PHASE II DRAINAGE REPORT

CD21-0045

Auburn Heights

JULY 2026

PREPARED FOR:

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Phase II Drainage Report

Auburn Heights, CD21-0045

Town of Castle Rock, Douglas County, Colorado

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Preparation Date: November 2, 2021
Revised: December 1, 2021
Revised: July 16, 2026

CERTIFICATION PAGE

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

_____

Asfund Yar Khan

Registered Professional Engineer

State of Colorado No. 0058639

"Auburn Ventures II, LP hereby certifies that the drainage facilities for Auburn Heights shall be constructed according to the design presented in this report. I understand that the Town of Castle Rock does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the Town of Castle Rock reviews drainage plans pursuant to the Municipal Code; but cannot, on behalf of Auburn Heights, guarantee that final drainage design review will absolve Auburn Ventures II, LP and/or their successors and/or assigns of future liability for improper design."

_____

Name of Developer

_____

Authorized Signature

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1.0 General Location and Description

A. Site Location

The Auburn Heights development is located in a portion of the south half of section 3, Township 8 South, Range 67 West of the 6th principal meridian in the Town of Castle Rock, Douglas County, Colorado. The site is bounded by Omni Gulch to the northwest, Auburn Ridge Apartments to the northeast, Auburn Drive to the southeast, and Castle Highlands Filing No. 2 to the southwest. Five multifamily residential buildings, a clubhouse, and free-standing garages are planned for this site.

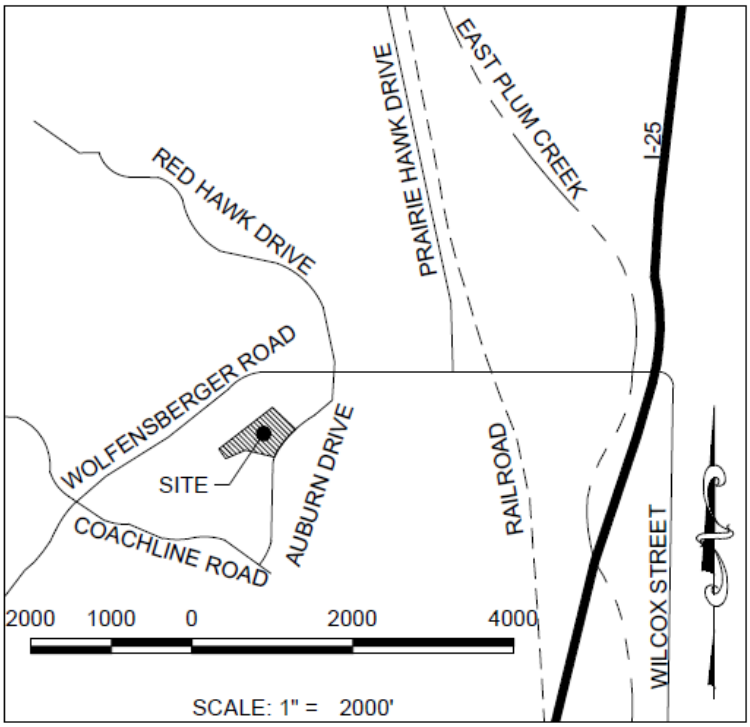


FIGURE 1: VICINITY MAP

B. Description of Property

Auburn Heights is a multifamily development and is approximately 6.1 acres. The existing ground generally slopes to the north and northeast where majority of the site's existing drainage pattern sheet-flows to Omni Gulch. The site contains slopes ranging from 2% to 25%. The Auburn Heights site contains an existing water quality pond developed during the Auburn Villas project.

The site lies within Zone X outside the 100-year floodplain per FEMA Flood Insurance Rate Map number 08035C0169G, dated March 16, 2016.

The onsite soil consists of Bresser-Truckton sandy loams with 5 to 25 percent slopes and Newlin gravelly sandy loam with 8 to 30 percent slopes. These soils are both classified as group B soils, meaning the soils have a high infiltration rate when thoroughly wet. Please refer to the Appendix for a copy of the NRCS soils map.

2.0 Drainage Basins and Sub-Basins

A. Major Drainage Basins

Majority of the site currently drains to the northwest towards Omni Gulch, an open channel. Within the limits of this project boundary, an existing water quality pond is located in the northwest corner that had been designed and constructed in association with Auburn Ridge Phase I. Approximately 1.5 acres of the project site sheet flows into the water quality pond in the existing state.

B. Minor Drainage Basins

The existing topography associated with this project site is divided into seven on-site drainage basins and two off-site drainage basins. Please refer to the Appendix for the Historic Drainage map for basin locations.

Historic Basin E1 is 0.02 acres and includes a small portion of the southwest corner of the site. E1 has a 5-year runoff coefficient of 0.01 and a 100-year runoff coefficient of 0.44. Stormwater flows from east to west, to design point 1e.

Historic Basin E2 is 0.06 acres that includes a small portion of the southwest corner of the site which sheet flows toward Millbrook Court. E2 has a 5-year runoff coefficient of 0.01 and a 100-year runoff coefficient of 0.44. Stormwater flows from north to south, to design point 2e.

Historic Basin E3 is 2.38 acres that contains a large portion of the western side of the site which sheet flows to Omni Gulch. E3 has a 5-year runoff coefficient of 0.01 and a 100-year runoff coefficient of 0.44. Stormwater flows from southwest to northeast, to design point 3e.

Historic Basin E4 is 0.29 acres that contains a small portion of the site located at the center of the south boundary and sheet flows toward Millbrook Court. E4 has a 5-year runoff coefficient of 0.01 and a 100-year runoff coefficient of 0.44. Stormwater flows from north to south, to design point 4e.

Historic Basin E5 is 0.67 acres that contains the eastern portion of the site which sheet flows to Auburn Drive. E5 has a 5-year runoff coefficient of 0.01 and a 100-year runoff coefficient of 0.44. Stormwater flows from southwest to northeast, to design point 5e.

Historic Basin E6 is 1.19 acres that covers the central portion of the site and sheet flows to the northeast toward Auburn Ridge. E6 has a 5-year runoff coefficient of 0.01 and a 100-year runoff coefficient of 0.44. Stormwater flows from southwest to northeast, to design point 6e.

Historic Basin E7 is 1.49 acres that covers the central portion of the site and drains to the existing water quality pond in the northwest portion of the site. E7 has a 5-year runoff coefficient of 0.01 and a 100-year runoff coefficient of 0.44. Stormwater flows from southwest to northeast, to design point 7e.

Historic Basin OS-1, as delineated by Manhard Consulting in association with the original Auburn Villas project, is 0.19 acres that consists of an existing building located north of the project site. OS-1 has a 5-year runoff coefficient of 0.71 and a 100-year runoff coefficient of 0.81.

Historic Basin OS-2, as delineated by Manhard Consulting in association with the original Auburn Villas project, is 0.67 acres that consists of an existing building, paved areas and landscaping, located north of the project site. OS-2 has a 5-year runoff coefficient of 0.76 and a 100-year runoff coefficient of 0.81.

The developed site consists of thirty-four (34) on-site drainage basins as well as the three offsite basins. Please refer to the Summary table below:

TABLE 1: DEVELOPED DRAINAGE BASIN SUMMARY

Basin ID	Area (AC)	Impervious (%)	C5	C100	Q5 (cfs)	Q100 (cfs)	Inlet Type	Emergency Overflow to Basin
D1	0.44	5.0	0.03	0.45	0.04	1.17	Offsite	Offsite
D2	0.49	58.3	0.51	0.71	1.02	2.62	Type C	D3
D3	0.42	60.7	0.53	0.71	0.91	2.28	Type C	D2 & D4
D4	1.25	69.8	0.62	0.76	2.88	6.59	15' Type R	D3 & D5
D5	1.11	73.9	0.65	0.78	2.85	6.36	15' Type R	D4 & Pond
D6	0.06	5.0	0.03	0.45	0.01	0.19	Nyloplast 8" Dome	D4
D7	0.07	95.0	0.76	0.84	0.25	0.52	Roof Drain	D6 & D4
D8	0.07	95.0	0.76	0.84	0.25	0.52	Roof Drain	D23 & D24
D9	0.07	95.0	0.76	0.84	0.25	0.52	Roof Drain	D25 & D26
D10	0.07	95.0	0.76	0.84	0.25	0.52	Roof Drain	D26 & D27
D11	0.23	95.0	0.76	0.84	0.83	1.70	Roof Drain	D28 & D29
D12	0.23	95.0	0.76	0.84	0.83	1.70	Roof Drain	D29 & D30
D13	0.23	95.0	0.76	0.84	0.83	1.70	Roof Drain	D5 & D21
D14	0.12	95.0	0.76	0.84	0.43	0.89	Roof Drain	D34 & D 33
D15	0.12	95.0	0.76	0.84	0.43	0.89	Roof Drain	D4 & D33
D16	0.16	95.0	0.86	0.89	0.65	1.26	Stub	D5
D17	0.03	95.0	0.86	0.89	0.12	0.24	Stub	D5
D18	0.11	95.0	0.76	0.84	0.39	0.81	Roof Drain	D22 & D 32
D19	0.13	95.0	0.76	0.84	0.47	0.96	Roof Drain	D35 & D5
D20	0.08	38.8	0.34	0.62	0.13	0.43	Offsite	Offsite
D21	0.35	26.7	0.15	0.51	0.18	1.21	Pond	Offsite
D22	0.11	13.2	0.11	0.49	0.04	0.37	Offsite	Offsite
D23	0.02	50.0	0.45	0.67	0.04	0.12	Nyloplast 8" Dome	D24
D24	0.01	50.0	0.45	0.67	0.02	0.06	Nyloplast 8" Dome	D23
D25	0.01	5.0	0.03	0.45	0.00	0.04	Nyloplast 8" Dome	D26

D26	0.01	5.0	0.03	0.45	0.00	0.04	Nyloplast 8" Dome	D25 & D27
D27	0.04	5.0	0.03	0.45	0.01	0.15	Nyloplast 8" Dome	D28
D28	0.02	5.0	0.03	0.45	0.00	0.08	Nyloplast 8" Dome	D27 & D29
D29	0.01	5.0	0.03	0.45	0.00	0.04	Nyloplast 8" Dome	D28 & D30
D30	0.02	5.0	0.03	0.45	0.00	0.08	Nyloplast 8" Dome	D29 & D31
D31	0.01	5.0	0.03	0.45	0.00	0.04	Nyloplast 8" Dome	D4
D32	0.05	41.0	0.36	0.63	0.09	0.27	Nyloplast 8" Dome	D2 & D33
D33	0.02	50.0	0.45	0.67	0.04	0.12	Nyloplast 8" Dome	D34 & D16
D34	0.03	35.0	0.31	0.60	0.04	0.16	Nyloplast 8" Dome	D4
D35	0.04	5.0	0.03	0.45	0.01	0.15	Nyloplast 8" Dome	D16 & D17
OS-1	0.19	95.0	0.76	0.84	0.70	1.41	Pond	Pond
OS-2	0.69	78.0	0.69	0.80	2.12	4.45	Pond	Pond
TOTAL	7.12	66.6	0.56	0.73	-	-	-	-

3.0 Design Criteria

A. Regulations

This drainage study is prepared in conformance with the Town of Castle Rock *Storm Drainage and Technical Criteria Manual* as revised June 2019, and per the Mile High Flood District Manuals 1-3, latest editions.

Town criteria require that full-spectrum detention be provided for the site. However, due to stormwater detention provided immediately upstream of the site, only water quality treatment is required for the proposed development. This detention pond is referred to as Pond A in the Castle Highlands Filing No. 2 Phase II Drainage Study. Both the narrative and calculations pertaining to the design of Pond A from this study by JR Engineering are included in Appendix F.

B. Drainage Studies, Master Plans, Site Constraints

The previous drainage studies impacting the site are the following:

- Castle Highlands Filing No. 2 Phase II Drainage Study by JR Engineering dated August 21, 2001.
- The Floodplain Modification Study for Omni Tributary Channel Stabilization Project by Wright Waters Engineers dated May 2018.

- The Auburn Villas Lot 2, Auburn Ridge Phase II Drainage Report by Manhard Consulting LTD dated May 2016.
- Auburn Ridge Drainage Details As-builts dated March 10, 2013.

There is an existing water quality pond in the northeast corner of the site that was constructed with the Auburn Ridge project engineered by Vermilion Peak Engineering. This water quality pond collects water from the central portion of the site, provides water quality treatment, then releases into Omni Gulch. As there is an existing spillway easement, this pond will be modified with this report to contain the pond within the easement. Please see drainage map exhibit for existing and preliminary modified conditions for the water quality pond. Details will be finalized in the Phase III Drainage Report. Per the Castle Highlands Filing No. 2 Phase II Drainage Study, "Pond A" upstream of the site provides the required detention for this lot and only water quality treatment is required prior to release into Omni Gulch.

Castle Highlands Filing No. 2 Phase II Drainage report by JR Engineering dated August 21, 2001, accounts for the required detention for Basin KK within the upstream detention pond. Both basins JJ and KK are located within this project site. Basins JJ and KK were determined to have a 100-year flow of 25.8 and 31.5 cfs, respectively (refer to the Appendix for referenced drainage basins and SF-form). The drainage basins to the water quality pond for the proposed site encompasses less area than Basins JJ and KK combined, along with a lower overall runoff for both the 5- and 100-year events. The difference in 100-year flow is due to the current site plan having a lower percent impervious and lower runoff coefficients. Please refer to Table 1 which outlines the current site plan parameters for all basins. Please refer to Table 2 below which shows the comparison of Basins JJ and KK with the weighted averages of the proposed basins.

TABLE 2: MASTER DRAINAGE COMPARISON

Basin ID	Area	Impervious (%)	C5	C100	Q5 (CFS)	Q100 (CFS)
JJ	3.8	70	0.65	0.8	11.0	25.8
KK	4.63	70	0.65	0.8	13.4	31.5
Proposed Basins	7.12	66.6	0.56	0.73	7.4	24.3

Total runoff from the proposed site is less than that assumed previously for Basins JJ and KK. The total proposed flow represents the outflow from the water quality pond in addition to offsite flows. See calculations for runoff routing in Appendix B.

As the volume of the existing water quality pond and the design of the existing outlet structure was designed per assumptions of developed flows for this project site, the outlet structure has been redesigned to drain the water quality capture volume within forty (40) hours.

C. Hydrology

The Town of Caste Rock requires the following return frequencies for the minor and major storms.

Minor Storm: 5-year
Major Storm: 100-year

As the site is 6.1 acres, the Rational Method was used to calculate the runoff for the historic and developed conditions. The historic and developed runoff coefficients were calculated by using the most recent Mile High Flood District Criteria manuals (Table 6-5) included in the Appendix.

D. Hydraulics

There are two (2) Type C inlets and two (2) 15' Type R inlets and two (2) Type C inlets proposed for this site. Inlet sizing and calculations can be found in Appendix C. There is a total of fourteen (14) Nyloplast 8" dome inlets that are located throughout lawn areas between buildings and sidewalks. Refer to the Appendix capacity calculations for the 8" dome inlets.

The water quality pond sizing and calculations can be found in Appendix C. The outlet structure will be modified to drain the Water Quality Capture Volume within 40 hours for this new development. Please refer to the pond details sheet and received as-builts of the existing outlet structure in the Appendix.

The existing outlet structure currently has 16 orifice holes spaced four inches apart with a diameter of 3/8 inch. The orifice plate will be modified to have a total of three orifice holes spaced 1.2 feet apart using a 27/64" drill bit. The total time to drain the 99% of the WQCV is 40 hours.

E. Storage and Water Quality Enhancement

The existing water quality pond has been designed to drain the Water Quality Capture Volume in 40 hours. The existing outlet structure will be modified for this new development to ensure the drain time remains 40 hours given the existing pond size. Please refer to Table 3 for total tributary basins to the pond.

TABLE 3: TRIBUTARY BASINS TO WQ POND

Basin ID	Acres	Imp
D2	0.49	58.27
D3	0.42	60.71
D4	1.25	69.80
D5	1.11	73.92
D6	0.06	5.00
D7	0.07	95.00
D8	0.07	95.00
D9	0.07	95.00
D10	0.07	95.00
D11	0.23	95.00
D12	0.23	95.00
D13	0.23	95.00
D14	0.12	95.00
D15	0.12	95.00
D16	0.16	95.00
D17	0.03	95.00
D18	0.11	95.00
D19	0.13	95.00
D21	0.35	26.71
D23	0.02	50.00
D24	0.01	50.00
D25	0.01	5.00
D26	0.01	5.00
D27	0.04	5.00
D28	0.02	5.00
D29	0.01	5.00
D30	0.02	5.00
D31	0.01	5.00
D32	0.05	41.00
D33	0.02	50.00
D34	0.03	35.00
D35	0.04	5.00
OS-1	0.19	95.00
OS-2	0.69	78.04
TOTAL	6.49	72.0

4.0 Stormwater Management Facility Design

A. Stormwater Conveyance Facilities

This site contains five multifamily residential buildings, a clubhouse, and free-standing garages. The drive aisles will include concrete pans in an inverted-crown street cross section to capture and direct stormwater to the water quality pond in the northeast corner of the site.

Inlets and storm pipes will also capture and direct water to the water quality pond.

B. Stormwater Storage Facilities

There is an existing water quality pond in the northeast corner of the site constructed during Auburn Ridge. This water quality pond collects water from the majority of the existing site, provides water quality treatment, then releases into Omni Gulch. Per the Castle Highlands Filing No. 2 Phase II Drainage Study, "Pond A" upstream of the site provides the required 100-year detention for this lot and only water quality treatment is required prior to release in Omni Gulch.

The existing outlet structure of the water quality pond will be redesigned to adequately drain the Water Quality Capture Volume in 40 hours for the proposed development. The water from the pond will be released into Omni Gulch which ultimately flows to East Plum Creek approximately one mile north of the site.

C. Water Quality Enhancement Control Measures

Employ Runoff Reduction Practices:

Reducing the peak runoff volumes is an important best management practice (BMP) to not overwhelm existing infrastructure or receiving bodies of water with developed stormwater flows. The existing water quality pond is designed to drain the Water Quality Capture Volume in forty (40) hours to reduce the release rate of major storm events.

Implement BMPs that Provide a Water Quality Capture Volume (WQCV) with Slow Release:

The water quality pond is designed to drain the WQCV in forty (40) hours to promote suspended solids to settle before discharging into Omni Gulch. Water draining from paved areas to the provided landscaping helps reduce runoff volume as it can infiltrate into the ground.

Stabilize Drainageways:

The adjacent channel, Omni Gulch located northwest of the project site, is being modified and stabilized through the Floodplain Modification Study completed by Wright Water Engineers in conjunction with the previous project, Auburn Villas. Approximately 360 feet of the existing channel will be stabilized with four cutoff wall grade control structures and drop structures.

Implement Site Specific and Other Source Control BMPs:

An existing overflow weir has been provided with the construction of the existing water quality pond. The overflow weir was considered with the redesign of the outlet structure to ensure a foot of freeboard is provided for flood control. The existing outlet structure will also be modified to drain the WQCV in forty (40) hours given the proposed improvements related to this project.

D. Floodplain Modification

A floodplain modification study was completed in conjunction with the Auburn Villas proposed site by Wright Water Engineers in May 2018. This floodplain modification study analyzed the stabilization of 360 feet of existing channel. The channel experiences erosion occurring intermittently along its length. There is a 100-year floodplain in the subject reach of the Omni Channel delineated in the Omni Industrial and Westfield Watersheds Flood Hazard Delineation (FHAD) report, dated April 2013. However, the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM), Map Number 09035C0169G, Effective March 16, 2016 (FEMA, 2016), shows the channel in the Project site being designated as Zone X floodplain (i.e., approximate floodplain with no Base Flood Elevation determined). See Appendix for FEMA map.

E. Geotechnical Investigation and Sub-Surface Collection System Design

A Geotechnical Engineering Study was performed by Kumar & Associates, Inc. on August 21, 2014, for the Castle Highlands Filing No. 2 project. Groundwater was not encountered in the borings during drilling, which ensures the constructability of the site.

F. Operation and Maintenance

The operation and maintenance of the water quality pond and storm drains will be owned and maintained by Auburn Ventures II, LP.

The water quality pond shall be regularly mowed and trimmed to keep vegetation under control, and the side slopes of the pond will be maintained to ensure stabilization. The Pond will be kept clear of trash and debris. Inspections of the outlet structure will occur annually, and the necessary repairs will be addressed immediately by the owner to maintain the function of the water quality pond. Storm drains and storm inlets need to be maintained regularly for sediment build up or clogged inlets. All storm infrastructure shall be inspected after major rain events.

The storm drainpipes and water quality enhancement control measures will be privately owned and maintained. The Town of Castle Rock will be granted easements over the private infrastructure for the Town's access in case the owner fails to maintain stormwater infrastructure.

Refer the Appendix D for Mile High Flood District best management practices for upkeeping stormwater infrastructure.

G. Additional Permitting Requirements

No additional permitting requirements are anticipated with this project.

H. General

The general runoff of the site directs runoff to the concrete pans located in the middle of the drive aisles. The concrete pans convey the stormwater to Type C inlets that ultimately convey the stormwater to the water quality pond in the northwest corner of the site.

The existing water quality pond was analyzed and re-designed by using the Mile High Flood District Detention spreadsheet. When inputting the as-built elevations and volumes in the stage storage, and putting in the existing outlet structure plate criteria, the WQCV was not being captured within forty hours and was overtopping the weir. To mediate this issue, the outlet structure plate will need to be modified by raising the grate elevation and using a flat top instead of slope of 4:1. By doing so, this allows the WQCV water surface elevation to be below the grate, meaning it will go through the orifice holes and into the outlet pipe.

The orifice plate will now have three orifice holes, each having a diameter of 13/16 inch, to drain the WQCV in forty hours. A 50% debris clogging factor was used within the design calculations, however if the grate is completely clean, the two-year storm will go through the plate rather than the spillway.

The five proposed inlets were sized using the UD Inlet spreadsheet which analyzed the five-year and 100-year storms to ensure that no ponding occurred outside of the drive aisle. The storm drains were sized using SewerGEMS. The combined basin flowrates were inputted from the SF-forms for the 5-year, and 100-year storms and the respective hydraulic grade lines (HGL) were profiled to ensure the 5-year HGL was within the pipe and the 100-year HGL was beneath the surface elevation.

5.0 Conclusions

A. Compliance with Standards

This drainage study complies with the Mile High Flood District standards and the Town of Castle Rock Standards for drainage facilities.

B. Variances

As Basins D1, D20, and D22 do not receive water quality before flowing offsite, a water quality exclusion is required, and the water quality compliance summary is included in the Appendix.

C. Drainage Concept

The proposed development is a total of 7.1 acres that will consist of five multi-unit buildings, a club house, covered parking, a pool, volleyball court, landscaping and paved areas which will ultimately increase the overall imperviousness of the project site, therefore, increasing stormwater runoff from its pre-construction characteristics. To mitigate this outcome, the existing water quality basin in the northwest corner of the site has been evaluated to capture the project site, as well as two offsite basins from Auburn Ridge, and drain the Water Quality Capture Volume (WQCV) in forty hours. Upstream of this project is a full spectrum extended detention basin (EDB) that has been sized for the 100-year stormwater runoff for this project site; therefore, the pond was only sized for WQCV before discharging into the adjacent channel, Omni Gulch.

6.0 References

1. Town of Castle Rock Standards and Specifications

2. Urban Storm Drainage Criteria Manual, Vol 1, 2, & 3

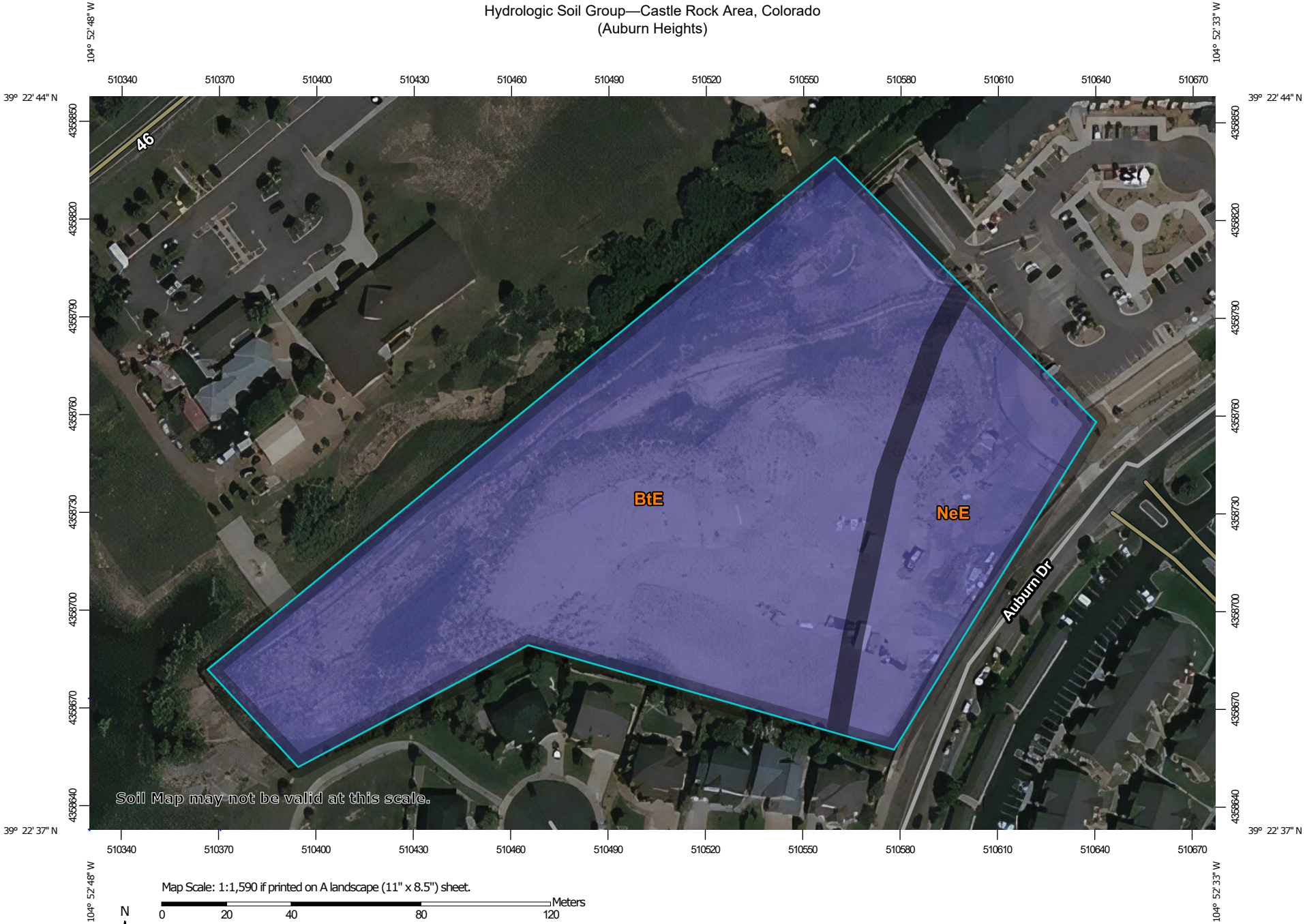
3. Web Soil Survey

4. FIRM, Flood Insurance Rate Map

APPENDIX A

Maps: Soils Map, FIRM, &
Historic/Developed Drainage Basins

Hydrologic Soil Group—Castle Rock Area, Colorado
(Auburn Heights)



Map Scale: 1:1,590 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 20 40 80 120

Feet
0 50 100 200 300

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Soil Rating Lines

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Soil Rating Points

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Water Features

Streams and Canals

Transportation

Rails
Interstate Highways
US Routes
Major Roads
Local Roads

Background

Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

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

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

Date(s) aerial images were photographed: Jul 24, 2018—Nov 19, 2018

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BtE	Bresser-Truckton sandy loams, 5 to 25 percent slopes	B	4.9	79.2%
NeE	Newlin gravelly sandy loam, 8 to 30 percent slopes	B	1.3	20.8%
Totals for Area of Interest			**6.2**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

K Factor, Whole Soil—Castle Rock Area, Colorado
(Auburn Heights)

Map Scale: 1:1,590 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 20 40 80 120

Feet
0 50 100 200 300

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

MAP LEGEND

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

Soils

Soil Rating Polygons
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Lines
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Soil Rating Points
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

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

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

Date(s) aerial images were photographed: Jul 24, 2018—Nov 19, 2018

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

K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BtE	Bresser-Truckton sandy loams, 5 to 25 percent slopes	.15	4.9	79.2%
NeE	Newlin gravelly sandy loam, 8 to 30 percent slopes	.10	1.3	20.8%
Totals for Area of Interest			**6.2**	**100.0%**

Description

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Factor K does not apply to organic horizons and is not reported for those layers.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables shown on this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Floodway Data table shown on this FIRM.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided by the Douglas County GIS Department and the Town of Castle Rock GIS Department. Additional input was provided by the City of Lone Tree and Town of Parker. These data are current as of 2010.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

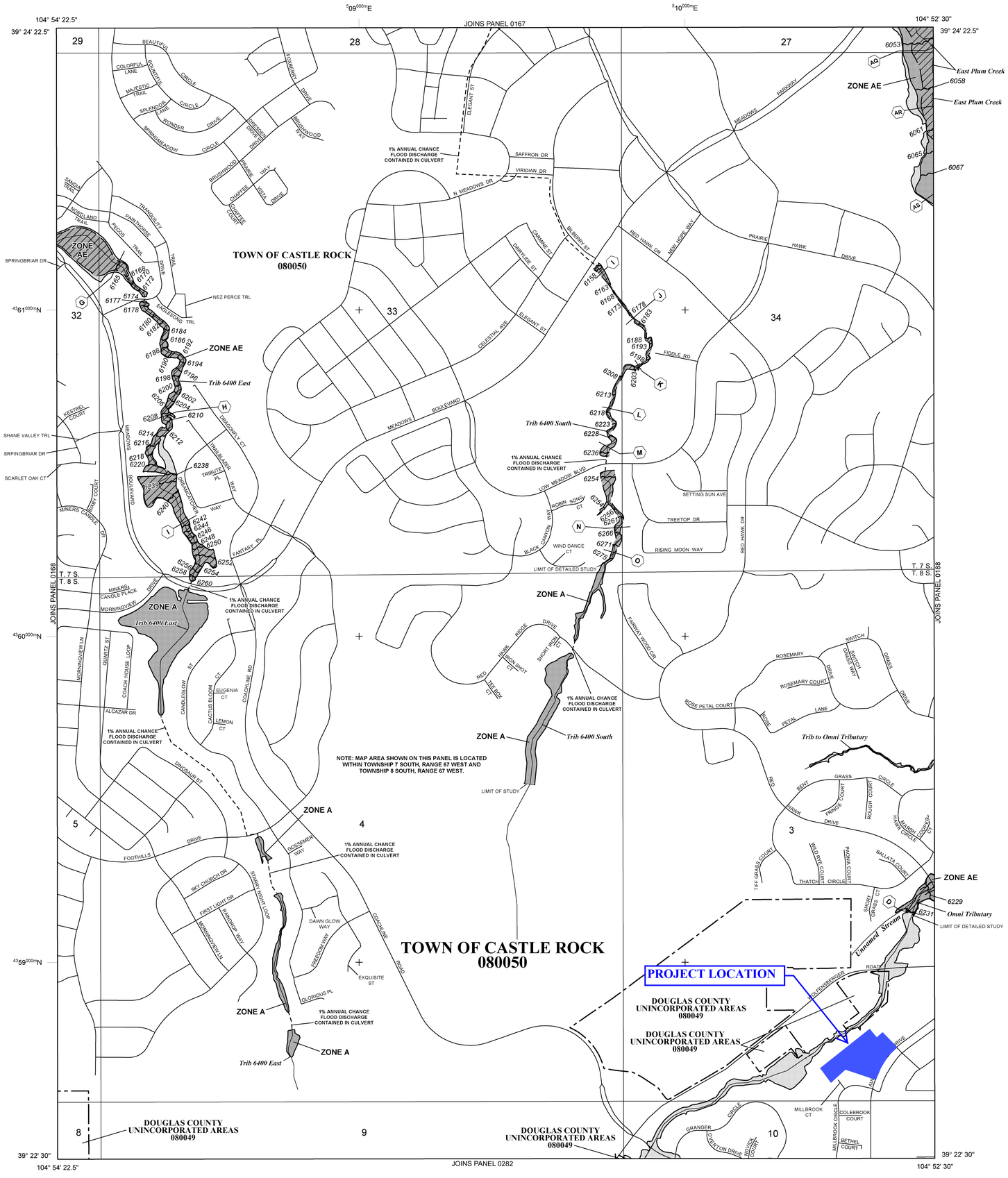
Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for multiple streams in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map,** how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% Annual Chance Floodplain Boundary
	0.2% Annual Chance Floodplain Boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A	Cross section line
23 — 23	Transect line
45° 02' 08", 93° 02' 12"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
4988000mN	1000-meter Universal Transverse Mercator grid values, zone 13
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP

SEPTEMBER 30, 2005

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

MARCH 16, 2016: to update corporate limits, to change base flood elevations, to add base flood elevations, to add special flood hazard areas, to update map format, to add roads and road names, to reflect updated topographic information, to incorporate previously issued letters of map revision.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0169G

FIRM

FLOOD INSURANCE RATE MAP

DOUGLAS COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 169 OF 495
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CASTLE ROCK, TOWN OF	080050	0169	G
DOUGLAS COUNTY	080049	0169	G

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

MAP NUMBER
08035C0169G
MAP REVISED
MARCH 16, 2016

Federal Emergency Management Agency

LEGEND

- XX-X BASIN DESIGNATION
  X.X = AREA IN ACRES
  C5 = 5-YR RUNOFF COEFFICIENT
  C100 = 100-YR RUNOFF COEFFICIENT
- DESIGN POINT
- PROPOSED BASIN BOUNDARY
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR

SUMMARY RUNOFF TABLE		
ONSITE BASIN	RUNOFF 5 YEAR (CFS)	PEAK 100 YEAR (CFS)
E1	0	.1
E2	0	.2
E3	0.1	4.5
E4	0	0.7
E5	0	1.5
E6	0	2.5
E7	0	3.1
OS1	0.7	1.4
OS2	2.1	4.4

TOWN APPROVAL BLOCK

TOWN OF CASTLE ROCK APPROVAL
PLANS ARE HEREBY APPROVED FOR ONE YEAR FROM DATE OF DEVELOPMENT SERVICES APPROVAL

Approved By:

DEVELOPMENT SERVICES Date

CALL 811
TWO WORKING DAYS
BEFORE YOU DIG
1-800-922-1987
UNCC UTILITY NOTIFICATION CENTER OF COLORADO

N:\0079865.0005 SERVICE GROUP\SWATER RESOURCES\05 FINAL\04 EXHIBITS\HISTORIC DRAINAGE MAP DWG, GREHM, 7/13/2026 12:23 PM

No.	Revisions	Date	Init.	Appr.	Date

Westwood
10333 E DRY CREEK RD.
SUITE 400
ENGLEWOOD, CO 80112
TEL: 720.482.9526
Westwoodps.com
Westwood Professional Services, Inc.

AUBURN VENTURES II, LP
ATTN: JOHN CICHON
15957 N 81ST STREET
SUITE 101
SCOTTSDALE, ARIZONA, 85260

AUBURN HEIGHTS
DRAINAGE MAP
HISTORIC

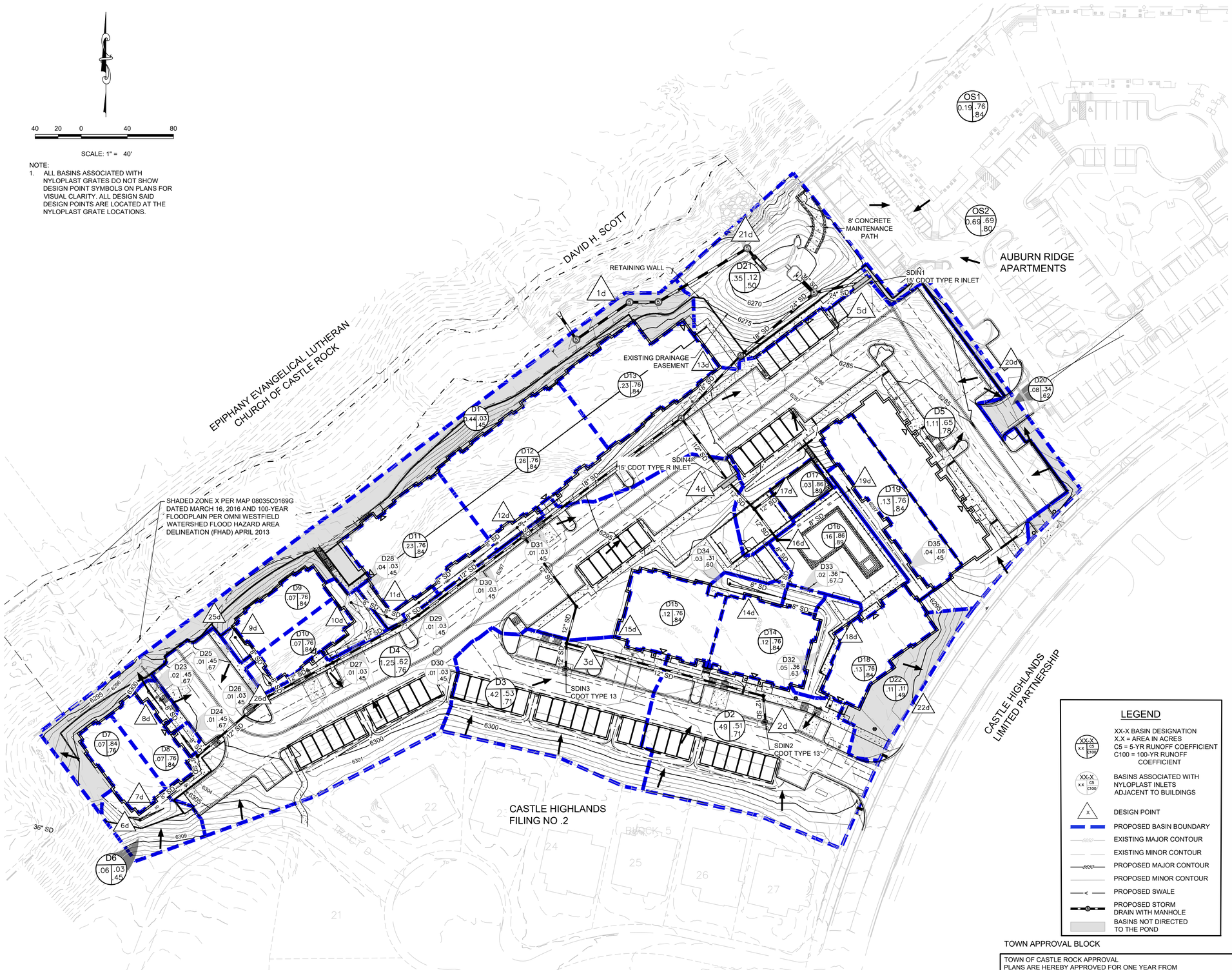
SCALE: AS SHOWN
PROJECT NO: R0031207.00
DRAWN BY: GR
CHECKED BY: AYK
DATE: JULY 2026
SHEET NUMBER DR-1

BASIN ID	RUNOFF 5-YR (CFS)	RUNOFF 100-YR (CFS)
D1	0.04	1.17
D2	1.02	2.62
D3	0.91	2.28
D4	2.88	6.59
D5	2.85	6.36
D6	0.01	0.19
D7	0.25	0.52
D8	0.25	0.52
D9	0.25	0.52
D10	0.25	0.52
D11	0.83	1.70
D12	0.83	1.70
D13	0.83	1.70
D14	0.43	0.89
D15	0.43	0.89
D16	0.65	1.26
D17	0.12	0.24
D18	0.39	0.81
D19	0.47	0.96
D20	0.13	0.43
D21	0.16	1.19
D22	0.04	0.37
D23	0.04	0.12
D24	0.02	0.06
D25	0.00	0.04
D26	0.01	0.15
D27	0.00	0.08
D28	0.00	0.04
D29	0.00	0.08
D30	0.00	0.04
D31	0.09	0.27
D32	0.04	0.12
D33	0.04	0.16
D34	0.01	0.15
D35	0.70	1.41

40 20 0 40 80

SCALE: 1" = 40'

NOTE:
1. ALL BASINS ASSOCIATED WITH NYLOPLAST GRATES DO NOT SHOW DESIGN POINT SYMBOLS ON PLANS FOR VISUAL CLARITY. ALL DESIGN SAID DESIGN POINTS ARE LOCATED AT THE NYLOPLAST GRATE LOCATIONS.



LEGEND

- XX-X BASIN DESIGNATION (C5 / C100)
- X.X = AREA IN ACRES
- C5 = 5-YR RUNOFF COEFFICIENT
- C100 = 100-YR RUNOFF COEFFICIENT
- BASINS ASSOCIATED WITH NYLOPLAST INLETS ADJACENT TO BUILDINGS
- DESIGN POINT
- PROPOSED BASIN BOUNDARY
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- PROPOSED SWALE
- PROPOSED STORM DRAIN WITH MANHOLE
- BASINS NOT DIRECTED TO THE POND

TOWN APPROVAL BLOCK

TOWN OF CASTLE ROCK APPROVAL
PLANS ARE HEREBY APPROVED FOR ONE YEAR FROM DATE OF DEVELOPMENT SERVICES APPROVAL

Approved By:

DEVELOPMENT SERVICES Date

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UNCC UTILITY NOTIFICATION CENTER OF COLORADO

N:\0079865.0005 SERVICE GROUPS\WATER RESOURCES\05 FINAL\04 EXHIBITS\DEVELOPED DRAINAGE MAP DWG, GREHM, 7/13/2026 3:52 PM

No.	Revisions	Date	Init.	Appr.	Date

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Westwood Professional Services, Inc.

AUBURN VENTURES II, LP
ATTN: JOHN CICHON
15957 N 83 ST STREET
SUITE 101
SCOTTSDALE, ARIZONA, 85260

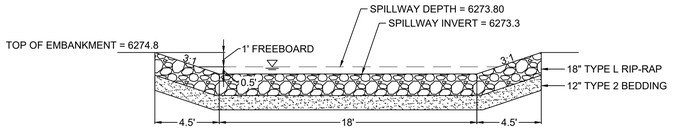
AUBURN HEIGHTS
DRAINAGE MAP
DEVELOPED

SCALE: AS SHOWN
PROJECT NO: R0031207.00
DRAWN BY: GR
CHECKED BY: AYK
DATE: JULY 2026
SHEET NUMBER DR-2

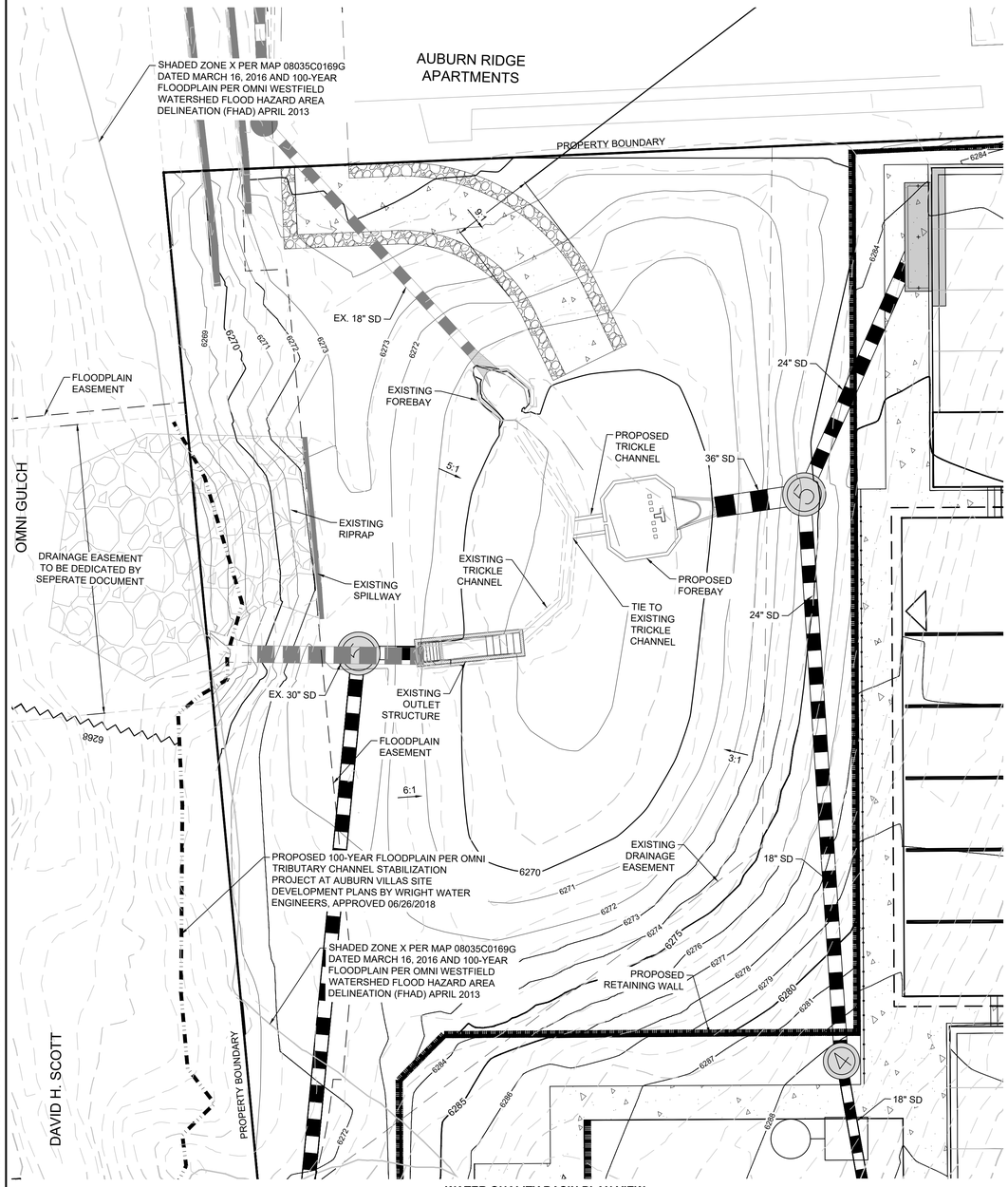
THIS SHEET IS FOR INFORMATION ONLY. POND DETAILS TO BE FINALIZED AT PHASE III REPORT.

10 5 0 10 20

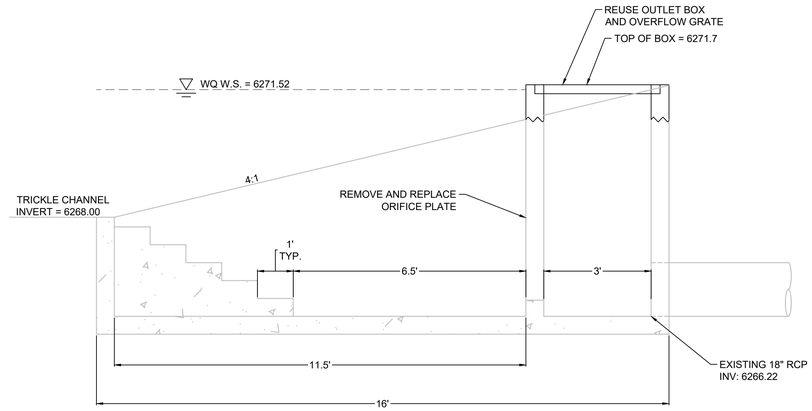
SCALE: 1" = 10'



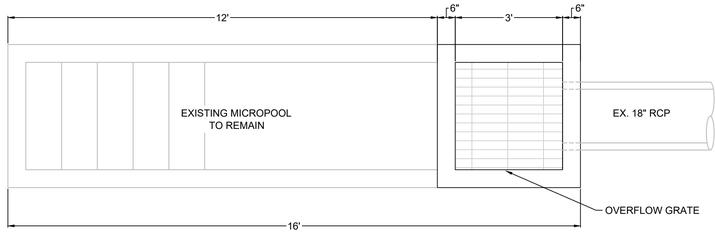
EMERGENCY OVERFLOW WEIR
SCALE: 1" = 5'



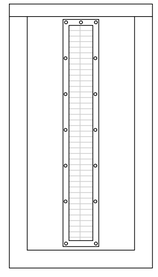
WATER QUALITY BASIN PLAN VIEW
SCALE: 1" = 10'



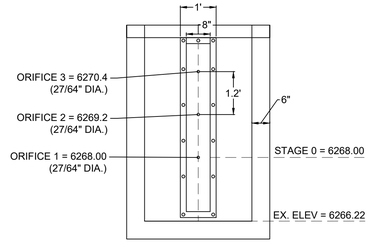
EXISTING OUTLET STRUCTURE SIDE VIEW MODIFICATIONS
SCALE: 1" = 2'



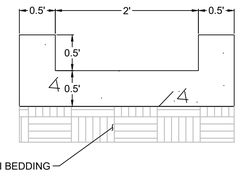
EXISTING OUTLET STRUCTURE TOP VIEW MODIFICATIONS
SCALE: 1" = 2'



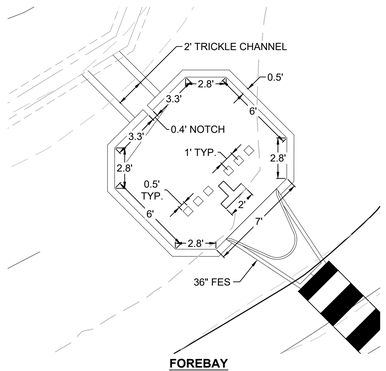
WELL SCREEN
SCALE: 1" = 2'



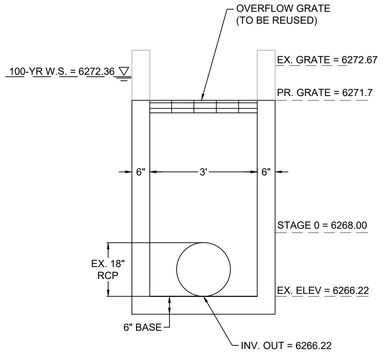
ORIFICE PLATE
SCALE: 1" = 2'



TRICKLE CHANNEL
SCALE: 1" = 1'



FOREBAY
SCALE: 1" = 1'



TOWN APPROVAL BLOCK

TOWN OF CASTLE ROCK APPROVAL
PLANS ARE HEREBY APPROVED FOR ONE YEAR FROM DATE OF DEVELOPMENT SERVICES APPROVAL

Approved By:

DEVELOPMENT SERVICES Date

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N:\0079895.00\06 CAD\ENGINEERING\SHEET SETS\CD'S\POND DETAILS.DWG, GREHM, 7/13/2026 4:19 PM

No.	Revisions	Date	Init.	Appr.	Date

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TEL: 720.482.9526
Westwoodps.com
Westwood Professional Services, Inc.

AUBURN VENTURES II, LP
ATTN: JOHN CICHON
15957 N 84ST STREET
SUITE 101
SCOTTSDALE, ARIZONA, 85260

AUBURN HEIGHTS
DRAINAGE MAP
WATER QUALITY BASIN DETAILS

SCALE:	PROJECT NO:
AS SHOWN	R0031207.00

DRAWN BY:	CHECKED BY:	DATE:
GR	AYK	JULY 2026

SHEET NUMBER DR-3

APPENDIX B

HYDROLOGIC COMPUTATIONS

SF-1 HISTORIC COMPOSITE BASIN LAND USE

Subdivision: Auburn Heights

Project Name: Auburn Heights
Project No.
Calculated By: LO
Checked By: CG
Date: 7/1/2026

Basin	Total Area	Soil Type A	Soil Type B	Soil Type C/D	Single Family Res.	Multi-Family Res.	School	Roof	Paved	Historic	Open Space	Gravel	Avg. Imp.	C_2	C_5	C_{100}
	(acres)	*(%)*	*(%)*	*(%)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(%)*			
E1	0.02	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	5.0	0.01	0.01	0.44
E2	0.06	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	5.0	0.01	0.01	0.44
E3	2.38	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	2.38	0.00	0.00	5.0	0.01	0.01	0.44
E4	0.29	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	5.0	0.01	0.01	0.44
E5	0.67	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	5.0	0.01	0.01	0.44
E6	1.19	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00	5.0	0.01	0.01	0.44
E7	1.49	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	1.49	0.00	0.00	5.0	0.01	0.01	0.44
OS-1	0.19	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	95.0	0.74	0.76	0.84
OS-2	0.67	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.06	0.50	0.11	0.00	0.00	80.2	0.69	0.71	0.81

Land Use	% Imp.
Single Family Res.	55
Multi-Family Res.	75
School	55
Roof	95
Paved	95
Historic	5
Open Space	5
Gravel	40

SF-2 HISTORIC TIME OF CONCENTRATION FOR EACH SUB-BASIN

SUB-BASIN DATA		INITIAL/OVERLAND FLOW TIME				CHANNELIZED FLOW TIME					TOTAL Tc	FIRST DESIGN POINT T_c		EFFECTIVE
DATA											$T_c = T_I + T_T$	MHFD T_c Check		T_c
BASIN	D.A.	C_5	L	S	T_i	L	S	LAND SURFACE	VEL.	T_t	Tc	LENGTH	MIN. T_c	
ID	(AC)		FT	FT/FT	MINUTES	FT	FT/FT		FPS	MINUTES	MINUTES	FT	MINUTES	MINUTES
E1	0.02	0.01	25	0.05	5.8	650	0.05	Short pasture and lawns	1.6	6.9	12.7	675	30.1	12.7
E2	0.06	0.01	80	0.02	14.0	120	0.02	Short pasture and lawns	1.0	2.0	16.0	200	26.6	16.0
E3	2.38	0.01	300	0.05	20.0	650	0.05	Short pasture and lawns	1.6	6.9	27.0	950	30.1	27.0
E4	0.29	0.01	110	0.02	16.4	120	0.02	Short pasture and lawns	1.0	2.0	18.4	230	26.6	18.4
E5	0.67	0.01	204	0.05	16.5	250	0.05	Short pasture and lawns	1.6	2.7	19.2	454	27.1	19.2
E6	1.19	0.01	300	0.05	20.0	300	0.05	Short pasture and lawns	1.6	3.2	23.2	600	27.5	23.2
E7	1.49	0.01	300	0.05	20.0	250	0.05	Short pasture and lawns	1.6	2.7	22.7	550	27.1	22.7

STANDARD FORM SF-3
HISTORIC STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

Subdivision Auburn Heights

Design Storm 5 YR
5-Year P1 = 1.43 in. Table 6-1

Project Name: Auburn Heights
Project No. 0
Calculated By: LO

	DIRECT RUNOFF								TOTAL RUNOFF							STREET		PIPE			TRAVEL TIME			
COMBINED BASINS	Design Point	Area Design.	Area (Ac)	Runoff Coeff. (C2)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Inlet Type	Q (Intercept)	Q (Bypass)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (minutes)	Notes
E1	1e	E1	0.02	0.01	12.7	0.00	3.5	0.0		0.0	0.0	12.7	0.00	3.5	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 1e
	1e	E1										12.7	0.00	3.5	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 1e.
	1e	E1										12.7	0.00	3.5	0.0	-	0.0				-	-	-	No Bypass Flow
E2	2e	E2	0.06	0.01	16.0	0.00	3.1	0.0		0.0	0.0	16.0	0.00	3.1	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 2e
	2e	E2										16.0	0.00	3.1	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 2e.
	2e	E2										16.0	0.00	3.1	0.0	-	0.0				-	-	-	No Bypass Flow
E3	3e	E3	2.38	0.01	27.0	0.02	2.4	0.1		0.1	0.0	27.0	0.02	2.4	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 3e
	3e	E3										27.0	0.02	2.4	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 3e.
	3e	E3										27.0	0.00	2.4	0.0	-	0.0				-	-	-	No Bypass Flow
E4	4e	E4	0.29	0.01	18.4	0.00	2.9	0.0		0.0	0.0	18.4	0.00	2.9	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 4e
	4e	E4										18.4	0.00	2.9	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 4e.
	4e	E4										18.4	0.00	2.9	0.0	-	0.0				-	-	-	No Bypass Flow
E5	5e	E5	0.67	0.01	19.2	0.01	2.9	0.0		0.0	0.0	19.2	0.01	2.9	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 5e
	5e	E5										19.2	0.01	2.9	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 5e.
	5e	E5										19.2	0.00	2.9	0.0	-	0.0				-	-	-	No Bypass Flow
E6	6e	E6	1.19	0.01	23.2	0.01	2.6	0.0		0.0	0.0	23.2	0.01	2.6	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 6e
	6e	E6										23.2	0.01	2.6	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 6e.
	6e	E6										23.2	0.00	2.6	0.0	-	0.0				-	-	-	No Bypass Flow
E7	7e	E7	1.49	0.01	22.7	0.01	2.6	0.0		0.0	0.0	22.7	0.01	2.6	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 7e
	7e	E7										22.7	0.01	2.6	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 7e.
	7e	E7										22.7	0.00	2.6	0.0	-	0.0				-	-	-	No Bypass Flow

STANDARD FORM SF-3
HISTORIC STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

Subdivision Auburn Heights

Design Storm 100 YR
100-Year P1 = 2.6 in. Table 6-1

Project Name: Auburn Heights
Project No. 0
Calculated By: LO

	DIRECT RUNOFF								TOTAL RUNOFF							STREET		PIPE			TRAVEL TIME			
COMBINED BASINS	Design Point	Area Design.	Area (Ac)	Runoff Coeff. (C100)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Inlet Type	Q (Intercept)	Q (Bypass)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (minutes)	Notes
E1	1e	E1	0.02	0.44	12.7	0.01	6.4	0.1	0.0	0.1	0.0	12.7	0.01	6.4	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 1e
	1e	E1										12.7	0.01	6.4	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 1e.
	1e	E1										12.7	0.00	6.4	0.0	-	0.0				-	-	-	No Bypass Flow
E2	2e	E2	0.06	0.44	16.0	0.03	5.7	0.2	0.0	0.2	0.0	16.0	0.03	5.7	0.2	Net Flow at Design Point								0.2 cfs - Net Flow at DP 2e
	2e	E2										16.0	0.03	5.7	0.2			0.2	*	*	-	-	-	0.2 cfs-Pipe Flow to DP 2e.
	2e	E2										16.0	0.00	5.7	0.0	-	0.0				-	-	-	No Bypass Flow
E3	3e	E3	2.38	0.44	27.0	1.05	4.3	4.5	0.0	4.5	0.0	27.0	1.05	4.3	4.5	Net Flow at Design Point								4.5 cfs - Net Flow at DP 3e
	3e	E3										27.0	1.05	4.3	4.5			4.5	*	*	-	-	-	4.5 cfs-Pipe Flow to DP 3e.
	3e	E3										27.0	0.00	4.3	0.0	-	0.0				-	-	-	No Bypass Flow
E4	4e	E4	0.29	0.44	18.4	0.13	5.3	0.7	0.0	0.7	0.0	18.4	0.13	5.3	0.7	Net Flow at Design Point								0.7 cfs - Net Flow at DP 4e
	4e	E4										18.4	0.13	5.3	0.7			0.7	*	*	-	-	-	0.7 cfs-Pipe Flow to DP 4e.
	4e	E4										18.4	0.00	5.3	0.0	-	0.0				-	-	-	No Bypass Flow
E5	5e	E5	0.67	0.44	19.2	0.29	5.2	1.5	0.0	1.5	0.0	19.2	0.29	5.2	1.5	Net Flow at Design Point								1.5 cfs - Net Flow at DP 5e
	5e	E5										19.2	0.29	5.2	1.5			1.5	*	*	-	-	-	1.5 cfs-Pipe Flow to DP 5e.
	5e	E5										19.2	0.00	5.2	0.0	-	0.0				-	-	-	No Bypass Flow
E6	6e	E6	1.19	0.44	23.2	0.52	4.7	2.5	0.0	2.5	0.0	23.2	0.52	4.7	2.5	Net Flow at Design Point								2.5 cfs - Net Flow at DP 6e
	6e	E6										23.2	0.52	4.7	2.5			2.5	*	*	-	-	-	2.5 cfs-Pipe Flow to DP 6e.
	6e	E6										23.2	0.00	4.7	0.0	-	0.0				-	-	-	No Bypass Flow
E7	7e	E7	1.49	0.44	22.7	0.66	4.8	3.1	0.0	3.1	0.0	22.7	0.66	4.8	3.1	Net Flow at Design Point								3.1 cfs - Net Flow at DP 7e
	7e	E7										22.7	0.66	4.8	3.1			3.1	*	*	-	-	-	3.1 cfs-Pipe Flow to DP 7e.
	7e	E7										22.7	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow

SF-1 DEVELOPED COMPOSITE BASIN LAND USE

Subdivision: Auburn Heights

Project Name: Auburn Heights
Project No.
Calculated By: LO
Checked By: MEL
Date: 7/1/2026

Basin	Total Area	Soil Type A	Soil Type B	Soil Type C/D	Single Family Res.	Multi-Family Res.	School	EDB	Paved	Historic	Grass	Roof	Avg. Imp.	C_2	C_5	C_{100}
	(acres)	*(%)*	*(%)*	*(%)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(acres)*	*(%)*			
D1	0.44	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	5.0	0.03	0.03	0.45
D2	0.49	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.24	0.00	0.20	0.05	58.3	0.50	0.51	0.71
D3	0.42	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.19	0.00	0.16	0.07	60.7	0.51	0.53	0.71
D4	1.25	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.81	0.00	0.35	0.09	69.8	0.61	0.62	0.76
D5	1.11	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.67	0.00	0.26	0.18	73.9	0.63	0.65	0.78
D6	0.06	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	5.0	0.03	0.03	0.45
D7	0.07	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	95.0	0.74	0.76	0.84
D8	0.07	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	95.0	0.74	0.76	0.84
D9	0.07	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	95.0	0.74	0.76	0.84
D10	0.07	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	95.0	0.74	0.76	0.84
D11	0.23	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	95.0	0.74	0.76	0.84
D12	0.23	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	95.0	0.74	0.76	0.84
D13	0.23	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	95.0	0.74	0.76	0.84
D14	0.12	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	95.0	0.74	0.76	0.84
D15	0.12	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	95.0	0.74	0.76	0.84
D16	0.16	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	95.0	0.84	0.86	0.89
D17	0.03	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	95.0	0.84	0.86	0.89
D18	0.11	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	95.0	0.74	0.76	0.84
D19	0.13	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	95.0	0.74	0.76	0.84
D20	0.08	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.03	0.00	0.05	0.00	38.8	0.33	0.34	0.62
D21	0.35	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.20	0.04	0.00	0.11	0.00	26.7	0.14	0.15	0.51
D22	0.11	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.01	0.00	0.10	0.00	13.2	0.10	0.11	0.49
D23	0.02	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	50.0	0.44	0.45	0.67
D24	0.01	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	50.0	0.44	0.45	0.67
D25	0.01	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	5.0	0.03	0.03	0.45
D26	0.01	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	5.0	0.03	0.03	0.45
D27	0.04	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	5.0	0.03	0.03	0.45
D28	0.02	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	5.0	0.03	0.03	0.45
D29	0.01	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	5.0	0.03	0.03	0.45
D30	0.02	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	5.0	0.03	0.03	0.45
D31	0.01	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	5.0	0.03	0.03	0.45
D32	0.05	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.02	0.00	0.03	0.00	41.0	0.35	0.36	0.63
D33	0.02	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	50.0	0.44	0.45	0.67
D34	0.03	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	35.0	0.30	0.31	0.60
D35	0.04	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	5.0	0.03	0.03	0.45
OS-1	0.19	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	95.0	0.74	0.76	0.84
OS-2	0.69	0.0%	100.0%	0.0%	0.00	0.00	0.00	0.00	0.50	0.00	0.13	0.06	78.0	0.68	0.69	0.80

Land Use	% Imp.
Single Family Res.	55
Multi-Family Res.	75
School	55
EDB	25
Paved	95
Historic	5
Grass	5
Roof	95

SF-2 TIME OF CONCENTRATION FOR EACH SUB-BASIN

SUB-BASIN DATA		INITIAL/OVERLAND FLOW TIME				CHANNELIZED FLOW TIME					TOTAL Tc	FIRST DESIGN POINT T_c		EFFECTIVE
DATA											$T_c = T_I + T_T$	MHFD T_c Check		T_c
BASIN	D.A.	C_5	L	S	T_i	L	S	LAND SURFACE	VEL.	T_t	Tc	LENGTH	MIN. T_c	
ID	(AC)		FT	FT/FT	MINUTES	FT	FT/FT		FPS	MINUTES	MINUTES	FT	MINUTES	MINUTES
D1	0.44	0.03	42	0.02	10.0	635	0.02	Grassed waterway	2.1	5.0	14.9	677	32.9	14.9
D2	0.49	0.51	81	0.02	7.6	100	0.02	Paved area	2.8	0.6	8.2	181	16.8	8.2
D3	0.42	0.53	81	0.02	7.4	80	0.01	Paved area	2.0	0.7	8.1	161	16.4	8.1
D4	1.25	0.62	65	0.02	5.6	590	0.01	Paved area	2.0	4.9	10.5	655	19.4	10.5
D5	1.11	0.65	110	0.02	6.8	250	0.01	Paved area	2.0	2.1	8.9	360	15.6	8.9
D6	0.06	0.03	35	0.02	9.1	35	0.02	Short pasture and lawns	1.0	0.6	9.7	70	25.6	9.7
D7	0.07	0.76	32	0.10	1.6	85	0.01	Paved area	2.0	0.7	2.3	117	10.5	5.0
D8	0.07	0.76	32	0.10	1.6	85	0.01	Paved area	2.0	0.7	2.3	117	10.5	5.0
D9	0.07	0.76	32	0.10	1.6	85	0.01	Paved area	2.0	0.7	2.3	117	10.5	5.0
D10	0.07	0.76	32	0.10	1.6	85	0.01	Paved area	2.0	0.7	2.3	117	10.5	5.0
D11	0.23	0.76	50	0.10	2.0	100	0.01	Paved area	2.0	0.8	2.9	150	10.6	5.0
D12	0.23	0.76	50	0.10	2.0	100	0.01	Paved area	2.0	0.8	2.9	150	10.6	5.0
D13	0.23	0.76	50	0.10	2.0	100	0.01	Paved area	2.0	0.8	2.9	150	10.8	5.0
D14	0.12	0.76	30	0.10	1.6	60	0.01	Paved area	2.0	0.5	2.1	90	10.5	5.0
D15	0.12	0.76	30	0.10	1.6	60	0.01	Paved area	2.0	0.5	2.1	90	10.5	5.0
D16	0.16	0.86	40	0.10	1.3	80	0.01	Paved area	2.0	0.7	1.9	120	10.7	5.0
D17	0.03	0.86	40	0.01	2.7	80	0.01	Paved area	2.0	0.7	3.4	120	10.7	5.0
D18	0.11	0.76	50	0.10	2.0	100	0.01	Paved area	2.0	0.8	2.9	150	10.8	5.0
D19	0.13	0.76	30	0.10	1.6	90	0.01	Paved area	2.0	0.8	2.3	120	10.7	5.0
D20	0.08	0.34	30	0.04	4.7	60	0.01	Paved area	2.0	0.5	5.2	90	10.5	5.2
D21	0.35	0.15	60	0.02	10.6	120	0.01	Short pasture and lawns	0.7	2.9	13.5	180	11.0	11.0
D22	0.11	0.11	50	0.02	10.1	120	0.01	Short pasture and lawns	0.7	2.9	13.0	170	10.9	10.9
D23	0.02	0.45	10	0.02	3.0	30	0.02	Short pasture and lawns	1.0	0.5	3.5	40	10.2	5.0
D24	0.01	0.45	10	0.02	3.0	20	0.02	Short pasture and lawns	1.0	0.3	3.3	30	10.2	5.0
D25	0.01	0.03	10	0.02	4.9	20	0.02	Short pasture and lawns	1.0	0.3	5.2	30	10.2	5.2
D26	0.01	0.03	10	0.02	4.9	20	0.02	Short pasture and lawns	1.0	0.3	5.2	30	10.2	5.2
D27	0.04	0.03	20	0.04	5.5	60	0.02	Short pasture and lawns	1.0	1.0	6.5	80	10.4	6.5
D28	0.02	0.03	10	0.02	4.9	20	0.02	Short pasture and lawns	1.0	0.3	5.2	30	10.2	5.2
D29	0.01	0.03	10	0.02	4.9	20	0.02	Short pasture and lawns	1.0	0.3	5.2	30	10.2	5.2
D30	0.02	0.03	10	0.02	4.9	40	0.02	Short pasture and lawns	1.0	0.7	5.5	50	10.3	5.5
D31	0.01	0.03	10	0.02	4.9	25	0.02	Short pasture and lawns	1.0	0.4	5.3	35	10.2	5.3
D32	0.05	0.36	15	0.02	4.1	77	0.02	Short pasture and lawns	1.0	1.3	5.4	92	10.5	5.4
D33	0.02	0.45	10	0.02	3.0	20	0.02	Short pasture and lawns	1.0	0.3	3.3	30	10.2	5.0
D34	0.03	0.31	10	0.02	3.6	20	0.02	Short pasture and lawns	1.0	0.3	3.9	30	10.2	5.0
D35	0.04	0.03	15	0.05	4.4	105	0.02	Short pasture and lawns	1.0	1.8	6.2	120	10.7	6.2
OS-1	0.19	0.76	50	0.02	3.5	130	0.02	Paved area	2.8	0.8	4.2	180	11.0	5.0
OS-2	0.69	0.69	120	0.04	5.1	220	0.01	Paved area	2.0	1.8	6.9	340	11.9	6.9

STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

Project Name: Auburn Heights
Project No. 0
Calculated By: LO

Subdivision Auburn Heights

Design Storm 5 YR
5-Year P1 = 1.43 in. Table 6-1

	DIRECT RUNOFF								TOTAL RUNOFF							STREET		PIPE			TRAVEL TIME			
COMBINED BASINS	Design Point	Area Design.	Area (Ac)	Runoff Coeff. (C2)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Inlet Type	Q (Intercept)	Q (Bypass)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (minutes)	Notes
D1	1d	D1	0.44	0.03	14.9	0.01	3.3	0.0		0.0	0.0	14.9	0.01	3.3	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 1d
	1d	D1							Offsite			14.9	0.01	3.3	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 1d.
	1d	D1										14.9	0.00	3.3	0.0	-	0.0				-	-	-	No Bypass Flow
D2	2d	D2	0.49	0.50	8.2	0.24	4.2	1.0		1.0	0.0	8.2	0.24	4.2	1.0	Net Flow at Design Point								1 cfs - Net Flow at DP 2d
	2d	D2							TYPE C INLET			8.2	0.24	4.2	1.0			1.0	*	*	-	-	-	1 cfs-Pipe Flow to DP 2d.
	2d	D2										8.2	0.00	4.2	0.0	-	0.0				-	-	-	No Bypass Flow
D3	3d	D3	0.42	0.51	8.1	0.22	4.2	0.9		0.9	0.0	8.1	0.22	4.2	0.9	Net Flow at Design Point								0.9 cfs - Net Flow at DP 3d
	3d	D3							TYPE C INLET			8.1	0.22	4.2	0.9			0.9	*	*	-	-	-	0.9 cfs-Pipe Flow to DP 3d.
	3d	D3										8.1	0.00	4.2	0.0	-	0.0				-	-	-	No Bypass Flow
D4	4d	D4	1.25	0.61	10.5	0.76	3.8	2.9		2.9	0.0	10.5	0.76	3.8	2.9	Net Flow at Design Point								2.9 cfs - Net Flow at DP 4d
	4d	D4							TYPE R INLET			10.5	0.76	3.8	2.9			2.9	*	*	-	-	-	2.9 cfs-Pipe Flow to DP 4d.
	4d	D4										10.5	0.00	3.8	0.0	-	0.0				-	-	-	No Bypass Flow
D5	5d	D5	1.11	0.63	8.9	0.70	4.0	2.8		2.8	0.0	8.9	0.70	4.0	2.8	Net Flow at Design Point								2.8 cfs - Net Flow at DP 5d
	5d	D5							TYPE R INLET			8.9	0.70	4.0	2.8			2.8	*	*	-	-	-	2.8 cfs-Pipe Flow to DP 5d.
	5d	D5										8.9	0.00	4.0	0.0	-	0.0				-	-	-	No Bypass Flow
D6	6d	D6	0.06	0.03	9.7	0.00	3.9	0.0		0.0	0.0	9.7	0.00	3.9	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 6d
	6d	D6							NYLOPLAST GRATE			9.7	0.00	3.9	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 6d.
	6d	D6										9.7	0.00	3.9	0.0	-	0.0				-	-	-	No Bypass Flow
D7	7d	D7	0.07	0.74	5.0	0.05	4.9	0.3		0.3	0.0	5.0	0.05	4.9	0.3	Net Flow at Design Point								0.3 cfs - Net Flow at DP 7d
	7d	D7							ROOF DRAIN			5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Pipe Flow to DP 7d.
	7d	D7										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D8	8d	D8	0.07	0.74	5.0	0.05	4.9	0.3		0.3	0.0	5.0	0.05	4.9	0.3	Net Flow at Design Point								0.3 cfs - Net Flow at DP 8d
	8d	D8							ROOF DRAIN			5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Pipe Flow to DP 8d.
	8d	D8										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D9	9d	D9	0.07	0.74	5.0	0.05	4.9	0.3		0.3	0.0	5.0	0.05	4.9	0.3	Net Flow at Design Point								0.3 cfs - Net Flow at DP 9d
	9d	D9							ROOF DRAIN			5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Pipe Flow to DP 9d.
	9d	D9										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D10	10d	D10	0.07	0.74	5.0	0.05	4.9	0.3		0.3	0.0	5.0	0.05	4.9	0.3	Net Flow at Design Point								0.3 cfs - Net Flow at DP 10d
	10d	D10							ROOF DRAIN			5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Pipe Flow to DP 10d.
	10d	D10										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D11	11d	D11	0.23	0.74	5.0	0.17	4.9	0.8		0.8	0.0	5.0	0.17	4.9	0.8	Net Flow at Design Point								0.8 cfs - Net Flow at DP 11d
	11d	D11							ROOF DRAIN			5.0	0.17	4.9	0.8			0.8	*	*	-	-	-	0.8 cfs-Pipe Flow to DP 11d.
	11d	D11										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D12	12d	D12	0.23	0.74	5.0	0.17	4.9	0.8		0.8	0.0	5.0	0.17	4.9	0.8	Net Flow at Design Point								0.8 cfs - Net Flow at DP 12d
	12d	D12							ROOF DRAIN			5.0	0.17	4.9	0.8			0.8	*	*	-	-	-	0.8 cfs-Pipe Flow to DP 12d.
	12d	D12										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D13	13d	D13	0.23	0.74	5.0	0.17	4.9	0.8		0.8	0.0	5.0	0.17	4.9	0.8	Net Flow at Design Point								0.8 cfs - Net Flow at DP 13d
	13d	D13							ROOF DRAIN			5.0	0.17	4.9	0.8			0.8	*	*	-	-	-	0.8 cfs-Pipe Flow to DP 13d.
	13d	D13										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D14	14d	D14	0.12	0.74	5.0	0.09	4.9	0.4		0.4	0.0	5.0	0.09	4.9	0.4	Net Flow at Design Point								0.4 cfs - Net Flow at DP 14d
	14d	D14							ROOF DRAIN			5.0	0.09	4.9	0.4			0.4	*	*	-	-	-	0.4 cfs-Pipe Flow to DP 14d.
	14d	D14										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D15	15d	D15	0.12	0.74	5.0	0.09	4.9	0.4		0.4	0.0	5.0	0.09	4.9	0.4	Net Flow at Design Point								0.4 cfs - Net Flow at DP 15d
	15d	D15							ROOF DRAIN			5.0	0.09	4.9	0.4			0.4	*	*	-	-	-	0.4 cfs-Pipe Flow to DP 15d.
	15d	D15										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D16	16d	D16	0.16	0.84	5.0	0.13	4.9	0.7		0.7	0.0	5.0	0.13	4.9	0.7	Net Flow at Design Point								0.7 cfs - Net Flow at DP 16d
	16d	D16							STUB			5.0	0.13	4.9	0.7			0.7	*	*	-	-	-	0.7 cfs-Pipe Flow to DP 16d.
	16d	D16										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow

D17	17d	D17	0.03	0.84	5.0	0.03	4.9	0.1	STUB	0.1	0.0	5.0	0.03	4.9	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 17d
	17d	D17										5.0	0.03	4.9	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 17d.
	17d	D17										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D18	18d	D18	0.11	0.74	5.0	0.08	4.9	0.4	ROOF DRAIN	0.4	0.0	5.0	0.08	4.9	0.4	Net Flow at Design Point								0.4 cfs - Net Flow at DP 18d
	18d	D18										5.0	0.08	4.9	0.4			0.4	*	*	-	-	-	0.4 cfs-Pipe Flow to DP 18d.
	18d	D18										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D19	19d	D19	0.13	0.74	5.0	0.10	4.9	0.5	ROOF DRAIN	0.5	0.0	5.0	0.10	4.9	0.5	Net Flow at Design Point								0.5 cfs - Net Flow at DP 19d
	19d	D19										5.0	0.10	4.9	0.5			0.5	*	*	-	-	-	0.5 cfs-Pipe Flow to DP 19d.
	19d	D19										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D20	20d	D20	0.08	0.33	5.2	0.03	4.8	0.1	OFFSITE	0.1	0.0	5.2	0.03	4.8	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 20d
	20d	D20										5.2	0.03	4.8	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 20d.
	20d	D20										5.2	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow
D21	21d	D21	0.35	0.14	11.0	0.05	3.7	0.2	POND	0.2	0.0	11.0	0.05	3.7	0.2	Net Flow at Design Point								0.2 cfs - Net Flow at DP 21d
	21d	D21										11.0	0.05	3.7	0.2			0.2	*	*	-	-	-	0.2 cfs-Pipe Flow to DP 21d.
	21d	D21										11.0	0.00	3.7	0.0	-	0.0				-	-	-	No Bypass Flow
D22	22d	D22	0.11	0.10	10.9	0.01	3.7	0.0	OFFSITE	0.0	0.0	10.9	0.01	3.7	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 22d
	22d	D22										10.9	0.01	3.7	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 22d.
	22d	D22										10.9	0.00	3.7	0.0	-	0.0				-	-	-	No Bypass Flow
D23	23d	D23	0.02	0.44	5.0	0.01	4.9	0.0	NYLOPLAST GRATE	0.0	0.0	5.0	0.01	4.9	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 23d
	23d	D23										5.0	0.01	4.9	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 23d.
	23d	D23										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D24	24d	D24	0.01	0.44	5.0	0.00	4.9	0.0	NYLOPLAST GRATE	0.0	0.0	5.0	0.00	4.9	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 24d
	24d	D24										5.0	0.00	4.9	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 24d.
	24d	D24										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D26	25d	D26	0.01	0.03	5.2	0.00	4.8	0.0	NYLOPLAST GRATE	0.0	0.0	5.2	0.00	4.8	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 25d
	25d	D26										5.2	0.00	4.8	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 26d.
	25d	D26										5.2	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow
D27	27d	D27	0.04	0.03	6.5	0.00	4.5	0.0	NYLOPLAST GRATE	0.0	0.0	6.5	0.00	4.5	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 27d
	27d	D27										6.5	0.00	4.5	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 27d.
	27d	D27										6.5	0.00	4.5	0.0	-	0.0				-	-	-	No Bypass Flow
D28	28d	D28	0.02	0.03	5.2	0.00	4.8	0.0	NYLOPLAST GRATE	0.0	0.0	5.2	0.00	4.8	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 28d
	28d	D28										5.2	0.00	4.8	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 28d.
	28d	D28										5.2	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow
D29	29d	D29	0.01	0.03	5.2	0.00	4.8	0.0	NYLOPLAST GRATE	0.0	0.0	5.2	0.00	4.8	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 29d
	29d	D29										5.2	0.00	4.8	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 29d.
	29d	D29										5.2	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow
D30	30d	D30	0.02	0.03	5.5	0.00	4.7	0.0	NYLOPLAST GRATE	0.0	0.0	5.5	0.00	4.7	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 30d
	30d	D30										5.5	0.00	4.7	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 30d.
	30d	D30										5.5	0.00	4.7	0.0	-	0.0				-	-	-	No Bypass Flow
D31	31d	D31	0.01	0.03	5.3	0.00	4.8	0.0	NYLOPLAST GRATE	0.0	0.0	5.3	0.00	4.8	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 31d
	31d	D31										5.3	0.00	4.8	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 31d.
	31d	D31										5.3	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow
D32	32d	D32	0.05	0.36	5.4	0.02	4.8	0.1	NYLOPLAST GRATE	0.1	0.0	5.4	0.02	4.8	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 32d
	32d	D32										5.4	0.02	4.8	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 32d.
	32d	D32										5.4	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow
D33	33d	D33	0.02	0.45	5.0	0.01	4.9	0.0	NYLOPLAST GRATE	0.0	0.0	5.0	0.01	4.9	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 33d
	33d	D33										5.0	0.01	4.9	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 33d.
	33d	D33										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D34	34d	D34	0.03	0.31	5.0	0.01	4.9	0.0	NYLOPLAST GRATE	0.0	0.0	5.0	0.01	4.9	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 34d
	34d	D34										5.0	0.01	4.9	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 34d.
	34d	D34										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
D35	35d	D35	0.04	0.03	6.2	0.00	4.6	0.0	NYLOPLAST GRATE	0.0	0.0	6.2	0.00	4.6	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 35d
	35d	D35										6.2	0.00	4.6	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 35d.
	35d	D35										6.2	0.00	4.6	0.0	-	0.0				-	-	-	No Bypass Flow
OS-1	o1	OS-1	0.19	0.76	5.0	0.14	4.9	0.7	POND	0.7	0.0	5.0	0.14	4.9	0.7	Net Flow at Design Point								0.7 cfs - Net Flow at DP o1
	o1	OS-1										5.0	0.14	4.9	0.7			0.7	*	*	-	-	-	0.7 cfs-Pipe Flow to DP o1.
	o1	OS-1										5.0	0.00	4.9	0.0	-	0.0				-	-	-	No Bypass Flow
OS-2	o2	OS-2	0.69	0.69	6.9	0.48	4.4	2.1	POND	2.1	0.0	6.9	0.48	4.4	2.1	Net Flow at Design Point								2.1 cfs - Net Flow at DP o2
	o2	OS-2										6.9	0.48	4.4	2.1			2.1	*	*	-	-	-	2.1 cfs-Pipe Flow to DP o2.
	o2	OS-2										6.9	0.00	4.4	0.0	-	0.0				-	-	-	No Bypass Flow
D25	25d	D25	0.01	0.03	5.2	0.00	4.8	0.0	NYLOPLAST GRATE	0.0	0.0	5.2	0.00	4.8	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 25d
	25d	D25										5.2	0.00	4.8	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 25d.
	25d	D25										5.2	0.00	4.8	0.0	-	0.0				-	-	-	No Bypass Flow

STANDARD FORM SF-3
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

Project Name: Auburn Heights
Project No. 0
Calculated By: LO

No Plot

Subdivision Auburn Heights

Design Storm 5 YR
5-Year P_1 = 1.43 in. Table 6-1

*Refer to CDs and SewerGEMS model for pipe slope and diamete

	DIRECT RUNOFF									TOTAL RUNOFF						STREET		PIPE			TRAVEL TIME				
Directly Upstream DP	Design Point	Area Design.	Area (Ac)	Runoff Coeff. (C2)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Inlet Type	Q (Intercept)	Q (Bypass)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (minutes)	Notes	Flow to DP
D1	1d.	1d.	-	-	-	-	-	-	-	0.0	0.0	14.9	0.01	3.3	0.0			0.0	*	*	-	-	-	0 cfs-Piped to DP OS	OS
	1d.	1d.																							
	1d.	1d.																							
D2	2d.	2d.	-	-	-	-	-	-	-	1.0	0.0	8.2	0.24	4.2	1.0			1.0	*	*	-	-	-	1 cfs-Piped to DP DF.	DF.
	2d.	2d.																							
	2d.	2d.																							
D3	3d.	3d.	-	-	-	-	-	-	-	0.9	0.0	8.1	0.22	4.2	0.9			0.9	*	*	-	-	-	0.9 cfs-Piped to DP DF.	DF.
	3d.	3d.																							
	3d.	3d.																							
D2, D3	DF.	DF.	-	-	-	-	-	-	-	1.9	0.0	8.2	0.46	4.2	1.9			1.9	*	*	-	-	-	1.9 cfs-Piped to DP DE.	DE.
	DF.	DF.																							
	DF.	DF.																							
D15	15d.	15d.	-	-	-	-	-	-	-	0.4	0.0	5.0	0.09	4.9	0.4			0.4	*	*	-	-	-	0.4 cfs-Piped to DP DE.	DE.
	15d.	15d.																							
	15d.	15d.																							
D2, D3, D15	DE.	DE.	-	-	-	-	-	-	-	2.3	0.0	8.2	0.55	4.2	2.3			2.3	*	*	-	-	-	2.3 cfs-Piped to DP DC.	DC.
	DE.	DE.																							
	DE.	DE.																							
D8	8d.	8d.	-	-	-	-	-	-	-	0.3	0.0	5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Piped to DP 23d.	23d.
	8d.	8d.																							
	8d.	8d.																							
D8	8d.	8d.	-	-	-	-	-	-	-	0.3	0.0	5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Piped to DP 9d.	9d.
	8d.	8d.																							
	8d.	8d.																							
D8, D23	23d.	23d.	-	-	-	-	-	-	-	0.3	0.0	5.0	0.06	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Piped to DP 24d.	24d.
	23d.	23d.																							
	23d.	23d.																							
D8, D23, D24	24d.	24d.	-	-	-	-	-	-	-	0.3	0.0	5.0	0.06	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Piped to DP DA.	DA.
	24d.	24d.																							
	24d.	24d.																							
D7	7d.	7d.	-	-	-	-	-	-	-	0.3	0.0	5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Piped to DP 6d.	6d.
	7d.	7d.																							
	7d.	7d.																							
D7, D6	6d.	6d.	-	-	-	-	-	-	-	0.2	0.0	9.7	0.05	3.9	0.2			0.2	*	*	-	-	-	0.2 cfs-Piped to DP DA.	DA.
	6d.	6d.																							
	6d.	6d.																							
D8, D23, D24, D7, D6	DA.	DA.	-	-	-	-	-	-	-	0.5	0.0	9.7	0.12	3.9	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP DB.	DB.
	DA.	DA.																							
	DA.	DA.																							
D8, D9	9d.	9d.	-	-	-	-	-	-	-	0.5	0.0	5.0	0.10	4.9	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP 25d.	25d.
	9d.	9d.																							
	9d.	9d.																							
D8, D9, D25	25d.	25d.	-	-	-	-	-	-	-	0.5	0.0	5.2	0.10	4.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP 26d.	26d.
	25d.	25d.																							
	25d.	25d.																							
D8, D9, D25, D26	26d.	26d.	-	-	-	-	-	-	-	0.5	0.0	5.2	0.10	4.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP DB.	DB.
	26d.	26d.																							
	26d.	26d.																							
D8, D23, D24, D7, D6, D8, D9, D25, D26	DB.	DB.	-	-	-	-	-	-	-	0.9	0.0	9.7	0.22	3.9	0.9			0.9	*	*	-	-	-	0.9 cfs-Piped to DP DC.	DC.
	DB.	DB.																							
	DB.	DB.																							
D10	10d.	10d.	-	-	-	-	-	-	-	0.3	0.0	5.0	0.05	4.9	0.3			0.3	*	*	-	-	-	0.3 cfs-Piped to DP 27d.	27d.
	10d.	10d.																							
	10d.	10d.																							
D10, D27	27d.	27d.	-	-	-	-	-	-	-	0.2	0.0	6.5	0.05	4.5	0.2			0.2	*	*	-	-	-	0.2 cfs-Piped to DP 28d.	28d.
	27d.	27d.																							
	27d.	27d.																							
D11	11d.	11d.	-	-	-	-	-	-	-	0.8	0.0	5.0	0.17	4.9	0.8			0.8	*	*	-	-	-	0.8 cfs-Piped to DP 28d.	28d.
	11d.	11d.																							
	11d.	11d.																							
D10, D27, D11, D28	28d.	28d.	-	-	-	-	-	-	-	1.0	0.0	6.5	0.22	4.5	1.0			1.0	*	*	-	-	-	1 cfs-Piped to DP 29d.	29d.
	28d.	28d.																							
	28d.	28d.																							
D10, D27, D11, D28, D29	29d.	29d.	-	-	-	-	-	-	-	1.0	0.0	6.5	0.22	4.5	1.0			1.0	*	*	-	-	-	1 cfs-Piped to DP 30d.	30d.
	29d.	29d.																							
	29d.	29d.																							
D10, D27, D11, D28, D29, D30	30d.	30d.	-	-	-	-	-	-	-	1.0	0.0	6.5	0.22	4.5	1.0			1.0	*	*	-	-	-	1 cfs-Piped to DP 31d.	31d.
	30d.	30d.																							
	30d.	30d.																							
D12	12d.	12d.	-	-	-	-	-	-	-	0.8	0.0	5.0	0.17	4.9	0.8			0.8	*	*	-	-	-	0.8 cfs-Piped to DP 31d.	31d.
	12d.	12d.																							

	12d.	12d.																								
D10, D27, D11, D28, D29, D30, D12, D31	31d.	31d.	-	-	-	-	-	-	-	1.8	0.0	6.5	0.40	4.5	1.8			1.8	*	*	-	-	-	1.8 cfs-Piped to DP DC.	DC.
	31d.	31d.																								
	31d.	31d.																								
D2, D3, D15, D8, D23, D24, D7, D6, D8, D9, D25, D26, D10, D27, D11, D28, D29, D30, D12, D31	DC.	DC.	-	-	-	-	-	-	-	4.6	0.0	9.7	1.17	3.9	4.6			4.6	*	*	-	-	-	4.6 cfs-Piped to DP DI.	DI.
	DC.	DC.																								
	DC.	DC.																								
D14	14d.	14d.	-	-	-	-	-	-	-	0.4	0.0	5.0	0.09	4.9	0.4			0.4	*	*	-	-	-	0.4 cfs-Piped to DP 33d.	33d.
	14d.	14d.																								
	14d.	14d.																								
D32	32d.	32d.	-	-	-	-	-	-	-	0.1	0.0	5.4	0.02	4.8	0.1			0.1	*	*	-	-	-	0.1 cfs-Piped to DP 33d.	33d.
	32d.	32d.																								
	32d.	32d.																								
D34	34d.	34d.	-	-	-	-	-	-	-	0.0	0.0	5.0	0.01	4.9	0.0			0.0	*	*	-	-	-	0 cfs-Piped to DP 33d.	33d.
	34d.	34d.																								
	34d.	34d.																								
D14, D32, D34, D33	33d.	33d.	-	-	-	-	-	-	-	0.6	0.0	5.4	0.13	4.8	0.6			0.6	*	*	-	-	-	0.6 cfs-Piped to DP DG.	DG.
	33d.	33d.																								
	33d.	33d.																								
D19	19d.	19d.	-	-	-	-	-	-	-	0.5	0.0	5.0	0.10	4.9	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP 35d.	35d.
	19d.	19d.																								
	19d.	19d.																								
D19, D35	35d.	35d.	-	-	-	-	-	-	-	0.4	0.0	6.2	0.10	4.6	0.4			0.4	*	*	-	-	-	0.4 cfs-Piped to DP DG.	DG.
	35d.	35d.																								
	35d.	35d.																								
D16	16d.	16d.	-	-	-	-	-	-	-	0.7	0.0	5.0	0.13	4.9	0.7			0.7	*	*	-	-	-	0.7 cfs-Piped to DP DG.	DG.
	16d.	16d.																								
	16d.	16d.																								
D14, D32, D34, D33, D19, D35, D16	DG.	DG.	-	-	-	-	-	-	-	1.6	0.0	6.2	0.36	4.6	1.6			1.6	*	*	-	-	-	1.6 cfs-Piped to DP DH.	DH.
	DG.	DG.																								
	DG.	DG.																								
D17	17d.	17d.	-	-	-	-	-	-	-	0.1	0.0	5.0	0.03	4.9	0.1			0.1	*	*	-	-	-	0.1 cfs-Piped to DP DH.	DH.
	17d.	17d.																								
	17d.	17d.																								
D14, D32, D34, D33, D19, D35, D16, D17	DH.	DH.	-	-	-	-	-	-	-	1.7	0.0	6.2	0.38	4.6	1.7			1.7	*	*	-	-	-	1.7 cfs-Piped to DP 4d.	4d.
	DH.	DH.																								
	DH.	DH.																								
D14, D32, D34, D33, D19, D35, D16, D17, D4	4d.	4d.	-	-	-	-	-	-	-	4.3	0.0	10.5	1.14	3.8	4.3			4.3	*	*	-	-	-	4.3 cfs-Piped to DP DI.	DI.
	4d.	4d.																								
	4d.	4d.																								
D2, D3, D15, D8, D23, D24, D7, D6, D8, D9, D25, D26, D10, D27, D11, D28, D29, D30, D12, D31,	DI.	DI.	-	-	-	-	-	-	-	8.8	0.0	10.5	2.31	3.8	8.8			8.8	*	*	-	-	-	8.8 cfs-Piped to DP DJ.	DJ.
	DI.	DI.																								
	DI.	DI.																								
D5	5d.	5d.	-	-	-	-	-	-	-	2.8	0.0	8.9	0.70	4.0	2.8			2.8	*	*	-	-	-	2.8 cfs-Piped to DP DJ.	DJ.
	5d.	5d.																								
	5d.	5d.																								
D2, D3, D15, D8, D23, D24, D7, D6, D8, D9, D25, D26, D10, D27, D11, D28, D29, D30, D12, D31,	DJ.	DJ.	-	-	-	-	-	-	-	11.4	0.0	10.5	3.01	3.8	11.4			11.4	*	*	-	-	-	11.4 cfs-Piped to DP POND.	POND.
	DJ.	DJ.																								
	DJ.	DJ.																								
OS-1	o1.	o1.	-	-	-	-	-	-	-	0.7	0.0	5.0	0.14	4.9	0.7			0.7	*	*	-	-	-	0.7 cfs-Piped to DP POND.	POND.
	o1.	o1.																								
	o1.	o1.																								
OS-2	o2.	o2.	-	-	-	-	-	-	-	2.1	0.0	6.9	0.48	4.4	2.1			2.1	*	*	-	-	-	2.1 cfs-Piped to DP Pond.	Pond.
	o2.	o2.																								
	o2.	o2.																								

STANDARD FORM SF-3
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

Subdivision Auburn Heights

Design Storm 100 YR
100-Year P1 = 2.6 in. Table 6-1

Project Name: Auburn Heights
Project No. 0
Calculated By: LO

	DIRECT RUNOFF								TOTAL RUNOFF							STREET		PIPE			TRAVEL TIME			
COMBINED BASINS	Design Point	Area Design.	Area (Ac)	Runoff Coeff. (C100)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Inlet Type	Q (Intercept)	Q (Bypass)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (minutes)	Notes
D1	1d	D1	0.44	0.45	14.9	0.20	5.9	1.2		1.2	0.0	14.9	0.20	5.9	1.2	Net Flow at Design Point								1.2 cfs - Net Flow at DP 1d
	1d	D1							Offsite			14.9	0.20	5.9	1.2			1.2	*	*	-	-	-	1.2 cfs-Pipe Flow to DP 1d.
	1d	D1										14.9	0.00	5.9	0.0	-	0.0				-	-	-	No Bypass Flow
D2	2d	D2	0.49	0.71	8.2	0.35	7.6	2.6		2.6	0.0	8.2	0.35	7.6	2.6	Net Flow at Design Point								2.6 cfs - Net Flow at DP 2d
	2d	D2							TYPE C INLET			8.2	0.35	7.6	2.6			2.6	*	*	-	-	-	2.6 cfs-Pipe Flow to DP 2d.
	2d	D2										8.2	0.00	7.6	0.0	-	0.0				-	-	-	No Bypass Flow
D3	3d	D3	0.42	0.71	8.1	0.30	7.6	2.3		2.3	0.0	8.1	0.30	7.6	2.3	Net Flow at Design Point								2.3 cfs - Net Flow at DP 3d
	3d	D3							TYPE C INLET			8.1	0.30	7.6	2.3			2.3	*	*	-	-	-	2.3 cfs-Pipe Flow to DP 3d.
	3d	D3										8.1	0.00	7.6	0.0	-	0.0				-	-	-	No Bypass Flow
D4	4d	D4	1.25	0.76	10.5	0.95	6.9	6.6		6.6	0.0	10.5	0.95	6.9	6.6	Net Flow at Design Point								6.6 cfs - Net Flow at DP 4d
	4d	D4							TYPE R INLET			10.5	0.95	6.9	6.6			6.6	*	*	-	-	-	6.6 cfs-Pipe Flow to DP 4d.
	4d	D4										10.5	0.00	6.9	0.0	-	0.0				-	-	-	No Bypass Flow
D5	5d	D5	1.11	0.78	8.9	0.86	7.4	6.4		6.4	0.0	8.9	0.86	7.4	6.4	Net Flow at Design Point								6.4 cfs - Net Flow at DP 5d
	5d	D5							TYPE R INLET			8.9	0.86	7.4	6.4			6.4	*	*	-	-	-	6.4 cfs-Pipe Flow to DP 5d.
	5d	D5										8.9	0.00	7.4	0.0	-	0.0				-	-	-	No Bypass Flow
D6	6d	D6	0.06	0.45	9.7	0.03	7.1	0.2		0.2	0.0	9.7	0.03	7.1	0.2	Net Flow at Design Point								0.2 cfs - Net Flow at DP 6d
	6d	D6							NYLOPLAST GRATE			9.7	0.03	7.1	0.2			0.2	*	*	-	-	-	0.2 cfs-Pipe Flow to DP 6d.
	6d	D6										9.7	0.00	7.1	0.0	-	0.0				-	-	-	No Bypass Flow
D7	7d	D7	0.07	0.84	5.0	0.06	8.8	0.5		0.5	0.0	5.0	0.06	8.8	0.5	Net Flow at Design Point								0.5 cfs - Net Flow at DP 7d
	7d	D7							ROOF DRAIN			5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Pipe Flow to DP 7d.
	7d	D7										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D8	8d	D8	0.07	0.84	5.0	0.06	8.8	0.5		0.5	0.0	5.0	0.06	8.8	0.5	Net Flow at Design Point								0.5 cfs - Net Flow at DP 8d
	8d	D8							ROOF DRAIN			5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Pipe Flow to DP 8d.
	8d	D8										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D9	9d	D9	0.07	0.84	5.0	0.06	8.8	0.5		0.5	0.0	5.0	0.06	8.8	0.5	Net Flow at Design Point								0.5 cfs - Net Flow at DP 9d
	9d	D9							ROOF DRAIN			5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Pipe Flow to DP 9d.
	9d	D9										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D10	10d	D10	0.07	0.84	5.0	0.06	8.8	0.5		0.5	0.0	5.0	0.06	8.8	0.5	Net Flow at Design Point								0.5 cfs - Net Flow at DP 10d
	10d	D10							ROOF DRAIN			5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Pipe Flow to DP 10d.
	10d	D10										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D11	11d	D11	0.23	0.84	5.0	0.19	8.8	1.7		1.7	0.0	5.0	0.19	8.8	1.7	Net Flow at Design Point								1.7 cfs - Net Flow at DP 11d
	11d	D11							ROOF DRAIN			5.0	0.19	8.8	1.7			1.7	*	*	-	-	-	1.7 cfs-Pipe Flow to DP 11d.
	11d	D11										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D12	12d	D12	0.23	0.84	5.0	0.19	8.8	1.7		1.7	0.0	5.0	0.19	8.8	1.7	Net Flow at Design Point								1.7 cfs - Net Flow at DP 12d
	12d	D12							ROOF DRAIN			5.0	0.19	8.8	1.7			1.7	*	*	-	-	-	1.7 cfs-Pipe Flow to DP 12d.
	12d	D12										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D13	13d	D13	0.23	0.84	5.0	0.19	8.8	1.7		1.7	0.0	5.0	0.19	8.8	1.7	Net Flow at Design Point								1.7 cfs - Net Flow at DP 13d
	13d	D13							ROOF DRAIN			5.0	0.19	8.8	1.7			1.7	*	*	-	-	-	1.7 cfs-Pipe Flow to DP 13d.
	13d	D13										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D14	14d	D14	0.12	0.84	5.0	0.10	8.8	0.9		0.9	0.0	5.0	0.10	8.8	0.9	Net Flow at Design Point								0.9 cfs - Net Flow at DP 14d
	14d	D14							ROOF DRAIN			5.0	0.10	8.8	0.9			0.9	*	*	-	-	-	0.9 cfs-Pipe Flow to DP 14d.
	14d	D14										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D15	15d	D15	0.12	0.84	5.0	0.10	8.8	0.9		0.9	0.0	5.0	0.10	8.8	0.9	Net Flow at Design Point								0.9 cfs - Net Flow at DP 15d
	15d	D15							ROOF DRAIN			5.0	0.10	8.8	0.9			0.9	*	*	-	-	-	0.9 cfs-Pipe Flow to DP 15d.
	15d	D15										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D16	16d	D16	0.16	0.89	5.0	0.14	8.8	1.3		1.3	0.0	5.0	0.14	8.8	1.3	Net Flow at Design Point								1.3 cfs - Net Flow at DP 16d
	16d	D16							STUB			5.0	0.14	8.8	1.3			1.3	*	*	-	-	-	1.3 cfs-Pipe Flow to DP 16d.

	16d	D16										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D17	17d	D17	0.03	0.89	5.0	0.03	8.8	0.2	STUB	0.2	0.0	5.0	0.03	8.8	0.2	Net Flow at Design Point								0.2 cfs - Net Flow at DP 17d
	17d	D17										5.0	0.03	8.8	0.2			0.2	*	*	-	-	-	0.2 cfs-Pipe Flow to DP 17d.
	17d	D17										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D18	18d	D18	0.11	0.84	5.0	0.09	8.8	0.8	ROOF DRAIN	0.8	0.0	5.0	0.09	8.8	0.8	Net Flow at Design Point								0.8 cfs - Net Flow at DP 18d
	18d	D18										5.0	0.09	8.8	0.8			0.8	*	*	-	-	-	0.8 cfs-Pipe Flow to DP 18d.
	18d	D18										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D19	19d	D19	0.13	0.84	5.0	0.11	8.8	1.0	ROOF DRAIN	1.0	0.0	5.0	0.11	8.8	1.0	Net Flow at Design Point								1 cfs - Net Flow at DP 19d
	19d	D19										5.0	0.11	8.8	1.0			1.0	*	*	-	-	-	1 cfs-Pipe Flow to DP 19d.
	19d	D19										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D20	20d	D20	0.08	0.62	5.2	0.05	8.7	0.4	OFFSITE	0.4	0.0	5.2	0.05	8.7	0.4	Net Flow at Design Point								0.4 cfs - Net Flow at DP 20d
	20d	D20										5.2	0.05	8.7	0.4			0.4	*	*	-	-	-	0.4 cfs-Pipe Flow to DP 20d.
	20d	D20										5.2	0.00	8.7	0.0	-	0.0				-	-	-	No Bypass Flow
D21	21d	D21	0.35	0.51	11.0	0.18	6.8	1.2	POND	1.2	0.0	11.0	0.18	6.8	1.2	Net Flow at Design Point								1.2 cfs - Net Flow at DP 21d
	21d	D21										11.0	0.18	6.8	1.2			1.2	*	*	-	-	-	1.2 cfs-Pipe Flow to DP 21d.
	21d	D21										11.0	0.00	6.8	0.0	-	0.0				-	-	-	No Bypass Flow
D22	22d	D22	0.11	0.49	10.9	0.05	6.8	0.4	OFFSITE	0.4	0.0	10.9	0.05	6.8	0.4	Net Flow at Design Point								0.4 cfs - Net Flow at DP 22d
	22d	D22										10.9	0.05	6.8	0.4			0.4	*	*	-	-	-	0.4 cfs-Pipe Flow to DP 22d.
	22d	D22										10.9	0.00	6.8	0.0	-	0.0				-	-	-	No Bypass Flow
D23	23d	D23	0.02	0.67	5.0	0.01	8.8	0.1	NYLOPLAST GRATE	0.1	0.0	5.0	0.01	8.8	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 23d
	23d	D23										5.0	0.01	8.8	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 23d.
	23d	D23										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D24	24d	D24	0.01	0.67	5.0	0.01	8.8	0.1	NYLOPLAST GRATE	0.1	0.0	5.0	0.01	8.8	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 24d
	24d	D24										5.0	0.01	8.8	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 24d.
	24d	D24										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D26	25d	D26	0.01	0.45	5.2	0.00	8.7	0.0	NYLOPLAST GRATE	0.0	0.0	5.2	0.00	8.7	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 25d
	25d	D26										5.2	0.00	8.7	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 26d.
	25d	D26										5.2	0.00	8.7	0.0	-	0.0				-	-	-	No Bypass Flow
D27	27d	D27	0.04	0.45	6.5	0.02	8.2	0.1	NYLOPLAST GRATE	0.1	0.0	6.5	0.02	8.2	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 27d
	27d	D27										6.5	0.02	8.2	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 27d.
	27d	D27										6.5	0.00	8.2	0.0	-	0.0				-	-	-	No Bypass Flow
D28	28d	D28	0.02	0.45	5.2	0.01	8.7	0.1	NYLOPLAST GRATE	0.1	0.0	5.2	0.01	8.7	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 28d
	28d	D28										5.2	0.01	8.7	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 28d.
	28d	D28										5.2	0.00	8.7	0.0	-	0.0				-	-	-	No Bypass Flow
D29	29d	D29	0.01	0.45	5.2	0.00	8.7	0.0	NYLOPLAST GRATE	0.0	0.0	5.2	0.00	8.7	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 29d
	29d	D29										5.2	0.00	8.7	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 29d.
	29d	D29										5.2	0.00	8.7	0.0	-	0.0				-	-	-	No Bypass Flow
D30	30d	D30	0.02	0.45	5.5	0.01	8.6	0.1	NYLOPLAST GRATE	0.1	0.0	5.5	0.01	8.6	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 30d
	30d	D30										5.5	0.01	8.6	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 30d.
	30d	D30										5.5	0.00	8.6	0.0	-	0.0				-	-	-	No Bypass Flow
D31	31d	D31	0.01	0.45	5.3	0.00	8.7	0.0	NYLOPLAST GRATE	0.0	0.0	5.3	0.00	8.7	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 31d
	31d	D31										5.3	0.00	8.7	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 31d.
	31d	D31										5.3	0.00	8.7	0.0	-	0.0				-	-	-	No Bypass Flow
D32	32d	D32	0.05	0.63	5.4	0.03	8.6	0.3	NYLOPLAST GRATE	0.3	0.0	5.4	0.03	8.6	0.3	Net Flow at Design Point								0.3 cfs - Net Flow at DP 32d
	32d	D32										5.4	0.03	8.6	0.3			0.3	*	*	-	-	-	0.3 cfs-Pipe Flow to DP 32d.
	32d	D32										5.4	0.00	8.6	0.0	-	0.0				-	-	-	No Bypass Flow
D33	33d	D33	0.02	0.67	5.0	0.01	8.8	0.1	NYLOPLAST GRATE	0.1	0.0	5.0	0.01	8.8	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 33d
	33d	D33										5.0	0.01	8.8	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 33d.
	33d	D33										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D34	34d	D34	0.03	0.60	5.0	0.02	8.8	0.2	NYLOPLAST GRATE	0.2	0.0	5.0	0.02	8.8	0.2	Net Flow at Design Point								0.2 cfs - Net Flow at DP 34d
	34d	D34										5.0	0.02	8.8	0.2			0.2	*	*	-	-	-	0.2 cfs-Pipe Flow to DP 34d.
	34d	D34										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
D35	35d	D35	0.04	0.45	6.2	0.02	8.3	0.1	NYLOPLAST GRATE	0.1	0.0	6.2	0.02	8.3	0.1	Net Flow at Design Point								0.1 cfs - Net Flow at DP 35d
	35d	D35										6.2	0.02	8.3	0.1			0.1	*	*	-	-	-	0.1 cfs-Pipe Flow to DP 35d.
	35d	D35										6.2	0.00	8.3	0.0	-	0.0				-	-	-	No Bypass Flow
OS-1	o1	OS-1	0.19	0.84	5.0	0.16	8.8	1.4	POND	1.4	0.0	5.0	0.16	8.8	1.4	Net Flow at Design Point								1.4 cfs - Net Flow at DP o1
	o1	OS-1										5.0	0.16	8.8	1.4			1.4	*	*	-	-	-	1.4 cfs-Pipe Flow to DP o1.
	o1	OS-1										5.0	0.00	8.8	0.0	-	0.0				-	-	-	No Bypass Flow
OS-2	o2	OS-2	0.69	0.80	6.9	0.55	8.0	4.4	POND	4.4	0.0	6.9	0.55	8.0	4.4	Net Flow at Design Point								4.4 cfs - Net Flow at DP o2
	o2	OS-2										6.9	0.55	8.0	4.4			4.4	*	*	-	-	-	4.4 cfs-Pipe Flow to DP o2.
	o2	OS-2										6.9	0.00	8.0	0.0	-	0.0				-	-	-	No Bypass Flow
D25	25d	D25	0.01	0.45	5.2	0.00	8.7	0.0	NYLOPLAST GRATE	0.0	0.0	5.2	0.00	8.7	0.0	Net Flow at Design Point								0 cfs - Net Flow at DP 25d
	25d	D25										5.2	0.00	8.7	0.0			0.0	*	*	-	-	-	0 cfs-Pipe Flow to DP 25d.
	25d	D25										5.2	0.00	8.7	0.0	-	0.0				-	-	-	No Bypass Flow

STANDARD FORM SF-3
STORM DRAINAGE SYSTEM DESIGN
(RATIONAL METHOD PROCEDURE)

Subdivision Auburn Heights

Project Name: Auburn Heights
Project No. 0
Calculated By: LO

No Plot

Design Storm 100 YR
100-Year P1 = 2.6 in. Table 6-1

*Refer to CDs and SewerGEMS model for pipe slope and diameter

	DIRECT RUNOFF									TOTAL RUNOFF							STREET		PIPE			TRAVEL TIME				
Directly Upstream DP	Design Point	Area Design.	Area (Ac)	Runoff Coeff. (C100)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Inlet Type	Q (Intercept)	Q (Bypass)	Tc (minutes)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (minutes)	Notes	Flow to DP
D1	1d.	1d.	-	-	-	-	-	-	-	1.2	0.0	14.9	0.20	5.9	1.2			1.2	*	*	-	-	-	1.2 cfs-Piped to DP OS	OS
	1d.	1d.																							
	1d.	1d.																							
D2	2d.	2d.	-	-	-	-	-	-	-	2.6	0.0	8.2	0.35	7.6	2.6			2.6	*	*	-	-	-	2.6 cfs-Piped to DP DF.	DF.
	2d.	2d.																							
	2d.	2d.																							
D3	3d.	3d.	-	-	-	-	-	-	-	2.3	0.0	8.1	0.30	7.6	2.3			2.3	*	*	-	-	-	2.3 cfs-Piped to DP DF.	DF.
	3d.	3d.																							
	3d.	3d.																							
D2, D3	DF.	DF.	-	-	-	-	-	-	-	4.9	0.0	8.2	0.65	7.6	4.9			4.9	*	*	-	-	-	4.9 cfs-Piped to DP DE.	DE.
	DF.	DF.																							
	DF.	DF.																							
D15	15d.	15d.	-	-	-	-	-	-	-	0.9	0.0	5.0	0.10	8.8	0.9			0.9	*	*	-	-	-	0.9 cfs-Piped to DP DE.	DE.
	15d.	15d.																							
	15d.	15d.																							
D2, D3, D15	DE.	DE.	-	-	-	-	-	-	-	5.7	0.0	8.2	0.75	7.6	5.7			5.7	*	*	-	-	-	5.7 cfs-Piped to DP DC.	DC.
	DE.	DE.																							
	DE.	DE.																							
D8	8d.	8d.	-	-	-	-	-	-	-	0.5	0.0	5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP 23d.	23d.
	8d.	8d.																							
	8d.	8d.																							
D8, D23	23d.	23d.	-	-	-	-	-	-	-	0.6	0.0	5.0	0.07	8.8	0.6			0.6	*	*	-	-	-	0.6 cfs-Piped to DP 24d.	24d.
	23d.	23d.																							
	23d.	23d.																							
D8, D23, D24	24d.	24d.	-	-	-	-	-	-	-	0.7	0.0	5.0	0.08	8.8	0.7			0.7	*	*	-	-	-	0.7 cfs-Piped to DP DA.	DA.
	24d.	24d.																							
	24d.	24d.																							
D7	7d.	7d.	-	-	-	-	-	-	-	0.5	0.0	5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP 6d.	6d.
	7d.	7d.																							
	7d.	7d.																							
D7, D6	6d.	6d.	-	-	-	-	-	-	-	0.6	0.0	9.7	0.09	7.1	0.6			0.6	*	*	-	-	-	0.6 cfs-Piped to DP DA.	DA.
	6d.	6d.																							
	6d.	6d.																							
D8, D23, D24, D7, D6	DA.	DA.	-	-	-	-	-	-	-	1.2	0.0	9.7	0.16	7.1	1.2			1.2	*	*	-	-	-	1.2 cfs-Piped to DP DB.	DB.
	DA.	DA.																							
	DA.	DA.																							
D9	9d.	9d.	-	-	-	-	-	-	-	0.5	0.0	5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP 25d.	25d.
	9d.	9d.																							
	9d.	9d.																							
D9, D25	25d.	25d.	-	-	-	-	-	-	-	0.6	0.0	5.2	0.06	8.7	0.6			0.6	*	*	-	-	-	0.6 cfs-Piped to DP 26d.	26d.
	25d.	25d.																							
	25d.	25d.																							
D9, D25, D26	26d.	26d.	-	-	-	-	-	-	-	0.6	0.0	5.2	0.07	8.7	0.6			0.6	*	*	-	-	-	0.6 cfs-Piped to DP DB.	DB.
	26d.	26d.																							
	26d.	26d.																							
D8, D23, D24, D7, D6, D9, D25, D26	DB.	DB.	-	-	-	-	-	-	-	1.7	0.0	9.7	0.23	7.1	1.7			1.7	*	*	-	-	-	1.7 cfs-Piped to DP DC.	DC.
	DB.	DB.																							
	DB.	DB.																							
D10	10d.	10d.	-	-	-	-	-	-	-	0.5	0.0	5.0	0.06	8.8	0.5			0.5	*	*	-	-	-	0.5 cfs-Piped to DP 27d.	27d.
	10d.	10d.																							
	10d.	10d.																							
D10, D27	27d.	27d.	-	-	-	-	-	-	-	0.6	0.0	6.5	0.08	8.2	0.6			0.6	*	*	-	-	-	0.6 cfs-Piped to DP 28d.	28d.
	27d.	27d.																							
	27d.	27d.																							
D11	11d.	11d.	-	-	-	-	-	-	-	1.7	0.0	5.0	0.19	8.8	1.7			1.7	*	*	-	-	-	1.7 cfs-Piped to DP 28d.	28d.
	11d.	11d.																							
	11d.	11d.																							
D10, D27, D11, D28	28d.	28d.	-	-	-	-	-	-	-	2.3	0.0	6.5	0.28	8.2	2.3			2.3	*	*	-	-	-	2.3 cfs-Piped to DP 29d.	29d.
	28d.	28d.																							
	28d.	28d.																							
D10, D27, D11, D28, D29	29d.	29d.	-	-	-	-	-	-	-	2.3	0.0	6.5	0.28	8.2	2.3			2.3	*	*	-	-	-	2.3 cfs-Piped to DP 30d.	30d.
	29d.	29d.																							

D29	29d.	29d.																									
D10, D27, D11, D28, D29, D30	30d.	30d.	-	-	-	-	-	-	-	2.4	0.0	6.5	0.29	8.2	2.4			2.4	*	*	-	-	-	2.4 cfs-Piped to DP 31d.	31d.
	30d.	30d.																									
	30d.	30d.																									
D12	12d.	12d.	-	-	-	-	-	-	-	1.7	0.0	5.0	0.19	8.8	1.7			1.7	*	*	-	-	-	1.7 cfs-Piped to DP 31d.	31d.
	12d.	12d.																									
	12d.	12d.																									
D10, D27, D11, D28, D29, D30, D12, D31	31d.	31d.	-	-	-	-	-	-	-	4.0	0.0	6.5	0.49	8.2	4.0			4.0	*	*	-	-	-	4 cfs-Piped to DP DC.	DC.
	31d.	31d.																									
	31d.	31d.																									
D2, D3, D15, D8, D23, D24, D7, D6, D9, D25, D26, D10,	DC.	DC.	-	-	-	-	-	-	-	10.5	0.0	9.7	1.47	7.1	10.5			10.5	*	*	-	-	-	10.5 cfs-Piped to DP DI.	DI.
	DC.	DC.																									
	DC.	DC.																									
D14	14d.	14d.	-	-	-	-	-	-	-	0.9	0.0	5.0	0.10	8.8	0.9			0.9	*	*	-	-	-	0.9 cfs-Piped to DP 33d.	33d.
	14d.	14d.																									
	14d.	14d.																									
D32	32d.	32d.	-	-	-	-	-	-	-	0.3	0.0	5.4	0.03	8.6	0.3			0.3	*	*	-	-	-	0.3 cfs-Piped to DP 33d.	33d.
	32d.	32d.																									
	32d.	32d.																									
D34	34d.	34d.	-	-	-	-	-	-	-	0.2	0.0	5.0	0.02	8.8	0.2			0.2	*	*	-	-	-	0.2 cfs-Piped to DP 33d.	33d.
	34d.	34d.																									
	34d.	34d.																									
D14, D32, D34, D33	33d.	33d.	-	-	-	-	-	-	-	1.4	0.0	5.4	0.16	8.6	1.4			1.4	*	*	-	-	-	1.4 cfs-Piped to DP DG.	DG.
	33d.	33d.																									
	33d.	33d.																									
D16	16d.	16d.	-	-	-	-	-	-	-	1.3	0.0	5.0	0.14	8.8	1.3			1.3	*	*	-	-	-	1.3 cfs-Piped to DP DG.	DG.
	16d.	16d.																									
	16d.	16d.																									
D19	19d.	19d.	-	-	-	-	-	-	-	1.0	0.0	5.0	0.11	8.8	1.0			1.0	*	*	-	-	-	1 cfs-Piped to DP 35d.	35d.
	19d.	19d.																									
	19d.	19d.																									
D19, D35	35d.	35d.	-	-	-	-	-	-	-	1.1	0.0	6.2	0.13	8.3	1.1			1.1	*	*	-	-	-	1.1 cfs-Piped to DP DG.	DG.
	35d.	35d.																									
	35d.	35d.																									
D14, D32, D34, D33, D16, D19, D35	DG.	DG.	-	-	-	-	-	-	-	3.6	0.0	6.2	0.43	8.3	3.6			3.6	*	*	-	-	-	3.6 cfs-Piped to DP DH.	DH.
	DG.	DG.																									
	DG.	DG.																									
D17	17d.	17d.	-	-	-	-	-	-	-	0.2	0.0	5.0	0.03	8.8	0.2			0.2	*	*	-	-	-	0.2 cfs-Piped to DP DH.	DH.
	17d.	17d.																									
	17d.	17d.																									
D14, D32, D34, D33, D16, D19, D35, D17	DH.	DH.	-	-	-	-	-	-	-	3.8	0.0	6.2	0.46	8.3	3.8			3.8	*	*	-	-	-	3.8 cfs-Piped to DP 4d.	4d.
	DH.	DH.																									
	DH.	DH.																									
D14, D32, D34, D33, D16, D19, D35, D17, D4	4d.	4d.	-	-	-	-	-	-	-	9.8	0.0	10.5	1.41	6.9	9.8			9.8	*	*	-	-	-	9.8 cfs-Piped to DP DI.	DI.
	4d.	4d.																									
	4d.	4d.																									
D2, D3, D15, D8, D23, D24, D7, D6, D9, D25, D26, D10,	DI.	DI.	-	-	-	-	-	-	-	19.9	0.0	10.5	2.88	6.9	19.9			19.9	*	*	-	-	-	19.9 cfs-Piped to DP DJ.	DJ.
	DI.	DI.																									
	DI.	DI.																									
D5	5d.	5d.	-	-	-	-	-	-	-	6.4	0.0	8.9	0.86	7.4	6.4			6.4	*	*	-	-	-	6.4 cfs-Piped to DP DJ.	DJ.
	5d.	5d.																									
	5d.	5d.																									
D2, D3, D15, D8, D23, D24, D7, D6, D9, D25, D26, D10,	DJ.	DJ.	-	-	-	-	-	-	-	25.9	0.0	10.5	3.75	6.9	25.9			25.9	*	*	-	-	-	25.9 cfs-Piped to DP POND.	POND.
	DJ.	DJ.																									
	DJ.	DJ.																									
OS-1	o1.	o1.	-	-	-	-	-	-	-	1.4	0.0	5.0	0.16	8.8	1.4			1.4	*	*	-	-	-	1.4 cfs-Piped to DP POND.	POND.
	o1.	o1.																									
	o1.	o1.																									
OS-2	o2.	o2.	-	-	-	-	-	-	-	4.4	0.0	6.9	0.55	8.0	4.4			4.4	*	*	-	-	-	4.4 cfs-Piped to DP POND.	POND.
	o2.	o2.																									
	o2.	o2.																									

APPENDIX C

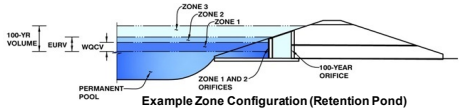
HYDRAULIC COMPUTATIONS

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.08 (April 2026)

Project: **Auburn Heights Water Quality Pond**

Basin ID: **Stage 0 = 6268**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	6.50	acres
Watershed Length =	740	ft
Watershed Length to Centroid =	370	ft
Watershed Slope =	0.020	ft/ft
Watershed Imperviousness =	72.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Castle Pines - City Office	

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

			Optional User Overrides
Water Quality Capture Volume (WQCV) =	0.154	acre-feet	acre-feet
Excess Urban Runoff Volume (EURV) =	0.515	acre-feet	acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	0.383	acre-feet	1.06 inches
5-yr Runoff Volume (P1 = 1.43 in.) =	0.564	acre-feet	1.43 inches
10-yr Runoff Volume (P1 = 1.66 in.) =	0.679	acre-feet	1.66 inches
25-yr Runoff Volume (P1 = 1.72 in.) =	0.729	acre-feet	inches
50-yr Runoff Volume (P1 = 2.26 in.) =	1.018	acre-feet	2.26 inches
100-yr Runoff Volume (P1 = 2.6 in.) =	1.214	acre-feet	2.60 inches
500-yr Runoff Volume (P1 = 3.07 in.) =	1.472	acre-feet	inches
Approximate 2-yr Detention Volume =	0.360	acre-feet	
Approximate 5-yr Detention Volume =	0.512	acre-feet	
Approximate 10-yr Detention Volume =	0.640	acre-feet	
Approximate 25-yr Detention Volume =	0.623	acre-feet	
Approximate 50-yr Detention Volume =	0.757	acre-feet	
Approximate 100-yr Detention Volume =	0.830	acre-feet	

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.154	acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =	0.154	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio (R_{LW}) =	user	

Total detention volume is less than 100-year volume.

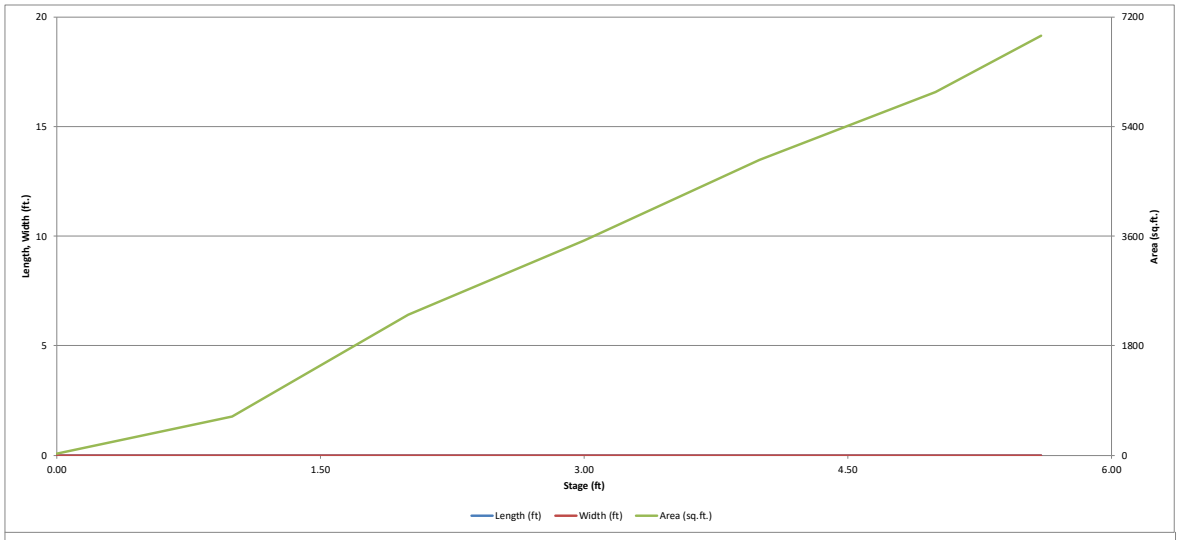
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

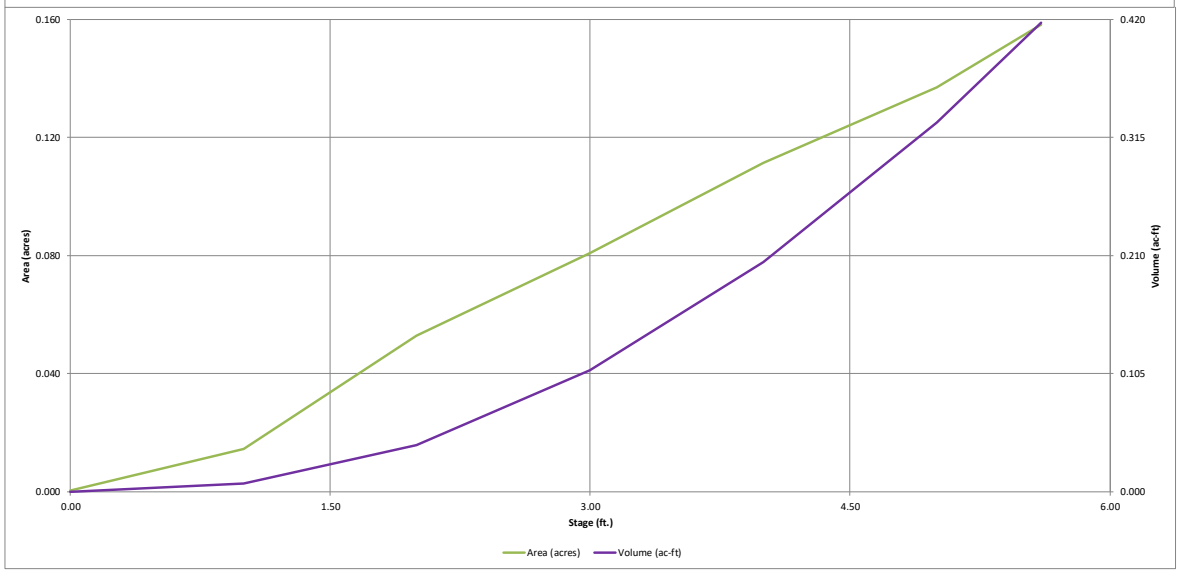
Depth Increment = ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	25	0.001		
6269	--	1.00	--	--	--	634	0.015	329	0.008
6270	--	2.00	--	--	--	2,304	0.053	1,798	0.041
6271	--	3.00	--	--	--	3,523	0.081	4,712	0.108
6272	--	4.00	--	--	--	4,851	0.111	8,899	0.204
6273	--	5.00	--	--	--	5,964	0.137	14,306	0.328
6273.6	--	5.60	--	--	--	6,894	0.158	18,164	0.417

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.08 (April 2026)



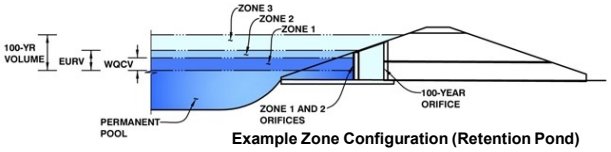


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.08 (April 2026)

Project: **Auburn Heights Water Quality Pond**

Basin ID: **Stage 0 = 6268**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.52	0.154	Orifice Plate
Zone 2			
Zone 3			
Total (all zones)		0.154	

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft²
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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

Centroid of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	3.750E-03	ft²
Depth at top of Zone using Orifice Plate =	3.70	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.54	sq. inches (diameter = 13/16 inch)	Elliptical Slot Area =	N/A	ft²

Calculated Parameters for Plate

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.20	2.40					
Orifice Area (sq. inches)	0.54	0.54	0.54					

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

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =			ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =			ft²
Depth at top of Zone using Vertical Orifice =			ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =			feet
Vertical Orifice Diameter =			inches				

Calculated Parameters for Vertical Orifice

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

	Not Selected	Not Selected			Not Selected	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.70		ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.70		feet
Overflow Weir Front Edge Length =	3.00		feet	Overflow Weir Slope Length =	3.00		feet
Overflow Weir Grate Slope =	0.00		H:V	Grate Open Area / 100-yr Orifice Area =	3.54		
Horiz. Length of Weir Sides =	3.00		feet	Overflow Grate Open Area w/o Debris =	6.26		ft²
Overflow Grate Type =	Type C Grate			Overflow Grate Open Area w/ Debris =	3.13		ft²
Debris Clogging % =	50%		%				

Calculated Parameters for Overflow Weir

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

	Not Selected	Not Selected			Not Selected	Not Selected	
Depth to Invert of Outlet Pipe =	1.78		ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	1.77		ft²
Circular Orifice Diameter =	18.00		inches	Outlet Orifice Centroid =	0.75		feet
				Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.49	feet
Spillway Crest Length =	18.00	feet	Stage at Top of Freeboard =	5.49	feet
Spillway End Slopes =	3.00	H:V	Basin Area at Top of Freeboard =	0.15	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	0.40	acre-ft

Calculated Parameters for Spillway

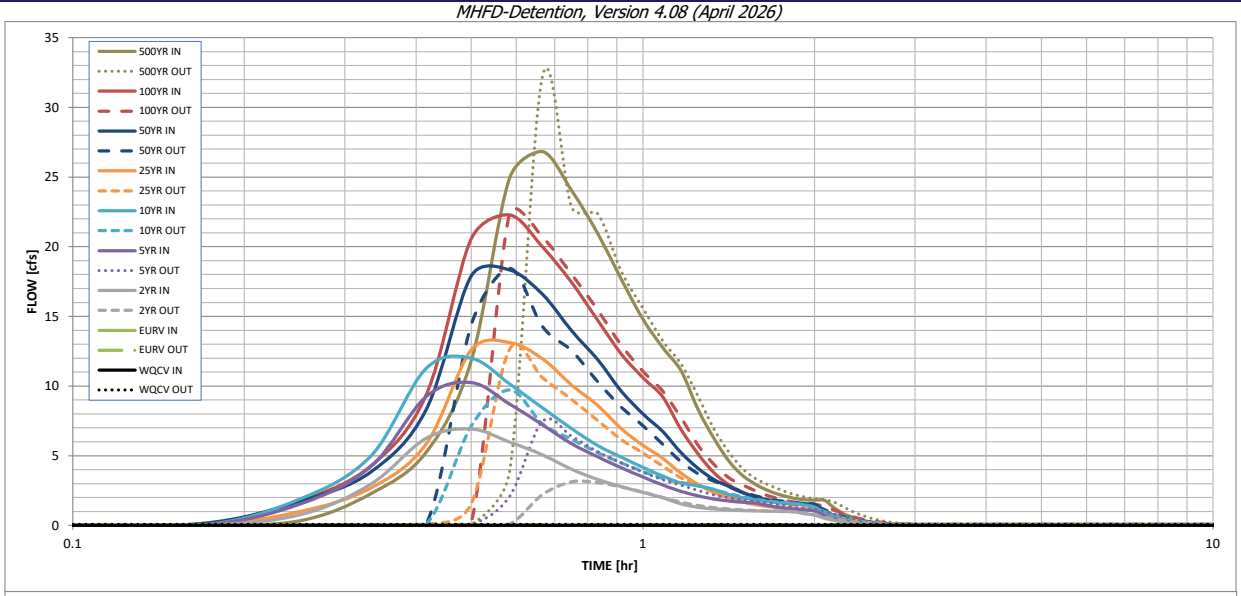
Routed Hydrograph Results

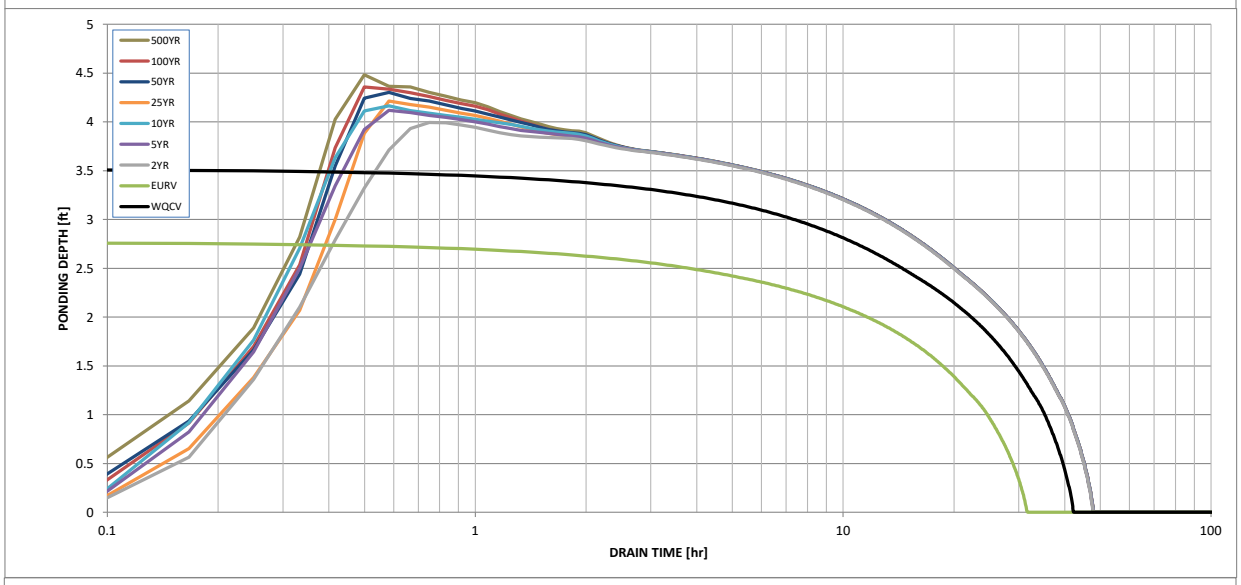
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

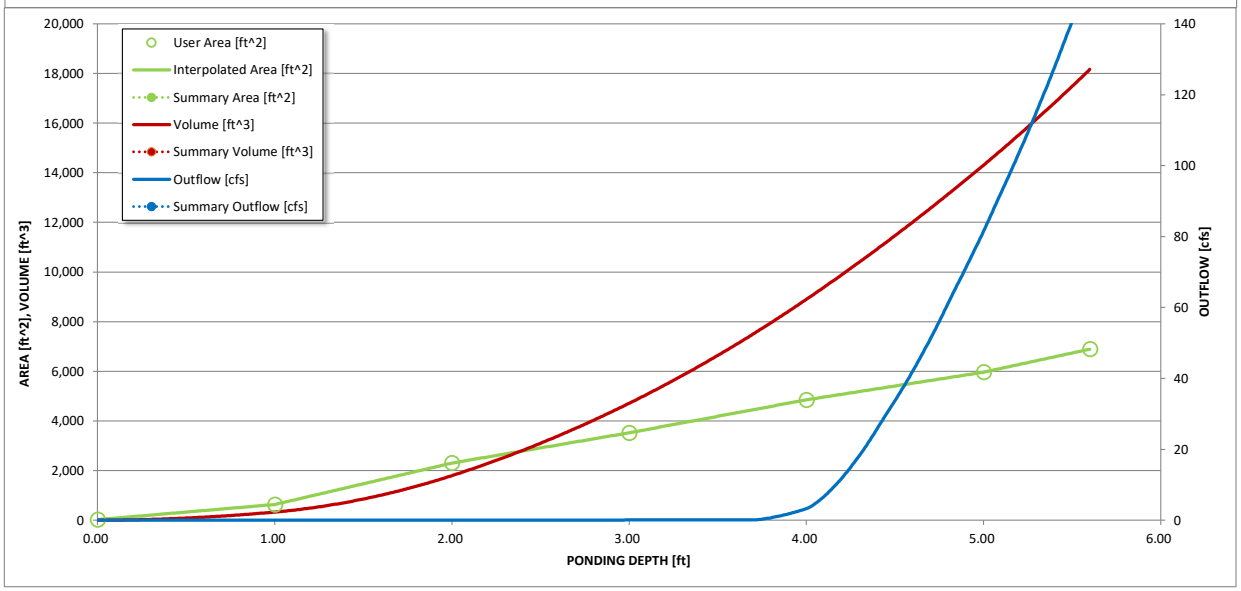
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.06	1.43	1.66	1.72	2.26	2.60	3.07
CUHP Runoff Volume (acre-ft) =	0.154	0.515	0.383	0.564	0.679	0.729	1.018	1.214	1.472
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.383	0.564	0.679	0.729	1.018	1.214	1.472
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.3	1.9	2.8	4.1	7.1	9.2	11.8
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.04	0.29	0.43	0.63	1.09	1.42	1.81
Peak Inflow Q (cfs) =	N/A	N/A	6.9	10.3	12.0	13.1	18.3	22.3	26.8
Peak Outflow Q (cfs) =	0.1	61.8	3.1	7.5	9.7	12.6	18.4	22.4	32.2
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	4.0	3.5	3.1	2.6	2.4	2.7
Structure Controlling Flow =	Plate	Plate	Overflow Weir 1	Spillway	Spillway	Spillway	Spillway	Spillway	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	0.48	0.8	1.0	1.1	1.4	1.7	2.1
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	24	38	36	35	34	31	29	27
Time to Drain 99% of Inflow Volume (hours) =	**40**	28	44	42	42	41	39	38	37
Maximum Ponding Depth (ft) =	3.52	2.76	3.99	4.12	4.16	4.21	4.30	4.36	4.48
Area at Maximum Ponding Depth (acres) =	0.10	0.07	0.11	0.11	0.12	0.12	0.12	0.12	0.12
Maximum Volume Stored (acre-ft) =	0.154	0.089	0.203	0.217	0.222	0.228	0.239	0.245	0.261

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.08 (April 2026)







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

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

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

Time Interval	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.06	0.33
	0:15:00	0.00	0.00	0.75	1.52	1.88	0.99	1.72	1.77	2.28
	0:20:00	0.00	0.00	2.97	4.24	4.99	2.69	3.84	4.27	5.24
	0:25:00	0.00	0.00	6.25	9.24	11.27	5.84	8.31	9.35	11.80
	0:30:00	0.00	0.00	6.93	10.25	12.00	12.59	17.89	20.57	24.92
	0:35:00	0.00	0.00	5.98	8.70	10.15	13.13	18.32	22.27	26.82
	0:40:00	0.00	0.00	5.07	7.21	8.44	11.95	16.58	19.98	24.03
	0:45:00	0.00	0.00	4.02	5.85	6.94	10.07	13.96	17.43	20.93
	0:50:00	0.00	0.00	3.29	4.92	5.72	8.59	11.88	14.70	17.66
	0:55:00	0.00	0.00	2.79	4.13	4.89	6.94	9.63	12.29	14.78
	1:00:00	0.00	0.00	2.36	3.47	4.17	5.75	8.00	10.60	12.75
	1:05:00	0.00	0.00	1.99	2.90	3.54	4.81	6.73	9.22	11.10
	1:10:00	0.00	0.00	1.54	2.45	3.04	3.75	5.22	6.88	8.31
	1:15:00	0.00	0.00	1.30	2.12	2.85	2.94	4.10	5.12	6.24
	1:20:00	0.00	0.00	1.18	1.89	2.58	2.36	3.29	3.77	4.59
	1:25:00	0.00	0.00	1.10	1.75	2.22	1.99	2.78	2.90	3.55
	1:30:00	0.00	0.00	1.06	1.65	1.98	1.69	2.32	2.37	2.89
	1:35:00	0.00	0.00	1.04	1.59	1.81	1.47	2.01	2.01	2.45
	1:40:00	0.00	0.00	1.02	1.40	1.70	1.35	1.82	1.77	2.17
	1:45:00	0.00	0.00	1.00	1.27	1.62	1.26	1.68	1.61	1.97
	1:50:00	0.00	0.00	1.00	1.18	1.56	1.20	1.59	1.51	1.85
	1:55:00	0.00	0.00	0.84	1.11	1.47	1.16	1.54	1.48	1.81
	2:00:00	0.00	0.00	0.74	1.03	1.31	1.14	1.51	1.47	1.79
	2:05:00	0.00	0.00	0.51	0.71	0.90	0.79	1.04	1.02	1.24
	2:10:00	0.00	0.00	0.34	0.48	0.61	0.54	0.70	0.69	0.84
	2:15:00	0.00	0.00	0.23	0.31	0.41	0.36	0.48	0.47	0.57
	2:20:00	0.00	0.00	0.14	0.20	0.26	0.23	0.31	0.30	0.37
	2:25:00	0.00	0.00	0.09	0.13	0.17	0.15	0.20	0.19	0.23
	2:30:00	0.00	0.00	0.05	0.08	0.10	0.09	0.12	0.12	0.14
	2:35:00	0.00	0.00	0.02	0.04	0.04	0.05	0.06	0.06	0.07
	2:40:00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
	2:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.08 (April 2026)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.
The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Elevation [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]

MHFD-Inlet, Version 6.00 (August 2025)

INLET MANAGEMENT

Project: AUBURN HEIGHTS
Minor: 5-year
Major: 100-year

Worksheet Protected

INLET NAME	SDIN5 (BASIN D5)	SDIN4 (BASIN D4)	SDIN3 (BASIN D3)	SDIN2 (BASIN D2)
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	In Sump	In Sump
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT/Denver 13 Valley Grate	CDOT/Denver 13 Valley Grate
Number of Inlet Units	1	1	1	1

USER-DEFINED INPUT

User-Defined Peak Flows

Minor Peak Flow, Q (cfs)	2.80	2.90	0.90	1.00
Major Peak Flow, Q (cfs)	6.40	6.60	2.30	2.60

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

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

CALCULATED OUTPUT

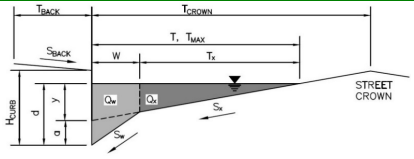
Minor Total Design Peak Flow, Q (cfs)	2.80	2.90	0.90	1.00
Major Total Design Peak Flow, Q (cfs)	6.40	6.60	2.30	2.60
Minor Inlet Interception Capacity, Q_a (cfs)	2.99	12.26	2.64	4.60
Major Inlet Interception Capacity, Q_a (cfs)	6.54	12.26	2.64	4.84
Minor Flow Bypassed Downstream, Qb (cfs)	N/A	N/A	N/A	N/A
Major Flow Bypassed Downstream, Qb (cfs)	N/A	N/A	N/A	N/A
Minor Flow Capture Percentage, C%	100%	100%	100%	100%
Major Flow Capture Percentage, C%	100%	100%	100%	100%

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

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

Project: **AUBURN HEIGHTS**

Inlet ID: **SDIN5 (BASIN D5)**



Gutter Geometry:

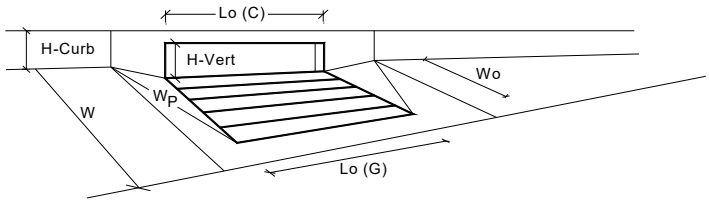
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	10.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.012	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	33.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.010	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	21.0	31.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is not applicable to Sump Condition				
MAJOR STORM Allowable Capacity is not applicable to Sump Condition	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



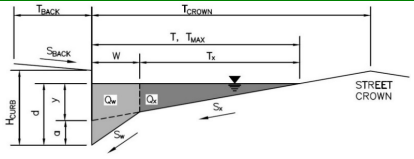
Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	3.4	4.6	inches
Grate Information		MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	15.00	15.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.20	0.30	ft
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.58	0.69	
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**3.0**	**6.5**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	$Q_{PEAK\ REQUIRED}$ =	2.8	6.4	cfs

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

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

Project: **AUBURN HEIGHTS**

Inlet ID: **SDIN4 (BASIN D4)**



Gutter Geometry:

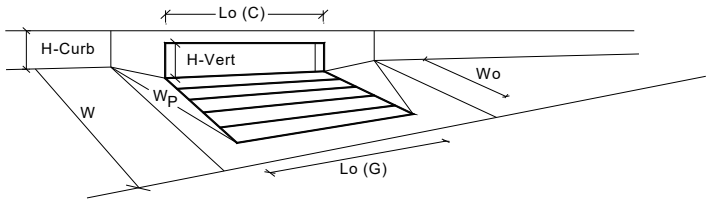
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	10.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.012	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	33.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.030	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	15.0	15.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is not applicable to Sump Condition				
MAJOR STORM Allowable Capacity is not applicable to Sump Condition	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)



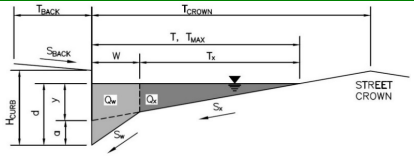
Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	6.0	6.0	inches
Grate Information		MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	15.00	15.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.42	0.42	ft
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.79	0.79	
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**12.3**	**12.3**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	$Q_{PEAK\ REQUIRED}$ =	2.9	6.6	cfs

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

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

Project: **AUBURN HEIGHTS**

Inlet ID: **SDIN3 (BASIN D3)**



Gutter Geometry:

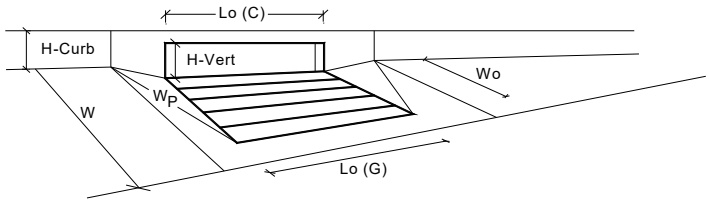
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	13.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.012	
Height of Curb at Gutter Flow Line	H_{CURB} =	0.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	14.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.010	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	14.0	14.0	ft
Warning 02 Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is not applicable to Sump Condition				
MAJOR STORM Allowable Capacity is not applicable to Sump Condition	**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	Type =	CDOT/Denver 13 Valley Grate		
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
Grate Information		MINOR	MAJOR	☑ Override Depths
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} =	0.43	0.43	
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) =	3.30	3.30	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	0.60	0.60	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	N/A	N/A	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	N/A	N/A	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	N/A	N/A	inches
Angle of Throat	Theta =	N/A	N/A	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	N/A	N/A	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	N/A	N/A	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	N/A	N/A	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	N/A	N/A	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	0.52	0.52	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	N/A	N/A	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	$RF_{Combination}$ =	N/A	N/A	

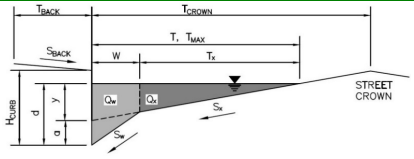
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**2.6**	**2.6**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	$Q_{PEAK\ REQUIRED}$ =	0.9	2.3	cfs

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

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

Project: **AUBURN HEIGHTS**

Inlet ID: **SDIN2 (BASIN D2)**



Gutter Geometry:

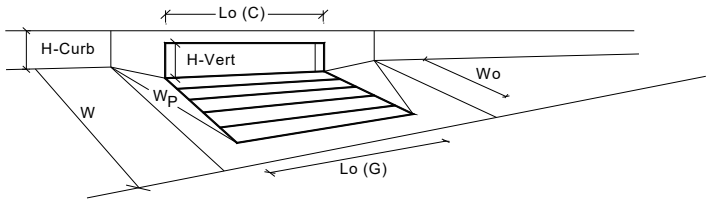
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	6.5	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.012	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	18.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.010	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	18.0	18.0	ft
Warning 02 Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	9.1	9.6	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is not applicable to Sump Condition				
MAJOR STORM Allowable Capacity is not applicable to Sump Condition	**Q_{allow} =**	**SUMP**	**SUMP**	**cfs**

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 6.00 (August 2025)

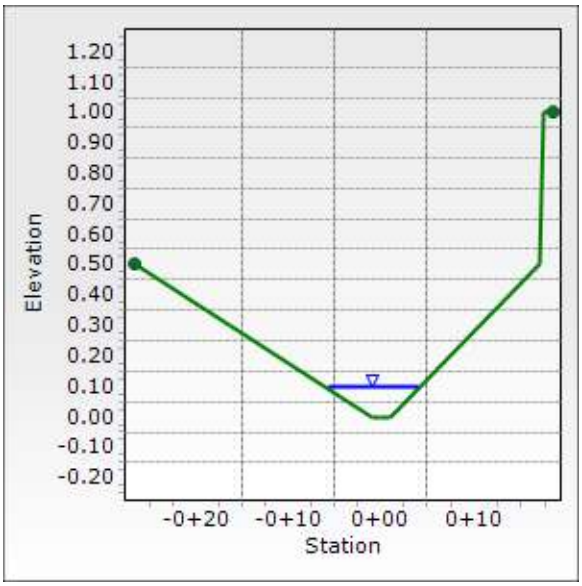


Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT/Denver 13 Valley Grate)	Type =	CDOT/Denver 13 Valley Grate		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	9.1	9.6	inches
Grate Information		MINOR	MAJOR	☑ Override Depths
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} =	0.43	0.43	
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) =	3.30	3.30	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	0.60	0.60	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	N/A	N/A	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	N/A	N/A	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	N/A	N/A	inches
Angle of Throat	Theta =	N/A	N/A	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	N/A	N/A	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	N/A	N/A	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	N/A	N/A	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	N/A	N/A	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	0.78	0.82	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	N/A	N/A	ft
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	1.00	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**4.6**	**4.8**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)	$Q_{PEAK\ REQUIRED}$ =	1.0	2.6	cfs

Cross Section for 5-YR BASIN D2 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	1.2 in
Discharge	1.00 cfs



Worksheet for 5-YR BASIN D2 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	1.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+27	0.53
-0+01	0.00
0+00	0.00
0+01	0.00
0+17	0.51
0+18	1.00
0+19	1.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+27, 0.53)	(0+19, 1.00)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	1.2 in
Roughness Coefficient	0.013
Elevation	0.10 ft
Elevation Range	0.0 to 1.0 ft
Flow Area	0.6 ft²
Wetted Perimeter	9.8 ft
Hydraulic Radius	0.7 in
Top Width	9.80 ft
Normal Depth	1.2 in
Critical Depth	1.3 in
Critical Slope	0.006 ft/ft
Velocity	1.73 ft/s
Velocity Head	0.05 ft
Specific Energy	0.14 ft
Froude Number	1.253

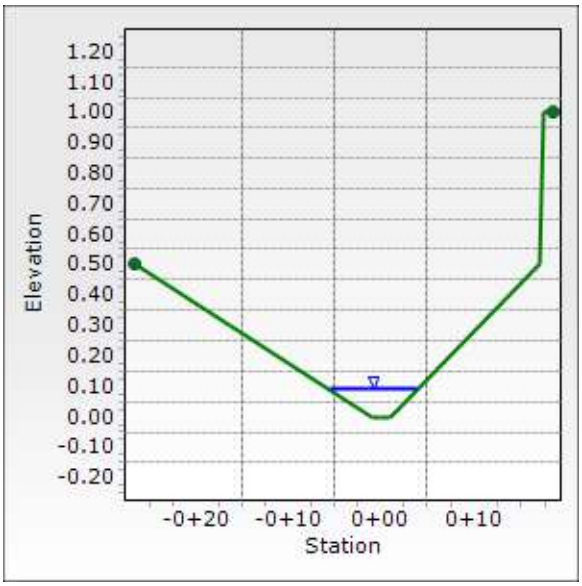
Worksheet for 5-YR BASIN D2 CONCRETE PAN

Results	
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.2 in
Critical Depth	1.3 in
Channel Slope	0.010 ft/ft
Critical Slope	0.006 ft/ft

Cross Section for 5-YR BASIN D3 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	1.1 in
Discharge	0.90 cfs



Worksheet for 5-YR BASIN D3 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	0.90 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+27	0.53
-0+01	0.00
0+00	0.00
0+01	0.00
0+17	0.51
0+18	1.00
0+19	1.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+27, 0.53)	(0+19, 1.00)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	1.1 in
Roughness Coefficient	0.013
Elevation	0.09 ft
Elevation Range	0.0 to 1.0 ft
Flow Area	0.5 ft²
Wetted Perimeter	9.4 ft
Hydraulic Radius	0.7 in
Top Width	9.42 ft
Normal Depth	1.1 in
Critical Depth	1.2 in
Critical Slope	0.006 ft/ft
Velocity	1.69 ft/s
Velocity Head	0.04 ft
Specific Energy	0.14 ft
Froude Number	1.250

Worksheet for 5-YR BASIN D3 CONCRETE PAN

Results	
Flow Type	Supercritical

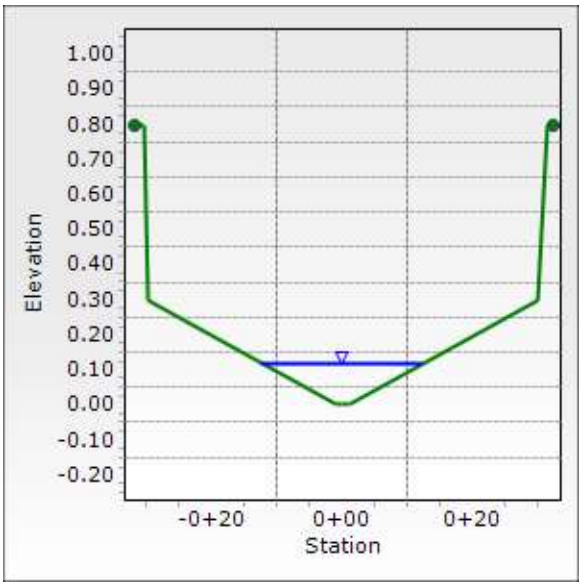
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.1 in
Critical Depth	1.2 in
Channel Slope	0.010 ft/ft
Critical Slope	0.006 ft/ft

Cross Section for 5-YR BASIN D4 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	1.4 in
Discharge	2.90 cfs



Worksheet for 5-YR BASIN D4 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	2.90 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+32	0.80
-0+31	0.80
-0+30	0.30
-0+01	0.00
0+00	0.00
0+01	0.00
0+30	0.30
0+32	0.80
0+33	0.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+32, 0.80)	(0+33, 0.80)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	1.4 in
Roughness Coefficient	0.013
Elevation	0.12 ft
Elevation Range	0.0 to 0.8 ft
Flow Area	1.6 ft²
Wetted Perimeter	24.8 ft
Hydraulic Radius	0.8 in
Top Width	24.82 ft
Normal Depth	1.4 in
Critical Depth	1.6 in
Critical Slope	0.006 ft/ft
Velocity	1.83 ft/s
Velocity Head	0.05 ft

Worksheet for 5-YR BASIN D4 CONCRETE PAN

Results	
Specific Energy	0.17 ft
Froude Number	1.280
Flow Type	Supercritical

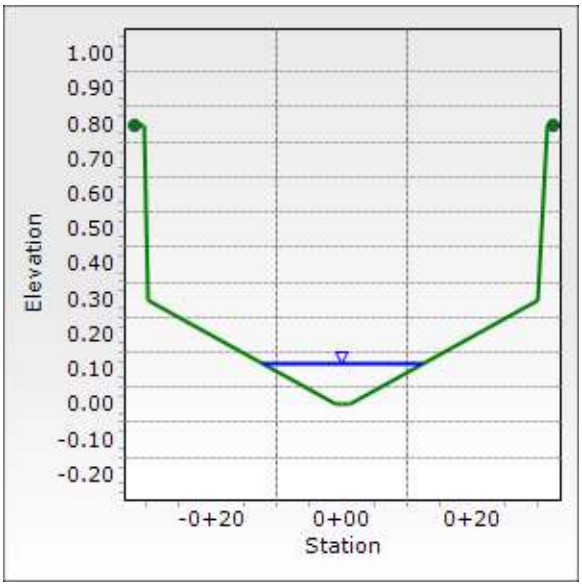
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.4 in
Critical Depth	1.6 in
Channel Slope	0.010 ft/ft
Critical Slope	0.006 ft/ft

Cross Section for 5-YR BASIN D5 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	1.4 in
Discharge	2.80 cfs



Worksheet for 5-YR BASIN D5 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	2.80 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+32	0.80
-0+31	0.80
-0+30	0.30
-0+01	0.00
0+00	0.00
0+01	0.00
0+30	0.30
0+32	0.80
0+33	0.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+32, 0.80)	(0+33, 0.80)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	1.4 in
Roughness Coefficient	0.013
Elevation	0.12 ft
Elevation Range	0.0 to 0.8 ft
Flow Area	1.5 ft²
Wetted Perimeter	24.6 ft
Hydraulic Radius	0.8 in
Top Width	24.56 ft
Normal Depth	1.4 in
Critical Depth	1.5 in
Critical Slope	0.006 ft/ft
Velocity	1.81 ft/s
Velocity Head	0.05 ft

Worksheet for 5-YR BASIN D5 CONCRETE PAN

Results	
Specific Energy	0.17 ft
Froude Number	1.269
Flow Type	Supercritical

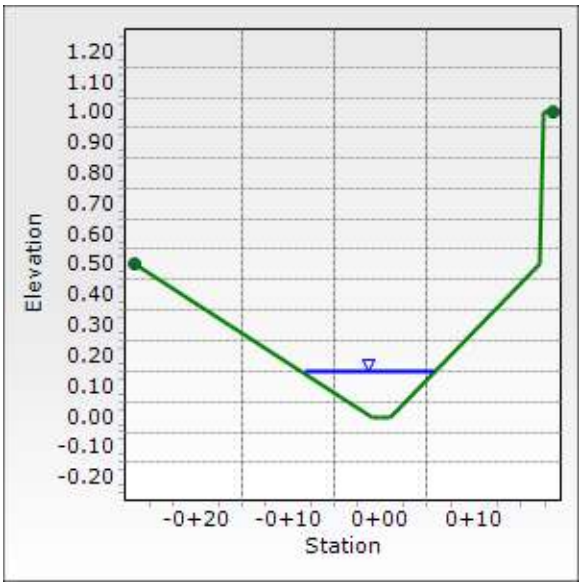
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.4 in
Critical Depth	1.5 in
Channel Slope	0.010 ft/ft
Critical Slope	0.006 ft/ft

Cross Section for 100-YR BASIN D2 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	1.8 in
Discharge	2.60 cfs



Worksheet for 100-YR BASIN D2 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	2.60 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+27	0.53
-0+01	0.00
0+00	0.00
0+01	0.00
0+17	0.51
0+18	1.00
0+19	1.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+27, 0.53)	(0+19, 1.00)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	1.8 in
Roughness Coefficient	0.013
Elevation	0.15 ft
Elevation Range	0.0 to 1.0 ft
Flow Area	1.2 ft²
Wetted Perimeter	13.8 ft
Hydraulic Radius	1.0 in
Top Width	13.81 ft
Normal Depth	1.8 in
Critical Depth	2.0 in
Critical Slope	0.005 ft/ft
Velocity	2.22 ft/s
Velocity Head	0.08 ft
Specific Energy	0.22 ft
Froude Number	1.339

Worksheet for 100-YR BASIN D2 CONCRETE PAN

Results	
Flow Type	Supercritical

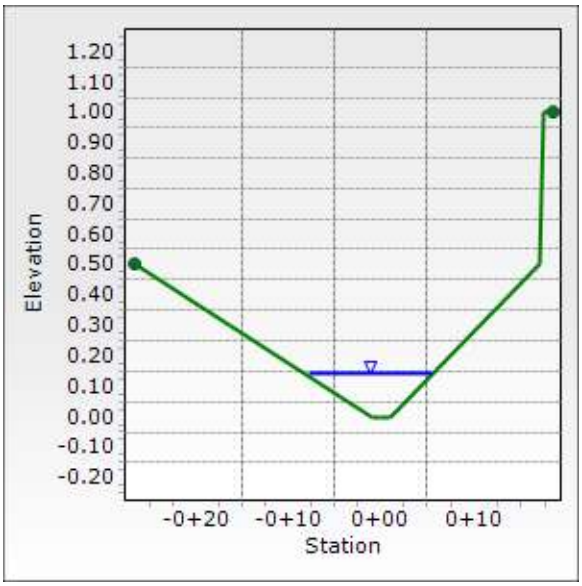
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.8 in
Critical Depth	2.0 in
Channel Slope	0.010 ft/ft
Critical Slope	0.005 ft/ft

Cross Section for 100-YR BASIN D3 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	1.7 in
Discharge	2.30 cfs



Worksheet for 100-YR BASIN D3 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	2.30 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+27	0.53
-0+01	0.00
0+00	0.00
0+01	0.00
0+17	0.51
0+18	1.00
0+19	1.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+27, 0.53)	(0+19, 1.00)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	1.7 in
Roughness Coefficient	0.013
Elevation	0.14 ft
Elevation Range	0.0 to 1.0 ft
Flow Area	1.1 ft²
Wetted Perimeter	13.2 ft
Hydraulic Radius	1.0 in
Top Width	13.21 ft
Normal Depth	1.7 in
Critical Depth	1.9 in
Critical Slope	0.005 ft/ft
Velocity	2.14 ft/s
Velocity Head	0.07 ft
Specific Energy	0.21 ft
Froude Number	1.327

Worksheet for 100-YR BASIN D3 CONCRETE PAN

Results	
Flow Type	Supercritical

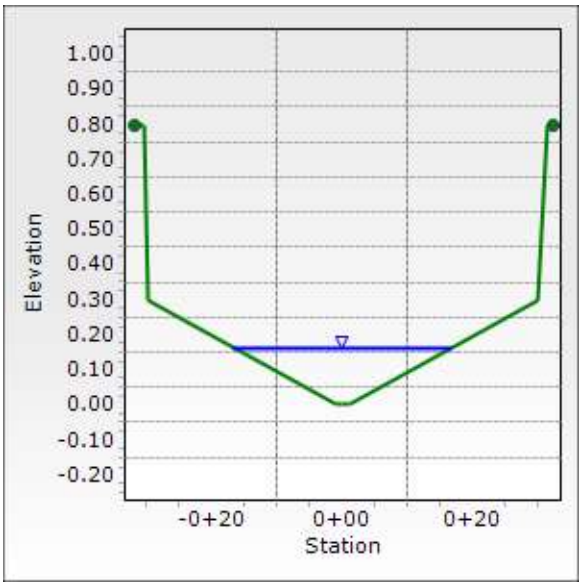
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.7 in
Critical Depth	1.9 in
Channel Slope	0.010 ft/ft
Critical Slope	0.005 ft/ft

Cross Section for 100-YR BASIN D4 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	2.0 in
Discharge	6.60 cfs



Worksheet for 100-YR BASIN D4 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	6.60 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+32	0.80
-0+31	0.80
-0+30	0.30
-0+01	0.00
0+00	0.00
0+01	0.00
0+30	0.30
0+32	0.80
0+33	0.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+32, 0.80)	(0+33, 0.80)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	2.0 in
Roughness Coefficient	0.013
Elevation	0.16 ft
Elevation Range	0.0 to 0.8 ft
Flow Area	2.9 ft²
Wetted Perimeter	33.8 ft
Hydraulic Radius	1.0 in
Top Width	33.81 ft
Normal Depth	2.0 in
Critical Depth	2.2 in
Critical Slope	0.005 ft/ft
Velocity	2.24 ft/s
Velocity Head	0.08 ft

Worksheet for 100-YR BASIN D4 CONCRETE PAN

Results	
Specific Energy	0.24 ft
Froude Number	1.338
Flow Type	Supercritical

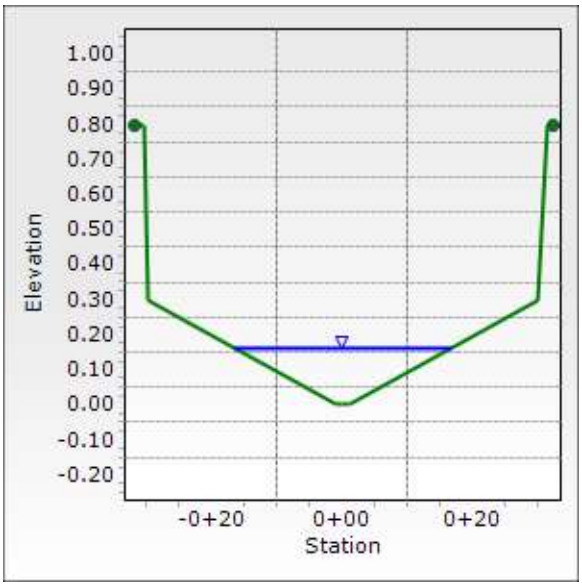
GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.0 in
Critical Depth	2.2 in
Channel Slope	0.010 ft/ft
Critical Slope	0.005 ft/ft

Cross Section for 100-YR BASIN D5 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Normal Depth	1.9 in
Discharge	6.40 cfs



Worksheet for 100-YR BASIN D5 CONCRETE PAN

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.010 ft/ft
Discharge	6.40 cfs

Section Definitions

Station (ft)	Elevation (ft)
-0+32	0.80
-0+31	0.80
-0+30	0.30
-0+01	0.00
0+00	0.00
0+01	0.00
0+30	0.30
0+32	0.80
0+33	0.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+32, 0.80)	(0+33, 0.80)	0.013

Options	
Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results	
Normal Depth	1.9 in
Roughness Coefficient	0.013
Elevation	0.16 ft
Elevation Range	0.0 to 0.8 ft
Flow Area	2.9 ft²
Wetted Perimeter	33.4 ft
Hydraulic Radius	1.0 in
Top Width	33.35 ft
Normal Depth	1.9 in
Critical Depth	2.2 in
Critical Slope	0.005 ft/ft
Velocity	2.23 ft/s
Velocity Head	0.08 ft

Worksheet for 100-YR BASIN D5 CONCRETE PAN

Results	
Specific Energy	0.24 ft
Froude Number	1.343
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.9 in
Critical Depth	2.2 in
Channel Slope	0.010 ft/ft
Critical Slope	0.005 ft/ft

APPENDIX D

MHFD BMPs

Description

Improperly disposed household wastes are a source of stormwater pollution. These wastes can include household chemicals, pet waste, yard waste, litter, automotive maintenance waste, and others. These materials can be transported in stormwater when the materials are dumped directly into the storm drains or when they are spilled on impervious surfaces and washed into the storm sewer system. Household wastes can contribute solids, nutrients, oxygen demanding substances, toxic substances, and bacteria to receiving waters. Improper disposal of household wastes on the ground surface can also lead to groundwater contamination.

Photograph DHW-1. Placing storm drain markers (or stenciling) at storm sewer inlets is a public education tool that can be used to educate citizens and discourage improper disposal of household waste in storm drains. Photo courtesy of Nonpoint Source Colorado.

Proper disposal of household waste is dependent on behavioral change, which can be encouraged through public education programs and local ordinances that prohibit improper disposal of household waste. Additionally, local governments can provide appropriate facilities for proper disposal of waste.

This Fact Sheet focuses primarily on household waste. See the Good Housekeeping Fact Sheet for additional information on waste management at commercial and industrial sites.

Appropriate Uses

Educational efforts related to proper disposal of household waste can be targeted to homeowners and businesses through municipal programs, civic groups, and others. Local governments should consider measures needed in the following general categories:

- **Household/Commercial Waste**: Household waste includes materials discarded on the land surface or into the stormwater system from residential and commercial areas. Wastes from commercial businesses are generated by stores, restaurants, hotels, offices, and other non-manufacturing activities. Household waste disposal objectives include containing and properly disposing of refuse (garbage), reducing litter, and encouraging proper household toxic waste disposal through public education and access to appropriate disposal facilities.

- **Litter**: Most litter is biodegradable and can create an oxygen demand in water as it decomposes. Examples of litter are paper products, used diapers, etc. Research by Keep America Beautiful, Inc. (1990) has shown that people litter where litter has already accumulated. Also according to Keep America Beautiful, Inc. (1987), pedestrians and motorists account for less than 25 percent of litter, with the other sources being household waste, commercial and industrial waste, haulage vehicles, loading docks, and construction sites. Reduction of litter through proper disposal can reduce its accumulation on the urban landscape and its eventual entry into the stormwater system.

- **Pet Waste**: Pet waste deposited on the ground can be transported by the storm drainage system to receiving waters or by overland flow into waterways. Fecal matter potentially contains pathogenic viruses and bacteria; it also creates an oxygen demand in water. The majority of improperly disposed pet waste occurs in public areas, such as streets and parks. Pet waste ordinances are common in municipalities; however, these are difficult to enforce, especially with limited municipal resources. Education can help bring this problem to the public's attention, and can thereby reduce deposition of pet waste on urban surfaces.

- **Yard Waste**: Yard waste includes limbs, leaves and grass clippings that can contribute nutrients, lawn chemicals, and oxygen demand to receiving waters when washed into storm sewers and waterways. Public education efforts on the benefits of composting and on proper disposal of yard waste can help to reduce the volume of yard waste entering the stormwater system and receiving waters. Most yard waste can be reused following composting, with the exception of weeds and diseased plant materials.

Composting

Composting is a natural method for recycling organics such as yard trimmings and food scraps, which comprise nearly a quarter of municipal solids waste generated (Keep America Beautiful 2010). Nearly half of all U.S. states now ban yard waste from landfills because it represents such a large volume that can be productively composted. Composted yard waste used as mulch or soil amendment can provide landscape water conservation benefits, reduce the burden on landfills and is protective of water quality.

- **Used Oil and Automotive Fluids**: Used oil and automotive fluids including antifreeze, brake fluid, transmission fluid, grease, other lubricants, and petroleum-based cleaning solvents are wastes generated during automobile maintenance by residential households and commercial businesses. These can enter the storm drainage system if poured directly into storm inlets or from residual on concrete or asphalt exposed to precipitation. Improper disposal of used oil and automotive fluids causes receiving waters to become contaminated with hydrocarbons and residual metals that can be toxic to stream organisms. Used oil and other petroleum products can be recycled and are accepted by many auto parts stores and repair shops. Public education on the location of these centers, the benefits of recycling, prevention of fluid leaks, and the importance of proper disposal for improving stormwater quality can reduce the amounts of oil and used automotive fluids reaching receiving waters.

- **Toxic Wastes**: Toxic wastes are generated in small quantities by residential households and commercial businesses. Examples include paint, solvents, putties, cleaners, waxes, polishes, oil products, aerosols, acids, caustics, pesticides, herbicides, and certain medicines or cosmetics. These products and their containers should always be disposed of in accordance with the product label or recycled, if appropriate. When such toxic substances are improperly disposed of by dumping on impervious surfaces or into street gutters or storm inlets, stormwater can transport these materials to receiving waters.

Municipal Recycling Programs

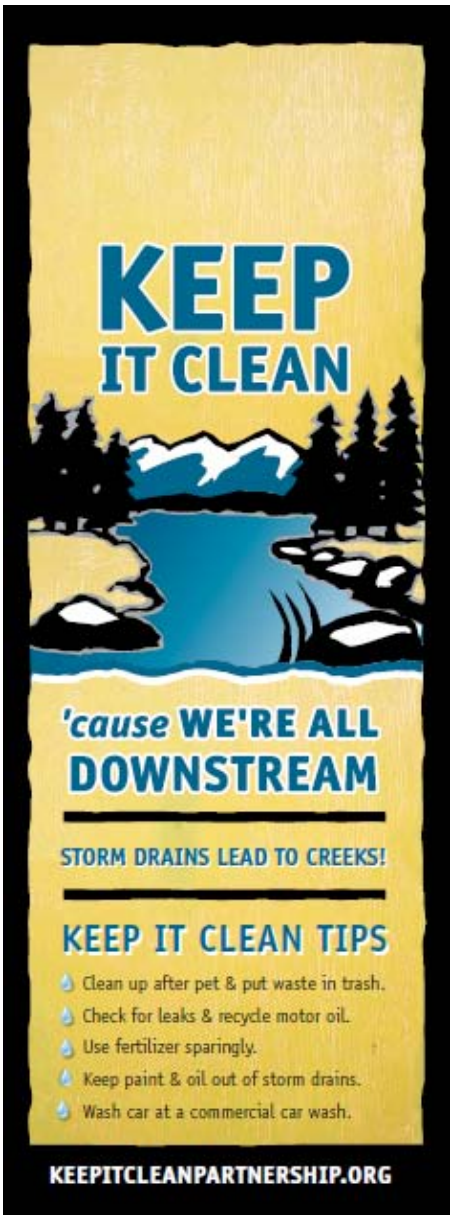
Many communities throughout the country have implemented municipal recycling programs, rather than relying on citizens to research and seek out recycling opportunities on their own. Curbside recycling programs and municipal education campaigns can improve the success of recycling programs. For more information on implementing a municipal recycling program, visit a variety of U.S. Environmental Protection Agency websites such as: http://www.epa.gov/epawaste/conserve/rrr/index.htm and http://www.epa.gov/region4/waste/rcra/mgtoolkit/index.html or review well developed local programs such as Denver Recycles.

Practice Guidelines

To reduce improper disposal of household waste, implement public education efforts regarding how improper disposal of wastes can degrade the quality of streams, rivers, lakes, and wetlands. Local governments have many public education options that can be tailored to fit local needs and budget constraints the best. Within local governments, opportunities for coordinated efforts among multiple departments may be beneficial. For example, properly composting of yard waste can provide a stormwater benefit when these materials are kept out of the gutter, as well as a water conservation benefit when the materials are reused as mulch and a solid waste management benefit when these materials are kept out of landfills. Similarly, public works and parks and recreation departments both benefit from efforts related to pet waste disposal signage as well as disposal facilities in parks.

Representative public education strategies may include:

- Development, publication, and distribution of brochures.
- Utility bill inserts, flyers, and handbills.
- Newspaper articles and/or advertisements.
- Development and distribution of educational videos.
- Public workshops, field demonstrations, or presentations to targeted civic organizations, youth organizations, etc.
- Developing and offering school curricula or assembly programs.
- Creating posters, signs, and graphics for installation at parks, school hallways, trails, etc.
- Storm drain stenciling to discourage dumping of materials into storm drains.
- Signs, including graphics, on dumpsters and other locations encouraging proper waste disposal.
- Signs in parks and along streets on pet waste control and ordinances.



Photograph DHW-2. Check with state and local water quality agencies for public education materials such as this door hanger developed by the Keep It Clean Partnership that can be adopted for use in your community. Photo courtesy of Nonpoint Source Colorado.

- Brochures and utility bill inserts on separation of wastes and recycling.
- Advertising the locations of existing toxic disposal sites and waste recycling centers.
- Advertising the locations of existing automobile fluids and used oil disposal sites.

- Developing campaigns promoting voluntary neighborhood clean-up efforts.
- Advertisements or notices of private locations accepting yard waste for composting.
- Information on backyard or neighborhood composting and proper disposal of yard waste.

In addition to public education efforts, local governments can provide facilities that provide readily available proper disposal opportunities. These practices include:

- Establishing and maintaining household toxics disposal sites.
- Annual or curbside collection of household toxics.
- Pet waste disposal bags in public parks.
- Providing waste containers in problem litter areas.
- Requiring waste-haulage truck covers.
- Seasonal or on-going collection programs for grass clippings, tree branches, and leaves with disposal at composting or chipping facilities, paired with distribution programs for reuse of composted or chipped materials.

With regard to household toxics, local governments should be aware that collection and disposal of household wastes is expensive. Such programs require adequate training of operators, analysis of unknown materials, safe transport and containers, extensive recordkeeping and awareness of regulatory requirements (e.g., the federal Resource Conservation and Recovery Act) regarding disposal of such materials.

Illicit Discharge Controls S-4

Description

Illicit discharges are non-stormwater discharges into a storm drain system, with some limited exceptions specified in state and local discharge permits (e.g., fire fighting water, springs, and others). Examples of illicit discharges include illegal dumping (e.g., used oil), accidental spills, failing septic systems, improper disposal of sewage from recreational activities such as boating or camping, and improper plumbing of sanitary discharges from residences and commercial or industrial establishments into the storm sewer system. A common cause of illicit discharges is connection of building or garage or floor drains to the storm sewer system.

Photograph IDC-1. Mapping and dry weather investigation of storm sewer outfalls is an important tool in identifying and removing illicit connections. Photo courtesy of WWE.

Control of illicit discharges involves a multi-faceted effort based on knowledge of the storm sewer system, use of ordinances to prohibit illicit discharges, development of a coordinated plan to detect and address illicit discharges, and a public education program to increase awareness of the problems caused by illicit discharges.

Appropriate Uses

Illicit discharge control measures are usually implemented by municipal governments and metropolitan districts, but may also be relevant to campus-scale developments or industries. Illicit discharge controls are closely related to practices identified in the Good Housekeeping BMP Fact Sheet.

Practice Guidelines

Practice guidelines for illicit discharge controls are discussed in three general categories:

1. Public education to reduce illegal dumping and discharges,
2. Municipal actions to identify and remove illegal connections to the storm sewer system, and
3. Accidental spill response measures.

Public Education to Reduce Illegal Dumping and Discharges

Public education and awareness are the foundation for reducing illegal dumping and some types of illicit discharges. For example, many citizens may not be aware that storm sewers drain to streams rather than wastewater treatment plants or may not be aware of the environmental damage caused by discharging soapy water, pet waste and other household wastes into the storm sewer system. Local governments should select public awareness and education approaches most effective for their communities, which may include a combination of some of these practices:

- Enactment of clearly written ordinances prohibiting illegal dumping and illicit connections. Many local governments already have such ordinances; however, citizens are often unaware of these. Publicity including news articles, door hangers, utility bill inserts, radio or TV advertisements, website highlights and other measures can be used to increase awareness. Such efforts may be particularly effective when connected to a specific water quality problem such as stream or lake impairments due to bacteria and/or nutrients.

- Storm drain stenciling involves placing a marker or using a stencil to paint a message on storm drains to discourage dumping down the storm drain. These messages are a public education tool so that citizens are aware that the materials that they dump down to the storm drain are discharged to a stream, as opposed to a wastewater treatment plant.

- Provide citizens with readily available contact information to report illegal dumping. Install a "hotline" telephone number to handle calls from citizens reporting illegal dumping or accidental spills.

- Create brochures and other guidance for businesses related to illegal discharges to the storm drain. Educational efforts should not only alert business owners that non-stormwater discharges are not allowed, but also provide guidance on BMPs to implement. For example, power washing discharges are process wastewater that may not be discharged to the storm sewer system. When power washing is conducted, storm drain inlet protection, wet vacuuming, collection systems, and/or other appropriate measures to prevent washwater from entering the storm drain system should be implemented.

Illicit Connections

Eliminating illicit connections plumbed into the storm drain system involves two different components:

1. Identifying and removing existing illicit connections; and

2. Preventing new illicit connections.

Removing Existing Connections

Existing illicit connections of sanitary sewers to the storm drainage system in existing developments can be identified by a systematic dry weather inspection of storm sewer outfalls following readily available illicit discharge detection and elimination guidance available from EPA. Initial screening typically involves mapping all storm sewer outfalls and conducting field inspections to identify suspect outfalls based on odor, sewage-related residue (e.g., toilet paper), discoloration, dry weather flows, etc. Grab samples of dry-weather discharges can be collected at suspect locations and analyzed for targeted water quality constituents (e.g., E. coli, temperature, pH, surfactants). Where illicit connections are probable, more advanced techniques can be used to isolate the likely source of the connection. Techniques such as temperature probes (to track diurnal temperature changes indicative of shower use suggesting a sanitary connection to a storm sewer), optical brightener screening (indicator of detergents), zinc chloride smoke testing, fluorometric dye testing, television camera inspections and other approaches can be used as follow-up measures. Once the illicit connection has been identified, the plumbing can be corrected and proper connections to the sanitary sewer system implemented.

Preventing Illicit Connections

Program elements to prevent illicit connections include:

- Ensure that existing building and plumbing codes prohibit physical connections of non-stormwater discharges to the storm drain system.
- Have a program in place to review and approve any proposed connection into a storm sewer.
- Require visual inspection of new developments or redevelopments during the construction phase to ensure that proper plumbing connections are implemented. Train field inspectors and develop field inspection procedures that prevent new illicit connections of sanitary sewer lines to storm sewers.

Accidental Spill Response

Although the storage, transport and disposal of hazardous and toxic substances is a highly regulated activity under state and federal laws, accidents will inevitably occur, resulting in potential release of chemicals and wastes into the storm sewer system. Most local police, fire, or other departments are trained and equipped to respond to such spills. Local governments should work with response personnel to ensure current mapping of storm drains and BMPs and review training procedures for spill response and cleanup. Proper training combined with readily available knowledge of the storm sewer system and appropriate spill control materials can result in more effective protection and blocking of the drainage system during spill response.

Additional Illicit Discharge Detection and Elimination Guidance

The Center for Watershed Protection and Robert Pitt (2004) prepared *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments* under EPA funding to provide guidance to communities in developing effective management programs and field guidance to reduce illicit discharges. This manual provides detailed guidance and field forms that can be used identify illicit connections.

Description

Good housekeeping practices are designed to maintain a clean and orderly work environment. The most effective first steps towards preventing pollution in stormwater from work sites simply involve using common sense to improve the facility's basic housekeeping methods. Poor housekeeping practices result in increased waste and potential for stormwater contamination.

Photograph GH-1. Use dry clean-up methods to remove spilled materials. Photo courtesy of Colorado Nonpoint Source Program.

A clean and orderly work site reduces the possibility of accidental spills caused by mishandling of chemicals and equipment and should reduce safety hazards to personnel. A well-maintained material and chemical storage area will reduce the possibility of stormwater mixing with pollutants.

Some simple procedures a facility can use to promote good housekeeping include improved operation and maintenance of machinery and processes, material storage practices, material inventory controls, routine and regular clean-up schedules, maintaining well organized work areas, signage, and educational programs for employees and the general public about all of these practices.

Appropriate Uses

Good housekeeping practices require education and training, typically targeted to industries and businesses, municipal employees, as well as the general public.

Practice Guidelines

Good housekeeping practices include these general areas:

- Operation and Maintenance
- Material Storage
- Material Inventory
- Training and Participation.

Operation and Maintenance

Consider implementing the following practices:

- Maintain dry and clean floors and ground surfaces by using brooms, shovels, vacuums or cleaning machines, rather than wet clean-up methods.
- Regularly collect and dispose of garbage and waste material.

- Routinely inspect equipment to ensure that it is functioning properly without leaking and conduct preventative maintenance and needed repairs.
- Train employees on proper clean up and spill response procedures.
- Designate separate areas of the site for auto parking, vehicle refueling and routine maintenance.
- Promptly clean up leaks, drips and other spills.
- Cover and maintain dumpsters and waste receptacles. Add additional dumpsters or increase frequency of waste collection if overflowing conditions reoccur.
- Where outdoor painting and sanding occur, implement these practices:
    - Conduct these activities in designated areas that provide adequate protection to prevent overspray and uncontrolled emissions. All operations should be conducted on paved surfaces to facilitate cleanup.
    - Use portable containment as necessary for outside operations.
    - Clean up and properly dispose of excess paint, paint chips, protective coatings, grit waste, etc.
- Maintain vegetation on facility grounds in a manner that minimizes erosion. Follow the Landscape Maintenance and Pesticide, Herbicide and Fertilizer Usage BMPs to ensure that minimum amounts of chemicals needed for healthy vegetation are applied in a manner that minimizes transport of these materials in runoff.

Material Storage Practices

Proper storage techniques include the following:

- Provide adequate aisle space to facilitate material transfer and ease of access for inspection.
- Store containers, drums, and bags away from direct traffic routes to reduce container damage resulting in accidental spills.
- Stack containers according to manufacturer's instructions to avoid damaging the containers from improper weight distribution. Also store materials in accordance with directions in Material Safety Data Sheets (MSDSs).
- Store containers on pallets or similar devices to prevent corrosion of containers that results from containers coming in contact with moisture on the ground.
- Store toxic or hazardous liquids within curbed areas or secondary containers.

Material Inventory Practices

An up-to-date materials inventory can keep material costs down by preventing overstocking, track how materials are stored and handled onsite, and identify which materials and activities pose the most risk to the environment. Assign responsibility of hazardous material inventory to individuals trained to handle such materials. A material inventory should include these steps:

- Identify all chemical substances present at work site. Perform a walk-through of the site, review

purchase orders, list all chemical substances used and obtain Material Safety Data Sheets (MSDS) for all chemicals.

- Label all containers. Labels should provide name and type of substance, stock number, expiration date, health hazards, handling suggestions, and first aid information. Much of, this information can be found on an MSDS.

- Clearly identify special handling, storage, use and disposal considerations for hazardous materials on the material inventory.

- Institute a shelf-life program to improve material tracking and inventory that can reduce the amount of materials that are overstocked and ensure proper disposal of expired materials. Careful tracking of materials ordered can result in more efficient materials use. Decisions on the amounts of hazardous materials that are stored on site should include an evaluation of any emergency control systems that are in place. All storage areas for hazardous materials should be designed to contain spills.

Training and Participation

Frequent and proper training in good housekeeping techniques reduces the likelihood that chemicals or equipment will be mishandled. To promote good housekeeping, consider implementing these practices:

- Discuss good housekeeping practices in training programs and meetings.

- Publicize pollution prevention concepts through posters or signs.

- Post bulletin boards with updated good housekeeping procedures, tips and reminders.

Description

Pesticides, herbicides, fertilizers, fuel and other landscape maintenance chemicals must be properly applied, stored, handled and disposed of to prevent contamination of surface water and groundwater. Misuse of pesticides and herbicides can result in adverse impacts to aquatic life, even at low concentrations. Misuse of fertilizer can result in increased algae growth in waterbodies due to excessive phosphorus and nitrogen loading.

Photograph PHF-1. Pesticide, fertilizer, and herbicide applications should be applied in the minimum quantities necessary to achieve specific landscaping objectives, while keeping chemicals out of storm drain systems. Photo courtesy of WWE.

Appropriate Uses

This BMP applies to both commercial and municipal landscaping operations, as well as to homeowners and homeowner associations. For commercial operations, the scale of chemical usage and handling is greater; therefore, additional measures are often required under federal and state law.

Practice Guidelines[1]

Public education regarding appropriate landscape chemical application and handling is an important action that local governments can take to reduce the likelihood that landscape chemicals are washed into storm drains and receiving waters through runoff. Local governments can make landscape care information available on websites, in utility mailers, lawn care centers, and other locations. A variety of professional organizations for lawn care professionals already exist and can be contacted for additional information or partnered with for both public education and landscape professional educational efforts and certification programs (See www.ext.colostate.edu and www.greenco.org.).

General Guidelines for Pesticide, Herbicide, and Fertilizer Application

- Apply fertilizers, pesticides, and other chemicals according to manufacturer's directions. The label is the law for pesticide usage. Apply pesticides and herbicides only when needed and use in a manner to minimize off-target effects. See the Landscape Management Fact Sheet for fertilizer application guidelines.
- Accurately diagnose the pest. Disease and insect symptoms can mimic each other in many plants. A fungicide will not control an insect, and an insecticide will not control a disease.
- Be aware that commercial chemical applicators must receive thorough training, licensure and proper certification prior to chemical use. Consult Colorado Department of Agriculture (CDA) Regulations for specific requirements.

[1] These practice guidelines have been adapted from the *GreenCO Best Management Practices for the Conservation and Protection of Water Quality in Colorado: Moving Toward Sustainability* (GreenCO and WWE 2008). See that manual for additional detail and references.

- Know characteristics of the application site, including soil type and depth to groundwater to avoid migration of chemicals into groundwater.
- Select pesticides and herbicides best suited to the characteristics of the target site and the particular pest or weed. Half-life, solubility, and adsorption should be compared to site characteristics to determine the safest chemical. Choose least toxic and less persistent sprays whenever possible based on comparison of labels and associated material safety data sheets.
- Employ application techniques that increase efficiency and allow the lowest effective application rate. Carefully calibrate application equipment and follow all label instructions.
- Recognize that it is not realistic for a landscape to be completely pest-free or weed-free. Consider using Integrated Pest Management (IPM) strategies to minimize chemical usage.
- Keep pesticide and fertilizer equipment properly calibrated according to the manufacturer's instructions and in good repair. Recalibrate equipment periodically to compensate for wear in pumps, nozzles and metering systems. Calibrate sprayers when new nozzles are installed.
- All mixing and loading operations must occur on an impervious surface.

Integrated Pest Management (IPM)

Integrated pest management (IPM) (also known as Plant Health Care) is the practice of using targeted biological, chemical, cultural, and physical measures to manage pests while minimizing or eliminating the use of chemical pesticides. IPM measures benefit the landscape and help reduce the likelihood that lawn chemicals will be washed into storm drainage systems in stormwater runoff. The pros and cons of various tools should be weighed and used in an integrated manner to achieve pest control objectives in a safe, effective, and cost-effective manner. Basic IPM practices that can be adopted include:

- Consider spot treatments of pests rather than treating the entire area.
- Consider pest occurrence and history when developing pest management strategies.
- Time pesticide application to minimize host plant damage and maximize pest control.
- Rotate annual garden plants to reduce the buildup of soil-borne pests. Clean up plant litter and remove weeds before they go to seed. Remove infested plant residue from the garden in the fall so that pests do not over-winter there.
- Implement cultural controls such as proper plant selection, planting time, and planting method to reduce susceptibility to insects, pests, and diseases, thereby reducing pesticide usage.
- Implement mechanical and physical controls where practical as an alternative to chemical application. Examples include a wide variety of practices such as "collars" around seedlings, mulching, solar heating, syringing, handpicking, mowing, hoeing, and traps.
- Use biological controls where appropriate to reduce pesticide usage. For example, introduce natural enemies of pests such as lady beetles and green lacewings. (Note: pesticides may kill these natural enemies.)
- Consider applying environmentally friendly chemical alternatives such as insecticidal soaps, horticultural oils, and other such measures when practical and effective and when mechanical approaches are impractical.

Application Practices

- Keep records of pesticide application and provide signage as required by law.
- Do not apply pesticides or herbicides during high temperatures, windy conditions or immediately prior to heavy rainfall or irrigation.
- Treat for and control noxious weeds prior to installing the landscape using an herbicide targeted to the weeds that are present and applied in accordance with the product label.
- Be aware that some pesticide formulations are not compatible with other pesticides and combining them may result in increased potency and phytotoxicity.

Managing Mosquitoes in Stormwater Facilities
(Adapted from: Peairs and Cranshaw 2007)

The key to mosquito control is larval management. Larvae occur in specific areas and can be controlled by modifying the habitat through drainage or insecticides applied to larval breeding sites. Weekly mosquito inspections at stormwater facilities with targeted treatments are frequently less costly and more effective than regular widespread application of insecticides. These inspections can be performed by a mosquito control source and typically start in mid-May and extend to mid-September. Mosquito control measures must be cost effective and environmentally sound. Consider alternatives before application of conventional chemical insecticides.

- **Habitat Modification:** Eliminating breeding sites, or habitat modification, is an effective and long-term solution. Proper maintenance of stormwater BMPs to avoid shallow standing water is important.
- **Natural Predators:** Fish, dragonfly nymphs, and diving beetles are natural predators of mosquito larvae; dragonflies, birds, and bats feed on adults. Consult the Colorado Division of Wildlife for recommendations, restrictions and regulations regarding mosquito-eating fish.
- **Insecticides:** Microbial insecticides such as the bacteria "Bti" (*Bacillus thuringiensis israeliensis*) can be as effective as chemical insecticides. Bti is toxic only to mosquito and midge larvae. It is not hazardous to non-target organisms but can reduce midge populations that serve as fish food.

  "Soft" chemical insecticides, such as the insect growth regulator methoprene, are toxic only to insects and other arthropods. They are similar to certain insect hormones and create imbalances in the levels of hormones needed for proper mosquito growth and development. They do not directly harm fish or other wildlife but can reduce the amount of available food.

  Mosquito larvae also can be controlled by the application of larvicidal oils or chemical insecticides to the water where they occur or are suspected to occur. Remember, several alternatives to conventional chemical larvicides have been developed because of concerns about applying chemicals to water that might be used for drinking or that contains fish and other aquatic life.

If larval control fails, adult mosquito control may be necessary. Adult control generally is done with insecticide applications using ground equipment or aircraft. For more information visit: www.ext.colostate.edu/westnile/mosquito_mgt.html or www.ext.colostate.edu/westnile/faq.html.

- Maintain a buffer zone around wells or surface water where pesticides are not applied. Consult local regulations and landscape ordinances, as well as the product label, for distances, which may vary depending on the type of chemical and the sensitivity of the waterbody. The purpose of this practice is to keep pesticides and herbicides out of surface waterbodies.

Storage Practices

- Storage areas should be secure and covered, preventing exposure to rain and unauthorized access. Commercial and municipal facilities should provide basic safety equipment such as fire extinguishers, warning signs (e.g., "no smoking"), adequate light and ventilation, and spill clean-up materials should be present. Floors and shelves should be non-porous (e.g., metal, concrete) to prevent sorption of chemicals. If possible, temperature control should be provided to avoid excessive heat or cold. Storage areas should be kept clear of combustible material and debris.

- Commercial operations handling large quantities of pesticides and fertilizers should consult the Colorado Department of Agriculture for storage and handling requirements. Commercial greenhouses and nurseries that are storing recycled water laden with fertilizer may need to provide secondary containment to contain the water in the event of a tank rupture or leak.

- Store chemicals in their original containers, tightly closed, with labels intact. Also inspect them regularly for leaks. Store nitrate-based and other oxidizing fertilizers separately from solvents, fuels, and pesticides to reduce fire risk. Follow the general principle of storing like chemicals together. Dry chemicals should be stored above liquids and on pallets to ensure that they do not get wet.

- Locate chemical storage and maintenance areas, as well as vehicle refueling and maintenance areas, away from wells and surface waterbodies in accordance with local regulations, typically at least 50 to 100 feet away.

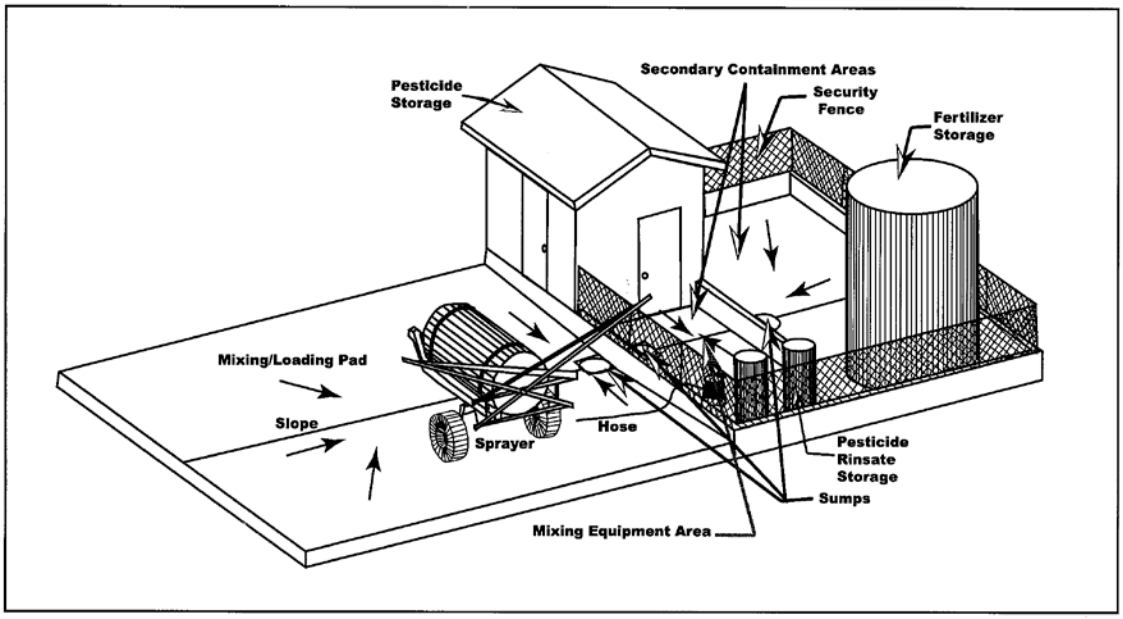


Figure PHF-1. Example Combined Pesticide and Fertilizer Storage and Mixing Area**.** Figure courtesy of *Designing Facilities for Pesticides and Fertilizer Containment*, Midwest Planning Service, Agricultural Engineering, Iowa State University 1991.

- Make available all Material Safety Data Sheets (MSDSs) in a readily accessible area. A list of all hazardous chemicals in the work place must be completed to ensure that all MSDSs are readily available.

- Do not store large quantities of pesticides for long periods of time. Adopt the "first in, first out" principle, using the oldest products first to ensure that the shelf life does not expire. Buy smaller quantities of pesticides and fertilizers, thereby reducing storage issues.

Spills and Disposal

- Never pour lawn and garden chemicals or rinse water down storm drains (or sanitary drains) and keep chemicals off impervious surfaces (e.g., streets, gutters) during application.

- Follow label directions for disposal. This typically involves triple-rinsing empty containers, puncturing and crushing. All visible chemicals should be cleaned from the container prior to disposal. Use local recycling or hazardous waste collection centers to dispose of unused chemicals.

- Properly manage chemical spills by cleaning them up as soon as possible, controlling actively spilling or leaking materials, containing the spilled material (e.g., with absorbents, sand), collecting the spilled material, storing or disposing of the spilled material, and following relevant spill reporting requirements. "Washing down" a spill with water is not an appropriate cleanup approach.

- Commercial operations should be aware of and comply with basic spill reporting requirements required by law, and keep chemical spill cleanup equipment, personal protective equipment and emergency phone numbers available when handling chemicals and their containers.

For More Information on Legal Requirements

Many federal and state regulations address pesticide, herbicide, and other chemical usage. These sources should be consulted for the most current legal requirements related to chemical handling, storage, application, disposal, and reporting of chemical spills. Examples include the federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Superfund Amendments and Reauthorization Act (SARA), the Emergency Planning and Community-Right-to-Know Act (EPCRA), and Occupational Safety and Health Administration (OSHA) requirements, particularly the Hazard Communication Standard. Colorado-related regulations include the Colorado Pesticide Applicator's Act, and the Colorado Water Quality Control Act (25-8-601 and 25-8-606), Senate Bill 90-126, and The Agricultural Chemicals and Groundwater Protection Act, which identifies special requirements for facilities handling more than 3,000 pounds (or 500 gallons) of bulk-formulated pesticides.

Description

Proper landscape maintenance, including maintenance of vegetated stormwater BMPs, is important to reduce nutrient and chemical loading to the storm drain system, reduce nuisance flows and standing water in stormwater BMPs, and maintain healthy vegetation that helps minimize erosion. Additionally, when landscapes and vegetated BMPs are over-irrigated, the ground remains saturated and capacity to infiltrate runoff is reduced.

Photograph LM-1. Over-irrigation and overspray can wash fertilizers and lawn chemicals into the storm drain system. These flows can comingle with storm runoff and cause nuisance flow conditions in stormwater BMPs. Photo courtesy of the City of Westminster.

Appropriate Uses

Appropriate lawn care practices are applicable to residential, commercial, municipal, and some industrial operations.

Practice Guidelines[1]

Practice guidelines for a healthy lawn that reduces pollution during both wet and dry weather conditions include a combination of practices such as mowing, aeration, fertilization, and irrigation. Also, see the Pesticide, Herbicide, and Fertilizer Usage BMP for information on proper use of these chemicals and Integrated Pest Management (IPM) strategies.

Lawn Mowing and Grass Clipping Waste Disposal

- Keep lawn clippings and debris out of gutters. When blowing walkways or mowing lawns, direct equipment so that the clippings blow back onto the lawn rather than into the street, or collect clippings blown onto the street and properly dispose of them.
- Mulch-mowing turfgrass at a height of 2.5 to 3 inches helps turfgrass develop deeper root systems. No more than one-third of the grass blade should be removed in a single mowing. Mulched grass clippings can return roughly 25 to 30% of the needed nitrogen that grass requires to be healthy, thereby reducing fertilizer requirements. Avoid throwing grass clippings onto streets and sidewalks to reduce nutrient pollution to surface waterbodies.
- Minimize thatch development by mowing at appropriate frequencies and heights for the grass type, avoiding overwatering, preventing over fertilization, and aerating the turf.

[1] These practice guidelines have been adapted from the *GreenCO Best Management Practices for the Conservation and Protection of Water Quality in Colorado: Moving Toward Sustainability* (GreenCO and WWE 2008). See this manual for additional detail and references.

Lawn Aeration

- Aerate turf once or twice per year, as needed, in the early spring and/or late fall to aid in capturing the natural precipitation during non-weed germination periods and prior to adding organic materials and fertilizers. Aeration reduces soil compaction and helps control thatch in lawns while helping water and fertilizer move into the root zone.

- A lawn can be aerated at any time the ground is not frozen, but should not be done when it is extremely hot and dry. Heavy traffic areas will require aeration more frequently.

- Do not use spike-type aerators, which compact the soil. Holes should be two to three inches deep and no more than two to four inches apart. Lawns should be thoroughly watered the day before aerating so plugs can be pulled more deeply and easily. Mark all sprinkler heads, shallow irrigation lines, and buried cable TV lines before aerating so those lines will not be damaged.

Phosphorus

Phosphorus is commonly overused and application should be based on soil tests. Phosphorus washing into surface waterbodies leads to excessive algae growth.

Phosphorous does not move out of the soil like nitrogen, so constant additions are unnecessary.

Fertilizer Application

- Apply fertilizer when needed to achieve a clearly defined objective such as increasing shoot growth, root growth, flowering or fruiting; enhancing foliage color, and plant appearance; or correcting or preventing nutrient deficiencies.

- Because manufactured fertilizers can be relatively high in nutrient content, it is critical to follow the manufacturer's directions, using the minimum amount recommended. Over-application "burns" leaves and may lead to water pollution, thatch buildup, excessive mowing, and weed growth.

- Only apply nutrients the plants can use. Fertilizer labels identify product contents in terms of ratios that indicate percentage of ingredients by product weight.

Soil Testing

There are several qualified laboratories in Colorado that provide soils tests to determine recommendations for fertilizer type and application rates. There are also commercially available quick test kits that are less accurate but could be used by a homeowner. Without an analysis, a homeowner may be buying unnecessary fertilizer or applying too much. A $20 to $40 soil analysis has potential to save an owner much more.

The CSU Extension program offers a soil testing service. Contact the CSU Extension for your county or visit http://www.ext.colostate.edu for more information including a list of laboratories.

- When practical and appropriate, base fertilizer application on soil analysis. Be aware that at many new development sites, soil conditions following grading often no longer consist of topsoil. "Basement" soils with poor texture and low nutrient content may be present. As a result, soil amendment is often needed to improve the physical properties (tilth) of the soil to provide a better environment for plant roots to improve nutrient uptake. Soil analysis can help to identify soil amendments that improve both the physical and nutrient characteristics of the soil, as well as identify fertilization requirements.

- Utilize split applications of slow-release (controlled-release) fertilizer forms such as IBDU, sulfur-coated urea and natural organic-based fertilizers (not to be confused with raw manure) to minimize the risk of nutrients leaching into groundwater or running off in surface water. When properly applied, other forms of fertilizer can also be safely used, provided that over-watering and over-fertilization do not occur.

- When applying fertilizer, broadcast it uniformly over the targeted area of the landscape. Keep fertilizer off streets, sidewalks, and driveways to prevent water pollution. Fertilizer that inadvertently falls on impervious surfaces should be swept back onto the lawn.

- Recommendations for fertilizer application vary among industry professionals. CSU Extension's fertilizer recommendations for established Colorado lawns are provided in the table below. Site-specific conditions should also be considered when determining the need for fertilizer.

Table LM-1. CSU Extension Recommendations for Nitrogen Application Rate

	Nitrogen Application Rate in Pounds/1,000 sq. ft.				
Turfgrass Species	Mid-March to April[A,B]	May to Mid-June[B]	July to Early August[B]	Mid-August to Mid-September[B, C]	Early October to Early November[B, D]
High Maintenance Bluegrass Ryegrass	0.5-1	1	Not Required	1	1-2 (optional)
Low Maintenance Bluegrass	0.5	0.5-1	Not Required	1	1 (optional)
Tall Fescue	0.5	0.5-1	Not Required	1	1 (optional)
Fine Fescue	0.5	0.5-1	Not Required	0.5-1	None
Buffalo grass, Blue Grama, Bermuda grass	None	0.5-1	0.5-1	None	None

Notes:

[A] The March-April nitrogen application may not be needed if prior fall fertilization was completed. If spring green-up and growth is satisfactory, delay fertilizing to May or June.

[B] Application rates may be reduced by 1/4 to 1/3 when grass clippings are left on the lawn.

[C] On very sandy soils do not fertilize turf after late September to prevent nitrogen from leaching into groundwater during the winter months.

[D] Apply when the grass is still green and at least 2-3 weeks prior to the ground freezing. Optional nitrogen applications are indicated for use where higher quality or heavily-used turf is present.

Source: T. Koski and V. Skinner, CSU Extension, 2003.

- If possible, properly irrigate turf following fertilization to help grass utilize applied nutrients and to minimize the potential for fertilizer burn. Care should be taken to avoid excessive irrigation that would result in fertilizer being washed away. Similarly, avoid application of fertilizer immediately prior to heavy rainfall.

- Fall is the best time of year to fertilize bluegrass lawns. Over-application of nitrogen fertilizer in April may cause grass to grow too fast before roots can support the growth, resulting in less heat tolerance.

- Generally, the Colorado Nursery and Greenhouse Association recommends waiting until the second growing season to fertilize ornamental (woody) plants. Commercial fertilizer should not be used in the backfill where it comes in direct contact with the roots.

- Maintain a buffer zone around wells or surface waterbodies where fertilizers are not applied to minimize pollution. Consult the fertilizer product label and local regulations and landscape ordinances for appropriate distances. Research in this area is limited; however, CSU Extension recommends a buffer of 6 to 10 feet for mowed turf areas.

- In areas with sandy soils, it is particularly important to avoid over-application of fertilizer that could leach into groundwater. These areas may be particularly well suited to slow-release fertilizer forms and conservative application rates.

Lawn Irrigation

- The approximate amount of water that needs to be applied **each week** for an average, traditional lawn to supplement normal rainfall is listed in Table 2. (Water utilities may provide additional guidance in terms of suggested run-times for various sprinkler types; http://www.denverwater.org/Conservation/.)

Table LM-2. General Guideline for Approximate Supplemental Water for an Average Traditional Lawn (inches per week)

Condition[3]	April[1]	May	June	July	Aug	Sept	Oct[2]
Non-Drought Conditions	1/4"	1"	1½"	1½"	1¼"	1"	1/2"
During Drought Restrictions (approx. 20% reduction)	1/4"	3/4"	1¼"	1¼"	1"	3/4"	1/2"

[1] For established lawns, water may not be required during April. Base decision on weather conditions.
[2] For established lawns, water is typically not required after Oct 15.
[3] Under less-than-average rainfall conditions, the amounts shown in the chart should be increased. If there is greater-than-normal rainfall, then the amount of supplemental water should be reduced.

- Consult with the CSU Extension Turfgrass program for recommendations for irrigating turfgrasses with lower water requirements (e.g. blue grama, buffalo grass). For native grasses, irrigation may be unnecessary or limited to certain conditions.

- Irrigate the lawn uniformly until the soil is moist to a depth of 4 to 6 inches to encourage deep roots. Frequent, light sprinklings moisten only the surface and may cause shallow-rooted turf and increase weed seed germination. Properly maintain the irrigation system to ensure that the irrigation is being applied at appropriate rates and to the turfgrass, not the sidewalk.

- Maintain irrigation systems in good operating condition with uniform distribution of water. "Smart" irrigation controllers and weather sensors can reduce water waste by shutting off irrigation during storm events and helping owners water according to the needs of the plants to replace water lost to evapotranspiration (ET).

- Proper irrigation can minimize the amount of fertilizer and other chemicals that are leached below the root zone of the grass or washed away by runoff.

Description

For obvious safety reasons, snow removal in Colorado is important; however, snow removal and management practices can adversely impact vegetation, soils, water quality, and air quality. Snow removal contractors and operators should be knowledgeable of these potential impacts and choose management measures with the fewest adverse impacts, while still protecting the public safety, health and welfare.

Photograph SIM-1. Snow storage locations should be clearly communicated to snow removal contractors and located where they can drain to stormwater BMPs or landscaped areas. Photo courtesy of WWE.

Appropriate Uses

Snow and ice management procedures are relevant for homeowners, contractors, business owners, and transportation departments.

Practice Guidelines[1]

- Physical removal of snow and ice by shovels, snowplows, or snow blowers usually has the least water quality and landscape impacts, provided that storage areas are not piled directly on landscape plants or drained directly to receiving waters. Plan for snow storage locations that minimize water quality and landscape impacts prior to winter.
- Ensure that equipment is calibrated to optimum levels according to manufacturer's instructions.
- Consider placing barriers in targeted site-specific locations (i.e., along streams or direct drainages) to route deicing material away from waterbodies.
- Reduce plowing speed in sensitive areas to prevent exposure to deicing material.
- Designate snow storage areas in locations that enable runoff to be directed to stormwater BMPs for treatment, when practicable.
- The use of deicing chemicals can have a severe impact on plants growing near roads and sidewalks. This can become a water quality issue when plants die and erosion results. Many deicing chemicals are salts and can adversely affect plants through either direct contact with foliage or through buildup in the soil over time. Representative impacts include:

[1]These practice guidelines have been adapted from the *GreenCO Best Management Practices for the Conservation and Protection of Water Quality in Colorado: Moving Toward Sustainability* (GreenCO and WWE 2008). See this manual for additional detail and references.

- Direct contact often occurs when the deicing chemicals accumulate on the plants due to drift during application, or when snow or ice containing the chemical is shoveled or blown onto nearby plants. Because these chemicals are salts, direct contact with the foliage may result in burning due to a rapid dehydration effect.

- Buildup of de-icing chemicals in the soil may have even more detrimental effects. Repeated application over time (either during a particular winter season or over many seasons) may damage plants by making their roots unable to take up water. Symptoms will include wilting even when the soil is moist, leaf burn or needle tip burn, stunting or lack of vigor, and/or deficiency symptoms for one or more plant nutrients. The structure of clay soils can be changed to the point that they are unable to support plant life.

- Deicing chemicals that are considered safer to use around plants include calcium magnesium acetate (CMA) or calcium chloride. As with all chemicals used in the landscape, be sure to read and follow label instructions and do not over apply.

- The Colorado Department of Transportation (CDOT) has conducted multiple studies on deicing chemicals. The SeaCrest Group (2001) studied three groups of deicers for CDOT that were chloride-based, acetate-based, and sanding materials. The chloride-based deicers included magnesium chloride (FreezGard Zero® with Shield LS®, Ice-Stop™ CI, Caliber™ M1000, Ice Ban™ M50), calcium chloride (Liquidow®, Armor®), and sodium chloride (road salt and Ice Slicer®). The acetate-based deicers include Calcium Magnesium Acetate (CMA®), Potassium Acetate (CF7®), Sodium Acetate (NAAC®), and CMAK™ (a mixture of CMA and Potassium Acetate). Table 1 contains a partial summary of the study findings.

- Highlights of the SeaCrest (2001) study regarding impacts associated with the three categories include:

  - The chloride-based deicers have been shown to have adverse effects on terrestrial vegetation. Damage to vegetation from deicing salts has been reported to a distance of 100-650 feet. However, there is a wide range of tolerance of different species of plants to the effects of chlorides. The chloride ions in deicers increase the salinity of the soil near the roadways where they are applied. The magnesium and calcium ions increase the stability and permeability of the soil, whereas sodium ions decrease soil stability and permeability.

  - The acetate-based deicers are organic and have different kinds of effects on the environment than the chloride-based deicers. The acetate ions are broken down by soil microorganisms and may result in oxygen depletion of the soil, which can impact vegetation; however, the acetate deicers CMA and Potassium Acetate (CMAK) are not harmful to terrestrial vegetation at the concentrations typically used on roadways. However, NAAC may potentially have an adverse effect on vegetation because of the presence of the sodium ion, which decreases the stability and permeability of the soil. The depletion of oxygen in the soil from the breakdown of the acetate ion can have a negative effect on plant growth, but field evidence of this effect is limited.

  - Sand is not a deicer, but is used for snow and ice control because it improves traction. Sand has a negative effect on water quality as a result of the increased turbidity caused by the presence of sand particles in water. Excessive quantities of sand can smother vegetation.

Table SIM-1. Potential Environmental Impacts of Various Deicers
(Source: The SeaCrest Group 2001)[2]

Deicer/ Parameter	Inhibited Magnesium Chloride (Liquid)	Caliber + Magnesium Chloride (Liquid)	Ice Ban + Magnesium Chloride (Liquid)	Sodium Chloride/ Ice Slicer (Solid)	Inhibited Calcium Chloride (Liquid)	CMA (Solid/ Liquid)	CMAK (Liquid)	Potassium Acetate (Liquid)	NAAC (Solid)	Sand
Chemicals	Trace metals	Trace metals, phosphorus, ammonia	Trace metals, phosphorus, ammonia, nitrates	Trace metals	Trace metals, ammonia, nitrates.	Trace metals	Trace metals, ammonia, nitrates.	Trace metals	Trace metals, phosphorus	Trace metals
Soil	Improves structure, increases salinity	Improves structure, increases salinity, oxygen depletion	Improves structure, increases salinity, oxygen depletion	Increases salinity; decreases stability	Improves structure, increases salinity	Improves structure; oxygen depletion	Improves structure; oxygen depletion	Improves structure; oxygen depletion	Decreases stability; oxygen depletion	Minimal effects
Water Quality	Increases salinity	Increases salinity; oxygen depletion	Increases salinity; oxygen depletion	Increases salinity	Increases salinity		Oxygen depletion	Oxygen depletion	Oxygen depletion	Increases turbidity
Air Quality	Minimal air pollution	Minimal air pollution	Minimal air pollution	Some air pollution	Minimal air pollution	Minimal air pollution	Minimal air pollution	Minimal air pollution	Some air pollution	High air pollu ion potential
Aquatic Organisms	Relatively low toxicity	Relatively low toxicity	Moderate toxicity	Relatively low toxicity	Relatively low toxicity	Relatively low toxicity	Moderate toxicity	Moderate toxicity	Relatively low toxicity	Can cover benthic organisms and cause mortality
Terrestrial Vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Chlorides damage vegetation	Minimal damage to vegetation	Minimal damage to vegetation	Minimal damage to vegetation	Effects to vegetation not determined	Can cover vegetation and cause mortality
Terrestrial Animals	Does not attract wildlife	Does not attract wildlife	Does not attract wildlife	Attracts wildlife contributing to road kills	Does not attract wildlife	Not expected to attract wildlife	Not expected to attract wildlife	Not expected to attract wildlife	May attract wildlife contributing to roadkills	May cover burrows of small animals and cause mortality

Note: Trace metals that may be present include arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, and zinc. Soil comments related to structure refer to the affect on soil stability, which relates to erosion. See http://www.coloradodot.info/programs/research/pdfs/2001/deicers.pdf/view for more information.

- Where practicable, do not use deicers to melt snow or ice completely, but to make their removal easier. Deicers melt down through the ice or snow to the hard surface, then spread out underneath. This undercuts and loosens the snow so shoveling and plowing can be done. For this reason, it is helpful to apply deicers prior to snow events in some cases.

- Research has shown that the shape of deicing particles affects the speed of their penetration through ice. Uniformly shaped spherical pellets of about 1/16 inch to 3/16 inch penetrate ice faster and more efficiently than other shapes.

- Try to avoid the use of rock salt since it is generally most damaging to plants, soils and concrete and metal surfaces. In areas where deicing salts are unavoidable, select plants with higher salt tolerances.

[2] The SeaCrest Group, 2001. *Evaluation of Selected Deicers Based on a Review of the Literature,* Report No. CDOT-DTD-2001-15. Prepared for Colorado Department of Transportation Research Branch.

- Do not plow snow directly into streams or wetlands. Snow storage and disposal areas should be located in an area where snowmelt can infiltrate into the ground, filter through a vegetated buffer or be otherwise treated prior to reaching streams and wetlands. Provide adequate storage volume to trap sediment left behind by melting snow and plan regular maintenance to remove accumulated sediment.

- In areas subject to heavy chemical deicing use, flushing the soil with water after the last freeze may alleviate burn potential. Year-round proper plant care will also make plants more tolerant to salt exposure. However, for the overall health of the landscape, the goal should be to reduce or minimize the use of deicing chemicals where they are not necessary for safety reasons.

- If an electric/mechanical snow melting device is used to dispose of removed snow (e.g., The Can snow melter, Snow Dragon, etc.), the owner or operator must obtain the appropriate permit prior to discharge. Snowmelt from melting machines is typically considered process wastewater.

Description

Street sweeping uses mechanical pavement cleaning practices to reduce sediment, litter and other debris washed into storm sewers by runoff. This can reduce pollutant loading to receiving waters and in some cases reduce clogging of storm sewers and prolong the life of infiltration oriented BMPs and reduce clogging of outlet structures in detention BMPs.

Different designs are available with typical sweepers categorized as a broom and conveyor belt sweeper, wet or dry vacuum-assisted sweepers, and regenerative-air sweepers. The effectiveness of street sweeping is dependent upon particle loadings in the area being swept, street texture, moisture conditions, parked car management, equipment operating conditions and frequency of cleaning (Pitt et al. 2004).

Photograph SSC-1. Monthly street sweeping from April through November removed nearly 40,690 cubic yards of sediment/debris from Denver streets in 2009. Photo courtesy of Denver Public Works.

Appropriate Uses

Street sweeping is an appropriate technique in urban areas where sediment and litter accumulation on streets is of concern for aesthetic, sanitary, water quality, and air quality reasons. From a pollutant loading perspective, street cleaning equipment can be most effective in areas where the surface to be cleaned is the major source of contaminants. These areas include freeways, large commercial parking lots, and paved storage areas (Pitt et al. 2004). Where significant sediment accumulation occurs on pervious surfaces tributary to infiltration BMPs, street sweeping may help to reduce clogging of infiltration media. In areas where construction activity is occurring, street sweeping should occur as part of construction site stormwater management plans. Vacuuming of permeable pavement systems is also considered a basic routine maintenance practice to maintain the BMP in effective operating condition. See the maintenance chapter for more information on permeable pavement systems. Not all sweepers are appropriate for this application.

Practice Guidelines[1]

1. Post street sweeping schedules with signs and on local government websites so that cars are not parked on the street during designated sweeping days.

2. Sweeping frequency is dependent on local government budget, staffing, and equipment availability, but monthly sweeping during non-winter months is a common approach in the metro Denver urban

[1] Practice guidelines adapted from CASQA (2003) *California Stormwater BMP Handbook*, Practice SC-70 Road and Street Maintenance.

area. Consider increasing sweeping frequency based on factors such as traffic volume, land use, field observations of sediment and trash accumulation, proximity to watercourses, etc. For example:

- Increase the sweeping frequency for streets with high pollutant loadings, especially in high traffic and industrial areas.
- Conduct street sweeping prior to wetter seasons to remove accumulated sediments.
- Increase the sweeping frequency for streets in special problem areas such as special events, high litter or erosion zones.

3. Perform street cleaning during dry weather if possible.
4. Avoid wet cleaning the street; instead, utilize dry methods where possible.
5. Maintain cleaning equipment in good working condition and purchase replacement equipment as needed. Old sweepers should be replaced with more technologically advanced sweepers (preferably regenerative air sweepers) that maximize pollutant removal.
6. Operate sweepers at manufacturer recommended optimal speed levels to increase effectiveness.
7. Regularly inspect vehicles and equipment for leaks and repair promptly.
8. Keep accurate logs of the number of curb-miles swept and the amount of waste collected.
9. Dispose of street sweeping debris and dirt at a landfill.
10. Do not store swept material along the side of the street or near a storm drain inlet.

Changes in Street Sweeper Technology (Source: Center for Watershed Protection 2002)

At one time, street sweepers were thought to have great potential to remove stormwater pollutants from urban street surfaces and were widely touted as a stormwater treatment practice in many communities. Street sweeping gradually fell out of favor, largely as a result of performance monitoring conducted as part of the National Urban Runoff Program (NURP). These studies generally concluded that street sweepers were not very effective in reducing pollutant loads (USEPA, 1983). The primary reason for the mediocre performance was that mechanical sweepers of that era were unable to pick up fine-grained sediment particles that carry a substantial portion of the stormwater pollutant load. In addition, the performance of sweepers is constrained by that portion of a street's stormwater pollutant load delivered from outside street pavements (e.g., pollutants that wash onto the street from adjacent areas or are directly deposited on the street by rainfall). Street sweeping technology, however, has evolved considerably since the days of the NURP testing. Today, communities have a choice in three basic sweeping technologies to clean their urban streets: traditional mechanical sweepers that utilize a broom and conveyor belt, vacuum-assisted sweepers, and regenerative-air sweepers (those that blast air onto the pavement to loosen sediment particles and vacuum them into a hopper).

For more information, see
http://www.cwp.org/Resource_Library/Center_Docs/PWP/ELC_PWP121.pdf

Storm Sewer System Cleaning S-12

Description[1]

Photograph SSC-1. Storm drain cleaning may help to remove pollutant sources and helps to maintain the capacity of the storm pipes.

Periodic storm sewer system cleaning can help to remove accumulated sediment, trash, and other substances from various components of the storm sewer system including inlets, pipes and stormwater BMPs. Some common pollutants found in storm drains include: trash and debris, sediments, oil and grease, antifreeze, paints, cleaners and solvents, pesticides, fertilizers, animal waste, and detergents. Routine cleaning reduces the amount of pollutants, trash, and debris both in the storm drain system and in receiving waters. Clogged drains and storm drain inlets can cause the drains to overflow, leading to increased erosion (Livingston et al. 1997). Cleaning increases dissolved oxygen, reduces levels of bacteria, and supports in-stream habitat. Areas with relatively flat grades or low flows should be given special attention because they rarely achieve high enough flows to flush themselves (Ferguson et al. 1997).

Appropriate Uses

Storm sewer system cleaning is typically conducted by local governments or state agencies; however, homeowners associations, businesses and industries are usually responsible for maintaining system components on their sites.

Due to the cost and time involved with storm sewer system cleaning, communities may target recurrent problem areas or use another type of prioritization system for maintenance. Also see the BMP Maintenance chapter for BMP-specific maintenance requirements.

Practice Guidelines

A variety of jet/vacuum vehicles can be used to remove debris from stormwater catch basins and pipes. This equipment breaks up clogged/accumulated material with high-pressure water jets and vacuums the material from the sewer. Water used in storm drain cleaning must be collected and properly disposed of, typically at a sanitary wastewater treatment facility.

Simpler methods in localized areas can also include manual trash collection and shoveling from inlets and outlets.

[1] Guidelines adapted from Center for Watershed Protection (2009) *Urban Stormwater Restoration Manual Series 8: Municipal Practices and Programs*.

S-12 Storm Sewer System Cleaning

Frequency and prioritization of storm sewer cleaning is affected by multiple factors such as the activity and intensity of use in the tributary area (e.g., parking lot, stadium), storm sewer system design, municipal budgets (staff and equipment), and other factors.

To be most effective, storm sewer cleaning needs an effective recordkeeping system and clearly defined procedures. CWP (2009) recommends the following practices:

- **Tracking**: The location and maintenance of storm drains should be tracked using a database and spatial referencing system (e.g., Global Positioning System or Geographic Information System). Additionally, knowing the type and era of the storm drain system may be of use since some inlets/catch basins are designed to be self-cleaning while others have some trapping capacity.

- **Frequency**: Should be defined such that blockage of storm sewer outlet is prevented and it is recommended that the sump should not exceed 40- 50 percent of its capacity. Semi-annual cleanouts in residential streets and monthly cleanouts for industrial streets are suggested by Pitt and Bissonnett (1984) and Mineart and Singh (1994). More frequent cleanouts should be scheduled in the fall as leaves can contribute 25% of nutrient loadings in catch basins.

- **Technology**: A variety of methods of cleaning catch basins are available, including manual cleaning, eductor vehicles, vacuum cleaning and vacuum combination jet cleaning. Choose the approach that is most effective for site conditions, taking into consideration budget, equipment, and staffing constraints.

- **Staff training**: Operators need to be properly trained in catch basin maintenance including waste collection and disposal methods. Staff should also be trained to report water quality problems and illicit discharges.

- **Material disposal**: Most catch basin waste is of acceptable quality for landfills. If it is suspected that catch basin waste contains hazardous material, it should be tested and disposed of accordingly. Maintenance personnel should keep a log of the amount of sediment collected and the removal date at the catch basin.

APPENDIX E

Summary of Water Quality
Conformance to MS4 Permit

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 Auburn Heights

Project Owner Auburn Ventures II, LP

Project Location South half of section 3, Township 8 South, Range 67 West of the 6th P.M.

ToCR Project Number SDP21-0037

Total Site Area 7.12 **acres**

Total Size of Common Plan of Development 7.12 **acres**

Check all that apply:

- ☑ **Project within Plum Creek Basin**
- ☐ **Project within Cherry Creek Basin**

Estimated construction completion date MAY 2027

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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. 1

   - ☐ 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: 0.63 acres
   - ☐ Stream Stabilization Sites
     Excluded impervious area: _____ acres
   - ☐ Trails
     Excluded impervious area: _____ acres
   - ☐ Oil and Gas Exploration

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

   If yes, complete the following:

   Excluded area: 0.63 acres

   Total Site area: 7.12 acres, 8.8 % site excluded

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

   If yes, complete the following:

   Excluded area: _____ acres

   Excluded impervious area: _____ acres

   Total Site area: _____ acres, _____ % site excluded

   Total Impervious area: _____ acres, _____ % impervious excluded

APPENDIX F

Referenced Information

From Reference 4

CASTLE HIGHLANDS FILING NO. 2
PHASE III DRAINAGE STUDY

Prepared for:

CASTLE ROCK EQUITIES, L.L.C.
6950 East Belleview Avenue, Suite 301
Englewood Colorado, 80111
Contact: Sam N. Perry

Prepared by:

JR ENGINEERING
6020 Greenwood Plaza Boulevard
Englewood, Colorado 80111
303.740.9393
Contact: Mr. James Fitzmorris

Project Number 2316.05

August 23, 1999
Revised: December 10, 1999

Project Number 14695.00

Revised: August 21, 2001

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D-26

Project: Castle Highlands Filing No. 2
Date: August 21, 2001

ENGINEER'S STATEMENT:

The enclosed drainage report, and exhibits, were prepared by me, or under my direct supervision, and are correct to the best of my knowledge and belief. Said drainage report has been prepared in accordance with applicable Town of Castle Rock criteria and is in conformance with the master plan of drainage for the effected area. I accept responsibility for any liability causes by negligent acts, errors or omissions on my part in preparing this report.

No signatures on Town copy

James P. Fitzmorris, P.E.
Colorado Registered Professional Engineer No. 28211
For and On Behalf of JR Engineering, Ltd.

OWNER/ DEVELOPER'S STATEMENT:

As Owner/Developer of land(s) identified within this report; I agree to proceed, implement and comply with all recommendations and requirements outlined herein.

Owner Name and Signature

TOWN OF CASTLE ROCK APPROVALS:

ENGINEERING DIVISION **DATE**

PUBLIC WORKS DIRECTOR **DATE**

General Location and Description

Location

Castle Highlands Filing No. 2 consists of 75.0 acres and is located in portions of Section 3 and 10, Township 8 South, Range 67 West of the Sixth Principal Meridian, Town of Castle Rock, Douglas County, Colorado (Figure 1). The site is bounded on the north and northwest by Wolfensberger Road, by Cedar Hill Cemetery on the east and by undeveloped land on the remaining sides.

Description of Property

Soils on the site consist of Bresser-Truckton sandy loam and Newlin gravelly sandy loam (Figure 2). Vegetation consists of native grasses, cacti, and stands of scrub oak. The site slopes northeasterly in direction at grades varying from one to thirty percent.

The site is undeveloped and is currently pastureland for livestock. The proposed development will include 31.9 acres of single family development, 8.5 acres of multi-family development, and 4.5 acres of commercial development. 8.8 acres will be dedicated as public right-of-way and 21.3 acres will remain as open space. The entire site will be overlot graded and temporary and permanent seeding will be used to minimize erosion.

Drainage Basins and Sub-Basins

Major Basin Description

Castle Highlands Filing No. 2 is within the East Plum Creek drainage basin. Plum Creek is located approximately one mile downstream of this site. The site is not within a 100-year flood plain as shown on FIRM maps 080049-0285c and 080049-0170c dated September 30, 1987. The Soil Conservation Service (figure 2) classifies the on-site soils as Hydrologic Group B.

Sub-Basin Description

The site slopes northeasterly in direction at grades varying from one to thirty percent. Approximately two-thirds of the site historicaly drains into an existing channel that outfalls into an existing on-stream detention pond. The pond outlets to the northeast into the continuation of said channel. A portion of the site drains into the channel downstream of the detention pond. The channel conveys flows under Wolfensberger Road via an existing 42" CMP and an existing 48" CMP which discharges in an existing channel on the north side of the road. The channel continues northeasterly in direction for approximately one mile where it outfalls into East Plum Creek.

The remaining one-quarter of the site also drains northeasterly. This area is routed to an existing channel along the south side of Wolfensberger Road. The channel along the south side of Wolfensberger Road continues easterly in direction for approximately thirteen hundred feet where it ties into a tributary of East Plum Creek.

This site accepts off-site flows from an undeveloped area to the southwest. A majority of this basin will remain as open space. Any developed portions will provide detention ponds that will not release at rates higher than historic. This site will release detained flows at historic rates as required by the Town of Castle Rock.

Drainage Design Criteria

Regulations

This report was prepared to meet the regulatory requirements of the Town of Castle Rock, Colorado. This report was prepared following guidelines and regulations within the "Town of Castle Rock Public Works Regulations" (TCRPWR, October 1, 1998) the Douglas County Storm Drainage Design and Technical Criteria (DCSDDTC) and the "Urban Storm Drainage Criteria Manual", (USDCM, 1992).

Development Criteria

This site was addressed in an approved preliminary drainage report by JR Engineering titled "Castle Highlands Preliminary Drainage Study" (September 1, 1994). This study identified historic flows for this site and upstream of this site. It defined required detention volumes and release rates. This site encompasses a majority of the area addressed in this study. The only area excluded from this filing is the multi-family site east of Auburn Drive. This study is in compliance with the preliminary study.

Hydrologic Criteria

This report analyzes the 5-year and 100-year storms for storm water conveyance systems and 10-year and 100-year storms for the detention requirements. All on-site runoff calculations utilized the Rational Method to determine runoff quantities. Runoff from the major offsite basin and it's continuation through this project was evaluated using the Colorado Urban Hydrograph Procedure (CUHP). Detention and release values were calculated using the CUHP runs from the Preliminary Study and the Empirical Formula, $V = KA$, where $K_{100} = (1.78I - 0.002I^2 - 3.56) / 1000$ and $K_{10} = (0.95I - 1.90) / 1000$. In this formula, "V" represents the required volume for the100-year or 10-year storm (acre-feet), "I" represents the developed basin imperviousness (%), and "A" represents the tributary area (acres).

Hydraulic Criteria

Open channel flow calculations utilized Manning's equation. Storm sewer capacities, hydraulic grades and energy grades were also calculated using Manning's equation. Pond release rates were calculated using standard weir and orifice equations.

Drainage Facility Design

General Concept

Conveyance of flood peaks within the Castle Highlands Subdivision will be handled through the use of storm sewers, streets and channelization. Both of the single-family areas drain into the

proposed detention pond (the modified existing pond, shown as "Pond A" on map). This detention pond has been sized to retain the increased runoff from the site and pass through historic off-site flows.

The future multi-family site (Lot 2, Block 7) will drain undetained into the existing channel downstream of "Pond A". The release rate from "Pond A" has been reduced to account for these undetained releases. On-site water quality facilities are recommended for the future multi-family site when it is developed. The Commercial site will be required to construct a detention/water quality pond to account for increased runoff. This pond will be designed and incorporated into the layout of the commercial site with the land development process for this parcel.

The off-site runoff through this site from Basin OS1 was obtained from the Castle Highlands Preliminary Drainage Study (Reference 6). The CUHP run shows the 100-year flow to be 485 cfs. This flow will be conveyed under Coachline Road with two 72-inch RCP pipes into a junction box. This box also receives the on-site flows from basins A-J, OS1A, OS1B, OS2, and OS3 through a 48-inch storm sewer located in Coachline Road. The flow from this box will be conveyed by a 72-inch RCP to an outlet point 950 feet downstream to the existing natural channel. The outlet of this pipe will be protected from erosion by riprap. Upstream of this outlet, the 72-inch pipe will pick up additional flow from an existing 29"x42" arch pipe under Wolfensberger Road. This pipe will connect to a new manhole on the south side of the road. A new 36-inch RCP will be extended to a manhole on the 72-inch pipe. The flow through this system was designed by using the CUHP run from the Preliminary Study, which determined the peak flow from both offsite and onsite basins to be 528 cfs. (Reference 6). The calculations are provided in Appendix B.

Beyond the end of the 72-inch pipe outlet, approximately 400 feet of the channel will remain in its natural condition other than the addition of riprap slope protection. This channel will lead directly to a drop structure into detention "Pond A". The detention pond outlet structure is designed to detain the water quality volume and 10-year storage volume. The release structure and a weir handle the 100-year release. Due to the volume of the release through the weir, a sloping boulder drop structure is incorporated at this point as well.

Specific Details

Most of the storm sewer system was designed to carry the 5-year runoff. The lines in Coachline Road west of the high point and basin A were designed to convey the 100-year storm. If the easterly inlet in basin A at design point 1 on this line were to overflow onto Coachline, the runoff would proceed easterly down Coachline instead of to the west and into "Pond A". All of the inlets at design points 1, 2, 3 and 5, in sump conditions, have an emergency overflow swale to convey runoff into Coachline in the event of inlet blockage.

The existing drainage channel will be improved by the installation of pipe, outlet protection and riprap slope protection. The channel improvements begin at the southwest corner of the site at "Drop A". A twin 72-inch RCP culvert will carry flows under the proposed Coachline Road. A single 72-inch RCP then continues in a northeasterly direction for approximately 950 feet. Bank improvements will be required at the 72-inch pipe outlet. The natural channel then continues through "Drop E" and into the on-stream detention pond "A". Downstream of the pond the

channel continues, unimproved, to an existing culvert at Wolfensberger Road . The channel calculations are provided in Appendix B.

Detention "Pond A" was designed in accordance with the preliminary study for this parcel (Reference 6). The CUHP run for the off-site basin shows peak flows of 485 cfs and 71 cfs for the 100-year and 10-year storms respectively at the southwest property line. The runoff from the future multi-family site west of Auburn Drive will be captured in "Pond A" via a swale located between lots 21 & 22.

The release structure is a three-stage structure consisting of a water quality riser, 10-year orifice and a 100-year weir with one-foot of freeboard. The required water quality volume is 48,000 cubic feet (CF) and the pond provides 51,700 CF of water quality storage. The water quality riser was designed to drain this volume over a 40 hour time period. The 10-year required storage volume is 104,100 CF and the pond provides 108,900 CF of storage. The outlet structure utilizes a 36" RCP (ref. 5, page 97, table 4). The pipe opening does not require an orifice plate since the calculated orifice diameter was 36". The100-year required volume is 442,950 CF per the CUHP runs performed with the preliminary drainage study. The pond provides 447,600 CF of storage at an elevation of 6292.4. The 100-year release is accommodated by the 36" RCP conveying 110 cfs and 389.1 cfs flowing through the weir at a depth of 1.7'. The top of weir elevation is 6290.7 and the top of berm elevation is 6294.0, which provides 1.6' of freeboard. A drop structure has been designed on the back side of this weir to reduce channel velocity to acceptable levels before resuming the natural stream configuration.

EROSION CONTROL

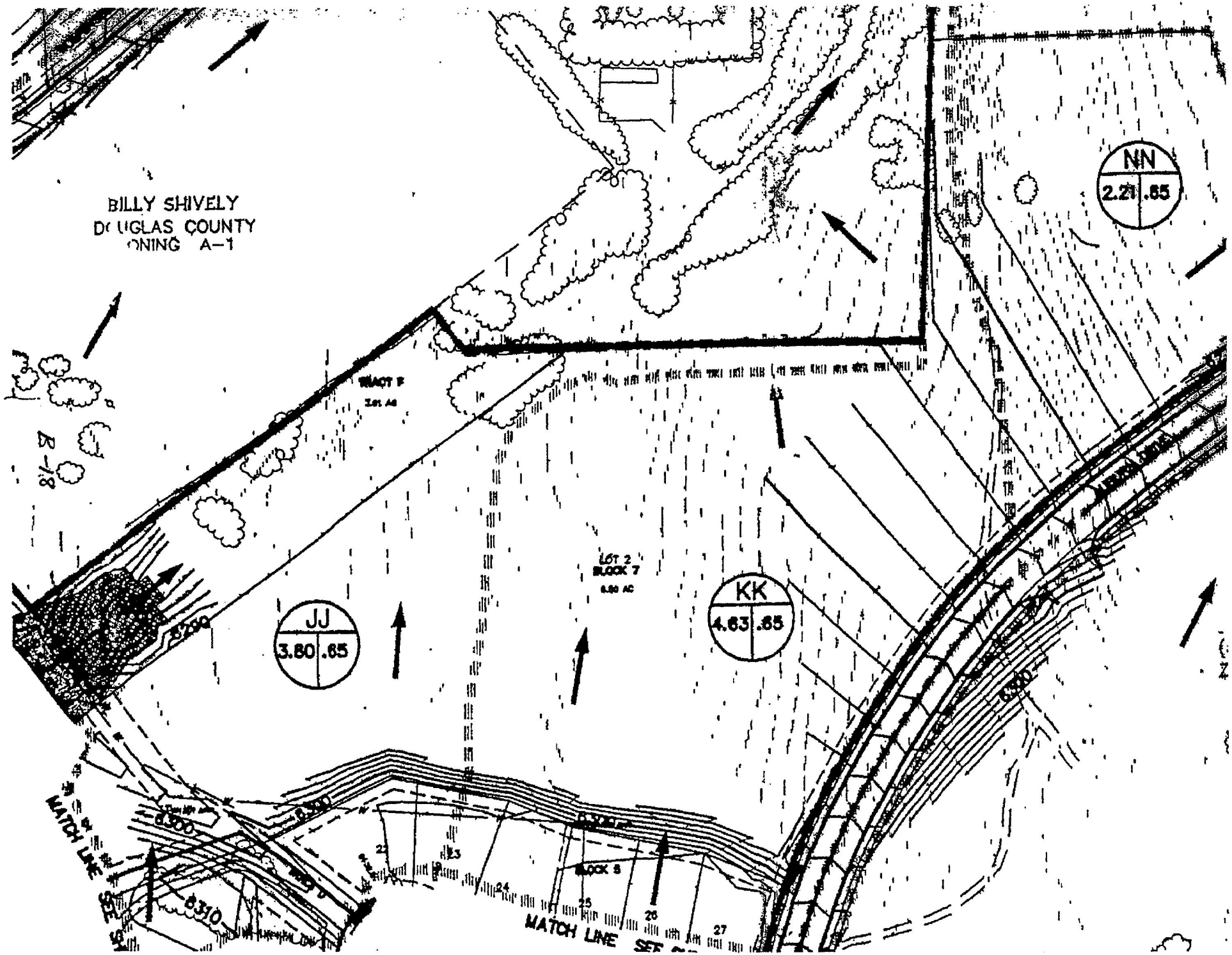
An erosion control plan has been provided to meet the requirements of the Town of Castle Rock. Specifically, the plan(s) address:

1. Overall Erosion Control measures.
2. Rip-rap dissipation devices at all storm drain outlets.
3. Criteria to mitigate erosion potential in all swales/channels.
4. Temporary and permanent erosion control measures for all improvements to off-site channels.

Calculations are provided in Appendix C.

CONCLUSIONS

The storm water conveyance system for Castle Highlands includes a storm sewer network, channel system and street system. Design calculations show the level of protection provided for the minor and major storm. Detention will be provided in an on-stream detention pond that will be located on site. Final design calculations for the storm sewer, detention ponds and channel improvements are provided in Appendix B.


BILLY SHIVELY
DOUGLAS COUNTY
ZONING A-1
NN
2.21 .65
JJ
3.80 .65
KK
4.63 .65
LOT 2
BLOCK 7
6.80 AC
MATCH LINE
MATCH LINE
BLOCK 8
6200
6300
6310
6300
6300
6300
22
23
24
25
26
27

Detention (V=KA)

Pond A

DETENTION REQUIREMENTS - ONSITE BASINS

Subdivision: Castle Highlands Filing No. 2
Location: Southwest of Auburn Drive and Wolfensberger Road

Project Name: Castle Highlands Filing No. 2
Project No. 2316.05
By: rdc
Checked By: [illegible]
Date: 6/21/99

SOIL GROUP B

Q10R= 0.23
Q100R= 0.85

Total Required Pond Volumes

BASIN/LAND USE	DRAINAGE AREA (AC.)	% IMPERV.	V_{10} (AC.FT.)	V_{100} (AC.FT.)	Q_{10R} (CFS)	Q_{100R} (CFS)
Onsite Basins A through KK	84.02	32	2.39	4.31	19.32	71.42
SUM			2.395	4.315	19.3	71.4

DETENTION PONDING FORMULAS:

$V_{100} = K_{100} \times A$ $\quad K_{100} = (1.78I - 0.002I2 - 3.56)/1000$ $\quad Q_{100R} = 1.00 \times A$

$V_{10} = K_{10} \times A$ $\quad K_{10} = (0.95I - 1.90)/1000$ $\quad Q_{10R} = 0.24 \times A$

D-30

Pond Volume (FAA Method)

Pond A1

Subdivision Castle Highlands Filing No. 2
Location Southwest of Auburn Drive and Wolfensberger Road

Project Name: Castle Highlands Filing No. 2
Project No. 2316.05
By: rdc
Checked By:
Date: 6/21/99

Volume=1/3 x Depth x (A+B+(A*B)^0.5)
A - Upper Surface
B - Lower Surface

POND A

Elevation	Surface Area (square feet)	A+B+(A*B)^0.5	1/3	Depth (feet)	Volume (cubic feet)	CumulativeVolume (cubic feet)
6283.00	0					
6284.00	2000	2000.00	666.67	1.00	667	667
6286.00	29600	39294.15	13098.05	2.00	26196	26863
6286.70	41731	106476.95	35492.32	0.70	24845	51707
6287.90	53974	143164.73	47721.58	1.20	57266	108973
6288.00	64260	177127.28	59042.43	0.10	5904	114878
6290.00	75400	209267.50	69755.83	2.00	139512	254389
6292.00	84100	239131.28	79710.43	2.00	159421	413810
6292.40	84880	253469.10	84489.70	0.40	33796	447606
6294.00	88000	259305.92	86435.31	1.60	138296	585902

D-31

REQUIRED WATER QUALITY VOLUME = 48,800 CUBIC FEET
PROVIDED VOLUME = 51,700 CF @ WSE=6286.7

REQUIRED 10-YEAR VOLUME= 104,100 CUBIC FEET
PROVIDED VOLUME= 108,900 CF @ WSE=6287.9

REQUIRED 100-YEAR VOLUME= 442,950 CUBIC FEET
PROVIDED VOLUME= 447,600 CF @ WSE=6292.4

Total Provided Pond Volumes

STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision Castle Highlands Filing No. 2
Location Southwest of Auburn Drive and Wolfensberger Road
Design Storm 100 Year

Project Name: Castle Highlands Filing No. 2
Project No. 2316.05
Calculated By: rdc
Checked By:
Date: 1/6/99

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			
		Area Desig.	Area (Ac)	Runoff Coeff.	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (min)	
		JJ	3.80	0.80	6.5	3.04	8.50	25.8													
		KK	4.63	0.80	6.4	3.70	8.50	31.5													
		LL	1.03	0.93	6.6	0.96	8.50	8.1													
		PP	0.90	0.93	5.0	0.84	9.20	7.7													
		MM	1.05	0.93	6.6	0.98	8.50	8.3													
		NN	2.21	0.89	6.3	1.97	8.50	16.7													
		OO	4.33	0.89	5.1	3.85	9.20	35.5													
		RR	1.31	0.93	5.5	1.22	8.80	10.7													

JR Engineering

CLIENT _____ JOB NO. 2316.05

PROJECT CASTLE HIGHLANDS #2 BY RDC CHK. BY JF DATE 10/14/94

SUBJECT DETENTION POND A DESIGN SHEET NO. ____ OF ____

DETENTION POND A IS AN ON-STREAM POND WITH LARGE OFF-SITE FLOWS OF 510 cfs. THIS POND WILL DETAIN RUNOFF FOR BASINS A - KK. THE RELEASE STRUCTURE IS DESIGNED TO ENSURE THAT THE 10 + 100 YEAR VOLUMES AS WELL AS THE WATER QUALITY VOLUME IS DETAINED IN THE PERTINENT EVENTS. IN THE 10-YEAR + 100 YEAR DESIGN STORMS, THE ON-SITE BASINS HAVE A SHORTER TIME OF CONCENTRATION AND THE REQUIRED VOLUMES ARE STORED WITH THE APPROPRIATE RELEASE RATES. WHEN THE OFF-SITE FLOWS REACH THE POND IN THE 100-YEAR STORM, EXCESS FLOWS ARE ROUTED OVER THE WEIR IN THE POND BANK ABOVE THE OUTLET PIPE.

JR Engineering

CLIENT _____ JOB NO. 2316.05

PROJECT CASTLE HIGHLANDS #2 BY RDC CHK. BY JLF DATE 10/14/99

SUBJECT DETENTION POND RELEASE SHEET NO. ____ OF ____

FROM "CASTLE HIGHLANDS PRELIMINARY DRAINAGE STUDY" SEPT. 1, 1994, JR ENGINEERING

OFFSITE 100 YEAR PEAK = 485 cfs

OFFSITE 10 YEAR PEAK = 71 cfs

10-YEAR RELEASE

71 cfs + (I=KA basins A-KK) − (UNDETAINED Basins JJ+KK)

71 cfs + 193 cfs − (13.7+16.7) = 529 cfs ←

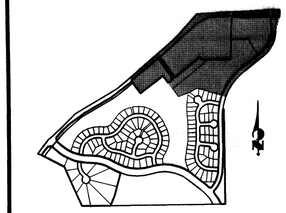
100-YEAR RELEASE

485 cfs + 714 cfs − (25.8+31.5) = 499.1 cfs ←

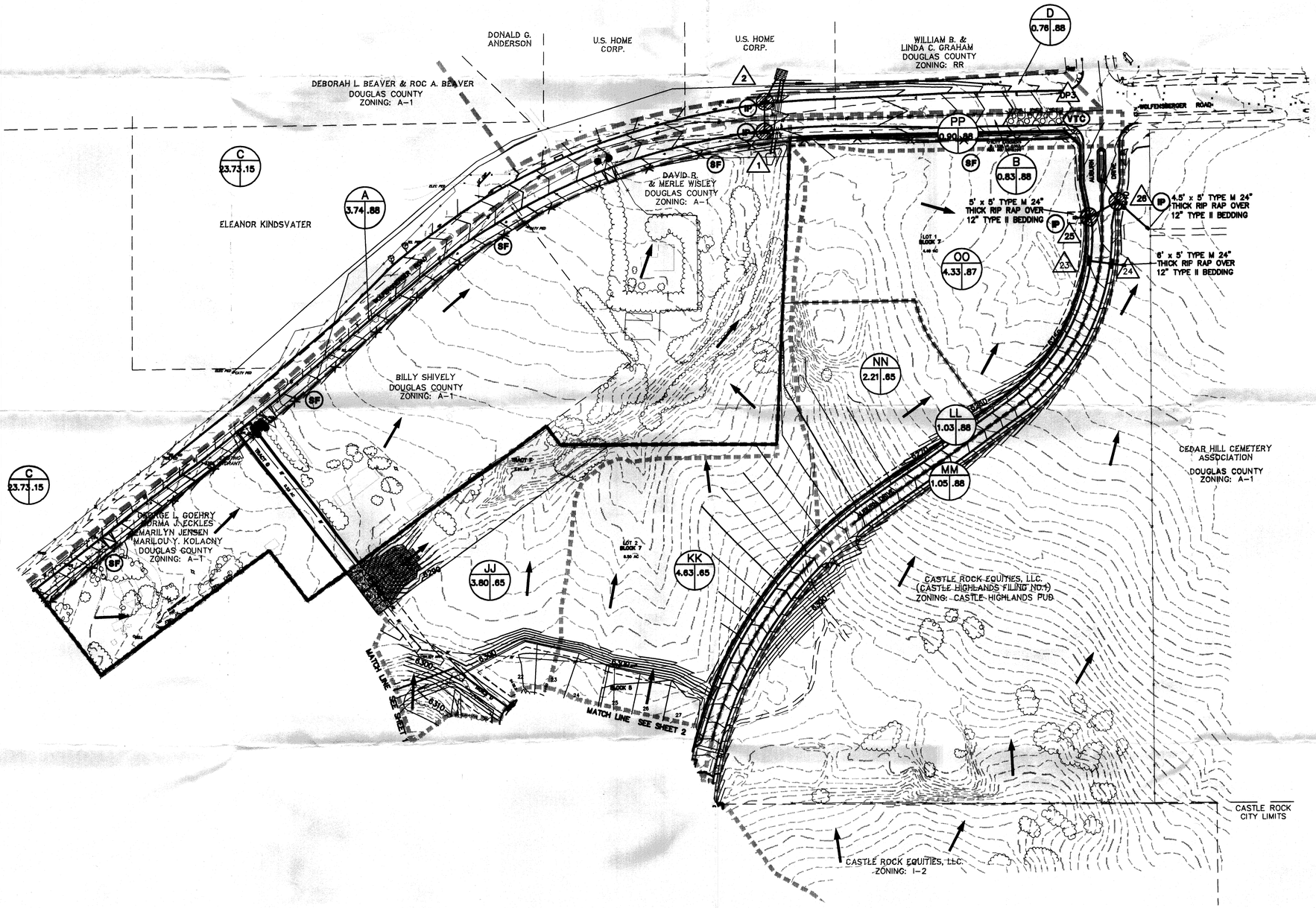
Impervious Area Calulation

Basin	Area	% Impervious	Area x % Imp.
A	3.59	0%	0.00
B	3.41	0%	0.00
C	5.47	0%	0.00
D	1.43	100%	1.43
E	1.16	22%	0.26
F	1.62	22%	0.36
G	1.86	22%	0.41
H	2.33	22%	0.51
I	0.36	100%	0.36
J	0.57	100%	0.57
K	0.54	41%	0.22
L	1.36	41%	0.56
M	2.29	41%	0.94
N	2.32	41%	0.95
O	1.24	100%	1.24
P	1.09	41%	0.45
Q	3.30	41%	1.35
R	3.30	41%	1.35
S	1.86	41%	0.76
T	1.59	41%	0.65
U	1.02	41%	0.42
V	8.07	0%	0.00
W	6.68	0%	0.00
X	0.98	100%	0.98
Y	0.23	100%	0.23
Z	1.80	41%	0.74
AA	0.99	0%	0.00
BB	0.23	100%	0.23
CC	1.05	100%	1.05
DD	0.98	100%	0.98
EE	2.12	41%	0.87
FF	1.86	41%	0.76
GG	1.81	41%	0.74
HH	2.20	0%	0.00
II	4.88	41%	2.00
JJ	3.80	70%	2.66
KK	4.63	70%	3.24
Total	**84.02**		**0.32**

PHASE III DRAINAGE MAP
CASTLE HIGHLANDS FILING NO. 2
A PORTION OF SECTION 3 AND SECTION 10, TOWNSHIP 8 SOUTH, RANGE 67 WEST OF THE 6TH PRINCIPAL MERIDIAN TOWN OF CASTLE ROCK, COUNTY OF DOUGLAS, STATE OF COLORADO



KEY MAP
1"=1000'



LEGEND

- 5665 — EXISTING CONTOUR
- 5665 — PROPOSED CONTOUR
- DRAINAGE DIRECTION
- A / B C — A – BASIN DESIGNATION; B – BASIN AREA; C – 5-YEAR RUNOFF COEFFICIENT
- N — N – DESIGN POINT

100 50 0 100 200

SCALE: 1" = 100'

PHASE III DRAINAGE MAP
CASTLE HIGHLANDS FILING NO. 2
JOB NO. 2316.05
JULY 23, 1999 REV. 12/10/99
SHEET 2 OF 2

JR Engineering, Ltd.
6020 Greenwood Plaza Blvd.
Englewood, Colorado 80111
Tel. (303) 740-9393
FAX (303) 721-9019

ENGINEERING/PLANNING/SURVEYING

X:\1460000.all\1460500\Drawings\Ch05d302.dwg Wed Aug 22 12:41:32 2001

POND VOLUME CALCULATIONS

SUBDIVISION **AUBURN VILLAS (AUBURN RIDGE LOT 2)**

CALCULATED BY **AMA** DATE **1/12/2016**

POND	ELEV	AREA (ft^2)	VOLUME (ft^3)	$VOLUME_{sum}$ (ft^3)	METHOD
Proposed WQ Basin	6269	0	0	0	prismoidal
	6270	554	184.73	184.73	
	6271	1509	992.56	1,177.30	
	6272	2470	1,970.05	3,147.35	
	6273	3779	3,101.66	6,249.01	
	6274	4582	4,173.96	10,422.97	
	6275	5600	11,789.84	14,937.19	

$V_{WQ}(ft^3)$= 7,492.32 By Interpolation **$Elev_{WQ}$(ft)= 6273.30**

Spillway

Project Description

Solve For	Headwater Elevation

Input Data

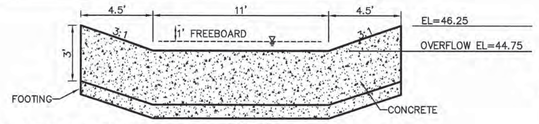
Discharge	39.45	ft³/s
Crest Elevation	6273.30	ft
Tailwater Elevation	0.00	ft
Weir Coefficient	3.00	US
Crest Length	18.00	ft

Results

Headwater Elevation	6274.11	ft
Headwater Height Above Crest	0.81	ft
Tailwater Height Above Crest	-6273.30	ft
Equal Side Slopes	0.25	ft/ft (H:V)
Flow Area	14.77	ft²
Velocity	2.67	ft/s
Wetted Perimeter	19.67	ft
Top Width	18.41	ft

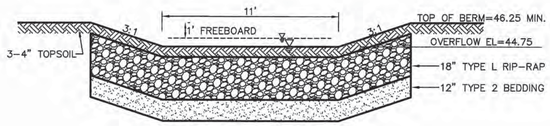
DOCUMENT CONTROL	DATE
PERMIT SET: APPROVED FOR CONSTRUCTION	2/28/13

FIGURE 14-9
CONCEPT FOR INTEGRAL FOREBAY AT END SECTION
LOT 1

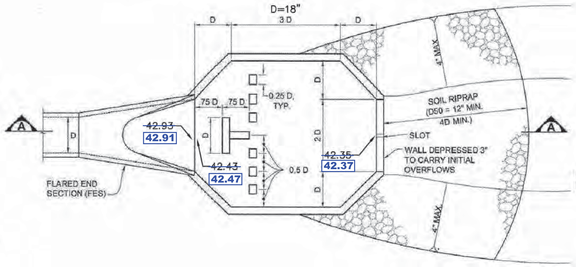


NOTE: THIS CUT-OFF WALL SHALL BE DESIGNED BY A STRUCTURAL ENGINEER

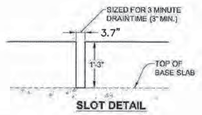
LOT 1
CUT-OFF WALL



LOT 1
EMERGENCY OVERFLOW WEIR

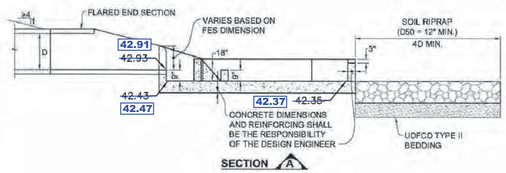


PLAN

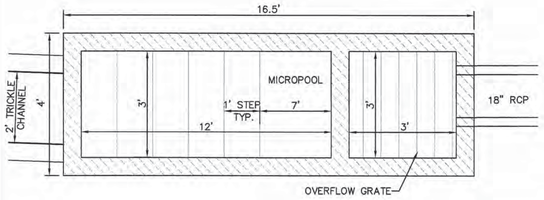


SLOT DETAIL

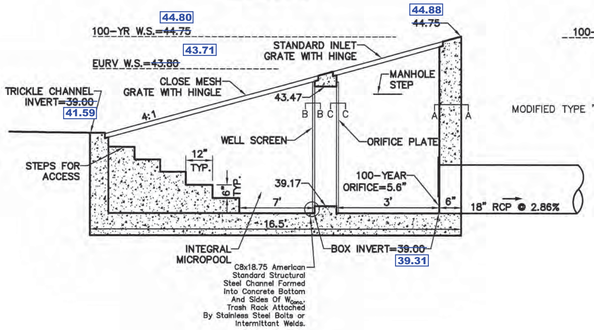
NOTES:
1. DIMENSIONS SHOWN ARE MINIMUMS AND APPLY TO FOREBAYS WITHIN MODIFIED EXTENDED DETENTION BASINS. FOREBAYS IN STANDARD EXTENDED DETENTION BASINS SHALL BE SIZED BASED ON UDFCD CRITERIA.
2. FOR D > 2.5FEET, FOREBAY REQUIRES RAMP INTO BOTTOM AND ACCESS ROAD LEADING TO STREET.



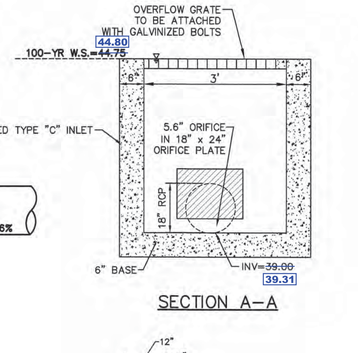
SECTION A

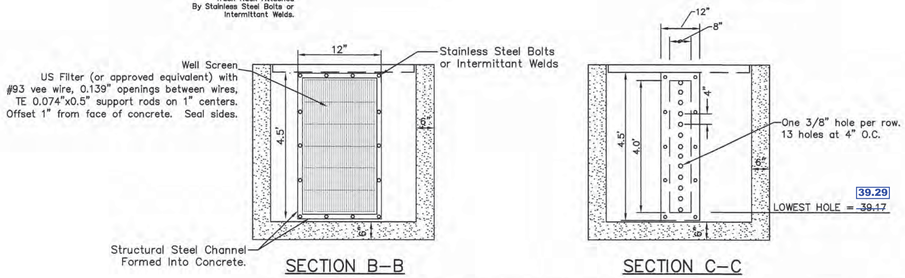


TOP VIEW



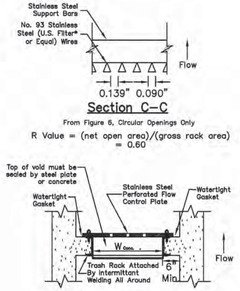
SECTION A-A





SECTION B-B

SECTION C-C



Section C-C

From Figure 6, Circular Openings Only

R Value = (net open area)/(gross rack area) = 0.60

Section B-B - Plan View

From Figure 6, Circular Openings Only

Limits for this Standardized Design:

1. All outlet plate openings are circular.
2. Maximum diameter of opening = 2 inches.

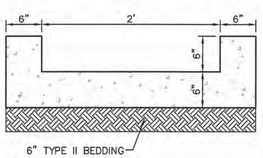
*U.S. Filter, St. Paul, Minnesota, USA

WQCV Trash Racks:

1. Well-screen trash racks shall be stainless steel and shall be attached by intermittant welds along the edge of the mounting frame.
2. Bar grate trash racks shall be aluminum and shall be bolted using stainless steel hardware.
3. Trash Rack widths are for specified trash rack material. Finer well-screen or mesh size than specified is acceptable, however, trash rack dimensions need to be adjusted for materials having a different open area/gross area ratio (R value)
4. Structural design of trash rack shall be based on full hydrostatic head with zero head downstream of the rack.

TRASH RACK DETAIL

WATER QUALITY FACILITY OUTLET STRUCTURE
LOT 1



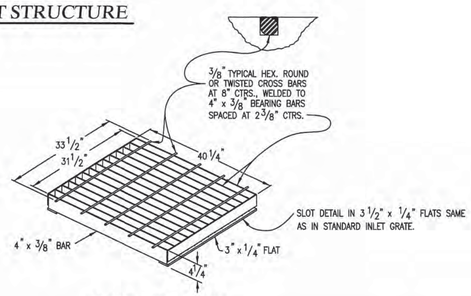
NOTE: PROVIDE CONTROL JOINT EVERY TEN (10) FEET.

2' TRICKLE CHANNEL
NTS

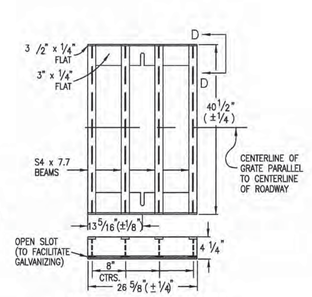
THE ASBUILT INFORMATION SHOWN HERON, WAS MADE UNDER MY SUPERVISION, AND REPRESETS MEASUREMENTS MADE IN THE FIELD ON 12-1-2014

COLORADO REGISTERED 12/2/14 37066 PROFESSIONAL LAND SURVEYOR

DOUGLAS ORT, PLS
ACCURATE ENGISURV
A MANHARD CONSULTING DIVISION

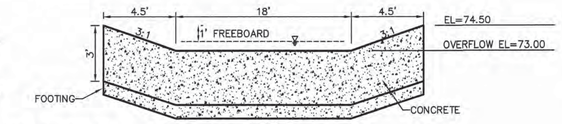


CLOSE MESH GRATE



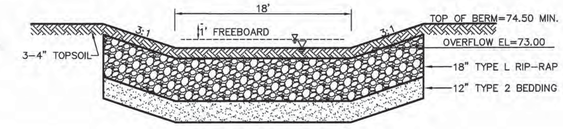
STANDARD INLET GRATE

FIGURE 14-9
CONCEPT FOR INTEGRAL FOREBAY AT END SECTION
LOT 2

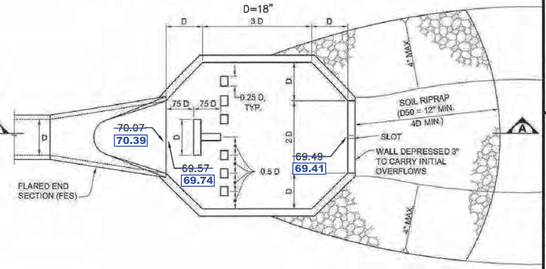


NOTE: THIS CUT-OFF WALL SHALL BE DESIGNED BY A STRUCTURAL ENGINEER

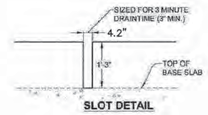
LOT 2
CUT-OFF WALL



LOT 2
EMERGENCY OVERFLOW WEIR

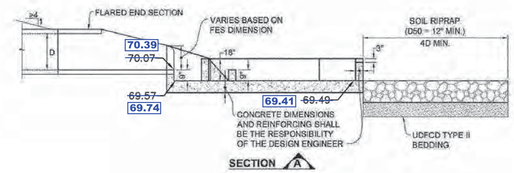


PLAN

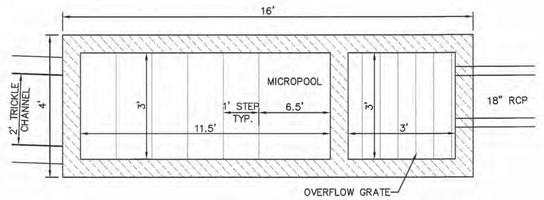


SLOT DETAIL

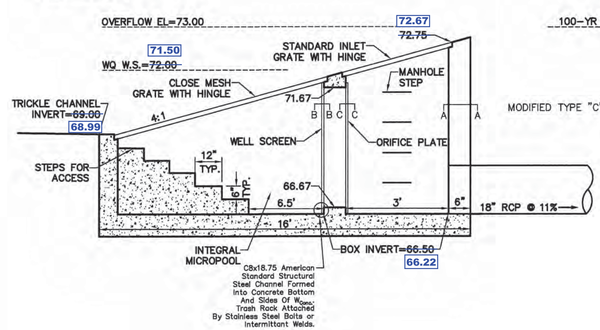
NOTES:
1. DIMENSIONS SHOWN ARE MINIMUMS AND APPLY TO FOREBAYS WITHIN MODIFIED EXTENDED DETENTION BASINS. FOREBAYS IN STANDARD EXTENDED DETENTION BASINS SHALL BE SIZED BASED ON UDFCD CRITERIA.
2. FOR D > 2.5FEET, FOREBAY REQUIRES RAMP INTO BOTTOM AND ACCESS ROAD LEADING TO STREET.



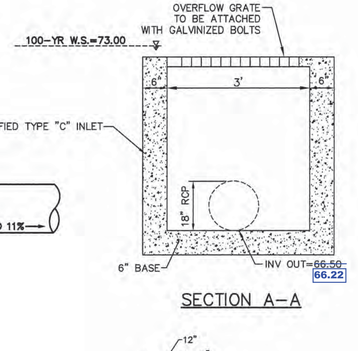
SECTION A

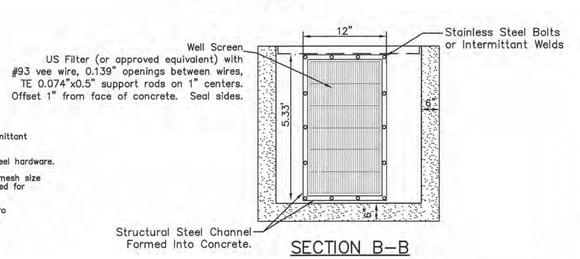


TOP VIEW



SECTION A-A





SECTION B-B

SECTION C-C

DETENTION FACILITY OUTLET STRUCTURE
LOT 2

CONSULTANT ENGINEER CERTIFICATION

I HEREBY AFFIRM THAT THESE FINAL CONSTRUCTION PLANS WERE PREPARED UNDER MY DIRECT SUPERVISION, IN ACCORDANCE WITH ALL APPLICABLE TOWN OF CASTLE ROCK AND STATE OF COLORADO STANDARDS AND STATUTES, RESPECTIVELY; AND THAT I AM FULLY RESPONSIBLE FOR ALL DESIGN AND REVISIONS RELATIVE TO SAID PLANS.

2/15/13
DATE

BRIAN KROMBEIN, PE, PLS
COLORADO NO. 34294
FOR AND ON BEHALF OF
VERMILION PEAK ENGINEERING LLC

COLORADO REGISTERED BRIAN KROMBEIN 34294 P.E. & PLS

TOWN OF CASTLE ROCK APPROVALS

THESE PLANS ARE HEREBY APPROVED FOR ONE YEAR FROM DATE OF DEVELOPMENT SERVICES APPROVAL

RECOMMEND APPROVAL BY:
ENGINEERING DIVISION — DATE

Approved Development Services
MAR 1 0 2013

APPROVED BY:
DEVELOPMENT SERVICES — DATE

Town of Castle Rock

UNTIL SUCH TIME AS THESE DRAWINGS ARE APPROVED BY THE APPROPRIATE REVIEWING AGENCIES, VERMILION PEAK ENGINEERING APPROVES THEM FOR CONSTRUCTION ONLY FOR THE PURPOSES DESIGNATED BY WRITTEN AUTHORIZATION.

PREPARED FOR
AUBURN VENTURES, LP
15957 NO. 81ST STREET #101
SCOTTSDALE, AZ 85260
480-256-0506

Vermilion Peak Engineering
Civil Engineering & Land Surveying
9801 Chadwick Way / Highlands Ranch, CO 80129
303-264-9516 / www.vermilionpeak.com

No.	REVISION	BY	DATE
1	CD12-0020 APPROVED FOR CONSTRUCTION	BK	2/28/13

H-SCALE	AS SHOWN	DESIGNED BY	BK
V-SCALE		DRAWN BY	BK
DATE	2/28/13	CHECKED BY	

AUBURN RIDGE

DRAINAGE DETAILS

SHEET C11 OF 14

JOB NO. 12014

Table 6-5. Runoff coefficients, *c*

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