LIBERTY TREE ACADEMY

DRAFT PRELIMINARY DRAINAGE REPORT

"Final" when complete

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:

May 1, 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 negligent acts, errors or omissions on my part in preparing this report.

_____
date

Use current signature blocks.

_____
Registered Professional Engineer
State of Colorado No._

Developer's Statement

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

_____
Business Name

By: _____

Title: _____

Address: _____

_____

El Paso County
Filed in accordance with Section 51.1 of the El Paso Land Development Code, as amended.

_____ _____
Director of Public Works date

Conditions:

TABLE OF CONTENTS

Provide Existing Drainage Plan

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I. GENERAL LOCATION AND DESCRIPTION

A. Location

The approximate latitude and longitude are 38°57'35"N and 104°35'11, which is in Township 12S, and Range 64W, Section 32, SW Quarter, as shown in **Figure 1**Error! Reference source not found.. 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 E**.

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 2.2 acre project area, undeveloped land, and a 240-ft wide drainage easement. This Preliminary 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

N

0 500 1,000

Feet

April 23, 2018

LIBERTY TREE ACADEMY

Matrix DESIGN GROUP
AN EMPLOYEE-OWNED COMPANY

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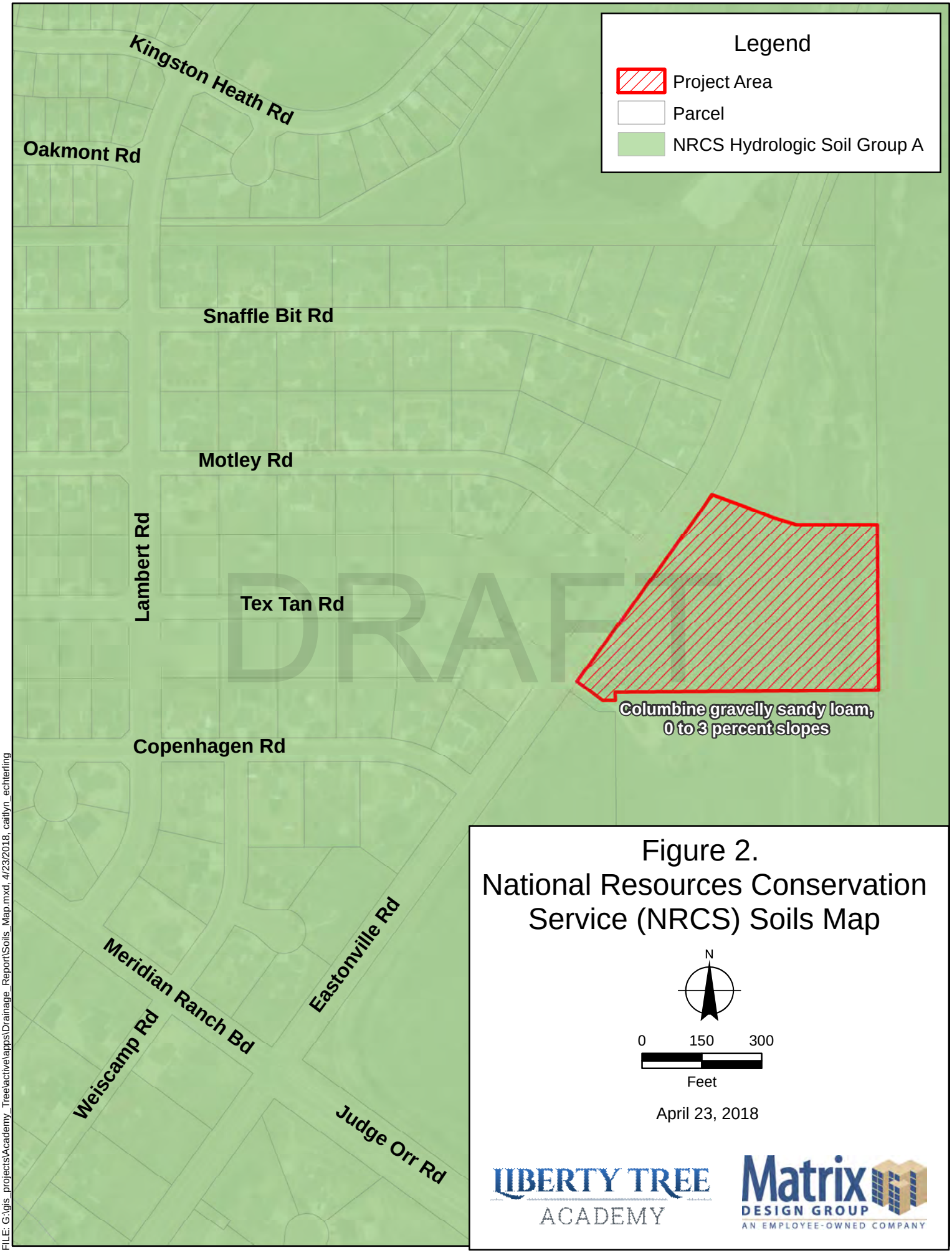

Figure 2.
National Resources Conservation Service (NRCS) Soils Map

N

0 150 300

Feet

April 23, 2018

LIBERTY TREE ACADEMY

Matrix DESIGN GROUP
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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 *Bennet 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 still 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 detention pond (Design Point 3). Basin OS2 will also be replanted consistent with existing ground cover and will be retained as a drainage easement.

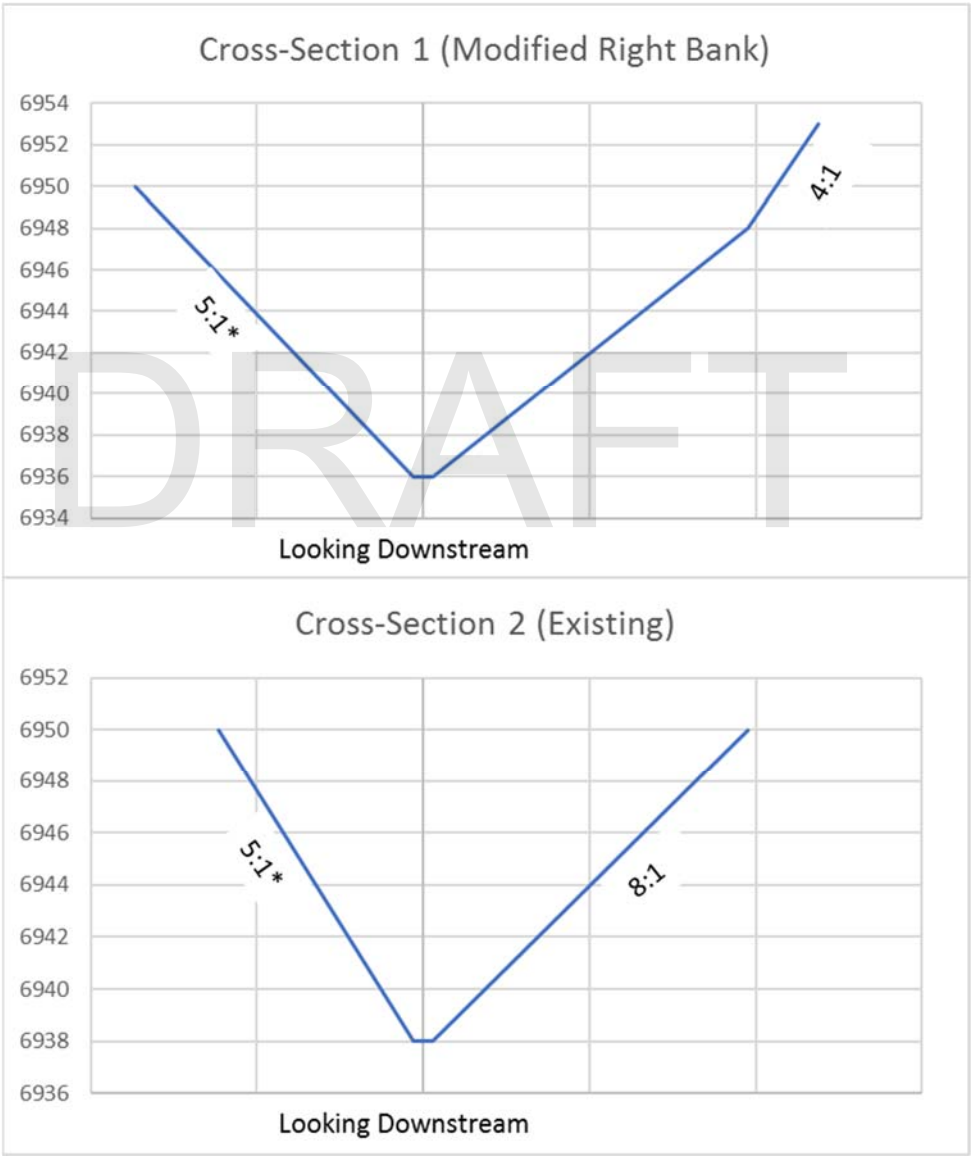
In order to ensure the existing off-site drainageway can sufficiently pass 100-year peak flows without resulting in adverse site impacts, a normal depth analysis was conducted using FlowMaster, version 8i. 100-year master planned flows from the DBPS were considered in this analysis (100-year DCM flows at Point C, 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 approximated Manning's n for the channel is based on a mixture of native grasses and willow stands (0.10). The resulting typical cross-sections are presented in **Figure 3**. The resulting water surface elevations and freeboard are presented in **Table 1**.

Table 1 – Drainageway Analysis (100-Year Master Planned Flows)

Scenario	Manning's n[1]	Flow Depth (feet)	Freeboard (feet)
Cross-section 1	0.10	10.6	3.4
Cross-section 2	0.10	11.1	0.9

Notes:

1. *Average of Manning's n for water surface elevation analyses for Willow Stands and Native Grasses based on values in Table 8-5 in UDFCD Volume 1.*
2. *100-Year Master Planned Flow = 1950 cfs, as per the DBPS for 100-year DCM flows at Point C, see **Appendix E**).*



** Estimated based on best judgement and Selected Alternative in DBPS.*

Figure 3 – Off-site Drainageway Capacity Evaluation

This is an old reference. New is 6.3.2, 6.3.5 -- https://planningdevelopment.elpasoco.com/wp-content/uploads/LandUseCode/EPC-Land-Use-Code-Chapter-6-2016.pdf

III. DRAINAGE DESIGN CRITERIA

A. Development Criteria Reference

This report is prepared in accordance with the following:

- Chapter V, Section 51.1 - Drainage, Erosion Control Plans and Subdivision Grading and Section 49.3 D - Drainage Facilities of the El Paso County Land Development Code.
- City of Colorado Springs Drainage Criteria Manual Volume 1 and Volume 1 Update (DCM-V1, DCM-V1-Update)
- City of Colorado Springs 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.

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 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 2**.

Table 2 – 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

Composite percent imperviousness, assuming Type A soils (see **Figure 2**), for each historic and proposed basin were determined using the land use categories presented in **Table 3** and **Appendix C**. These composite percent imperviousness values were then used to determine runoff coefficients using UD-Rational, Version 2.00, and Table 6-6 in DCM-V1-Update.

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 lands that drain to the proposed detention pond. This basin is included in the grading extents of this project but will be restored to natural conditions. Even though Basin OS1 is considered undeveloped at this time, the off-site flow analysis percent imperviousness (45%), as per DCM-V1-Update criteria, was assumed.

Table 3 – 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
Offsite Flow Analysis (when Land Use is undefined)	45

IV. DRAINAGE FACILITY DESIGN

A. General Concept

Rational?

The site was analyzed using the SCS method for both the historic and the developed conditions for the design storms outlined in the adopted sections of the DCM-V1. A detention pond is proposed at the downstream boundary of the project area such that the release rate for each design storm will be at or below the historic flow rates as determined by the historic analysis.

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 retain 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.

B. Specific Details

Historic and proposed hydrologic conditions are presented in **Tables 4** and **5**, respectively. 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. 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.

In order to preserve historic flow rates, a full spectrum detention pond will be used to detain proposed site release rates. Based on this hydraulic analysis, the total active pond volume required is **0.40** acre-ft (**0.63** acre-ft with 1-ft of freeboard). This detention pond will be located at the northeast corner of the school. The outlet structure was sized using UD-Detention, version 3.07, in accordance with DCM-V1-Update criteria.

Flow will enter the detention pond via the concrete pans within the parking lot and flow down a riprap rundown to the forebay. The pond forebay is sized for 5% of the WQCV, as per DCM-V2. DCM-V2 recommends a pipe through berm to release the forebay volume, but UDFCD has phased this approach out for watersheds less than 20 acres. This design utilizes a 1-ft tall (to the notch invert) notched concrete weir to release 2% of undetained 100-year peak flows, as per Table EDB-4 in UDFCD Volume 3. The 100-year undetained flows are provided in Table 5 for basins A and OS1, which inflow into the detention pond. The target release rate is 0.28 cfs, which can be achieved with a 6-inch by 6-inch notch.

The low flow channel will be concrete and 9-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 between 0.4% and 1%, as per UDFCD Volume 3. The adjacent vegetated areas will slope towards the low flow channel at slopes between 2 to 3%, minimum, as per DCM-V2 and UDFCD Volume 3.

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 under 72-hours. An 18-inch pipe with a restrictor plate will maintain a 2.5-ft deep micropool within the outlet structure (see UDFCD Volume 3, Section T-12, Figure OS-5 in **Appendix B**). Outflows will be conveyed under the existing water line to the Bennett Ranch drainageway. Outfall protection will be provided at the pipe outfall.

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 (to be provided as part of future submissions).

Table 4 – Pre-developed Hydrology

Design Point	Drainage Area (ac)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
4 (Basin HA)	6.20	0.24	1.2	2.6	5.0	6.7	8.8

Notes:

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

Table 5 – Post-developed Hydrology

Design Point	Drainage Area (ac)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
1 (Basin A)	3.0	4.3	5.7	6.8	8.1	9.5	11.1
2 (Basin OS1)	1.1	0.66	1.0	1.4	1.9	2.3	2.7
3 (Pond A)		0.09	0.12	0.15	0.73	1.3	1.3
4 (Basin OS2)	2.1	0.08	0.41	0.90	1.7	2.3	3.0
Total (Pond A + OS2)	**6.2**	**0.17**	**0.53**	**1.1**	**2.4**	**3.6**	**4.3**

Notes:

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

Based on this analysis, the proposed detention pond will release flows resulting from each design storm at or below the historic flow rates as determined by the historic analysis.

V. REFERENCES

Bentley. 2009. FlowMaster Hydraulic Toolbox, Version 8i. November 4, 2009.

El Paso County. 2016. Engineering Criteria Manual, Revision 6. El Paso County. Adopted 12/23/2004. Revised 12/13/2016.

El Paso County. 1994. City of Colorado Springs Drainage Criteria Manual Volume 1 (DCM 1). Chapters 1 through 5. Prepared by City of Colorado Springs. Adopted by El Paso County. October 1994.

El Paso County. 2014. City of Colorado Springs Drainage Criteria Manual Volume 1 Update (DCM 1). Chapters 6 through 13. Prepared by City of Colorado Springs. Adopted by El Paso County. May 2014.

El Paso County. 2002. City of Colorado Springs Drainage Criteria Manual Volume 2 (DCM 2). Prepared by City of Colorado Springs. Adopted by El Paso County. November 2002.

El Paso County. 2000. El Paso County Land Development Code, Chapter V. El Paso County. Last Updated June 29, 2000.

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.

Urban Drainage and Flood Control District (UDFCD). 2018. Urban Storm Drainage Criteria Manual, Volumes 1 through 3. Urban Drainage and Flood Control District. Last updated April 2018.

Urban Drainage and Flood Control District (UDFCD). 2017a. UD-Detention, Version 3.07. Urban Drainage and Flood Control District. Last updated February 2017.

Urban Drainage and Flood Control District (UDFCD). 2017b. UD-Rational, Version 2.00. Urban Drainage and Flood Control District. Last updated May 2017.

APPENDIX A – SITE PHOTOS

Figure A1. Project area looking east.

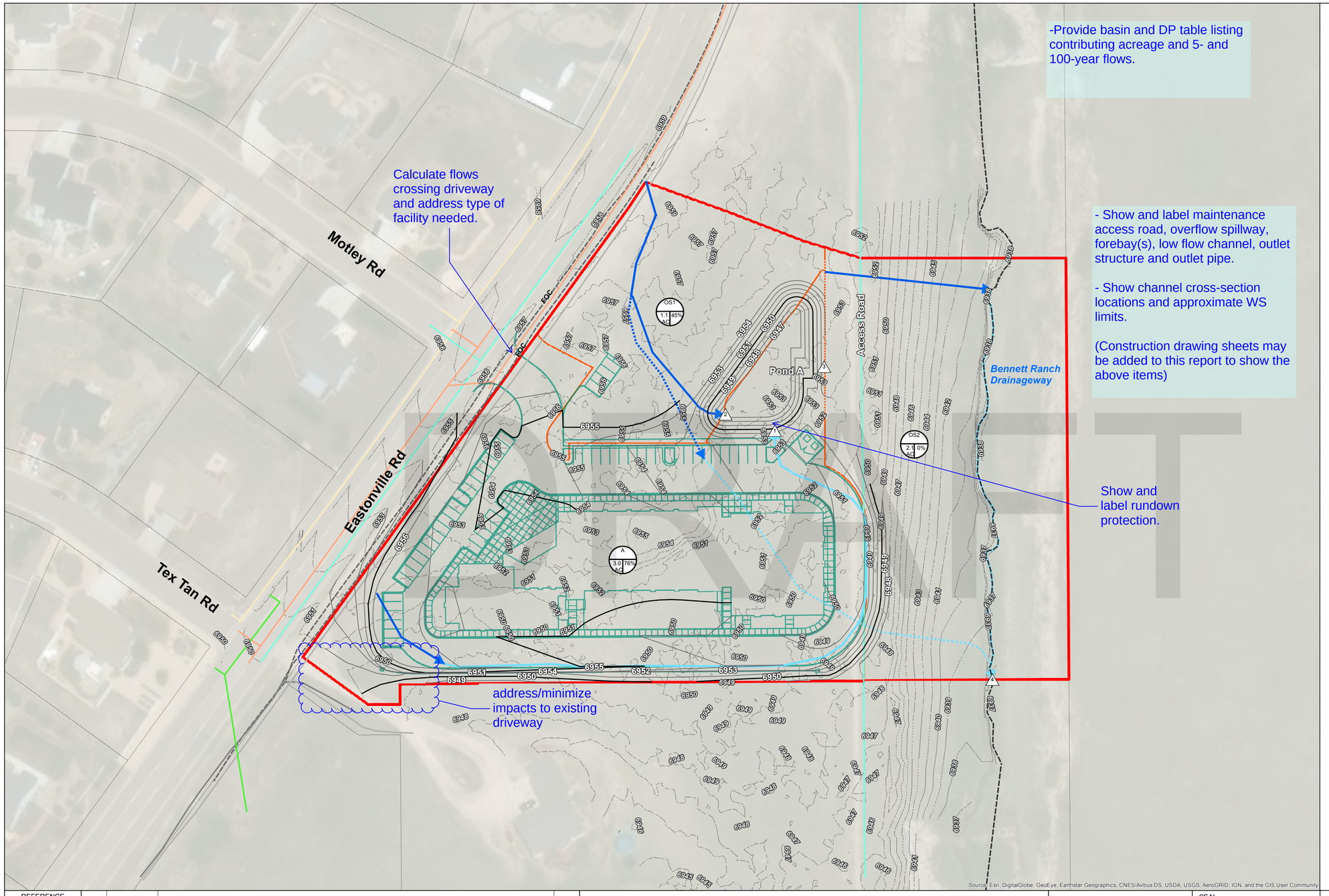
Figure A2. Project area looking south east along utility access towards the drainage easement.

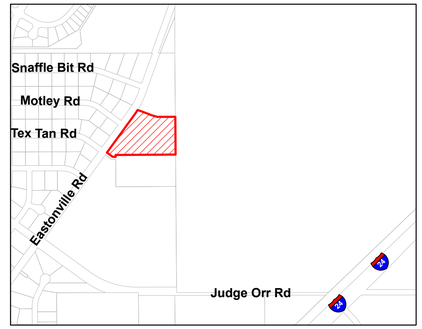
Figure A3. Project area looking north along Eastonville Road right-of-way.

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





VICINITY MAP

Legend

- Existing Contours (1ft)

Proposed contours

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

Proposed Flow Paths

- Channelized
- Overflow

Existing Flow Paths

- Channelized
- Overflow
- Proposed School and Parking
- Overall Proposed Basin/ Historic Basin
- Proposed Sub-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

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PLOT DATE: 5/1/2018
THIS DRAWING IS CURRENT AS OF THE PLOT DATE AND MAY BE SUBJECT TO CHANGE.

PREPARED BY:
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SEAL

PRELIMINARY
THIS DRAWING HAS NOT BEEN APPROVED BY GOVERNING AGENCIES AND IS SUBJECT TO CHANGE

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

LIBERTY TREE ACADEMY

PRELIMINARY DRAINAGE PLAN

FIGURE A-2. PROPOSED DRAINAGE PLAN

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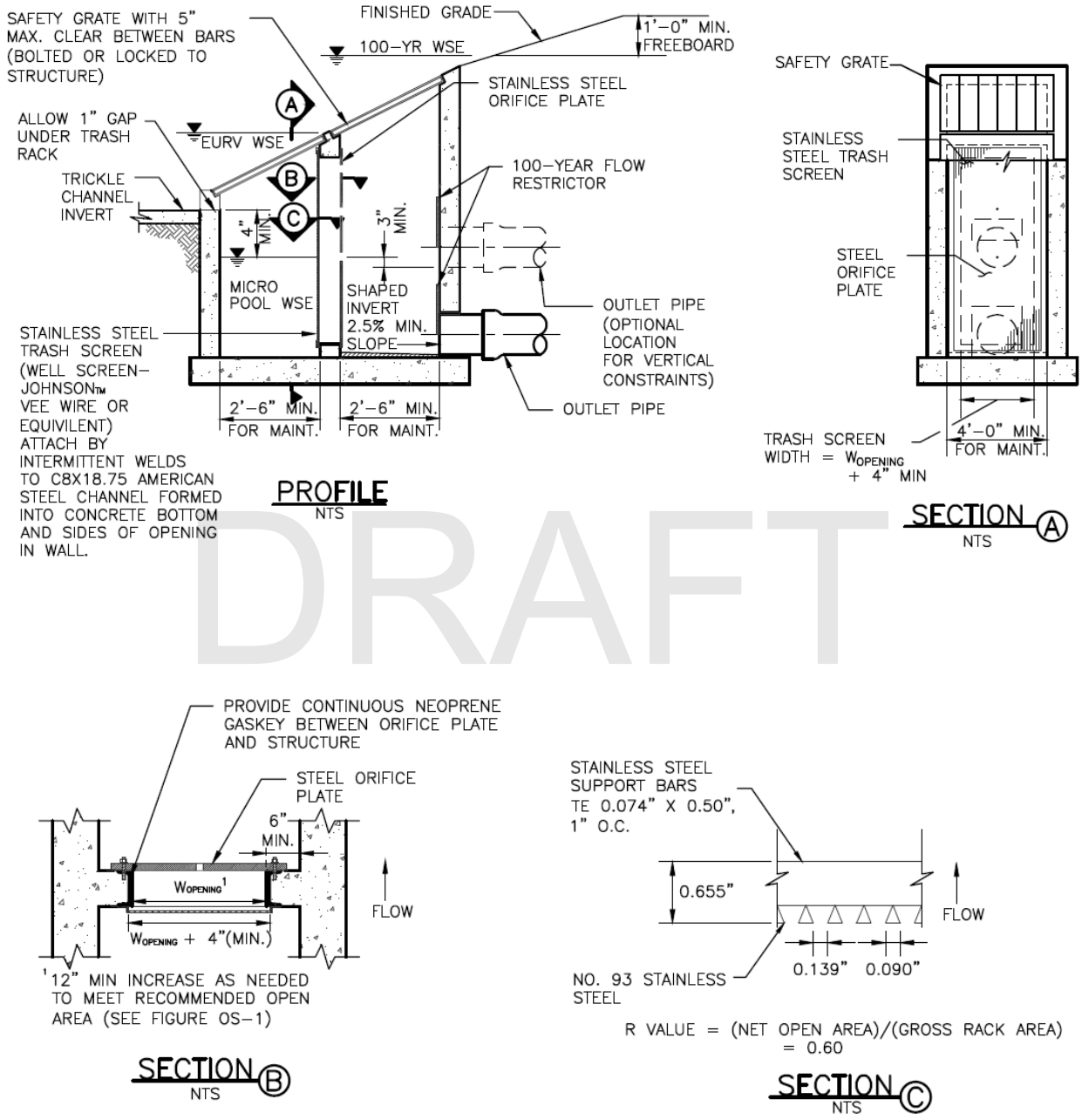


Figure OS-7. Full spectrum detention outlet structure for 5-acre impervious area or less

Selected Pages from the Bennett Ranch

Drainage Basin Planning Study

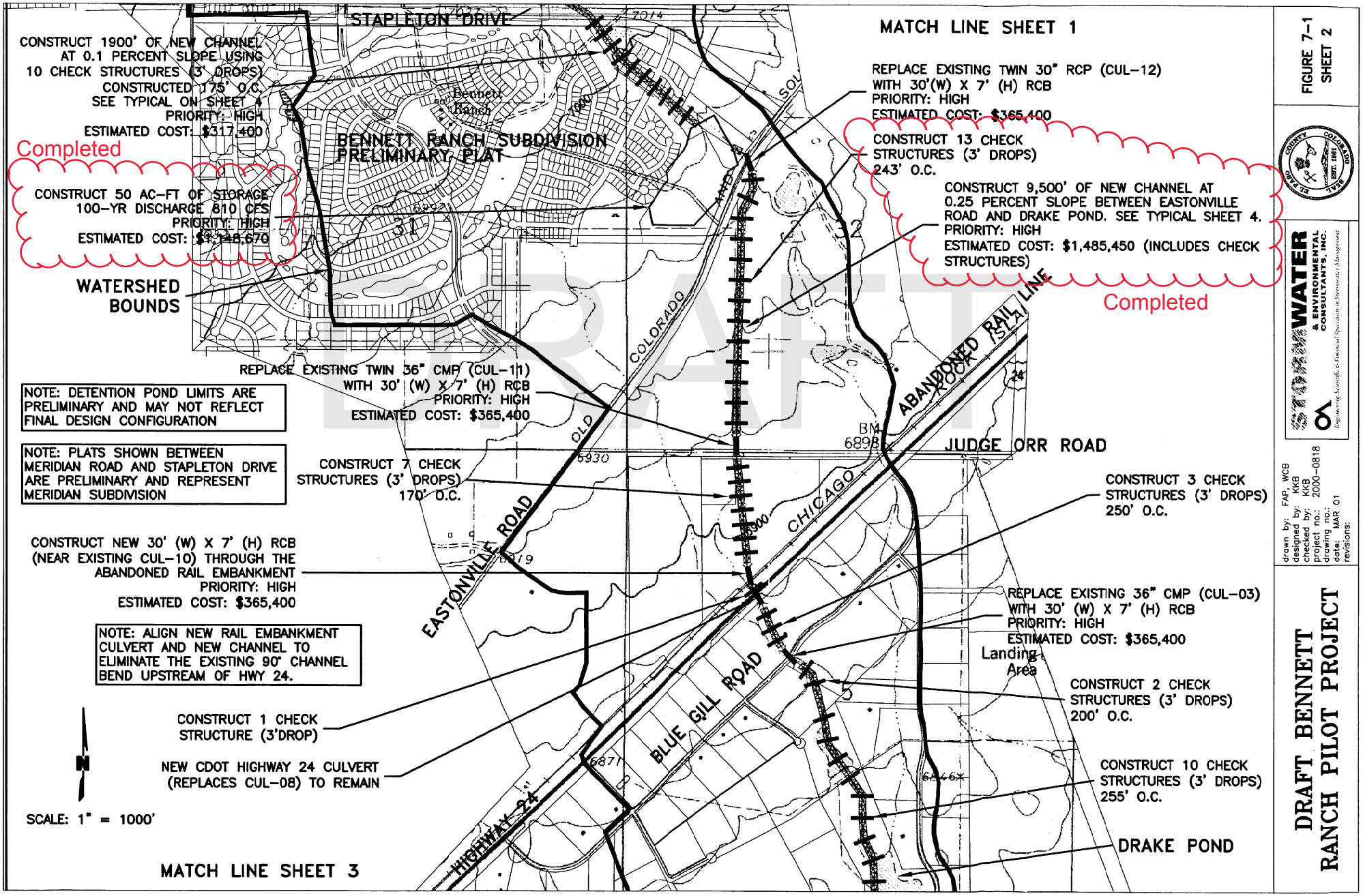
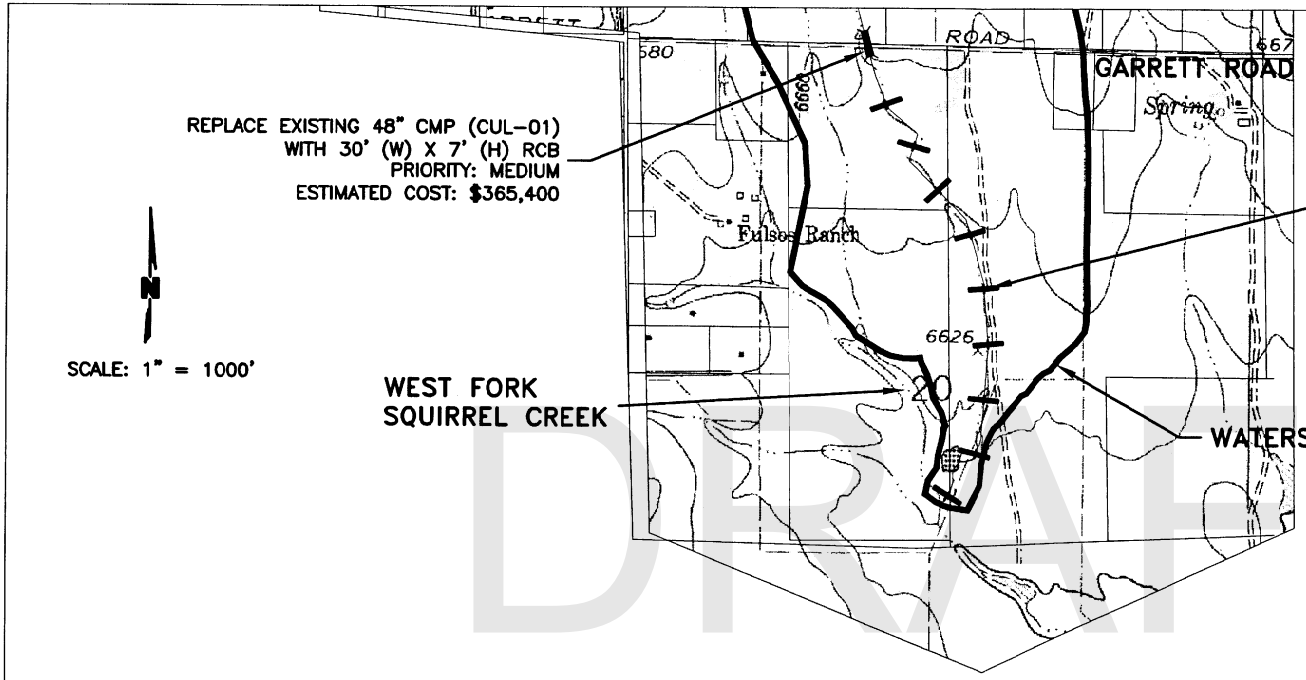


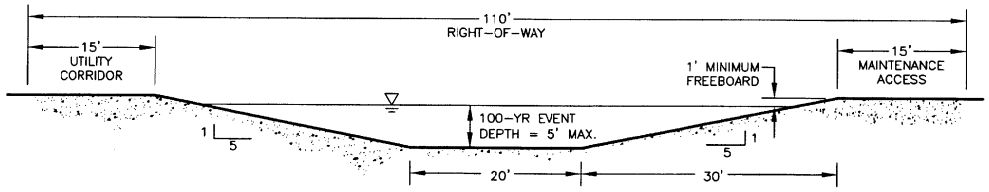
FIGURE 7-1
SHEET 2

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

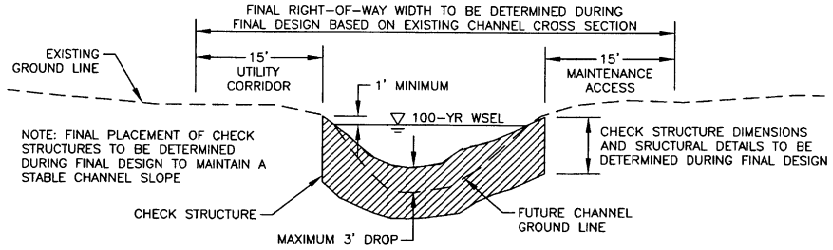
drawn by: FAP, WCB
designed by: KKB
checked by: KKB
project no.: 2000-0818
drawing no.:
date: MAR 01
revisions:

DRAFT BENNETT RANCH PILOT PROJECT

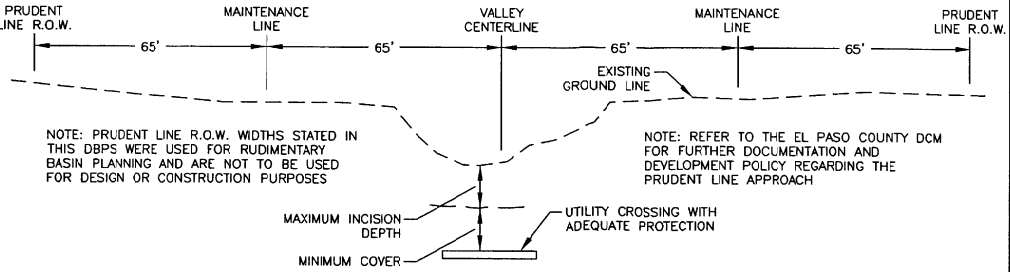




TYPICAL NEW CHANNEL CROSS SECTION
STAPLETON DRIVE TO DRAKE POND
SCALE: 1"=10'



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

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

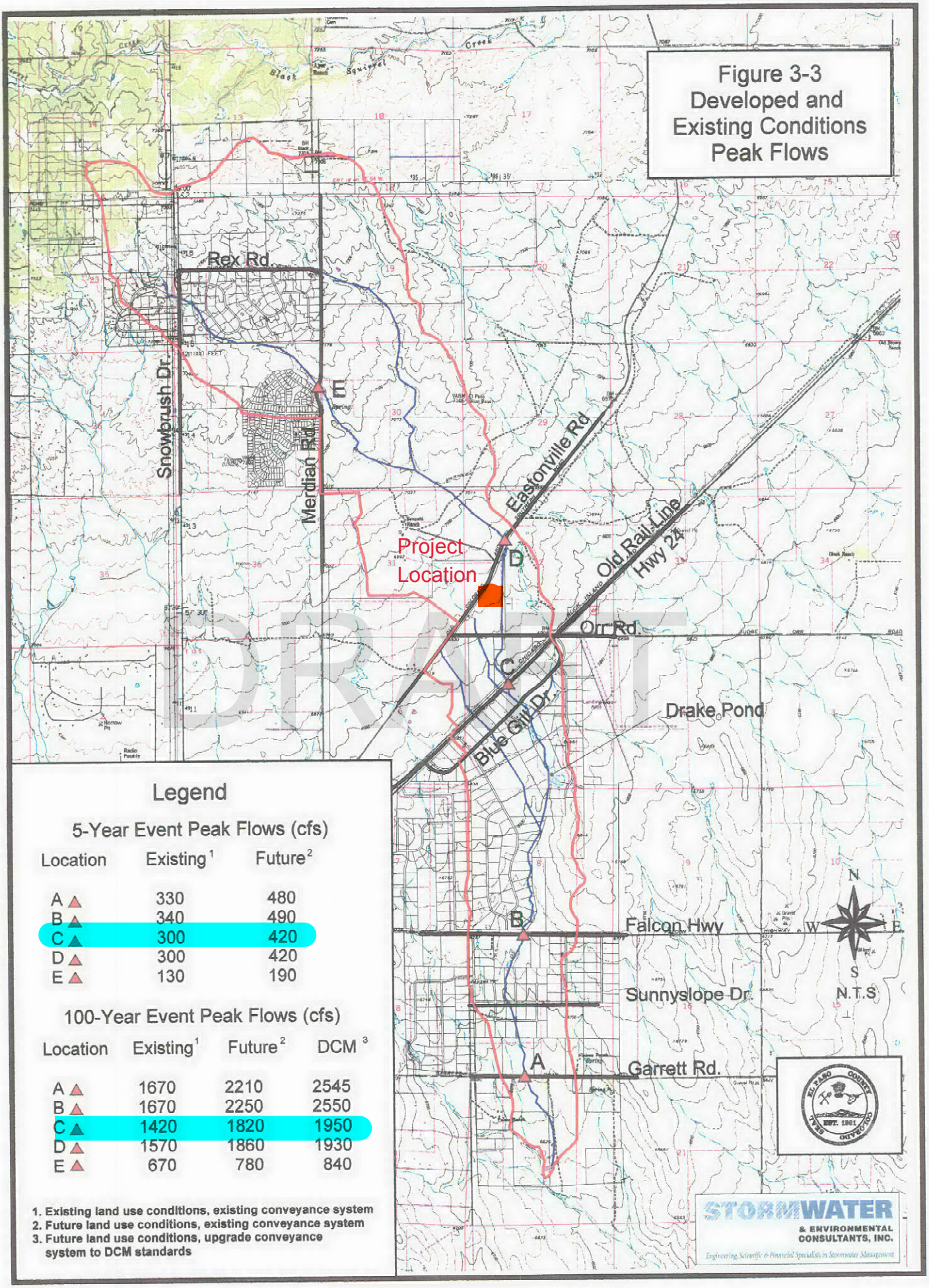


Figure 3-3
Developed and
Existing Conditions
Peak Flows
Rex Rd.
Snowbrush Dr.
Meridian Rd.
Eastonville Rd.
Old Rail Line
Hwy 24
Project
Location
Orr Rd.
Blue Gill Dr.
Drake Pond
Falcon Hwy
Sunnyslope Dr.
Garrett Rd.
A
B
C
D
E
N
S
E
W
N.T.S
DRAFT
Legend
5-Year Event Peak Flows (cfs)
Location Existing[1] 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

APPENDIX C – HYDROLOGIC ANALYSIS

Composite Imperviousness Calculations

Basin ID	Land Use					Calculated	
	Pasture/ Meadow, Lawn	Playground	Paved, Drive and Walk, Detention	Roofs	Offsite Flow Analysis	Total Area	Composite % Impervious[1]
	0%	13%	100%	90%	45%	(ac)	(%)
HA	6.2					6.2	0%
A	0.6	0.1	1.6	0.6		3.0	74%
OS1					1.1	1.1	45%
OS2	2.1					2.1	0%
A + OS1	0.6	0.1	1.6		1.1	4.1	53%

Notes:

1. *Calculated based on weighted area.*

UD-Rational, Version 2.00, Released May 2017

Proposed Condition

Runoff Coefficient

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C					
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	3.00	A	95.0	0.57	0.59	0.60	0.63	0.66	0.69
OS2	2.10	A	45.0	0.02	0.08	0.15	0.25	0.30	0.35
OS1	1.10	A	0.0	0.26	0.32	0.38	0.44	0.48	0.51

Notes:

2. *Subcatchment A assumes proposed condition percent imperviousness and UD-Rational calculated runoff coefficients.*
3. *Subcatchment OS1 assumes Lawn/ Pasture/ Meadow land use, as per Table 6-6 in the DCM-V1-Update, since the drainage easement is to retain the existing surface characteristics.*
4. *Subcatchment OS2 assumes "Offsite Flow Analysis" surface characteristics, as per Table 6-6 in the DCM-V1-Update, since future uses of this land are currently unknown.*

Overland Flow Time

Subcatchment Name	Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)
A	100	56.0	55.5	0.005	11.66
OS2	300	53.0	38.0	0.050	18.75
OS1	300	59	54	0.017	20.61

Notes:

1. *Elevations and flow paths are derived from proposed site grading, as shown in **Figure B-1**.*
2. *For Subcatchment A, the maximum flow path was set to 100-feet which is consistent with criteria for urban areas in DCM-V1-Update.*
3. *For the offsite flow areas (OS1 and OS2), the maximum flow path was set to 300-feet which is consistent with criteria for non-urban areas in DCM-V1-Update.*

Channelized Flow Time

Subcatchment Name	Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)
A	665	55.5	48.0	0.011	20	2.12	5.22
OS2	407	38.0	37.0	0.002	15	0.74	9.12
OS1	1			0.001	2.5	0.08	0.21

Notes:

1. *Elevations and flow paths are derived from proposed site grading, as shown in* ***Figure B-1****.*

Time of Concentration

Subcatchment Name	Computed t_c (min)	Regional t_c (min)	Selected t_c (min)
A	16.88	18.81	16.88
OS2	27.88	27.29	27.29
OS1	20.82	26.06	20.82

Rainfall Intensity, I (in/hr)

Subcatchment Name	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	2.55	3.22	3.75	4.29	4.83	5.40
OS2	1.95	2.46	2.87	3.28	3.68	4.13
OS1	2.29	2.89	3.37	3.85	4.33	4.85

Notes:

1. *Rainfall depths were derived from the NOAA Atlas 2 rainfall depths presented in Table 6-2 of the DCM-V1 (see below).*

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

Peak Flow, Q (cfs)

Subcatchment Name	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	4.35	5.66	6.78	8.11	9.51	11.13
OS2	0.08	0.41	0.90	1.72	2.32	3.03
OS1	0.66	1.02	1.41	1.86	2.29	2.72

Existing Condition

Runoff Coefficient

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C					
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
HA	6.20	A	0.0	0.02	0.08	0.15	0.25	0.30	0.35

Overland Flow Time

Subcatchment Name	Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)
HA	300.00	59.00	53.00	0.020	25.38

Channelized Flow Time

Subcatchment Name	Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)
HA	665.00	53.00	37.00	0.024	20	3.10	3.57

Time of Concentration

Subcatchment Name	Computed t_c (min)	Regional t_c (min)	Selected t_c (min)
HA	28.95	33.94	28.95

Rainfall Intensity, I (in/hr)

Subcatchment Name	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
HA	1.91	2.40	2.80	3.20	3.60	4.04

Peak Flow, Q (cfs)

Subcatchment Name	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
HA	0.24	1.19	2.61	4.97	6.71	8.76

APPENDIX D – HYDRAULIC ANALYSIS

UD-Detention, Version 3.07, Released February 2017

Proposed Full Spectrum Detention

Required Volume Calculation

Selected BMP Type =	EDB			
Watershed Area =	4.10	acres		
Watershed Length =	765	ft		
Watershed Slope =	0.010	ft/ft		
Watershed Imperviousness =	53%	percent		
Percentage Hydrologic Soil Group A =	100%	percent		
Percentage Hydrologic Soil Group B =	0%	percent		
Percentage Hydrologic Soil Groups C/D =	0%	percent		
Desired WQCV Drain Time =	40	hours, as per Section 4.2 of DCM-V1-Update		
Location for 1-hr Rainfall Depths =	User Input		Optional User Override 1-hr Precipitation	
Water Quality Capture Volume (WQCV) =	0.073	acre-feet		
Excess Urban Runoff Volume (EURV) =	0.255	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.174	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.228	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.281	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.347	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.429	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.525	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet		inches
Approximate 2-yr Detention Volume =	0.164	acre-feet		
Approximate 5-yr Detention Volume =	0.216	acre-feet		
Approximate 10-yr Detention Volume =	0.263	acre-feet		
Approximate 25-yr Detention Volume =	0.320	acre-feet		
Approximate 50-yr Detention Volume =	0.356	acre-feet		
Approximate 100-yr Detention Volume =	0.399	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.07	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.18	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.14	acre-feet
Total Detention Basin Volume =	0.40	acre-feet

Notes:

1. *As per Section 4.1.2 in DCM-V1-Update, "These equations apply to all FSDs and the EURV need not be added to the flood control volume or to the WQCV".*

Outlet Structure Assumptions

1. Zone 1 (WQCV) – Orifice Plate with 40-hour drain time
2. Zone 2 (EURV) – Orifice Plate with up to 32-hour drain time for EURV minus WQCV (72 hours to drain full EURV in accordance with DCM-V1-Update)
3. Zone 3 (100-year) – Weir and Pipe (with Restrictor Plate)
4. Spillway – crest located 1-ft above the 100-year water surface elevation

Peak Outflows from Pond

WQCV (cfs)	EURV (cfs)	2-yr (cfs)	5-yr (cfs)	10-yr (cfs)	25-yr (cfs)	50-yr (cfs)	100-yr (cfs)
0.0	0.14	0.09	0.12	0.15	0.73	1.27	1.31

Total Volume

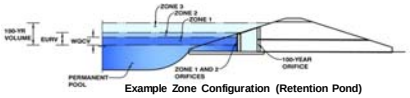
0.40 Acre-feet (based on 100-year volume) 0.63 acre-feet with 1-ft of freeboard

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: _____

Basin ID: _____



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 =	53.00%	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) =	0.073	acre-feet	
Excess Urban Runoff Volume (EURV) =	0.255	acre-feet	
2-yr Runoff Volume (P1 = 1.19 in.) =	0.174	acre-feet	
5-yr Runoff Volume (P1 = 1.5 in.) =	0.228	acre-feet	
10-yr Runoff Volume (P1 = 1.75 in.) =	0.281	acre-feet	
25-yr Runoff Volume (P1 = 2 in.) =	0.347	acre-feet	
50-yr Runoff Volume (P1 = 2.25 in.) =	0.429	acre-feet	
100-yr Runoff Volume (P1 = 2.52 in.) =	0.525	acre-feet	
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet	
Approximate 2-yr Detention Volume =	0.164	acre-feet	
Approximate 5-yr Detention Volume =	0.216	acre-feet	
Approximate 10-yr Detention Volume =	0.263	acre-feet	
Approximate 25-yr Detention Volume =	0.320	acre-feet	
Approximate 50-yr Detention Volume =	0.356	acre-feet	
Approximate 100-yr Detention Volume =	0.399	acre-feet	

Optional User Override 1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
	inches

Stage-Storage Calculation

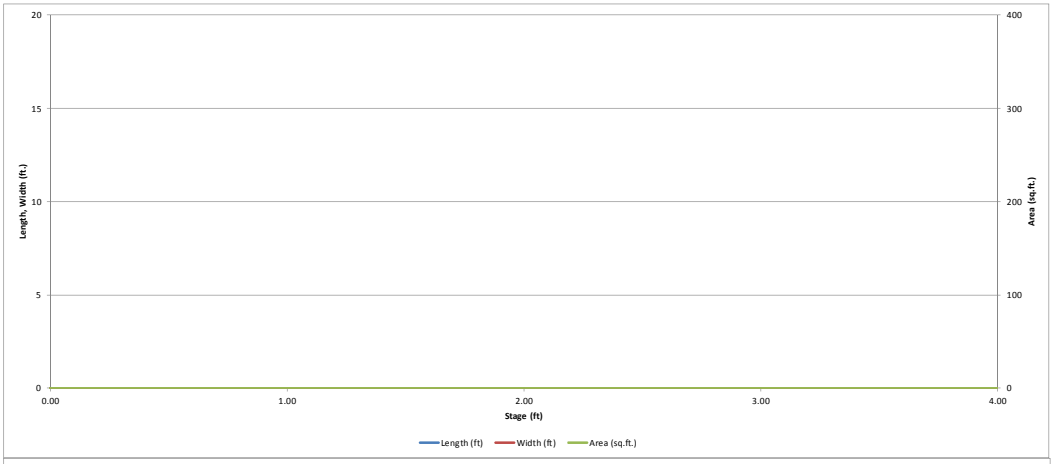
Zone 1 Volume (WQCV) =	0.073	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.181	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.144	acre-feet
Total Detention Basin Volume =	0.399	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

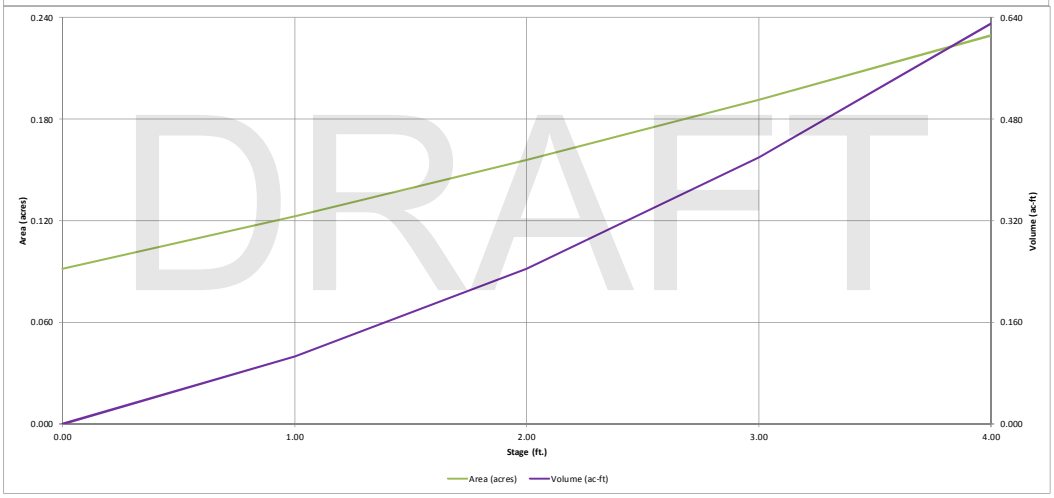
Depth Increment = 0.1 ft

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	--	--	--	3,989	0.092		
	--	1.00	--	--	--	5,338	0.123	4,610	0.106
	--	2.00	--	--	--	6,787	0.156	10,658	0.245
	--	3.00	--	--	--	8,337	0.191	18,288	0.420
	--	4.00	--	--	--	9,987	0.229	27,450	0.630

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



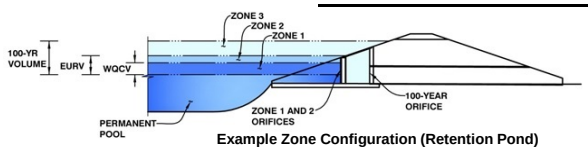


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project:

Basin ID:



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.72	0.073	Orifice Plate
Zone 2 (EURV)	2.06	0.181	Orifice Plate
Zone 3 (100-year)	2.89	0.144	Weir&Pipe (Restrict)
		0.399	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 Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	9.653E-03	ft^2
Depth at top of Zone using Orifice Plate =	1.73	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	6.91	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	1.39	sq. inches (diameter = 1-5/16 inches)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.80	1.60					
Orifice Area (sq. inches)	1.39	1.39	1.39					

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

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

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

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.06	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.31	N/A	feet
Overflow Weir Front Edge Length =	4.00	N/A	feet	Over Flow Weir Slope Length =	5.15	N/A	feet
Overflow Weir Slope =	4.00	N/A	H:V (enter zero for flat grate)	Grate Open Area / 100-yr Orifice Area =	89.42	N/A	should be ≥ 4
Horiz. Length of Weir Sides =	5.00	N/A	feet	Overflow Grate Open Area w/o Debris =	10.31	N/A	ft^2
Overflow Grate Open Area % =	50%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	5.15	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.83	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.12	N/A	ft^2
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.10	N/A	feet
Restrictor Plate Height Above Pipe Invert =	2.10		inches	Half-Central Angle of Restrictor Plate on Pipe =	0.70	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	3.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.66	feet
Spillway Crest Length =	2.00	feet	Stage at Top of Freeboard =	4.66	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.23	acres
Freeboard above Max Water Surface =	1.00	feet			

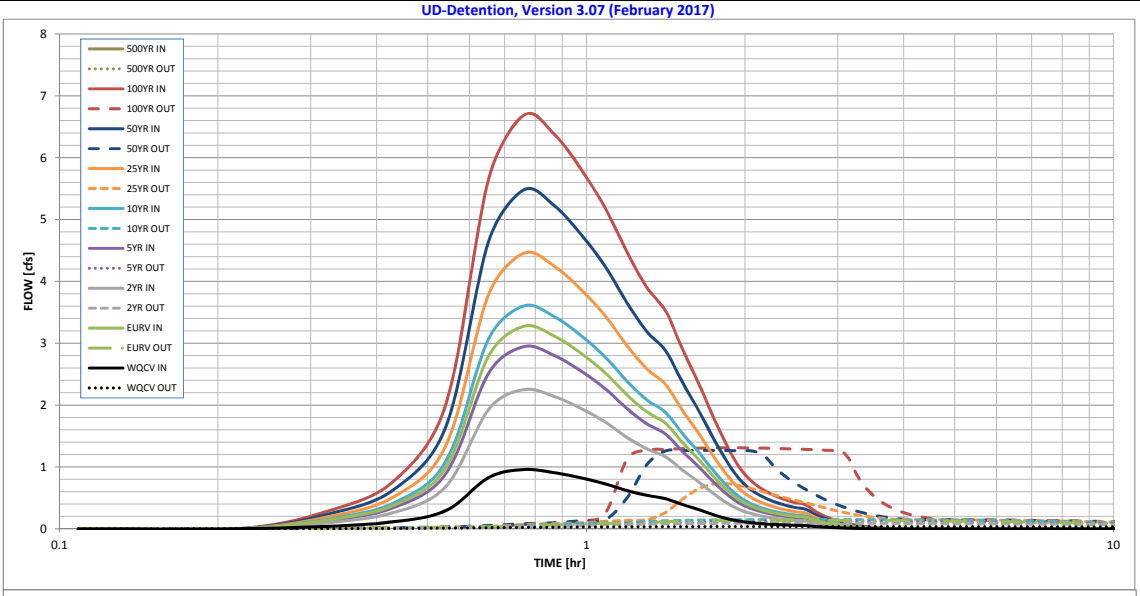
Calculated Parameters for Spillway

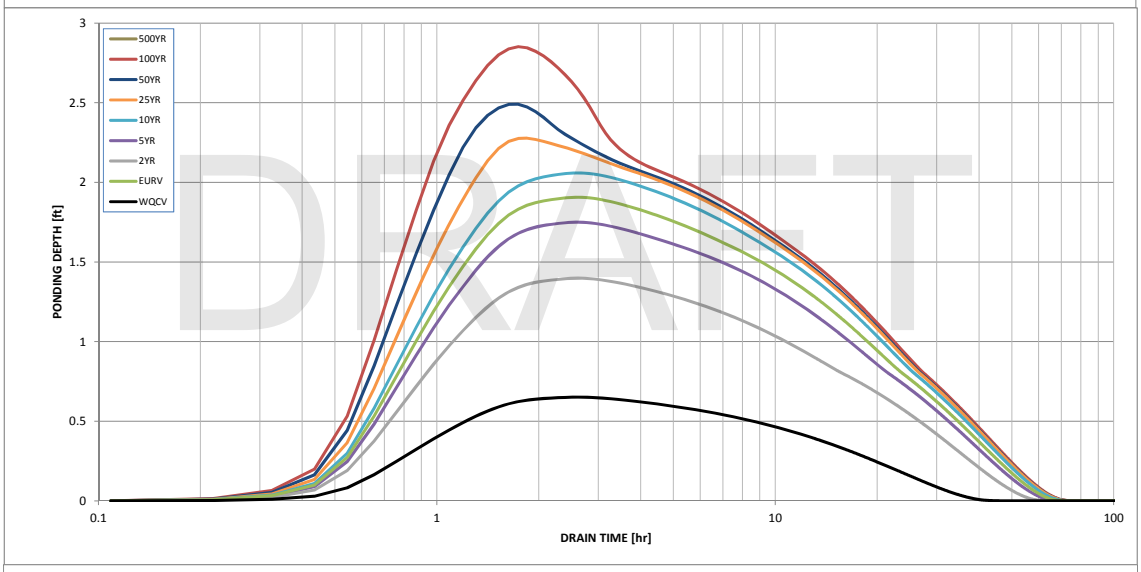
Routed Hydrograph Results

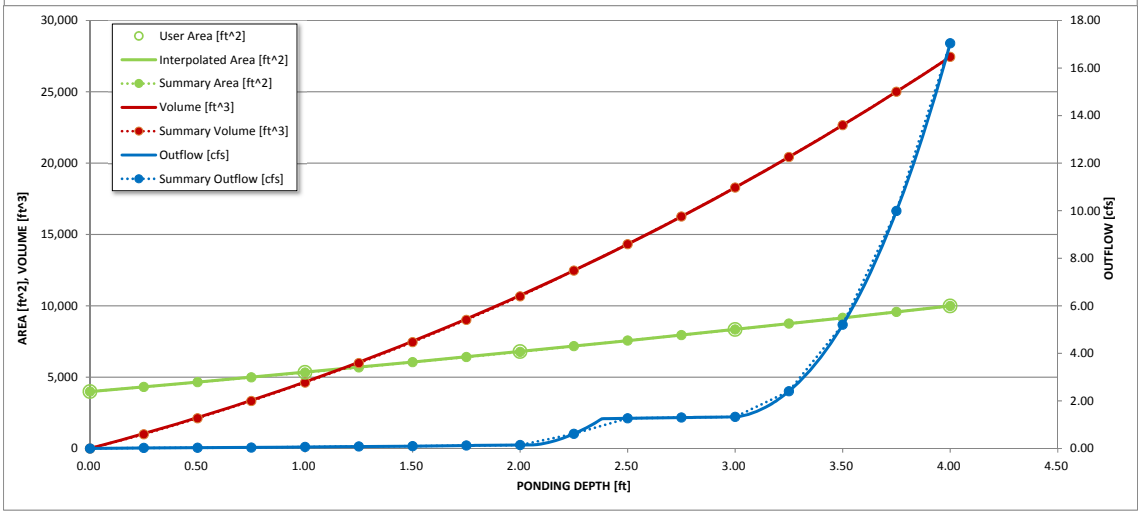
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	0.00
Calculated Runoff Volume (acre-ft) =	0.073	0.255	0.174	0.228	0.281	0.347	0.429	0.525	0.000
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.073	0.254	0.174	0.228	0.280	0.347	0.428	0.524	#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	0.0	0.0	0.0	0.1	0.6	1.4	0.0
Peak Inflow Q (cfs) =	1.0	3.3	2.3	2.9	3.6	4.5	5.5	6.7	#N/A
Peak Outflow Q (cfs) =	0.0	0.14	0.09	0.12	0.15	0.73	1.27	1.31	#N/A
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	8.5	4.4	9.9	2.2	1.0	#N/A
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	#N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	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) =	37	57	51	55	58	57	56	54	#N/A
Time to Drain 99% of Inflow Volume (hours) =	40	62	56	61	64	64	63	63	#N/A
Maximum Ponding Depth (ft) =	0.65	1.91	1.40	1.75	2.06	2.28	2.49	2.85	#N/A
Area at Maximum Ponding Depth (acres) =	0.11	0.15	0.14	0.15	0.16	0.17	0.17	0.19	#N/A
Maximum Volume Stored (acre-ft) =	0.066	0.231	0.157	0.208	0.254	0.290	0.327	0.392	#N/A

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







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

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

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.

	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	#N/A
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
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	0:13:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
Constant	0:19:34	0.04	0.15	0.10	0.13	0.16	0.20	0.25	0.30	#N/A
0.767	0:26:05	0.12	0.39	0.27	0.36	0.43	0.54	0.66	0.80	#N/A
	0:32:36	0.30	1.02	0.70	0.91	1.12	1.38	1.69	2.06	#N/A
	0:39:07	0.83	2.79	1.93	2.51	3.07	3.78	4.64	5.65	#N/A
	0:45:38	0.96	3.27	2.25	2.95	3.60	4.46	5.48	6.69	#N/A
	0:52:10	0.91	3.12	2.14	2.80	3.43	4.25	5.22	6.38	#N/A
	0:58:41	0.82	2.83	1.94	2.55	3.12	3.86	4.76	5.81	#N/A
	1:05:12	0.73	2.52	1.72	2.26	2.77	3.44	4.24	5.18	#N/A
	1:11:43	0.62	2.16	1.48	1.94	2.38	2.96	3.65	4.47	#N/A
	1:18:14	0.54	1.89	1.29	1.70	2.08	2.58	3.18	3.89	#N/A
	1:24:46	0.49	1.71	1.17	1.53	1.88	2.34	2.88	3.53	#N/A
	1:31:17	0.39	1.40	0.95	1.25	1.54	1.92	2.37	2.91	#N/A
	1:37:48	0.31	1.13	0.77	1.01	1.25	1.56	1.93	2.37	#N/A
	1:44:19	0.23	0.86	0.58	0.77	0.95	1.19	1.47	1.82	#N/A
	1:50:50	0.16	0.63	0.42	0.56	0.70	0.87	1.09	1.35	#N/A
	1:57:22	0.12	0.46	0.31	0.41	0.51	0.64	0.79	0.98	#N/A
	2:03:53	0.10	0.36	0.24	0.32	0.40	0.50	0.62	0.76	#N/A
	2:10:24	0.08	0.30	0.20	0.27	0.33	0.41	0.51	0.63	#N/A
	2:16:55	0.07	0.25	0.17	0.23	0.28	0.35	0.43	0.53	#N/A
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	2:43:00	0.04	0.14	0.09	0.12	0.15	0.19	0.23	0.28	#N/A
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	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
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	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
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	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
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	6:31:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#N/A
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	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]
	0.00	3,989	0.092	0	0.000	0.00
	0.25	4,313	0.099	996	0.023	0.02
	0.50	4,650	0.107	2,116	0.049	0.03
	0.75	4,987	0.114	3,321	0.076	0.04
	1.00	5,324	0.122	4,610	0.106	0.07
	1.25	5,686	0.131	5,986	0.137	0.08
	1.50	6,048	0.139	7,453	0.171	0.10
	1.75	6,410	0.147	9,010	0.207	0.12
	2.00	6,772	0.155	10,658	0.245	0.15
	2.25	7,174	0.165	12,471	0.286	0.62
	2.50	7,562	0.174	14,313	0.329	1.27
	2.75	7,949	0.182	16,252	0.373	1.30
	3.00	8,337	0.191	18,288	0.420	1.33
	3.25	8,749	0.201	20,423	0.469	2.41
	3.50	9,162	0.210	22,662	0.520	5.20
	3.75	9,575	0.220	25,004	0.574	9.99
	4.00	9,987	0.229	27,450	0.630	17.04

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).

Forebay Weir Sizing

Determine total undetained 100-year peak flow to the pond:

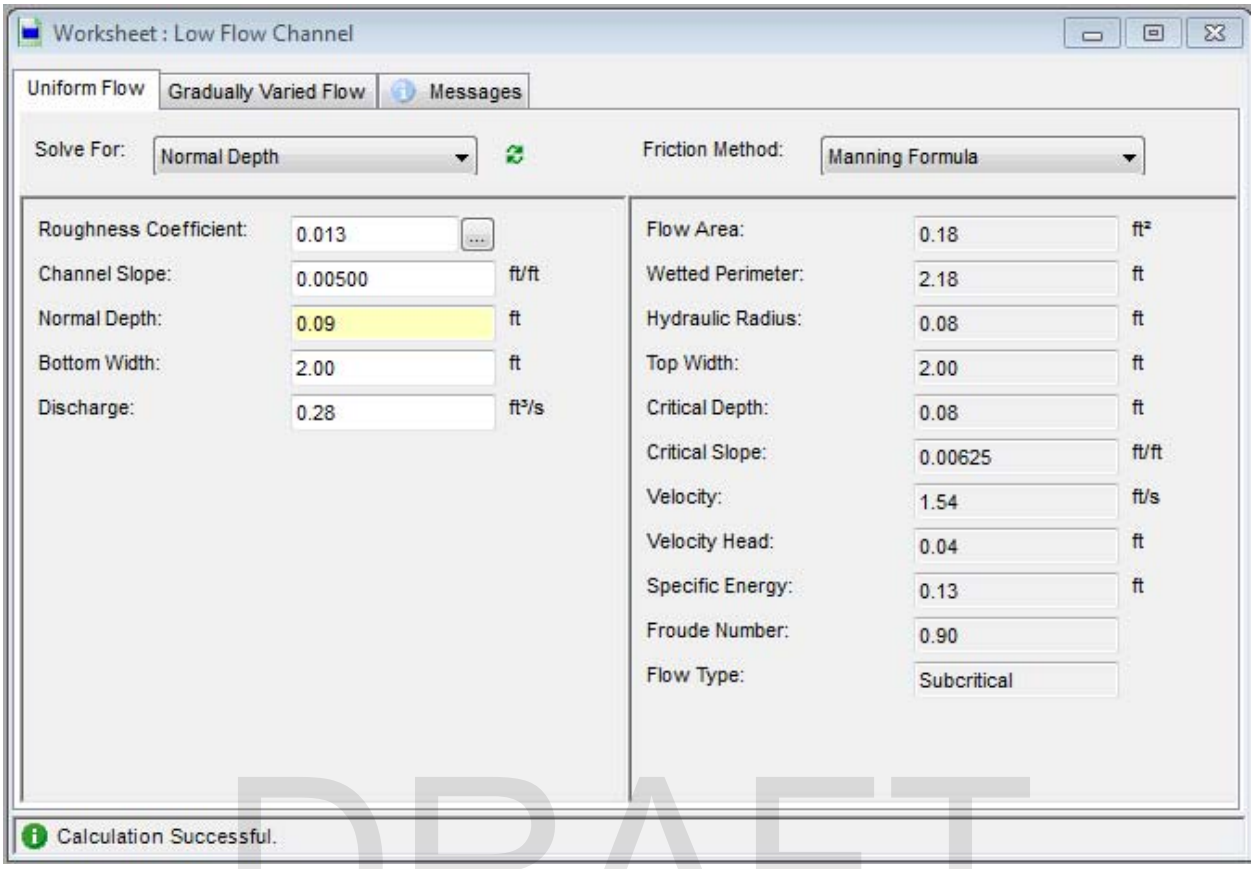
Design Point	Q_{100} (cfs)
1 (Basin A)	11.1
2 (Basin OS1)	2.7
Total (Pond A Inflow)	13.8
2% of Total	**0.28**

Size forebay weir to release 2% of undetained 100-year peak flows using the broad-crested weir equation:

Bottom Length of Weir	L =	1.00		
Angle of Side Slope Weir (Left)	Left Angle =	0.00	H:V =	0.00
Angle of Side Slope Weir (Right)	Right Angle =	0.00	H:V =	0.00
Stage for Weir Crest	Stage =	1.00		
Coef. for Rectangular Weir	C_w =	3.00		
Coef. for Trapezoidal Weir	C_t =	3.00		

Stage (ft)	Rectangular Weir (cfs)
1.21	0.28

Size concrete (n = 0.013) low flow channel to convey 2% of undetained 100-year peak flows, minimum:


Worksheet : Low Flow Channel
Uniform Flow
Gradually Varied Flow
Messages
Solve For:
Normal Depth
Friction Method:
Manning Formula
Roughness Coefficient:
0.013
Channel Slope:
0.00500
ft/ft
Normal Depth:
0.09
ft
Bottom Width:
2.00
ft
Discharge:
0.28
ft³/s
Flow Area:
0.18
ft²
Wetted Perimeter:
2.18
ft
Hydraulic Radius:
0.08
ft
Top Width:
2.00
ft
Critical Depth:
0.08
ft
Critical Slope:
0.00625
ft/ft
Velocity:
1.54
ft/s
Velocity Head:
0.04
ft
Specific Energy:
0.13
ft
Froude Number:
0.90
Flow Type:
Subcritical
Calculation Successful.

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)

Worksheet for Cross-section 1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.00250	ft/ft
Discharge	1950.00	ft³/s

Section Definitions

Station (ft)	Elevation (ft)
-0+87	6950.00
-0+03	6936.00
0+03	6936.00
0+98	6948.00
1+19	6953.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(-0+87, 6950.00)	(1+19, 6953.00)	0.100

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		10.63	ft
Elevation Range	6936.00 to 6953.00 ft		
Flow Area		845.67	ft²
Wetted Perimeter		154.67	ft
Hydraulic Radius		5.47	ft
Top Width		153.11	ft
Normal Depth		10.63	ft
Critical Depth		5.07	ft

Worksheet for Cross-section 1

Results

Critical Slope		0.10559	ft/ft
Velocity		2.31	ft/s
Velocity Head		0.08	ft
Specific Energy		10.71	ft
Froude Number		0.17	
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	10.63	ft
Critical Depth	5.07	ft
Channel Slope	0.00250	ft/ft
Critical Slope	0.10559	ft/ft

Worksheet for Cross-section 2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.100	
Channel Slope	0.00250	ft/ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	8.00	ft/ft (H:V)
Bottom Width	3.00	ft
Discharge	1950.00	ft^3/s

Results

Normal Depth	11.09	ft
Flow Area	833.17	ft^2
Wetted Perimeter	149.00	ft
Hydraulic Radius	5.59	ft
Top Width	147.21	ft
Critical Depth	5.39	ft
Critical Slope	0.10494	ft/ft
Velocity	2.34	ft/s
Velocity Head	0.09	ft
Specific Energy	11.18	ft
Froude Number	0.17	
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	11.09	ft
Critical Depth	5.39	ft
Channel Slope	0.00250	ft/ft

Worksheet for Cross-section 2

GVF Output Data

Critical Slope	0.10494	ft/ft

APPENDIX E – REFERENCED DOCUMENTS

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.

El Paso County Assessor Map

Markup Summary

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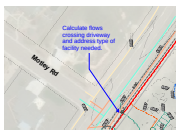

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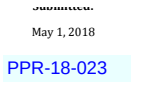
address/minimize impacts to existing driveway



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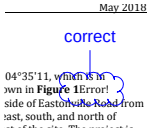

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correct

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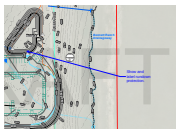

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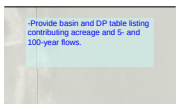

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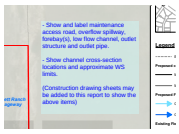
-Provide basin and DP table listing contributing acreage and 5- and 100-year flows.



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Author: dsdrice
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- Show and label maintenance access road, overflow spillway, forebay(s), low flow channel, outlet structure and outlet pipe.

- Show channel cross-section locations and approximate WS limits.

(Construction drawing sheets may be added to this report to show the above items)

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Author: dsdrice
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This is an old reference. New is 6.3.2, 6.3.5 -- https://planningdevelopment.elpasoco.com/wp-content/uploads/LandUseCode/EPC-Land-Use-Code-Chapter-6-2016.pdf

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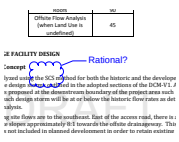

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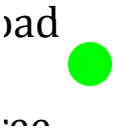
Rational?



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