



Phase II Drainage Report

QuikTrip Store & Bubble Bath #4267

Lot 2, Plum Creek Commons Unit Two
407 S Wilcox Street, Castle Rock, CO 80104

Prepared for Developer:

QuikTrip Corporation

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Prepared by:

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KH Project No.: 096888068

Prepared: June 5, 2026



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ENGINEER'S CERTIFICATION STATEMENT

I affirm that this report and plan for the Phase II drainage design of Lot 2, Plum Creek Commons Unit Two 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 Manual 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.

SIGNATURE: _____

Jessica McCallum, P.E.
Registered Professional Engineer
State of Colorado No. 59054

TABLE OF CONTENTS

GENERAL LOCATION AND DESCRIPTION	3
SITE LOCATION.....	3
DESCRIPTION OF PROPERTY AND LAND USE	3
DRAINAGE BASINS AND SUB-BASINS	4
MAJOR DRAINAGE BASINS	4
MINOR DRAINAGE BASINS	4
DRAINAGE DESIGN CRITERIA.....	6
REGULATIONS	6
DRAINAGE STUDIES, MASTER PLANS, AND SITE CONSTRAINTS.....	6
HYDROLOGY.....	7
STORAGE AND WATER QUALITY ENHANCEMENT	7
STORMWATER MANAGEMENT FACILITY DESIGN	8
STORMWATER CONVEYANCE FACILITIES	8
STORMWATER STORAGE FACILITIES	8
WATER QUALITY ENHANCEMENT CONTROL MEASURES	9
FLOODPLAIN MODIFICATION	10
GEOTECHNICAL INVESTIGATION AND SUB-SURFACE COLLECTION SYSTEM DESIGN	10
OPERATION AND MAINTENANCE.....	10
ADDITIONAL PERMITTING REQUIREMENTS	11
CONCLUSIONS.....	11
COMPLIANCE WITH STANDARDS.....	11
VARIANCES	11
DRAINAGE CONCEPT.....	12
LIST OF REFERENCES	13

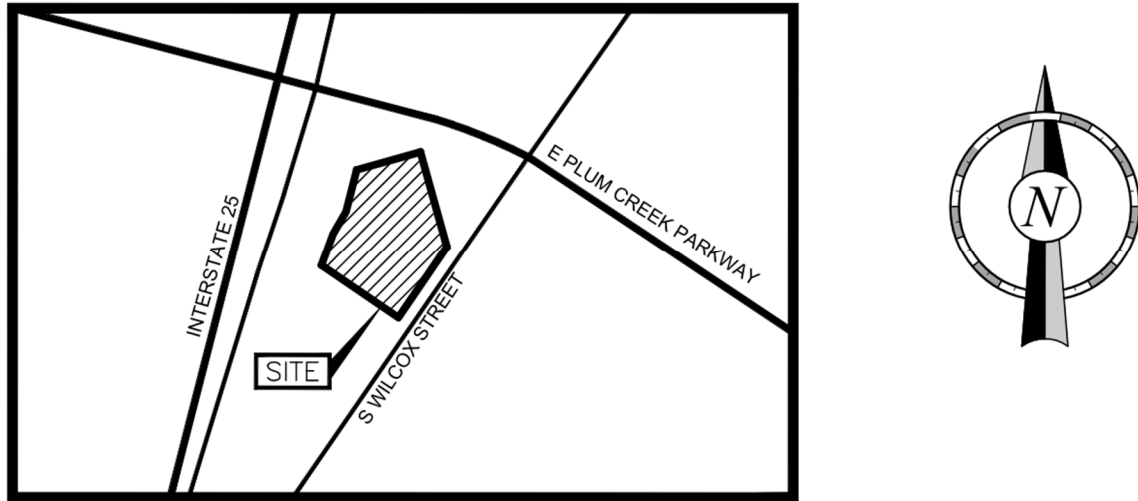
APPENDICES

- Appendix A – Hydrologic Computations
- Appendix B – Hydraulic Computations
- Appendix C – Water Quality Enhancement Best Management Practices
- Appendix D – Referenced Information
- Appendix E – Drainage Maps
- Appendix F – Permanent Water Quality Worksheet
- Appendix G – MS4 Compliance Summary

GENERAL LOCATION AND DESCRIPTION

Site Location

A vicinity map is provided below for reference:



The proposed development is located at 407 South Wilcox Street in Castle Rock, Colorado and is within a portion of the Southwest Quarter of Section 11, Township 8 South, Range 67 West of the 6th P.M., Town of Castle Rock, County of Douglas, State of Colorado. The proposed development is within Lot 2, Plum Creek Commons Unit Two (the "Site") and is bounded to the north by East Plum Creek Parkway and Lot 1, Plum Creek Commons Unit Two (Land Use: Commercial), to the east by South Wilcox Street, to the south by Lot 1, Plum Creek Commons Unit One (Land Use: Commercial), and to the west by Tract B, Plum Creek Commons Unit Two (Land Use: Exempt).

Description of Property and Land Use

The Site is 3.11 acres and features an existing two-story commercial building with the lower level partially below grade. There are paved parking lots and associated drive lanes around the building to the east and north and a gravel lot to the west. The rest of the Site appears to consist of semi-sparse grasses, trees, and shrubs. There is no evidence of recent street construction or repairs. The proposed land use for the Site is commercial, remaining the same as the existing land use.

The north half of the Site generally slopes from south to north at slopes up to 2:1, with the south half sloping from east to west and north to south at slopes up to 2:1. An NRCS Web Soil Survey shows loamy and sandy soils with hydrologic group classifications of Type C and D. The Site has no drainageways within its bounds, although East Plum Creek runs along the west property line. The Site is within Flood Hazard Zones X and AE and within the 100-year floodplain. No significant geologic features are on the Site.

The proposed development will consist of a new fuel station with one detached pump canopy for automobiles, a stand-alone QuikTrip convenience store with private access drives and associated landscaping, sidewalks, utilities, and parking, and a Bubble Bath car wash, and approximately 3.27 acres will be disturbed (the "Project"). Stormwater will

be captured via curb and gutter, routed through an onsite storm sewer, and routed to two proposed underground detention facilities located onsite.

DRAINAGE BASINS AND SUB-BASINS

Major Drainage Basins

The Project lies within the East Plum Creek Watershed Protection District and is directly adjacent to East Plum Creek. There are no off-site flow patterns that impact the Project.

Minor Drainage Basins

The Project was delineated into multiple sub-basins to evaluate the runoff produced by the proposed conditions. The existing and proposed land uses within the sub-basins described in the section below are commercial. Individual sub-basin details such as runoff coefficient calculations and imperviousness percentages, calculated via the rational method, are provided in **Appendix A**, including the estimated 5-year and 100-year peak flows. A detailed summary of each sub-basin is included below. The proposed drainage maps have been provided in **Appendix E** to illustrate the sub-basins. The proposed inlet calculations are provided in **Appendix B**. There are no irrigation facilities that are impacted by the Site drainage.

Sub-basin P1A1 consists of the roof area from the proposed convenience store. Runoff from this sub-basin will be collected by internal roof drains and conveyed via underground storm sewer to the proposed north underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff would overland flow west into the inlet at Design Point A3 in the parking lot.

Sub-Basin P1A2 consists of the proposed fuel canopy. Runoff from this sub-basin will be collected by internal roof drains and conveyed via underground storm sewer to the proposed north underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff would overland flow north into the inlet at Design Point A3 in the parking lot.

Sub-Basin P1A3 consists of the sidewalk and parking areas surrounding the fuel canopy and is comprised of concrete and asphalt. Runoff from this sub-basin will sheet flow to the north to a proposed Denver No. 16 Combination Inlet in sump at Design Point ("DP") A3 that is located within the parking stalls to the north of the fuel canopy and then flow to the proposed north underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff would pond in the parking stalls until it spills north to sub-basin POS-2, eventually being routed offsite along East Plum Creek Parkway.

Sub-Basin P1B1 consists of the roof area from the proposed Bubble Bath car wash. Runoff from this sub-basin will be collected by internal roof drains and conveyed via

underground storm sewer to the proposed south underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff would overland flow north into the inlet at DP B2 within the parking stalls and be routed to the proposed southern underground detention structure.

Sub-Basin P1B2 consists of the asphalt drive aisles and landscaping areas adjacent to the Bubble Bath car wash and QuikTrip convenience store. Runoff from this sub-basin will sheet flow to a proposed 5' Type R Curb Inlet in sump, located within the parking stalls at DP B2. It will then flow to the proposed south underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff will pond within the parking stalls then sheet flow north, crossing the pavement underneath the fuel canopy into Sub-Basin P1A3, where it will be collected by the proposed in-sump inlet at DP A3.

Sub-Basin P1B3 consists of asphalt pavement vacuum stalls and drive aisles with minimal landscape areas located south of the Bubble Bath car wash. Runoff from this sub-basin sheet flows to the proposed singular Denver No. 16 Combination Inlet in sump at DP B3, located at the center of the sub-basin. It will then be routed through the storm sewer system to the proposed south underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff will pond along the curb and gutter at DP B3 then sheet flow southwest, crossing the landscape area and flow into Sub-Basin P1B6, where it will be collected by the proposed in-sump inlet at DP B6.

Sub-Basin P1B4 consists of the asphalt drive aisles and landscape areas to the southeast of the Bubble Bath car wash. Runoff from this sub-basin sheet flows to the southeast corner of the sub-basin along curb and gutter to a proposed Denver No. 16 Combination Inlet in sump at DP B4. It will then flow to the proposed south underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff will pond along the curb and gutter then sheet flow southeast, crossing the landscape area and flow into Sub-Basin P1B5, where it will be collected by the proposed in-sump inlet at DP B5.

Sub-Basin P1B5 consists of the landscape area and asphalt drive aisle at the southeastern corner of the Site. Runoff from this sub-basin sheet flows to the southwest area of the sub-basin to a proposed Denver No. 16 Combination Inlet in-sump at DP B5. It will then flow to the proposed south underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff pond along the curb and gutter then flow southwest, crossing the landscape area and flow into Sub-Basin P1B4, where it will be collected by the proposed in-sump inlet at DP B4.

Sub-Basin P1B6 consists of the landscape area and asphalt drive aisle at the southwestern corner of the Site. Runoff from this sub-basin sheet flows to the southwest

area of the sub-basin to a proposed Denver No. 16 Combination Inlet in-sump at DP B6. It will then flow to the proposed south underground detention structure, eventually outfalling to the existing storm sewer system along East Plum Creek Parkway.

In a clogged condition, runoff will pond along the curb and then sheet flow west into Sub-Basin POS-1.

Sub-Basin POS-1 consists of the western landscape area along the western boundary of the Site. Runoff will sheet flow west and drain onto the offsite neighboring property. The peak 100-year flow to the adjacent property is 2.03 cubic feet per second (“cfs”), which is a decrease from the 9.48 cfs in the existing condition. This sub-basin does not drain to an on-site structural water quality control, but it is impractical to collect the flows from this basin due to existing topography. The sub-basin follows historic drainage patterns.

Sub-Basin POS-2 consists of landscape areas and drive aisles located near the northern entrance of the site. Runoff from this sub-basin sheet flows to the north area of the sub-basin to a proposed 5’ Type R Curb Inlet at DP 2. The peak 100-year flow of this sub-basin is 3.78 cfs, which is a decrease from the 7.86 cfs in the existing condition, and the flow will be collected by an inlet instead of sheet flowing directly onto the adjacent property. This sub-basin does not drain to an on-site structural water quality control, but it is impractical to collect the flows from this basin due to existing topography. The sub-basin follows historic drainage patterns.

Sub-Basin POS-3 consists of off-site landscape areas, concrete sidewalks, and drive aisles located along the eastern entrance of the site and east property line. Runoff will sheet flow northeast to the South Wilcox Street right-of-way. The peak 100-year flow to the South Wilcox Street right-of-way is 1.00 cfs. This sub-basin does not drain to an on-site structural water quality control, but it is impractical to collect the flows from this basin due to existing topography. The sub-basin follows historic drainage patterns.

Existing and proposed drainage maps can be found in **Appendix E**.

DRAINAGE DESIGN CRITERIA

Regulations

The Town of Castle Rock Storm Drainage Design and Technical Criteria Manual (the “SDDTCM”), updated February 2025, was used to develop the drainage design within this report. This SDDTCM refers to Mile High Flood District (“MHFD”); the Urban Storm Drainage Criteria Manual (“USDCM”), Volumes 1-3, updated March 2024, (the “Manual”) was used in conjunction with the SDDTCM.

Drainage Studies, Master Plans, and Site Constraints

The Site is currently developed. Runoff from the existing northeastern portion of the Site drains south to north to the existing storm sewer inlet located along East Plum Creek Parkway. The existing southwestern portion of the Site drains north to south and east to west to offsite unimproved areas to the south and west of the Site.

The Site is within the study area for the East Plum Creek Watershed Master Plan Preliminary Design Report (the “Master Study”). The Master Study conducted a Stream

Stability Assessment adjacent to the Site, and the Site falls within Reach 3. The floodplain of Reach 3 has less preferred wetland plant species and ranges from 200 feet to 400 feet, and there is an area of bridge scour at Wilcox Bridge and Plum Creek Parkway that the Town was currently (at time of Master Study in February 2009) searching for an alternative solution for.

No adjacent properties use the Site for stormwater conveyance in the existing or proposed conditions.

Site constraints of existing topography and the location of open space relative to drive aisles and the ultimate storm sewer outfall generate the need for two separate underground detention structures to meet detention requirements. Additionally, existing topography along the west side of the Site that slopes down to the existing off-site concrete trail and the required cross accesses to the developments to the north and south of the Site create the need for a retaining wall along the west side of the Site.

Hydrology

The rational method was used to determine runoff generated onsite in accordance with SDDTCM Section 6.3. The major and minor storms analyzed were the 100- and 5-year storms, respectively. One-hour point rainfall values used were 1.43 inches for the minor storm and 2.60 inches for the major storm per Section 6.1.1 of the SDDTCM. Rational calculations can be found in **Appendix A**.

MHFD's UD-Detention spreadsheet and the site's watershed characteristics were used to determine the design volumes for the onsite underground detention facilities.

Hydraulics

The Project will construct a private storm sewer network onsite including curb inlets, roof drain networks, and storm sewer pipe. All inlets were sized using the MHFD's UD-Inlet workbook. Storm sewer hydraulics will be modeled against Town Criteria using Bentley StormCAD. All hydraulic calculations will be performed for the major and minor storm events. Results are included in **Appendix B**.

The proposed underground detention facilities were sized using MHFD's UD-Detention spreadsheet to provide water quality and full spectrum detention for portions of the Site. The two underground detention facilities accept flows from the roof drains and storm sewer systems and outflow to the existing inlet and storm sewer system along East Plum Creek Parkway. Release rates from the underground detention facilities will not exceed the historic flows tributary to this existing inlet from the Site, determined via rational calculations of the existing conditions.

Storage and Water Quality Enhancement

Two underground detention facilities are used to manage the runoff generated by the proposed development. Portions of the Project will continue to discharge via sheet flow to adjacent properties and existing storm sewer at reduced peak flow rates relative to existing conditions and following historic drainage patterns. The majority of Project runoff will be collected and conveyed to two proposed underground detention facilities for water quality and full spectrum detention.

In accordance with SDDTCM and the Manual, detention facilities are sized to provide the required Water Quality Capture Volume (“WQCV”), Excess Urban Runoff Volume (“EURV”), and 100-year event volumes. The total required storage volume includes the 100-year detention volume plus an additional volume equal to 0.5 times the WQCV.

The proposed detention facilities are designed to detain and release runoff at rates that do not exceed allowable discharge rates for developed conditions. Detention calculations are provided in **Appendix C**.

The four-step approach to water quality planning is discussed in the Water Quality Enhancement Control Measures section below.

STORMWATER MANAGEMENT FACILITY DESIGN

Stormwater Conveyance Facilities

Runoff generated onsite generally sheet flows across pavement and is captured within drive aisles or parking areas at curb inlets. An underground storm network collects runoff and flows from roof drains and connects to the existing storm sewer to the north of the Site along East Plum Creek Parkway. Sub-basins with this drainage pattern are designated with “P1” in their name.

Some runoff will leave the Project via sheet flow drain onto neighboring properties or be captured by a curb inlet before connecting to the existing storm sewer to the north of the Site along East Plum Creek Parkway without being treated for water quality or detention. This consistent with historic patterns and flow rates. These sub-basins are designated with a “POS” in the name.

Detention calculations are provided in **Appendix C**.

Stormwater Storage Facilities

Two underground detention structures are proposed to provide water quality and full spectrum detention for the Project.

The proposed north underground detention structure will capture runoff from the convenience store roof, fuel canopy, adjacent asphalt areas, and surrounding landscape areas, totaling approximately 0.71 acres. The proposed north underground detention structure will capture runoff from the car wash roof, adjacent asphalt areas, and surrounding landscape areas, totaling approximately 1.32 acres.

Each detention facility is designed in accordance with MHFD full-spectrum detention criteria to control runoff from frequent and major storm events. Release rates are controlled to match or be less than allowable discharge rates for the 5-year and 100-year storm events.

Detention facilities will be privately owned and maintained by the property owner. Drainage easements will be provided should access, inspection, and maintenance by the Town of Castle Rock be necessary.

Water Quality Enhancement Control Measures

The four steps in the water quality design process prescribed in Section 14.1 of the SDDTCM are described below.

1. Reduce Runoff Volume to the Maximum Extent Practicable.

Opportunities to reduce runoff are limited with this Project. Impervious area is generally at the minimum required to make the Project function. Grade changes along the west and north property lines means that portions of the Project in these areas must remain pervious, landscaped areas.

2. Provide Water Quality Capture Volume and Flood Control Detention via Full-Spectrum Detention.

Runoff for the Project is managed through full-spectrum detention.

The proposed drainage system conveys runoff via inlets and storm sewer to two underground detention facilities that provide both water quality and flood control. Each facility is sized per SDDTCM requirements.

Full-spectrum detention is incorporated to control increases in runoff rates associated with developed conditions, particularly during frequent storm events that contribute to channel erosion and degradation. By controlling discharge rates across a range of storm events, the proposed detention facilities reduce the frequency and magnitude of erosive flows in downstream drainageways.

This approach minimizes potential impacts to downstream infrastructure, supports water quality objectives, and reduces the need for future channel stabilization.

Sub-basins POS-1, POS-2, and POS-3 do not drain to the proposed onsite underground water quality and full-spectrum detention facilities. POS-1 contains landscaped area on the west and north sides of the Project, where existing topography makes it impractical to capture the runoff generated by the sub-basin. POS-2 contains landscaped area and a drive aisle that connects to the existing shared access drive to the Site, and existing topography makes it impractical to capture the runoff generated by the sub-basin. POS-3 contains landscaped area, public sidewalk, and the east access to the Site within South Wilcox Road right-of-way, so it is impractical to capture the runoff generated by the sub-basin. Per SDDTCM Section 13.1.5, areas with land disturbance to undeveloped land that will remain undeveloped is able to be excluded from water quality enhancement and full-spectrum detention. Per SDDTCM Section 13.1.4, constrained redevelopment sites, which the Project is categorized as because the existing condition is more than 75% impervious, require that WQCV and detention be provided for a minimum of 50% of the site, and WQCV and detention are provided for 62% (2.03 acres) of the Project.

3. Utilize Stream Channel Stabilization Techniques.

Stabilization techniques will be provided for the adjacent East Plum Creek in the form of stream bank protection.

4. Undertake Source Control.

The proposed land use has potential for illicit discharges. Because this is a proposed gas station and car wash, there is potential for chemicals, oils, and other pollutants to enter the stormwater system. Spill containment measures will include grading away from fuel dispensing areas, covered fueling areas where applicable, and adherence to state and federal spill prevention requirements. The car wash will discharge to the sanitary sewer system and will not enter the storm system. BMP SNOUTs will be utilized at inlets adjacent to fuel dispensing areas to capture any fuel discharge. BMP SNOUTs are water quality devices that allow floatable and sinkable pollution to be removed from stormwater prior to entering the adjacent storm pipe system. The SNOUT hood is installed over the catch basin or curb inlet outlet with a deep sump, the bottom of the hood extends below the pipe invert forming a baffle to trap oils and debris on the surface with heavier solids sinking to the bottom of the sump, and the intermediate layer is forced out of the structure.

Floodplain Modification

The Site is directly adjacent to East Plum Creek floodplain located to the west of the Site, and stream stabilization is proposed. A LOMR for East Plum Creek adjacent to the Site was put into effect in 2019. There are no proposed modifications to the Floodplain or Zone AE since development occurs outside of these Zones and within Zone X.

A floodplain analysis and floodplain development permit will be submitted for.

Geotechnical Investigation and Sub-Surface Collection System Design

No evidence of geological hazards has been identified at the Site. Groundwater was encountered during site analysis at depths of approximately 18 to 23 feet below existing grade. Based on the proposed grading, groundwater is not anticipated to significantly influence the proposed underground detention facilities. Appropriate construction measures may be required if groundwater is encountered during construction.

Operation and Maintenance

All proposed stormwater infrastructure will be owned and maintained by the property owner. QuikTrip Corporation is anticipated to be the property owner prior to construction.

Grass buffers around the perimeter of the Site should be subject to the following maintenance activities:

- Mow and keep free of weeds weekly during the growing season
- Inspect for evidence of erosion monthly and after large rain events
- Verify designed vegetation density monthly
- Ensure irrigation facilities are functioning adequately if vegetation growth issues are present

The underground detention facilities should be subject to the following maintenance activities:

- Inspect for structural defects twice annually
- Remove any trash, debris, and sediment twice annually and after large rain events
- Clean outlet structure twice annually or upon evidence of long draw down times

Good housekeeping, such as keeping the parking lot free of pollutants, trash, and sediment should be ongoing.

The roof drains, inlets, and storm piping will require periodic inspection and maintenance as needed and will fall under the responsibility of the property owner to keep in functional condition.

Additional Permitting Requirements

No additional permits have been identified for this development.

CONCLUSIONS

Compliance with Standards

The drainage design presented in this report was designed in accordance with the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual and the MHFD Urban Storm Drainage Criteria Manual. The Site is within the East Plum Creek drainage basin.

Variances

A variance is requested from SDDTCM Section 13.1.4 for Constrained Redevelopment Sites. The Project qualifies as a Constrained Redevelopment Site because the impervious area in the existing condition exceeds 75%. Because the Project is a redevelopment, it is not feasible to capture and treat 100% of the runoff from the Project due to constraints of existing infrastructure and maintaining access to adjacent properties. Per the standards for Constrained Redevelopment Sites, WQCV and detention is required to be provided for a minimum of 50% of the site, and WQCV and detention are provided for 62% (2.03 acres) of the Project.

A variance is requested from SDDTCM Section 13.1.5 for Sites with Land Disturbance to Undeveloped Land that will Remain Undeveloped, excluded from Water Quality Enhancement and Full-Spectrum Detention. The landscaped areas that will remain undeveloped around the Project perimeter will not be captured and routed to the underground facilities for water quality and full-spectrum detention, and thus, an exclusion is requested per the above Section. It is not practical to capture these areas due to existing topography and proximity to adjacent properties. Historic flow conditions are maintained.

A variance is requested from SDDTCM Section 13.2.3 which states that underground detention is discouraged and allowed only by variance. The Site is constrained by East Plum Creek to the west, which sits approximately 25 feet below the Site in the existing condition, which requires the use of a retaining wall for any significant development on the Site. The steep existing grades and required wall location restricts the available footprint needed to construct a conventional detention pond with appropriate side slopes and setbacks. Construction of a surface facility in this area would introduce potential stability concerns due to the proximity of detention storage to retaining walls. Infiltration based or porous landscape detention alternatives were also evaluated, but this is not feasible due to the potential for saturated soil conditions to adversely impact retaining

wall performance and stability. The soils are Type C and D, which have poor infiltration. Underground detention is proposed as the most practical and least impactful solution and allows the Project to meet water quality standards and detention requirements.

Drainage Concept

The proposed development will collect runoff using roof drains, curb and gutter, inlets, and an underground storm sewer system. Runoff will be conveyed via the underground storm sewer system to two underground detention vaults that provide water quality and full-spectrum detention for the Project.

REFERENCES

Custom Soil Resource Report, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey, April 10, 2026.

East Plum Creek Watershed Master Plan Preliminary Design Report CH2MHILL, February 2009.

Flood Insurance Rate Map, Map Number 08035C0301G, Federal Emergency Management Agency, March 16, 2016.

Storm Drainage Design and Technical Criteria Manual, Castle Rock Water Department, February 2025.

Urban Storm Drainage Criteria Manual, Volumes 1-3, Urban Drainage and Flood Control District, March 2024.

APPENDIX A – HYDROLOGIC COMPUTATIONS

Calculation of Peak Runoff using Rational Method

Designer: RJP
Company: Kimley-Horn & Associates
Date: 5/20/2026
Project: QuikTrip 4267
Location: Castle Rock

MHFD-Rational, Version 3.00 (August 2025)

Cells of this color are for required user-input
 Cells of this color are for optional override values

$$t_i = \frac{0.395(1.1 - C_s)\sqrt{L_i}}{S_i^{0.33}}$$

$$\text{Computed } t_c = t_i + t_t$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Regional } t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

$$\begin{aligned}
 t_{c \text{ minimum}} &= 5 \text{ (urban)} \\
 t_{c \text{ minimum}} &= 10 \text{ (non-urban)}
 \end{aligned}$$

$$\text{Selected } t_c = \max\{t_{\text{minimum}}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Provide input for area, soil type, and imperviousness on the Runoff Coeffs worksheet.

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group(s)	Imperviousness	Runoff Coefficient, C							Overland (Initial) Flow Time					Channelized (Travel) Flow Time							
				WQE & 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Overland Flow Length L _i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S _i (ft/ft)	Overland Flow Time t _i (min)	Channelized Flow Length L _i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S _i (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V _i (ft/sec)	Channelized Flow Time t _i (min)	
E1	1.20	C/D	91.6%	0.76	0.78	0.81	0.83	0.85	0.86	0.88	340.00				0.023	8.05	0.00			0.018	20	2.68	0.00
E2	1.92	C/D	65.0%	0.52	0.56	0.61	0.68	0.71	0.75	0.79	167.00				0.012	11.76	0.00			0.014	20	2.37	0.00
E3	0.16	C/D	54.2%	0.43	0.48	0.53	0.62	0.66	0.71	0.76	15.00				0.010	4.36	0.00			0.010	20	2.00	0.00

Calculation of Peak Runoff using Rational Method

[Select MHFD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website \(click this link\).](#)

	WQE	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1-hour rainfall depth, P1 (in) =		1.06	1.43	1.66		2.26	2.60	

1-hour rainfall depth, P1 (in) =	1.06	1.43	1.66	2.26
	a	b	c	
Rainfall Intensity Equation Coefficients =	28.50	10.00	0.786	
				$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$

$$Q(cfs) = CIA$$

Rainfall Intensity Equation Coefficients =

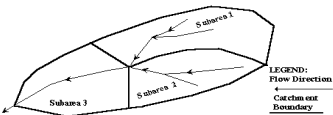
[illegible]

Determination of Runoff Coefficients for Rational Method

Designer: RJP
Company: Kimley-Horn & Associates
Date: 5/20/2026
Project: QuikTrip 4267
Location: Castle Rock

MHFD-Rational, Version 3.00 (August 2025)

Cells of this color are for required user-input
Cells of this color are for optional override values



Provide subcatchment names on the Rational Calcs worksheet to open up the table below.																								
Subcatchment Name	# of Subareas	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness				Runoff Coefficient, C								(Optional) Override Runoff Coefficient, C								Comments
				Imperviousness Source	Imperviousness Category	Calculated Imperviousness	(Optional) Override Imperviousness	WQE & 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	WQE & 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr			
E1	4	1.20	C/D			91.6%	91.6%	0.76	0.78	0.81	0.83	0.85	0.86	0.88	0.76	0.78	0.81	0.83	0.85	0.86	0.88			
		0.05	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65										
		0.02	C/D	Surface Type	Gravel - High Traffic Areas	80%		0.65	0.69	0.72	0.77	0.79	0.81	0.84										
		0.95	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89										
		0.18	C/D	Surface Type	Roofs	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89										
E2	4	1.92	C/D			65.0%	65.0%	0.52	0.56	0.61	0.68	0.71	0.75	0.79	0.52	0.56	0.61	0.68	0.71	0.75	0.79			
		0.65	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65										
		0.59	C/D	Surface Type	Gravel - High Traffic Areas	80%		0.65	0.69	0.72	0.77	0.79	0.81	0.84										
		0.32	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89										
		0.36	C/D	Surface Type	Roofs	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89										
E3	2	0.16	C/D			54.2%	54.2%	0.43	0.48	0.53	0.62	0.66	0.71	0.76	0.43	0.48	0.53	0.62	0.66	0.71	0.76			
		0.09	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65										
		0.07	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89										

Calculation of Peak Runoff using Rational Method

Designer: RJP
Company: Kimley-Horn
Date: 5/20/2026
Project: QuikTrip 4267
Location: Castle Rock, CO

MHFD-Rational, Version 3.00 (August 2025)

Cells of this color are for required user-input

Cells of this color are for optional override values

$$t_i = \frac{0.395(1.1 - C_s)\sqrt{L_i}}{S_i^{0.33}}$$

$$\text{Computed } t_c = t_i + t_t$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Regional } t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

$$t_{c \text{ minimum}} = 5 \text{ (urban)}$$

$$t_{c \text{ minimum}} = 10 \text{ (non-urban)}$$

$$\text{Selected } t_c = \max\{t_{\text{minimum}}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Provide input for area, soil type, and imperviousness on the Runoff Coeffs worksheet.

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group(s)	Imperviousness	Runoff Coefficient, C							Overland (Initial) Flow Time					Channelized (Travel) Flow Time						
				WQE & 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Overland Flow Length L _i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S _i (ft/ft)	Overland Flow Time t _i (min)	Channelized Flow Length L _t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S _t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V _t (ft/sec)	Channelized Flow Time t _t (min)
P1A1	0.16	C/D	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	25.00			0.010	2.62	0.00			0.018	20	2.68	0.00
P1A2	0.17	C/D	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	70.00			0.010	4.39	0.00			0.014	20	2.37	0.00
P1A3	0.38	C/D	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	100.00			0.023	3.99	150.00			0.010	20	2.00	1.25
P1B1	0.10	C/D	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	60.00			0.010	4.07	125.00			0.070	20	5.29	0.39
P1B2	0.59	C/D	79.7%	0.66	0.68	0.72	0.77	0.79	0.81	0.84	25.00			0.020	2.98	230.00			0.010	20	2.00	1.92
P1B3	0.29	C/D	74.6%	0.61	0.64	0.68	0.74	0.76	0.79	0.82	50.00			0.010	5.83	115.00			0.010	20	2.00	0.96
P1B4	0.21	C/D	59.3%	0.48	0.52	0.57	0.65	0.69	0.73	0.77	50.00			0.023	5.64	65.00			0.011	20	2.10	0.52
P1B5	0.07	C/D	62.9%	0.51	0.55	0.59	0.67	0.70	0.74	0.79	32.00			0.022	4.35	40.00			0.020	20	2.83	0.24
P1B6	0.06	C/D	82.0%	0.67	0.70	0.73	0.78	0.80	0.82	0.85	65.00			0.019	4.69	0.00			0.030	20	3.46	0.00
POS-1	0.51	C/D	20.0%	0.14	0.20	0.28	0.43	0.49	0.57	0.65	90.00			0.200	5.75	0.00			0.018	20	2.68	0.00
POS-2	0.57	C/D	66.1%	0.54	0.57	0.62	0.69	0.72	0.75	0.80	50.00			0.030	4.68	92.00			0.040	20	4.00	0.38
POS-3	0.16	C/D	58.9%	0.47	0.51	0.56	0.65	0.68	0.72	0.77	35.00			0.026	4.56	35.00			0.011	20	2.12	0.28

Calculation of Peak Runoff using Rational Method

Designer: _____
Company: _____
Date: _____
Project: _____
Location: _____

[Select MHFD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website \(click this link\)](#)

1-hour rainfall depth, P1 (in) =

WQE	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
	1.06	1.43	1.66		2.26	2.60	
	a	b	c				

Rainfall Intensity Equation Coefficients =

28.50	10.00	0.786
-------	-------	-------

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

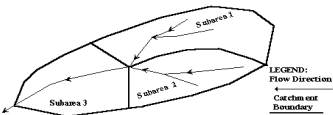
Subcatchment Name	Time of Concentration				Rainfall Intensity, I (in/hr)								Peak Flow, Q (cfs)							
	Computed t _c (min)	Regional t _c (min)	Selected t _c (min)	(Optional) Override t _c (min)	WQE	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	WQE	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
P1A1	2.62	9.85	5.00			3.60	4.85	5.63		7.67	8.82			0.45	0.63	0.75		1.06	1.23	
P1A2	4.39	9.85	5.00			3.60	4.85	5.63		7.67	8.82			0.48	0.67	0.79		1.12	1.31	
P1A3	5.24	10.97	5.24			3.55	4.79	5.56		7.57	8.71			1.06	1.47	1.75		2.48	2.89	
P1B1	4.46	10.20	5.00			3.60	4.85	5.63		7.67	8.82			0.28	0.39	0.47		0.66	0.77	
P1B2	4.90	14.34	5.00			3.60	4.85	5.63		7.67	8.82			1.39	1.96	2.39		3.56	4.22	
P1B3	6.79	14.30	6.79			3.29	4.44	5.15		7.02	8.07			0.58	0.82	1.01		1.53	1.83	
P1B4	6.16	16.52	6.16			3.39	4.57	5.31		7.23	8.32			0.34	0.50	0.63		1.04	1.27	
P1B5	4.59	15.58	5.00			3.60	4.85	5.63		7.67	8.82			0.13	0.19	0.23		0.38	0.46	
P1B6	4.69	12.06	5.00			3.60	4.85	5.63		7.67	8.82			0.15	0.22	0.26		0.39	0.46	
POS-1	5.75	22.60	10.00			2.87	3.87	4.49		6.11	7.03			0.20	0.39	0.64		1.53	2.03	
POS-2	5.06	15.19	5.06			3.58	4.83	5.61		7.64	8.79			1.10	1.58	1.98		3.13	3.78	
POS-3	4.84	16.31	5.00			3.60	4.85	5.63		7.67	8.82			0.27	0.40	0.51		0.84	1.02	

Determination of Runoff Coefficients for Rational Method

Designer: RJP
Company: Kimley-Horn
Date: 5/20/2026
Project: QuikTrip 4267
Location: Castle Rock, CO

MHFD-Rational, Version 3.00 (August 2025)

Cells of this color are for required user-input
Cells of this color are for optional override values



Provide subcatchment names on the Rational Calcs worksheet to open up the table below.																							
Subcatchment Name	# of Subareas	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness				Runoff Coefficient, C							(Optional) Override Runoff Coefficient, C								Comments
				Imperviousness Source	Imperviousness Category	Calculated Imperviousness	(Optional) Override Imperviousness	WQFE & 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	WQFE & 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr		
P1A1	1	0.16	C/D			95.0%	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	0.79	0.81	0.83	0.85	0.86	0.87	0.89		
		0.16	C/D	Surface Type	Roofs	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1A2	1	0.17	C/D			95.0%	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	0.79	0.81	0.83	0.85	0.86	0.87	0.89		
		0.17	C/D	Surface Type	Roofs	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1A3	1	0.38	C/D			95.0%	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	0.79	0.81	0.83	0.85	0.86	0.87	0.89		
		0.38	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1B1	1	0.10	C/D			95.0%	95.0%	0.79	0.81	0.83	0.85	0.86	0.87	0.89	0.79	0.81	0.83	0.85	0.86	0.87	0.89		
		0.10	C/D	Surface Type	Roofs	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1B2	2	0.59	C/D			79.7%	79.7%	0.66	0.68	0.72	0.77	0.79	0.81	0.84	0.66	0.68	0.72	0.77	0.79	0.81	0.84		
		0.12	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
		0.47	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1B3	2	0.29	C/D			74.6%	74.6%	0.61	0.64	0.68	0.74	0.76	0.79	0.82	0.61	0.64	0.68	0.74	0.76	0.79	0.82		
		0.08	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
		0.21	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1B4	2	0.21	C/D			59.3%	59.3%	0.48	0.52	0.57	0.65	0.69	0.73	0.77	0.48	0.52	0.57	0.65	0.69	0.73	0.77		
		0.10	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
		0.11	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1B5	2	0.07	C/D			62.9%	62.9%	0.51	0.55	0.59	0.67	0.70	0.74	0.79	0.51	0.55	0.59	0.67	0.70	0.74	0.79		
		0.03	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
		0.04	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
P1B6	2	0.06	C/D			82.0%	82.0%	0.67	0.70	0.73	0.78	0.80	0.82	0.85	0.67	0.70	0.73	0.78	0.80	0.82	0.85		
		0.01	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
		0.05	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
POS-1	1	0.51	C/D			20.0%	20.0%	0.14	0.20	0.28	0.43	0.49	0.57	0.65	0.14	0.20	0.28	0.43	0.49	0.57	0.65		
		0.51	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
POS-2	2	0.57	C/D			66.1%	66.1%	0.54	0.57	0.62	0.69	0.72	0.75	0.80	0.54	0.57	0.62	0.69	0.72	0.75	0.80		
		0.22	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
		0.35	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									
POS-3	2	0.16	C/D			58.9%	58.9%	0.47	0.51	0.56	0.65	0.68	0.72	0.77	0.47	0.51	0.56	0.65	0.68	0.72	0.77		
		0.08	C/D	Surface Type	Disturbed Soil	20%		0.14	0.20	0.28	0.43	0.49	0.57	0.65									
		0.08	C/D	Surface Type	Roadways and Paved Streets	95%		0.79	0.81	0.83	0.85	0.86	0.87	0.89									

APPENDIX B – HYDRAULIC COMPUTATIONS

INLET MANAGEMENT

Project: QuikTrip 4267

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	P1A3	P1B2
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	In Sump	In Sump
Inlet Type	Denver No. 16 Combination	CDOT Type R Curb Opening
Number of Inlet Units	1	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	1.47	1.96
Major Peak Flow, Q (cfs)	2.89	4.22

Bypass (Carry-Over) Flow from Upstream

Inlets must be organized from upstream (left) to downstream (right) in order for

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received
Bypass Flow Description (Optional):		
Minor Bypass Flow Received, Q_b (cfs)	0.00	0.00
Major Bypass Flow Received, Q_b (cfs)	0.00	0.00

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	1.47	1.96
Major Total Design Peak Flow, Q (cfs)	2.89	4.22
Minor Inlet Interception Capacity, Q_a (cfs)	5.56	5.38
Major Inlet Interception Capacity, Q_a (cfs)	5.56	5.38
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A
Minor Flow Capture Percentage, C%	100%	100%
Major Flow Capture Percentage, C%	100%	100%

INLET MANAGEMENT

Project: QuikTrip 4267

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	P1B3	P1B4
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	In Sump	In Sump
Inlet Type	Denver No. 16 Combination	Denver No. 16 Combination
Number of Inlet Units	1	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.82	0.50
Major Peak Flow, Q (cfs)	1.83	1.27

Bypass (Carry-Over) Flow from Upstream

bypass flows to be linked.

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received
Bypass Flow Description (Optional):		
Minor Bypass Flow Received, Q_b (cfs)	0.00	0.00
Major Bypass Flow Received, Q_b (cfs)	0.00	0.00

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.82	0.50
Major Total Design Peak Flow, Q (cfs)	1.83	1.27
Minor Inlet Interception Capacity, Q_a (cfs)	5.56	1.87
Major Inlet Interception Capacity, Q_a (cfs)	5.56	1.87
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A
Minor Flow Capture Percentage, C%	100%	100%
Major Flow Capture Percentage, C%	100%	100%

INLET MANAGEMENT

Project: QuikTrip 4267

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	P1B5	P1B6
Inlet Application (Street or Area)	STREET	STREET
Hydraulic Condition	In Sump	In Sump
Inlet Type	Denver No. 16 Combination	Denver No. 16 Combination
Number of Inlet Units	1	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	0.19	0.22
Major Peak Flow, Q (cfs)	0.46	0.46

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received
Bypass Flow Description (Optional):		
Minor Bypass Flow Received, Q_b (cfs)	0.00	0.00
Major Bypass Flow Received, Q_b (cfs)	0.00	0.00

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	0.19	0.22
Major Total Design Peak Flow, Q (cfs)	0.46	0.46
Minor Inlet Interception Capacity, Q_a (cfs)	2.80	5.56
Major Inlet Interception Capacity, Q_a (cfs)	2.80	5.56
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A
Minor Flow Capture Percentage, C%	100%	100%
Major Flow Capture Percentage, C%	100%	100%

INLET MANAGEMENT

Project: QuikTrip 4267

Minor: 5-year

Major: 100-year

Worksheet Protected

INLET NAME	POS-2
Inlet Application (Street or Area)	STREET
Hydraulic Condition	On Grade
Inlet Type	CDOT Type R Curb Opening
Number of Inlet Units	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	1.58
Major Peak Flow, Q (cfs)	3.78

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	
Bypass Flow Description (Optional):	
Minor Bypass Flow Received, Q_b (cfs)	
Major Bypass Flow Received, Q_b (cfs)	

CALCULATED OUTPUT

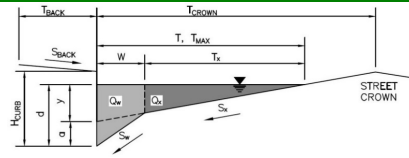
Minor Total Design Peak Flow, Q (cfs)	1.58
Major Total Design Peak Flow, Q (cfs)	3.78
Minor Inlet Interception Capacity, Q_a (cfs)	1.49
Major Inlet Interception Capacity, Q_a (cfs)	2.58
Minor Flow Bypassed Downstream, Q_b (cfs)	0.09
Major Flow Bypassed Downstream, Q_b (cfs)	1.20
Minor Flow Capture Percentage, C%	94%
Major Flow Capture Percentage, C%	68%

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

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

Project: QuikTrip 4267

Inlet ID: P1A3

**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)

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)

$T_{BACK} =$	0.0	ft
$S_{BACK} =$		ft/ft
$n_{BACK} =$	0.012	

$H_{CURB} =$	6.00	inches
$T_{CROWN} =$	50.0	ft
$W =$	2.00	ft
$S_x =$	0.030	ft/ft
$S_y =$	0.083	ft/ft
$S_0 =$	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	
$T_{MAX} =$	25.0	25.0	ft
$d_{MAX} =$	6.0	6.0	inches

☐
☐

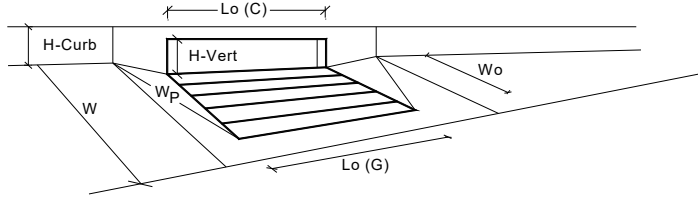
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

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

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)

Type of Inlet Denver No. 16 Combination
 Local Depression (additional to continuous gutter depression 'a' from above)
 Number of Unit Inlets (Grate or Curb Opening)
 Water Depth at Flowline (outside of local depression)

Grate Information

Length of a Unit Grate
 Width of a Unit Grate
 Open Area Ratio for a Grate (typical values 0.15-0.90)
 Clogging Factor for a Single Grate (typical value 0.50 - 0.70)
 Grate Weir Coefficient (typical value 2.15 - 3.60)
 Grate Orifice Coefficient (typical value 0.60 - 0.80)

Curb Opening Information

Length of a Unit Curb Opening
 Height of Vertical Curb Opening in Inches
 Height of Curb Orifice Throat in Inches
 Angle of Throat
 Side Width for Depression Pan (typically the gutter width of 2 feet)
 Clogging Factor for a Single Curb Opening (typical value 0.10)
 Curb Opening Weir Coefficient (typical value 2.3-3.7)
 Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)

Low Head Performance Reduction (Calculated)

Depth for Grate Midwidth
 Depth for Curb Opening Weir Equation
 Grated Inlet Performance Reduction Factor for Long Inlets
 Curb Opening Performance Reduction Factor for Long Inlets
 Combination Inlet Performance Reduction Factor for Long Inlets

Total Inlet Interception Capacity (assumes clogged condition)

Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)

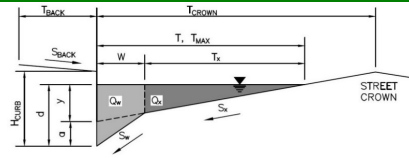
	MINOR	MAJOR	
Type =	Denver No. 16 Combination		
a _{local} =	2.00	2.00	inches
No =	1	1	
Ponding Depth =	6.0	6.0	inches
	MINOR	MAJOR	Override Depths
L _o (G) =	3.00	3.00	feet
W _o =	1.73	1.73	feet
A _{ratio} =	0.31	0.31	
C _f (G) =	0.50	0.50	
C _w (G) =	3.60	3.60	
C _o (G) =	0.60	0.60	
	MINOR	MAJOR	
L _o (C) =	3.00	3.00	feet
H _{vert} =	6.50	6.50	inches
H _{throat} =	5.25	5.25	inches
Theta =	0.00	0.00	degrees
W _p =	2.00	2.00	feet
C _f (C) =	0.10	0.10	
C _w (C) =	3.70	3.70	
C _o (C) =	0.66	0.66	
	MINOR	MAJOR	
d _{Grate} =	0.52	0.52	ft
d _{Curb} =	0.33	0.33	ft
RF _{Grate} =	0.94	0.94	
RF _{Curb} =	N/A	N/A	
RF _{Combination} =	0.94	0.94	
	MINOR	MAJOR	
Q _s =	5.6	5.6	cfs
Q _{PEAK REQUIRED} =	1.5	2.9	cfs

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

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

Project: QuikTrip 4267

Inlet ID: P1B2

**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)

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)

$T_{BACK} =$	10.0	ft
$S_{BACK} =$	0.250	ft/ft
$n_{BACK} =$	0.012	

$H_{CURB} =$	6.00	inches
$T_{CROWN} =$	61.0	ft
$W =$	2.00	ft
$S_x =$	0.013	ft/ft
$S_w =$	0.083	ft/ft
$S_0 =$	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	
$T_{MAX} =$	30.0	30.0	ft
$d_{MAX} =$	6.0	6.0	inches

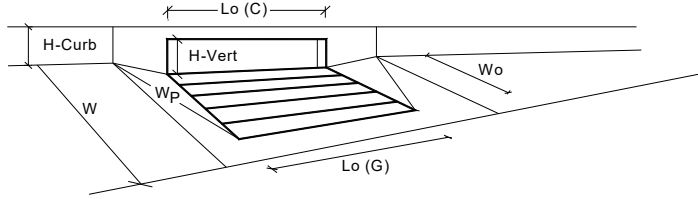
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

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

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



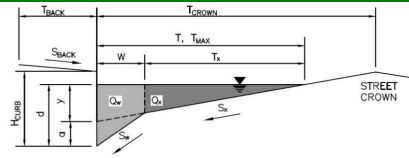
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
<u>Grate Information</u>		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	
<u>Curb Opening Information</u>		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	
<u>Low Head Performance Reduction (Calculated)</u>		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} =	2.0	4.2	cfs

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

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

Project: QuikTrip 4267

Inlet ID: P1B3

**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)

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)

$T_{BACK} =$	25.0	ft
$S_{BACK} =$	0.040	ft/ft
$n_{BACK} =$	0.012	

$H_{CURB} =$	6.00	inches
$T_{CROWN} =$	50.0	ft
$W =$	2.00	ft
$S_x =$	0.040	ft/ft
$S_w =$	0.083	ft/ft
$S_0 =$	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	
$T_{MAX} =$	20.0	20.0	ft
$d_{MAX} =$	6.0	6.0	inches

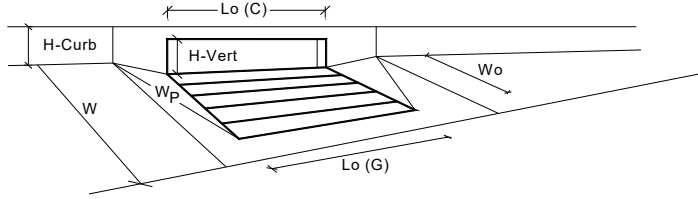
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

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

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)

Type of Inlet Denver No. 16 Combination
 Local Depression (additional to continuous gutter depression 'a' from above)
 Number of Unit Inlets (Grate or Curb Opening)
 Water Depth at Flowline (outside of local depression)

Grate Information

Length of a Unit Grate
 Width of a Unit Grate
 Open Area Ratio for a Grate (typical values 0.15-0.90)
 Clogging Factor for a Single Grate (typical value 0.50 - 0.70)
 Grate Weir Coefficient (typical value 2.15 - 3.60)
 Grate Orifice Coefficient (typical value 0.60 - 0.80)

Curb Opening Information

Length of a Unit Curb Opening
 Height of Vertical Curb Opening in Inches
 Height of Curb Orifice Throat in Inches
 Angle of Throat
 Side Width for Depression Pan (typically the gutter width of 2 feet)
 Clogging Factor for a Single Curb Opening (typical value 0.10)
 Curb Opening Weir Coefficient (typical value 2.3-3.7)
 Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)

Low Head Performance Reduction (Calculated)

Depth for Grate Midwidth
 Depth for Curb Opening Weir Equation
 Grated Inlet Performance Reduction Factor for Long Inlets
 Curb Opening Performance Reduction Factor for Long Inlets
 Combination Inlet Performance Reduction Factor for Long Inlets

Total Inlet Interception Capacity (assumes clogged condition)

Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)

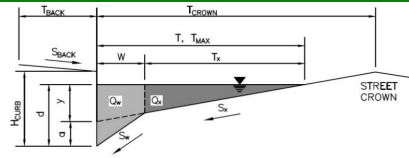
	MINOR	MAJOR	
Type =	Denver No. 16 Combination		
a _{local} =	2.00	2.00	inches
No =	1	1	
Ponding Depth =	6.0	6.0	inches
	MINOR	MAJOR	Override Depths
L _o (G) =	3.00	3.00	feet
W _o =	1.73	1.73	feet
A _{ratio} =	0.31	0.31	
C _f (G) =	0.50	0.50	
C _w (G) =	3.60	3.60	
C _o (G) =	0.60	0.60	
	MINOR	MAJOR	
L _o (C) =	3.00	3.00	feet
H _{vert} =	6.50	6.50	inches
H _{throat} =	5.25	5.25	inches
Theta =	0.00	0.00	degrees
W _p =	2.00	2.00	feet
C _f (C) =	0.10	0.10	
C _w (C) =	3.70	3.70	
C _o (C) =	0.66	0.66	
	MINOR	MAJOR	
d _{Grate} =	0.52	0.52	ft
d _{Curb} =	0.33	0.33	ft
RF _{Grate} =	0.94	0.94	
RF _{Curb} =	N/A	N/A	
RF _{Combination} =	0.94	0.94	
	MINOR	MAJOR	
Q _s =	5.6	5.6	cfs
Q _{PEAK REQUIRED} =	0.8	1.8	cfs

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

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

Project: QuikTrip 4267

Inlet ID: P1B4

**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)

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)

$T_{BACK} =$	5.0	ft
$S_{BACK} =$	0.335	ft/ft
$n_{BACK} =$	0.012	

$H_{CURB} =$	6.00	inches
$T_{CROWN} =$	31.0	ft
$W =$	2.00	ft
$S_x =$	0.017	ft/ft
$S_w =$	0.083	ft/ft
$S_0 =$	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	
$T_{MAX} =$	15.0	15.0	ft
$d_{MAX} =$	6.0	6.0	inches

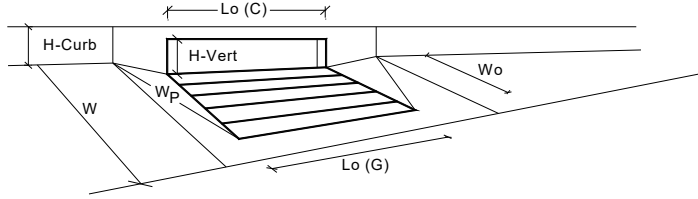
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

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

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)

Type of Inlet Denver No. 16 Combination
 Local Depression (additional to continuous gutter depression 'a' from above)
 Number of Unit Inlets (Grate or Curb Opening)
 Water Depth at Flowline (outside of local depression)

Grate Information

Length of a Unit Grate
 Width of a Unit Grate
 Open Area Ratio for a Grate (typical values 0.15-0.90)
 Clogging Factor for a Single Grate (typical value 0.50 - 0.70)
 Grate Weir Coefficient (typical value 2.15 - 3.60)
 Grate Orifice Coefficient (typical value 0.60 - 0.80)

Curb Opening Information

Length of a Unit Curb Opening
 Height of Vertical Curb Opening in Inches
 Height of Curb Orifice Throat in Inches
 Angle of Throat
 Side Width for Depression Pan (typically the gutter width of 2 feet)
 Clogging Factor for a Single Curb Opening (typical value 0.10)
 Curb Opening Weir Coefficient (typical value 2.3-3.7)
 Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)

Low Head Performance Reduction (Calculated)

Depth for Grate Midwidth
 Depth for Curb Opening Weir Equation
 Grated Inlet Performance Reduction Factor for Long Inlets
 Curb Opening Performance Reduction Factor for Long Inlets
 Combination Inlet Performance Reduction Factor for Long Inlets

Total Inlet Interception Capacity (assumes clogged condition)

Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)

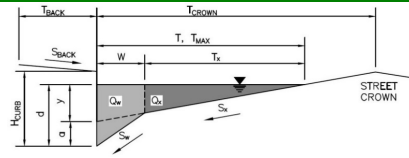
	MINOR	MAJOR	
Type =	Denver No. 16 Combination		
a_{local} =	2.00	2.00	inches
No =	1	1	
Ponding Depth =	4.1	4.1	inches
	MINOR	MAJOR	Override Depths
L_o (G) =	3.00	3.00	feet
W_o =	1.73	1.73	feet
A_{ratio} =	0.31	0.31	
C_f (G) =	0.50	0.50	
C_w (G) =	3.60	3.60	
C_o (G) =	0.60	0.60	
	MINOR	MAJOR	
L_o (C) =	3.00	3.00	feet
H_{vert} =	6.50	6.50	inches
H_{throat} =	5.25	5.25	inches
Theta =	0.00	0.00	degrees
W_p =	2.00	2.00	feet
C_f (C) =	0.10	0.10	
C_w (C) =	3.70	3.70	
C_o (C) =	0.66	0.66	
	MINOR	MAJOR	
d_{Grate} =	0.36	0.36	ft
d_{Curb} =	0.17	0.17	ft
RF_{Grate} =	0.63	0.63	
RF_{Curb} =	N/A	N/A	
$RF_{Combination}$ =	0.63	0.63	
	MINOR	MAJOR	
Q_s =	1.9	1.9	cfs
$Q_{PEAK REQUIRED}$ =	0.5	1.3	cfs

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

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

Project: QuikTrip 4267

Inlet ID: P1B5

**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)

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)

T_{BACK}	=	0.0	ft
S_{BACK}	=		ft/ft
n_{BACK}	=	0.012	

H_{CURB}	=	6.00	inches
T_{CROWN}	=	24.0	ft
W	=	2.00	ft
S_X	=	0.022	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}	=	12.0	12.0	ft
d_{MAX}	=	6.0	6.0	inches
		☐	☐	

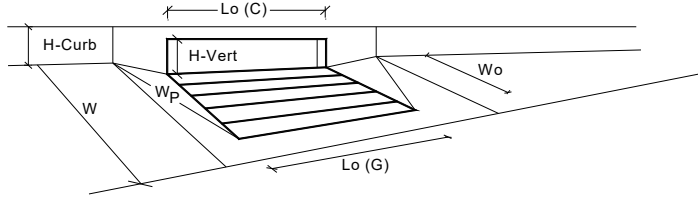
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

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

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



Design Information (Input)

Type of Inlet Denver No. 16 Combination
 Local Depression (additional to continuous gutter depression 'a' from above)
 Number of Unit Inlets (Grate or Curb Opening)
 Water Depth at Flowline (outside of local depression)

Grate Information

Length of a Unit Grate
 Width of a Unit Grate
 Open Area Ratio for a Grate (typical values 0.15-0.90)
 Clogging Factor for a Single Grate (typical value 0.50 - 0.70)
 Grate Weir Coefficient (typical value 2.15 - 3.60)
 Grate Orifice Coefficient (typical value 0.60 - 0.80)

Curb Opening Information

Length of a Unit Curb Opening
 Height of Vertical Curb Opening in Inches
 Height of Curb Orifice Throat in Inches
 Angle of Throat
 Side Width for Depression Pan (typically the gutter width of 2 feet)
 Clogging Factor for a Single Curb Opening (typical value 0.10)
 Curb Opening Weir Coefficient (typical value 2.3-3.7)
 Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)

Low Head Performance Reduction (Calculated)

Depth for Grate Midwidth
 Depth for Curb Opening Weir Equation
 Grated Inlet Performance Reduction Factor for Long Inlets
 Curb Opening Performance Reduction Factor for Long Inlets
 Combination Inlet Performance Reduction Factor for Long Inlets

Total Inlet Interception Capacity (assumes clogged condition)

Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)

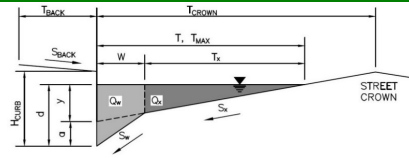
	MINOR	MAJOR	
Type =	Denver No. 16 Combination		
a _{local} =	2.00	2.00	inches
No =	1	1	
Ponding Depth =	4.6	4.6	inches
	MINOR	MAJOR	Override Depths
L _o (G) =	3.00	3.00	feet
W _o =	1.73	1.73	feet
A _{ratio} =	0.31	0.31	
C _f (G) =	0.50	0.50	
C _w (G) =	3.60	3.60	
C _o (G) =	0.60	0.60	
	MINOR	MAJOR	
L _o (C) =	3.00	3.00	feet
H _{vert} =	6.50	6.50	inches
H _{throat} =	5.25	5.25	inches
Theta =	0.00	0.00	degrees
W _p =	2.00	2.00	feet
C _f (C) =	0.10	0.10	
C _w (C) =	3.70	3.70	
C _o (C) =	0.66	0.66	
	MINOR	MAJOR	
d _{Grate} =	0.41	0.41	ft
d _{Curb} =	0.22	0.22	ft
RF _{Grate} =	0.72	0.72	
RF _{Curb} =	N/A	N/A	
RF _{Combination} =	0.72	0.72	
	MINOR	MAJOR	
Q _s =	2.8	2.8	cfs
Q _{PEAK REQUIRED} =	0.2	0.5	cfs

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

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

Project: QuikTrip 4267

Inlet ID: P1B6

**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)

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)

T_{BACK}	=	3.5	ft
S_{BACK}	=	0.201	ft/ft
n_{BACK}	=	0.012	

H_{CURB}	=	6.00	inches
T_{CROWN}	=	40.0	ft
W	=	2.00	ft
S_x	=	0.024	ft/ft
S_w	=	0.083	ft/ft
S_0	=	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}	20.0	20.0	ft
d_{MAX}	6.0	6.0	inches

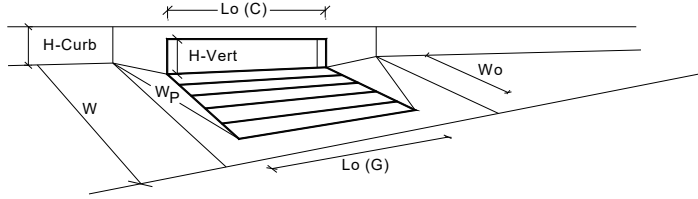
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
Q_{allow}	SUMP	SUMP	cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



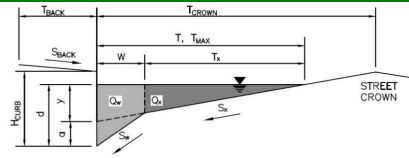
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	Denver No. 16 Combination	Type =	Denver No. 16 Combination		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
<u>Grate Information</u>		MINOR		MAJOR	
Length of a Unit Grate		L _o (G) =	3.00	3.00	feet
Width of a Unit Grate		W _o =	1.73	1.73	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	0.31	0.31	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _f (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	3.60	3.60	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	0.60	0.60	
<u>Curb Opening Information</u>		MINOR		MAJOR	
Length of a Unit Curb Opening		L _o (C) =	3.00	3.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.50	6.50	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	5.25	5.25	inches
Angle of Throat		Theta =	0.00	0.00	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) =	3.70	3.70	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.66	0.66	
<u>Low Head Performance Reduction (Calculated)</u>		MINOR		MAJOR	
Depth for Grate Midwidth		d _{Grate} =	0.52	0.52	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.33	0.33	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	0.94	0.94	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	0.94	0.94	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _s =	5.6	5.6	cfs
		Q _{PEAK REQUIRED} =	0.2	0.5	cfs

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

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

Project: QuikTrip 4267

Inlet ID: POS-2

**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)

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)

T_{BACK}	=	0.0	ft
S_{BACK}	=		ft/ft
n_{BACK}	=	0.020	

H_{CURB}	=	6.00	inches
T_{CROWN}	=	24.0	ft
W	=	2.00	ft
S_X	=	0.031	ft/ft
S_W	=	0.083	ft/ft
S_O	=	0.042	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

☐ ☐

MINOR STORM Allowable Capacity is based on Depth Criterion

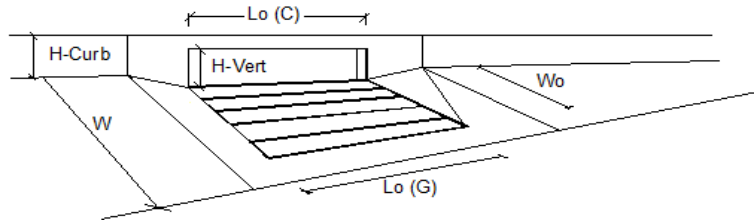
MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q_{allow}	12.3	12.3	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 1.58 cfs on sheet 'Inlet Management'**Major storm max. allowable capacity GOOD - greater than the design peak flow of 3.78 cfs on sheet 'Inlet Management'**

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 6.00 (August 2025)

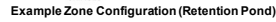


Design Information (Input)		MINOR		MAJOR
Type of Inlet	CDOT Type R Curb Opening ▼	Type =	CDOT Type R Curb Opening	
Local Depression (additional to continuous gutter depression 'a')		a _{LOCAL} =	3.0	3.0 inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1
Length of a Single Unit Inlet (Grate or Curb Opening)		L _u =	5.00	5.00 ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _u =	N/A	N/A ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _f (G) =	N/A	N/A
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _f (C) =	0.10	0.10
Street Hydraulics: OK - Q < Allowable Street Capacity		MINOR		MAJOR
Total Inlet Interception Capacity		Q _s =	1.5	2.6 cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.1	1.2 cfs
Capture Percentage = Q _s /Q _o		C% =	94	68 %

APPENDIX C – WATER QUALITY ENHANCEMENT BEST MANAGEMENT PRACTICES

MHFD-Detention, Version 4.06 (July 2022)

Basin ID: North Underground Detention Structure

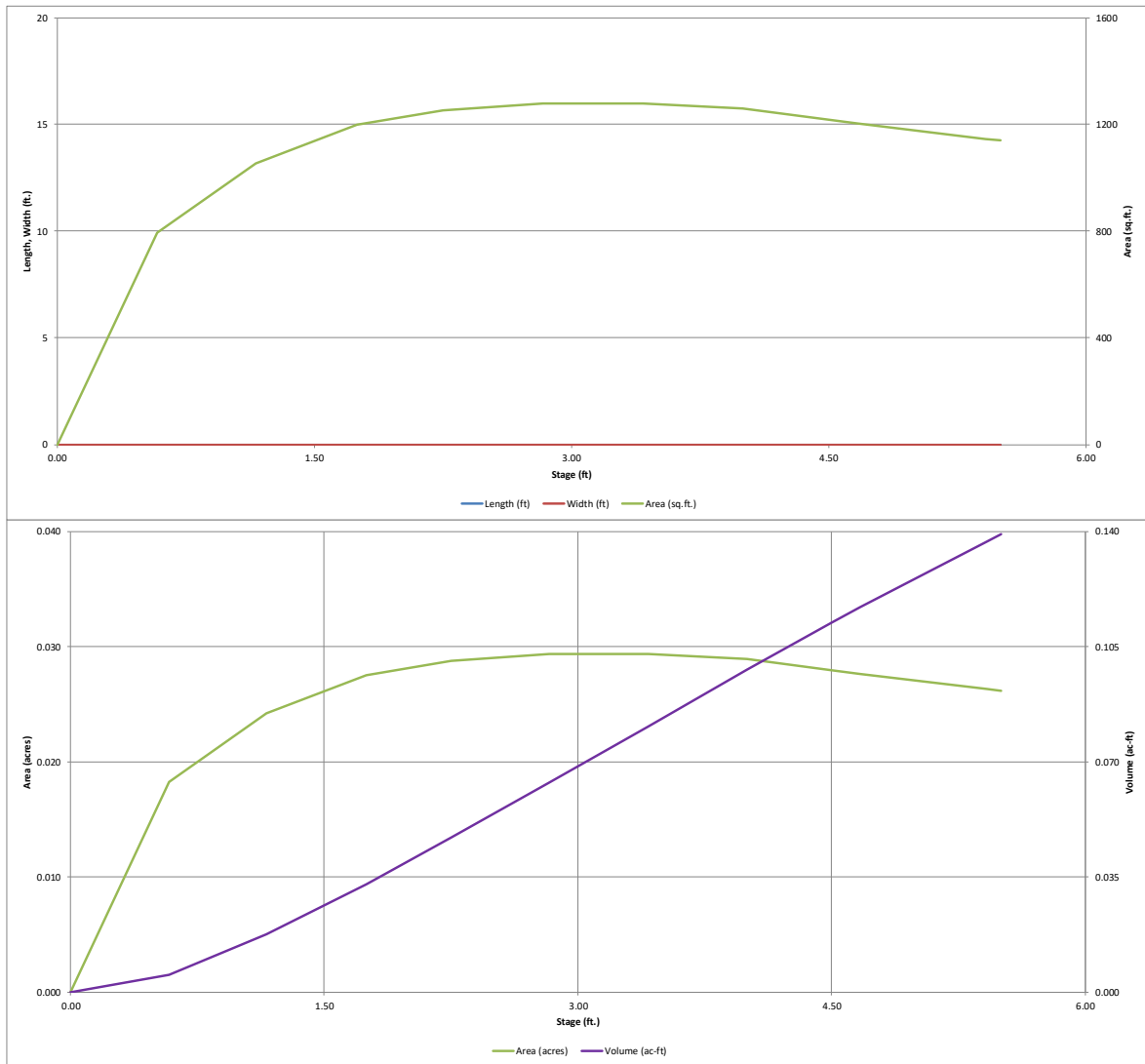


	acre-feet
	acre-feet
1.06	inches
1.43	inches
1.66	inches
	inches
2.26	inches
2.60	inches
	inches

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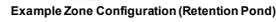
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)



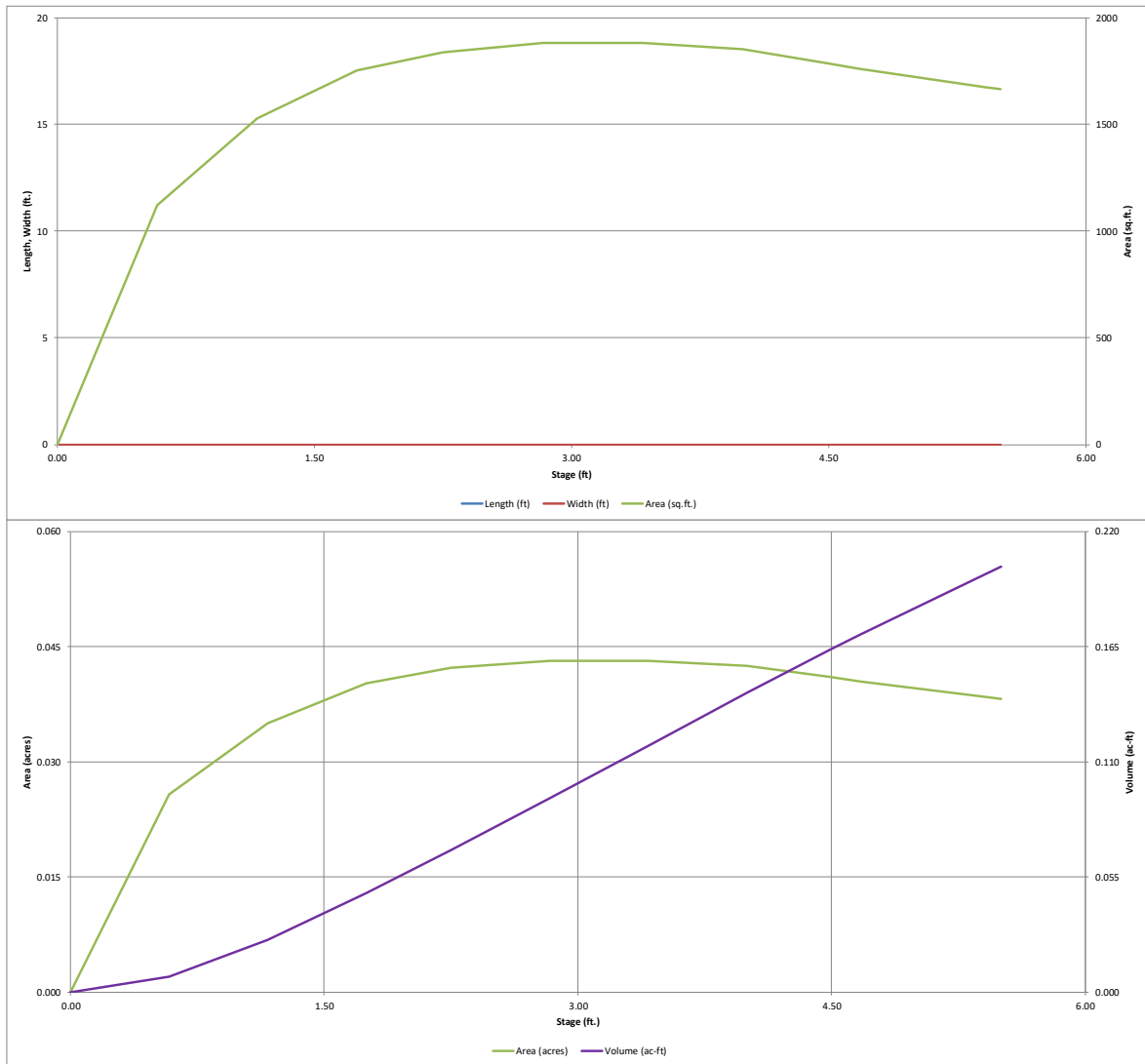
MHFD-Detention, Version 4.06 (July 2022)

Basin ID: South Underground Detention Structure

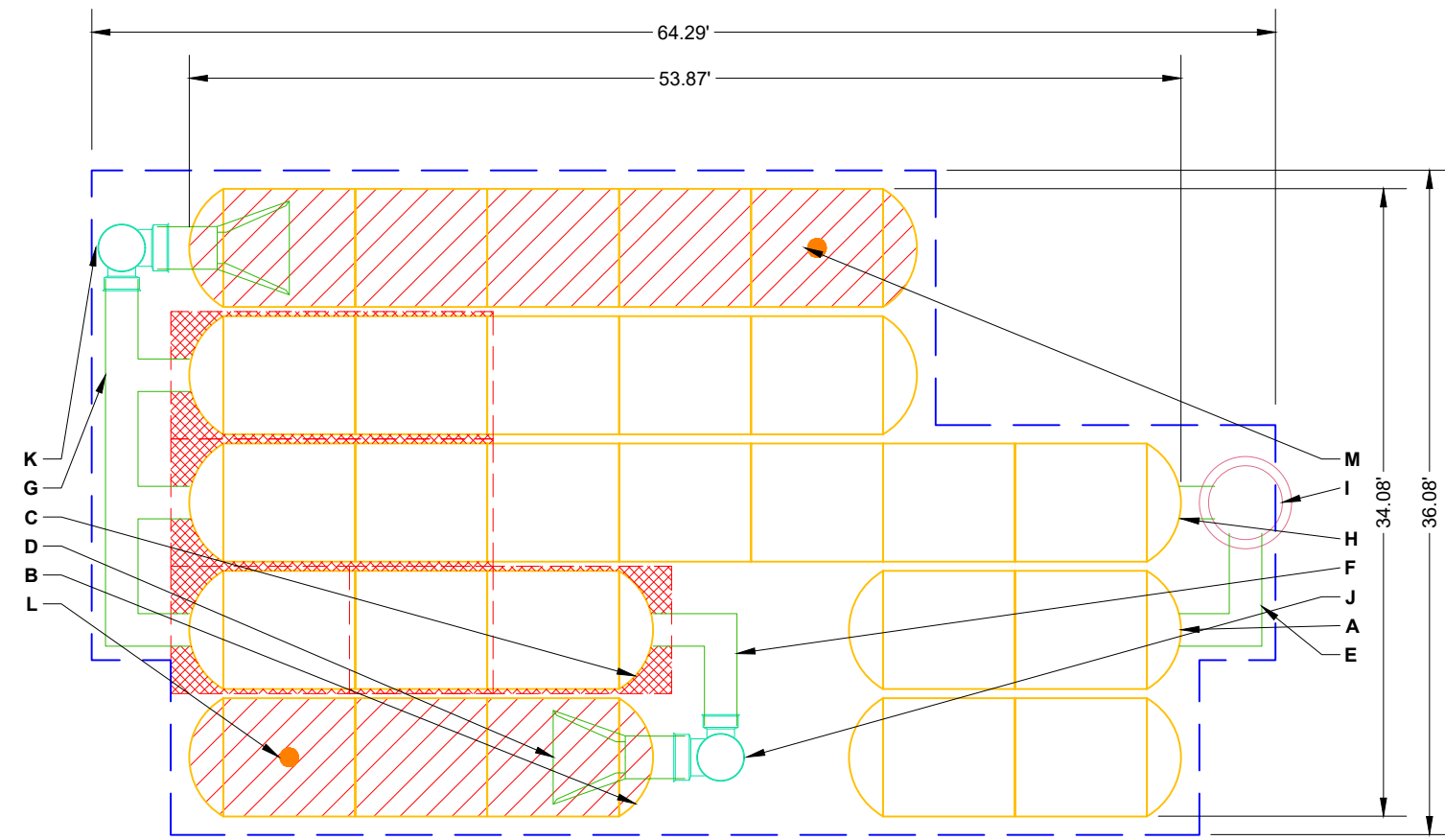
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DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)



PROPOSED LAYOUT: NORTH BASIN		CONCEPTUAL ELEVATIONS: NORTH BASIN						*INVERT ABOVE BASE OF CHAMBER	
	BASIN			PART TYPE	ITEM ON LAYOUT	DESCRIPTION		INVERT	MAX FLOW
27	I STORMWTH MC-3500 CHAMBERS	MINIMUM ALLOWABLE GRADE (UNPAVED WITH TRAFFIC)	12.50		A	18" BOTTOM PRE-CORED END CAP, PART# MC3500IEPP18BC / TYP OF ALL 18" BOTTOM CONNECTIONS			
14	I STORMWTH MC-3500 END CAPS	MINIMUM ALLOWABLE GRADE (UNPAVED NO TRAFFIC)	6.00		A	24" BOTTOM PRE-CORED END CAP, PART# MC3500IEPP24BC / TYP OF ALL 24" BOTTOM CONNECTIONS AND ISOLATOR PLUS ROWS			
12	STONE ABOVE INLET	MINIMUM ALLOWABLE GRADE (TOP OF RIGID CONCRETE PAVEMENT)	9.00		B	24" TOP PRE-CORED END CAP, PART# MC3500IEPP18TC / TYP OF ALL 18" TOP CONNECTIONS			
6	STONE BELOW INLET	MINIMUM ALLOWABLE GRADE (BASE OF FLEXIBLE PAVEMENT)	6.00		B	18" TOP PRE-CORED END CAP, PART# MC3500IEPP18TC / TYP OF ALL 18" TOP CONNECTIONS			
40	STONE MANHOLE	TOP OF STONE	6.00		C	D INSTALL FLAME ON 24 ACCESS PIPE / PART# MCCLAMP (TYP 2 PLACES)			
6273	INSTALLED SYSTEM VOLUME (CF) (PERIMETER STONE INCLUDED)	TOP OF MC-3500 CHAMBER:	2.42		F	18" x 18" TOP MANIFOLD, ADS N-12	1.77'		
	(COVER STONE INCLUDED)	18" x 18" TOP MANIFOLD INVERT:	2.42		F	18" x 18" TOP MANIFOLD, ADS N-12	20.03'		
	(BASE STONE INCLUDED)	18" x 18" BOTTOM MANIFOLD INVERT:	0.90		G	18" x 18" TOP MANIFOLD, ADS N-12	20.03'		
1985	SYSTEM AREA (SF)	18" BOTTOM CONNECTION INVERT:	0.90		H	18" BOTTOM CONNECTION	1.77'		
230.9	SYSTEM PERIMETER (ft)	BOTTOM OF MC-3500 CHAMBER:	0.00		I	OCS (DESIGN BY ENGINEER / PROVIDED BY OTHERS)		8.0 CFS OUT	
		BOTTOM OF STONE:	0.00		J	NYLOPLAST (INLET W/ ISO PLUS ROW)			
			0.00		K	NYLOPLAST (INLET W/ ISO PLUS ROW)		8.2 CFS IN	
			0.00		L	INSPECTION PORT			
			0.00		M	" SEE DETAIL			
			0.00		N	" SEE DETAIL			



- ISOLATOR ROW PLUS
(SEE DETAIL)
- PLACE MINIMUM 17.50' OF ADSP125 WOVEN GEOTEXTILE OVER BEDDING STONE AND UNDERNEATH CHAMBER FEET FOR SCOUR PROTECTION AT ALL CHAMBER INLET ROWS
- BED LIMITS

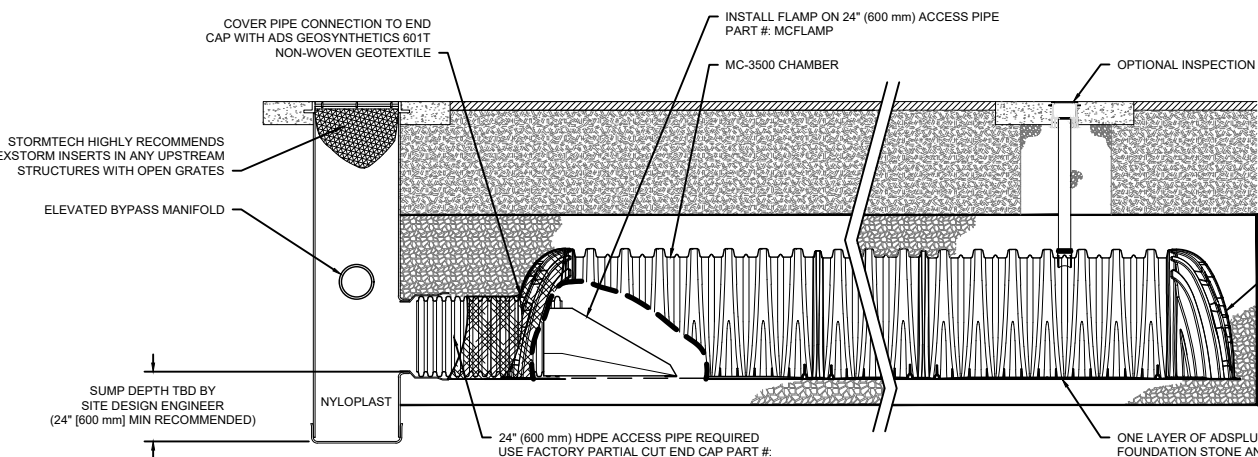
NOTES

- THE SITE DESIGN ENGINEER MUST REVIEW ELEVATIONS AND IF NECESSARY ADJUST GRADING TO ENSURE THE CHAMBER COVER REQUIREMENTS ARE MET.
- NOT FOR CONSTRUCTION:** THIS LAYOUT IS FOR DIMENSIONAL PURPOSES ONLY TO PROVE CONCEPT & THE REQUIRED STORAGE VOLUME CAN BE ACHIEVED ON SITE.

INSPECTION & MAINTENANCE

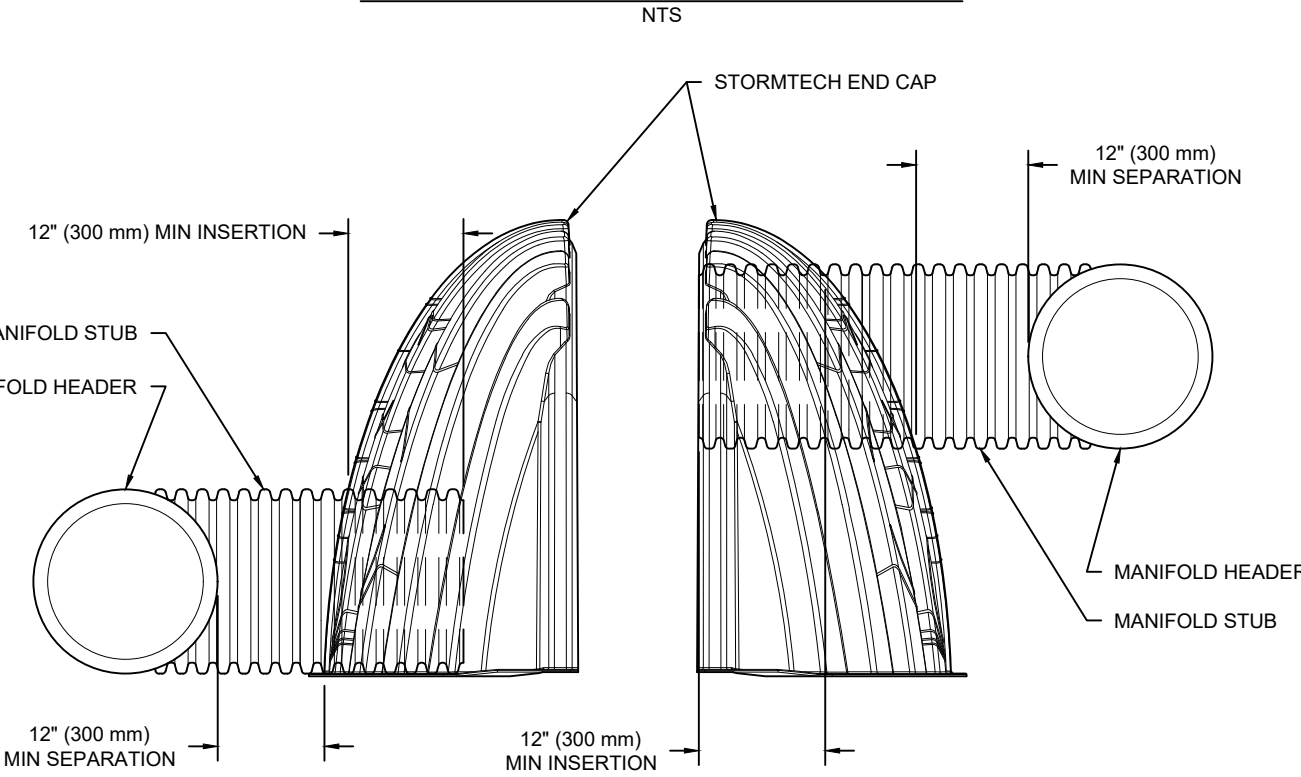
- STEP 1 INSPECT ISOLATOR ROW PLUS FOR SEDIMENT
- A. INSPECTION POINTS (IF PRESENT)
1. REMOVE COVER LID ON NYLON LAST INLINE DRAIN
 2. REMOVE AND CLEAN FLEXPORT FILTER IF INSTALLED
 3. USING A FLASHLIGHT, INSPECT DOWNSTREAM OF ISOLATOR ROW FOR DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
 4. LOWER A CAMERA INTO ISOLATOR ROW PLUS FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
- B. IF SEDIMENT IS AT OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- C. ISOLATOR PLUS
1. REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW
 2. USING A FLASHLIGHT, INSPECT DOWNSTREAM OF ISOLATOR ROW FOR DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
 3. IF SEDIMENT IS AT OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- D. FOLLOW OSHA REGULATIONS FOR FALL PROTECTION IF ENTERING MANHOLES TO INSPECT
- E. MIRRORS ON POLES OR CAMERAS MAY BE USED TO AVOID A CONFINED SPACE ENTRY
- F. FOLLOW OSHA REGULATIONS FOR FALL PROTECTION IF ENTERING MANHOLES TO INSPECT
- G. IF SEDIMENT IS AT OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.

- STEP 2) CLEAN OUT ISOLATOR ROW PLUS USING THE JETVAC PROCESS
- A. A FIXED CULVERT CLEANING NOZZLE WITH REAR FACING SPREAD OF 45° (1.1 m) OR MORE IS PREFERRED
 - B. APPLY MULTIPLE PASSES OF JETVAC UNTIL BACKFLUSH WATER IS CLEAN
 - C. VACUUM STRUCTURE SUMP AS REQUIRED



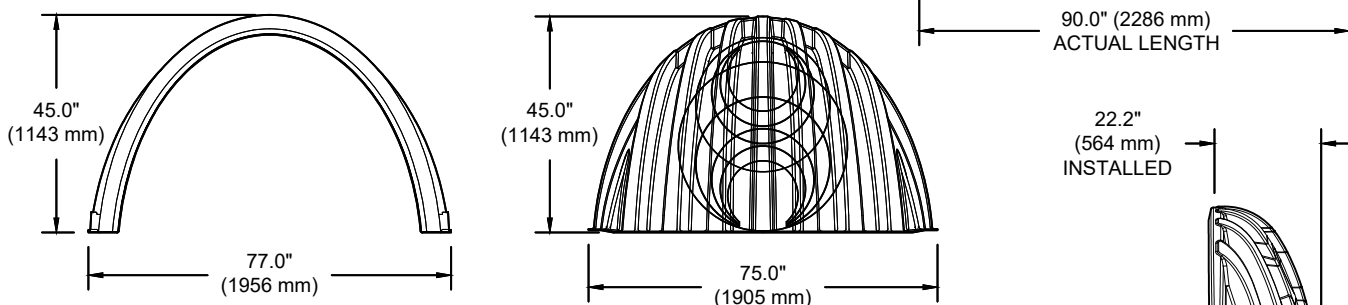
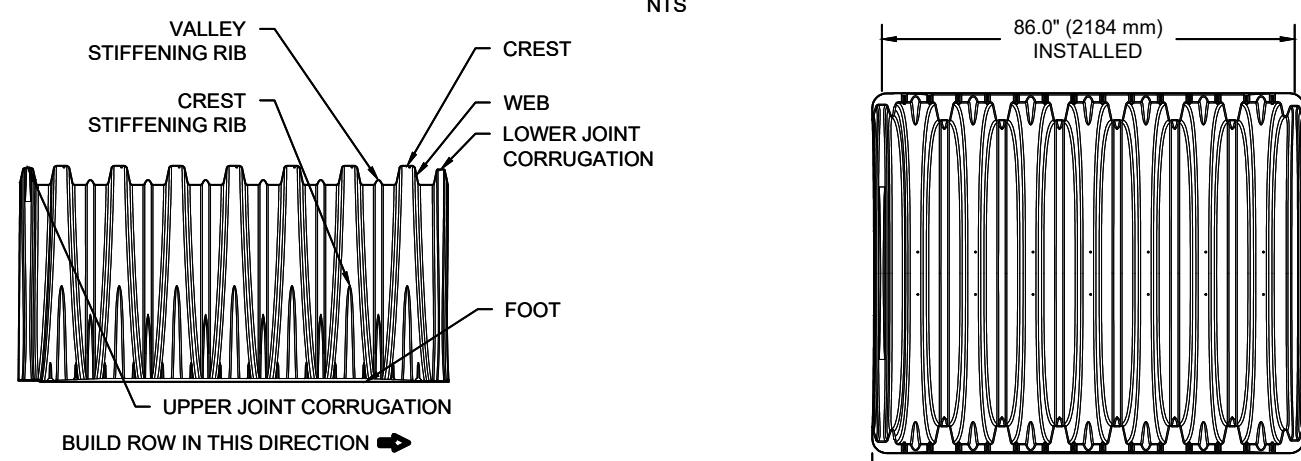
MC-3500 ISOLATOR ROW PLUS DETAIL
NTS

MC-SERIES END CAP INSERTION DETAIL



NOTE: MANIFOLD STUB MUST BE LAID HORIZONTAL FOR A PROPER FIT IN END CAP OPENING.

MC-3500 TECHNICAL SPECIFICATION



- | | |
|---------------------------------------|---|
| NOMINAL CHAMBER SPECIFICATIONS | |
| SIZE (W X H X INSTALLED LENGTH) | 77.0" X 45.0" X 86.0" (1956 mm X 1143 mm X 2184 mm) |
| CHAMBER STORAGE | 100.0 CUBIC FEET (3.11 m³) |
| MINIMUM INSTALLED STORAGE*
WEIGHT | 175.0 CUBIC FEET (4.96 m³)
134 lbs. (60.8 kg) |
| NOMINAL END CAP SPECIFICATIONS | |
| SIZE (W X H X INSTALLED LENGTH) | 75.0" X 45.0" X 22.2" (1905 mm X 1143 mm X 564 mm) |
| END CAP STORAGE | 14.9 CUBIC FEET (0.42 m³) |
| MINIMUM INSTALLED STORAGE*
WEIGHT | 45.1 CUBIC FEET (1.28 m³)
49 lbs. (22.2 kg) |

*ASSUMES 12" (305 mm) STONE ABOVE, 9" (229 mm) STONE FOUNDATION, 6" SPACING BETWEEN CHAMBERS, 6" (152 mm) STONE PERIMETER IN FRONT OF END CAPS AND 40% STONE POROSITY

STUBS AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
STUBS AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
END CAPS WITH A WELDED CROWN PLATE END WITH "C"
END CAPS WITH A PREFABRICATED WELDED STUB END WITH "W"

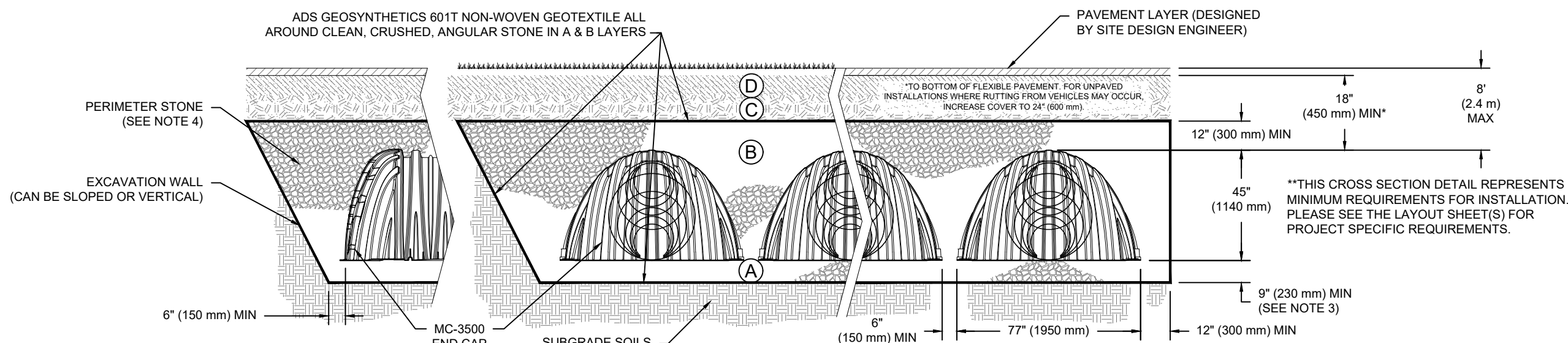
PART #	STUB	B	C
MC3500IEPP06T	6" (150 mm)	33.21" (844 mm)	---
MC3500IEPP06B	---	---	0.66" (17 mm)
MC3500IEPP08T	8" (200 mm)	31.16" (791 mm)	---
MC3500IEPP08B	---	---	0.81" (mm)
MC3500IEPP10T	10" (250 mm)	29.04" (738 mm)	---
MC3500IEPP10B	---	---	0.93" (24 mm)
MC3500IEPP12T	12" (300 mm)	26.36" (670 mm)	---
MC3500IEPP12B	---	---	1.35" (34 mm)
MC3500IEPP15T	15" (375 mm)	23.39" (594 mm)	---
MC3500IEPP15B	---	---	1.50" (38 mm)
MC3500IEPP18TC	---	20.03" (509 mm)	---
MC3500IEPP18TW	18" (450 mm)	---	---
MC3500IEPP18BC	---	---	1.77" (45 mm)
MC3500IEPP18BW	---	---	---
MC3500IEPP24TC	---	14.48" (368 mm)	---
MC3500IEPP24TW	24" (600 mm)	---	---
MC3500IEPP24BC	---	---	2.06" (52 mm)
MC3500IEPP24BW	---	---	---
MC3500IEPP30BC	30" (750 mm)	---	2.75" (70 mm)

CUSTOM PRECURED INVERTS ARE AVAILABLE UPON REQUEST. INVENTORIED MANIFOLDS INCLUDE 12-24" (300-600 mm) SIZE ON SIZE AND 15-48" (375-1200 mm) ECCENTRIC MANIFOLDS. CUSTOM INVERT LOCATIONS ON THE MC-350 END CAP CUT IN THE FIELD ARE NOT RECOMMENDED FOR PIPE SIZES GREATER THAN 10" (250 mm). THE INVERT LOCATION IN COLUMN 'B' ARE THE HIGHEST POSSIBLE FOR THE PIPE SIZE.

ACCEPTABLE FILL MATERIALS: STORMTECH MC-3500 CHAMBER SYSTEMS

	MATERIAL LOCATION	DESCRIPTION	AASHTO MATERIAL CLASSIFICATIONS	COMPACTION / DENSITY REQUIREMENT
D	FINAL FILL: FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'D' LAYER	ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUBGRADE REQUIREMENTS.	N/A	PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS.
C	INITIAL FILL: FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE (B' LAYER) TO 24" (600 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'C' LAYER.	GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUBBASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER.	AASHTO M145 ¹ A-1, A-2.4, A-3 OR AASHTO M43 ¹ 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	BEGIN COMPACTIONS AFTER 24" (600 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 12" (300 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS.
B	EMBEDMENT STONE: FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE (A' LAYER) TO THE 'C' LAYER ABOVE.	CLEAN, CRUSHED, ANGULAR STONE OR RECYCLED CONCRETE ²	AASHTO M43 ¹ 3, 357, 4, 467, 5, 56, 57	NO COMPACTION REQUIRED.
A	FOUNDATION STONE: FILL BELOW CHAMBERS FROM THE SUBGRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER.	CLEAN, CRUSHED, ANGULAR STONE OR RECYCLED CONCRETE ²	AASHTO M43 ¹ 3, 357, 4, 467, 5, 56, 57	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE. ^{2,3}

- PLEASE NOTE:
1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
 2. STORMTIECH COMPACTATION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 9" (230 mm) (MAX) LIFTS USING TWO FULL COVERS WITH A VIBRATORY COMPACTOR.
 3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT SURFACE MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR SPECIAL CONSTRUCTION DETAILS.
 4. ONCE LAYER 'C' IS PLACED, ANY SOLID/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST PAVEMENT SUBBASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.
 5. WHERE RECYCLED CONCRETE AGGREGATE IS USED IN LAYERS 'A' OR 'B' THE MATERIAL SHOULD ALSO MEET THE ACCEPTABILITY CRITERIA OUTLINED IN TECHNICAL NOTE 6.20 "RECYCLED CONCRETE STRUCTURAL BACKFILL".

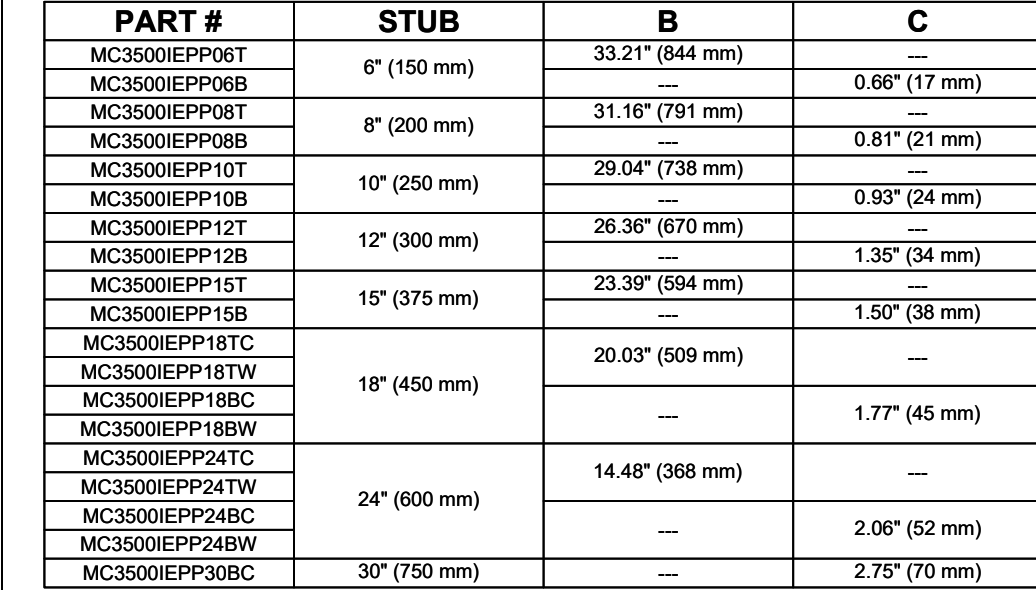
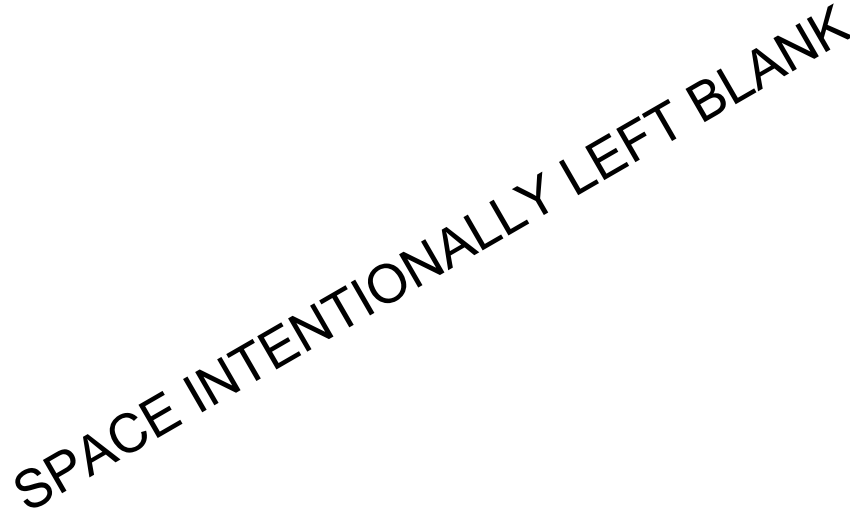


NOTES:

1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS" CHAMBER CLASSIFICATION 45x76 DESIGNATION SS.
2. MC-3500 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". THE STRUCTURE ENGINEER IS RESPONSIBLE FOR ASSESSING THE BEARING REQUIREMENT (ALLOWABLE BEARING CAPACITY) OF THE SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE WITH CONSIDERATION FOR THE RANGE OF EXPECTED SOIL MOISTURE CONDITIONS. REFERENCE STORMTECH DESIGN MANUAL FOR BEARING CAPACITY GUIDANCE.
3. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS.
4. REQUIREMENTS FOR HANDLING AND INSTALLATION:
- TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
 - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 3".
 - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 500 (LB/IN²/FT). THE ASC IS DEFINED IN SECTION 6.2.2 OF ASTM F2418, AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.

NOTES

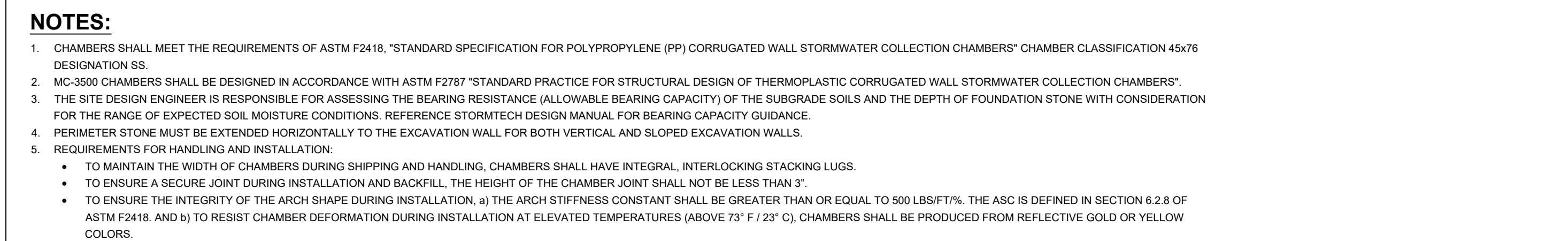
- THE SITE DESIGN ENGINEER MUST REVIEW ELEVATIONS AND IF NECESSARY ADJUST GRADING TO ENSURE THE CHAMBER COVER REQUIREMENTS ARE MET.
- **NOT FOR CONSTRUCTION:** THIS LAYOUT IS FOR DIMENSIONAL PURPOSES ONLY TO PROVE CONCEPT & THE REQUIRED STORAGE VOLUME CAN BE ACHIEVED ON SITE.



ACCEPTABLE FILL MATERIALS: STORMTECH MC-3500 CHAMBER SYSTEMS				
	MATERIAL LOCATION	DESCRIPTION	ASHTO MATERIAL CLASSIFICATIONS	COMPACTION / DENSITY REQUIREMENT
D	FINAL FILL: FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'D' LAYER	ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUBGRADE REQUIREMENTS.	N/A	PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS.
C	INITIAL FILL: FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE ('B' LAYER) TO 24" (600 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUBBASE MAY BE A PART OF THE 'C' LAYER.	GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUBBASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER.	ASHTO M45 ¹ A-1, A-2.4, A-3 OR ASHTO M43 ¹ 3, 357, 4, 467, 5, 96, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	BEGIN COMPACTIONS AFTER 24" (600 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 12" (300 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS.
B	EMBEDMENT STONE: FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE ('A' LAYER) TO THE 'C' LAYER ABOVE.	CLEAN, CRUSHED, ANGULAR STONE OR RECYCLED CONCRETE ²	ASHTO M43 ¹ 3, 357, 4, 567, 5, 56, 57	NO COMPACTION REQUIRED.
A	FOUNDATION STONE: FILL BELOW CHAMBERS FROM THE SUBGRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER.	CLEAN, CRUSHED, ANGULAR STONE OR RECYCLED CONCRETE ³	ASHTO M43 ¹ 3, 357, 4, 567, 5, 56, 57	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE. ^{2,3}

PLEASE NOTE:

1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
2. STORMTECH COMPACTION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 9" (230 mm) (MAX) LIFTS USING TWO FULL COVERSAGES WITH A VIBRATORY COMPACTOR.
3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT MAX MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR COMPACTION REQUIREMENTS.
4. ONCE LAYER 'C' IS PLACED, ANY SOIL/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST VEMENTABLE SUBBASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.
5. WHERE RECYCLED CONCRETE AGGREGATE IS USED IN LAYERS 'A' OR 'B' THE MATERIAL SHOULD ALSO MEET THE ACCEPTABILITY CRITERIA OUTLINED IN TECHNICAL NOTE 6.20 "RECYCLED CONCRETE STRUCTURAL BACKFILL".



6	MC-SERIES END CAP INSERTION DETAIL
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1	MC-3500 CROSS SECTION DETAIL
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APPENDIX D – REFERENCED INFORMATION

National Flood Hazard Layer FIRMeTte



104°52'9"W 39°22'8"N



Legend

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

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
GENERAL STRUCTURES		Area of Undetermined Flood Hazard Zone D
		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
MAP PANELS		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Digital Data Available
		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **4/10/2026 at 4:23 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Basemap Imagery Source: USGS National Map 2023



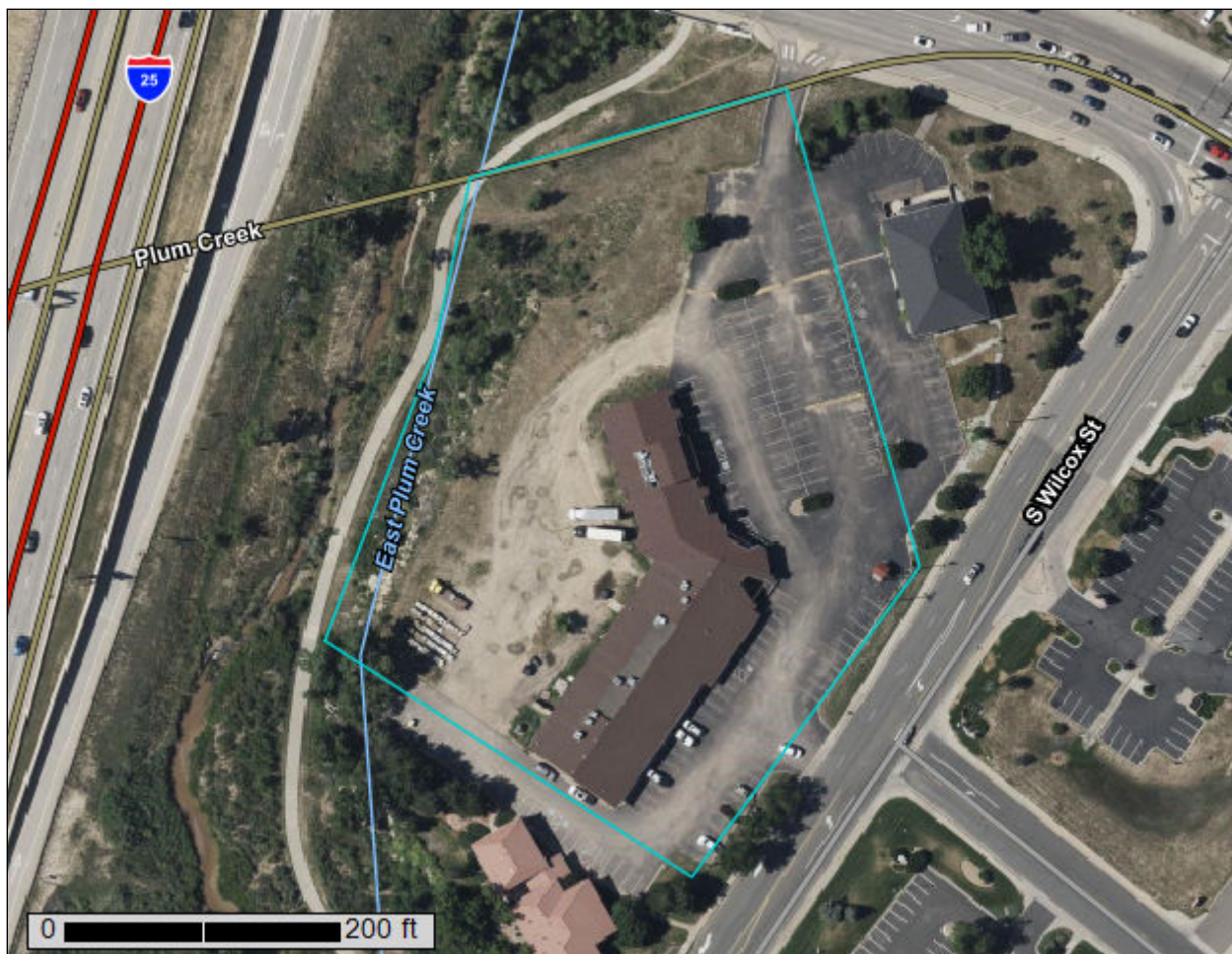
United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National
Cooperative Soil Survey,
a joint effort of the United
States Department of
Agriculture and other
Federal agencies, State
agencies including the
Agricultural Experiment
Stations, and local
participants

Custom Soil Resource Report for **Castle Rock Area, Colorado**



April 10, 2026

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

Preface	2
How Soil Surveys Are Made	5
Soil Map	8
Soil Map.....	9
Legend.....	10
Map Unit Legend.....	11
Map Unit Descriptions.....	11
Castle Rock Area, Colorado.....	13
Lu—Loamy alluvial land, dark surface.....	13
Se—Sandy wet alluvial land.....	14
References	16

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

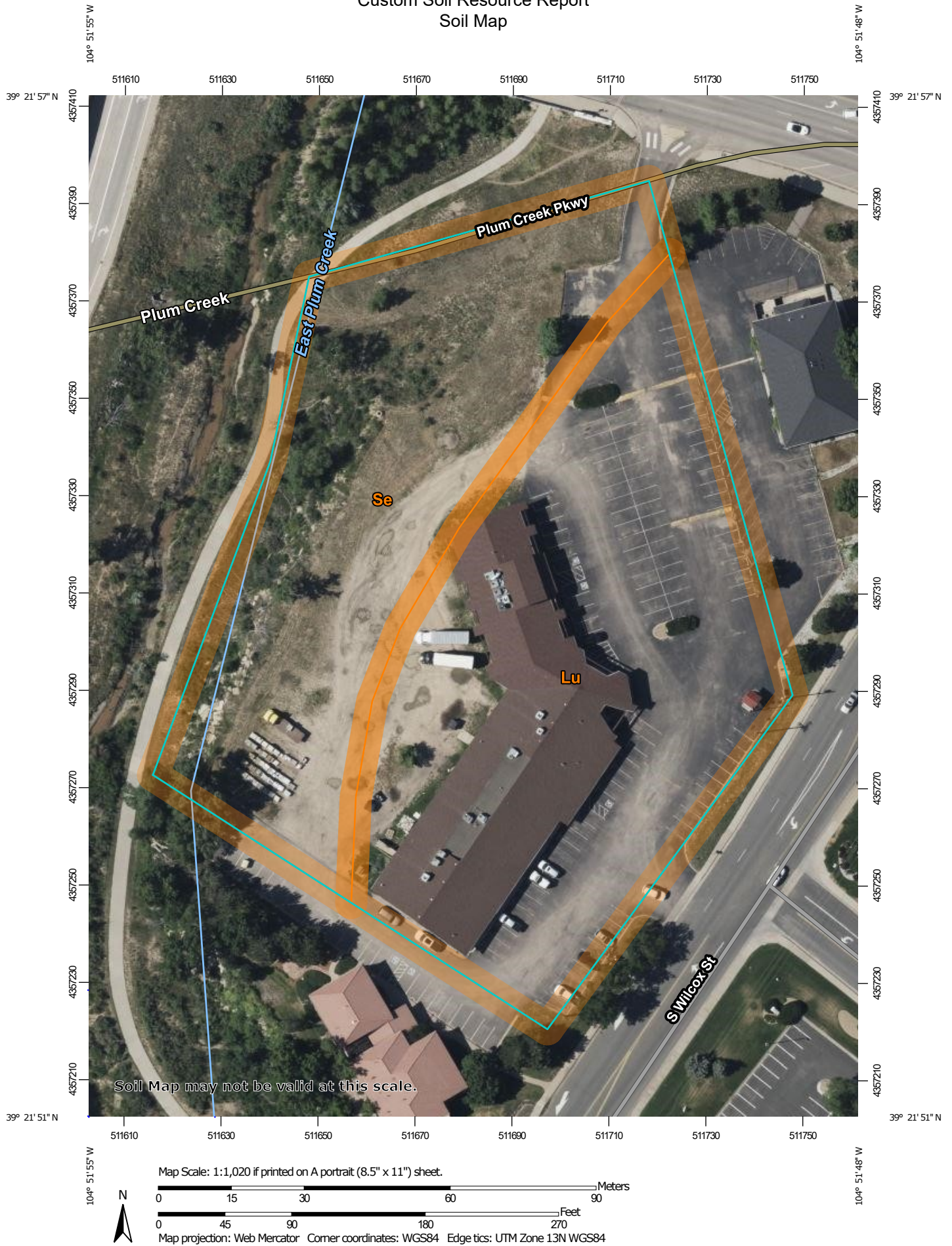
Custom Soil Resource Report

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report Soil Map



Custom Soil Resource Report

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

Special Point Features

 Blowout

 Borrow Pit

 Clay Spot

 Closed Depression

 Gravel Pit

 Gravelly Spot

 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water

 Perennial Water

 Rock Outcrop

 Saline Spot

 Sandy Spot

 Severely Eroded Spot

 Sinkhole

 Slide or Slip

 Sodic Spot

 Spoil Area

 Stony Spot

 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

Water Features

 Streams and Canals

Transportation

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

Background

 Aerial Photography

MAP INFORMATION

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

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

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

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

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Castle Rock Area, Colorado

Survey Area Data: Version 18, Aug 29, 2025

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

Date(s) aerial images were photographed: Mar 1, 2023—Sep 1, 2023

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Lu	Loamy alluvial land, dark surface	2.0	56.7%
Se	Sandy wet alluvial land	1.5	43.3%
Totals for Area of Interest		3.6	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however,

onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Castle Rock Area, Colorado

Lu—Loamy alluvial land, dark surface

Map Unit Setting

National map unit symbol: jqzc
Elevation: 7,000 to 8,000 feet
Mean annual precipitation: 17 to 19 inches
Mean annual air temperature: 44 to 46 degrees F
Frost-free period: 115 to 120 days
Farmland classification: Not prime farmland

Map Unit Composition

Loamy alluvial land, dark surface: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Loamy Alluvial Land, Dark Surface

Setting

Landform: Flood plains, Swales
Down-slope shape: Linear
Across-slope shape: Linear

Typical profile

H1 - 0 to 20 inches: sandy loam
H2 - 20 to 40 inches: stratified loamy sand to clay loam
H3 - 40 to 60 inches: sand and gravel

Properties and qualities

Slope: 0 to 4 percent
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 6.00 in/hr)
Depth to water table: About 48 to 72 inches
Frequency of flooding: Frequent
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: C
Ecological site: R049XC202CO - Loamy Foothill Palmer Divide
Hydric soil rating: No

Minor Components

Sandy alluvial land

Percent of map unit: 14 percent
Hydric soil rating: No

Fluvaquentic haplustolls

Percent of map unit: 1 percent

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Landform: Terraces
Hydric soil rating: Yes

Se—Sandy wet alluvial land

Map Unit Setting

National map unit symbol: jr04
Elevation: 5,500 to 6,600 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 120 to 135 days
Farmland classification: Not prime farmland

Map Unit Composition

Sandy wet alluvial land: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sandy Wet Alluvial Land

Setting

Landform: Major drainageways, Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Weathered alluvium derived from arkose

Typical profile

H1 - 0 to 6 inches: coarse sand
H2 - 6 to 60 inches: stratified coarse sand to sandy loam

Properties and qualities

Slope: 1 to 4 percent
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: Frequent
Available water supply, 0 to 60 inches: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Loamy wet alluvial land

Percent of map unit: 9 percent
Hydric soil rating: No

Custom Soil Resource Report

Sandy alluvial land

Percent of map unit: 9 percent

Hydric soil rating: No

Fluventic haplaquolls

Percent of map unit: 2 percent

Landform: Terraces

Hydric soil rating: Yes

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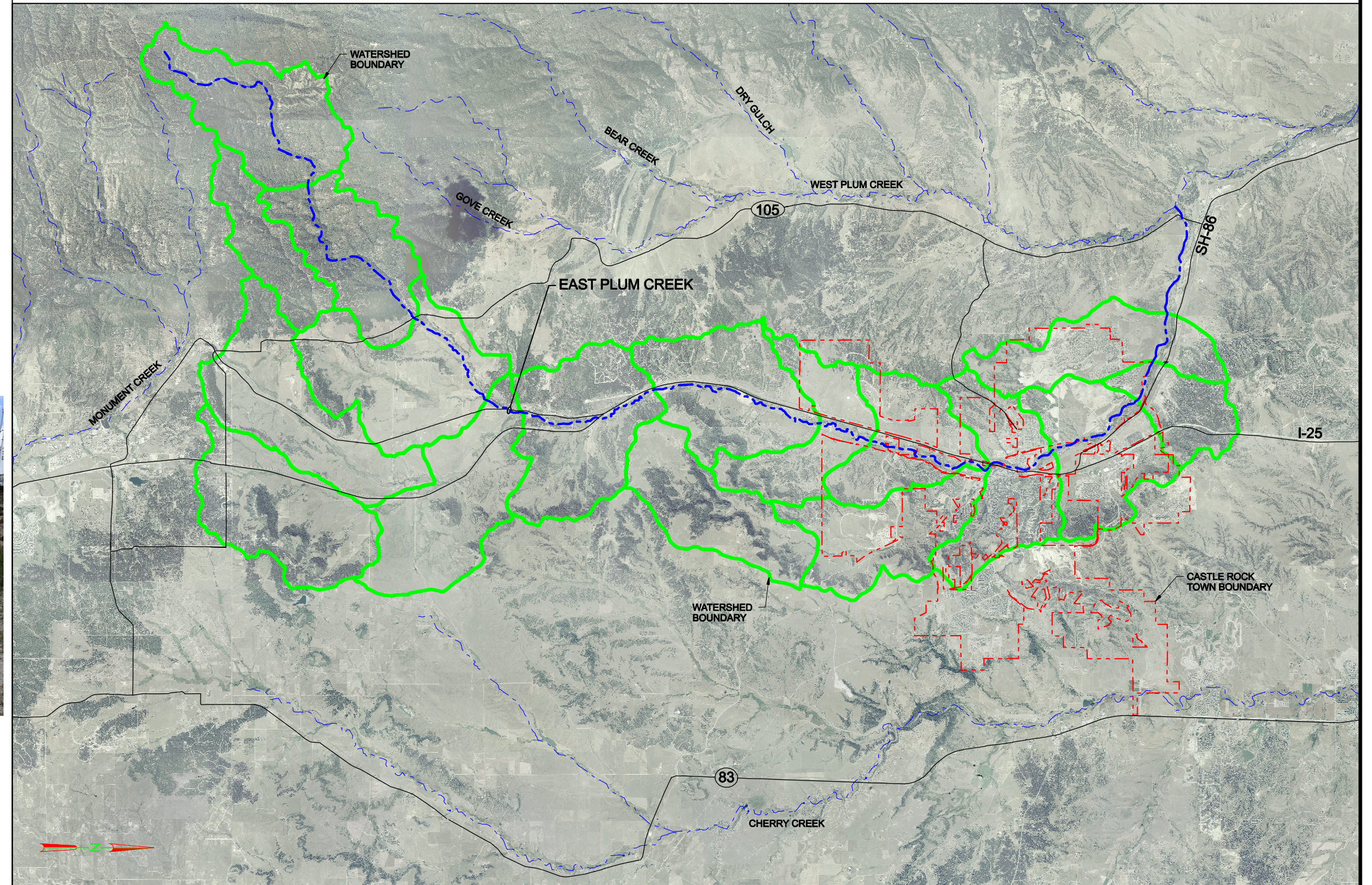
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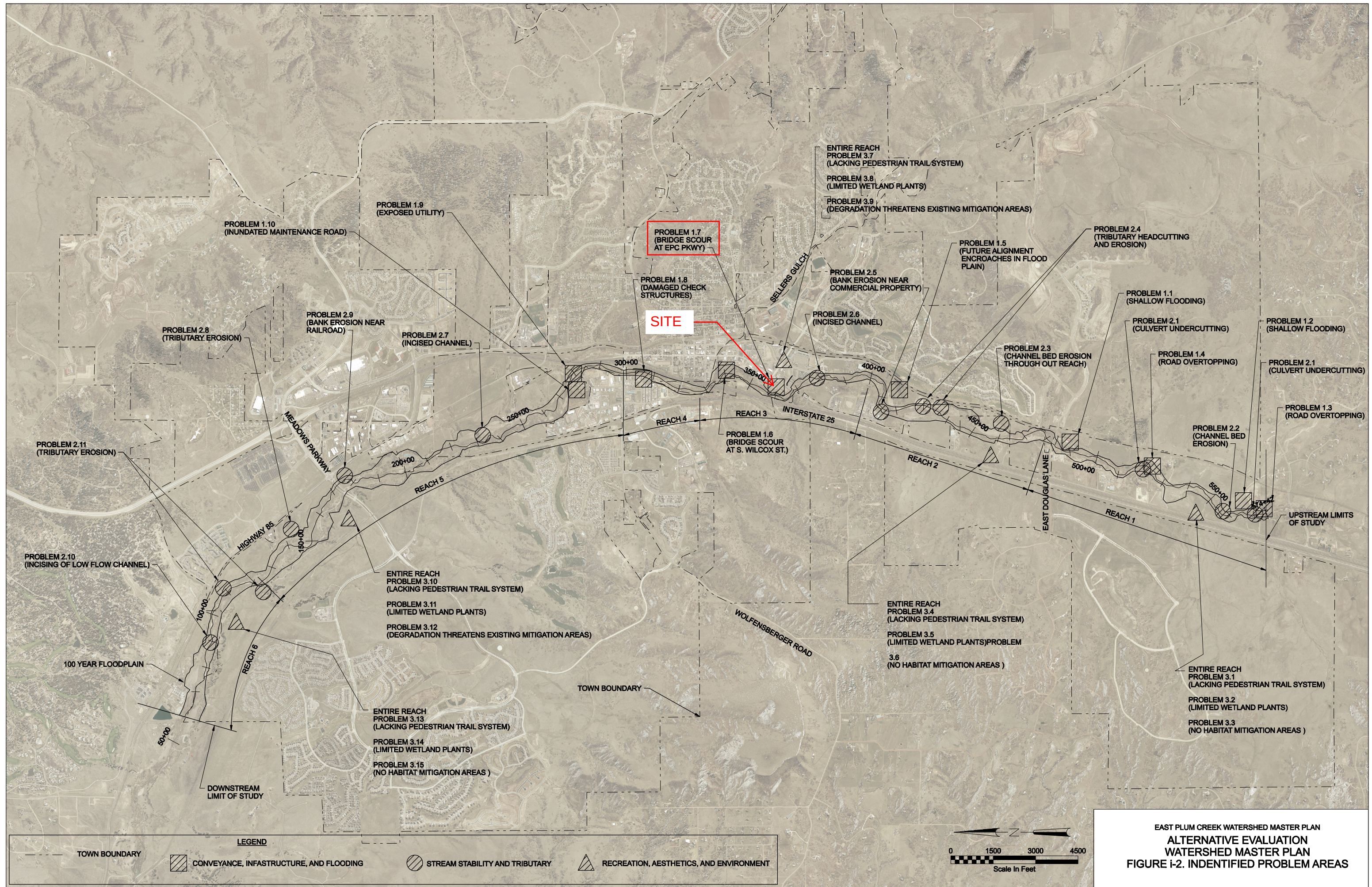
EAST PLUM CREEK WATERSHED MASTER PLAN PRELIMINARY DESIGN REPORT

FEBRUARY 2009



PREPARED FOR:





Reach Description

Reaches were established to match certain characteristics within East Plum Creek and the surrounding watershed. Below are descriptions of the reach characteristics, a plan view of the reaches and their locations are shown in Figures IV-2 and IV-3.

Reach 1

Reach 1 is approximately 1.6 miles long and is located in the upper most reach in this study. The reach is located within active agricultural land and is bounded upstream by the limit of the Town boundary and downstream by Crystal Valley Parkway. The floodplain ranges in width from approximately 180 feet to 350 feet and has a gentle meander pattern. The low flow channel bed material is predominantly sand with small gravel sized particles. Much of the low flow channel is braided with deposition on the inside bends of meanders. The width and flow depth of the low flow channel varied from approximately 5 ft to 10 ft and 0.5 ft to 1.5 ft, respectively.

Vegetation within the floodplain of Reach 1 is dominated by a mixture of riparian grasses, forbs, and shrubs intermixed with pockets of woodlands. Plant composition and diversity are fairly variable along the reach, and species diversity and abundance appear to be higher in sections with less channel erosion. The stream channel supports intermittent herbaceous and scrub-shrub fringe wetlands that typically extend between 1 to 20 feet from the channel banks. Extensive wetland development beyond the channel fringe appears to be limited by the incised channel banks found along parts of the reach. Many of the wetlands are dominated by woody species such as sandbar willow (*Salix exigua*). Herbaceous wetlands are often dominated by sedges (*Carex spp.*). Noxious weeds in Reach 1 include Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), Russian knapweed (*Acroptilon repens*), and musk thistle (*Carduus nutans*).

Soil classifications within the flood plain of Reach 1 are predominately Type C soils of the Fondis series (FoB, Fod, and Fu). With some Type B soils classified as Newlin Gravelly Sandy Loam (NeE) and the Bresser Sandy Loam (BrB).

Reach 2

Reach 2 is approximately 1.6 miles long and is just downstream of Reach 1 and is within the upper reach of the study area. The reach begins downstream of Crystal Valley Parkway and ends to the east of Brookside Circle and South Wilcox Street. The reach is bounded to west by mostly open space, highways, and a few commercial developments and to the east by low to medium density single family development. The floodplain ranges from 300 feet to 400 feet and has a gentle meander pattern. The low flow channel bed material is predominantly sand with small gravel sized particles. Much of the low flow channel is braided with deposition on the inside bends of meanders. The width and flow depth of the low flow channel varied from approximately 5 ft to 10 ft and 0.5 ft to 1.5 ft, respectively.

Vegetation within the floodplain of Reach 2 is dominated by a mixture of riparian grasses, forbs, and shrubs intermixed with pockets of woodlands. Plant composition and diversity are fairly uniform. The stream channel supports intermittent herbaceous and scrub-shrub fringe wetlands that typically extend between 1 to 10 feet from the channel banks. Some small wetland areas exist beyond the immediate banks of the channel, but extensive wetland development beyond the channel fringe appears to be limited by the incised channel banks. Many of the wetlands are dominated by woody species such as sandbar willow (*Salix exigua*). Herbaceous wetlands are often dominated by sedges (*Carex spp.*). Noxious weeds in Reach 2 include Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), Russian knapweed (*Acroptilon repens*), and musk thistle (*Carduus nutans*).

Soil classifications within the flood plain of Reach 2 are predominately Type B soils classified as Newlin Gravelly Sandy Loam (NeE) and the Bresser Sandy Loam (BrB).

Reach 3

Reach 3 is approximately 1.1 miles long and is located upstream of the downtown area. The reach begins downstream of Reach 2 and ends at the confluence of East Plum Creek and Sellers Gulch. The reach is bounded to the west by mostly open space, highways, and a few commercial developments and to the east by low to medium density single family development and sparse commercial development. The floodplain ranges from 200 feet to 400 feet and has a gentle meander pattern. The low flow channel bed material is predominantly sand with small gravel sized particles. Much of the low flow channel is braided with deposition on the inside bends of meanders. The width and depth of the low flow channel varies from approximately 5 ft to 10 ft and 0.5 ft to 1.5 ft, respectively.

Vegetation within the floodplain of Reach 3 is dominated by a mixture of riparian grasses, forbs, and shrubs intermixed with pockets of woodlands. Plant composition and diversity are variable. The stream channel supports mostly continuous herbaceous and scrub-shrub fringe wetlands that typically extend between 1 to 10 feet from the channel banks, with most of the wetlands concentrated near the northern end of the reach. Some small wetland areas exist beyond the immediate banks of the channel, but extensive wetland development beyond the channel fringe appears to be limited by the incised channel banks. Many of the wetlands are dominated by woody species such as sandbar willow (*Salix exigua*). Herbaceous wetlands are often dominated by sedges (*Carex spp.*). Noxious weeds in Reach 3 include Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), Russian knapweed (*Acroptilon repens*), yellow toadflax (*Linaria vulgaris*), and musk thistle (*Carduus nutans*). This reach is part of a wetland augmentation area, and good wetland and riparian habitat for Preble’s meadow jumping mouse (*Zapus hudsonius preblei*) and other species extend throughout the reach.

Soil classifications within the flood plain of Reach 3 are predominately Type B soils classified as Newlin Gravelly Sandy Loam (NeE) and the Bresser Sandy Loam (BrB).

Reach 4

Reach 4 is the shortest reach with a length of approximately 0.6 miles. The reach is located through the center of downtown. The reach begins downstream of the confluence of East Plum Creek and Sellers Gulch and ends at the East Wolfensberger Road. The reach is bounded to west by single family and commercial developments and to the east by downtown Castle Rock. The floodplain ranges from 100 feet to 150 feet and has a gentle meander pattern. The low flow channel bed material is predominantly sand with small gravel sized particles. The floodplain has been encroached and is bounded with supported rock gabion walls. The width and depth of the low flow channel varied from approximately 5 ft to 10 ft and 0.5 ft to 1.5 ft, respectively.

Vegetation within the floodplain of Reach 4 is dominated by a mixture of riparian grasses, forbs, and shrubs intermixed with pockets of woodlands. Plant composition and diversity is fairly uniform. The stream channel supports continuous herbaceous and scrub-shrub fringe wetlands that typically extend between 10 to 20 feet from the channel banks. Many large wetland areas exist beyond the immediate banks of the channel, which are likely influenced by the small dams that raise the local water table, relatively high natural groundwater conditions and/or occasional overbank flooding. Many of the wetlands are dominated by woody species such as sandbar willow (*Salix exigua*). Herbaceous wetlands are often dominated by sedges (*Carex spp.*). Noxious weeds in Reach 4 include Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), Russian knapweed (*Acroptilon repens*), and musk thistle (*Carduus*

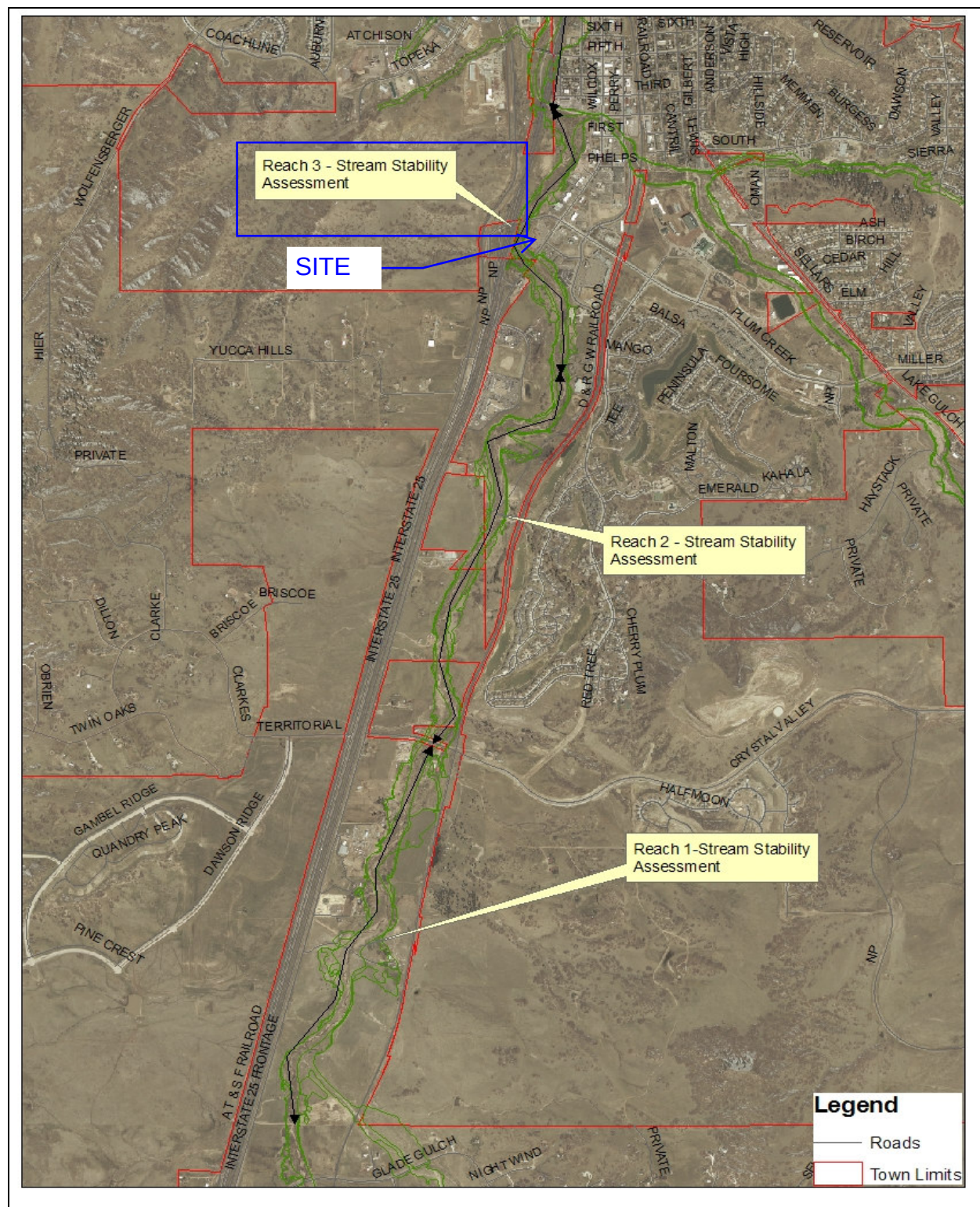


Figure IV-2 Reaches 1 to 3 on East Plum Creek

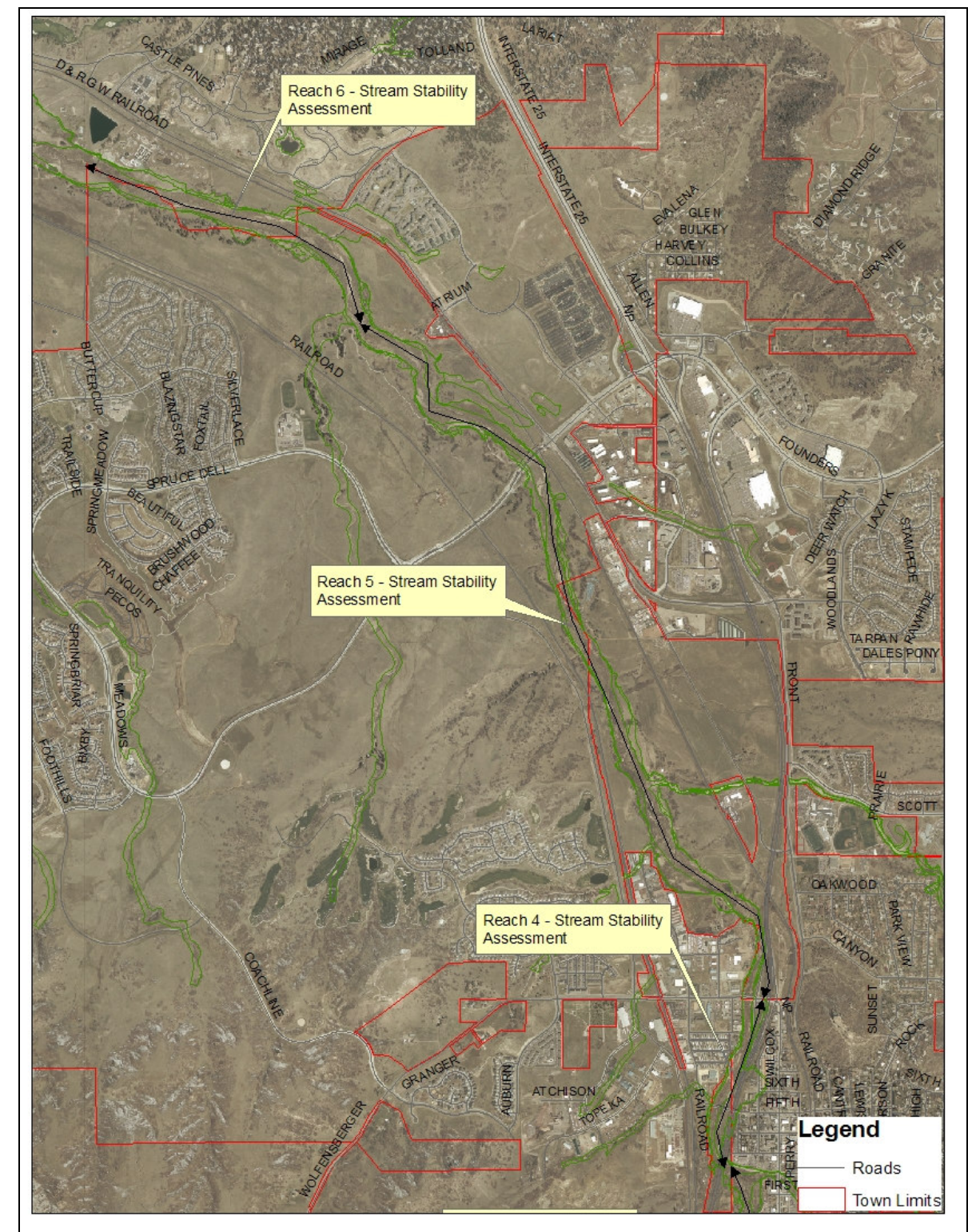


Figure IV-3 Reaches 4 to 6 on East Plum Creek

Reach 3

The floodplain of Reach 3 has less of the preferred wetland plant species. Most of these species are confined to areas near the low flow channel. It is predicted that degradation of the low flow channel has reduced the groundwater table in the area, resulting in less wetland vegetation and leaving large tree species and noxious weeds that have a deep enough root system to gather water. Steep vertical banks are observed throughout Reach 3, which are a result of the low flow channel meandering into the floodplain banks, cutting into the toe of the bank and causing a slope failure. Major hydraulic structures found in this reach are experiencing severe undercutting around piers that are located within East Plum Creek. The lack of preferred wetland species and exposure of piers are a direct result of the incising low flow channel within this reach.

The beginning of Reach 3 is marked by a steep bank that is being eroded by the low flow channel of East Plum Creek. The bank is being slowly cut back towards the property line of local commercial property. Exhibit IV-11 shows this bank from the view at the low flow elevation and Exhibit IV-12 is an aerial view that shows the plan view of the property and bank erosion.



Exhibit IV-11: Bank Erosion near Commercial Development



Exhibit IV-12: Plan View of Bank Erosion near Commercial Development

Within this reach, East Plum Creek crosses two major bridges, South Wilcox Street and East Plum Creek Parkway. As previously mentioned, the incised low flow channel is exposing the pile foundations of the bridges. Exhibit IV-13 shows exposure of the pier foundations at the South Wilcox Bridge and East Plum Creek.



Exhibit IV-13: Pier group underneath South Wilcox Bridge and East Plum Creek

Between the South Wilcox Bridge and East Plum Creek Parkway outcroppings of shale rock are seen in the low flow channel. At East Plum Creek Parkway degradation of the low flow channel has caused exposure

V. Problem Areas

Introduction

Identification of problem areas is at the heart of any master planning effort. The hydrologic and hydraulic evaluations provide the quantitative foundation for the determination of problem areas. However, a comprehensive field assessment of the watershed also provided invaluable information related to the condition of the watershed and obvious problem areas. In combination, the problem areas identified in the East Plum Creek watershed are clear and well documented.

Evaluation of existing facilities

The evaluation of existing facilities was based on an assessment of the facility’s ability to meet fundamental performance criteria in five basic categories: conveyance and flooding, stream stability, infrastructure, aesthetics and recreation, and tributary problems. It is understood that some of the five categories may overlap, for example, a conveyance problem may also be associated with an infrastructure problem and an aesthetics problem may also be associated with a stream stability problem. These overlaps will be identified and sorted in the Alternative Development Evaluation portion of this report. Figure V-1 highlights areas discussed in this section as problem areas defined by the fundamental performance criteria.

Conveyance and Flooding

For the determination of conveyance capacity and flooding problems within the study area, Hydraulic Engineering Center River Analysis Software (HEC-RAS) was used in conjunction with the 100 year peak flow rates from the baseline hydrology. HEC-RAS provides a qualitative analysis of the hydraulic characteristics during the 100 year event, while site visits, literature and photographic reviews provide a quantitative insight to East Plum Creek, its flooding history and previous conveyance problems. Problem areas associated with conveyance and flooding were defined using the following criteria:

- No roadway or embankment overtopping for Arterial and Collector Roads
- No out of channel flooding encroaching onto private property

East Plum Creek has been a well defined floodplain for some time. Initially development surrounding East Plum Creek was rural and low density single family development that most likely used the creek for irrigation purposes and for the unique scenery provided from lush vegetation and the Rocky Mountains in the backdrop. As the Town increased in size and population, more encroachment has been seen on East Plum Creek, particularly in the areas nearest to downtown.

Even with recent development, the hydraulic analysis results of the future condition did not present many areas with flooding problems and/or conveyance issues. The following are the areas identified as needing attention to handle flooding and conveyance for the 100-year flow rates down East Plum Creek:

- East Plum Creek and Douglas Lane: In this area East Plum Creek overtops its banks and causes shallow flooding to private property near the creek. The floodplain from the 2005 FIS also showed this area as being inundated during the 100-year event.
- East Plum Creek and Private Road at Station 571+71: Shallow flooding near private property occurs when East Plum Creek overtops its banks in this area for the 100-year event.

- East Plum Creek and Future Perry Street alignment: The future alignment encroaches into the 100-year floodplain.
- Maintenance Road at Station 275+00: The 100-year event shows the maintenance road to be in the floodplain.

It was acknowledged that many of the minor storm sewer systems within the watershed were not analyzed to the size and scope of this study. Areas specifically noted as problem areas that are not on East Plum Creek are discussed under Tributary Problems.

Stream Stability

A comprehensive Stream Stability Analysis of East Plum Creek through the study area is presented in the previous section. Bank erosion, incising of the low flow channel, and undercutting of hydraulic structures are more prominent in the downstream reaches of the study area. Identified problem areas are

- Incising of the low flow channel near Station 90+00
- Bank erosion near railroad at Meadows Parkway
- Incised channel near Station 230+00
- Incised channel near Station 380+00
- Channel bed erosion throughout Reach 2
- Bank erosion near commercial property near Station 410+00
- Channel bed erosion near Station 560+00
- Culvert undercutting at Private Road at Station 531+08
- Culvert undercutting at Private Road at Station 571+71

Infrastructure

The infrastructure analysis of structures within the study area was done using the results of the HEC-RAS evaluation conducted as part of the FHAD portion of this study, site visits, and conversations with the Town. This evaluation was determined to be sufficiently detailed to allow an accurate determination of the infrastructure concerns that are associated with East Plum Creek.

From conversations with the Town, some areas addressed in this section have already been identified and are in line to be repaired. This report will still mention these areas as identified problem areas to be thorough and complete. Infrastructure defined as a problem area was defined using the following criteria:

- Observed Scour around bridge piers
- Observed head cutting at culverts
- Roadway and embankment overtopping of major or arterial bridges and roads

With the development of the Town, most of the major bridges that cross East Plum Creek have been constructed within the last 10 to 15 years. Major crossings that were constructed within the last 5 years, such as Douglas Lane have more than ample freeboard to pass the 100-year storm event. Some bridges that were constructed more than 10 years ago are showing signs of scour to the point that the concrete sections of the piers have been undercut and the steel piling is exposed. Identified problem areas associated with infrastructure are shown below:

- Bridge scour at South Wilcox St.
- Bridge scour at East Plum Creek Parkway
- Road overtopping at Private Road at Station 531+08

example, the construction of grade control structures under the B2 alternative already enhances the environment in the vicinity and can be further enhanced to provide pedestrian crossings for the proposed Front Range Trail Alignment. This is one example of how the exclusion of items under Sub Plan C is neither an economic advantage nor an optimal solution for the study area.

- Elimination of Do Nothing: The Do Nothing plan assumes that the Town will not alter or enhance the study area except for maintenance needs. Under this alternative, the Town is left without a tool in place to address existing problems. Having a preliminary design in place, allows the Town to appropriately allocate maintenance and construction costs by passing the costs to development within the study area that may benefit from the improvements. The do nothing alternative will address the necessary enhancement of existing habitat mitigation areas, flood protection from undersized structures, and will tolerate the continuous incising of the low flow channel. This alternative is not considered to be either the most economical nor optimal solution for the study area.

TABLE VI-1
Possible Combinations of Alternatives for East Plum Creek

Priority Level	Alternatives		
-	DO NOTHING		
1	A1	A1+B1*	A1+B1+C1
2	A1+A2	A1+A2+B1+B2	A1+A2+B1+B2+C1+C2*
3	A1+A2+A3	A1+A2+A3+B1+B2+B3	A1+A2+A3+B1+B2+B3+C1+C2+C3*

*Alternatives Considered

Plan 1 - High Priority Alternative

This alternative consists of Priority 1 items in sub plans A and B. The purpose of this plan is to address immediate needs that jeopardize the safety and integrity of critical structures. See Table VI-2 below for a summary of Plan 1. Figures VI-2, VI-3, and VI-4 show recommended improvements under this plan.

TABLE VI-2
Summary of Plan 1 – High Priority Alternative

Location	Problem ID	Proposed Solution or Improvement
Reach 1		
Overtopping at two private roads at Station 572+00 and 530+00		Place embankment protection at the downstream face of the private roads to prevent embankment erosion during overtopping.
House near Floodplain and Overtopping of Crystal Valley Parkway at Station 482+00		Demolish the old Perry Street Bridge. Add channel Improvements to enhance the conveyance capacity upstream of the bridge. This includes re-grading the channel, applying bank protection, and reducing the roughness value in the channel.
Reach 2		
Proposed Perry St. Alignment Encroaches into Floodplain at Station 420+00		Add slope protection to roadway embankment to protect road. Construct the new alignment to match approximately a 280 foot span with a single pier, causing no more than 1 foot rise to the 100 year WSE.

TABLE VI-2
Summary of Plan 1 – High Priority Alternative

Location	Problem ID	Proposed Solution or Improvement
	Bank Instability Near Commercial Development at Station 415+00	Provide bank protection up to the 10 year water surface. Bank protection will consist of sized riprap. Elevations above the 10-year WSE will require a vegetative slope protection application.
Reach 3		
	Bridge Scour at Wilcox Bridge and Plum Creek Parkway	Alternative is currently being done by Town
Reach 4		
No High Priority Alternative		
Reach 5		
	Utility Protection at Station 274+00	Protect exposed utility pipe by constructing a 3’ drop structure downstream of the utility
	Maintenance Road in Floodplain at Station 275+00	Protect roadway embankment with buried riprap
	Bank Stability at Station 175+00 to Protect Railroad*	Add bank protection and adjust low flow channel with two 1’ drops
Reach 6		
No High Priority Alternative		

*Drops vary in Selected Plan

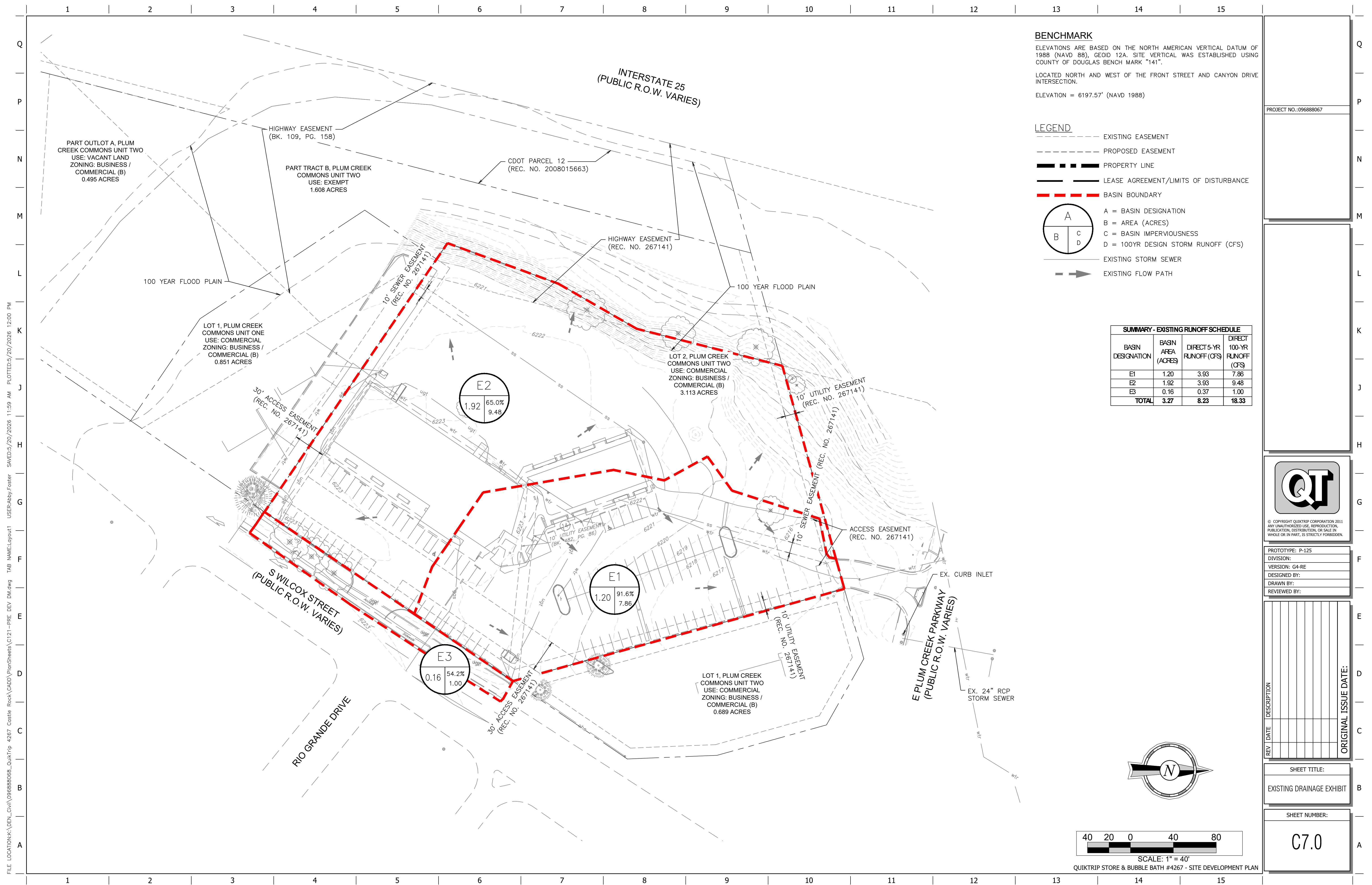
Plan 2 – General Priority and Recreational Plan

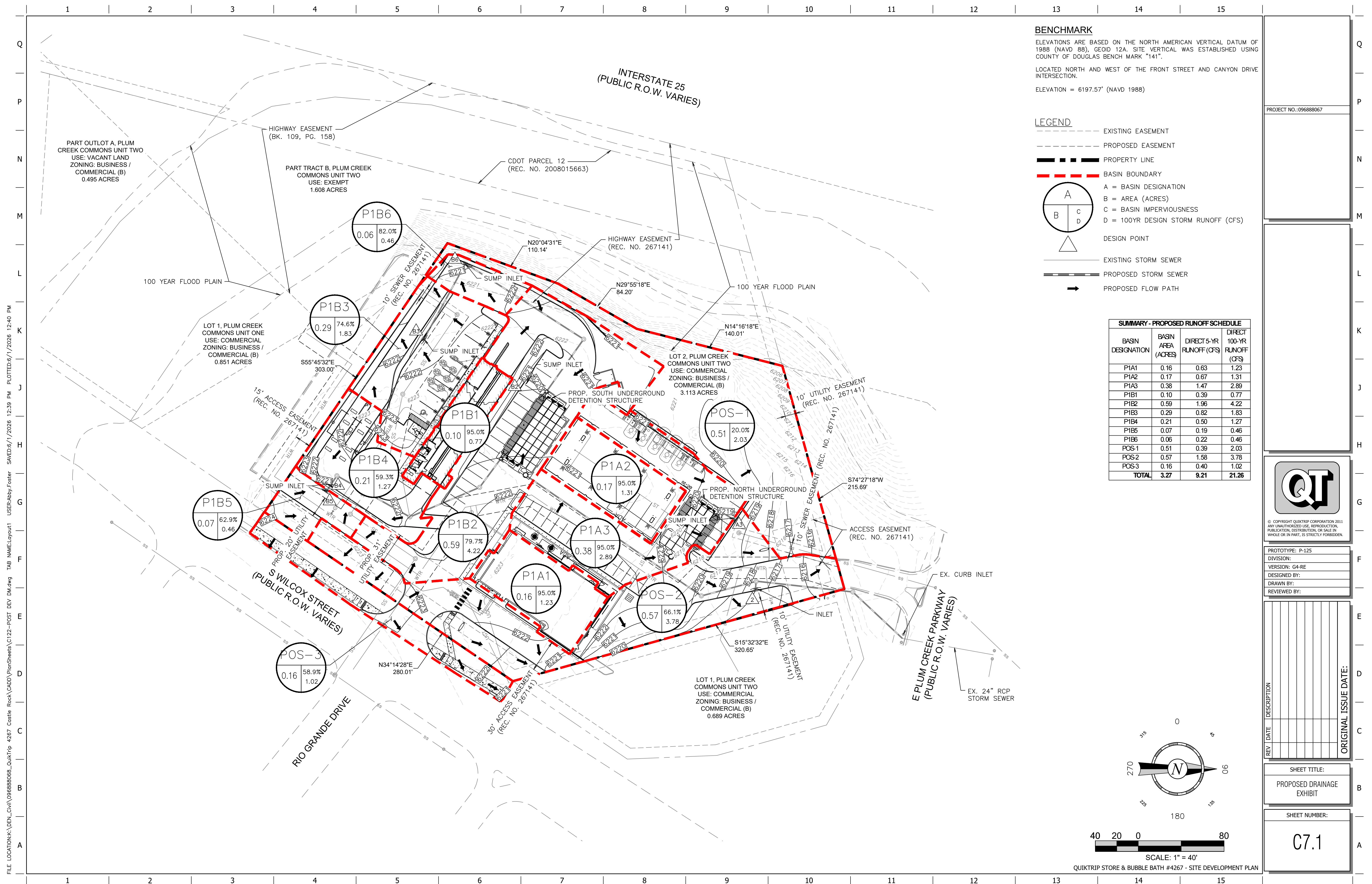
This plan combines all priority level two items in sub-plans A, B, and C with those identified in Plan 1- High Priority Plan. This not only addresses immediate needs but also longer term needs that will prevent future problems from occurring. This plan provides the necessary grade control to acquire a 0.55% slope, detention and water quality benefits for future development, and addresses all the flood control problems that are shown in Plan 1. See Table VI-3 below for a summary of Plan 2. Figures VI-5, VI-6, and VI-7 show recommended improvements under this plan.

TABLE VI-3
Summary of Plan 2 – General Priority and Recreation Plan

Location	Problem ID	Proposed Solution or Improvement
Reach 1		
	Overtopping at two private roads at Station 572+00 and 530+00 and channel bed erosion.	Place embankment protection at the downstream face of the private roads to prevent embankment erosion during overtopping. Place Outlet Protection downstream of the culvert at Station 572+00
	Stream Stability / Floodplain Enhancement*	Construct three, 1’ drop structures between Stations 569+00 and 564+00
	Water Quality / Flood Attenuation at Station 532+00 ¹	Construct a 10 acre-foot Water Quality / Detention Pond near Station 532+00

APPENDIX E – DRAINAGE MAPS





APPENDIX F – PERMANENT WATER QUALITY WORKSHEET

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

Project:

Project #:

Applicant:

[illegible]

Section	Question	Response	Instructions
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 No	Proceed to next line. Proceed to 3.1.2.
	Is the trail for a roadway?	Yes No	Proceed to 3.1.2. 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 No	This exclusion does not apply. Permanent water quality is required. Proceed to 3.1.3.
3.1.3	Does the project add impervious area?	No Yes	Project is excluded. Submit variance for <u>Pavement Management Sites Excluded from Permanent Water Quality Requirements</u> . 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 Yes	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Does the project add more than one acre of paved area per mile to an existing roadway?	No Yes	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Does the project increase the width by two times or more, on average, of the original roadway area?	No Yes	Existing areas of site are excluded only. Submit variance for <u>Existing Roadway Surfaces Only Excluded from Permanent Water Quality Requirements</u> . 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 No	Project is excluded. Submit variance for <u>Oil and Gas Exploration Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.2.
3.2.2	Is the project for stream stabilization?	Yes No	Project is excluded. Submit variance for <u>Stream Stabilization Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.3.
3.2.3	Is the project for installation or maintenance of aboveground or 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 No	Project is excluded. Submit variance for <u>Aboveground and Underground Utilities Excluded from Permanent Water Quality Requirements</u> . 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 No	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.
3.2.5	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No Yes	Project is excluded. Submit study along with variance for <u>Non-residential and Non-commercial Infiltration Conditions Excluded from Permanent Water Quality Requirements</u> . This exclusion does not apply. Permanent water quality is required.

Section	Question	Response	Instructions
3.3	Category 3: Residential, Agricultural 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.

APPENDIX G – MS4 COMPLIANCE SUMMARY



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 _____

Project Owner _____

Project Location _____

ToCR Project Number _____

Total Site Area _____ acres

Total Size of Common Plan of Development _____ acres

Check all that apply:

☐ **Project within Plum Creek Basin**

☐ **Project within Cherry Creek Basin**

Estimated construction completion date _____

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: _____ acres

Total Site area: _____ acres, _____ % 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