

**FINAL DRAINAGE REPORT
FOR
ELECTRONIC STORAGE
LOT 2 MOUNTAIN STATES PIPE AND SUPPLY
7765 ELECTRONIC DRIVE
COLORADO SPRINGS, COLORADO**

NOVEMBER 2020

Prepared For:
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TNE Job No. 1971.00
County Job No. PPR-20-020

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TABLE OF CONTENTS

| | |
|------------------------------|---------|
| Engineer's Statement | Page 3 |
| Purpose | Page 4 |
| General Description | Page 4 |
| Existing Drainage Conditions | Page 5 |
| Proposed Drainage Conditions | Page 6 |
| Hydrologic Calculations | Page 9 |
| Hydraulic Calculations | Page 9 |
| Floodplain Statement | Page 9 |
| Water Quality | Page 9 |
| Construction Cost Opinion | Page 10 |
| Drainage Fees | Page 10 |
| Maintenance | Page 10 |
| Summary | Page 11 |
| Bibliography | Page 11 |

APPENDICES

VICINITY MAP

S.C.S. SOILS MAP

FEMA FIRM MAP

HYDROLOGIC CALCULATIONS

HYDRAULIC CALCULATIONS

DETENTION CALCULATIONS

DRAINAGE PLAN

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DESIGN 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 County for drainage reports and said report is in conformity with the applicable 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.

Dane Frank, P.E. 50207
On behalf of Terra Nova Engineering, Inc.

Date

OWNER/DEVELOPER'S STATEMENT:

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

Authorized Signature

Date

Printed Name, Title

Business Name

Address

EL PASO COUNTY:

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.

Jennifer Irvine, P.E.
County Engineer / ECM Administrator

Date

Conditions:

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PURPOSE

The purpose of this Final Drainage Report is to identify and analyze the proposed drainage patterns, determine proposed runoff quantities, size drainage structures for conveyance of developed runoff, and present solutions to drainage impacts on-site and off-site resulting from this development. The site has previously been platted and has previously been studied in:

“Preliminary and Final Drainage Report for TMC Design Corporation”, dated December 2011, prepared by Stillwater Engineering.

Per El Paso County, there is no record on file that the above report was approved by the County.

GENERAL DESCRIPTION

This Final Drainage Report (FDR) is an analysis of approximately 2.25 acres of undeveloped land located at 7765 Electronic Drive. This site is being developed as a mini storage facility. The site is in the southeast quarter of Section 32, Township 13 South, Range 65 West of the 6th Principal Meridian within El Paso County. The parcels are bounded to the north by Electronic Drive, to the east by Marksheffel Road, to the south by LOT 6 AKERS ACRES SUB 1, EX THAT PT CONV TO COUNTY FOR R/W BY REC #210004057, and to the west by WLY 631.22 FT OF TRACT 5 AKERS ACRES SUB NO 1. (See vicinity map, Appendix).

The site lies within the Sand Creek Basin, with storm runoff surface draining from the southeast corner of the site, and flowing south, then west along streets, before entering Sand Creek. There are also storm inlets in Marksheffel Road that flow into a storm sewer that flows south along Markcheffel to an unknown outfall, which presumably also drains into Sand Creek.

Soils for this project are delineated by the map in the appendix as Blakeland loamy sand (8), 1 to 9 percent slopes. Soils in the study area are shown as mapped by S.C.S. in the “Soils Survey of El Paso County Area” and contains soils of Hydrologic Group A.

The site is undeveloped with mostly grass and dirt surfaces, and a small number of trees. The site drains to the southeast, with an average slope of 6.1%.

EXISTING DRAINAGE CONDITIONS

There is one existing building and stormwater pond in the southeast corner of the site. There is also a small drainage swale on the south side of Electronic Drive, which is in the right of way, that prevents runoff flowing south from entering the site. There are 24” RCP culverts in this swale at each driveway to the site.

The existing stormwater pond is a 0.16 ac-ft water quality and detention structure that was designed in the 2011 drainage report. It collects runoff from basin EX-A. The pond has an outlet structure that drains to the public storm sewer system via a private storm pipe that leaves the pond/site to the south. This pond appears to be functioning as designed.

There are four drainage basins, two of which are offsite. See attached Existing Drainage Map (in appendix).

Basin OS-Z is 4.01 acres and drains to Design Point Z along Electronic Drive. This basin is offsite and no flow from it enters the site. Basin OS-Z has flows of $Q_5 = 7.3$ cfs and $Q_{100} = 16.5$ cfs.

Basin OS-Y is 2.55 acres and drains to Design Point Y at the west side of the site. This basin is offsite and runoff from this basin flows onto the site and into basin EX-B. Basin OS-Y has flows of $Q_5 = 2.1$ cfs and $Q_{100} = 8.2$ cfs.

Basin EX-A is 2.54 acres and drains to Design Point A at the existing stormwater pond. After going through the pond, runoff drains through an outlet structure to the public storm sewer system via a private storm pipe that leaves the pond/site to the south. There is also a 18” RCP culvert that

carries water under a paved portion of the basin to the pond. Basin EX-A has flows of $Q_5 = 3.2$ cfs and $Q_{100} = 9.5$ cfs.

Basin EX-B is 1.91 acres and drains to Design Point B at the south side of the site. Runoff flows off the site and onto the adjacent property. Basin EX-B has flows of $Q_5 = 0.9$ cfs and $Q_{100} = 5.4$ cfs. Design Point B has combined flows of $Q_5 = 3.0$ cfs and $Q_{100} = 13.6$ cfs from basins OS-Y and EX-B.

PROPOSED DRAINAGE CONDITIONS

Runoff in the developed conditions consists of 10 basins; seven onsite basins and three offsite basins. Below is a description of the runoff in the developed conditions and how it will be safely routed, treated and detained. See appendix for calculations.

Offsite Basins

Basin OS-E is 0.44 acres and drains to Design Point E on the western edge of the site. Runoff sheet flows onto the site from Basin OS-E. Basin OS-E has flows of $Q_5 = 0.4$ cfs and $Q_{100} = 1.7$ cfs.

Basin OS-F is 1.38 acres and drains to Design Point F on the western edge of the site. Runoff sheet flows onto the site from Basin OS-F. Basin OS-F has flows of $Q_5 = 1.2$ cfs and $Q_{100} = 4.6$ cfs.

Basin OS-G is 0.01 acres and drains to Design Point G on the north edge of the site. Runoff sheet flows onto the site from Basin OS-G. Basin OS-G has flows of $Q_5 = 0.1$ cfs and $Q_{100} = 0.1$ cfs.

Onsite Basins

Basin PR-1 is 0.37 acres and drains to Design Point 1 at the northwest edge of the paved area onsite. Basin PR-1 is a hillside, the bottom of which will be at the top of curb at Design Point 1. Basin PR-1 has flows of $Q_5 = 0.2$ cfs and $Q_{100} = 1.1$ cfs. Design Point 1 has combined flows of $Q_5 = 0.6$ cfs and $Q_{100} = 2.8$ cfs from basins OS-E and PR-1.

OS-F does not appear to enter basin PR-2 or PR-4. My previous comment mistakenly indicated OS-F. It appears that it should be OS-G as it appears that a part of OS-G may enter basin PR-2.

Basin PR-2 is 0.62 acres and drains to Design Point 2 at the southeast edge of the paved area onsite. Basin PR-2 has flows of $Q_5 = 0.2$ cfs and $Q_{100} = 1.1$ cfs. Design Point 2 has combined flows of $Q_5 = 3.9$ cfs and $Q_{100} = 9.4$ cfs from basins OS-E, OS-F, PR-1, and PR-2. There are valley gutters and curb and gutter in this basin that channel runoff around the building and toward the pond. There is a 2'x2' area inlet on the southwest side of the building in this basin that is at the end of the storm sewer the roof drains will connect to, that will provide a cleanout location for this run of storm sewer (this inlet has zero runoff capture). There are two curb inlets at Design Point 2 that each take half of the basin's flow and send it to the pond via storm sewers.

Basin PR-3 is 0.45 acres and drains to Design Point 3 at the southwest edge of the building roof. Roof drains will connect to the adjacent storm sewer on the southwest side of the building. Basin PR-3 has flows of $Q_5 = 2.3$ cfs and $Q_{100} = 4.5$ cfs.

Basin PR-4 is 0.32 acres and drains to Design Point 4 at the outlet of the onsite detention basin. Basin PR-4 has flows of $Q_5 = 0.2$ cfs and $Q_{100} = 1.2$ cfs. Design Point 4 has combined flows of $Q_5 = 6.3$ cfs and $Q_{100} = 15.1$ cfs from basins OS-E, OS-F, PR-1, PR-2, PR-3, and PR-4.

Basin PR-5 is 0.34 acres and drains to Design Point 5 at the southeast corner of the site. This basin is undeveloped/landscaping area. Basin PR-5 has flows of $Q_5 = 0.1$ cfs and $Q_{100} = 1.0$ cfs. Design Point 5 has combined flows of $Q_5 = 1.3$ cfs and $Q_{100} = 5.6$ cfs from basins OS-F and PR-5.

Basin PR-6 is 0.03 acres and drains to Design Point 6 at the northeast corner of the site. This basin is a landscaping area that flows offsite to the north into the drainage ditch/swale along Electronic Drive. Basin PR-6 has flows of $Q_5 = 0.0$ cfs and $Q_{100} = 0.1$ cfs.

Basin PR-7 is 0.13 acres and drains to Design Point 7 at the east edge of the site. This basin is landscaping area that sheet flows offsite to the adjacent lot. Basin PR-7 has flows of $Q_5 = 0.1$ cfs and $Q_{100} = 0.6$ cfs. Some of the runoff from this basin will flow into the existing stormwater pond on adjacent Lot 1. The portion of this basin that will flow to the existing pond, is already flowing to the existing pond, so there won't be any change to the flow reaching the existing pond from this basin.

At Design Point 4 the combined flow ($Q_5=6.3$ cfs and $Q_{100}=15.1$ cfs) of the development will be captured in a 0.202 acre-foot Extended Detention Basin. Runoff entering the pond on the northwest side will be routed through storm sewers into a 39 cu-ft concrete lined forebay with a 1.0 feet high concrete cutoff wall. A 3 inch notch in the wall drains the flow to a 1' concrete trickle channel, then the runoff is routed to the 3.0' deep micropool which has a 6" deep initial surcharge area. The 1.77 acres tributary to the EDB are 62% impervious. Based upon this we need a WQCV of 0.036 ac-ft, an EURV volume of 0.098 ac-ft and 100-year volume of 0.068 ac-ft for a total volume needed of 0.202 ac-ft. The bottom of the micropool elevation is at 6480.00 while the top of the ISV elevation is at 6483.00. The WQCV orifice starts at 6482.50 with 3 5/8 inch diameter holes spaced 14.60 inches apart. A 2'x2' outlet structure is set at 6485.75. The 100-year elevation tops out at 6486.54. A 12" HDPE outlet will release $Q_5=0.0$ cfs and $Q_{100}=1.4$ cfs discharge southeast, across two lots, and to an existing storm inlet (~5'x5' grate). This inlet is piped to an adjacent curb inlet in the Marksheffel Road right of way.

Runoff from the site currently flows to this offsite storm inlet being connected to, either by surface flow, or through the existing stormwater pond on Lot 1. The runoff directed to the proposed onsite pond will no longer surface flow to this offsite inlet, but will instead flow to this inlet through the proposed storm sewer.

In an effort to protect receiving water and as part of the "four-step process to minimize adverse impacts of urbanization" this site was analyzed in the following manner:

1. Reduce Runoff- The proposed impervious areas on the site are surrounded by landscaping and green space areas. Additionally, the new improvements and impervious areas on the site will be routed to a proposed private Extended Detention Basin. These items will reduce the volume of runoff using ponding and infiltration.
2. Stabilize Drainageways- There are no existing or proposed drainageways onsite. Additionally, the outflow of the Extended Detention Basin is carried by storm sewer until it connects with an existing public storm sewer system.
3. Provide Water Quality Capture Volume (WQCV)- The Extended Detention Basin has been sized and designed to sufficiently capture the required WQCV and slowly release it though

the three hole outlet, thereby allowing solids and contaminants to settle out.

4. Consider Need for Industrial and Commercial BMPs- The proposed development is an indoor mini storage facility; therefore, no Industrial and Commercial BMPs have been proposed.

HYDROLOGIC CALCULATIONS

Hydrologic calculations were performed using the El Paso County Storm Drainage Design Criteria Manual - Volumes 1 & 2, latest editions. The Rational Method was used to estimate storm water runoff anticipated from design storms with 5-year and 100-year recurrence intervals. The Urban Drainage Criteria Manual was used to calculate the detention and water quality volume.

HYDRAULIC CALCULATIONS

Hydraulic calculations were estimated using the Manning's Formula and the methods described in the El Paso County Storm Drainage Design Criteria Manual – Volumes 1 & 2, latest editions. The pertinent data sheets are included in the appendix of this report.

A culvert is proposed at the entrance to the site. Design calculations have been included for the proposed culvert.

Street runoff capacity calculations for the onsite drive isles have been included.

FLOODPLAIN STATEMENT

No portion of this site is within a designated F.E.M.A. floodplain, as determined by Flood Insurance Rate Map No. 08041C0756 G, dated December 7, 2018 (see appendix).

WATER QUALITY

The proposed detention basin provides water quality treatment for the proposed development.

Runoff from basins PR-5, PR-6, PR-7, and OS-C are not captured by the proposed detention basin. Basin PR-5 is a landscaping area, some of which is below the detention pond, with no impervious area. Basin PR-6 is a landscaping area, behind a curb, with no impervious area. Basin PR-7 is a

OS-F?



landscaping area, all of which flows away from the detention pond, some of which flows to the existing stormwater pond on Lot 1. Basin OS-G is a part of the driveway in the right of way that drains into the existing drainage road side drainage swale that it crosses. The combined area of these basins is 0.51 acres, with only 0.01 acres (driveway) being impervious. Basins PR-5, PR-6, and PR-7 would qualify as grass buffers, which provide water quality treatment, and can be considered undeveloped (open space). Section I.7.1.C.1 of the ECM allows up to 20%, not to exceed 1 acre, of a development site to not be treated for water quality.

CONSTRUCTION COST OPINION

Public Reimbursable

None

Public Non-Reimbursable

| | | | |
|-----------------|-------|-------|-----------------|
| 1. 24" RCP | 50 LF | \$ 78 | <u>\$ 3,900</u> |
| Total \$ | | | 3,900 |

Private Non-Reimbursable

| | | | |
|-------------------------|--------|-----------|------------------|
| 1. 12" HDPE | 707 LF | \$ 40 | \$ 28,280 |
| 2. 15" HDPE | 82 LF | \$ 45 | \$ 3,690 |
| 3. 2'x2' Area Inlet | 1 EA | \$ 3,000 | \$ 3,000 |
| 4. 8' D-10-R Curb Inlet | 2 EA | \$ 7,800 | \$ 15,600 |
| 2. EDB | 1 EA | \$ 60,000 | <u>\$ 60,000</u> |
| Total \$ | | | 110,570 |

DRAINAGE FEES

This drainage report is part of a site development application; therefore, no drainage fees are due.

MAINTENANCE

The Extended Detention Basin is private and will be maintained by the property owner. The proposed storm sewers are private and will be maintained by the property owner. The proposed culvert is public and will be maintained by the County.

SUMMARY

Development of this site will not adversely affect the surrounding development. This report is in general conformance with the previous reports which included this site. Site runoff and storm drain appurtenances from the Electronic Storage development will not adversely affect the downstream and surrounding developments and will be safely routed to the proposed extended detention basin and runoff reduced to the allowable pre-developed rates while slowly treating the water quality capture volume. Runoff leaving the proposed extended detention basin is then routed to the existing public storm sewer system.

PREPARED BY:
TERRA NOVA ENGINEERING, INC.

Dane Frank, P.E.
Project Engineer

Jobs/1971.00/drainage/197100 FDR.doc

BIBLIOGRAPHY

El Paso County Drainage Criteria Manual-Volumes 1 & 2, latest edition

El Paso County Board Resolution No 15-042 (Adoption of Chapter 6 and Section 3.2.1 Chapter 13 of the City of Colorado Springs Drainage Criteria Manual dated May 2014, Hydrology and Full Spectrum Detention)

Preliminary and Final Drainage Report for TMC Design Corporation, dated December 2011, prepared by Stillwater Engineering

VICINITY MAP



Electronic Storage - Vicinity Map



Map data ©2019 Google 1000 ft

North is up ^

Electronic Storage - Location Map

Image Dated Oct 2018

Electronic Dr

SITE

Markshoff Rd

Google Earth

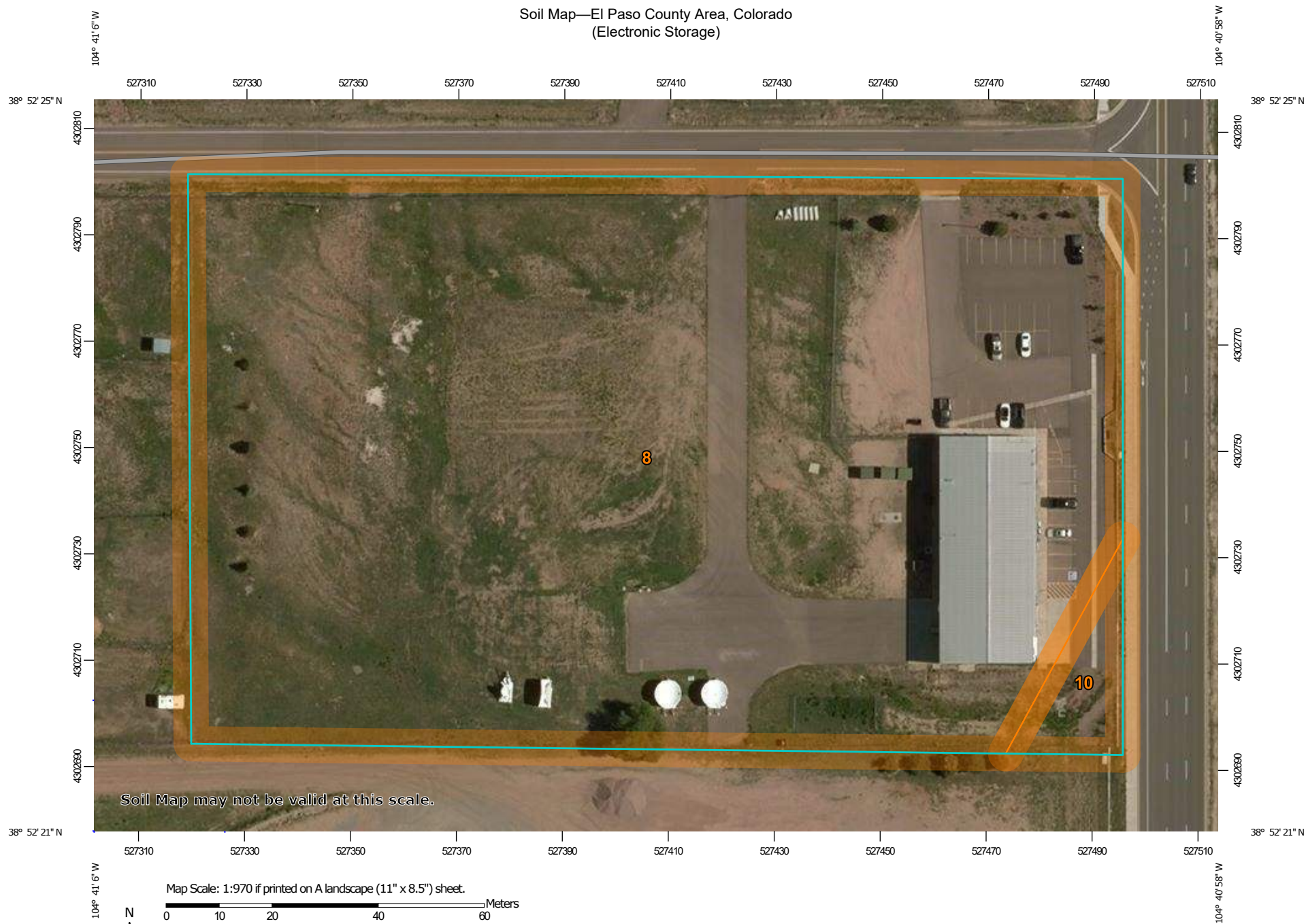
© 2018 Google

400 ft



S.C.S. SOILS MAP

Soil Map—El Paso County Area, Colorado (Electronic Storage)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils



Soil Map Unit Polygons



Soil Map Unit Lines



Soil Map Unit Points

Special Point Features



Blowout



Borrow Pit



Clay Spot



Closed Depression



Gravel Pit



Gravelly Spot



Landfill



Lava Flow



Marsh or swamp



Mine or Quarry



Miscellaneous Water



Perennial Water



Rock Outcrop



Saline Spot



Sandy Spot



Severely Eroded Spot



Sinkhole



Slide or Slip



Sodic Spot



Spoil Area



Stony Spot



Very Stony Spot



Wet Spot



Other



Special Line Features

Water Features



Streams and Canals

Transportation



Rails



Interstate Highways



US Routes



Major Roads



Local Roads

Background



Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

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

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

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 17, Sep 13, 2019

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

Date(s) aerial images were photographed: Jun 3, 2014—Jun 17, 2014

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

Map Unit Legend

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|------------------------------------|---|--------------|----------------|
| 8 | Blakeland loamy sand, 1 to 9 percent slopes | 4.6 | 97.6% |
| 10 | Blendon sandy loam, 0 to 3 percent slopes | 0.1 | 2.4% |
| Totals for Area of Interest | | 4.7 | 100.0% |

El Paso County Area, Colorado

8—Blakeland loamy sand, 1 to 9 percent slopes

Map Unit Setting

National map unit symbol: 369v

Elevation: 4,600 to 5,800 feet

Mean annual precipitation: 14 to 16 inches

Mean annual air temperature: 46 to 48 degrees F

Frost-free period: 125 to 145 days

Farmland classification: Not prime farmland

Map Unit Composition

Blakeland and similar soils: 98 percent

Minor components: 2 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Blakeland

Setting

Landform: Hills, flats

Landform position (three-dimensional): Side slope, talf

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Alluvium derived from sedimentary rock and/or
eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 11 inches: loamy sand

AC - 11 to 27 inches: loamy sand

C - 27 to 60 inches: sand

Properties and qualities

Slope: 1 to 9 percent

Depth to restrictive feature: More than 80 inches

Natural drainage class: Somewhat excessively drained

Runoff class: Low

Capacity of the most limiting layer to transmit water (Ksat): High to
very high (5.95 to 19.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum in profile: 5 percent

Available water storage in profile: Low (about 4.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e

Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: A

Ecological site: Sandy Foothill (R049BY210CO)

Hydric soil rating: No

Minor Components

Other soils

Percent of map unit: 1 percent

Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent

Landform: Depressions

Hydric soil rating: Yes

Data Source Information

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 17, Sep 13, 2019

El Paso County Area, Colorado

10—Blendon sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 3671

Elevation: 6,000 to 6,800 feet

Mean annual precipitation: 14 to 16 inches

Mean annual air temperature: 46 to 48 degrees F

Frost-free period: 125 to 145 days

Farmland classification: Not prime farmland

Map Unit Composition

Blendon and similar soils: 98 percent

Minor components: 2 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Blendon

Setting

Landform: Terraces, alluvial fans

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Sandy alluvium derived from arkose

Typical profile

A - 0 to 10 inches: sandy loam

Bw - 10 to 36 inches: sandy loam

C - 36 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 0 to 3 percent

Depth to restrictive feature: More than 80 inches

Natural drainage class: Well drained

Runoff class: Low

Capacity of the most limiting layer to transmit water (Ksat):

Moderately high to high (0.60 to 2.00 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum in profile: 2 percent

Available water storage in profile: Moderate (about 6.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: B

Ecological site: Sandy Foothill (R049BY210CO)

Hydric soil rating: No

Minor Components

Other soils

Percent of map unit: 1 percent

Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent

Landform: Depressions

Hydric soil rating: Yes

Data Source Information

Soil Survey Area: El Paso County Area, Colorado

Survey Area Data: Version 17, Sep 13, 2019

FEMA FIRM MAP

NOTES TO USERS

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

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

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

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

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

The projection used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The horizontal datum was NAD83, GRS80 spheroid. Differences in datum, spheroid projection or UTM zone codes used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

Flood elevations on this map are referenced to the **North American Vertical Datum of 1988 (NAVD88)**. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov/> or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, NGS512
National Geodetic Survey
SSM-C-3, #5002
1315 East-West Highway
Silver Spring, MD 20910-3282

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

Base Map information shown on this FIRM was provided in digital format by El Paso County, Colorado Springs Utilities, City of Fountain, Bureau of Land Management, National Oceanic and Atmospheric Administration, United States Geological Survey, and Anderson Consulting Engineers, Inc. These data are current as of 2006.

This map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map. The profile baselines depicted on this map represent the hydraulic modeling baselines that match the flood profiles and Floodway Data Tables if applicable, in the FIS report. As a result, the profile baselines may deviate significantly from the new base map channel representation and may appear outside of the floodplain.

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

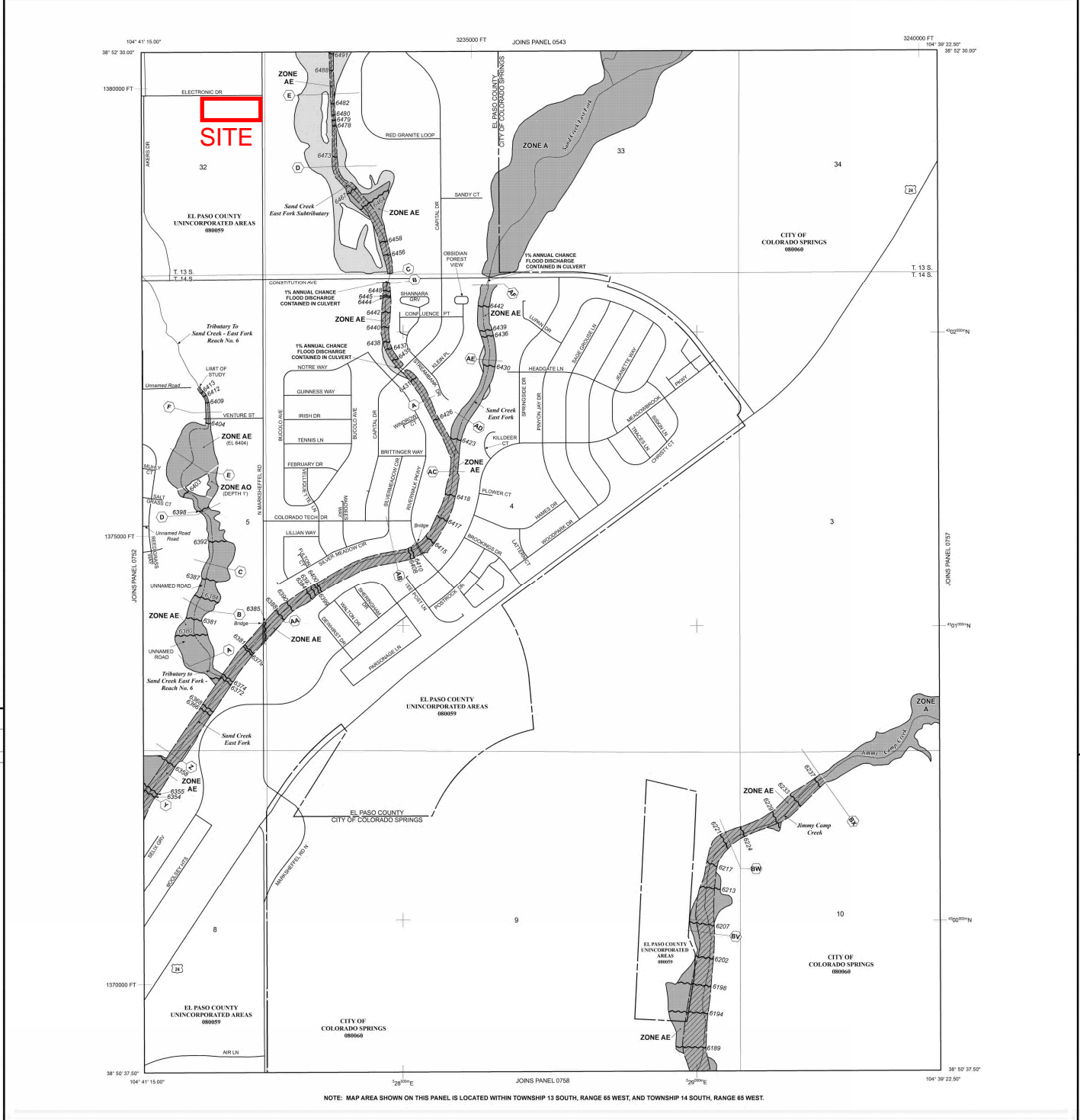
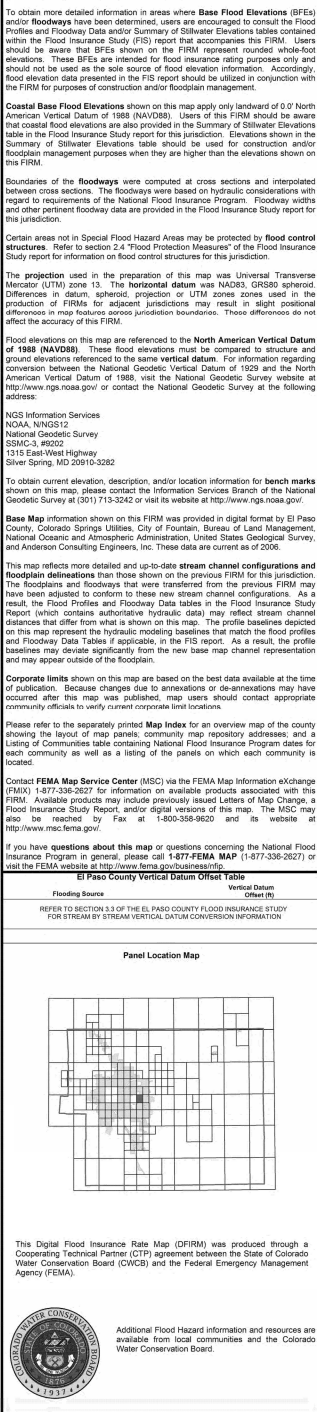
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses, and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which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

Contact **FEMA Map Service Center (MSC)** via the FEMA map information exchange (PMIX) 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The MSC may also be reached by Fax at 1-800-358-9620 and its website at <http://www.msc.fema.gov/>.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov/businessinfo>.

El Paso County Vertical Datum Offset Table

| Flooding Source | Vertical Datum Offset (ft) |
|---|----------------------------|
| REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION | |



HYDROLOGIC CALCULATIONS

ELECTRONIC STORAGE
(Area Runoff Coefficient Summary)

EXISTING CONDITIONS

| | | <i>STREETS / DEVELOPED</i> | | | <i>OVERLAND / UNDEVELOPED</i> | | | <i>WEIGHTED</i> | |
|-------|------------|----------------------------|----------------|------------------|-------------------------------|----------------|------------------|-----------------|------------------|
| BASIN | TOTAL AREA | AREA | C ₅ | C ₁₀₀ | AREA | C ₅ | C ₁₀₀ | C ₅ | C ₁₀₀ |
| | (Acres) | (Acres) | | | (Acres) | | | | |
| OS-Z | 4.01 | 4.01 | 0.45 | 0.59 | 0.00 | 0.09 | 0.36 | 0.45 | 0.59 |
| OS-Y | 2.55 | 2.55 | 0.20 | 0.44 | 0.00 | 0.09 | 0.36 | 0.20 | 0.44 |
| EX-A | 2.54 | 2.54 | 0.30 | 0.50 | 0.00 | 0.09 | 0.36 | 0.30 | 0.50 |
| EX-B | 1.91 | 1.91 | 0.12 | 0.39 | 0.00 | 0.09 | 0.36 | 0.12 | 0.39 |

Note: Basin C values are based on measured impervious values.

Percent impervious values are: 64%, 20%, 37%, and 7%.

Calculated by: DLF

Date: 8/5/2020

Checked by: LD

DEVELOPED CONDITIONS

| | | <i>STREETS / DEVELOPED</i> | | | <i>OVERLAND / UNDEVELOPED</i> | | | <i>WEIGHTED</i> | |
|-------|------------|----------------------------|----------------|------------------|-------------------------------|----------------|------------------|-----------------|------------------|
| BASIN | TOTAL AREA | AREA | C ₅ | C ₁₀₀ | AREA | C ₅ | C ₁₀₀ | C ₅ | C ₁₀₀ |
| | (Acres) | (Acres) | | | (Acres) | | | | |
| OS-E | 0.44 | 0.44 | 0.20 | 0.44 | 0.00 | 0.09 | 0.36 | 0.20 | 0.44 |
| OS-F | 1.38 | 1.38 | 0.20 | 0.44 | 0.00 | 0.09 | 0.36 | 0.20 | 0.44 |
| OS-G | 0.01 | 0.01 | 0.90 | 0.96 | 0.00 | 0.09 | 0.36 | 0.90 | 0.96 |
| PR-1 | 0.37 | 0.00 | 0.90 | 0.96 | 0.37 | 0.09 | 0.36 | 0.09 | 0.36 |
| PR-2 | 0.62 | 0.62 | 0.90 | 0.96 | 0.00 | 0.09 | 0.36 | 0.90 | 0.96 |
| PR-3 | 0.45 | 0.45 | 0.90 | 0.96 | 0.00 | 0.09 | 0.36 | 0.90 | 0.96 |
| PR-4 | 0.32 | 0.32 | 0.09 | 0.36 | 0.00 | 0.09 | 0.36 | 0.09 | 0.36 |
| PR-5 | 0.34 | 0.34 | 0.09 | 0.36 | 0.00 | 0.09 | 0.36 | 0.09 | 0.36 |
| PR-6 | 0.03 | 0.03 | 0.09 | 0.36 | 0.00 | 0.09 | 0.36 | 0.09 | 0.36 |
| PR-7 | 0.13 | 0.13 | 0.20 | 0.44 | 0.00 | 0.09 | 0.36 | 0.20 | 0.44 |

Calculated by: DLF

Date: 1/10/2020

Checked by: LD

ELECTRONIC STORAGE AREA DRAINAGE SUMMARY

EXISTING CONDITIONS

| | | WEIGHTED | | OVERLAND | | | | STREET / CHANNEL FLOW | | | | T _i | INTENSITY | | TOTAL FLOWS | |
|-------|--------------------------|--------------------------------|------------------|----------------|----------------|----------------|-------------------------|-----------------------|--------------|-------------------|-------------------------|----------------|---------------------------|-----------------------------|----------------------------|------------------------------|
| BASIN | AREA TOTAL (Acres) | C ₅ | C ₁₀₀ | C ₅ | Length (ft) | Height (ft) | T _C (min) | Length (ft) | Slope (%) | Velocity (fps) | T _t (min) | TOTAL (min) | I ₅ (in/hr) | I ₁₀₀ (in/hr) | Q ₅ (c.f.s.) | Q ₁₀₀ (c.f.s.) |
| | | * For Calcs See Runoff Summary | | | | | | | | | | | | | | |
| OS-Z | 4.01 | 0.45 | 0.59 | 0.45 | 300 | 20.0 | 6.2 | 900 | 6.0% | 3.7 | 4.1 | 10.3 | 4.0 | 7.0 | 7.3 | 16.5 |
| OS-Y | 2.55 | 0.20 | 0.44 | 0.20 | 300 | 16.6 | 9.1 | 0 | 6.0% | 4.9 | 0.0 | 9.1 | 4.2 | 7.3 | 2.1 | 8.2 |
| EX-A | 2.54 | 0.30 | 0.50 | 0.30 | 300 | 13.2 | 8.8 | 0 | 4.0% | 1.0 | 0.0 | 8.8 | 4.3 | 7.5 | 3.2 | 9.5 |
| EX-B | 1.91 | 0.12 | 0.39 | 0.12 | 300 | 18.2 | 9.6 | 0 | 6.0% | 4.9 | 0.0 | 9.6 | 4.1 | 7.2 | 0.9 | 5.4 |

DEVELOPED CONDITIONS

| | | WEIGHTED | | OVERLAND | | | | STREET / CHANNEL FLOW | | | | T _i | INTENSITY | | TOTAL FLOWS | |
|-------|--------------------------|--------------------------------|------------------|----------------|----------------|----------------|-------------------------|-----------------------|--------------|-------------------|-------------------------|----------------|---------------------------|-----------------------------|----------------------------|------------------------------|
| BASIN | AREA TOTAL (Acres) | C ₅ | C ₁₀₀ | C ₅ | Length (ft) | Height (ft) | T _C (min) | Length (ft) | Slope (%) | Velocity (fps) | T _t (min) | TOTAL (min) | I ₅ (in/hr) | I ₁₀₀ (in/hr) | Q ₅ (c.f.s.) | Q ₁₀₀ (c.f.s.) |
| | | * For Calcs See Runoff Summary | | | | | | | | | | | | | | |
| OS-E | 0.44 | 0.20 | 0.44 | 0.20 | 100 | 7.0 | 5.4 | 0 | 5.0% | 1.1 | 0.0 | 5.4 | 4.9 | 8.8 | 0.4 | 1.7 |
| OS-F | 1.38 | 0.20 | 0.44 | 0.20 | 300 | 21.0 | 8.4 | 0 | 5.0% | 1.1 | 0.0 | 8.4 | 4.3 | 7.6 | 1.2 | 4.6 |
| OS-G | 0.01 | 0.90 | 0.96 | 0.90 | 20 | 2.0 | 0.6 | 0 | 5.0% | 4.5 | 0.0 | 0.6 | 6.7 | 13.0 | 0.1 | 0.1 |
| PR-1 | 0.37 | 0.09 | 0.36 | 0.09 | 100 | 6.0 | 6.4 | 0 | 5.0% | 4.5 | 0.0 | 6.4 | 4.7 | 8.4 | 0.2 | 1.1 |
| PR-2 | 0.62 | 0.90 | 0.96 | 0.90 | 100 | 5.0 | 1.4 | 300 | 6.0% | 4.9 | 1.0 | 2.4 | 5.8 | 10.9 | 3.2 | 6.5 |
| PR-3 | 0.45 | 0.90 | 0.96 | 0.90 | 100 | 0.5 | 2.9 | 0 | 5.0% | 4.5 | 0.0 | 2.9 | 5.6 | 10.4 | 2.3 | 4.5 |
| PR-4 | 0.32 | 0.09 | 0.36 | 0.09 | 40 | 10.0 | 2.8 | 0 | 5.0% | 1.1 | 0.0 | 2.8 | 5.7 | 10.5 | 0.2 | 1.2 |
| PR-5 | 0.34 | 0.09 | 0.36 | 0.09 | 100 | 5.0 | 6.8 | 0 | 5.0% | 1.1 | 0.0 | 6.8 | 4.6 | 8.2 | 0.1 | 1.0 |
| PR-6 | 0.03 | 0.09 | 0.36 | 0.09 | 20 | 2.7 | 2.6 | 0 | 5.0% | 1.1 | 0.0 | 2.6 | 5.7 | 10.7 | 0.0 | 0.1 |
| PR-7 | 0.13 | 0.20 | 0.44 | 0.20 | 20 | 1.2 | 3.0 | 0 | 5.0% | 1.1 | 0.0 | 3.0 | 5.6 | 10.4 | 0.1 | 0.6 |

Calculated by: DLF

Date: 8/5/2020

Checked by: LD

ELECTRONIC STORAGE PROPOSED SURFACE ROUTING SUMMARY

| <i>Design Point(s)</i> | <i>Contributing Basins</i> | <i>Area Ac</i> | <i>Flow</i> | |
|-----------------------------------|---|---------------------------|-----------------------------|-------------------------------|
| | | | <i>Q₅</i> | <i>Q₁₀₀</i> |
| Z | OS-Z | 4.01 | 7.3 | 16.5 |
| Y | OS-Y | 2.55 | 2.1 | 8.2 |
| A | EX-A | 2.54 | 3.2 | 9.5 |
| B | EX-B, OS-Y | 4.46 | 3.1 | 13.6 |
| E | OS-E | 0.44 | 0.4 | 1.7 |
| F | OS-F | 1.38 | 1.2 | 4.6 |
| G | OS-G | 0.01 | 0.1 | 0.1 |
| 1 | OS-A, PR-1 | 0.81 | 0.6 | 2.8 |
| 2 | OS-A, OS-C, PR-1, PR-2 | 1.44 | 3.9 | 9.4 |
| 3 | PR-3 | 0.45 | 2.3 | 4.5 |
| 4 | OS-A, OS-C, PR-1, PR-2, PR-3, PR-4 | 2.21 | 6.3 | 15.1 |
| 5 | OS-B, PR-5 | 1.72 | 1.3 | 5.6 |
| 6 | PR-6 | 0.03 | 0.0 | 0.1 |
| 7 | PR-7 | 0.13 | 0.1 | 0.6 |

Calculated by: DLF

Date: 8/5/2020

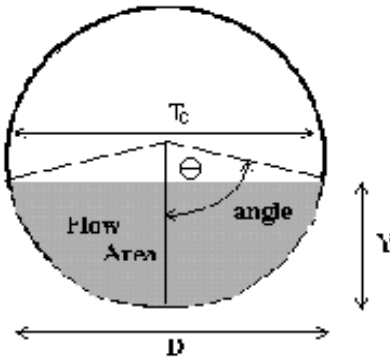
Checked by: LD

HYDRAULIC CALCULATIONS

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

Project: **Electronic Storage**

Pipe ID: **Entrance Culvert**



Design Information (Input)

| | | | |
|------------------------|---------|--------|--------|
| Pipe Invert Slope | $S_o =$ | 0.0200 | ft/ft |
| Pipe Manning's n-value | $n =$ | 0.0130 | |
| Pipe Diameter | $D =$ | 24.00 | inches |
| Design discharge | $Q =$ | 5.00 | cfs |

Full-flow Capacity (Calculated)

| | | | |
|----------------------------|------------|-------|---------|
| Full-flow area | $A_f =$ | 3.14 | sq ft |
| Full-flow wetted perimeter | $P_f =$ | 6.28 | ft |
| Half Central Angle | $\theta =$ | 3.14 | radians |
| Full-flow capacity | $Q_f =$ | 32.08 | cfs |

Calculation of Normal Flow Condition

| | | | |
|--|-----------------|-------|---------------|
| Half Central Angle ($0 < \theta < 3.14$) | $\theta =$ | 1.09 | radians |
| Flow area | $A_n =$ | 0.67 | sq ft |
| Top width | $T_n =$ | 1.77 | ft |
| Wetted perimeter | $P_n =$ | 2.17 | ft |
| Flow depth | $Y_n =$ | 0.53 | ft |
| Flow velocity | $V_n =$ | 7.42 | fps |
| Discharge | $Q_n =$ | 5.00 | cfs |
| Percent Full Flow | $\text{Flow} =$ | 15.6% | of full flow |
| Normal Depth Froude Number | $Fr_n =$ | 2.12 | supercritical |

Calculation of Critical Flow Condition

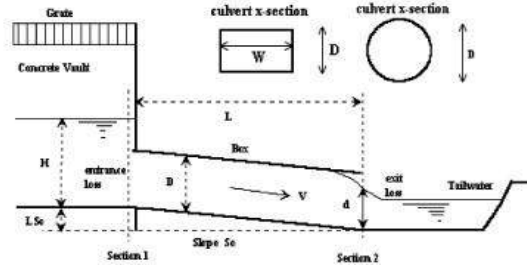
| | | | |
|--|--------------|------|---------|
| Half Central Angle ($0 < \theta_c < 3.14$) | $\theta_c =$ | 1.36 | radians |
| Critical flow area | $A_c =$ | 1.15 | sq ft |
| Critical top width | $T_c =$ | 1.95 | ft |
| Critical flow depth | $Y_c =$ | 0.79 | ft |
| Critical flow velocity | $V_c =$ | 4.35 | fps |
| Critical Depth Froude Number | $Fr_c =$ | 1.00 | |

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: **Electronic Storage**

Basin ID: **Entrance Culvert**

Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches
Inlet Edge Type (choose from pull-down list)

D = 24 inches

Grooved End with Headwall

OR:

Box Culvert: Barrel Height (Rise) in Feet
Barrel Width (Span) in Feet
Inlet Edge Type (choose from pull-down list)

Height (Rise) = ft.

Width (Span) = ft.

Square Edge w/ 30-78 deg. Flared Wingwall

Number of Barrels
Inlet Elevation at Culvert Invert
Outlet Elevation at Culvert Invert OR Slope of Culvert (ft v./ft h.)
Culvert Length in Feet
Manning's Roughness
Bend Loss Coefficient
Exit Loss Coefficient

No = 1

Inlet Elev = 6497.5 ft. elev.

Outlet Elev = 6496.5 ft. elev.

L = 50 ft.

n = 0.013

K_b = 0

K_x = 1

Design Information (calculated):

Entrance Loss Coefficient
Friction Loss Coefficient
Sum of All Loss Coefficients
Orifice Inlet Condition Coefficient
Minimum Energy Condition Coefficient

K_e = 0.20

K_f = 0.62

K_s = 1.82

C_d = 0.99

KE_{low} = -0.0794

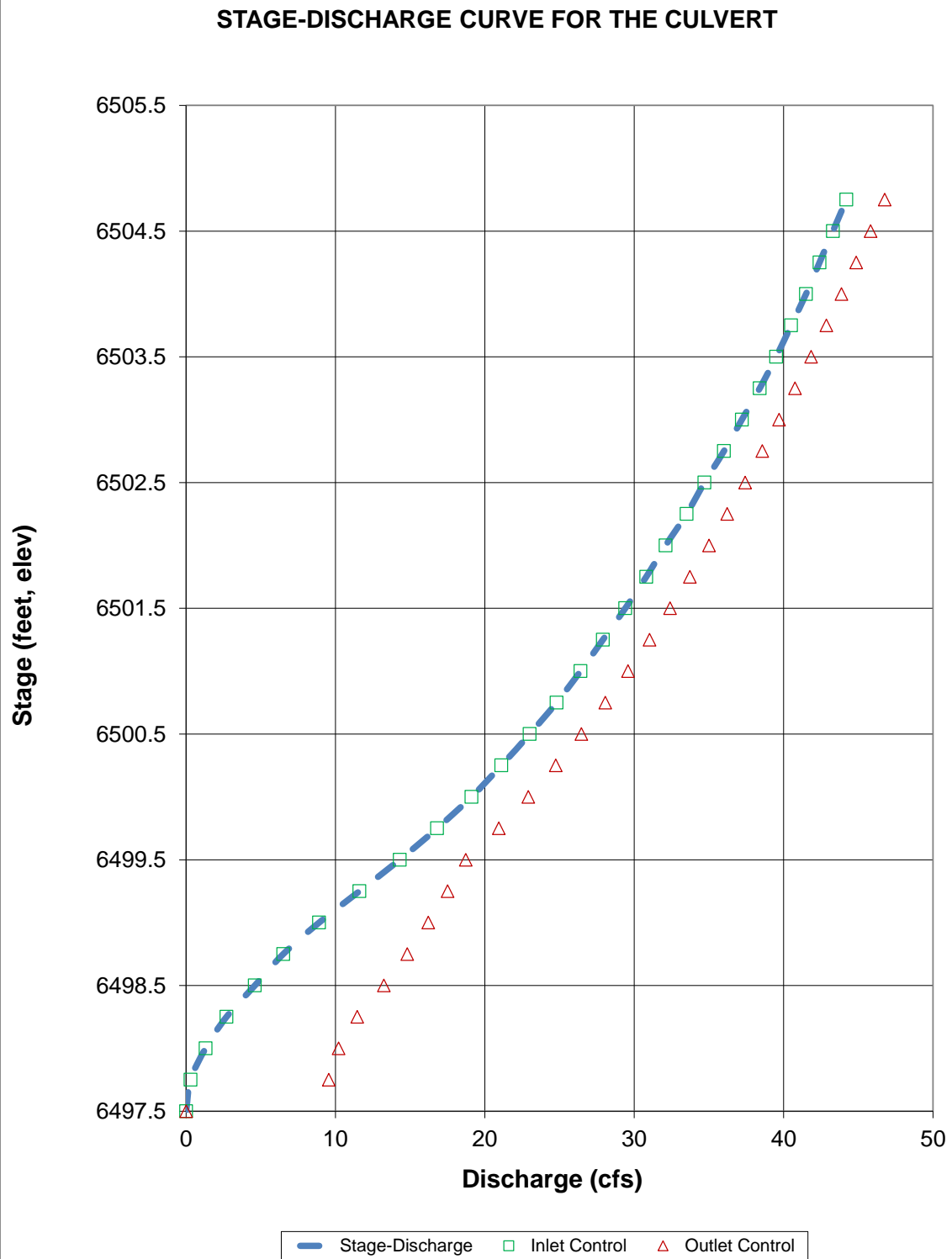
Calculations of Culvert Capacity (output):

| Water Surface Elevation (ft., linked) | Tailwater Surface Elevation ft | Culvert Inlet-Control Flowrate cfs | Culvert Outlet-Control Flowrate cfs | Controlling Culvert Flowrate cfs (output) | Inlet Equation Used: | Flow Control Used |
|--|-----------------------------------|---------------------------------------|--|--|----------------------|-------------------|
| 6497.50 | | 0.00 | 0.00 | 0.00 | No Flow (WS < inlet) | N/A |
| 6497.75 | | 0.30 | 9.55 | 0.30 | Min. Energy Eqn. | INLET |
| 6498.00 | | 1.30 | 10.21 | 1.30 | Min. Energy Eqn. | INLET |
| 6498.25 | | 2.70 | 11.45 | 2.70 | Min. Energy Eqn. | INLET |
| 6498.50 | | 4.60 | 13.23 | 4.60 | Min. Energy Eqn. | INLET |
| 6498.75 | | 6.50 | 14.80 | 6.50 | Regression Eqn. | INLET |
| 6499.00 | | 8.90 | 16.20 | 8.90 | Regression Eqn. | INLET |
| 6499.25 | | 11.60 | 17.50 | 11.60 | Regression Eqn. | INLET |
| 6499.50 | | 14.30 | 18.72 | 14.30 | Regression Eqn. | INLET |
| 6499.75 | | 16.80 | 20.92 | 16.80 | Regression Eqn. | INLET |
| 6500.00 | | 19.10 | 22.91 | 19.10 | Regression Eqn. | INLET |
| 6500.25 | | 21.10 | 24.75 | 21.10 | Regression Eqn. | INLET |
| 6500.50 | | 23.00 | 26.46 | 23.00 | Regression Eqn. | INLET |
| 6500.75 | | 24.80 | 28.06 | 24.80 | Regression Eqn. | INLET |
| 6501.00 | | 26.40 | 29.58 | 26.40 | Regression Eqn. | INLET |
| 6501.25 | | 27.90 | 31.02 | 27.90 | Regression Eqn. | INLET |
| 6501.50 | | 29.40 | 32.39 | 29.40 | Regression Eqn. | INLET |
| 6501.75 | | 30.80 | 33.72 | 30.80 | Regression Eqn. | INLET |
| 6502.00 | | 32.10 | 35.00 | 32.10 | Regression Eqn. | INLET |
| 6502.25 | | 33.50 | 36.22 | 33.50 | Regression Eqn. | INLET |
| 6502.50 | | 34.70 | 37.42 | 34.70 | Regression Eqn. | INLET |
| 6502.75 | | 36.00 | 38.57 | 36.00 | Regression Eqn. | INLET |
| 6503.00 | | 37.20 | 39.69 | 37.20 | Regression Eqn. | INLET |
| 6503.25 | | 38.40 | 40.76 | 38.40 | Regression Eqn. | INLET |
| 6503.50 | | 39.50 | 41.83 | 39.50 | Regression Eqn. | INLET |
| 6503.75 | | 40.50 | 42.85 | 40.50 | Orifice Eqn. | INLET |
| 6504.00 | | 41.50 | 43.86 | 41.50 | Orifice Eqn. | INLET |
| 6504.25 | | 42.40 | 44.85 | 42.40 | Orifice Eqn. | INLET |
| 6504.50 | | 43.30 | 45.81 | 43.30 | Orifice Eqn. | INLET |
| 6504.75 | | 44.20 | 46.76 | 44.20 | Orifice Eqn. | INLET |

Processing Time: 00.89 Seconds

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

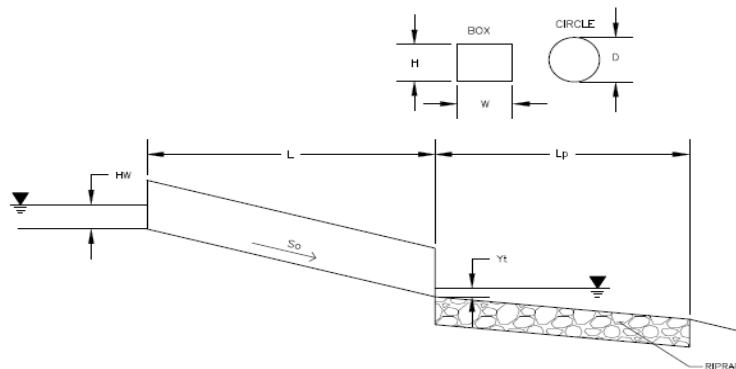
Project: Electronic Storage
Basin ID: Entrance Culvert



Determination of Culvert Headwater and Outlet Protection

Project: **Electronic Storage**

Basin ID: **Entrance Culvert**



Soil Type:

Choose One:

☒ Sandy

☐ Non-Sandy

Supercritical Flow! Using D_a to calculate protection type.

Design Information (Input):

Design Discharge

Q = 5 cfs

Circular Culvert:

Barrel Diameter in Inches

D = 24 inches

Inlet Edge Type (Choose from pull-down list)

Square End with Headwall

Box Culvert:

Barrel Height (Rise) in Feet

Height (Rise) = ft

Barrel Width (Span) in Feet

Width (Span) = ft

Inlet Edge Type (Choose from pull-down list)

Number of Barrels

No = 1

Inlet Elevation

Elev IN = 6497.5 ft

Outlet Elevation **OR** Slope

Elev OUT = 6496.5 ft

Culvert Length

L = 50 ft

Manning's Roughness

n = 0.013

Bend Loss Coefficient

k_b = 0

Exit Loss Coefficient

k_x = 1

Tailwater Surface Elevation

Elev Y_t = ft

Max Allowable Channel Velocity

V = 5 ft/s

Required Protection (Output):

Tailwater Surface Height

Y_t = 0.80 ft

Flow Area at Max Channel Velocity

A_t = 1.00 ft²

Culvert Cross Sectional Area Available

A = 3.14 ft²

Entrance Loss Coefficient

k_e = 0.50

Friction Loss Coefficient

k_f = 0.62

Sum of All Losses Coefficients

k_s = 2.12

Culvert Normal Depth

Y_n = 0.53 ft

Culvert Critical Depth

Y_c = 0.79 ft

Tailwater Depth for Design

d = 1.39 ft

Adjusted Diameter **OR** Adjusted Rise

D_a = 1.27 ft

Expansion Factor

$1/(2*\tan(\Theta))$ = 6.70

Flow/Diameter^{2.5} **OR** Flow/(Span * Rise^{1.5})

$Q/D^{2.5}$ = 0.88 ft^{0.5}/s

Froude Number

Fr = 2.12

Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise

Y_t/D = 0.63

Supercritical!

Inlet Control Headwater

HW_i = 1.09 ft

Outlet Control Headwater

HW_o = 0.48 ft

Design Headwater Elevation

HW = 6,498.59 ft

Headwater/Diameter **OR** Headwater/Rise Ratio

HW/D = 0.55

Minimum Theoretical Riprap Size

d_{50} = 2 in

Nominal Riprap Size

d_{50} = 6 in

UDFCD Riprap Type

Type = VL

Length of Protection

L_p = 6 ft

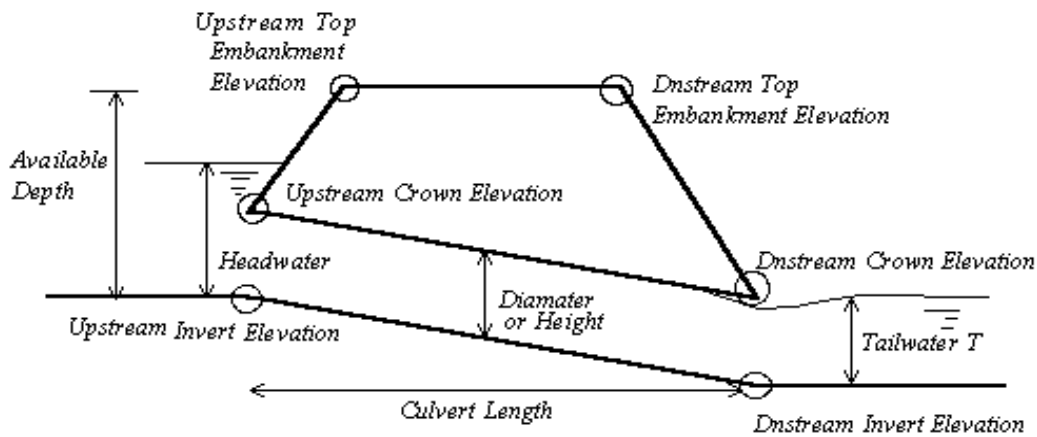
Width of Protection

T = 3 ft

Vertical Profile for the Culvert

Project = **Electronic Storage**

Box ID = **Entrance Culvert**



Culvert Information (Input)

| | | | |
|-------------------------------------|----------|---------|--------|
| Barrel Diameter or Height | D or H = | 24.00 | inches |
| Barrel Length | L = | 50.00 | ft |
| Barrel Invert Slope | So = | 0.0200 | ft/ft |
| Downstream Invert Elevation | EDI = | 6496.50 | ft |
| Downstream Top Embankment Elevation | EDT = | 6499.50 | ft |
| Upstream Top Embankment Elevation | EUT = | 6501.00 | ft |
| Design Headwater Depth (not elev.) | Hw = | 1.09 | ft |
| Tailwater Depth (not elev.) | Yt = | 1.39 | ft |

Culvert Hydraulics (Calculated)

| | | | |
|---------------------------|--------|------|----|
| Available Headwater Depth | HW-a = | 3.50 | ft |
| Design Hw/D ratio | Hw/D = | 0.55 | |

Culvert Vertical Profile

| | | | |
|-----------------------------|----------|---------|----|
| Upstream Invert Elevation | EUI = | 6497.50 | ft |
| Upstream Crown Elevation | EUC = | 6499.50 | ft |
| Upstream Soil Cover Depth | Upsoil = | 1.50 | ft |
| Downstream Invert Elevation | EDI = | 6496.50 | ft |
| Downstream Crown Elevation | EDC = | 6498.50 | ft |
| Downstream Soil Cover Depth | Dnsoil = | 1.00 | ft |

MANNING'S EQUATION FOR PIPE FLOW

Project: Electronic Storage Location: Roof Drains Storm Pipe (Need Q=4.5 cfs)
By: Dane Frank Date: 1/13/2020
Chk. By: Date: mdo version 12.8.00

Clear Data
Entry Cells

INPUT

D= 12 inches
d= 12 inches
n= 0.012 manning's coeff
θ= 0.0 degrees
S= 0.1 slope in/in

Mannings Formula

$$Q=(1.486/n)AR_h^{2/3}S^{1/2}$$

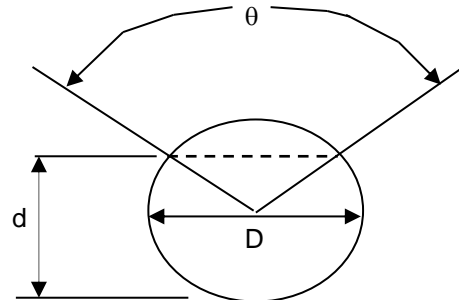
$$R=A/P$$

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient



$$V=(1.49/n)R_h^{2/3}S^{1/2}$$

$$Q=V \times A$$

| | | | Solution to Mannings Equation | | Manning's n-values | |
|----------------------|----------------------|----------------------|-------------------------------|-----------|--------------------|-------|
| Area,ft ² | Wetted Perimeter, ft | Hydraulic Radius, ft | velocity ft/s | flow, cfs | | |
| 0.79 | 3.14 | 0.25 | 15.54 | 12.20 | PVC | 0.01 |
| | | | | | PE (<9"dia) | 0.015 |
| | | | | | PE (>12"dia) | 0.02 |
| | | | | | PE(9-12"dia) | 0.017 |
| | | | | | CMP | 0.025 |
| | | | | | ADS N12 | 0.012 |
| | | | | | HCMP | 0.023 |
| | | | | | Conc | 0.013 |

Created by: Mike O'Shea

MANNING'S EQUATION FOR PIPE FLOW

Project: Electronic Storage Location: SW Pond Inlet ST Pipe (Need Q=9.2 cfs)

By: Dane Frank

Date: 8/28/2020

Chk. By:

Date:

mdo version 12.8.00

Clear Data
Entry Cells

INPUT

D= 15 inches
d= 15 inches
n= 0.012 mannings coeff
θ= 0.0 degrees
S= 0.049 slope in/in

Mannings Formula

$$Q = (1.486/n) A R_h^{2/3} S^{1/2}$$

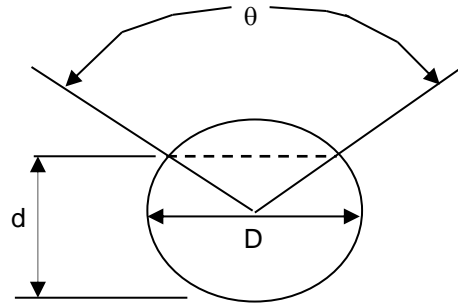
$$R = A/P$$

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient



$$V = (1.49/n) R_h^{2/3} S^{1/2}$$

$$Q = V \times A$$

| | | | Solution to Mannings Equation | | Manning's n-values | |
|----------------------|----------------------|----------------------|-------------------------------|-----------|--------------------|-------|
| Area,ft ² | Wetted Perimeter, ft | Hydraulic Radius, ft | velocity ft/s | flow, cfs | | |
| 1.23 | 3.93 | 0.31 | 12.62 | 15.49 | PVC | 0.01 |
| | | | | | PE (<9"dia) | 0.015 |
| | | | | | PE (>12"dia) | 0.02 |
| | | | | | PE(9-12"dia) | 0.017 |
| | | | | | CMP | 0.025 |
| | | | | | ADS N12 | 0.012 |
| | | | | | HCMP | 0.023 |
| | | | | | Conc | 0.013 |

Created by: Mike O'Shea

MANNING'S EQUATION FOR PIPE FLOW

Project: Electronic Storage Location: NE Pond Inlet ST Pipe (Need Q=4.7 cfs)
By: Dane Frank Date: 1/13/2020
Chk. By: Date: mdo version 12.8.00

Clear Data
Entry Cells

INPUT

D= 12 inches
d= 12 inches
n= 0.012 mannings coeff
θ= 0.0 degrees
S= 0.049 slope in/in

Mannings Formula

$$Q=(1.486/n)AR_h^{2/3}S^{1/2}$$

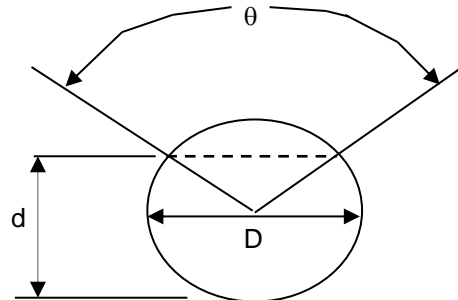
$$R=A/P$$

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient



$$V=(1.49/n)R_h^{2/3}S^{1/2}$$

$$Q=V \times A$$

| | | | Solution to Mannings Equation | | Manning's n-values | |
|----------------------|----------------------|----------------------|-------------------------------|-----------|--------------------|-------|
| Area,ft ² | Wetted Perimeter, ft | Hydraulic Radius, ft | velocity ft/s | flow, cfs | | |
| 0.79 | 3.14 | 0.25 | 10.88 | 8.54 | PVC | 0.01 |
| | | | | | PE (<9"dia) | 0.015 |
| | | | | | PE (>12"dia) | 0.02 |
| | | | | | PE(9-12"dia) | 0.017 |
| | | | | | CMP | 0.025 |
| | | | | | ADS N12 | 0.012 |
| | | | | | HCMP | 0.023 |
| | | | | | Conc | 0.013 |

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **NW of Bldg Street Capacity (Need 3 cfs)**

By: **Dane Frank**

Date: **1/13/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

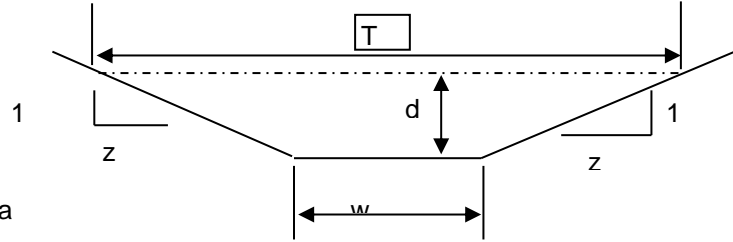
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 25
z (sideslope)= 50
b (btm width, ft)= 0
d (depth, ft)= 0.6
S (slope, ft/ft) 0.005
n low = 0.013
n high = 0.013

Clear Data
Entry Cells

| | | | | Low N | | High N | | | |
|---|----------|-------------------------|-------------------------|-----------------|-----------|------------------|-----------|-----|-------|
| Depth, ft | Area, sf | Wetted Perimeter, ft | Hydraulic Radius, ft | Velocity, | | | | T = | Dm = |
| | | | | Velocity, fps | Flow, cfs | fps | Flow, cfs | | |
| 0.6 | 13.50 | 45.02 | 0.30 | 3.62110768 | 48.885 | 3.621108 | 48.885 | | 45 |
| | | | | | | | | | 0.300 |
| | | | | Sc low = 0.0037 | | Sc high = 0.0037 | | | |
| s _c = critical slope ft / ft | | | | | | | | | |
| T = top width of the stream | | | | .7 Sc | | 1.3 Sc | | | |
| d _m = a/T = mean depth of flow | | | | 0.0026 | | 0.0048 | | | |
| | | | | | | | | | |

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **NE of Bldg Street Capacity (Need 4.7 cfs)**

By: **Dane Frank**

Date: **8/28/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

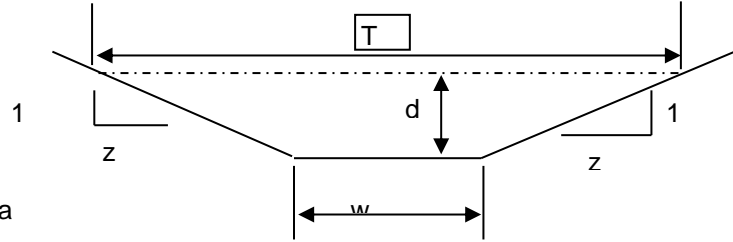
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 25
z (sideslope)= 25
b (btm width, ft)= 0
d (depth, ft)= 0.6
S (slope, ft/ft) 0.1
n low = 0.013
n high = 0.013

Clear Data
Entry Cells

| | | Low N | | High N | | | |
|-----------|----------|----------------------|----------------------|---------------|-----------|---------------|-----------|
| Depth, ft | Area, sf | Wetted Perimeter, ft | Hydraulic Radius, ft | Velocity, fps | Flow, cfs | Velocity, fps | Flow, cfs |
| 0.6 | 9.00 | 30.02 | 0.30 | 16.1897726 | 145.708 | 16.18977 | 145.708 |
| | | | | T = | | 30 | |
| | | | | Dm = | | 0.300 | |
| | | | | Sc low = | | 0.0037 | |
| | | | | Sc high = | | 0.0037 | |
| | | | | .7 Sc | | 1.3 Sc | |
| | | | | 0.0026 | | 0.0048 | |
| | | | | .7 Sc | | 1.3 Sc | |
| | | | | 0.0026 | | 0.0048 | |

s_c = critical slope ft / ft

T = top width of the stream

$d_m = a/T$ = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **SE of Bldg Street Capacity (Need 4.7 cfs)**

By: **Dane Frank**

Date: **8/28/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

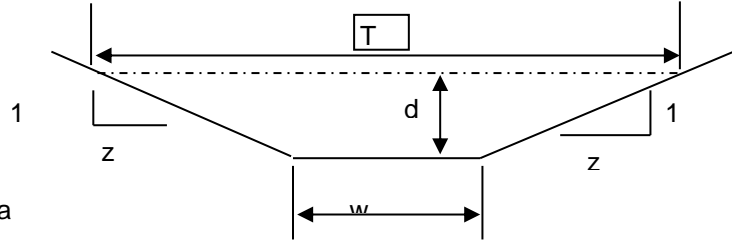
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 50
z (sideslope)= 0
b (btm width, ft)= 0
d (depth, ft)= 0.5
S (slope, ft/ft) 0.01
n low = 0.013
n high = 0.013

Clear Data
Entry Cells

| | | | | Low N | | High N | | | |
|---|----------|-------------------------|-------------------------|-----------------|-----------|------------------|-----------|-----|------|
| Depth, ft | Area, sf | Wetted Perimeter, ft | Hydraulic Radius, ft | Velocity, | | | | T = | Dm = |
| | | | | Velocity, fps | Flow, cfs | fps | Flow, cfs | | |
| 0.5 | 6.25 | 25.50 | 0.25 | 4.47601532 | 27.9751 | 4.476015 | 27.9751 | | 25 |
| | | | | Sc low = 0.0040 | | Sc high = 0.0040 | | | |
| s _c = critical slope ft / ft | | | | | | | | | |
| T = top width of the stream | | | | .7 Sc 1.3 Sc | | .7 Sc 1.3 Sc | | | |
| d _m = a/T = mean depth of flow | | | | 0.0028 0.0052 | | 0.0028 0.0052 | | | |

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **SW of Bldg Street Capacity (Need 4.7 cfs)**

By: **Dane Frank**

Date: **8/28/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

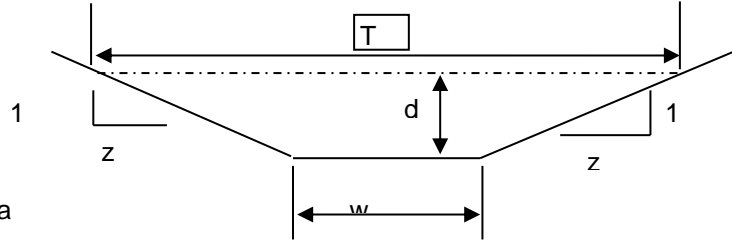
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 25
z (sideslope)= 0
b (btm width, ft)= 0
d (depth, ft)= 0.5
S (slope, ft/ft) 0.1
n low = 0.013
n high = 0.013

Clear Data
Entry Cells

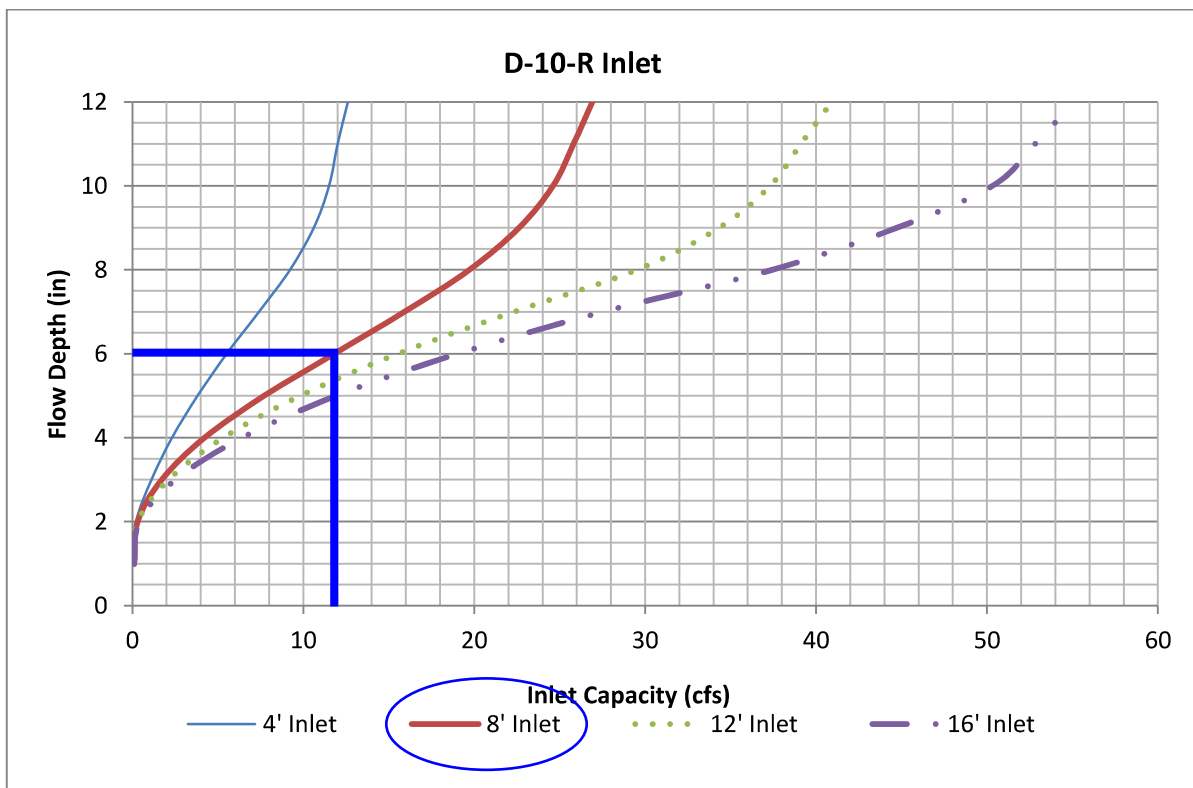
| | | | | Low N | | High N | | | |
|---|----------|-------------------------|-------------------------|---------------|-----------|-----------|-----------|--------|------|
| Depth, ft | Area, sf | Wetted Perimeter, ft | Hydraulic Radius, ft | Velocity, | | | | T = | Dm = |
| | | | | Velocity, fps | Flow, cfs | fps | Flow, cfs | | |
| 0.5 | 3.13 | 13.01 | 0.24 | 13.967008 | 43.6469 | 13.96701 | 43.6469 | | 12.5 |
| | | | | Sc low = | | Sc high = | | 0.0041 | |
| s _c = critical slope | | | | .7 Sc | | 1.3 Sc | | .7 Sc | |
| T = top width of the stream | | | | 0.0029 | | 0.0054 | | 0.0029 | |
| d _m = a/T = mean depth of flow | | | | | | | | 0.0054 | |

s_c = critical slope ft / ft

T = top width of the stream

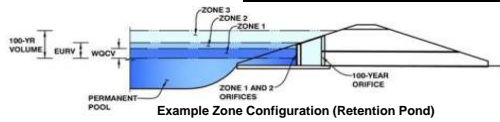
d_m = a/T = mean depth of flow

Created by: Mike O'Shea

Figure 8-12. Inlet Capacity Chart Sump Conditions, Curb Opening (D-10-R) Inlet

DETENTION CALCULATIONS

MHFD-Detention, Version 4.03 (May 2020)

Basin ID: EDB

| | | |
|---|------------|---------|
| Selected BMP Type = | EDB | |
| Watershed Area = | 1.77 | acres |
| Watershed Length = | 340 | ft |
| Watershed Length to Centroid = | 170 | ft |
| Watershed Slope = | 0.060 | ft/ft |
| Watershed Imperviousness = | 62.00% | percent |
| Percentage Hydrologic Soil Group A = | 98.0% | percent |
| Percentage Hydrologic Soil Group B = | 2.0% | percent |
| Percentage Hydrologic Soil Groups C/D = | 0.0% | percent |
| Target WQCV Drain Time = | 40.0 | hours |
| Location for 1-hr Rainfall Depths = Denver - Capitol Building | | |

Optional User Overrides

| | | | | | |
|--|-------|-----------|--|------|-----------|
| Water Quality Capture Volume (WQCV) = | 0.036 | acre-feet | | | acre-feet |
| Excess Urban Runoff Volume (EURV) = | 0.134 | acre-feet | | | acre-feet |
| 2-yr Runoff Volume (P1 = 1.19 in.) = | 0.091 | acre-feet | | 1.19 | inches |
| 5-yr Runoff Volume (P1 = 1.5 in.) = | 0.120 | acre-feet | | 1.50 | inches |
| 10-yr Runoff Volume (P1 = 1.75 in.) = | 0.143 | acre-feet | | 1.75 | inches |
| 25-yr Runoff Volume (P1 = 2 in.) = | 0.175 | acre-feet | | 2.00 | inches |
| 50-yr Runoff Volume (P1 = 2.25 in.) = | 0.205 | acre-feet | | 2.25 | inches |
| 100-yr Runoff Volume (P1 = 2.52 in.) = | 0.242 | acre-feet | | 2.52 | inches |
| 500-yr Runoff Volume (P1 = 3 in.) = | 0.305 | acre-feet | | 3.00 | inches |
| Approximate 2-yr Detention Volume = | 0.087 | acre-feet | | | |
| Approximate 5-yr Detention Volume = | 0.114 | acre-feet | | | |
| Approximate 10-yr Detention Volume = | 0.138 | acre-feet | | | |
| Approximate 25-yr Detention Volume = | 0.167 | acre-feet | | | |
| Approximate 50-yr Detention Volume = | 0.184 | acre-feet | | | |
| Approximate 100-yr Detention Volume = | 0.202 | acre-feet | | | |

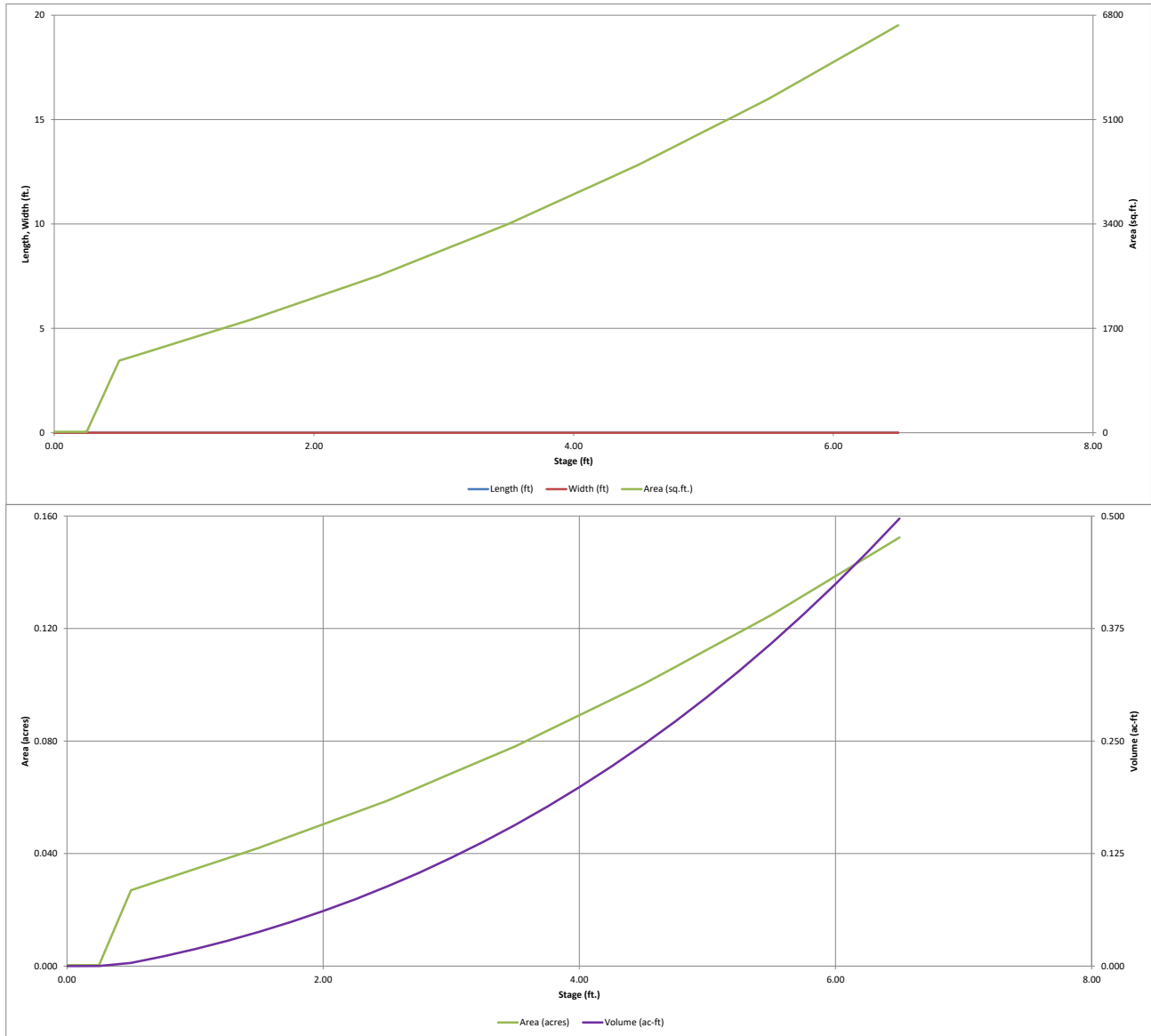
| | | |
|---|-------|-----------------|
| Zone 1 Volume (WQCV) = | 0.036 | acre-feet |
| Zone 2 Volume (EURV - Zone 1) = | 0.098 | acre-feet |
| Zone 3 Volume (100-year - Zones 1 & 2) = | 0.068 | acre-feet |
| Total Detention Basin Volume = | 0.202 | acre-feet |
| Initial Surcharge Volume (ISV) = | user | 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 Slopes (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 |

[illegible]

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)

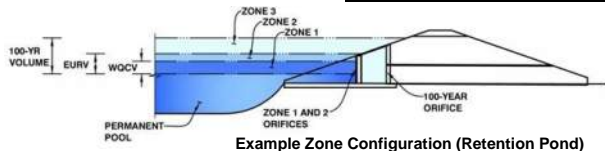


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Project: **Electronic Storage**

Basin ID: **EDB**



Example Zone Configuration (Retention Pond)

| | Estimated Stage (ft) | Estimated Volume (ac-ft) | Outlet Type |
|-------------------|----------------------|--------------------------|-------------------|
| Zone 1 (WQCV) | 1.45 | 0.036 | Orifice Plate |
| Zone 2 (EURV) | 3.20 | 0.098 | Orifice Plate |
| Zone 3 (100-year) | 4.04 | 0.068 | Weir&Pipe (Rect.) |
| Total (all zones) | | 0.202 | |

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

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

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

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

Invert of Lowest Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = inches
Orifice Plate: Orifice Area per Row = sq. inches (diameter = 5/8 inch)

Calculated Parameters for Plate
WQ Orifice Area per Row = ft²
Elliptical Half-Width = feet
Elliptical Slot Centroid = feet
Elliptical Slot Area = ft²

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

| | Row 1 (required) | Row 2 (optional) | Row 3 (optional) | Row 4 (optional) | Row 5 (optional) | Row 6 (optional) | Row 7 (optional) | Row 8 (optional) |
|--------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Stage of Orifice Centroid (ft) | 0.00 | 1.07 | 2.13 | | | | | |
| Orifice Area (sq. inches) | 0.31 | 0.31 | 0.31 | | | | | |

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

User Input: Vertical Orifice (Circular or Rectangular)

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

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

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

Overflow Weir Front Edge Height, H_o = ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length = feet
Overflow Weir Grate Slope = H:V
Horiz. Length of Weir Sides = feet
Overflow Grate Open Area % = %
Debris Clogging % = %

Calculated Parameters for Overflow Weir
Height of Grate Upper Edge, H_u = feet
Overflow Weir Slope Length = feet
Grate Open Area / 100-yr Orifice Area =
Overflow Grate Open Area w/o Debris = ft²
Overflow Grate Open Area w/ Debris = ft²

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

Depth to Invert of Outlet Pipe = ft (distance below basin bottom at Stage = 0 ft)
Rectangular Orifice Width = inches
Rectangular Orifice Height = inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate
Outlet Orifice Area = ft²
Outlet Orifice Centroid = feet
Half-Central Angle of Restrictor Plate on Pipe = radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

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

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

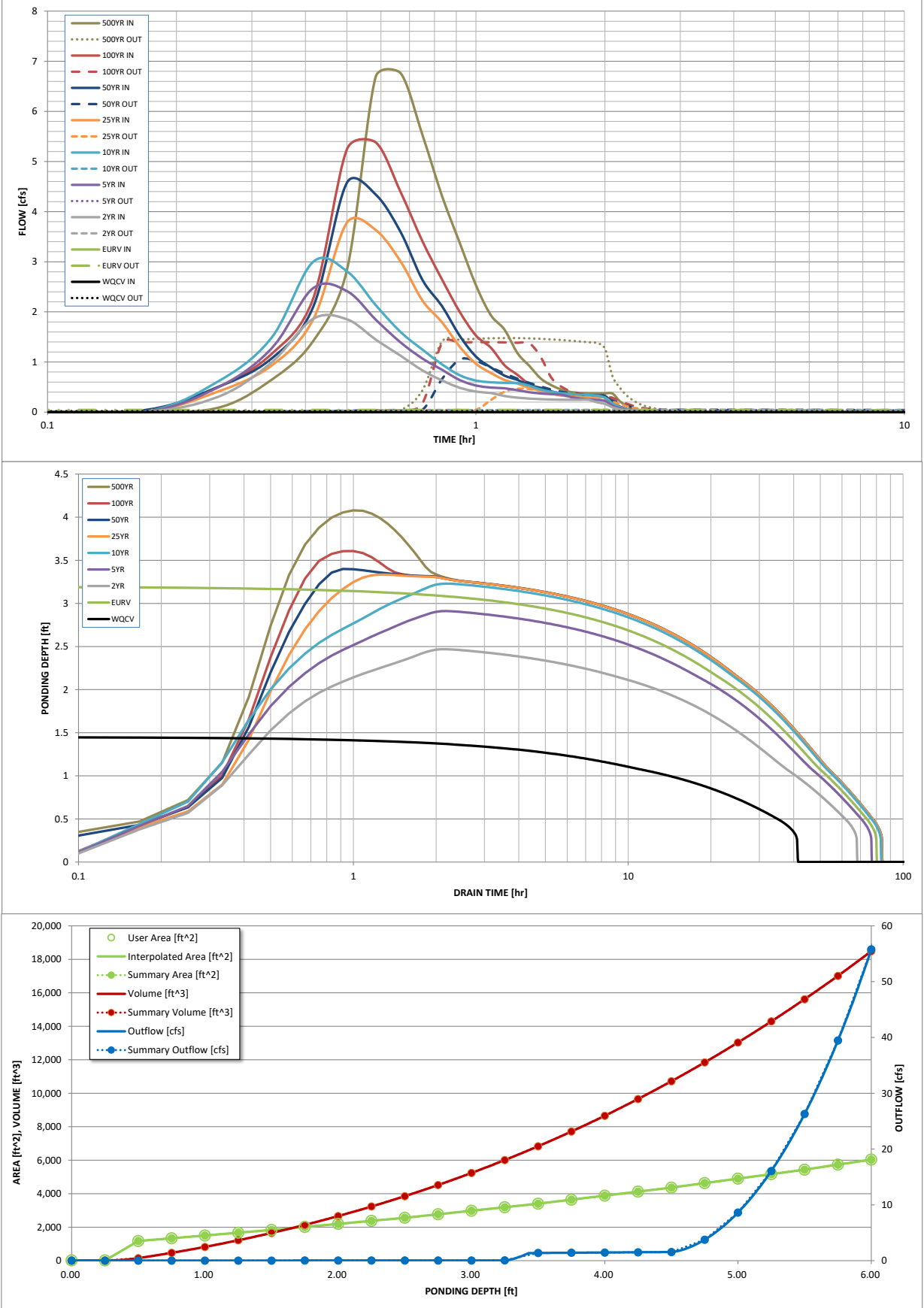
Routed Hydrograph Results

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

| | WQCV | EURV | 2 Year | 5 Year | 10 Year | 25 Year | 50 Year | 100 Year | 500 Year |
|---|-------|-------|--------|--------|---------|-----------------|-----------------|----------------|----------------|
| Design Storm Return Period = | N/A | N/A | 1.19 | 1.50 | 1.75 | 2.00 | 2.25 | 2.52 | 3.00 |
| One-Hour Rainfall Depth (in) = | 0.036 | 0.134 | 0.091 | 0.120 | 0.143 | 0.175 | 0.205 | 0.242 | 0.305 |
| CUHP Runoff Volume (acre-ft) = | N/A | N/A | 0.091 | 0.120 | 0.143 | 0.175 | 0.205 | 0.242 | 0.305 |
| Inflow Hydrograph Volume (acre-ft) = | N/A | N/A | 0.0 | 0.0 | 0.1 | 0.5 | 1.0 | 1.5 | 2.4 |
| CUHP Predevelopment Peak Q (cfs) = | N/A | N/A | | | | | | | |
| OPTIONAL Override Predevelopment Peak Q (cfs) = | N/A | N/A | | | | | | | |
| Predevelopment Unit Peak Flow, q (cfs/acre) = | N/A | N/A | 0.01 | 0.02 | 0.03 | 0.30 | 0.55 | 0.87 | 1.37 |
| Peak Inflow Q (cfs) = | N/A | N/A | 1.9 | 2.5 | 3.0 | 3.8 | 4.6 | 5.4 | 6.8 |
| Peak Outflow Q (cfs) = | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.0 | 1.4 | 1.5 |
| Ratio Peak Outflow to Predevelopment Q = | N/A | N/A | N/A | 1.0 | 0.8 | 0.9 | 1.1 | 0.9 | 0.6 |
| Structure Controlling Flow = | Plate | Plate | Plate | Plate | Plate | Overflow Weir 1 | Overflow Weir 1 | Outlet Plate 1 | Outlet Plate 1 |
| Max Velocity through Grate 1 (fps) = | N/A | N/A | N/A | N/A | N/A | 0.1 | 0.4 | 0.5 | 0.5 |
| 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 | 73 | 63 | 70 | 76 | 75 | 73 | 72 | 69 |
| Time to Drain 99% of Inflow Volume (hours) = | 41 | 78 | 66 | 75 | 80 | 81 | 80 | 79 | 78 |
| Maximum Ponding Depth (ft) = | 1.46 | 3.20 | 2.47 | 2.91 | 3.23 | 3.33 | 3.40 | 3.61 | 4.08 |
| Area at Maximum Ponding Depth (acres) = | 0.04 | 0.07 | 0.06 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 |
| Maximum Volume Stored (acre-ft) = | 0.036 | 0.134 | 0.086 | 0.114 | 0.136 | 0.144 | 0.148 | 0.165 | 0.205 |

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.00 (December 2019)



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

FORBAY VOLUMES

FORBAY VOLUME

Required Forbay Volume = 1% of WQCV

WQCV = 0.035 ac-ft

WQCV = 1,525 cu-ft

1% of WQCV = 15 cu-ft

| <i>ELEV</i> | <i>AREA</i> | <i>AREA AVG.</i> | <i>DELTA ELEV.</i> | <i>VOLUME</i> | <i>VOLUME TOTAL</i> |
|-------------|-------------|----------------------|------------------------|---------------|-------------------------|
| 6483.00 | 39 | 39 | 1 | 39 | |
| 6484.00 | 39 | | | | 39 |

Design Volume: 39 cu-ft
0.001 ac-ft

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

By: **Dane Frank**

Chk By:

Location: **Forebay Notch - Q=13.9 cfs * 2% = 0.28 cfs**

Date: **8/31/2020**

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

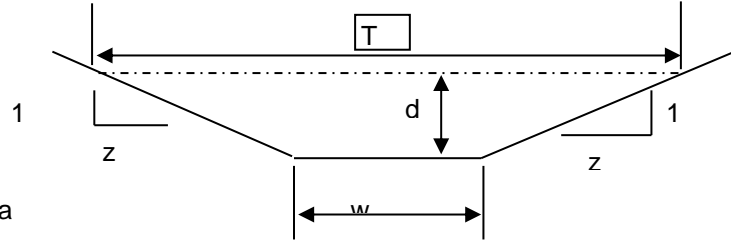
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 0
z (sideslope)= 0
b (btm width, ft)= 0.19
d (depth, ft)= 1
S (slope, ft/ft) 0.005
n low = 0.013
n high = 0.013

Clear Data
Entry Cells

| Depth, ft | Area, sf | Wetted Perimeter, ft | Hydraulic Radius, ft | Low N | | High N | | |
|-----------|----------|-------------------------|-------------------------|-----------------|-----------|------------------|-----------|------------|
| | | | | Velocity, fps | Flow, cfs | Velocity, fps | Flow, cfs | |
| 1 | 0.19 | 2.19 | 0.09 | 1.58391326 | 0.30094 | 1.583913 | 0.30094 | T = 0.19 |
| | | | | | | | | Dm = 1.000 |
| | | | | Sc low = 0.0641 | | Sc high = 0.0641 | | |
| | | | | .7 Sc | 1.3 Sc | .7 Sc | 1.3 Sc | |
| | | | | 0.0448 | 0.0833 | 0.0448 | 0.0833 | |

s_c = critical slope ft / ft

T = top width of the stream

d_m = a/T = mean depth of flow

Created by: Mike O'Shea

MANNING'S EQUATION for OPEN CHANNEL FLOW

Project: **Electronic Storage**

Location: **EDB Trickle Channels (need Q= 0.28 cfs)**

By: **Dane Frank**

Date: **8/31/2020**

Chk By:

Date:

version 12-2004

Mannings Formula

$$Q = (1.486/n)AR_h^{2/3}S^{1/2}$$

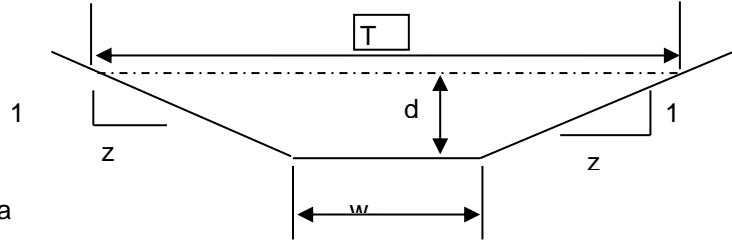
$$R = A/P$$

A = cross sectional area

P= wetted perimeter

S = slope of channel

n = Manning's roughness coefficient



$$V = (1.49/n)R_h^{2/3}S^{1/2}$$

$$Q = V \times A$$

INPUT

z (sideslope)= 0
z (sideslope)= 0
b (btm width, ft)= 0.3
d (depth, ft)= 0.5
S (slope, ft/ft) 0.005
n low = 0.013
n high = 0.013

Clear Data
Entry Cells

| Depth, ft | Area, sf | Wetted Perimeter, ft | Hydraulic Radius, ft | Low N | | High N | | |
|-----------|----------|-------------------------|-------------------------|-----------------|-----------|------------------|-----------|------------|
| | | | | Velocity, fps | Flow, cfs | Velocity, fps | Flow, cfs | |
| 0.5 | 0.15 | 1.30 | 0.12 | 1.91555431 | 0.28733 | 1.915554 | 0.28733 | T = 0.3 |
| | | | | Sc low = 0.0219 | | Sc high = 0.0219 | | Dm = 0.500 |
| | | | | .7 Sc | 1.3 Sc | .7 Sc | 1.3 Sc | |
| | | | | 0.0153 | 0.0285 | 0.0153 | 0.0285 | |

s_c = critical slope ft / ft

T = top width of the stream










$d_m = a/T$ = mean depth of flow

Created by: Mike O'Shea

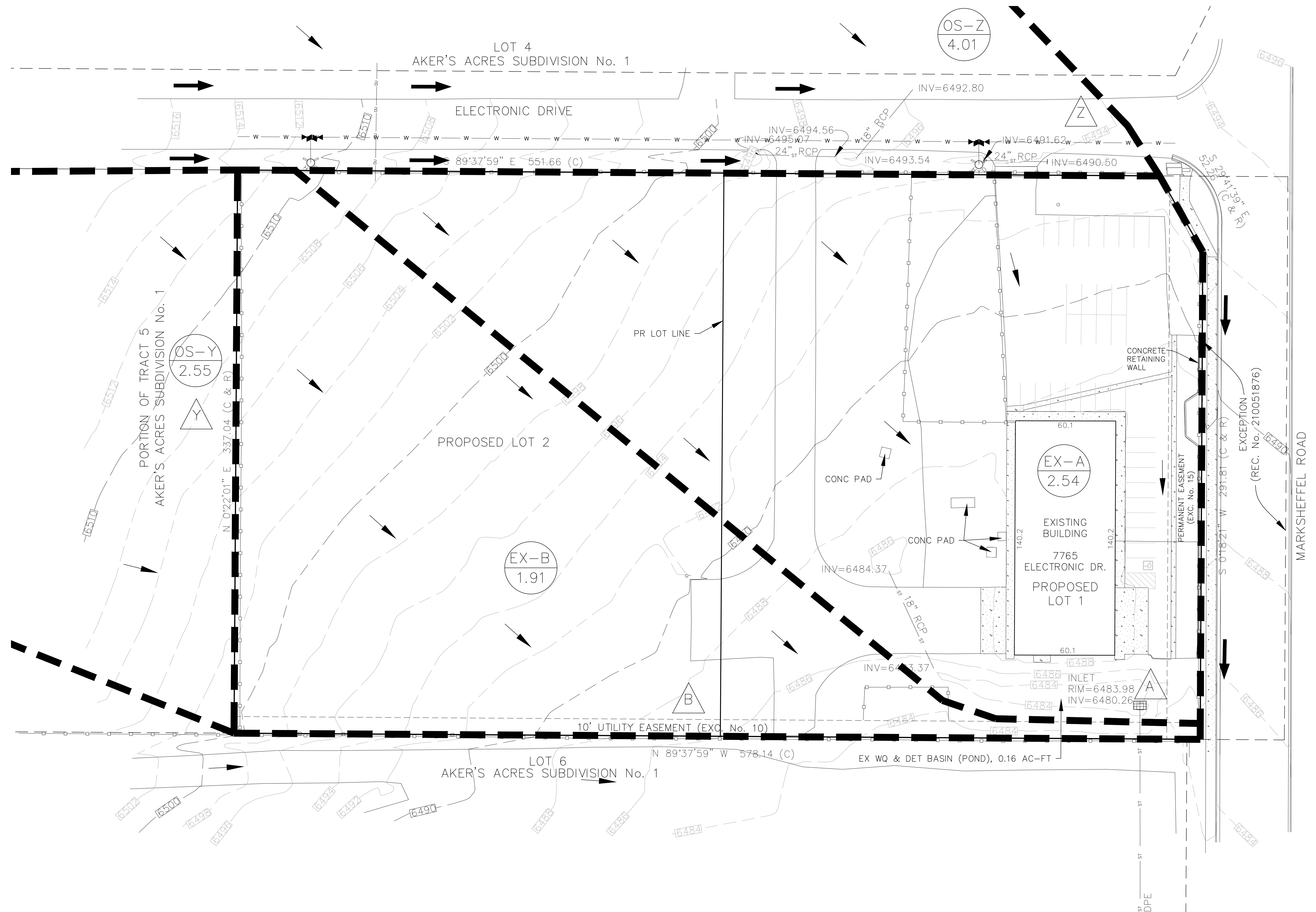
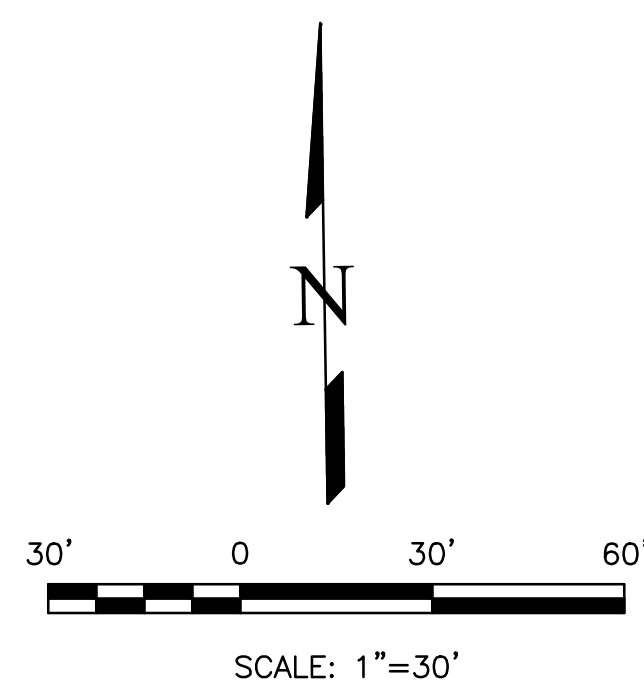
DRAINAGE MAPS

ELECTRONIC STORAGE
SITE DEVELOPMENT PLAN
EXISTING DRAINAGE MAP
NOVEMBER 2020

| DESIGN POINT | BASIN | AREA (ACRES) | FLOW | |
|--------------|-------|--------------|------------|--------------|
| | | | 5 YR (cfs) | 100 YR (cfs) |
| Z | OS-Z | 4.01 | 7.3 | 16.5 |
| Y | OS-Y | 2.55 | 2.1 | 8.2 |
| A | EX-A | 2.54 | 3.2 | 9.5 |
| B | EX-B | 1.91 | 0.9 | 5.4 |

 BASIN DESIGNATION
 AREA IN BASIN (AC)
 DESIGN POINT
 BASIN BOUNDARY
 EXISTING 1' CONTOUR
 EXISTING 10' CONTOUR
 GROUND SURFACE FLOW DIRECTION
 ROAD AND DITCH FLOW DIRECTION
 CHAIN-LINK FENCE

1. ALL FEATURE SHOWN ARE EXISTING.
2. NO GRADING CHANGES ARE INCLUDED IN THIS PLAN
3. THE OFFSITE BASINS ARE BASED ON FIMS GROUND SURFACE CONTOURS. FIMS DATA IS FROM 2012.

[illegible]

UNTIL SUCH TIME AS THESE
DRAWINGS ARE APPROVED
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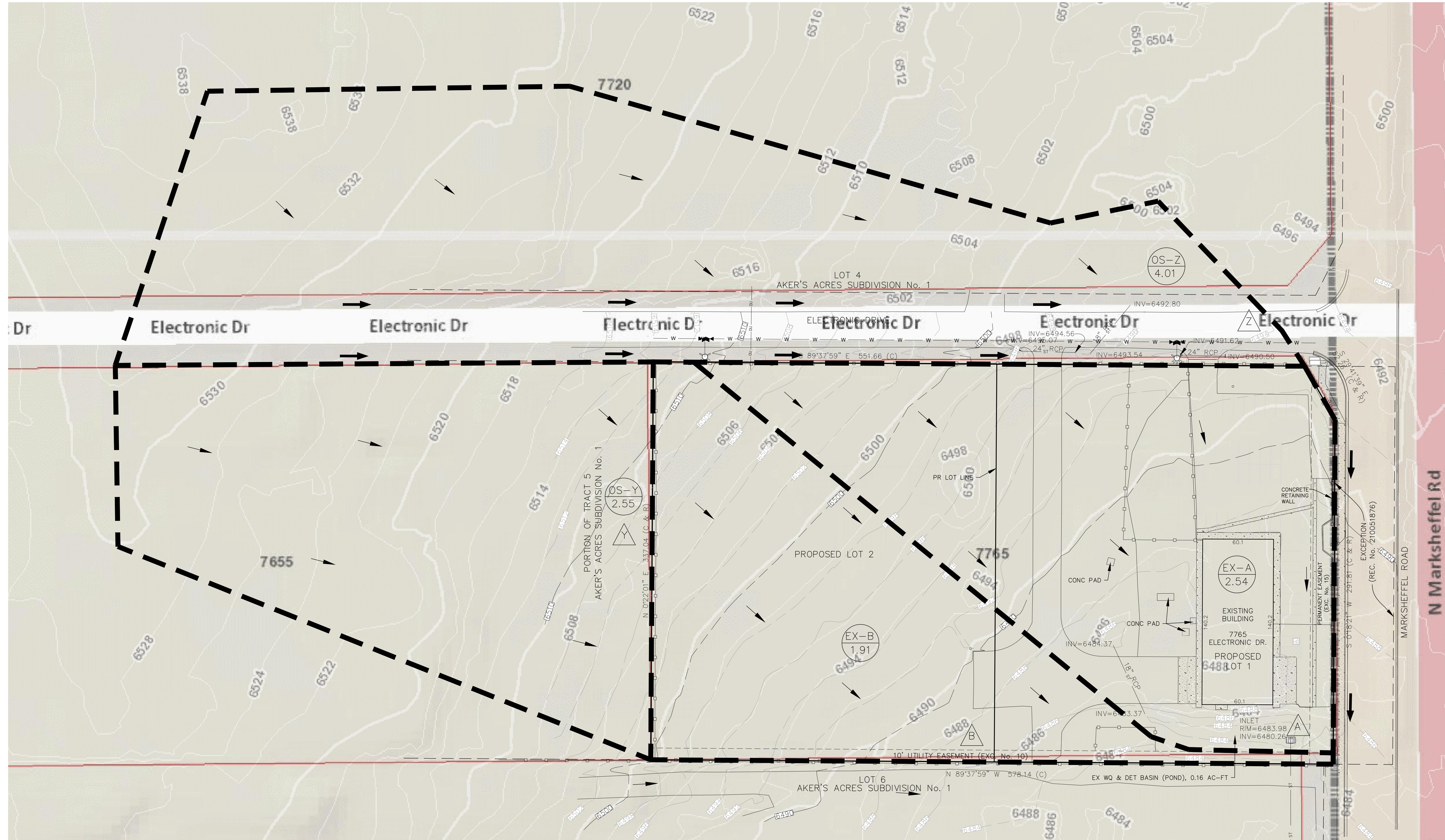
ELECTRONIC STORAGE

UNIVERSITY OF CALIFORNIA

| |
|----------------------|
| DESIGNED BY DLF |
| DRAWN BY DLF |
| CHECKED BY LD |
| SCALE AS SHOWN |
| SCALE N/A |
| DB NO. 1971.00 |
| DATE ISSUED 11/16/20 |
| SHEET NO. 1 OF 4 |

NOTES

1. ALL FEATURE SHOWN ARE EXISTING.
2. NO GRADING CHANGES ARE INCLUDED IN THIS PLAN.
3. THE OFFSITE BASINS ARE BASED ON FIMS GROUND SURFACE CONTOURS. FIMS DATA IS FROM 2012.



| | | | |
|--|--|---|--|
| <h2 style="margin: 0;">ELECTRONIC STORAGE</h2> | | <h2 style="margin: 0;">EXISTING OFFSITE BASINS</h2> | |
| DESIGNED BY DLF DRAWN BY DLF CHECKED BY LD | | H-SCALE AS SHOWN V-SCALE N/A | |
| JOB NO. 1971.00 DATE ISSUED 11/16/20 | | SHEET NO. 2 OF 20 | |

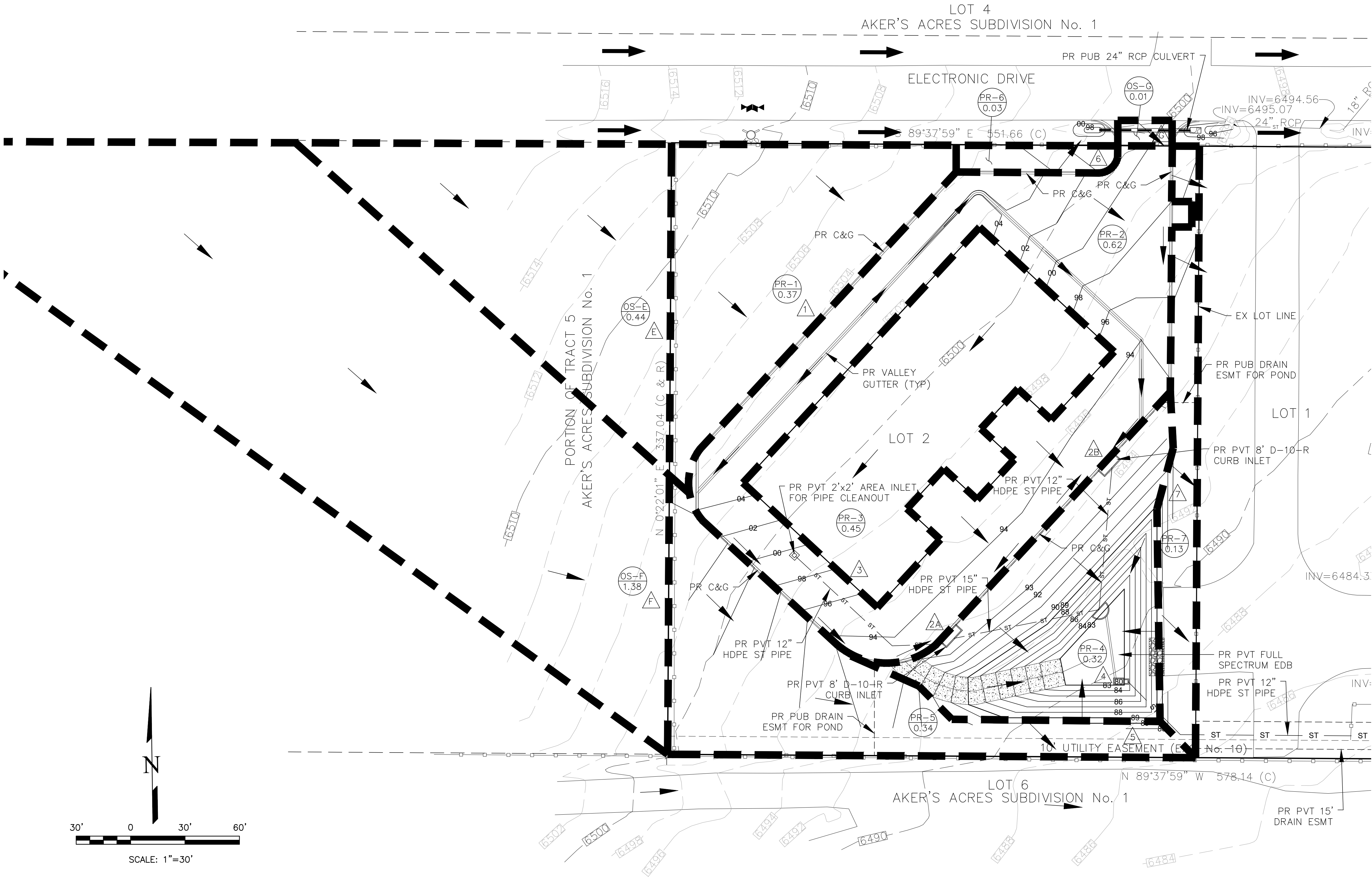
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| BASIN SUMMARY | | | | |
|---------------|-------|--------------|------------|--------------|
| DESIGN POINT | BASIN | AREA (ACRES) | FLOW | |
| | | | 5 YR (cfs) | 100 YR (cfs) |
| E | OS-E | 0.44 | 0.4 | 1.7 |
| F | OS-F | 1.38 | 1.2 | 4.6 |
| G | OS-G | 0.01 | 0.1 | 0.1 |
| 1 | PR-1 | 0.37 | 0.2 | 1.1 |
| 2 | PR-2 | 0.62 | 3.2 | 6.5 |
| 3 | PR-3 | 0.45 | 2.3 | 4.5 |
| 4 | PR-4 | 0.32 | 0.2 | 1.2 |
| 5 | PR-5 | 0.34 | 0.1 | 1.0 |
| 6 | PR-6 | 0.03 | 0.0 | 0.1 |
| 7 | PR-7 | 0.13 | 0.1 | 0.6 |

| DESIGN POINT SUMMARY | | | | |
|----------------------|-------------------------------|--------------|------------|--------------|
| DESIGN POINT | CONTRIBUTING BASINS | AREA (ACRES) | FLOW | |
| | | | 5 YR (cfs) | 100 YR (cfs) |
| E | OS-E | 0.44 | 0.4 | 1.7 |
| F | OS-F | 1.38 | 1.2 | 4.6 |
| G | OS-G | 0.01 | 0.1 | 0.1 |
| 1 | OS-E,PR-1 | 0.81 | 0.6 | 2.8 |
| 2 | OS-E,OS-F,PR-1,PR-2 | 1.44 | 3.9 | 9.4 |
| 2A | HALF OF BASIN TOTAL | --- | 2.0 | 4.7 |
| 2B | HALF OF BASIN TOTAL | --- | 2.0 | 4.7 |
| 3 | PR-3 | 0.45 | 2.3 | 4.5 |
| 4 | OS-E,OS-F,PR-1,PR-2,PR-3,PR-4 | 2.21 | 6.3 | 15.1 |
| 5 | OS-F,PR-5 | 1.72 | 1.3 | 5.6 |
| 6 | PR-6 | 0.03 | 0.0 | 0.1 |
| 7 | PR-7 | 0.13 | 0.1 | 0.6 |

LEGEND

- BASIN DESIGNATION
- AREA IN BASIN (AC)
- DESIGN POINT
- BASIN BOUNDARY
- EXISTING 1' CONTOUR
- EXISTING 10' CONTOUR
- GROUND SURFACE FLOW DIRECTION
- ROAD AND DITCH FLOW DIRECTION
- CHAIN-LINK FENCE



ELECTRONIC STORAGE
SITE DEVELOPMENT PLAN
PROPOSED DRAINAGE MAP
NOVEMBER 2020

REVISIONS

| NO. | DESCRIPTION | DATE |
|-----|-------------|------|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

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PROPOSED DRAINAGE MAP

DESIGNED BY DLF
DRAWN BY DLF
CHECKED BY LD
H-SCALE AS SHOWN
V-SCALE N/A
JOB NO. 1971.00
DATE ISSUED 11/16/20
SHEET NO. 2 OF 4

