LIBERTY TREE ACADEMY

FINAL DRAINAGE REPORT

Prepared for:

Liberty Tree Academy
8579 Eastonville Road
Peyton, CO 80831

Prepared by:

Matrix Design Group, Inc.
1601 Blake Street, Suite 200
Denver, CO 80202

Project Number: 18.995.001

Submitted:

August 8, 2018

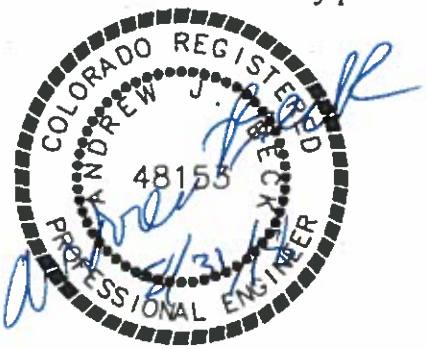
PPR-18-023

LIBERTY TREE ACADEMY

Matrix DESIGN GROUP

Engineer's Statement

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the City/County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.



Andrew Beck, PE
Matrix Design Group
1601 Blake Street, Suite 300
Denver, CO 80202

Developers Statement:

I, the developer have read and will comply with all of the requirements specified in this drainage report and plan.

Ronnie Wilson, Vice President
Liberty Tree Academy Building Corporation
PO Box 64614
Colorado Springs, CO 80962

EL PASO COUNTY ONLY:

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual, and Land Development Code as amended.

Approved
by Elizabeth Nijkamp
El Paso County Planning and Community Development
on behalf of Jennifer Irvine, County Engineer, ECM Administrator
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Jennifer Irvine, P.E. Date
County Engineer / ECM Administrator

Conditions:

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I. GENERAL LOCATION AND DESCRIPTION

A. Location

The proposed Liberty Tree Academy is within Township 12S, and Range 64W, Section 32, SW Quarter, of El Paso County, Colorado as shown in **Figure 1**. The approximate latitude and longitude are 38°57'35"N and 104°35'11. The lot is situated along the east side of Eastonville Road from Tex Tan Road to Snaffle Bit Road. The project area is located east, south, and north of residential parcels. Unplatted agricultural land exists to the east of the site. The project is situated in Woodmen Hills Filing No. 10 (Plat Number 10942). To the north is Woodmen Hills Filing No. 11 (Plat Number 11258). The current El Paso Assessor map is provided in **Appendix F**.

The project is located within the Bennett Ranch (CHWS1200) drainage basin. The project drains to the southeast to the Bennett Ranch drainageway.

B. Description of Property

The overall 12-acre lot consists of the 4.15 acre project area (school and detention), undeveloped land, and a 240-ft wide drainage easement. This Final Drainage Report only considers the 3.6-acre area disturbed by construction and 2.2-acre project site. The rest of the lot (except for the drainage easement) will be developed by future projects.

The ground cover currently consists of native grasses, including Blue Grama with a few dispersed alders and other plant species consistent with pasture land in the Colorado Semi-arid plains environment. Willows line the drainageway on the east side of the site. Photos of existing site vegetation are included in **Appendix A**.

Slopes across the property typically range from 1-5%, with some local slopes around small mounds up to 20%. The slope from the access road to the drainageway is approximately 8:1. According to National Resources Conservation Service (NRCS) soil datasets, the predominant soil type is Columbine gravelly sandy loam, 0 to 3 percent slopes. This soil type is generally consistent with a Type A hydrologic soil group (HSG). NRCS soil data was obtained from the Soil Survey Geographic (SSURGO) Database for Arapahoe County, Colorado. The spatial dataset was last updated September 23, 2016 (version 7) and the tabular dataset was last updated October 10, 2017 (version 14). The soils map and a breakdown of HSG group by basin is provided in **Figure 2**.

The site includes a 240-ft wide drainage easement along the eastern boundary associated with Bennett Ranch drainageway, which flows from north to south along the property boundary. The boundary of the drainage easement is marked by an existing access road, which overlays a parallel water line. Existing sewer, gas, fiber optic, underground electric, underground telephone, water, and storm utilities are located within the Eastonville Road right-of-way. General locations of existing utilities are presented in **Figure B-1**. No irrigation facilities exist onsite.

Figure 1.
Liberty Tree Academy
Vicinity Map

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0 500 1,000

Feet

April 23, 2018

LIBERTY TREE ACADEMY

Matrix DESIGN GROUP
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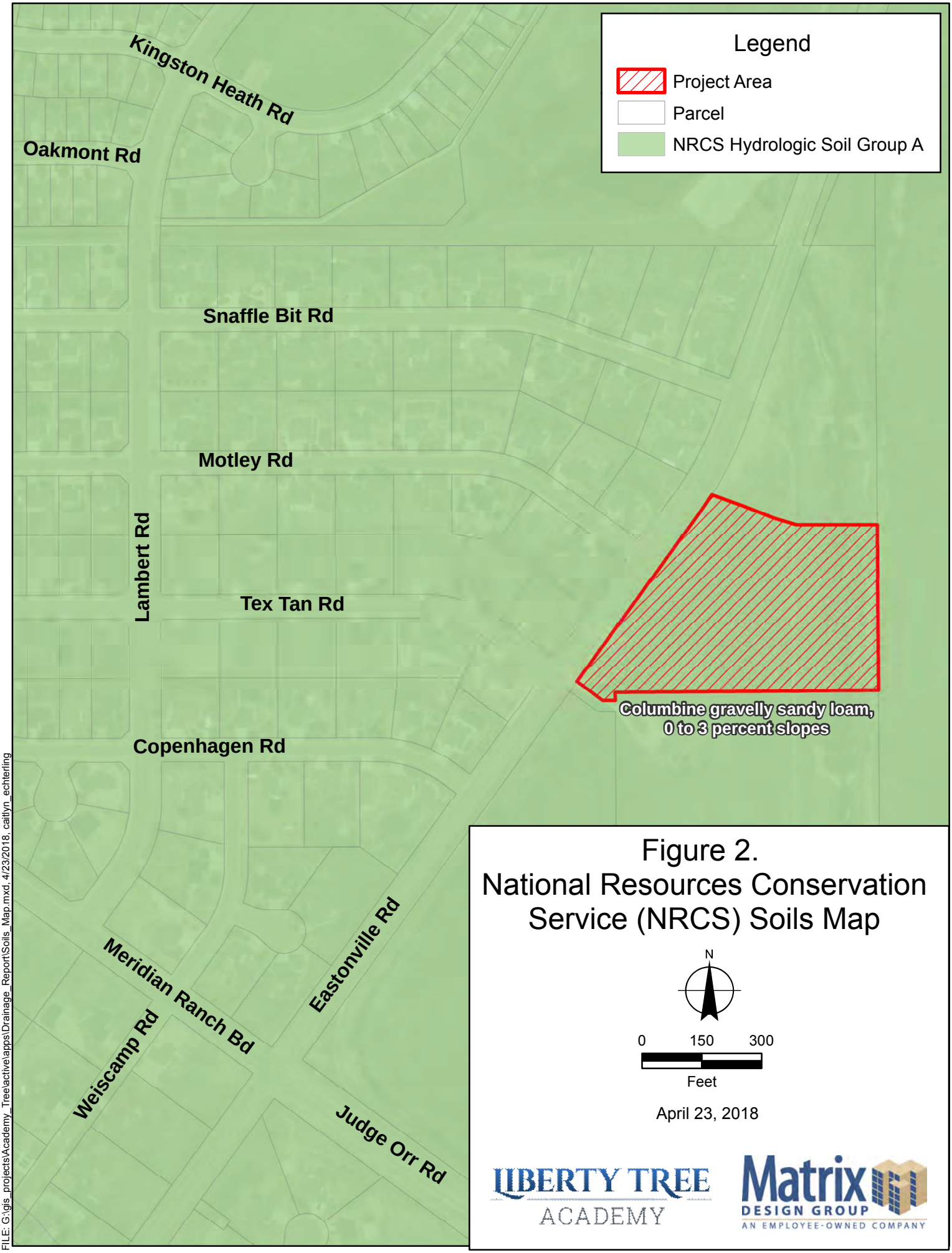

Figure 2.
National Resources Conservation Service (NRCS) Soils Map

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April 23, 2018

LIBERTY TREE ACADEMY

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II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Descriptions

The project falls between Design Points (DP) D and C in the *Bennett Ranch Drainage Basin Planning Study (DBPS)* (El Paso County 2001). Between these design points, surface runoff flows to the southeast and the drainageway flows from north to south. The selected plan in the DBPS proposes a 50 acre-ft detention pond upstream of the project area at DP D and 9,500 linear-ft of new channel at 0.25% with thirteen 3-ft drop structures between Eastonville Road (DP D) and Drake Pond (between DP C and B). Based on the 2016 aerial, it appears that these proposed improvements are constructed. Selected pages from the DBPS are provided in **Appendix E**.

A Flood Insurance Study exists for El Paso County, Colorado and Incorporated Areas (FEMA 1999). The property is not located within a FEMA defined Floodplain, as identified on Flood Insurance Rate Map, Unincorporated El Paso County Community Panel Number 080059 0575 F, Effective March 17, 1997 (see **Appendix E**). The FIRM was revised in the vicinity of the project by Letter of Map Revision (LOMR) Case Number 12-08-0659P, on July 12, 2013. This LOMR extended the floodplain upstream, however, the project is located outside of this boundary.

B. Sub-basin Description

The overall proposed and historic drainage basins for the project area are coincident and both drain to Design Point 4. Existing topography routes surface flows southeast across the lot to the drainage easement access road. East of the access road, an approximately 8:1 embankment slopes to the east to the invert of the Bennett Ranch drainageway. The lot encompasses both banks of the drainageway within the 240-ft wide drainage easement.

The proposed project area is contained within Basin A with some grading to match the existing surface within Basins OS1 and OS2. Basin OS1 will be replanted consistent with existing ground cover until a future project by others develop this land. Under interim conditions, this off-site basin will drain to the proposed extended detention basin (Design Point 3). Basin OS2 will also be replanted consistent with existing ground cover and will be maintained as a drainage easement.

C. Conveyance of Offsite Runoff

Offsite runoff from basin OS-1 will sheet flow into a proposed Extended Detention Basin (EDB). The extended detention basin is designed to accommodate this extra undeveloped area; should this area develop in the future, the extended detention basin will have to be redesigned to accommodate the increased impervious area. Basin OS-2 will remain undeveloped and will continue to drain east to Bennett Ranch Drainageway.

A normal depth flow analysis was performed to ensure the existing off-site Bennett Ranch Drainageway could sufficiently pass 100-year peak offsite runoff without resulting in adverse site impacts. A detailed description of this analysis can be found in Section IV.C.3. 100-yr offsite runoff in the channel is lower than the emergency overflow weir elevation of the onsite extended detention basin.

III. DRAINAGE DESIGN CRITERIA

A. Development Criteria Reference

1. Design Criteria

This report is prepared in accordance with the following criterion:

- Chapter Six, Section 6.3.2 – Drainage and Section 6.3.5 - Grading and Erosion Control of the El Paso County Land Development Code.
- El Paso County Drainage Criteria Manual Volume 1 and Volume 1 Update (DCM-V1, DCM-V1-Update)
- El Paso County Drainage Criteria Manual Volume 2 (DCM-V2)
- Engineering Criteria Manual for El Paso County

In addition, Urban Drainage Flood Control District (UDFCD) criteria manuals and spreadsheet tools were used to guide design assumptions. El Paso County adopts the use of UDFCD UD-Rational and UD-Detention within the listed references above.

2. Previous Drainage Studies

There are several existing drainage reports and studies used in the development of this report. They are:

- El Paso County. 2001. Bennett Ranch Pilot Project Drainage Basin Planning Study. El Paso County. November 2001.
- Federal Emergency Management Agency (FEMA). 1999. Flood Insurance Study El Paso County, Colorado and Unincorporated Areas. Revised August 23, 1999.
- Federal Emergency Management Agency (FEMA). 1997. Flood Insurance Rate Map Number 08041C0575 F. El Paso County, Colorado and Unincorporated Areas. Effective August 17, 1997.
- Federal Emergency Management Agency (FEMA). 2013. Letter of Map Revision Case No. 12-08-0659P, Flood Insurance Rate Map Number 08041C0575 F. El Paso County, Colorado and Unincorporated Areas. Effective July 12, 2013.

The site is not within a FEMA regulatory floodplain (See **Appendix E**). The Bennet Ranch Pilot Project Drainage Basin Planning Study (Bennet Ranch DBPS) outlines the improvements to the adjacent drainage channel and upstream detention basin. Anticipated runoff in the adjacent channel during the 100-yr event may cause backwater events into the proposed extended detention basin, but will be below the crest elevation of the emergency overflow weir (see Section IV.C.4).

The site will utilize an extended detention basin and will therefore not cause significant increases in runoff rates due to development which would negatively impact downstream properties (see Section IV.C.2).

B. Hydrologic Criteria

Based on Figures 6-6 through 6-17 of the DCM-V1, the NOAA Atlas 2 rainfall depths presented in Table 6-2 of the DCM-V1 Update applies. The basin size is less than 2 square-miles; therefore, Depth Area Reduction Factors are not required. The one-hour rainfall depths used in this analysis are presented in **Table 3**.

Table 1 – One-Hour Rainfall Depths

D_2 (in)	D_5 (in)	D_{10} (in)	D_{25} (in)	D_{50} (in)	D_{100} (in)
1.19	1.50	1.75	2.00	2.25	2.52

The rational method was used to calculate the runoff, as outlined in Section 6.2 of the UDFCD Volume 1, with the exception of the impervious values, runoff coefficients, and intensities, which were taken from the DMC-V1-Update. For street and gutter capacity, the minor design storm was the 5-yr event. The major design storm is the 100-yr event.

Composite percent imperviousness, assuming Type A soils (see **Figure 2**), for each historic and proposed basin were determined using the land use categories in Table 6-6 of the DCM-V1-Update. These values are presented in **Table 4** and **Appendix C**. Percent imperviousness was calculated for Basin A as 74%, which is associated with the proposed school building, parking lots, drives, sidewalks, and playground. Basin OS2 consists of the drainage easement which will remain pasture/ lawn but is part of the grading extents of this project. The associated percent imperviousness is 0%. Basin OS1 consists of off-site land that drain to the proposed extended detention basin. This basin is included in the grading extents of this project but will be restored to natural conditions with an associated imperviousness of 0%. Should Basin OS-1 be developed in the future, the total runoff and detention volumes will need to be reevaluated.

Table 2 – Percent Imperviousness from Table 6-6 of DCM-V1-Update

Land Use or Surface Characteristic	Percent Imperviousness
Pasture/ Meadow, Lawn	0
Playground	13
Paved, Drive and Walks, Detention	100
Roofs	90

Water quality and stormwater detention will be provided by the onsite extended detention basin. Total detention volumes and discharges were determined using UDFCD's UD-Detention_v3.07 (See Section IV).

IV. DRAINAGE FACILITY DESIGN

A. General Concept

Generally, existing site flows are to the southeast. East of the access road, there is a surface break and the site slopes approximately 8:1 towards the offsite drainageway. This section of the property is not included in planned development in order to maintain existing drainage patterns and avoid changes to the drainage easement. A residential property is situated on the southern edge of the site. Under proposed conditions, the site will be sloped away from this property to prevent any adverse impacts.

All runoff from the developed area will be routed to the proposed extended detention basin (EDB) in northeast corner of the project area. The extended detention basin will maintain historic outflow to the existing Bennet Ranch Drainageway.

B. BMP Selection Process

Per section I.7.2 of El Paso ECM, a four-step process is used to select structural BMPs for the site. Discussion of these four steps and decision matrix is found below.

1. Employ Runoff Reduction Practices

Opportunities to minimize directly connected impervious areas were limited for this site; Most of the disturbed site is utilized for the building footprint or parking area. Vegetation is provided by landscape islands and around the building, although this was not considered as a formal water quality measure for our calculations. All runoff from the site is routed to an extended detention basin.

2. Stabilize Drainageways

All channelized runoff on the site is conveyed via curb and gutter to a curb cut at a riprap rundown to the extended detention basin, and energy is dissipated in a concrete forebay. A trickle channel conveys channelized runoff within the extended detention basin to its outlet. The extended detention basin outfalls to Bennet Ranch Drainageway, which was previously stabilized with drop structures, in accordance with the Bennet Ranch DBPS (See Section II.A and **Appendix E**).

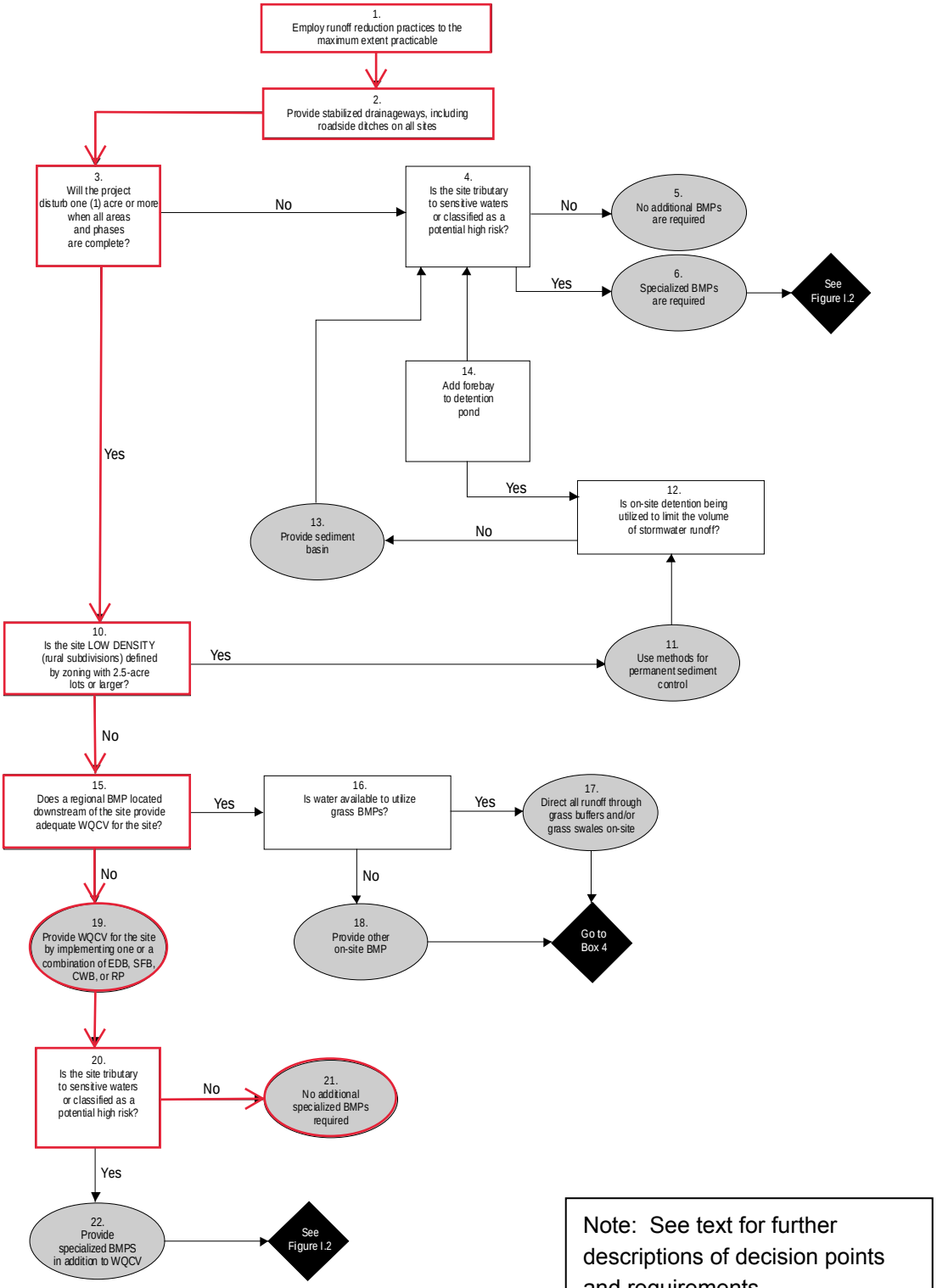
3. Provide WQCV

Water Quality Capture Volume (WQCV) is provided within the Excess Urban Runoff Volume (EURV) in the onsite extended detention basin. See **Appendix D** for extended detention basin design.

4. Consider Need for Industrial and Commercial BMPs

The proposed use for this site, a school, does not warrant Covering of Storage/Handling Areas or Spill Containment and Control.

Figure I-1. BMP Requirements Flowchart for New Development and Redevelopment Sites - For Selecting Post-Construction BMPs in Compliance with El Paso County's Stormwater NPDES Permit



C. Specific Details

1. Proposed Runoff Patterns and Quantities

The proposed grading will preserve historic flow paths away from Eastonville Road towards the drainageway. Along the western boundary of the project area, the site will be graded towards the school to prevent site flows from running off onto the adjacent property, and a cross pan and high point in the driveway will keep offsite runoff in Eastonville Road from entering the project.

Basin A contains all developed area proposed within the site. Curb and gutter systems will capture and convey runoff from the fire lane and parking lot to the detention pond. A separate piped system will convey roof runoff to the detention pond. Basin OS-1 will remain vegetated and will drain via sheet flow to the proposed extended detention basin.

All regraded areas within OS2 will be revegetated. This basin will continue to sheet flow directly to Bennet Ranch Drainageway.

Historic and proposed runoff values are presented in **Tables 3** and **4**, respectively.

Table 3 – Pre-developed Hydrology

Design Point	Drainage Area (ac)	Q_5 (cfs)	Q_{100} (cfs)
Eastonville Road	0.46	1.81	3.23
4 (Basin HA)	6.20	1.15	8.48

Notes:

1. *See Appendix C for detailed hydrology calculations.*

Table 4 – Post-developed Hydrology

Design Point	Drainage Area (ac)	Q_5 (cfs)	Q_{100} (cfs)
1 (Basin A)	3.0	6.79	13.36
2 (Basin OS1)	1.1	0.23	1.70
3 (A+OS1)	4.1	6.38	13.98
4 (Basin OS2)	2.1	0.34	2.48

Notes:

1. *See Appendix C for detailed hydrology calculations.*
2. *See Appendix D for detailed hydraulics calculations.*

2. Extended Detention Basin Design

The extended detention basin will be located at the northeast corner of the site and will intercept all developed runoff from the site and convey attenuated flows to the Bennett Ranch Drainageway. The proposed extended detention basin will preserve historic flow rates to Bennett Ranch Drainageway and provide full spectrum detention (WQCV, EURV and 100-yr detention). Detailed design calculations, outlet configuration, and design drawings for the following section can be found in **Appendix D.**

Volumes and Release Rates

The basin and outlet structure were sized using UD-Detention, version 3.07, in accordance with DCM-V1-Update criteria. The outlet structure utilizes an orifice plate to release the water quality capture volume (WQCV) over 40-hours and the extended urban runoff volume (EURV) in 72-hours. A 2.5' micropool in front of the orifice plate will provide settlement. A drop box and 18-inch pipe with a restrictor plate will attenuate runoff events exceeding the EURV. Outflows will be conveyed under to the existing stabilized channel in Bennett Ranch drainageway. Total detention volumes and release rate summary are provided in the table below:

Table 5 - EDB Volume and Flow Rates Summary

EDB Summary

Design Storm Return Period	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Predevelopment Peak Q (UDFCD) (cfs)	0.0	0.0	0.002	0.015	0.034	0.074	0.56	1.38
Predevelopment Peak Q (Rational) (cfs)=	N/A	N/A	0.229	1.15	2.52	4.81	6.49	8.48
Developed Peak Inflow Q (cfs)	0.97	3.37	2.32	3.03	3.71	4.57	5.62	6.82
Dev. Peak Outflow Q (UDFCD)(cfs)=	0.031	0.102	0.082	0.10	0.29	1.12	1.21	1.24
Calculated Runoff Volume (acre-ft)	0.075	0.263	0.180	0.236	0.289	0.357	0.439	0.535
Maximum Volume Stored (acre-ft)	0.068	0.243	0.165	0.217	0.257	0.283	0.330	0.400
Maximum Ponding Elevation (ft)	6946.69	6948.12	6947.55	6947.94	6948.21	6948.38	6948.67	6949.08

In the 100-yr event, the proposed release rate from the detention basin will be 90% of the existing inflow rate. In the 2-yr through 50-yr events, the predevelopment runoff calculated using UD-Detention workbook was very low (<1 cfs), which is due to the small tributary area. As a result, the workbook calculated developed outflow exceeds the predeveloped inflow for these conditions. Restricting outflow for these conditions any further would cause retention in excess of 72 hours. A more appropriate method for calculating the 2-yr through 50-yr events is the rational method, the results of which are presented the table above. Proposed outflow from the extended detention basin at DP 3 is than the historic runoff at DP 3 as calculated with the rational method. **See Appendix C** for detailed calculations.

Emergency Overflow and Freeboard

The calculated 100-yr WSEL is 6949.08'. Placing the emergency overflow weir crest at this elevation would reduce the cover of the waterline parallel to the access road to less than 5'. In order to maintain 5' of cover over the waterline, it is proposed that the emergency overflow weir elevation be set at 6951.00'. In the condition that the outlet structure became completely clogged, the 100-yr event runoff volume, 0.439 ac-ft, would have a ponded depth of 6949.78'. Total freeboard between the 100-yr WSEL (clogged condition) and weir crest is 1.22'.

The 10-ft wide emergency spillway was sized to convey 100-year undetained flows (14.0 cfs) with 6 inches of flow depth and consists of soil riprap (Type VL riprap) in accordance with Figure 12-21 from UDFCD Volume 2. In the event the emergency overflow weir is activated, some ponding in the parking lot would occur, but would be less than 12".

Other Design Components

Runoff will enter the detention pond via the concrete pans within the parking lot and flow down a riprap rundown to the forebay. The 6" tall pond forebay is sized for 2% of the WQCV, as per DCM-V2. The target release rate (2% of undetained runoff into the EDB) is 0.28 cfs, which can be achieved with a 4.1-inch notch.

The trickle channel will be concrete and 4-inch deep as per DCM-V2. Per criteria, the capacity of the channel is sized to convey the maximum possible forebay outlet capacity, at a minimum. The flat bottom longitudinal slope will be graded at 0.5% per UDFCD Volume 3. The adjacent vegetated areas will slope towards the low flow channel at 3%, as per DCM-V2 and UDFCD Volume 3.

Maintenance access to the pond will be along the existing drainage easement access road via the proposed school fire lane and include ramps with less than 10% slopes to the forebay, pond bottom, and outlet structure. The pond will be maintained by Liberty Tree Academy as part of grounds maintenance via a Stormwater BMP Maintenance Agreement, which can be found in **Appendix F**.

3. Curb and Gutter/ Street Capacity

An 8-ft wide crosspan, in accordance with El Paso's Standard Details, will be constructed at the driveway intersection with Eastonville Road to convey offsite runoff within the road. Flowmaster V8i was used for the capacity calculations for the driveway/cross pan. Onsite curb/gutter capacity was calculated using UD-Inlet_v4.05. All street and curb calculations are provided in **Appendix D**.

4. Offsite Channel Capacity

In order to ensure the existing off-site drainageway can sufficiently pass 100-year peak runoff without resulting in adverse site impacts, a normal depth analysis was conducted using FlowMaster, version 8i. 100-year outflow from the upstream detention pond as described in the DBPS was considered in this analysis (see **Appendix E**). Two typical drainageway cross-sections were cut along the project extents. The longitudinal channel slope was estimated based on available contours and the DBPS Selected Alternative (0.25%).

The resulting typical cross-sections are presented in **Figure 4**. The cross-section points on the west bank are taken from survey. Cross section points from the east bank are calculated based on the typical channel cross section found in the *Bennet Ranch* DBPS (See **Appendix E**). It is assumed that some incision of the channel has occurred since the construction of the stabilized channel, and the toe (the invert of the original channel) is equal to the surveyed elevation 5' west of the surveyed flowline. The Manning's n for the channel sections is taken from Table 8-5 of UDFCD Volume 1, which is summarized in **Table 6**. The resulting water flow depths and freeboard are presented in **Table 7**.

Table 6 – Manning's n

Location and Cover	**Manning's n[1]**
Main Channel (bankfull channel)	
Sand or clay bed	0.04
Vegetated Overbanks	
Native Grasses	0.05
Willow Stands, woody shrubs	0.16

Notes:

1. Manning's n for assessing water surface elevation and water depth

A detailed cross section and corresponding segments for each manning's n used can be found in **Appendix D**. Normal flow depths for the channel are as follows:

Table 7 – Offsite Channel Flow Depth Summary

Scenario	100-yr WSEL (feet)	Flow Depth (feet)	Freeboard (feet)
Cross-section 1	6943.90	7.14	7.10
Cross-section 2	6945.87	7.87	5.13

Notes:

1. *100-Year Master Planned Flow = 810 cfs, as per the DBPS for 100-year release rate from the upstream pond, see **Appendix E**).*
2. *Freeboard is measured from weir crest elevation. = 6951.0*

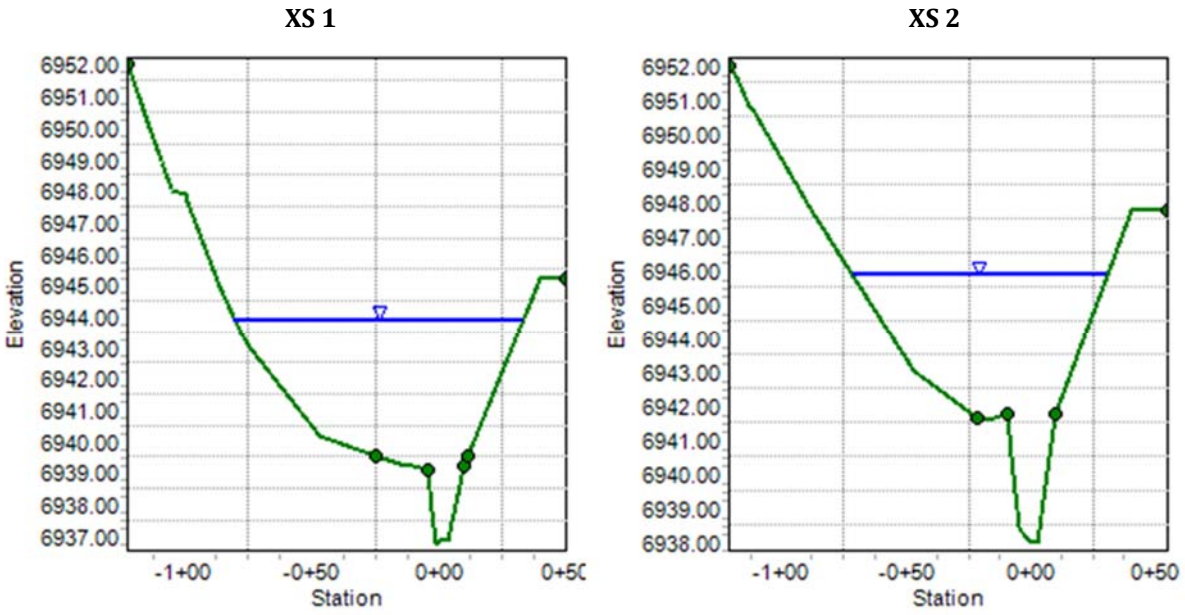


Figure 4 – Offsite Drainageway Capacity Evaluation
Cross sections, looking upstream
Q100=810 cfs (release rate of upstream basin)

There is a signification amount of freeboard between 100-yr channel WSEL and the onsite emergency overflow weir crest. The 100-yr WSEL at Section X2 (6945.87), however, is higher than the invert of the detention basin outlet pipe (6942.00). Because of difference in peak timing, it is not anticipated that this will negatively impact the ability for the EDB to drain in 72 hours or less.

The offsite channel can convey 60 cfs without any backwater effect on the pond (WSEL = invert of outlet pipe = 6942.00'). Backflow would not occur into the pond until offsite flow of 538 cfs (WSEL = Invert of pond = 6945). Calculations can be found in **Appendix D**.

V. DRAINAGE FEES

Drainage and Bridge fees were paid with the Woodmen Hills Filing #10 final plate, therefore no fees are due.

VI. REFERENCES

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APPENDIX A – SITE PHOTOS

Figure A1. Project area looking east.

Figure A2. Project area looking south east along utility access towards the drainage easement.

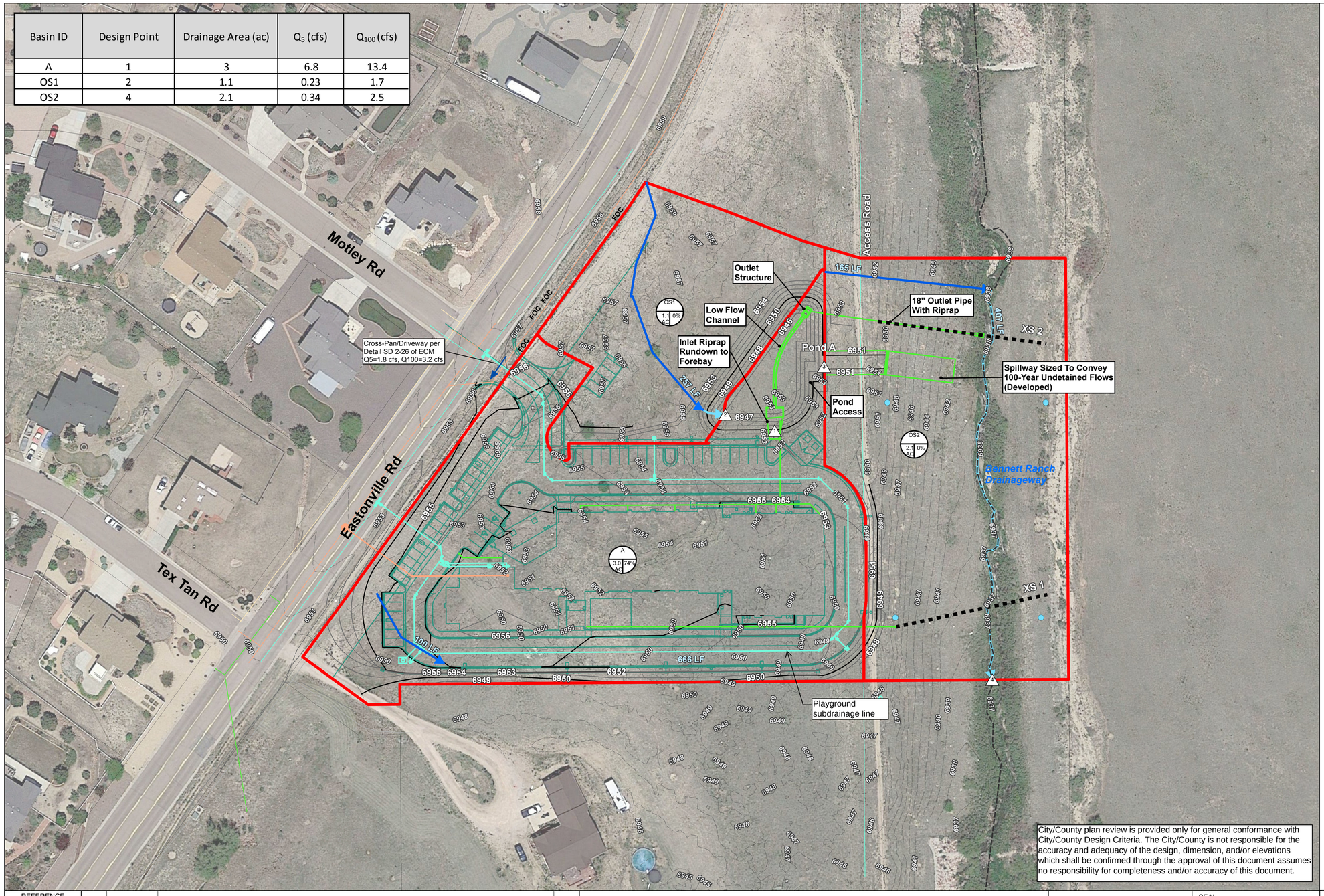
Figure A3. Project area looking north along Eastonville Road right-of-way.

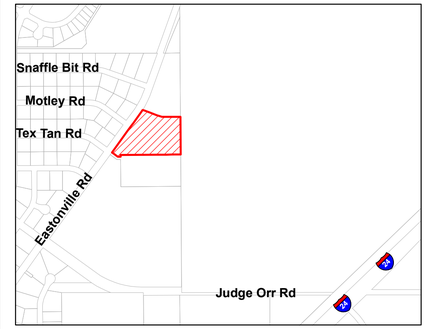
Figure A4. Project area looking south towards adjacent residential property.

Figure A5. Bennett Ranch drainageway looking upstream (north) along eastern extent of the project area.

APPENDIX B – DRAINAGE PLANS

Basin ID	Design Point	Drainage Area (ac)	Q_5 (cfs)	Q_{100} (cfs)
A	1	3	6.8	13.4
OS1	2	1.1	0.23	1.7
OS2	4	2.1	0.34	2.5





VICINITY MAP

Legend

- Approximate 100-year Water Surface
- Channel Cross-section (XS)
- Proposed School and Parking
- Existing Contours (1ft)

Existing Utilities

- Fiber Optic Cable
- Gas
- Sewer
- Storm
- Underground Electric
- Underground Telephone
- Water

Proposed contours

- Major (5 ft)
- Minor (1 ft)

Proposed Flow Paths

- Channelized
- Overflow
- Parcel

Proposed Utilities

- Sewer
- Storm
- Water (Domestic & Fire)
- Proposed Drainage Basin

N

0 25 50 100 150

SCALE IN FEET

City/County plan review is provided only for general conformance with City/County Design Criteria. The City/County is not responsible for the accuracy and adequacy of the design, dimension, and/or elevations which shall be confirmed through the approval of this document assumes no responsibility for completeness and/or accuracy of this document.

REFERENCE DRAWINGS

No.	DATE	DESCRIPTION	BY

REVISIONS

COMPUTER FILE MANAGEMENT

FILE NAME: G:\gis_projects\Liberty_Tree_Academy\active\apps\Drainage_Report\FigureA-1_Proposed_Drainage_Plan.mxd
CTB FILE:
PLOT DATE: 8/7/2018
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PREPARED BY:
Matrix DESIGN GROUP
AN EMPLOYEE-OWNED COMPANY

SEAL

FOR AND ON BEHALF OF MATRIX DESIGN GROUP, INC.
PROJECT No.

LIBERTY TREE ACADEMY

FINAL DRAINAGE PLAN

FIGURE A-1. PROPOSED DRAINAGE PLAN

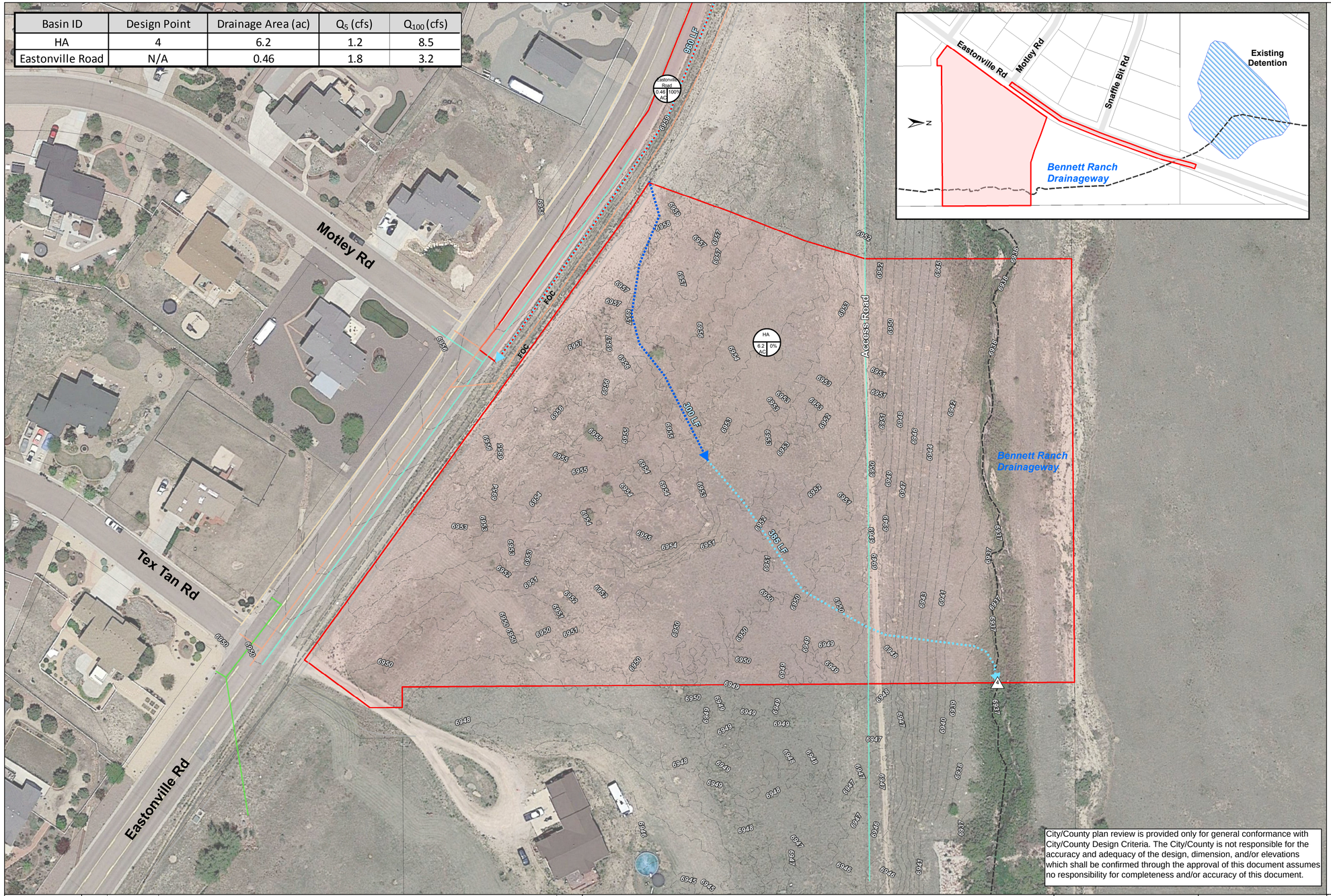
DESIGNED BY: CE
DRAWN BY: CE
CHECKED BY:

SCALE
HORIZ. 1" = 400'
VERT.

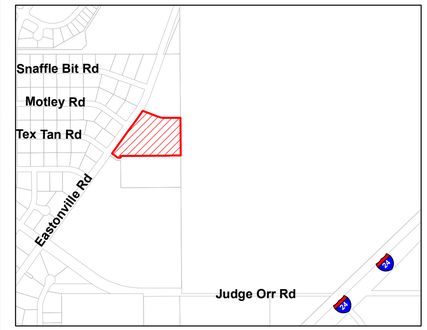
DATE ISSUED:

SHEET OF

Basin ID	Design Point	Drainage Area (ac)	Q_5 (cfs)	Q_{100} (cfs)
HA	4	6.2	1.2	8.5
Eastonville Road	N/A	0.46	1.8	3.2



City/County plan review is provided only for general conformance with City/County Design Criteria. The City/County is not responsible for the accuracy and adequacy of the design, dimension, and/or elevations which shall be confirmed through the approval of this document assumes no responsibility for completeness and/or accuracy of this document.



VICINITY MAP

Legend

- Existing Contours (1ft)

Existing Flow Paths

- Channelized
- Overflow
- Existing Drainage Basin
- Parcel

Existing Utilities

- Fiber Optic
- Gas
- Sewer
- Storm
- Underground Electric
- Underground Telephone
- Water

N

0 25 50 100 150

SCALE IN FEET

REFERENCE DRAWINGS

No.	DATE	DESCRIPTION	BY

REVISIONS

COMPUTER FILE MANAGEMENT

FILE NAME: G:\gis_projects\Liberty_Tree_Academy\active\apps\Drainage_Report\FigureA-2_Existing_Drainage_Plan.mxd
CTB FILE:
PLOT DATE: 8/7/2018
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PREPARED BY:
Matrix DESIGN GROUP
AN EMPLOYEE-OWNED COMPANY

SEAL

FOR AND ON BEHALF OF MATRIX DESIGN GROUP, INC.
PROJECT No.

LIBERTY TREE ACADEMY

FINAL DRAINAGE PLAN

FIGURE A-2. EXISTING DRAINAGE PLAN

DESIGNED BY: CE
DRAWN BY: CE
CHECKED BY:

SCALE
HORIZ. 1" = 400'
VERT.

DATE ISSUED:

SHEET OF

APPENDIX C – HYDROLOGIC ANALYSIS

Project Name: Liberty Tree Academy
Job Number: 18.995.001
Subject: Composite Runoff Coefficients
Date: 8/10/2018
Designed by: MAS

Global Parameters							
Land Use	% Imp.	C_2	C_5	C_{10}	C_{25}	C_{50}	C_{100}
Pasture/ Meadow, Lawn	0	0.02	0.08	0.15	0.25	0.30	0.35
Playground	13	0.07	0.16	0.24	0.32	0.37	0.41
Paved, Drive and Walk, Detention	100	0.89	0.90	0.92	0.94	0.95	0.96
Roofs	90	0.71	0.73	0.75	0.78	0.80	0.81

*Type A Soils

Subbasin	Total Area (acres)	Land Use Area per Sub-Basin								Composite Imperviousness	Composite Runoff Coefficient					
		Pasture/ Meadow, Lawn		Playground		Paved, Drive and Walk, Detention		Roofs			2-year	5-year	10-year	25-year	50-year	100-year
		Area (acres)	%	Area (acres)	%	Area (acres)	%	Area (acres)	%							
EXISTING																
Eatonville Rd	0.46	0.00	0.0%	0.00	0.0%	0.46	100.0%	0.00	0.0%	**100.0%**	**0.89**	**0.90**	**0.92**	**0.94**	**0.95**	**0.96**
HA	6.20	6.20	100.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	**0.0%**	**0.02**	**0.08**	**0.15**	**0.25**	**0.30**	**0.35**
PROPOSED																
A	3.00	0.61	20.2%	0.12	4.0%	1.64	54.8%	0.63	20.9%	**74.2%**	**0.64**	**0.67**	**0.70**	**0.74**	**0.76**	**0.78**
OS1	1.10	1.10	100.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	**0.0%**	**0.02**	**0.08**	**0.15**	**0.25**	**0.30**	**0.35**
OS2	2.10	2.10	100.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	**0.0%**	**0.02**	**0.08**	**0.15**	**0.25**	**0.30**	**0.35**
A+OS1	**4.10**	**1.71**	**41.6%**	**0.12**	**2.9%**	**1.64**	**40.1%**	**0.63**	**15.3%**	**54.3%**	**0.48**	**0.51**	**0.55**	**0.61**	**0.64**	**0.67**

STORM DRAINAGE SYSTEM COMPUTATION FORM

Location: Liberty Tree Academy
Date: August 10, 2018
Designed by: MAS

Design Storm: 5 yr.
P1, 5-yr: 1.5 in.

Sub-Basin Data					Overland Time (ti)			Travel Time (tt)					tc Check					Runoff	
Design Pt.	Basin ID	Area	Coefficient "C5"	CA	Length (300' max)	Slope	$t_i=(0.395(1.1-C5)*L_i^{0.5})/S_0^{0.33}$	Length	Slope	Cv, conveyance factor	Velocity = Cv * Slope^0.5	tt	tc=ti+tt	Total length	tc = (26-17i)+Lt/(60(14i+9)St^0.5	Minimum tc	Final tc	Intensity "I"	Total Peak Discharge "Q5"
		acres			ft	%	min.	ft	%		fps	min	min	ft	min	min	min	in/hr	*cfs*
	EXISTING																		
	Eatonville Rd	0.46	0.90	0.41	21	2.5%	1.2	960	1.3%	20	2.3	7.0	8.3	981	15.1	5.0	8.3	4.36	1.81
4	HA	6.20	0.08	0.50	300	2.0%	25.7	385	2.4%	7	1.1	5.9	31.6	685	30.6	5.0	30.6	2.33	1.15
	PROPOSED																		
1	A	3.00	0.67	2.01	100	0.5%	10.0	665	1.1%	20	2.1	5.2	15.2	765	18.8	5.0	15.2	3.39	6.79
2	OS1	1.10	0.08	0.09	257	1.8%	24.6	20	25.0%	7	3.5	0.1	24.7	277	26.1	5.0	24.7	2.63	0.23
3	A+OS1	4.10	0.51	2.09	100	0.5%	13.6	665	1.1%	20.0	2.1	5.2	18.8	765	23.1	5.0	18.8	3.04	6.38
4	OS2	2.10	0.08	0.17	165	9.1%	11.5	407	0.3%	2.5	0.1	46.9	58.5	572	39.0	5.0	39.0	2.01	0.34

*Intensity values from Figure 6-5 of DCM-V1-Update

STORM DRAINAGE SYSTEM COMPUTATION FORM

Location: Liberty Tree Academy
Date: August 10, 2018
Designed by: MAS

Design Storm: 100 yr.
P1, 100-yr: 2.52 in.

Sub-Basin Data						Overland Time (ti)			Travel Time (tt)					tc Check					Runoff	
Design Pt.	Basin ID	Area	Coefficient "C5"	Coefficient "C100"	CA	Length (300' max)	Slope	$ti=(0.395(1.1-C5)*L_i^{0.5})/S_0^{0.33}$	Length	Slope	Cv, conveyance factor	Velocity = Cv * Slope^0.5	tt	tc=ti+tt	Total length	$tc = (26-17i)+Lt/(60(14i+9)St^{0.5}$	Minimum tc	Final tc	Intensity "I"	Total Peak Discharge "Q100"
		acres				ft	%	min.	ft	%		fps	min	min	ft	min	min	min	in/hr	*cfs*
	EXISTING																			
	Eatonville Rd	0.46	0.90	0.96	0.44	21	2.5%	1.2	960	1.3%	20	2.3	7.0	8.3	981	15.1	5.0	8.3	7.32	3.23
4	HA	6.20	0.08	0.35	2.17	300	2.0%	25.7	385	2.4%	7	1.1	5.9	31.6	685	30.6	5.0	30.6	3.91	8.48
	PROPOSED																			
1	A	3.00	0.67	0.78	2.35	100	0.5%	10.0	665	1.1%	20	2.1	5.2	15.2	765	18.8	5.0	15.2	5.69	13.36
2	OS1	1.10	0.08	0.35	0.39	257	1.8%	24.6	20	25.0%	7	3.5	0.1	24.7	277	26.1	5.0	24.7	4.42	1.70
3	A+OS1	4.10	0.51	0.67	2.73	100	0.5%	13.6	665	1.1%	20.0	2.1	5.2	18.8	765	23.1	5.0	18.8	5.11	13.98
4	OS2	2.10	0.08	0.35	0.74	165	9.1%	11.5	407	0.3%	2.5	0.1	46.9	58.5	572	39.0	5.0	39.0	3.37	2.48

*Intensity values from Figure 6-5 of DCM-V1-Update

EXISTING RUNOFF ANALYSIS

Location: Liberty Tree Academy
Date: August 10, 2018
Designed by: MAS

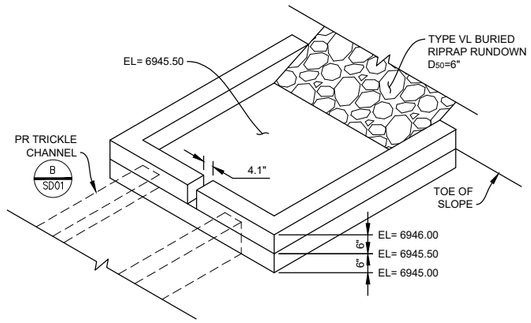
Basin Name:	**HA**
Area (ac.)	6.20
Imperv. (%)	0%
Tc (min.)	30.60

Design Storm	P1 (in)	Runoff Coefficient	Intensity "I"	Total Peak Discharge "Q100"
			in/hr	*cfs*
2	**1.19**	0.02	1.85	0.23
5	**1.5**	0.08	2.33	1.15
10	**1.75**	0.15	2.71	2.52
25	**2**	0.25	3.10	4.81
50	**2.25**	0.30	3.49	6.49
100	**2.52**	0.35	3.91	8.48

*Intensity values from Figure 6-5 of DCM-V1-Update

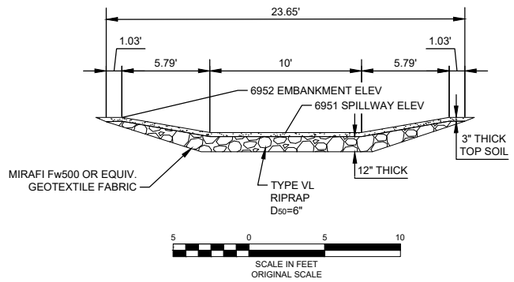
APPENDIX D – HYDRAULIC ANALYSIS

Extended Detention Basin Design



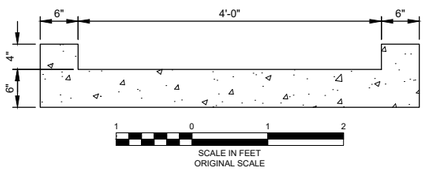
FOREBAY DETAIL (A)

SCALE: N.T.S.
SEE PLAN FOR LIMITS.

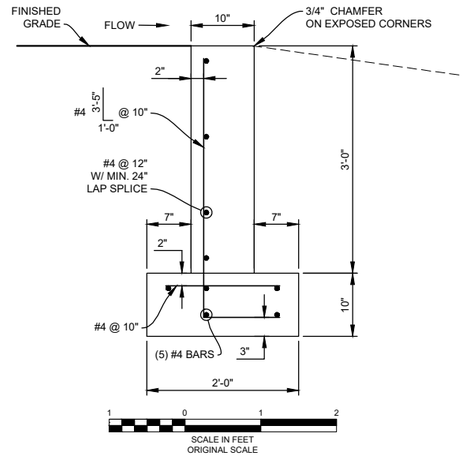


SPILLWAY SECTION (C)

SCALE: 1" = 5'



TRICKLE CHANNEL SECTION (B)



CONCRETE OVERFLOW WALL SECTION (D)

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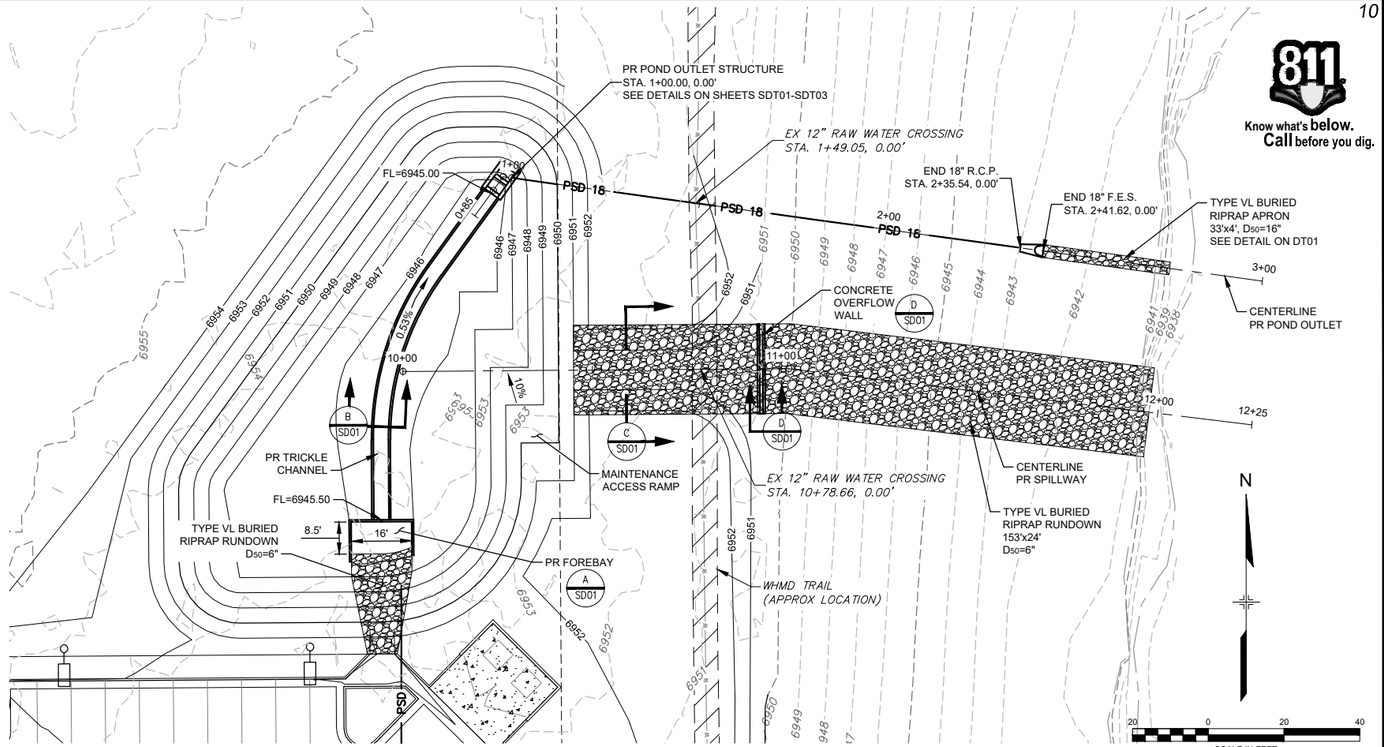
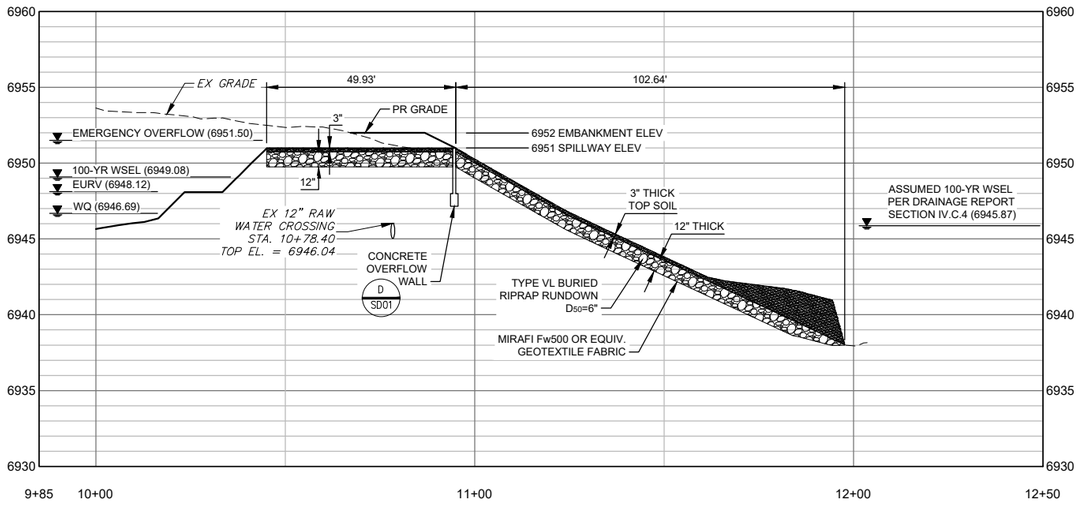


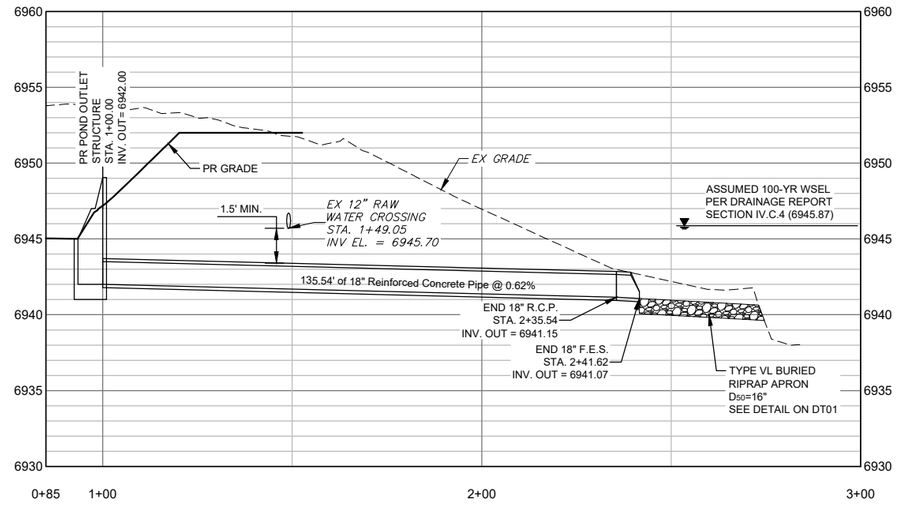
PLAN

SCALE: 1"=20'



SPILLWAY PROFILE

SCALE: 1"=20'(H), 1"=5'(V)



POND OUTLET PROFILE

SCALE: 1"=20'(H), 1"=5'(V)

REFERENCE DRAWINGS
X-995-MDG22x34
X-995-PR-UTIL
X-995-EX-BASE
X-995-EX-MAP
X-995-PR-BASE

No.	DATE	DESCRIPTION	BY
		REVISIONS	

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PREPARED BY: Matrix DESIGN GROUP, AN EMPLOYEE-OWNED COMPANY

SEAL

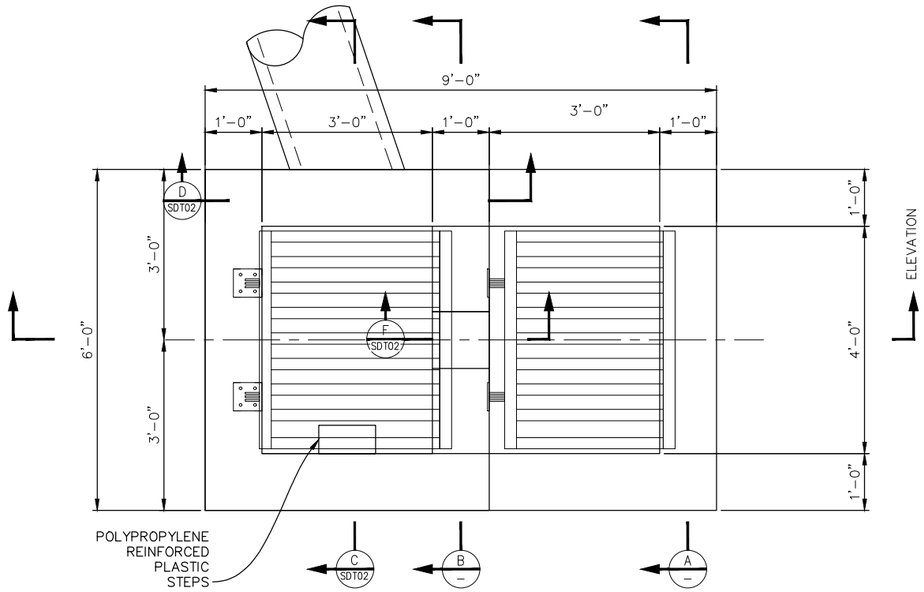
FOR AND ON BEHALF OF MATRIX DESIGN GROUP, INC.
PROJECT No. 18.995.001

LIBERTY TREE ACADEMY

TOWN OF PEYTON, EL PASO COUNTY
CONSTRUCTION DOCUMENTS, PCD FILE NO. PPR-18-023

POND OUTLET & SPILLWAY PLAN & PROFILE

DESIGNED BY:	ACR	SCALE	DATE ISSUED:	AUGUST 2018	DRAWING No.
DRAWN BY:	ACR	HORIZ.AS SHOWN			
CHECKED BY:	DRK	VERT. 1" = 5'	SHEET	10 OF 29	SD01



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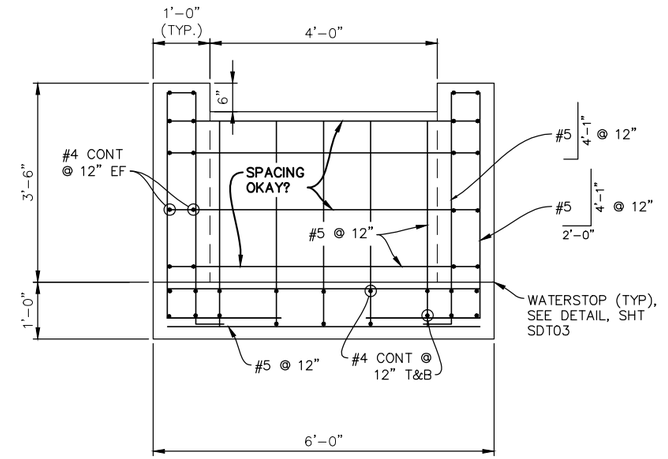

SECTION
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A
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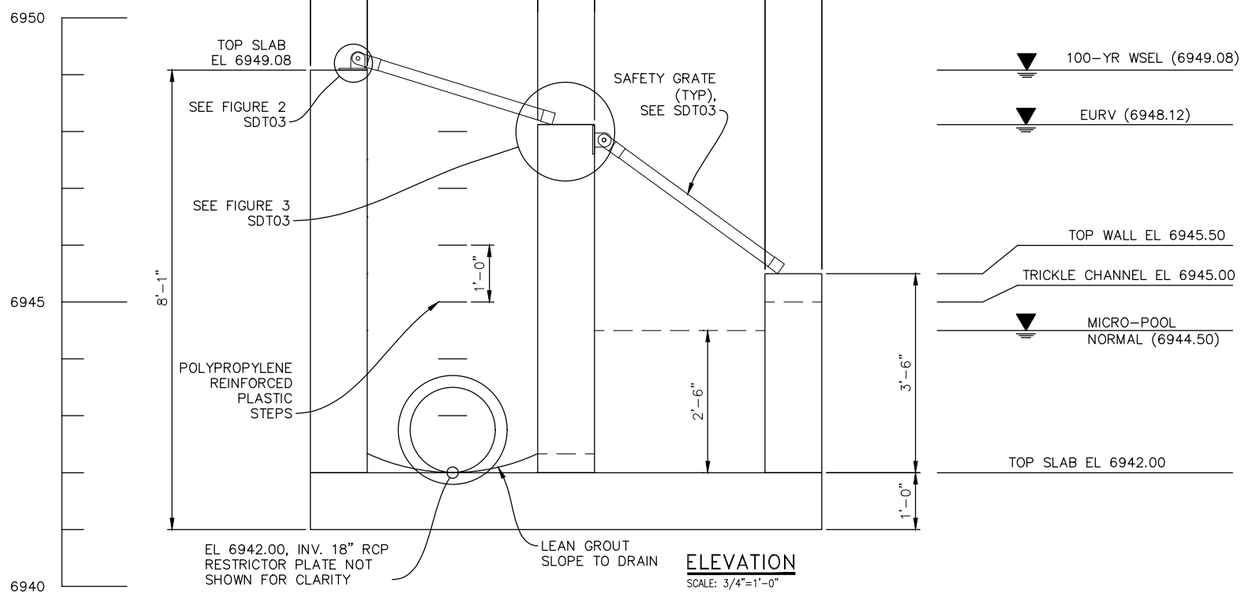

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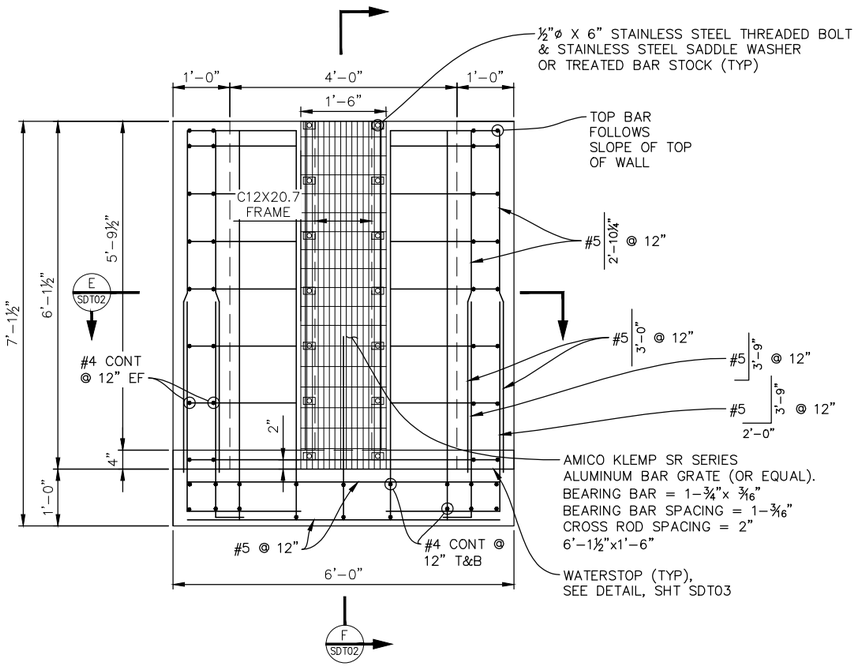

SECTION
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No.	DATE	DESCRIPTION	BY

REVISIONS

REFERENCE DRAWINGS
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LIBERTY TREE ACADEMY

PREPARED BY:
Matrix DESIGN GROUP
AN EMPLOYEE-OWNED COMPANY

SEAL
COLORADO REGISTERED 24520 PROFESSIONAL ENGINEER
8/10/18

FOR AND ON BEHALF OF
MATRIX DESIGN GROUP, INC.
PROJECT No. 18.995.001

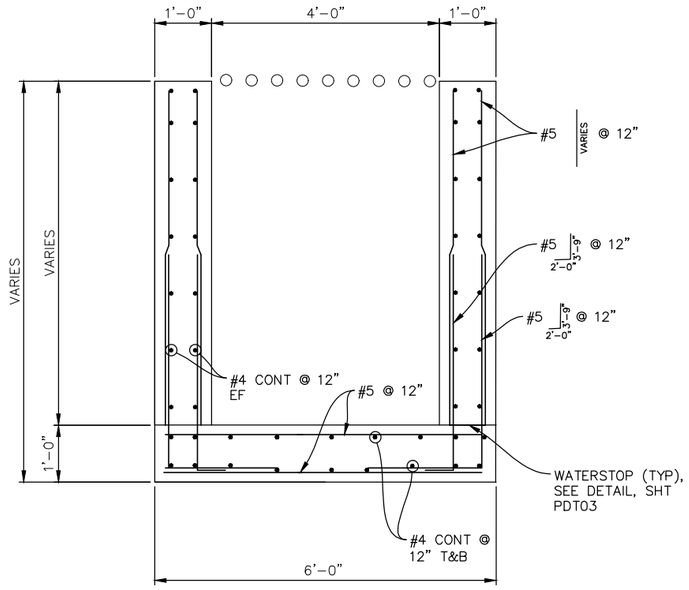
LIBERTY TREE ACADEMY

TOWN OF PEYTON, EL PASO COUNTY
CONSTRUCTION DOCUMENTS, PCD FILE NO. PPR-18-023

POND OUTLET STRUCTURE DETAILS

DESIGNED BY:	ACR	SCALE	DATE ISSUED:	AUGUST 2018	DRAWING No.
DRAWN BY:	ACR	HORIZ. 3/8" = 1'-0"			
CHECKED BY:	DRK	VERT. 3/8" = 1'-0"	SHEET	20 OF 29	SDT01

Know what's below. Call before you dig.



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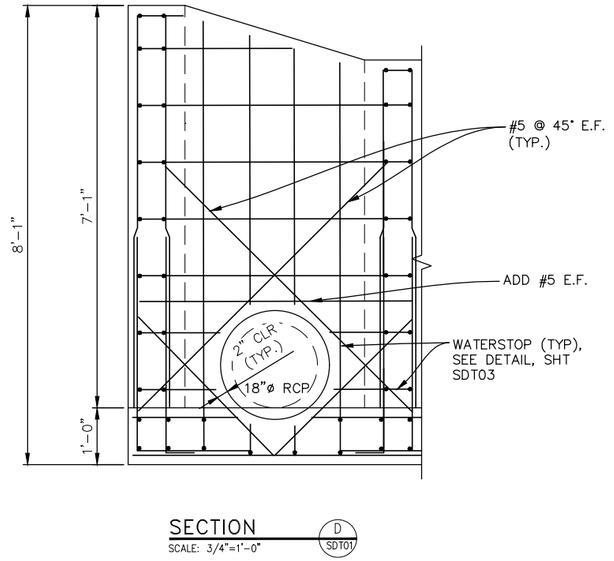

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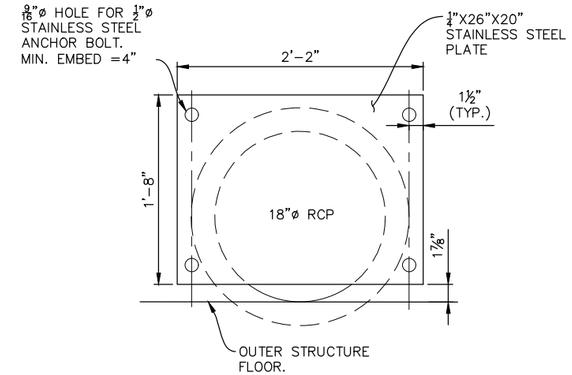

RESTRICTOR PLATE DETAIL
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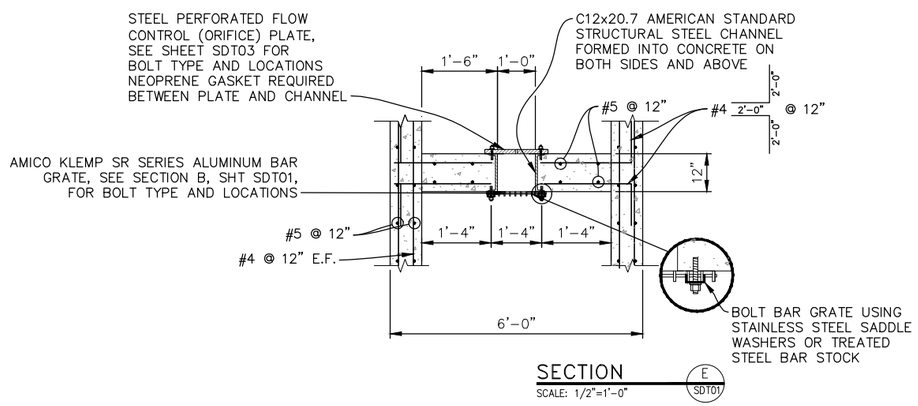

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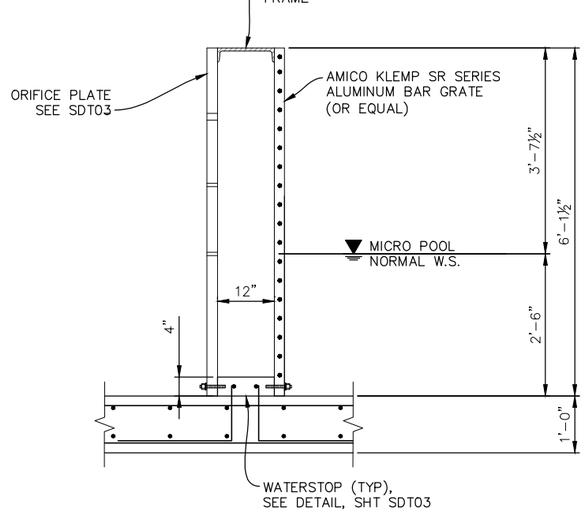

SECTION F
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No.	DATE	DESCRIPTION	BY

REVISIONS

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SHEET KEY

PREPARED FOR: LIBERTY TREE ACADEMY
PREPARED BY: Matrix DESIGN GROUP, AN EMPLOYEE-OWNED COMPANY

SEAL: COLORADO REGISTERED 24520 PROFESSIONAL ENGINEER 8/10/18

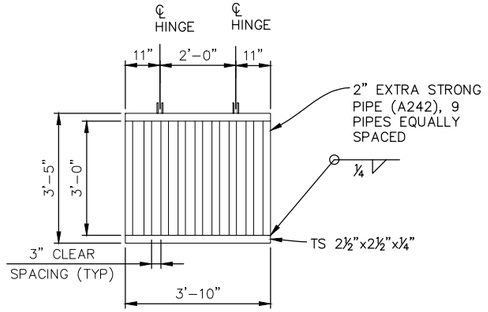
FOR AND ON BEHALF OF MATRIX DESIGN GROUP, INC.
PROJECT No. 18.995.001

LIBERTY TREE ACADEMY

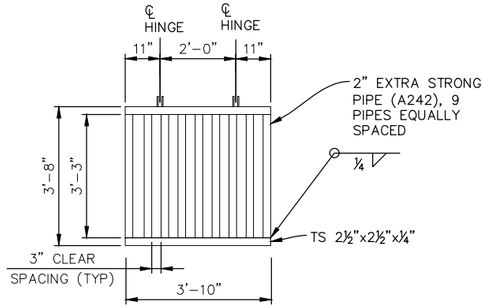
TOWN OF PEYTON, EL PASO COUNTY
CONSTRUCTION DOCUMENTS, PCD FILE NO. PPR-18-023

POND OUTLET STRUCTURE DETAILS

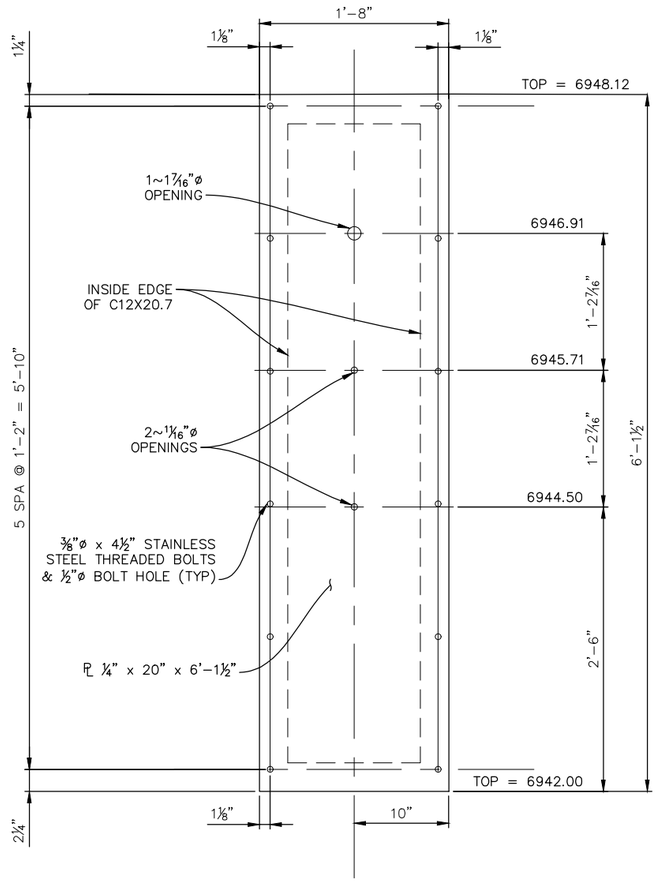
DESIGNED BY:	ACR	SCALE	DATE ISSUED:	AUGUST 2018	DRAWING No.
DRAWN BY:	ACR	HORIZ.			
CHECKED BY:	DRK	VERT.	SHEET	21 OF 29	SDT02



UPPER SAFETY GRATE PLAN
½"=1'–0"



LOWER SAFETY GRATE PLAN
1/2"=1'–0"



ORIFICE PLATE
1–1/2"=1'–0"

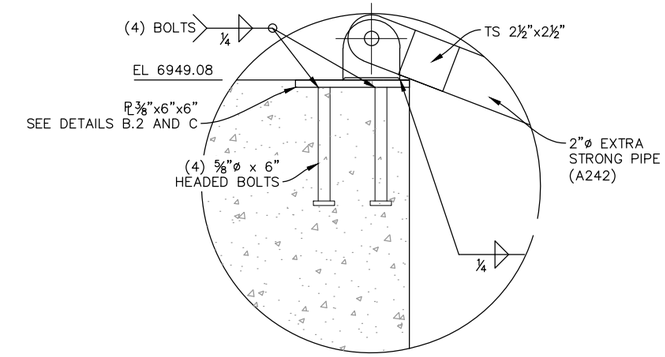


FIGURE 2
SAFETY GRATE HINGE
3"=1'–0"

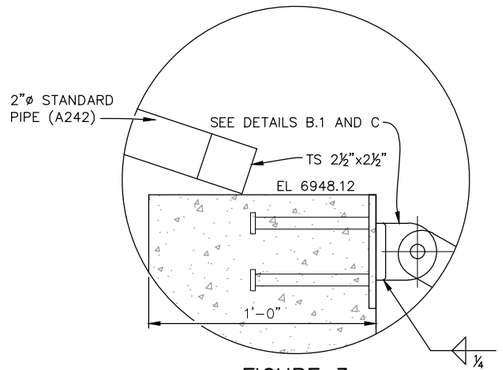
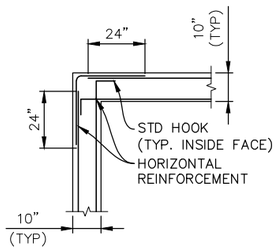
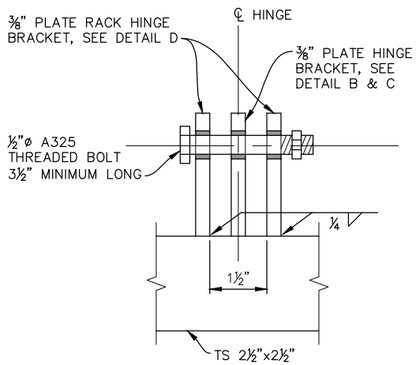


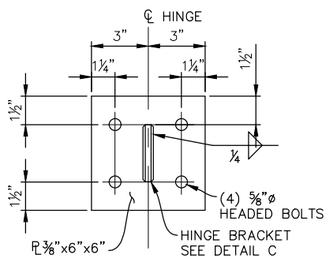
FIGURE 3
SAFETY GRATE HINGE
3"=1'–0"



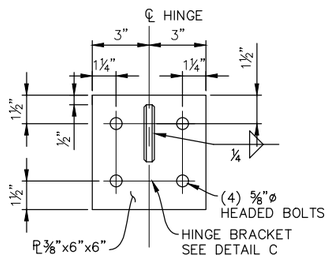
CORNER REINFORCING DETAIL PLAN VIEW
3/8"=1'–0"



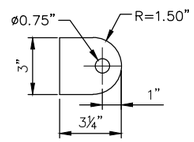
DETAIL A
6"=1'–0"



DETAIL B.1
(LOWER SAFETY GRATE ONLY)
3"=1'–0"

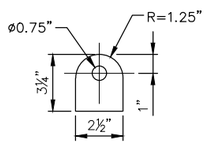


DETAIL B.2
(UPPER SAFETY GRATE ONLY)
3"=1'–0"



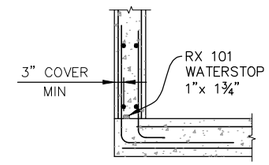
⅜" STEEL PLATE, A242 OR A588 (1 PER HINGE)

DETAIL C
HINGE BRACKET
3"=1'–0"



⅜" STEEL PLATE, A242 OR A588 (2 PER HINGE)

DETAIL D
RACK–HINGE BRACKET
3"=1'–0"



NOTES:

WATERSTOP SHALL BE VOLCLAY WATERSTOP RX 101 OR EARTHSHIELD JP 648 OR APPROVED EQUAL.

PLACE WATERSTOP FOR ENTIRETY OF EACH HORIZONTAL & VERTICAL CONSTRUCTION JOINT.

FOLLOW MANUFACTURER'S INSTALLATION INSTRUCTIONS.

WATERSTOP DETAIL

Know what's below. Call before you dig.

REFERENCE DRAWINGS
X-995-MDG22x34

No.	DATE	DESCRIPTION	BY

REVISIONS

COMPUTER FILE MANAGEMENT
FILE NAME: R:\18.995.001 (Liberty Tree Academy)\Dwg\Construction Plans\Structures\SDT01-03.dwg
CTB FILE: ----
PLOT DATE: 8/10/2018 10:16 AM
THIS DRAWING IS CURRENT AS OF PLOT DATE AND MAY BE SUBJECT TO CHANGE.

SHEET KEY

PREPARED FOR: LIBERTY TREE ACADEMY
PREPARED BY: Matrix DESIGN GROUP, AN EMPLOYEE-OWNED COMPANY

SEAL
COLORADO REGISTERED PROFESSIONAL ENGINEER
24520
8/10/18
FOR AND ON BEHALF OF MATRIX DESIGN GROUP, INC.
PROJECT No. 18.995.001

LIBERTY TREE ACADEMY

TOWN OF PEYTON, EL PASO COUNTY
CONSTRUCTION DOCUMENTS, PCD FILE NO. PPR-18-023

POND OUTLET STRUCTURE DETAILS

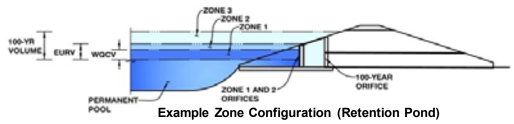
DESIGNED BY:	ACR	SCALE	DATE ISSUED:	AUGUST 2018	DRAWING No.
DRAWN BY:	ACR	HORIZ. AS SHOWN			
CHECKED BY:	DRK	VERT. AS SHOWN	SHEET	22 OF 29	STD03

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Liberty Tree

Basin ID: Extended Detention Basin



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB			
Watershed Area =	4.10	acres		
Watershed Length =	765	ft		
Watershed Slope =	0.010	ft/ft		
Watershed Imperviousness =	54.28%	percent		
Percentage Hydrologic Soil Group A =	100.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.075	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.263	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.180	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.236	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.289	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.357	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.439	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.535	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet		inches
Approximate 2-yr Detention Volume =	0.169	acre-feet		
Approximate 5-yr Detention Volume =	0.223	acre-feet		
Approximate 10-yr Detention Volume =	0.271	acre-feet		
Approximate 25-yr Detention Volume =	0.329	acre-feet		
Approximate 50-yr Detention Volume =	0.366	acre-feet		
Approximate 100-yr Detention Volume =	0.409	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.075	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.188	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.146	acre-feet
Total Detention Basin Volume =	0.409	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	--	--	--	0	0.000		
6,945.0	--	0.50	--	--	--	12	0.000	3	0.000
6,946.0	--	1.50	--	--	--	1,876	0.043	928	0.021
6,947.0	--	2.50	--	--	--	4,873	0.112	4,322	0.099
6,948.0	--	3.50	--	--	--	6,225	0.143	9,871	0.227
6,949.0	--	4.50	--	--	--	7,678	0.176	16,823	0.386
6,949.5	--	5.00	--	--	--	8,455	0.194	20,856	0.479
6,950.0	--	5.50	--	--	--	9,232	0.212	25,278	0.580
6,951.0	--	6.50	--	--	--	11,057	0.254	35,423	0.813
6,952.0	--	7.50	--	--	--	22,159	0.509	52,031	1.194
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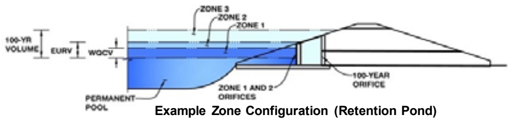
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Liberty Tree

Basin ID: Extended Detention Basin



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB			
Watershed Area =	4.10	acres		
Watershed Length =	765	ft		
Watershed Slope =	0.010	ft/ft		
Watershed Imperviousness =	54.28%	percent		
Percentage Hydrologic Soil Group A =	100.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.075	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.263	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.180	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.236	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.289	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.357	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.439	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.535	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.41 in.) =	0.821	acre-feet	3.41	inches
Approximate 2-yr Detention Volume =	0.169	acre-feet		
Approximate 5-yr Detention Volume =	0.223	acre-feet		
Approximate 10-yr Detention Volume =	0.271	acre-feet		
Approximate 25-yr Detention Volume =	0.329	acre-feet		
Approximate 50-yr Detention Volume =	0.366	acre-feet		
Approximate 100-yr Detention Volume =	0.409	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.075	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.188	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.146	acre-feet
Total Detention Basin Volume =	0.409	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	--	--	--	0	0.000		
6,945.0	--	0.50	--	--	--	12	0.000	3	0.000
6,946.0	--	1.50	--	--	--	1,876	0.043	928	0.021
6,947.0	--	2.50	--	--	--	4,873	0.112	4,322	0.099
6,948.0	--	3.50	--	--	--	6,225	0.143	9,871	0.227
6,949.0	--	4.50	--	--	--	7,678	0.176	16,823	0.386
6,949.5	--	5.00	--	--	--	8,455	0.194	20,856	0.479
6,950.0	--	5.50	--	--	--	9,232	0.212	25,278	0.580
6,951.0	--	6.50	--	--	--	11,057	0.254	35,423	0.813
6952	--	7.50	--	--	--	22,159	0.509	52,031	1.194
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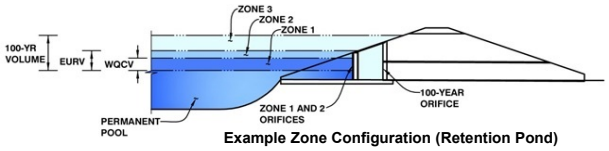
Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: Liberty Tree

Basin ID: Extended Detention Basin



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.27	0.075	Orifice Plate
Zone 2 (EURV)	3.75	0.188	Orifice Plate
Zone 3 (100-year)	4.63	0.146	Weir&Pipe (Restrict)
		0.409	Total

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

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

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	3.62	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	15.00	inches
Orifice Plate: Orifice Area per Row =	N/A	inches

Calculated Parameters for Plate

WQ Orifice Area per Row =	N/A	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

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	1.21	2.41					
Orifice Area (sq. inches)	0.37	0.37	1.62					

	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	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.63	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	4.00	N/A	feet
Overflow Weir Slope =	3.13	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	3.00	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	4.59	N/A	feet
Over Flow Weir Slope Length =	3.15	N/A	feet
Grate Open Area / 100-yr Orifice Area =	90.32	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	8.82	N/A	ft^2
Overflow Grate Open Area w/ Debris =	4.41	N/A	ft^2

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

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	18.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	1.88		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	0.10	N/A	ft^2
Outlet Orifice Centroid =	0.09	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	0.66	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	6.50	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	10.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	0.50	feet

Calculated Parameters for Spillway

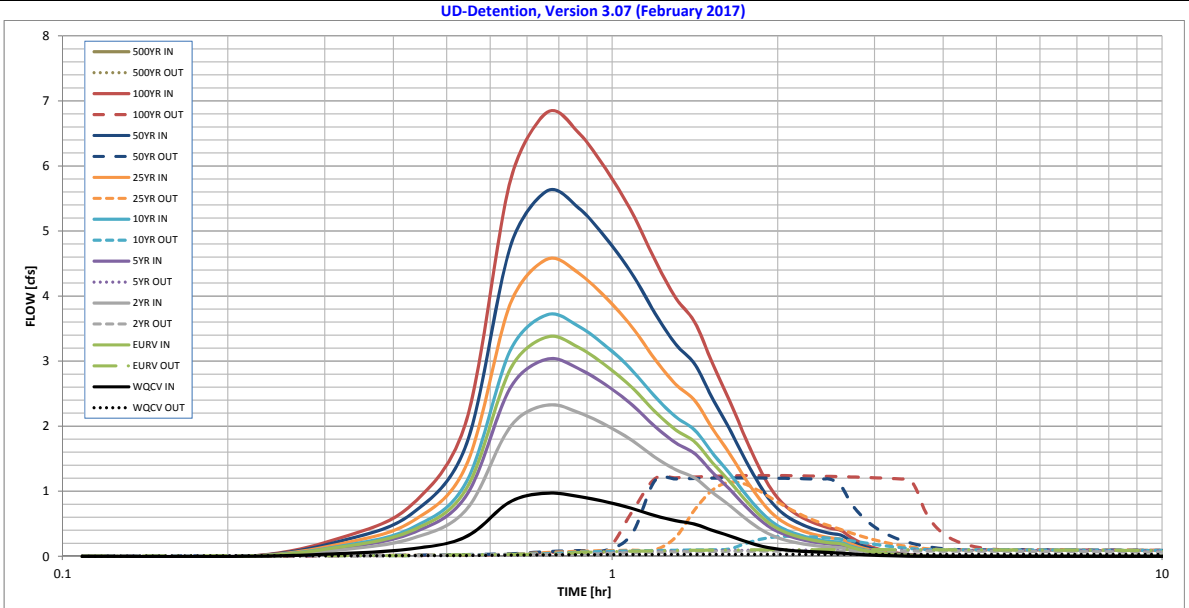
Spillway Design Flow Depth=	0.34	feet
Stage at Top of Freeboard =	7.34	feet
Basin Area at Top of Freeboard =	0.47	acres

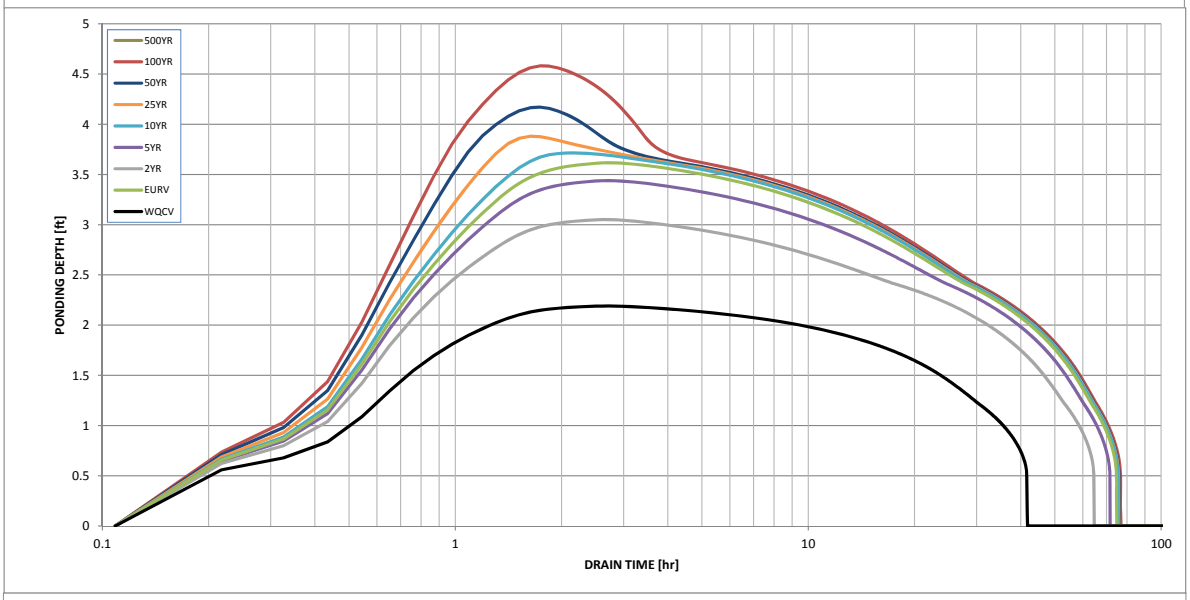
Routed Hydrograph Results

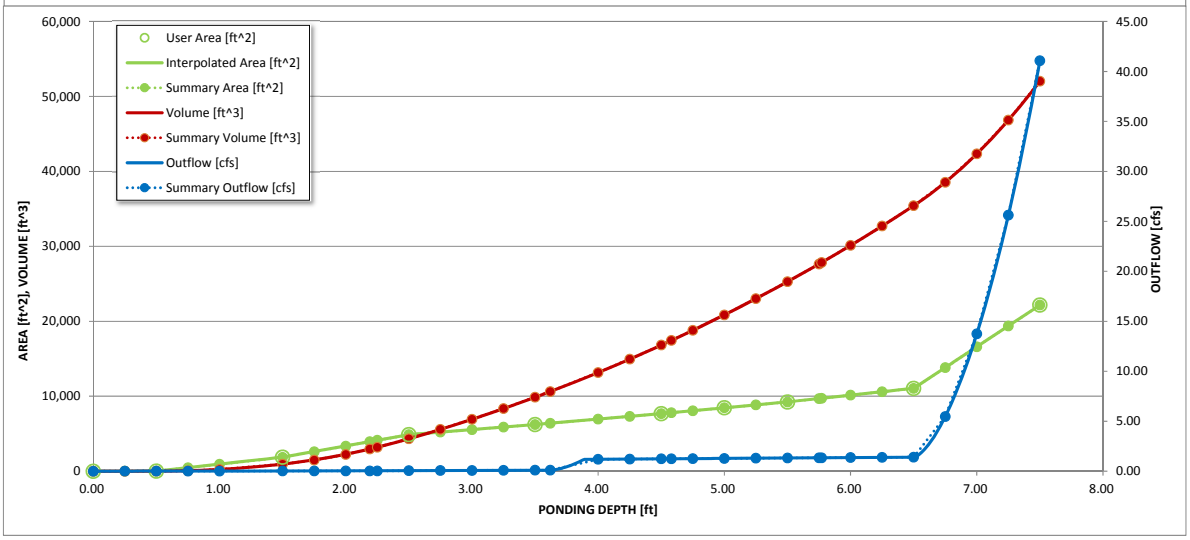
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	0.00
Calculated Runoff Volume (acre-ft) =	0.075	0.263	0.180	0.236	0.289	0.357	0.439	0.535	0.000
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.074	0.262	0.180	0.235	0.289	0.356	0.439	0.535	#N/A
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.00	0.00	0.01	0.02	0.14	0.34	0.00
Predevelopment Peak Q (cfs) =	0.0	0.0	0.002	0.015	0.034	0.074	0.564	1.4	0.0
Peak Inflow Q (cfs) =	1.0	3.4	2.324	3.031	3.713	4.567	5.615	6.8	#N/A
Peak Outflow Q (cfs) =	0.0	0.1	0.082	0.097	0.294	1.116	1.206	1.2	#N/A
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	6.6	8.7	15.1	2.1	0.9	#N/A
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1	#N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.0	0.1	0.1	0.1	#N/A
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) =	39	67	59	64	67	65	64	62	#N/A
Time to Drain 99% of Inflow Volume (hours) =	**41**	72	63	69	73	72	72	71	#N/A
Maximum Ponding Depth (ft) =	2.19	3.62	3.05	3.44	3.72	3.89	4.17	4.58	#N/A
Area at Maximum Ponding Depth (acres) =	0.09	0.15	0.13	0.14	0.15	0.16	0.17	0.18	#N/A
Maximum Volume Stored (acre-ft) =	0.068	0.243	0.165	0.217	0.257	0.283	0.330	0.400	#N/A

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

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

Time Interval	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	#N/A
	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]
6.52 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	0:06:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
Hydrograph Constant	0:13:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	0:19:34	0.04	0.15	0.11	0.14	0.17	0.21	0.25	0.30	#N/A
0.767	0:26:05	0.12	0.41	0.28	0.37	0.45	0.55	0.67	0.82	#N/A
	0:32:36	0.30	1.04	0.72	0.94	1.15	1.41	1.73	2.10	#N/A
	0:39:07	0.84	2.87	1.99	2.59	3.16	3.88	4.75	5.76	#N/A
	0:45:38	0.97	3.37	2.32	3.03	3.71	4.57	5.62	6.82	#N/A
	0:52:10	0.92	3.21	2.21	2.88	3.53	4.35	5.35	6.51	#N/A
	0:58:41	0.83	2.92	2.01	2.62	3.22	3.96	4.87	5.92	#N/A
	1:05:12	0.74	2.59	1.78	2.33	2.86	3.52	4.34	5.29	#N/A
	1:11:43	0.63	2.23	1.52	2.00	2.46	3.03	3.74	4.56	#N/A
	1:18:14	0.55	1.95	1.33	1.75	2.14	2.65	3.26	3.97	#N/A
	1:24:46	0.49	1.76	1.20	1.58	1.94	2.39	2.95	3.60	#N/A
	1:31:17	0.40	1.44	0.98	1.29	1.59	1.96	2.43	2.96	#N/A
	1:37:48	0.32	1.17	0.79	1.04	1.29	1.60	1.98	2.42	#N/A
	1:44:19	0.24	0.88	0.60	0.79	0.98	1.22	1.51	1.86	#N/A
	1:50:50	0.17	0.65	0.43	0.58	0.72	0.90	1.12	1.38	#N/A
	1:57:22	0.12	0.47	0.32	0.42	0.52	0.65	0.81	1.00	#N/A
	2:03:53	0.10	0.37	0.25	0.33	0.41	0.51	0.63	0.78	#N/A
	2:10:24	0.08	0.31	0.21	0.27	0.34	0.42	0.52	0.64	#N/A
	2:16:55	0.07	0.26	0.18	0.23	0.29	0.36	0.44	0.54	#N/A
	2:23:26	0.06	0.23	0.16	0.21	0.25	0.31	0.39	0.48	#N/A
	2:29:58	0.06	0.21	0.14	0.19	0.23	0.28	0.35	0.43	#N/A
	2:36:29	0.05	0.19	0.13	0.17	0.21	0.26	0.32	0.40	#N/A
	2:43:00	0.04	0.14	0.10	0.13	0.16	0.19	0.24	0.29	#N/A
	2:49:31	0.03	0.10	0.07	0.09	0.11	0.14	0.17	0.21	#N/A
	2:56:02	0.02	0.08	0.05	0.07	0.08	0.10	0.13	0.16	#N/A
	3:02:34	0.01	0.05	0.04	0.05	0.06	0.08	0.09	0.11	#N/A
	3:09:05	0.01	0.04	0.03	0.03	0.04	0.05	0.07	0.08	#N/A
	3:15:36	0.01	0.03	0.02	0.02	0.03	0.04	0.05	0.06	#N/A
	3:22:07	0.00	0.02	0.01	0.02	0.02	0.03	0.03	0.04	#N/A
	3:28:38	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03	#N/A
	3:35:10	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.02	#N/A
	3:41:41	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	#N/A
	3:48:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	3:54:43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:01:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:07:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:14:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:20:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:27:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:33:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:40:22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:46:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:53:24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	4:59:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:06:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:12:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:19:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:26:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:32:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:39:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:45:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:52:05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	5:58:36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:05:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:11:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:18:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:24:41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:31:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:37:43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:44:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:50:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	6:57:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:03:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:10:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:16:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:23:22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:29:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:36:24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:42:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
	7:49:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

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]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]
Micropool = 6944.5	0.00	0	0.000	0	0.000	0.00
6944.75	0.25	6	0.000	1	0.000	0.01
6945	0.50	12	0.000	3	0.000	0.01
6945.25	0.75	459	0.011	60	0.001	0.01
6945.5	1.00	926	0.021	233	0.005	0.01
6946	1.50	1,858	0.043	928	0.021	0.02
6946.25	1.75	2,595	0.060	1,484	0.034	0.03
6946.5	2.00	3,345	0.077	2,226	0.051	0.03
WQCV = 6946.69	2.19	3,944	0.091	2,955	0.068	0.03
6946.75	2.25	4,124	0.095	3,197	0.073	0.03
6947	2.50	4,873	0.112	4,322	0.099	0.05
6947.25	2.75	5,211	0.120	5,582	0.128	0.07
6947.5	3.00	5,549	0.127	6,927	0.159	0.08
6947.75	3.25	5,887	0.135	8,357	0.192	0.09
6948	3.50	6,225	0.143	9,871	0.227	0.10
EURV = 6948.12	3.62	6,400	0.147	10,628	0.244	0.10
6948.5	4.00	6,952	0.160	13,165	0.302	1.19
6948.75	4.25	7,315	0.168	14,949	0.343	1.21
6949	4.50	7,678	0.176	16,823	0.386	1.24
100-YR WSEL = 6949.08	4.58	7,803	0.179	17,442	0.400	1.24
6949.25	4.75	8,067	0.185	18,791	0.431	1.26
6949.5	5.00	8,455	0.194	20,856	0.479	1.28
6949.75	5.25	8,844	0.203	23,019	0.528	1.30
100-YR (clogged) = 6949.78	5.28	8,890	0.204	23,285	0.535	1.30
6950	5.50	9,232	0.212	25,278	0.580	1.32
6950.25	5.75	9,689	0.222	27,643	0.635	1.34
6950.5	6.00	10,145	0.233	30,122	0.692	1.36
6950.75	6.25	10,601	0.243	32,716	0.751	1.38
Spillway Crest = 6951	6.50	11,057	0.254	35,423	0.813	1.40
6951.25	6.75	13,833	0.318	38,534	0.885	5.47
6951.5	7.00	16,608	0.381	42,339	0.972	13.75
6951.75	7.25	19,384	0.445	46,838	1.075	25.62
Berm Crest = 6952	7.50	22,159	0.509	52,031	1.194	41.08

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

Design Procedure Form: Extended Detention Basin (EDB)

UD-BMP (Version 3.07, March 2018)

Designer: MAS
Company: Matrix
Date: August 9, 2018
Project: Liberty Tree Academy
Location: Rundown Forebay

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1. Basin Storage Volume

A) Effective Imperviousness of Tributary Area, I_a — I_a = 54.0 %

B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$) — i = 0.540

C) Contributing Watershed Area — Area = 4.100 ac

D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm — d_6 = in

E) Design Concept (Select EURV when also designing for flood control)

Choose One
- ○ Water Quality Capture Volume (WQCV)
- ◉ Excess Urban Runoff Volume (EURV)

F) Design Volume (WQCV) Based on 40-hour Drain Time
($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area$) — V_{DESIGN} = 0.074 ac-ft

G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume
($V_{WQCV\ OTHER} = (d_6 * (V_{DESIGN}/0.43))$) — $V_{DESIGN\ OTHER}$ = ac-ft

H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired) — $V_{DESIGN\ USER}$ = ac-ft

I) NRCS Hydrologic Soil Groups of Tributary Watershed
- i) Percentage of Watershed consisting of Type A Soils — HSG_A = 100 %
- ii) Percentage of Watershed consisting of Type B Soils — HSG_B = 0 %
- iii) Percentage of Watershed consisting of Type C/D Soils — $HSG_{C/D}$ = 0 %

J) Excess Urban Runoff Volume (EURV) Design Volume
For HSG A: $EURV_A = 1.68 * i^{1.28}$
For HSG B: $EURV_B = 1.36 * i^{1.08}$
For HSG C/D: $EURV_{C/D} = 1.20 * i^{1.08}$
— $EURV_{DESIGN}$ = 0.261 ac-ft

K) User Input of Excess Urban Runoff Volume (EURV) Design Volume (Only if a different EURV Design Volume is desired) — $EURV_{DESIGN\ USER}$ = ac-ft

---

2. Basin Shape: Length to Width Ratio
(A basin length to width ratio of at least 2:1 will improve TSS reduction.)

L : W = 2.0 : 1

---

3. Basin Side Slopes

A) Basin Maximum Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred) — Z = 4.00 ft / ft

---

4. Inlet

A) Describe means of providing energy dissipation at concentrated inflow locations:

---

5. Forebay

A) Minimum Forebay Volume (V_{FMIN} = 2% of the WQCV) — V_{FMIN} = 0.001 ac-ft

B) Actual Forebay Volume — V_F = 0.002 ac-ft

C) Forebay Depth (D_F = 18 inch maximum) — D_F = 6.0 in

D) Forebay Discharge

i) Undetained 100-year Peak Discharge — Q_{100} = 14.10 cfs

ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$) — Q_F = 0.28 cfs

E) Forebay Discharge Design

Choose One
- ○ Berm With Pipe
- ◉ Wall with Rect. Notch
- ○ Wall with V-Notch Weir

Flow too small for berm w/ pipe

F) Discharge Pipe Size (minimum 8-inches) — Calculated D_P = in

G) Rectangular Notch Width — Calculated W_N = 4.1 in

Cross Section for Trickle Channel

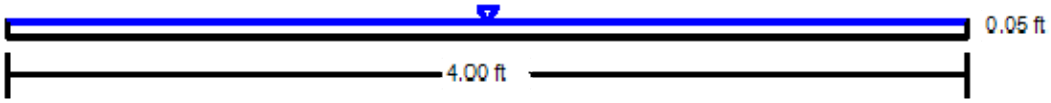
Project Description

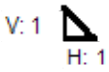
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00500	ft/ft
Normal Depth	0.05	ft
Bottom Width	4.00	ft
Discharge	0.25	ft³/s

Cross Section Image





Spillway Capacity Calculation

Spillway Section

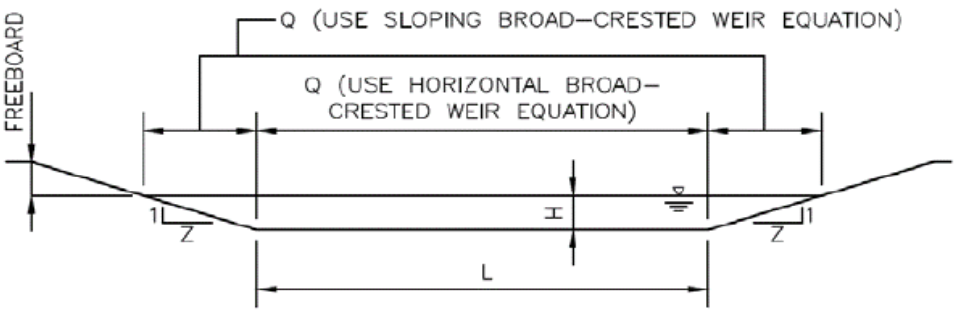


Fig. 12-20 of UDFCD V1

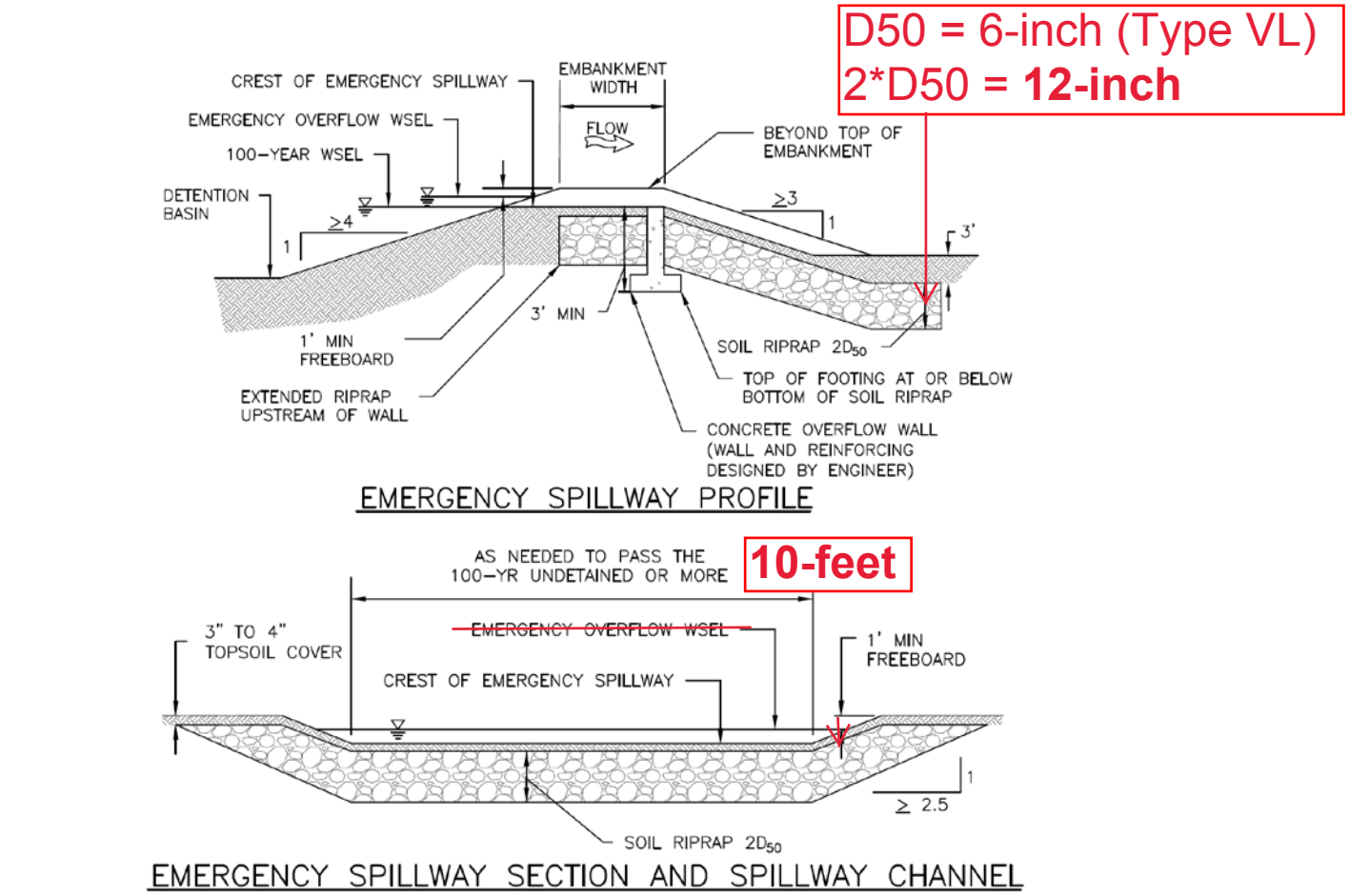
Horizontal Broad Crested Weir: $Q=C_{BCW}LH^{1.5}$ *Eq. 12-20 of UDFCD V1*

Sloping Broad-Crested Weir: $Q=\left(\frac{2}{5}\right)C_{BCW}ZH^{2.5}$ *Eq. 12-21 of UDFCD V1*

100-yr Undetained Runoff	Q =	13.98	cfs
Side slope (horizontal: vertical)	Z =	4	
Broad Crested Weir Coefficient	C_{BCW} =	3.0	
Head above Weir Crest	H =	0.5	ft

Total Required Length $L=\frac{Q-2\left(\frac{2}{5}\right)C_{BCW}ZH^{2.5}}{CH^{1.5}}$

Bottom Length of Weir	L =	10	ft
Unit Discharge	q =	1.40	cfs/ft



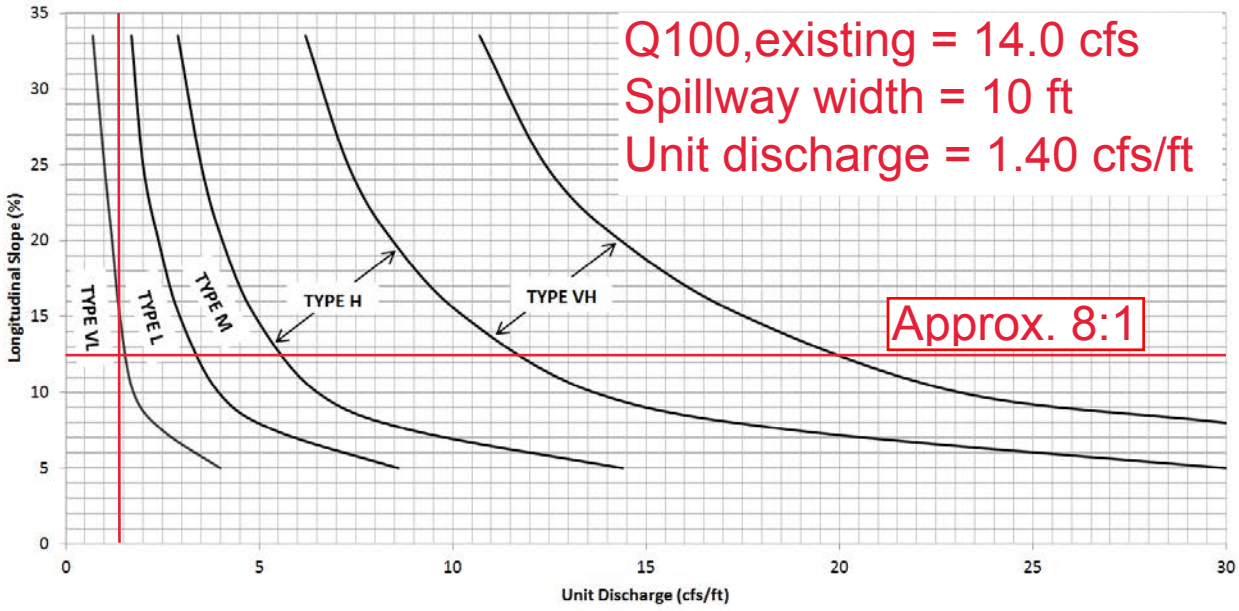
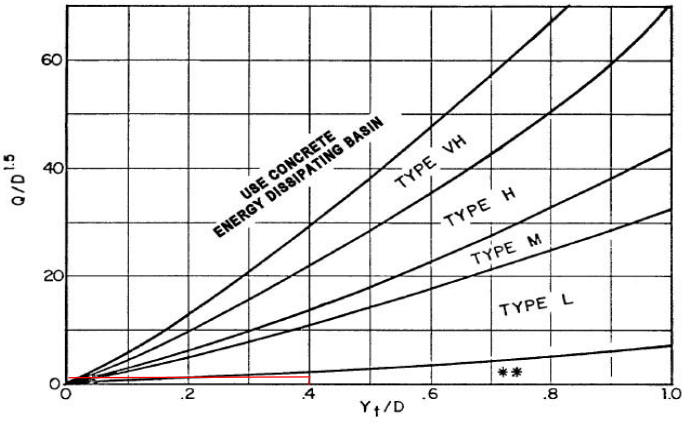


Figure 12-21. Embankment protection details and rock sizing chart (adapted from Arapahoe County)

18" RCP Outfall Protection

Q (cfs)	Dc (ft)	Yt/Dt	Yt	$Q/D^{1.5}$	Selected Riprap
1.24	1.5	0.4	0.6	0.674971	Type-VL



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

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

Curb and Gutter / Street Capacity

Existing Gutter Capacity Determination

1. Calculate upstream runoff along the gutter line.

The gutter line on the southeast side of Eastonville extends from the proposed driveway to the north side of the Bennet Ranch drainageway crossing.

Google Streetview at the upstream end of the gutter line (north side of Bennet Ranch drainageway crossing).

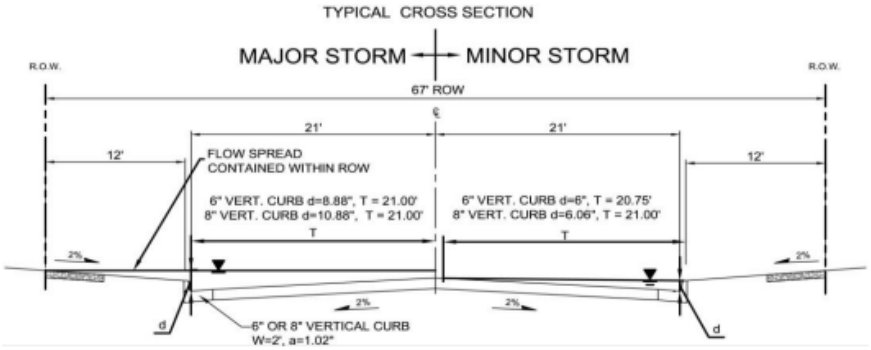
Google Streetview at the upstream end of the gutter line (south side of Bennet Ranch drainageway crossing). Transition from block to 6 inch curb.

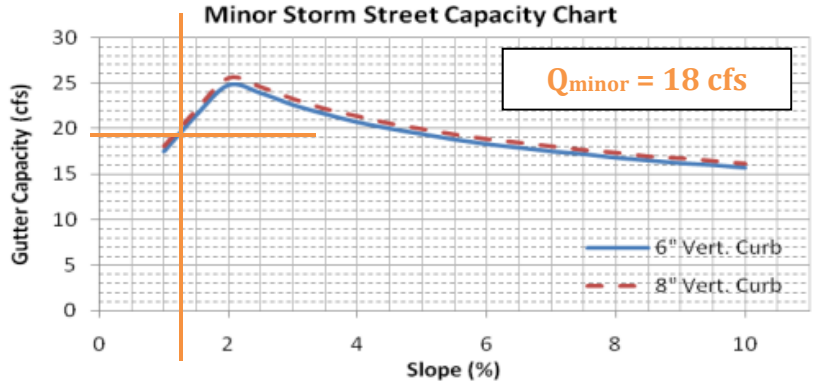
The roadway is crowned in the center with two 20 ft wide lanes plus 2 ft wide gutters on each side as per survey, aerial, and CDOT data. To determine the drainage area to the project driveway, the length was measured along the flow line from the driveway to the upstream end of the gutter line. This length (960 ft) was then multiplied by the lane width (20 ft) to get a drainage area of 0.46 acres. The entire drainage area is paved (100% imperviousness). Runoff was calculated using the Rational Method (see **Appendix C, Existing Conditions**).

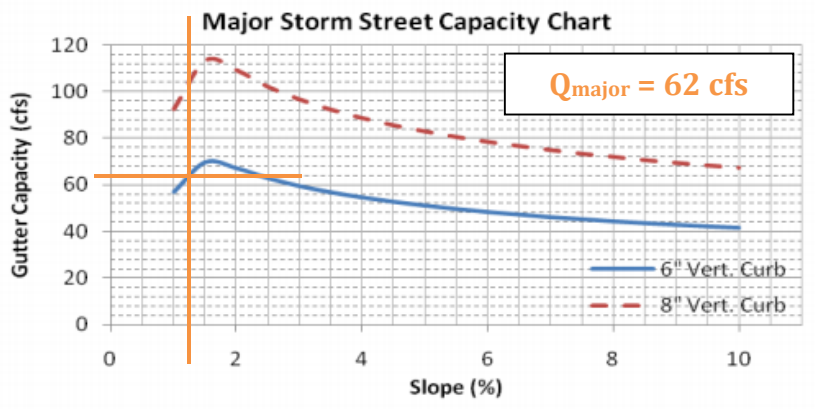
2. Calculate maximum allowable flow in gutter based on El Paso criteria for minor arterials.

Gutter capacity was determined using the street capacity charts in Chapter 7 of DCM-V1-Update. The street is a minor arterial, however, the typical cross-section in Figure 7-5 for Collectors with Parking applies to this roadway (6" vertical curve, d = 6", T_{max} = 22' (20' travel lane with 2' wide gutter)).

Figure 7-5. Street Capacity Charts Collector (with Parking)







These charts shall only be used for the standard street sections as shown. The capacity shown is based on ½ the street section as calculated by the UD-Inlet spreadsheets. Minor storm capacities are based on no crown overtopping, curb height or maximum allowable spread widths. Major storm capacities are based on flow being containing within the public right-of-way, including conveyance capacity behind the curb. The UDFCD Safety Reduction Factor was applied. An 'n_{STREET}' of 0.016 and 'n_{BACK}' of 0.020 was used. Calculations were done using UD-Inlet 3.00.xls, March, 2011.

Parameter	Value	Note
Flow spread, T (ft)	21	Length from crown to gutterline (based on CDOT lane width) plus 1 ft gutter width.
Longitudinal slope, S (ft/ft)	0.013	Measured from the 5958 to 5951 contour.
Manning's n, n	0.016	From Figure 7-5 of DCM-V1-Update.
Minor gutter capacity, Q (cfs)	**18**	Using Figure 7-5 of DCM-V1-Update.
5-year Q (cfs)	**1.8**	From Existing Conditions, UD-Rational.
Major gutter capacity, Q (cfs)	**62**	Using Figure 7-5 of DCM-V1-Update.
100-year Q (cfs)	**3.2**	From Existing Conditions, UD-Rational.

As summarized in the table above, runoff in the minor and major event will be contained within the R.O.W. of Eastonville Road without entering the site.

3. Calculate maximum allowable flow in cross pan/driveway section.

The driveway section geometry was determined from El Paso County Detail SD 2-26 for Typical Cross Pan Layout Detail. Depth from the flowline of the cross pan to the crown of the road is 6.8 inches; the corresponding maximum allowable flow is 51.0 cfs, as shown in the following FlowMasterV8i calculation sheets. The minor and major events will be sufficiently to conveyed in the proposed cross pan along Eatonville Road without entering the site.

Cross Pan and Driveway Section

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.01300	ft/ft
Normal Depth	0.57	ft

Section Definitions

Station (ft)	Elevation (ft)
-0+22	0.57
-0+02	0.17
0+00	0.00
0+06	0.17
0+36	0.76

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+22, 0.57)	(-0+02, 0.17)	0.016
(-0+02, 0.17)	(0+06, 0.17)	0.013
(0+06, 0.17)	(0+36, 0.76)	0.016

Options

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

Results

Discharge		50.95	ft³/s
Elevation Range	0.00 to 0.76 ft		
Flow Area		11.87	ft²
Wetted Perimeter		48.02	ft
Hydraulic Radius		0.25	ft
Top Width		48.00	ft

Cross Pan and Driveway Section

Results

Normal Depth		0.57	ft
Critical Depth		0.65	ft
Critical Slope		0.00522	ft/ft
Velocity		4.29	ft/s
Velocity Head		0.29	ft
Specific Energy		0.85	ft
Froude Number		1.52	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.57	ft
Critical Depth	0.65	ft
Channel Slope	0.01300	ft/ft
Critical Slope	0.00522	ft/ft

Cross Pan and Driveway Section

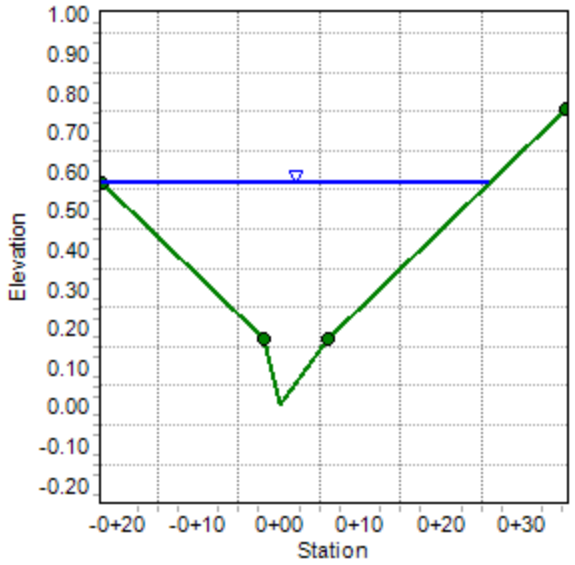
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.01300	ft/ft
Normal Depth	0.57	ft
Discharge	50.95	ft³/s

Cross Section Image



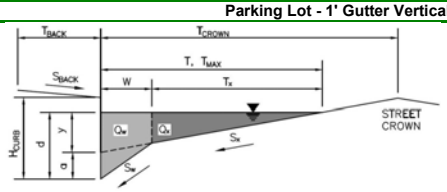
Version 4.05 Released March 2017

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

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

Project: Liberty Tree Academy

Inlet ID: Parking Lot - 1' Gutter Vertical Catch Curb



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	20.0	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} =	0.016	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	30.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.008	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} =	30.0	30.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**16.9**	**143.0**	**cfs**

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

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

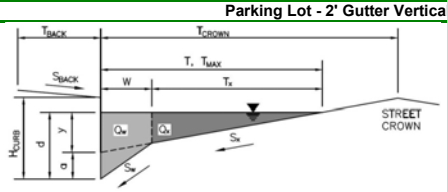
Version 4.05 Released March 2017

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

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

Project: Liberty Tree Academy

Inlet ID: Parking Lot - 2' Gutter Vertical Catch Curb



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	20.0	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} =	0.016	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	30.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.008	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} =	30.0	30.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☑	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**11.9**	**126.2**	**cfs**

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

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

Bennet Ranch Drainageway Capacity

Worksheet for X1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00250	ft/ft
Discharge	810.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
-1+22	6952.00
-1+16	6950.54
-1+13	6950.00
-1+10	6949.29
-1+09	6949.00
-1+09	6948.91
-1+06	6948.39
-1+05	6948.06
-1+05	6948.00
-1+00	6947.87
-1+00	6947.87
-0+99	6947.65
-0+86	6944.96
-0+78	6943.42
-0+74	6942.94
-0+47	6940.17
-0+25	6939.53
-0+16	6939.30
-0+10	6939.19
-0+04	6939.09
-0+03	6937.77
-0+02	6937.26
-0+02	6936.77
-0+01	6936.76
0+00	6936.87
0+03	6936.85
0+04	6936.83

Worksheet for X1

Input Data

Station (ft)	Elevation (ft)
0+04	6936.87
0+10	6939.19
0+12	6939.53
0+40	6945.19
0+50	6945.19

Start Station	Ending Station	Roughness Coefficient
(-1+22, 6952.00)	(-0+25, 6939.53)	0.050
(-0+25, 6939.53)	(-0+04, 6939.09)	0.160
(-0+04, 6939.09)	(0+10, 6939.19)	0.040
(0+10, 6939.19)	(0+12, 6939.53)	0.160
(0+12, 6939.53)	(0+50, 6945.19)	0.050

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		7.14	ft
Elevation Range	6936.76 to 6952.00 ft		
Flow Area		396.96	ft²
Wetted Perimeter		115.86	ft
Hydraulic Radius		3.43	ft
Top Width		113.90	ft
Normal Depth		7.14	ft
Critical Depth		4.13	ft
Critical Slope		0.08816	ft/ft

Worksheet for X1

Results

Velocity		2.04	ft/s
Velocity Head		0.06	ft
Specific Energy		7.20	ft
Froude Number		0.19	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.14	ft
Critical Depth	4.13	ft
Channel Slope	0.00250	ft/ft
Critical Slope	0.08816	ft/ft

Cross Section for X1

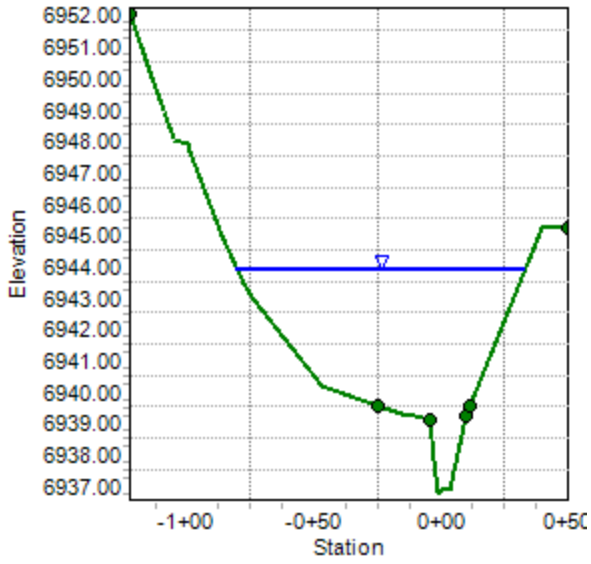
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00250	ft/ft
Normal Depth	7.14	ft
Discharge	810.00	ft³/s

Cross Section Image



Worksheet for X2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00250	ft/ft
Discharge	810.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
-1+21	6952.00
-1+18	6951.62
-1+13	6950.84
-1+11	6950.71
-0+89	6947.86
-0+87	6947.61
-0+85	6947.40
-0+47	6943.05
-0+46	6943.02
-0+22	6941.67
-0+17	6941.62
-0+10	6941.78
-0+08	6940.48
-0+05	6938.40
-0+03	6938.21
0+00	6938.00
0+02	6938.02
0+03	6938.02
0+10	6941.78
0+40	6947.78
0+55	6947.78

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient

Worksheet for X2

Input Data

Start Station	Ending Station	Roughness Coefficient
(-1+21, 6952.00)	(-0+22, 6941.67)	0.050
(-0+22, 6941.67)	(-0+10, 6941.78)	0.160
(-0+10, 6941.78)	(0+10, 6941.78)	0.040
(0+10, 6941.78)	(0+55, 6947.78)	0.050

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		7.87	ft
Elevation Range	6938.00 to 6952.00 ft		
Flow Area		346.08	ft²
Wetted Perimeter		104.77	ft
Hydraulic Radius		3.30	ft
Top Width		102.19	ft
Normal Depth		7.87	ft
Critical Depth		4.97	ft
Critical Slope		0.06270	ft/ft
Velocity		2.34	ft/s
Velocity Head		0.09	ft
Specific Energy		7.96	ft
Froude Number		0.22	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft

Worksheet for X2

GVF Output Data

Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.87	ft
Critical Depth	4.97	ft
Channel Slope	0.00250	ft/ft
Critical Slope	0.06270	ft/ft

Cross Section for X2

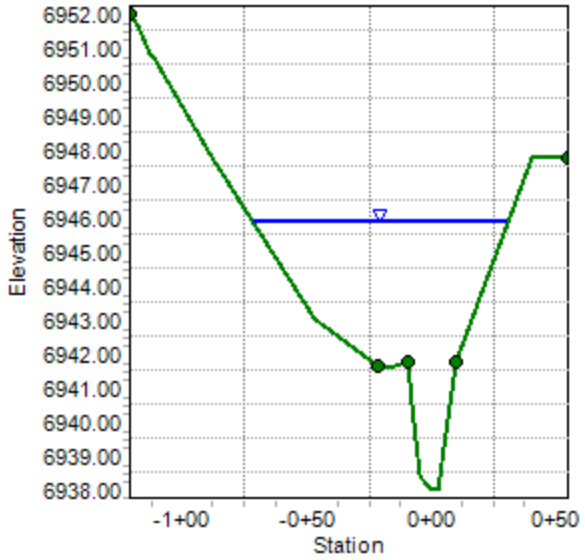
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00250	ft/ft
Normal Depth	7.87	ft
Discharge	810.00	ft³/s

Cross Section Image



Cross Section for X2, WSEL = 6942

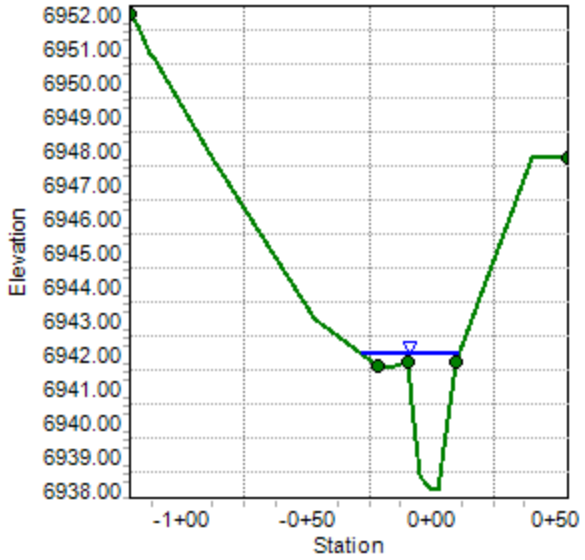
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00250	ft/ft
Normal Depth	4.00	ft
Discharge	59.97	ft³/s

Cross Section Image



Cross Section for X2, WSEL = 6945

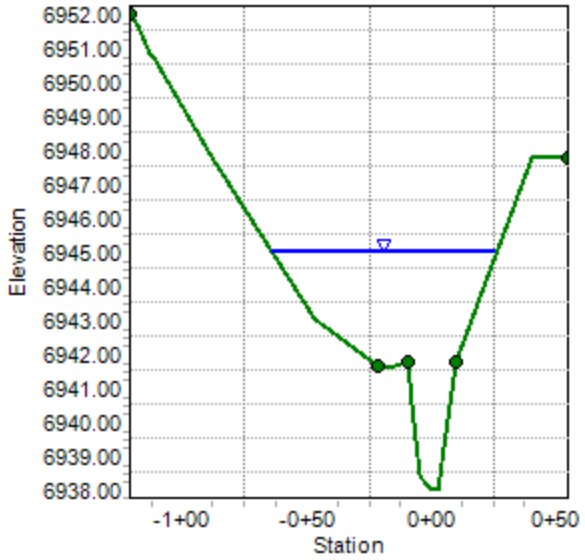
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00250	ft/ft
Normal Depth	7.00	ft
Discharge	537.83	ft³/s

Cross Section Image



APPENDIX E – REFERENCED DOCUMENTS

Selected Pages from the Bennett Ranch

Drainage Basin Planning Study

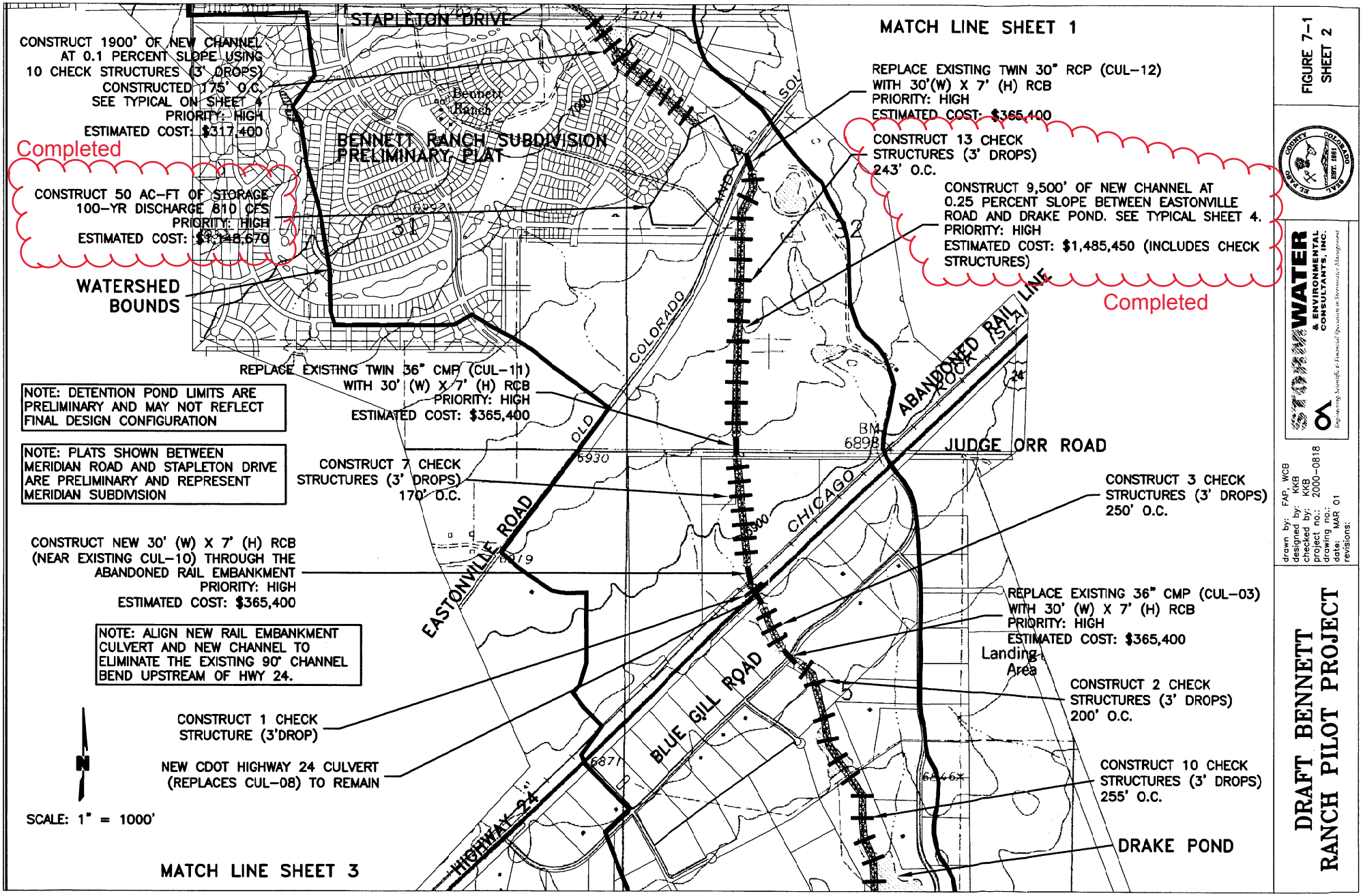
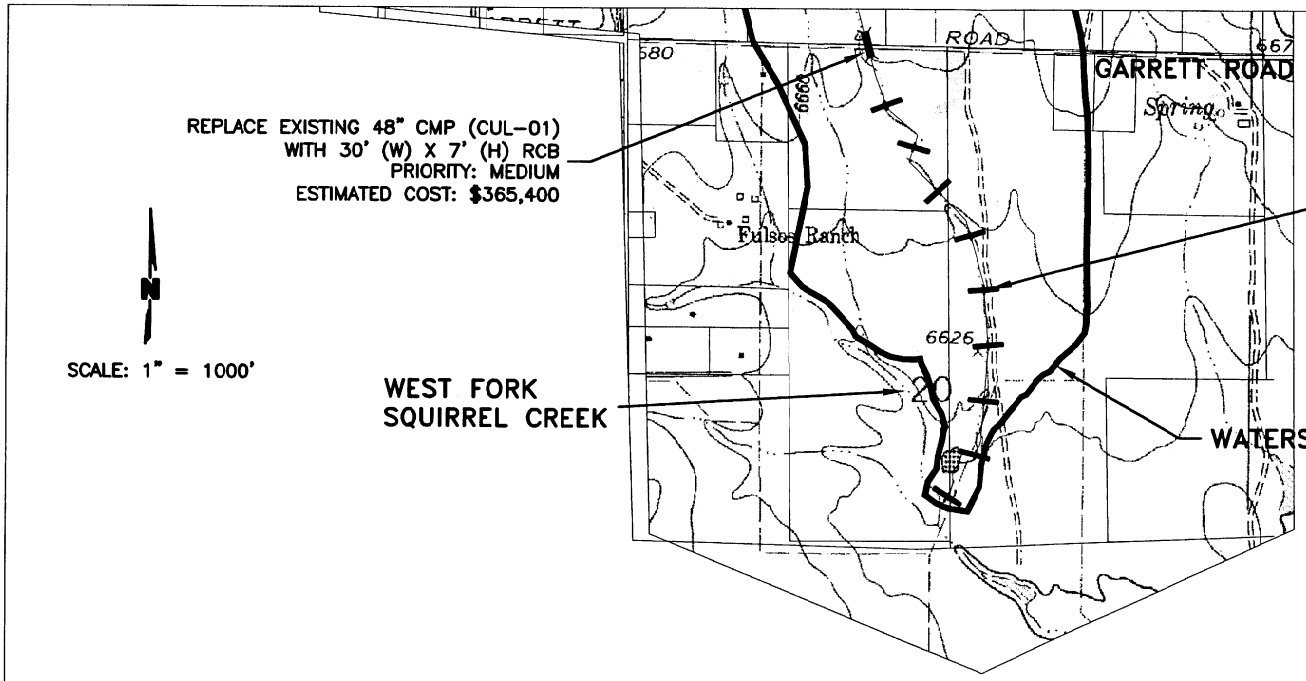


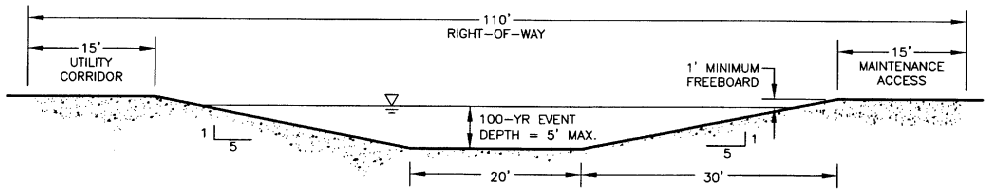
FIGURE 7-1
SHEET 2

WATER & ENVIRONMENTAL CONSULTANTS, INC.

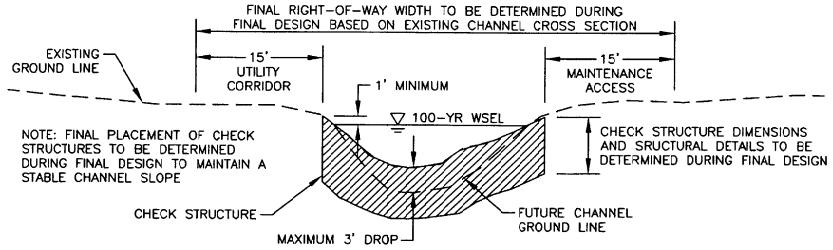
drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:

DRAFT BENNETT RANCH PILOT PROJECT

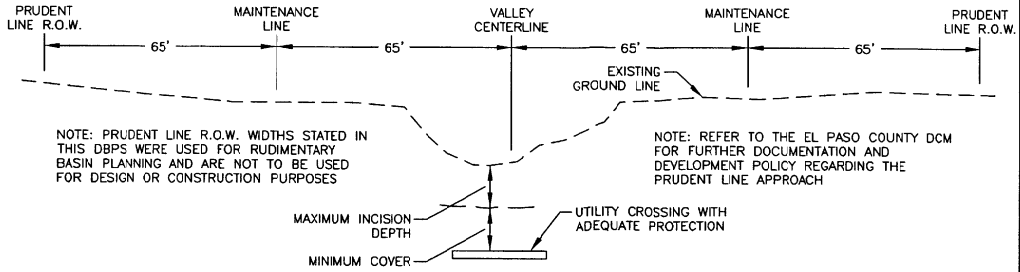




TYPICAL NEW CHANNEL CROSS SECTION
STAPLETON DRIVE TO DRAKE POND
SCALE: 1"=10'



TYPICAL EXISTING CHANNEL CROSS
SECTION WITH CHECK STRUCTURES
SUNNYSLOPE DRIVE TO WEST FORK SQUIRREL CREEK
SCALE: 1"=10'



TYPICAL PRUDENT LINE CHANNEL
SNOWBRUSH DRIVE TO MERIDIAN ROAD
NOT TO SCALE

FIGURE 7-1
SHEET 4

EL PASO COUNTY COLORADO ESTD. 1861

WATER
& ENVIRONMENTAL
CONSULTANTS, INC.
Engineering, Scientific & Financial Specialists in Stormwater Management

drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR '01
revisions:

DRAFT BENNETT RANCH PILOT PROJECT

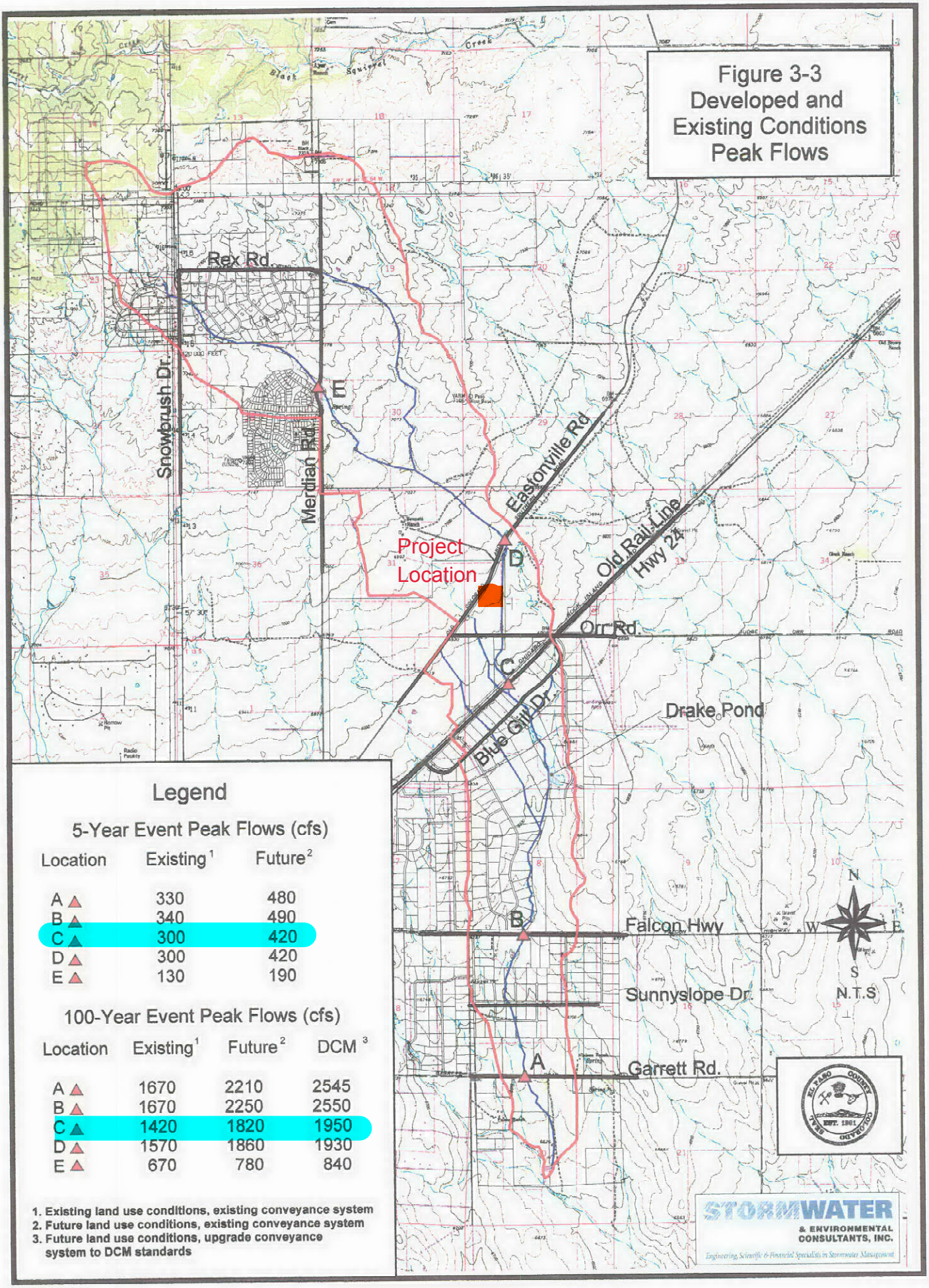
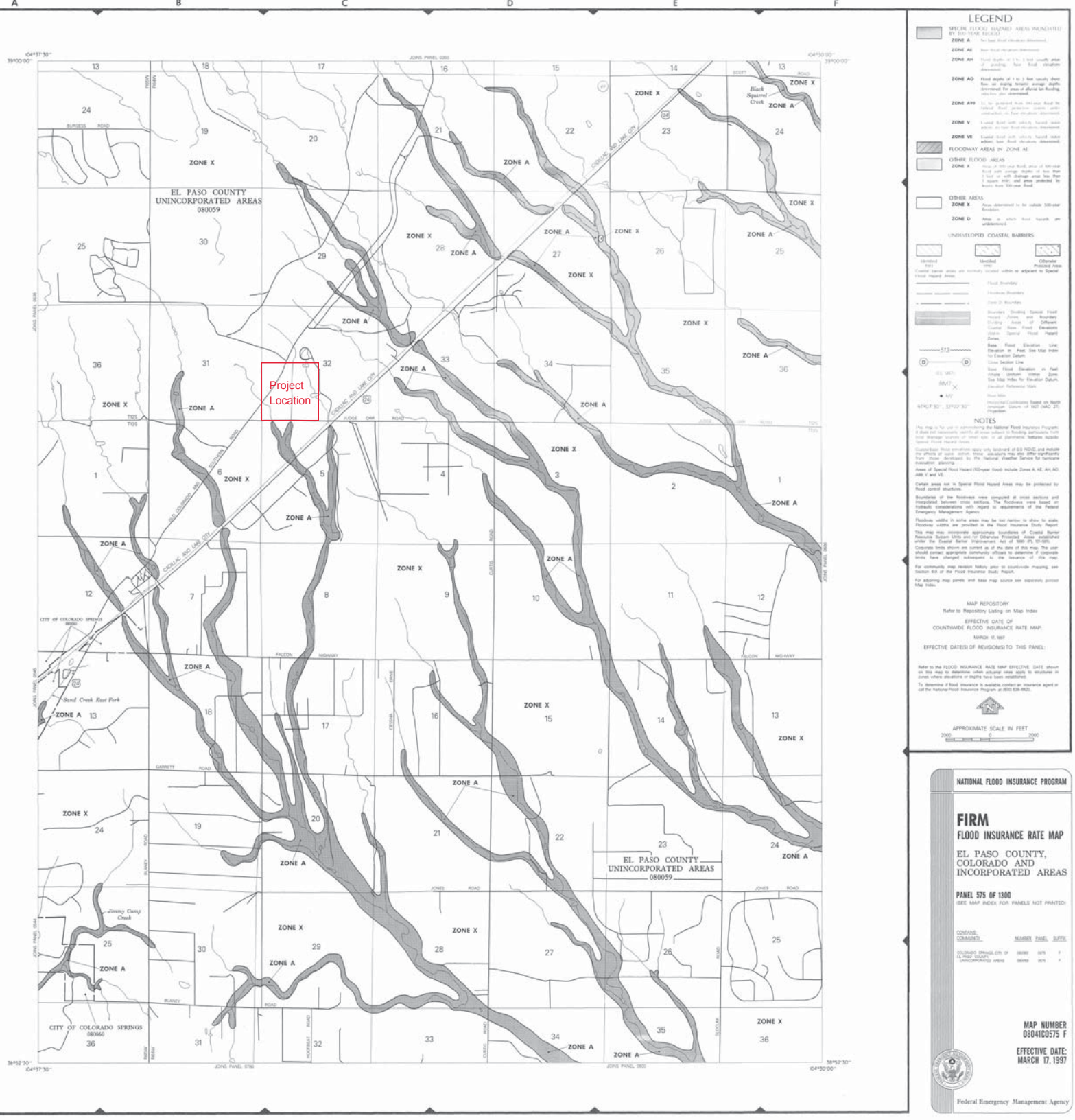


Figure 3-3
Developed and
Existing Conditions
Peak Flows
Rex Rd.
Snowbrush Dr.
Meridian Rd.
Eastonville Rd.
Old Rail Line
Hwy 24
Project
Location
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
A
B
C
D
E
N
S
E
W
N.T.S
Legend
5-Year Event Peak Flows (cfs)
Location Existing[1] Future[2]
A 330 480
B 340 490
C 300 420
D 300 420
E 130 190
100-Year Event Peak Flows (cfs)
Location Existing[1] Future[2] DCM[3]
A 1670 2210 2545
B 1670 2250 2550
C 1420 1820 1950
D 1570 1860 1930
E 670 780 840
1. Existing land use conditions, existing conveyance system
2. Future land use conditions, existing conveyance system
3. Future land use conditions, upgrade conveyance system to DCM standards
STORMWATER
& ENVIRONMENTAL CONSULTANTS, INC.
Engineering, Scientific & Financial Specialists in Stormwater Management

FEMA Flood Maps


Project Location
EL PASO COUNTY UNINCORPORATED AREAS 080059
CITY OF COLORADO SPRINGS 080060
Black Squirrel Creek
Sand Creek East Fork
Jimmy Camp Creek
ZONE A
ZONE X
LEGEND
NOTES
MAP REPOSITORY
Refer to Repository Listing on Map Index
EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP:
MARCH 17, 1997
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL:
APPROXIMATE SCALE IN FEET
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
EL PASO COUNTY, COLORADO AND INCORPORATED AREAS
PANEL 575 OF 1300
(SEE MAP INDEX FOR PANELS NOT PRINTED)
MAP NUMBER 08041C0575 F
EFFECTIVE DATE: MARCH 17, 1997
Federal Emergency Management Agency

URBAN DRAINAGE FLOOD CONTROL DISTRICT STANDARDS

Table EDB-4. EDB component criteria

	On-Site EDBs for Watersheds up to 1 Impervious Acre[1]	EDBs with Watersheds between 1 and 2 Impervious Acres[1]	EDBs with Watersheds up to 5 Impervious Acres	EDBs with Watersheds over 5 Impervious Acres	EDBs with Watersheds over 20 Impervious Acres
Forebay Release and Configuration	EDBs should not be used for watersheds with less than 1 impervious acre.	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch or berm/pipe[2] configuration
Minimum Forebay Volume		1% of the WQCV	2% of the WQCV	3% of the WQCV	3% of the WQCV
Maximum Forebay Depth		12 inches	18 inches	18 inches	30 inches
Trickle Channel Capacity		≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity
Micropool		Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2
Initial Surcharge Volume		Depth ≥ 4 inches	Depth ≥ 4 inches	Depth ≥ 4 in. Volume ≥ 0.3% WQCV	Depth ≥ 4 in. Volume ≥ 0.3% WQCV

[1] EDBs are not recommended for sites with less than 2 impervious acres. Consider a sand filter or rain garden.

[2] Round up to the first standard pipe size (minimum 8 inches).

5. **Forebay Design**: The forebay provides an opportunity for larger particles to settle out in an area that can be easily maintained. The length of the flow path through the forebay should be maximized, and the slope minimized to encourage settling. The appropriate size of the forebay may be as much a function of the level of development in the tributary area as it is a percentage of the WQCV. When portions of the watershed may remain disturbed for an extended period of time, the forebay size will need to be increased due to the potentially high sediment load. Refer to Table EDB-4 for a design criteria summary. When using this table, the designer should consider increasing the size of the forebay if the watershed is not fully developed.

   The forebay outlet should be sized to release 2% of the undetained peak 100-year discharge. A soil riprap berm with 3:1 sideslopes (or flatter) and a pipe outlet or a concrete wall with a notch outlet should be constructed between the forebay and the main EDB. It is recommended that the berm/pipe configuration be reserved for watersheds in excess of 20 impervious acres to accommodate the minimum recommended pipe diameter of 8 inches. When using the berm/pipe configuration, round up to the nearest standard pipe size and use a minimum diameter of 8 inches. The floor of the forebay should be concrete or lined with grouted boulders to define sediment removal limits. With either configuration, soil riprap should also be provided on the downstream side of the forebay berm or wall if the downstream grade is lower than the top of the berm or wall. The forebay will overtop frequently so this protection is necessary for erosion control. All soil riprap in the area of the forebay should be seeded and erosion control fabric should be placed to retain the seed in this high flow area.

6. **Trickle Channel:** Convey low flows from the forebay to the micropool with a trickle channel. The trickle channel should have a minimum flow capacity equal to the maximum release from the forebay outlet.

   - **Concrete Trickle Channels:** A concrete trickle channel will help to establish the bottom of the basin long-term and may also facilitate regular sediment removal. It can be a "V" shaped concrete drain pan or a concrete channel with curbs. A flat-bottom channel facilitates maintenance. A slope between 0.4% - 1% is recommended to encourage settling while reducing the potential for low points within the pan.

   - **Soft-bottom Trickle Channels**: When designed and maintained properly, soft-bottom trickle channels can allow for an attractive alternative to concrete. They can also improve water quality. However, they are not appropriate for all sites. Be aware, maintenance of soft bottom trickle channels requires mechanical removal of sediment and vegetation. Additionally, this option provides mosquito habitat. For this reason, UDFCD recommends that they be considered on a case-by-case basis and with the approval of the local jurisdiction. It is recommended that soft bottom trickle channels be designed with a consistent longitudinal slope from forebay to micropool and that they not meander. This geometry will allow for reconstruction of the original design when sediment removal in the trickle channel is necessary. The trickle channel may also be located along the toe of the slope if a straight channel is not desired. The recommended minimum depth of a soft bottom trickle channel is 1.5 feet. This depth will help limit potential wetland growth to the trickle channel, preserving the bottom of the basin.

     Riprap and soil riprap lined trickle channels are not recommended due to past maintenance experiences, where the riprap was inadvertently removed along with the sediment during maintenance.

7. **Micropool and Outlet Structure**: Locate the outlet structure in the embankment of the EDB and provide a permanent micropool directly in front of the structure. Submerge the well screen to the bottom of the micropool. This will reduce clogging of the well screen because it allows water to flow though the well screen below the elevation of the lowest orifice even when the screen above the water surface is plugged. This will prevent shallow ponding in front of the structure, which provides a breeding ground for mosquitoes (large shallow puddles tend to produce more mosquitoes than a smaller, deeper permanent pond).

   Basins with micropools have fewer mosquitoes. Micropools reduce shallow wet areas where breeding is most favorable.

   Micropool side slopes may be vertical walls or stabilized slopes of 3:1 (horizontal:vertical). For watersheds with less than 5 impervious acres, the micropool can be located inside the outlet structure (refer to Figures OS-7 and OS-8 provided in Fact Sheet T-12). The micropool should be at least 2.5 feet in depth with a minimum surface area of 10 square feet. The bottom should be concrete unless a baseflow is present or anticipated or if groundwater is anticipated. Riprap is not recommended because it complicates maintenance operations.

   Where possible, place the outlet in an inconspicuous location as shown in Photo EDB-3. This urban EDB utilizes landscaped parking lot islands connected by a series of culverts (shown in Photo EDB-4) to provide the required water quality and flood control volumes.

   The outlet should be designed to release the WQCV over a 40-hour period. Draining a volume of water over a specified time can be done through an orifice plate as detailed in Fact Sheet T-12. Use reservoir routing calculations as discussed in the *Storage* Chapter of Volume 2 to assist in the design. Two workbooks tools have been developed by UDFCD for this purpose, UD-FSD and UD-Detention. Both are available at www.udfcd.org. UD-FSD is recommended for a typical EDB full spectrum detention design. UD-Detention uses the same methodology and can be used for a full spectrum detention basin or a WQCV only design. It also allows for a wider range of outlet controls should the user want to specify something beyond what is shown in Fact Sheet T-12.

   Refer to BMP Fact Sheet T-12 for schematics pertaining to structure geometry, grates, trash racks, orifice plate, and all other necessary components.

   The outlet may have flared or parallel wing walls as shown in Figures EDB-1 and EDB-2, respectively. Either configuration should be recessed into the embankment to minimize its profile. Additionally, the trash rack should be sloped with the basin side-slopes.

Off-site Drainageway Analysis

From UDFCD, Volume 1:

Table 8-5. Recommended roughness values

Location and Cover	When Assessing Velocity, Froude No., Shear Stress	When Assessing Water Surface Elevation and Water Depth
Main Channel (bankfull channel)		
Sand or clay bed	0.03	0.04
Gravel or cobble bed	0.035	0.07
Vegetated Overbanks		
Turfgrass sod	0.03	0.04
Native grasses	0.032	0.05
Herbaceous wetlands (few or no willows)	0.06	0.12
Willow stands, woody shrubs	0.07	0.16

(Source: Chow 1959, USDA 1954, Barnes 1967, Arcement and Schneider 1989, Jarrett 1985)

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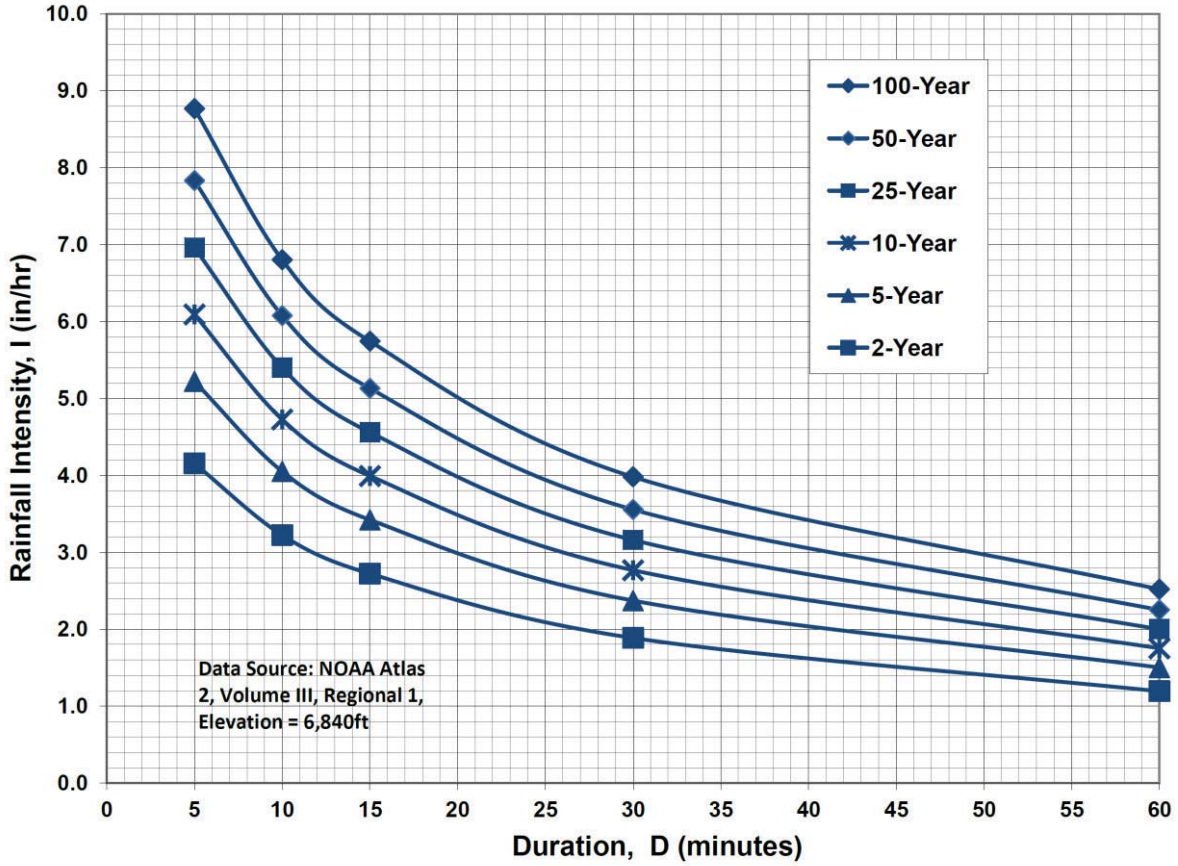
Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

$I_{2} = -1.19 \ln(D) + 6.035$

Note: Values calculated by equations may not precisely duplicate values read from figure.