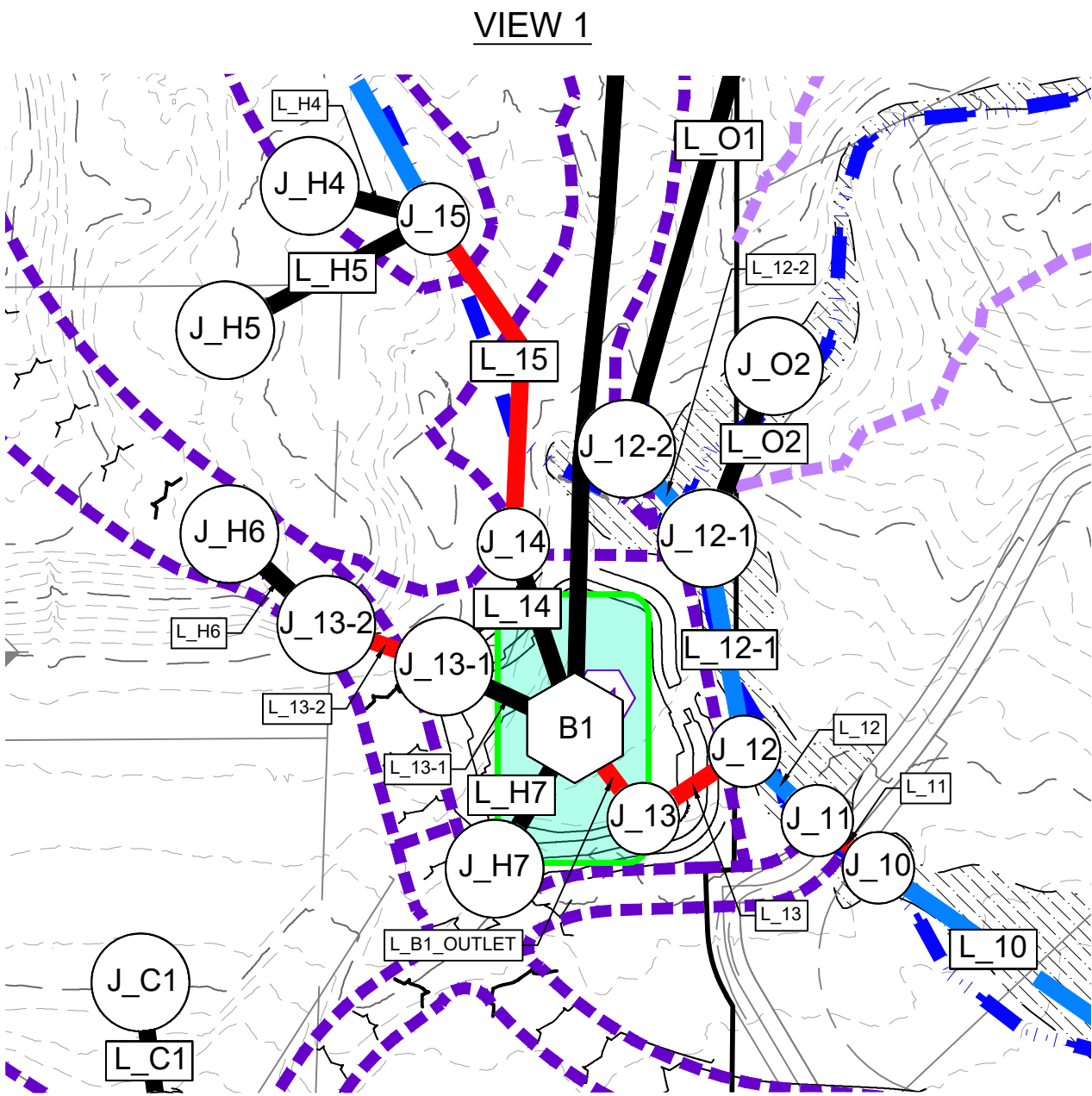
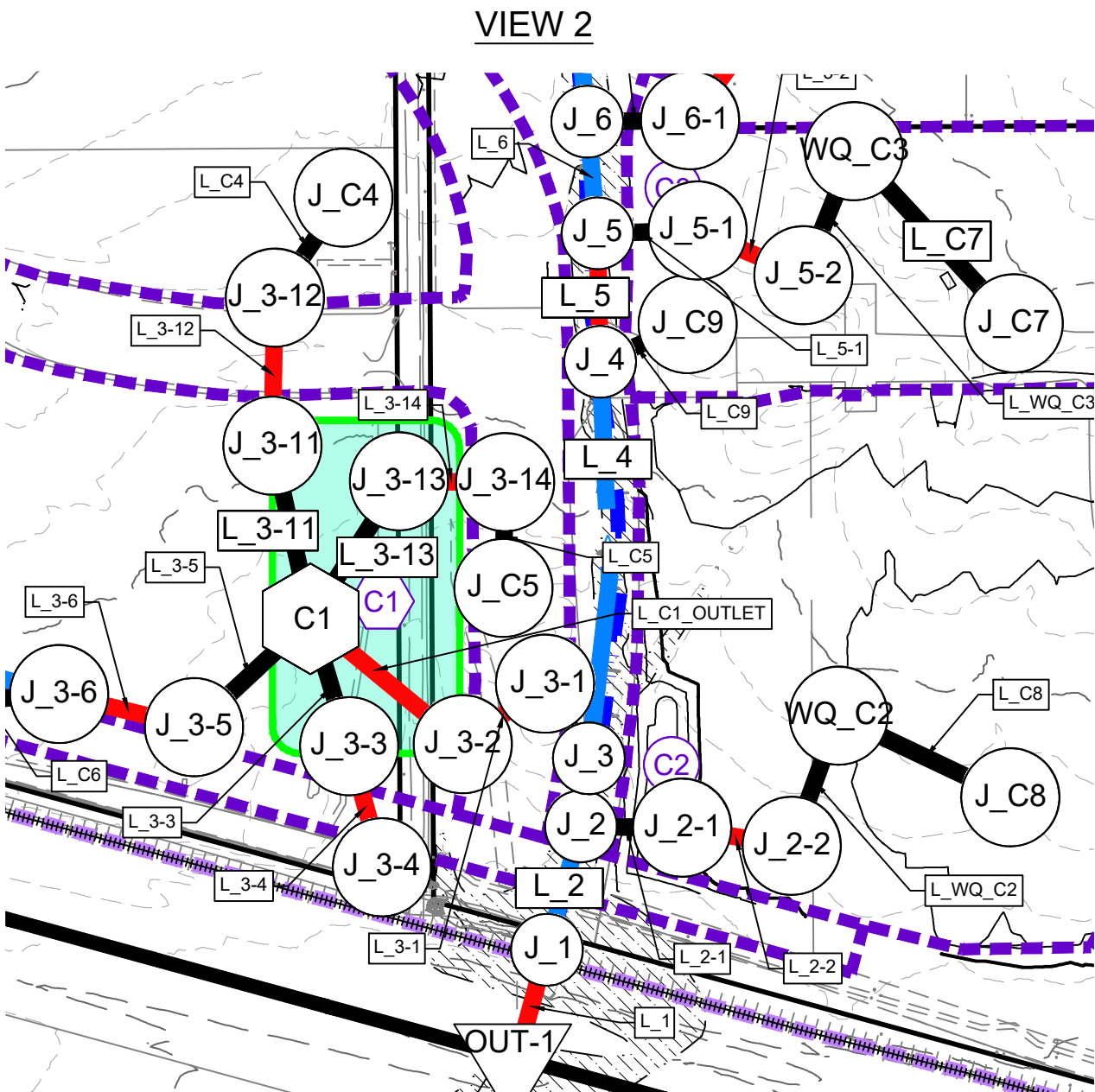
- DUMMY LINK
- PROPOSED STORM SEWER
- PROPOSED CHANNEL

LEGEND

- BASIN DESIGNATION
- AREA (AC) / IMPERVIOUSNESS
- DESIGN POINT
- DIRECTIONAL FLOW ARROW
- EMERGENCY OVERFLOW ROUTE
- PROPOSED DRAINAGE BASIN
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- EASEMENT
- RIGHT OF WAY (R.O.W.)
- CENTERLINE
- PROJECT BOUNDARY
- PROPOSED STORM & STUB OUT
- EXISTING STORM & STUB OUT
- 100-YEAR FEMA FLOODPLAIN
- 100-YEAR TOWN FLOODPLAIN

NOTES:

- DRAINAGE BASINS AND POND LOCATIONS ARE APPROXIMATE.
- POND CONFIGURATIONS AND LOCATIONS ARE CONCEPTUAL AND MAY CHANGE DUE TO FIELD CONDITIONS AND/OR FINAL SITE CONFIGURATIONS.
- THE SITE LIES WITHIN FEMA FLOOD ZONE X.
- TOWN 100-YEAR FLOODPLAINS ASSOCIATED WITH THE SOUTH DAWSON, NORTH DAWSON, GAMBEL RIDGE, AND GAMBEL RIDGE NORTH TRIBUTARIES WILL BE RE-EVALUATED BY A FLOODPLAIN MODIFICATION STUDY.
- EFFORTS WILL BE MADE TO STABILIZE, PROTECT, AND PRESERVE THE MAJOR DRAINAGEWAYS ON-SITE. IMPACTS WILL BE LIMITED TO IMPROVEMENTS IN THE AREAS OF DISCHARGES FROM THE PROPOSED DETENTION FACILITIES AND AS IDENTIFIED IN THE MASTER DRAINAGE PLANS FOR THE DRAINAGEWAYS. THE IMPROVEMENTS WILL CONFORM TO THE TOWN OF CASTLE ROCK STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA MANUAL. THESE IMPROVEMENTS WILL BE DESIGNED TO MITIGATE EROSION AND PRESERVE THE NATURAL CHARACTER AND HISTORICAL DRAINAGE PATTERNS TO THE GREATEST EXTENT FEASIBLE.
- THE INTERCHANGE AT TERRITORIAL ROAD, CRYSTAL VALLEY PARKWAY, AND I-25 (CVI) IS A TOWN, COUNTY AND STATE PROJECT. CHANNEL IMPROVEMENTS FOR THE GAMBEL RIDGE MAJOR DRAINAGEWAY THROUGH THE SITE WILL BE PART OF THE CVI PROJECT.



DAWSON TRAILS - FILING 2 INFRASTRUCTURE

CASTLE ROCK, COLORADO

PHASE III DRAINAGE REPORT

PROPOSED BASIN D SWMM MAP

NOT FOR
CONSTRUCTION

DESIGNED BY: JCK
DRAWN BY: EKT
CHECKED BY:

JOB NO.
20-224
SHEET
1 OF 1

Know what's below.
Call before you dig.



#	REVISION DESCRIPTION	DATE	BY
1	1ST SUBMITTAL	10/09/2022	JCK

CORE CONSULTANTS, INC.
34733 S. BROADWAY
DENVER, CO 80113
303.703.4444
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CORE

LAND DEVELOPMENT
ENERGY
PUBLIC INFRASTRUCTURE

Final Design

Interstate 25 South Express Lanes:

Castle Rock to Monument (The Gap)

Hydrology and Hydraulics Report

Prepared For:

CDOT Region 1 Hydraulics
7328 S. Revere Parkway, Suite 204A
Centennial, CO 80112

CH2M Project No.: 680954

CDOT Project No.: C 0252-475

CDOT Project Code: 22589

December 2020

Prepared By:



9191 Jamaica Street
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Existing Crossing Culverts

The existing culverts along the Project corridor include various sizes, type, and materials. All culverts are proposed to remain along the existing culvert alignment such that the outfalls of the culverts will mimic the historical patterns. Culverts were analyzed based upon CDOT criteria for overtopping and headwater-to-depth (HW/D) ratio. Guidance for velocities were based upon CDOT criteria to maintain self-cleaning aspects for minimum velocities while mitigating high velocities using outlet protection.

Figure 2: CDOT Design Overtopping Criteria Table 7.2

Table 7.2 Table of Design Frequencies

Drainage Type		Frequency
A.	Cross Drainage	
	Multilane Roads - including interstate	
	In Urban Areas	100-year*
	In Rural Areas	50-year
	Two-Lane Roads	
	In Urban Areas	100-year
	In Rural Areas	
	$Q_{50} \geq 4000$ cfs	50-year
	$Q_{50} < 4000$ cfs	25-year
	Culvert Outlet Scour Protection	10-year
B.	Pedestrian Walkways and Bikeways	2 to 5-year
	Bridge Foundation Scour	100 and 500-year
	Parallel Drainage	
	Roadway Overtopping and Revetment	Same as for Cross Drainage
C.	Side Drains	2 to 10-year [#]
	Storm Drains	
	Major System	100-year
D.	Minor System	2 to 5-year
	Detour Culverts	monthly discharges for 2 to 5-year

Notes: *Urban cross culverts (not Interstate); if $Q_{100} < 100$ cfs, consider designing the culvert using the storm drain Minor System Frequency.

[#]Side drains shall not cause water to flow onto the highway at a greater probability than applies to cross drainage.

Figure 3: CDOT HW/D Criteria Table 9.3

Table 9.3 Maximum Headwater Depth to Structure Depth Ratios, HW/D.

Range of Diameter or Height or Rise, inches	Maximum HW/D
Less than 36 in.	2.0
36 in. to 60 in.	1.7
Larger than 60 in. but less than 84 in.	1.5
84 in. to less than 120 in.	1.2
120 in. or larger	1.0

V. RECOMMENDED DESIGN

Reference K - p26

Culverts

Approximately 100 culverts were analyzed to determine if they were hydraulically sufficient, of which 35 are in Package 1, and 32 in package 2. CDOT criteria requires 24-inch pipes to be upsized to at least 36 inches based upon the roadway design; however, based on CDOT guidance for this project, 24-inch pipes that are determined to be hydraulically adequate will not be upsized. CSP pipes under the mainline interstate will be replaced with RCP with the exception of one double 48-inch crossing and crossings that will be abandoned. All proposed pipe culverts, including storm drain pipes, are proposed as RCP under pay item 603.

Hydraulic analysis was performed using FHWA HY-8 culvert analysis software to determine capacity of all existing culverts. The flows were used from the proposed hydrology and accommodated roadside and median drainage that may affect flows. Locations where an inlet system tied into a mainline culvert were modeled as a single continuous culvert section. Additional flow from the inlet system tie-ins was not incorporated into the mainline analysis as the time of concentration lag factor allows the inlet systems flow to pass prior to offsite runoff reaching the respective mainline culvert. Culverts which have inlets for entrances were modelled through Bentley's MicroStation and InRoads Storm Sewer Analysis software in order to account for losses associated with the inlet and followed the same design process as above except to incorporate all structures (inlets and pipes) in the culvert network. The upstream inlets were modeled in a sump condition and clogging factor of 50% was used for conservative calculation. Final design of these culverts will reflect the sump condition. Three culvert crossings were modeled in this way in Package 1.

The frontage road culvert analysis was based upon a 25-year design flow. At MP176.75 (STA1824+42.37) and MP178.63 (STA1921+43.14), these locations were analyzed using off-site hydrology as they were part of the mainline system, thus it determined that the time of concentration lag factor would not contribute flow to this system. The remaining frontage road culvert locations began either at the existing grass median or were completely independent with no connecting mainline system. These culverts were analyzed using on-site and ditch flow.

At MP178.49 (STA1914+03.31) the culvert that passes under the frontage road is in outlet control due to topography constraints on the western limit. Water may flow full in the pipe in this segment across the frontage road; however, it is not overtopping the roadway neither at the inlet nor outlet, thus, there are no anticipated negative impacts to the travel way.

Culverts crossing the railroad and dirt roads were not analyzed as they fall outside the scope of the project. Downstream culverts that cross the frontage roads or interchange ramps will be upsized to match the upstream mainline culverts.

Outlet velocities for the culverts are generally kept between 3 and 22 feet per second. In Package 1, only the 10'x6' CBC at station 1938+26.83 (milepost 178.94) has an outlet velocity greater than 22 feet per second. An energy dissipator is proposed for this culvert to reduce the velocity from 22.79 and reduce scour downstream. The energy dissipator will be constructed as part of Package 2. In Package 3, there are four pipes with velocities greater than 22 feet per second located at 1451+97.90 (milepost 169.69), 1455+96.33 (milepost 169.77), 1462+70.70 and 1574+25.00. Concrete anchor blocks will be used in conjunction with the steep pipes for overall stability. The design was requested by CDOT to limit the use of longer riprap rundowns and convey the runoff to the bottom of the roadway embankment in the pipe system, to reduce erosion concerns at these specific locations.

In Package 2, there are 15 existing culverts deemed sufficient that need to be extended due to roadway grading. In Package 4, there are four existing culverts determined to be hydraulically sufficient that need to be extended due to roadway grading. The geometry of some extensions would cause cover issues on certain crossings, namely MP164.34 (STA1170+31.60) an existing 36-inch RCP and MP165.72 (STA1240+28.93) an existing 24inch RCP. Extending these culverts at their existing grade caused cover and grading issues on their respective upstream sides. These two crossings will need to be replaced from the median inlet to the upstream invert and have their pipe's slopes adjusted to better conform to proposed conditions.

Tapered Culverts

The existing tapered CBCs were initially analyzed using Federal Highway Administration's (FHWA) HY-8 culvert program evaluating for the design events. In HY-8, the CBCs were modeled as the smaller section, and if sufficient, would be hydraulically sufficient for the larger section. MP175.26 and MP178.94 were further analyzed after not being

sufficient based on the previous methodology. These two CBCs were modeled through EPA SWMM to incorporate the tapered geometry and were modeled as such.

In HY8, both the larger upstream section and smaller downstream section models are in inlet control. The tapered models built in EPA SWMM verified that these two locations are in inlet control, thus the upstream section is the controlling factor. The EPA SWMM models were compared to the HY-8 results of the upstream section and are reasonably close to one another. The results can be seen below in Table 3 and 4.

Table 3: Summary for MP175.26

Milepost	Model	HW/D	HW/D Limit
175.26	HY-8	*1.06	1.2
175.26	EPA SWMM	0.94	1.2

*Note that this value is based off the larger upstream section model in HY-8.

Table 4: Summary for MP178.94

Milepost	Model	HW/D	HW/D Limit
178.94	HY-8	*1.51	1.5
178.94	EPA SWMM	1.57	1.5

*Note that this value is based off the larger upstream section model in HY-8.

Due to these CBCs being in inlet control, as verified through the EPA SWMM model, it is a reasonable approach to model these sections using the upstream end through HY8 for analysis. The HY8 analysis concludes that MP 175.26 is hydraulically adequate and MP178.94 is within a reasonable HW/D range to justify hydraulic sufficiency as well.

Headwalls and Wingwalls

Headwalls and wingwalls will primarily be used for RCPs 48 inches and greater and all CBCs. Culverts smaller than 48 inches will incorporate flared end sections unless roadway slope geometry dictates otherwise. Headwalls and wingwalls will be added to Package 1 culverts in Package 2 of the Project. The contractor will be responsible for providing temporary drainage until these improvements are constructed and may be required to provide interim shoring until the proposed headwalls and wingwalls are construction.

In Package 4, the embankment grading on County Line Road encroaches into the existing channel resulting in an extension of the existing culvert at MP 163.43. This extension does not leave adequate room for the use of flared end sections; therefore, standard headwalls based on M-601-12 will be utilized at MP 163.40, MP 163.43, and MP 163.46.

Recommendations for proposed culverts can be seen in **Appendix C**.

Inlet Systems

Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Highway Number (ON) 5D: 025A _

Mile Post (ON)11: 178.940 mi

Bridge Name: 025A178940BL

Inspection Date: 8/27/2014

Sufficiency Rating: 65.0 NA

NBI Reporting ID:	025A178940B	Hist Signif 37:	5	JW Inspection Date 93B	
Rgn/Sectn 2E/2M:	15	Posting status 41:	A	SI Date 93C:	
Trans Region 2T	-1	Service on/un 42A/B:	1 5	Bridge Cost 94:	\$ -1
County Code 3:	035	Main Mat/Desgn 43A/B:	1 19	Roadway Cost 95:	\$ -1
DOUGLAS		Appr Mat/Desgn 44A/B:	0 00	Total Cost 96:	\$ -1
Place Code 4:	00000	Main Spans Unit 45:	1	Year of Cost Estimate 97:	-1
non-city		Approach Spans 46:	0	Brdr Brdg Code/% 98A/B:	
Rte.(On/Under)5A:	1	Horiz Clr 47:	38.0 ft	Border Bridge Number 99:	
Signing Prefix 5B:	1	Max Span 48:	10.0 ft	Defense Highway 100:	1
Level of Service 5C:	1	Str Length 49:	10.0 ft	Parallel Structure 101:	N
Directional Suffix 5E:	0	Curb Wdth L/R 50A/B:	0.0 ft 0.0 ft	Direction of Traffic 102:	2
Feature Intersected 6:		Width Curb to Curb 51:	0.0 ft	Temporary Structure 103:	#
UNNAMED DRAINAGE		Width Out to Out 52:	261.0 ft	Highway System 104:	1
Facility Carried 7:		Deck Area:	2,604.9 sq. ft	Fed Lands Hiway 105:	
I-25 ML		Min Clr Ovr Brdg 53:	99.99	Year Reconstructed 106:	0000
Alias Str No.8A:		Min Undrclr Ref 54A:	N	Deck Type 107:	N
I-25-178.94BL		Min Undrclr 54B:	0.0 ft	Wearing Surface 108A:	N
Prli Str No. 8P		Min Lat Clrnce Ref R 55A:	N	Membrane 108B:	N
		Min Lat Undrclr R 55B:	0.0 ft	Deck Protection 108C:	N
Location 9:		Min Lat Undrclr L 56:	0.0 ft	Truck ADT 109:	6 %
2.6 MI S OF CASTLE ROCK		Deck 58:	N	Trk Net 110:	
Max Clr 10:	99.9 ft	Super 59:	N	Pier Protection 111:	#
BaseHiway Net12:		Sub 60:	N	NBIS Length 112:	N
InsinvRout 13A	-1	Channel/Protection 61:	5	Scour Critical 113:	8
InsinvRout No13B:	-1	Culvert 62:	7	Scour Watch 113M:	
Latitude 16:	39d 20' 22"	Oprrtg Rtg Method 63:	5 No rating	Future ADT 114:	91,600
Longitude 17:	104d 52' 34"	Operating Rating 64:	40.0	Year of Future ADT 115:	2028
Range18A:		Inv Rtg Method 65:	5	CDOT Str Type 120A:	CBC
Township18B:		Inventory Rating 66:	36.0	CDOT Constr Type 120B:	02
Section18C:		Asph/Fill Thick 66T:	072 "in"	Inspection Indic 122A:	
Detour Length 19:	123.7 mi	Str. Evaluation 67:	7	Inspection Trip 122AA:	
Toll Facility 20:	3	Deck Geometry 68:	N	Inspection Schedule ID:	-1
Custodian 21:	1	Undrclr Vert/Hor 69:	N	Maintenance Patrol 123:	-1
Owner 22:	1	Posting 70:	5	Expansion Dev/Type124:	
Functional Class 26:	01	Waterway Adequacy 7:	7	Brdg Rail Type/Mod 125A/B:	-1
Year Built 27:	1965	Approach Alignment 72:	8	Posting Trucks 129A/B/C:	0 0 0
Lanes on 28A:	8	Type of Work 75A:		Str Rating Date 130:	2/5/2010
Lanes Under 28B:	0	Work Done By 75B:		Special Equip 133:	-1
ADT 29:	55,500	Length of Improvment 76:		Vert Clr N/E 134A/B/C:	-1.00 -1.00
Year of ADT 30:	2008	Insp Team Indicator 90B:	Stantec	Vert Clr S/W 135A/B/C:	-1.00 -1.00
Design Load 31:	5	Inspector Name 90C:	NGOQ	Vertical Clr Date:	1/1/1901
Apr Rdwy Width 32:	128.0 ft	Frequency 91:	48 months	Weight Limit Color: 135:	
Median 33:	2	FC Frequency 92A:		Str Billing Type:	
Skew 34:	0.00 °	JW Frequency 92B:		Userkey 1 - System:	MINORS
Structure Flared 35:	0	SI Frequency 92C:		Userkey 7-Update Indic:	
Sfty Rail 36a/b/c/d:	1 1 1 1	FC Inspection Date 93A:			
Rail ht36h:	28 "in"				

Inspector Name: NGOQ

Colorado Department of Transportation
Structure Inspection and Inventory Report (English Units)

Highway Number (ON) 5D: 025A _

Mile Post (ON)11: 178.940 mi

Element Inspection Report

Elem/Env	Description	Units	Total Qty	% in 1	CS 1	% in 2	CS 2	% in 3	CS 3	% in 4	CS 4	% in 5	CS 5
241/1	Concrete Culvert	(LF)	261	95 %	249	2 %	5	3 %	7	0 %	0	0 %	0
327/1	Culvert Wingwalls	(EA)	4	100 %	4	0 %	0	0 %	0	0 %	0	0 %	0
335/1	Culvert Headwalls	(EA)	2	100 %	2	0 %	0	0 %	0	0 %	0	0 %	0
361/1	Scour Smart Flag	(EA)	1	100 %	1	0 %	0	0 %	0	0 %	0	0 %	0
502/1	ChannProtMatCond	(EA)	1	100 %	1	0 %	0	0 %	0	0 %	0	0 %	0

Elem/Env	Description	Element Notes
241/1	Concrete Culvert	10 ft W x 6 ft H from inlet to near median, then tapers to 7 ft W x 6 ft H from median to outlet cast-in-place concrete box culvert with 2 to 6 ft cover - (8) hairline cracks in bottom of top slab parallel to centerline of roadway with (6) rust stains. Insufficient cover exposing reinforcing at drop inlet portion. Spall with exposed and corroded reinforcing near drop inlet. 11 ft 6 inch drop structure inside CBC 20 ft from outlet.
327/1	Culvert Wingwalls	Concrete, flared, at inlet and outlet. Exposed up to 21 inches footing at east wingwalls.
335/1	Culvert Headwalls	Concrete at inlet and outlet.
361/1	Scour Smart Flag	Up to 21 inches exposed bottom slab and wingwall footing. Previous noted: Concrete apron slab at outlet with spillway previously severely undermined - Repaired between 2005 and 2010 inspections.
502/1	ChannProtMatCond	Concrete apron slab at outlet with spillway previously severely undermined - Repaired between 2005 and 2010 inspections.

Bridge Notes

GPS RT: LAT N39 degrees 20 minutes 21.5 seconds LONG W104 degrees 52 minutes 30.3 seconds

Colorado Department of Transportation

Structure Inspection and Inventory Report (English Units)

Highway Number (ON) 5D: 025A _

Mile Post (ON)11: 178.940 mi

Inspection Notes

Date 8/27/2012 -

Temp: 57 Degrees Time: 7:45 AM Weather: Cloudy, breeze

Scope:

☒ NBI: ☒ Element: ☐ Underwater: ☐ Fracture Critical: ☐ Other: Type: Regular NBI

Team Leader Inspection Check-off:

- ☐ FCM's
- ☐ Posting Signs
- ☐ Essential Repair Verification
- ☐ Vertical Clearance
- ☐ Stream Bed Profile

Inspection Team:

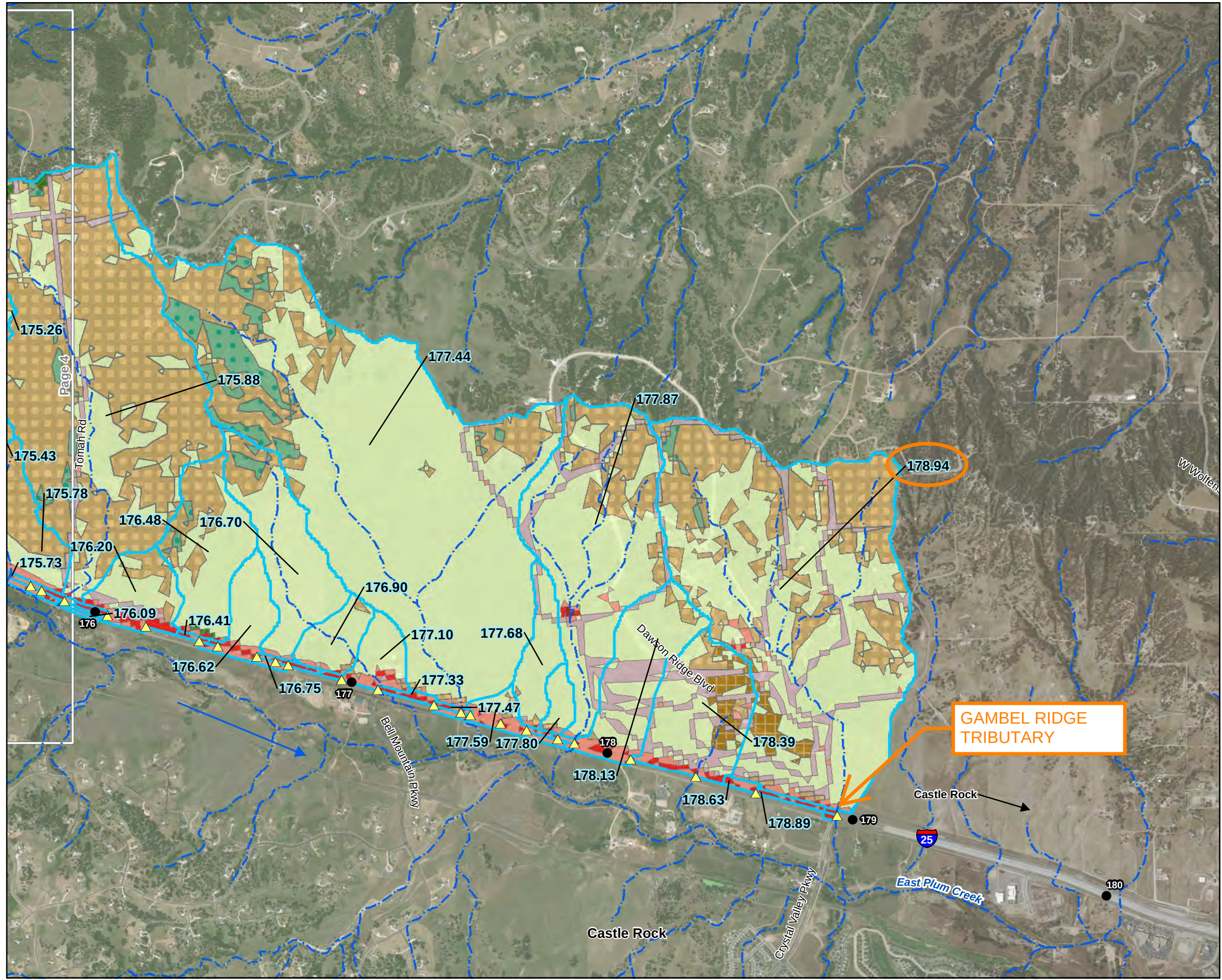
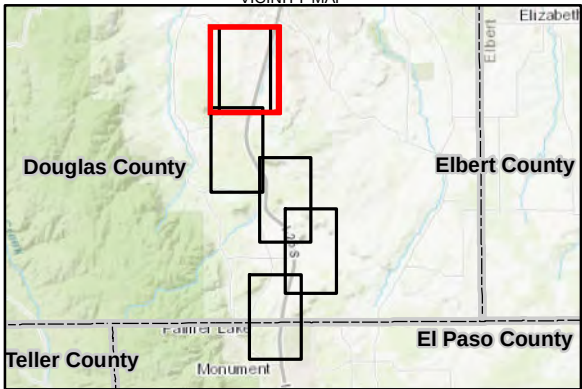
Inspection Date: 08/27/2014

Inspector: NGOQ

Digitally signed by Quyen Ngo
Date: 2014.09.25 11:13:01
+06'00'

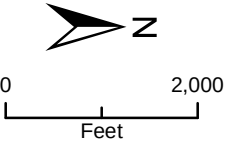
Quyen Ngo

Inspector (Team Leader)



- LEGEND
- Milepost
 - ▲ Culvert Crossing
 - East Plum Creek Bridge
 - ▭ County Boundary
 - ▭ Match Line
 - - - National Hydrography Dataset Flowline
 - ➔ Direction of Flow
 - ▭ Proposed Basin Area
 - 161.65 Basin Name/Milepost of Crossing Culvert
- Land Cover
- Open Water
 - Developed, Open Space
 - Developed, Low Intensity
 - Developed, Medium Intensity
 - Developed, High Intensity
 - Barren Land (Rock/Sand/Clay)
 - Deciduous Forest
 - Evergreen Forest
 - Shrub/Scrub
 - Grassland/Herbaceous
 - Cultivated Crops
 - Emergent Herbaceous Wetlands

Source:
- National Land Cover Database, 2011
- National Hydrography Dataset - USGS 2017



Project: I-25 Gap Package 1
Description: Hydrology Summary

Project No. 680954
Calculated by: JC

Station	MP	Area (ac)	C and CN							Point Precipitation (in) and Rainfall Intensity (in/hr)									Flows (cfs)			Method Used	
			NRCS Soil Type A	NRCS Soil Type B	NRCS Soil Type C	NRCS Soil Type D	C5	C50	C100	Tc (mins)	1hr (5yr)	1hr (50yr)	1hr (100yr)	6hr (5yr)	6hr (50yr)	6hr (100yr)	I5	I50	I100	Q5	Q50		Q100
1593+85.70	172.41	100	25.7%	74.3%	0.0%	0.0%	0.15	0.39	0.46	51							1.6	2.6	2.9	24	99	136	Rational
1671+36.74	173.87	253	42.0%	38.3%	14.8%	4.9%	0.20	0.39	0.46	46	1.4	2.1	2.6	2.2	3.0	3.4				80	236	307	CUHP
1676+22.96	173.97	3	0.0%	100.0%	0.0%	0.0%	0.86	0.89	0.90	6							4.5	7.2	8.3	13	22	25	Rational
1689+73.03	174.22	301	35.9%	29.4%	33.1%	1.6%	0.22	0.42	0.49	49	1.4	2.1	2.6	2.2	3.0	3.4				130	357	459	CUHP
1707+11.07	174.54	5	31.8%	68.2%	0.0%	0.0%	0.86	0.88	0.89	11							3.7	5.9	6.8	16	26	30	Rational
1711+29.10	174.62	283	33.5%	43.5%	23.0%	0.0%	0.02	0.26	0.35	84	1.4	2.1	2.6	2.2	3.0	3.4				36	221	305	CUHP
1725+20.60	174.88	32	4.9%	11.1%	83.9%	0.0%	0.26	0.52	0.58	28							2.3	3.7	4.2	20	61	79	Rational
1738+13.34	175.13	5	0.0%	0.0%	100.0%	0.0%	0.86	0.88	0.89	8							4.1	6.5	7.5	18	29	34	Rational
1745+14.68	175.26	602	22.7%	3.0%	73.8%	0.6%	0.04	0.32	0.41	94	1.4	2.1	2.6	2.2	3.0	3.4				124	533	716	CUHP
1748+05.31	175.32	1	0.0%	0.0%	100.1%	0.0%	0.86	0.88	0.89	9							4.1	6.5	7.5	4	6	7	Rational
1754+58.25	175.43	40	0.0%	0.0%	100.0%	0.0%	0.14	0.46	0.54	42							1.8	2.9	3.3	11	53	72	Rational
1761+97.61	175.58	4	0.0%	0.0%	100.1%	0.0%	0.86	0.88	0.89	11							3.8	6.0	6.9	13	21	24	Rational
1770+46.52	175.73	4	0.0%	0.0%	100.1%	0.0%	0.86	0.88	0.89	10							3.9	6.2	7.1	15	24	28	Rational
1772+87.19	175.78	76	0.0%	0.0%	100.0%	0.0%	0.16	0.47	0.55	41							1.9	2.9	3.4	23	106	142	Rational
1777+86.29	175.88	594	4.4%	19.2%	65.9%	10.5%	0.06	0.39	0.48	130	1.4	2.1	2.6	2.2	3.0	3.4				128	431	576	CUHP
1786+96.49	176.09	3	0.0%	0.0%	100.0%	0.0%	0.86	0.88	0.89	9							4.0	6.3	7.2	10	17	20	Rational
1794+90.79	176.20	52	0.0%	0.0%	89.5%	10.5%	0.28	0.54	0.60	22							2.7	4.2	4.9	39	118	153	Rational
1805+97.32	176.41	2	0.0%	0.0%	0.0%	100.1%	0.86	0.88	0.89	12							3.6	5.7	6.6	5	8	9	Rational
1809+86.22	176.48	102	0.0%	59.7%	4.9%	35.4%	0.04	0.37	0.46	56							1.5	2.4	2.7	6	90	130	Rational
1817+96.42	176.62	38	0.0%	29.0%	1.1%	69.9%	0.16	0.46	0.54	41							1.8	2.9	3.3	11	51	69	Rational
1821+81.30	176.70	116	0.0%	19.9%	25.3%	54.8%	0.05	0.40	0.49	75							1.2	2.0	2.3	7	90	127	Rational
1824+42.37	176.75	3	0.0%	61.0%	39.0%	0.0%	0.86	0.89	0.90	12							3.6	5.7	6.5	9	15	18	Rational
1835+53.16	176.90	33	0.0%	37.8%	61.6%	0.6%	0.08	0.40	0.49	33							2.1	3.4	3.9	5	45	64	Rational
1843+04.34	177.10	32	0.0%	68.9%	31.1%	0.0%	0.22	0.49	0.56	24							2.5	4.0	4.6	18	62	82	Rational
1854+69.45	177.33	4	0.0%	94.0%	6.0%	0.0%	0.85	0.88	0.89	18							3.0	4.7	5.4	10	16	18	Rational
1860+30.28	177.44	819	0.0%	23.3%	55.6%	21.1%	0.04	0.39	0.48	173	1.4	2.1	2.6	2.2	3.0	3.4				159	557	751	CUHP
1862+19.82	177.47	2	0.0%	32.2%	67.8%	0.0%	0.86	0.88	0.89	9							4.1	6.5	7.5	6	10	12	Rational
1868+52.25	177.53	19	0.0%	8.9%	87.4%	3.6%	0.55	0.70	0.74	11							3.7	5.8	6.7	39	78	95	Rational
1873+93.89	177.68	44	0.0%	50.1%	21.0%	28.9%	0.13	0.44	0.52	57							1.5	2.4	2.7	9	46	63	Rational
1880+37.61	177.80	15	0.0%	100.0%	0.0%	0.0%	0.04	0.36	0.46	41							1.8	2.9	3.3	1	16	23	Rational
1883+78.77	177.87	264	0.0%	16.9%	73.7%	9.5%	0.13	0.44	0.53	95	1.4	2.1	2.6	2.2	3.0	3.4				74	206	269	CUHP
1895+49.32	178.13	100	0.0%	43.8%	17.2%	39.0%	0.28	0.53	0.60	38							1.9	3.1	3.5	53	163	211	Rational
1908+95.31	178.39	111	0.0%	66.3%	32.0%	1.7%	0.28	0.53	0.60	35							2.0	3.2	3.7	63	190	246	Rational
1921+43.14	178.63	3	0.0%	100.0%	0.0%	0.0%	0.85	0.88	0.89	13							3.4	5.4	6.3	9	15	17	Rational
1935+41.68	178.89	3	0.0%	88.3%	11.7%	0.0%	0.86	0.89	0.90	15							3.3	5.2	5.9	9	15	18	Rational
1938+26.83	178.94	623	4.8%	53.8%	41.4%	0.0%	0.10	0.40	0.49	112	1.4	2.1	2.6	2.2	3.0	3.4				170	533	698	CUHP

HY-8 Culvert Analysis Report 178.94 Existing

Site Data - 178.94 Existing (10'x6')

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 6342.55 ft

Outlet Station: 323.00 ft

Outlet Elevation: 6324.22 ft

Number of Barrels: 1

Culvert Data Summary - 178.94 Existing (10'x6')

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0130

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75° flare) Wingwall

Inlet Depression: None

Tailwater Channel Data - 178.94 Existing (10'x6')

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 12.00 ft

Side Slope (H:V): 4.00 (1:1)

Channel Slope: 0.0568

Channel Manning's n: 0.0600

Channel Invert Elevation: 6324.22 ft

Roadway Data for Crossing: 178.94 Existing (10'x6')

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 6352.04 ft

Roadway Surface: Paved

Roadway Top Width: 136.00 ft

Table 1 - Culvert Summary Table: 178.94 Existing (10'x6')

Discharge Names	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)
10 year	238.00	238.00	6346.40	3.849	0.0*	1-S2n	0.964	2.601	1.005	1.787	23.678	6.957
100 year	698.00	698.00	6351.62	9.070	0.0*	5-S2n	1.959	5.329	2.223	3.070	31.400	9.363

Table 2 - Downstream Channel Rating Curve (Crossing: 178.94 Existing (10'x6'))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
238.00	6326.01	1.79	6.96	6.33	1.07
698.00	6327.29	3.07	9.36	10.88	1.16

Table 3 - Summary of Culvert Flows at Crossing: 178.94 Existing (10'x6')

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	178.94 Existing (10'x6') Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6346.40	10 year	238.00	238.00	0.00	1
6351.62	100 year	698.00	698.00	0.00	1
6352.04	Overtopping	726.76	726.76	0.00	Overtopping

Straight Culvert

Inlet Elevation (invert): 6342.55 ft, Outlet Elevation (invert): 6324.22 ft

Culvert Length: 323.52 ft, Culvert Slope: 0.0567



Crystal Valley Interchange Project Packages 1 and 2

Floodplain Modification Study
Gambel Ridge
E Plum Creek to Dawson Trails Boulevard
FD24-0003
April 2024

Prepare For:
Town of Castle Rock – Public Works
4175 North Castleton Court
Castle Rock, Colorado 80104

Prepared By:
Jacobs Engineering Group
6312 S. Fiddlers Green Circle
Suite's 300N, 200N
Greenwood Village, CO 80111

Contact:
Troy D. Slocum, PE, CFM
Troy.Slocum@Jacobs.com

4. Hydrologic and Hydraulic Analysis

4.1 Hydrologic Analysis

Existing Conditions Model

The existing condition SWMM model geometry is unchanged from the those presented in the Flood Hazard Area Delineation Gambel Ridge and Douglas Land Tributary Watersheds dated July 2014.

Proposed Conditions Model

The proposed conditions hydrologic model is based on the existing conditions model with adjustments made to account for the proposed improvements to be constructed as part of the proposed Crystal Valley Interchange improvements. These changes are primarily the proposed Full Spectrum Detention (FSD) ponds which will reduce the peak flow rates from the developed project area.

The proposed improvements include the Southeast and East FSD ponds which drain to Gambel Ridge east of I-25 (See Figure 2 for pond locations). The outfall hydrographs from those ponds were added to the SWMM node 1070.

The proposed North and South FSD ponds outfall directly to E Plum Creek rather than Gambel Ridge and stormwater flows generated within those basins are no longer included in the Gambel Ridge hydrologic model (See Figure 2 for pond locations).

The proposed West (C1) FSD pond and the proposed Costco water quality pond (C2) drain to Gambel Ridge west of the railroad and I-25(See Figure 2 for pond locations). The outfall hydrographs from those two ponds are added to the SWMM node 1020.

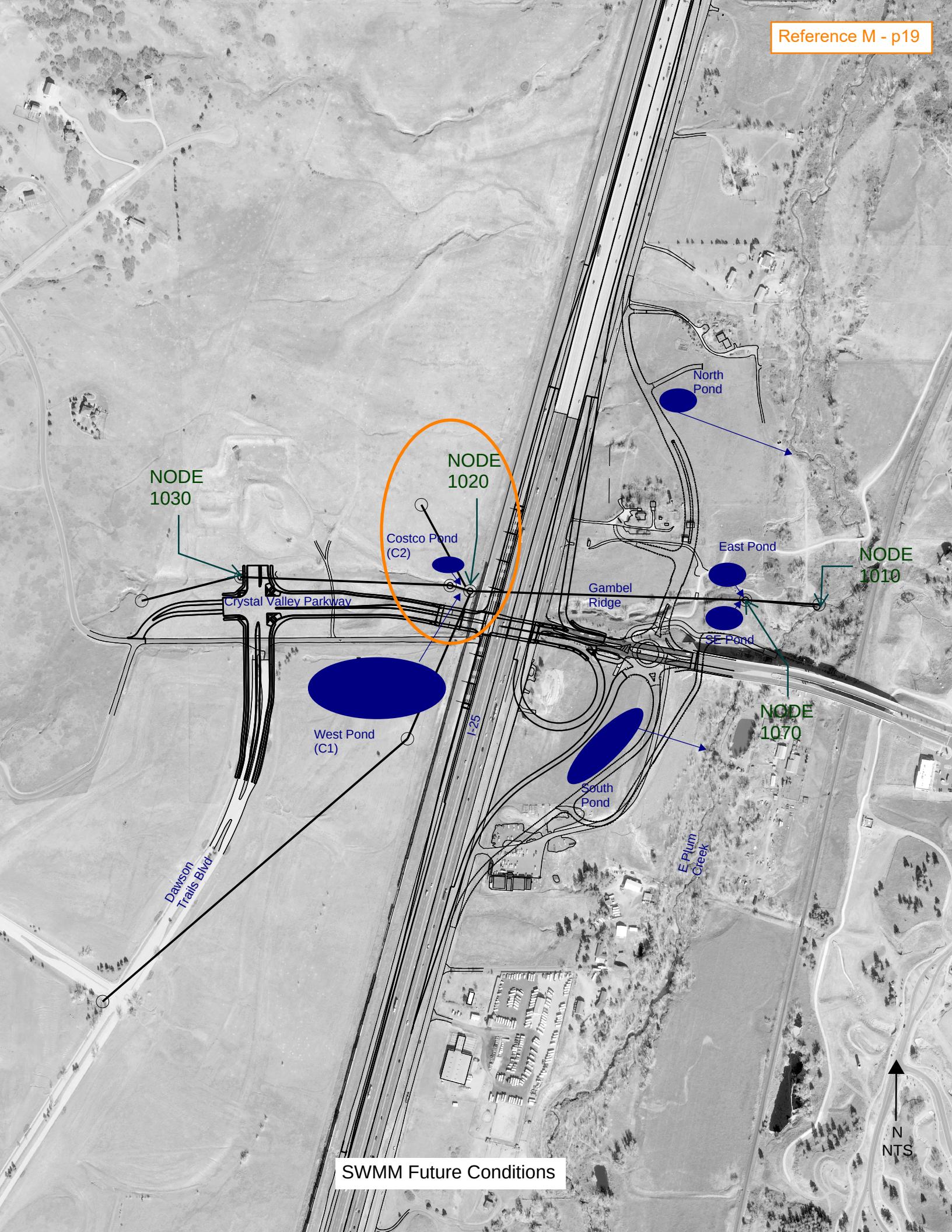
The drainage areas west of Dawson Trails Boulevard remain unchanged from the existing model in the proposed conditions.

Future Conditions Model

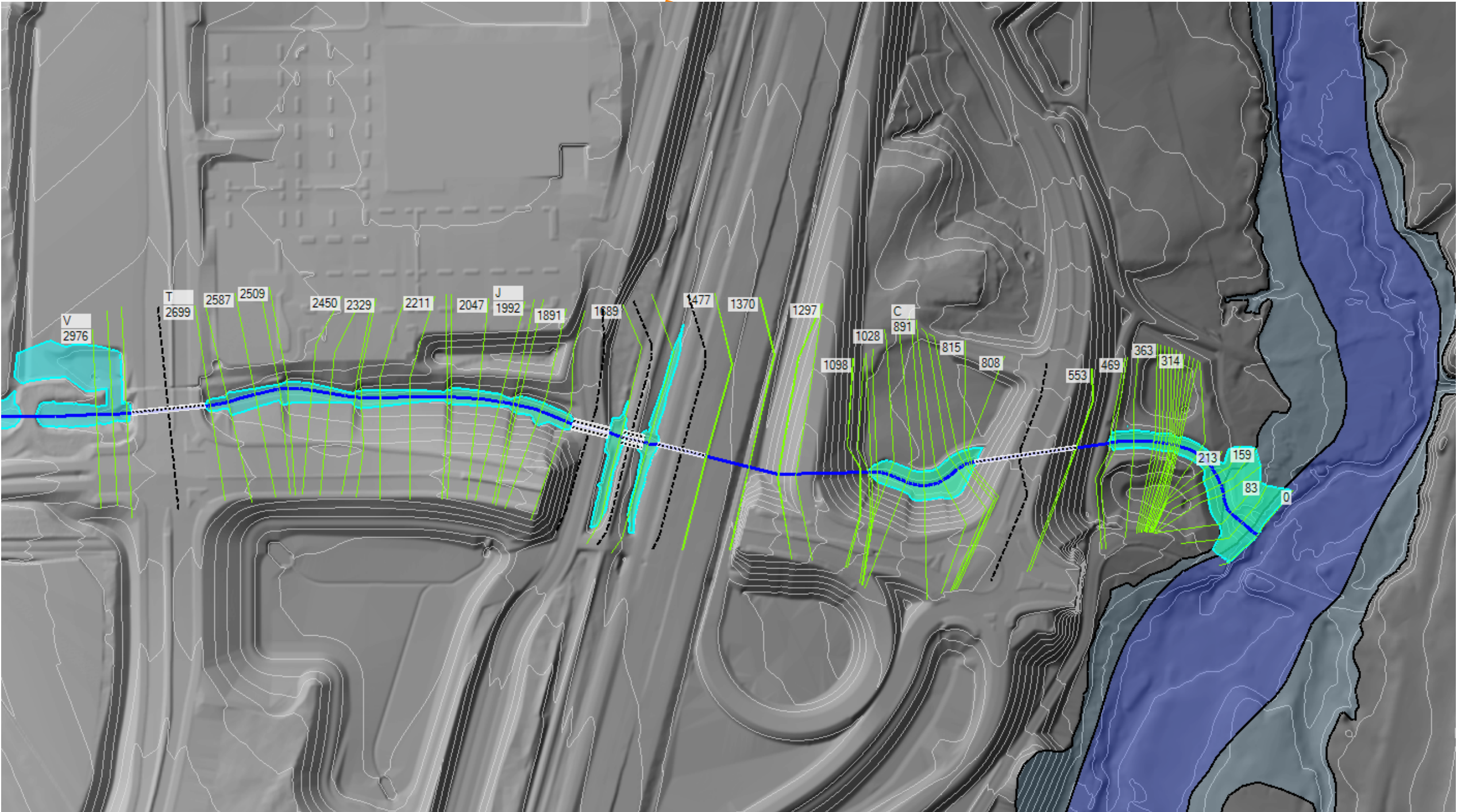
The Flood Hazard Area Delineation (FHAD) and the Gambel Ridge and Douglas Lane Tributary Watersheds Master Plan note that the existing peak flow rates generated in the basins west of I-25 produce flow rates in excess of the capacity of the existing railroad and I-25 culverts. The future developed flow rates are to be attenuated to approximately 630 cfs at the existing railroad culvert in order to meet the existing capacity of the culverts.

The future conditions SWMM model uses the conceptual proposed conditions model for the anticipated development design east of Dawson Trails Boulevard and accounts for additional detention west of Dawson Trails Boulevard to achieve the required peak flow rates at the existing railroad and I-25 culverts. The development east of Dawson Trails Boulevard will provide the additional detention ponds to reduce peak flow rate at the Dawson Trails Boulevard culvert to the planned 476 cfs. The hydrograph representing the developed area is added at Node 1030 just upstream of the Dawson Trails Blvd. culvert.

The future flow rates are used for the Hydraulic Modeling of Gambel Ridge and to evaluate the changes in the water surface elevations and channel velocities. The Future Conditions SWMM layout is shown in Figure 2.



SWMM Future Conditions

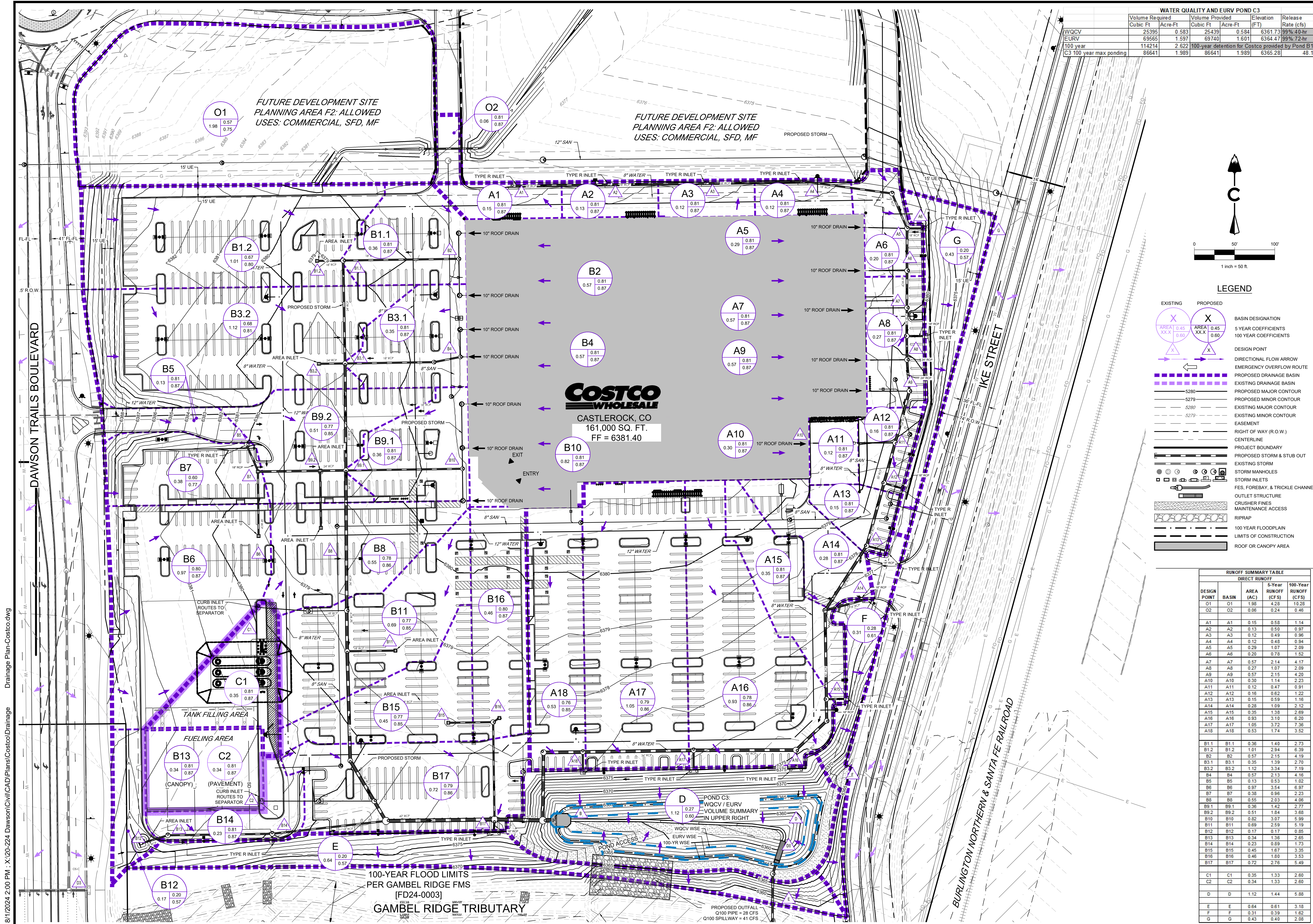


HEC-RAS Plan: 100yr_Future River: Gambel Ridge Reach: Proposed Profile: 100yr_Fut

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Proposed	6819 AG	100yr_Fut	117.00	6493.33	6493.99	6493.99	6494.19	0.026103	4.43	33.76	80.98	0.98
Proposed	6319 AF	100yr_Fut	117.00	6476.88	6477.82	6477.82	6478.12	0.022487	5.08	28.15	47.24	0.96
Proposed	5819 AE	100yr_Fut	117.00	6459.05	6460.12	6460.12	6460.48	0.022139	5.34	25.49	36.81	0.97
Proposed	5319 AD	100yr_Fut	117.00	6441.54	6442.13	6442.13	6442.33	0.027848	4.35	33.62	82.78	1.00
Proposed	4990 AC	100yr_Fut	117.00	6428.90	6429.76	6429.76	6430.05	0.023951	4.96	28.70	51.36	0.98
Proposed	4658 AB	100yr_Fut	117.00	6420.50	6423.91	6421.71	6423.94	0.000454	1.35	86.81	46.48	0.16
Proposed	4590 Twin_Oaks_Rd	Culvert										
Proposed	4547 AA	100yr_Fut	874.00	6419.43	6423.04	6423.04	6423.84	0.010229	7.79	142.18	94.97	0.79
Proposed	4264 Z	100yr_Fut	874.00	6415.07	6416.81	6416.81	6417.31	0.020077	7.52	163.03	166.00	1.01
Proposed	3832 Y	100yr_Fut	921.00	6400.59	6406.57	6405.19	6406.74	0.001577	3.73	342.93	193.00	0.32
Proposed	3791 Clarkes_Cir	Culvert										
Proposed	3742 X	100yr_Fut	921.00	6400.38	6403.98	6403.98	6404.74	0.011423	7.98	154.85	110.38	0.83
Proposed	3335 W	100yr_Fut	921.00	6387.62	6390.41	6390.41	6391.31	0.016403	9.22	127.97	72.77	0.99
Proposed	2976 V	100yr_Fut	470.00	6378.82	6382.59	6382.59	6383.42	0.008339	8.08	71.17	42.85	0.86
Proposed	2937	100yr_Fut	470.00	6377.94	6380.78	6380.78	6381.69	0.009216	7.91	65.30	177.70	0.90
Proposed	2903	100yr_Fut	470.00	6372.78	6378.66	6378.66	6378.88	0.000983	3.94	136.32	45.73	0.31
Proposed	2803 Dawson_Trail	Culvert										
Proposed	2699 T	100yr_Fut	470.00	6371.31	6374.66	6374.39	6375.61	0.008518	7.84	59.95	25.58	0.86
Proposed	2657	100yr_Fut	470.00	6370.46	6373.50	6373.50	6374.71	0.078829	8.63	53.73	42.38	0.96
Proposed	2587	100yr_Fut	470.00	6368.56	6371.93	6371.78	6372.70	0.006432	7.36	73.99	44.00	0.77
Proposed	2529	100yr_Fut	470.00	6368.06	6371.14	6371.14	6371.89	0.046631	6.73	67.77	47.64	0.74
Proposed	2509	100yr_Fut	470.00	6363.44	6367.57		6367.90	0.011867	4.59	102.09	49.71	0.44
Proposed	2450	100yr_Fut	470.00	6363.19	6366.96		6367.50	0.003924	6.23	88.48	46.13	0.61
Proposed	2404 R	100yr_Fut	470.00	6363.03	6366.22	6366.22	6367.19	0.008829	8.12	63.63	36.87	0.88
Proposed	2344	100yr_Fut	470.00	6361.76	6364.97	6364.97	6365.86	0.045977	7.67	62.34	35.01	0.84
Proposed	2329	100yr_Fut	470.00	6357.90	6362.08		6362.46	0.013960	4.75	95.30	41.40	0.44
Proposed	2282	100yr_Fut	470.00	6357.69	6361.60		6362.14	0.003707	6.20	86.20	39.85	0.60
Proposed	2211	100yr_Fut	470.00	6357.47	6360.65	6360.65	6361.70	0.009322	8.34	60.51	32.15	0.91
Proposed	2121 K	100yr_Fut	470.00	6355.82	6359.04	6359.04	6359.97	0.055896	7.74	60.84	32.12	0.84
Proposed	2111	100yr_Fut	470.00	6353.31	6356.53	6356.53	6357.48	0.057617	7.85	60.40	31.06	0.85
Proposed	2047	100yr_Fut	470.00	6352.01	6355.85	6355.23	6356.46	0.004103	6.51	80.95	35.95	0.63
Proposed	1992 J	100yr_Fut	470.00	6351.83	6355.05	6355.05	6356.10	0.008948	8.37	60.34	30.47	0.89
Proposed	1959	100yr_Fut	470.00	6349.76	6353.00	6353.00	6353.96	0.041927	7.96	60.01	29.82	0.86
Proposed	1949	100yr_Fut	470.00	6347.28	6351.82	6350.50	6352.13	0.005760	4.64	104.70	39.37	0.41
Proposed	1891	100yr_Fut	591.00	6346.56	6351.79	6350.02	6351.99	0.001010	4.07	174.53	53.54	0.33
Proposed	1825	100yr_Fut	591.00	6346.37	6351.00	6349.87	6351.81	0.003812	7.24	81.66	38.15	0.63
Proposed	1763 Collector_B	Culvert										
Proposed	1689	100yr_Fut	591.00	6345.44	6351.27	6346.98	6351.32	0.000144	1.80	329.19	272.53	0.13
Proposed	1664 RR	Culvert										
Proposed	1619 H	100yr_Fut	591.00	6343.21	6350.69	6345.33	6350.74	0.000140	1.85	321.35	416.55	0.13
Proposed	1539 I_25	Culvert										
Proposed	1477	100yr_Fut	591.00	6339.53	6346.46	6344.33	6347.97	0.003212	9.85	60.00		0.66
Proposed	1475	100yr_Fut	591.00	6339.53	6345.08	6345.08	6347.83	0.004397	13.30	44.43	8.00	1.00
Proposed	1370	100yr_Fut	591.00	6337.03	6342.58	6342.58	6345.33	0.004397	13.30	44.43	8.00	1.00
Proposed	1368	100yr_Fut	591.00	6336.83	6341.63	6341.63	6343.99	0.003517	12.32	47.99	10.00	0.99
Proposed	1297	100yr_Fut	591.00	6335.50	6340.30	6340.30	6342.66	0.003517	12.32	47.99	10.00	0.99
Proposed	1295	100yr_Fut	591.00	6335.30	6340.10	6340.10	6342.46	0.003517	12.32	47.99	10.00	0.99
Proposed	1252	100yr_Fut	591.00	6334.78	6339.58	6339.58	6341.94	0.003516	12.31	47.99	10.00	0.99
Proposed	1098	100yr_Fut	591.00	6332.70	6337.50	6337.50	6339.86	0.003517	12.32	47.99	10.00	0.99
Proposed	1096	100yr_Fut	591.00	6322.70	6329.39	6327.50	6330.90	0.003212	9.85	60.00		0.67
Proposed	1078	100yr_Fut	591.00	6322.64	6329.33	6327.44	6330.84	0.003212	9.85	60.00		0.67
Proposed	1074	100yr_Fut	591.00	6322.60	6329.33	6327.79	6330.79	0.003653	9.71	60.84	17.49	0.67
Proposed	1057	100yr_Fut	591.00	6322.56	6329.93	6326.66	6330.15	0.000712	3.72	158.80	43.16	0.28
Proposed	1028	100yr_Fut	591.00	6322.47	6329.98	6326.58	6330.11	0.000414	3.31	221.36	57.82	0.22
Proposed	983 E	100yr_Fut	591.00	6322.34	6329.95	6326.45	6330.09	0.000422	3.35	224.85	56.03	0.23
Proposed	937 D	100yr_Fut	591.00	6322.20	6329.98	6326.00	6330.06	0.000230	2.52	299.94	68.28	0.17
Proposed	891 C	100yr_Fut	591.00	6322.06	6330.00	6325.71	6330.04	0.000137	1.98	377.10	81.18	0.13
Proposed	845	100yr_Fut	591.00	6321.93	6329.97	6325.74	6330.03	0.000200	2.43	317.99	71.80	0.16
Proposed	827	100yr_Fut	591.00	6321.88	6329.91	6326.04	6330.02	0.000325	3.10	239.06	59.62	0.20
Proposed	815	100yr_Fut	591.00	6321.84	6329.87	6325.94	6330.01	0.000444	3.18	209.91	53.75	0.22
Proposed	808	100yr_Fut	591.00	6321.81	6329.60	6325.89	6329.98	0.001090	4.99	118.46	45.29	0.33
Proposed	689 Frontage_Rd	Culvert										
Proposed	553	100yr_Fut	591.00	6319.02	6323.82	6323.82	6326.18	0.003516	12.31	47.99	10.00	0.99
Proposed	550	100yr_Fut	591.00	6303.72	6308.52	6308.52	6310.88	0.003516	12.31	47.99	10.00	0.99
Proposed	469	100yr_Fut	591.00	6303.33	6308.13	6308.13	6310.49	0.003512	12.31	48.02	10.00	0.99
Proposed	457	100yr_Fut	591.00	6303.25	6306.91	6306.91	6308.43	0.010672	9.93	60.09	40.36	0.99
Proposed	412	100yr_Fut	591.00	6303.12	6306.42	6305.72	6307.00	0.004049	6.25	101.25	40.70	0.62
Proposed	363	100yr_Fut	591.00	6302.97	6306.12	6305.60	6306.77	0.004855	6.72	95.16	39.78	0.68
Proposed	354	100yr_Fut	591.00	6302.94	6306.06	6305.54	6306.73	0.005003	6.71	94.13	39.64	0.69
Proposed	345	100yr_Fut	591.00	6302.91	6306.05	6305.46	6306.67	0.004774	6.47	96.89	41.24	0.67
Proposed	336	100yr_Fut	591.00	6302.88	6306.04	6305.43	6306.62	0.004400	6.22	100.89	42.96	0.64
Proposed	327	100yr_Fut	591.00	6302.87	6305.98	6305.33	6306.51	0.039602	5.49	103.63	45.07	0.58
Proposed	323	100yr_Fut	591.00	6302.82	6305.31	6305.31	6306.23	0.104201	7.68	77.14	41.36	0.95
Proposed	319	100yr_Fut	591.00	6302.06	6304.65	6304.65	6305.59	0.112517	7.79	75.98	39.46	0.97
Proposed	314	100yr_Fut	591.00	6300.96	6303.58	6303.58	6304.56	0.116492	7.93	74.53	37.35	0.99
Proposed	310	100yr_Fut	591.00	6299.84	6302.53	6302.53	6303.52	0.116825	8.01	73.74	36.38	0.99
Proposed	306	100yr_Fut	591.00	6298.79	6301.47	6301.47	6302.46	0.116440	8.02	73.73	36.26	0.99
Proposed	301 A	100yr_Fut	600.00	6297.84	6301.65	6300.48	6302.02	0.020401	4.93	121.80	43.53	0.52
Proposed	254	100yr_Fut	600.00	6297.69	6301.20	6300.30	6301.66	0.003930	5.45	110.17	41.94	0.59
Proposed	213	100yr_Fut	600.00	6297.56	6300.15	6300.15	6301.14	0.123025	7.98	75.14	37.11	0.99
Proposed	185	100yr_Fut	600.00	6292.53	6300.02	6295.12	6300.07	0.000649	1.83	329.21	125.47	0.14
Proposed	159	100yr_Fut	600.00	6292.44	6300.00	6295.04	6300.05	0.000573	1.81	335.83	160.13	0.13
Proposed	136	100yr_Fut	600.00	6292.38	6300.00	6294.91	6300.05	0.000145	1.79	335.22	151.13	0.13

BACK POCKET

DRAINAGE MAPS



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1	FOR APPROVAL	08/01/24		

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CASTLE ROCK, CO
DRAINAGE PLAN

DESIGNED BY: LC
DRAWN BY: LC
CHECKED BY: MG

JOB NO.
20-224
SHEET
1 OF 1