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

DECEMBER 2020

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

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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 Date

On behalf of Terra Nova Engineering, Inc.

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. Date

County Engineer / ECM Administrator

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. The 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 9 basins; seven onsite basins and two 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.

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.

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 = 3.8 cfs and Q_{100} = 9.3 cfs from basins OS-E, 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, 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, and PR-7 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 landscaping area, all of which flows away from the detention pond, some of which flows to the existing stormwater pond on Lot 1. The combined area of these basins is 0.50 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

None

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	$ 60,000
		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.

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

Google Maps

Electronic Storage - Vicinity Map

Map data ©2019 Google 1000 ft

North is up ^

Electronic Storage - Location Map

Image Dated Oct 2018

S.C.S. SOILS MAP

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

Map Scale: 1:970 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 10 20 40 60

Feet: 0 45 90 180 270

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil 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 **floodways** 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 zones zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the **North American Vertical Datum of 1988 (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, N/NGS12
National Geodetic Survey
SSMC-3, #9202
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.

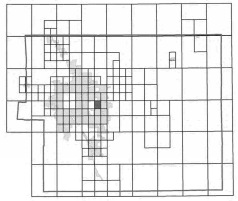
Contact **FEMA Map Service Center** (MSC) via the FEMA Map Information eXchange (FMIX) 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this 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/business/nfip.

El Paso County Vertical Datum Offset Table

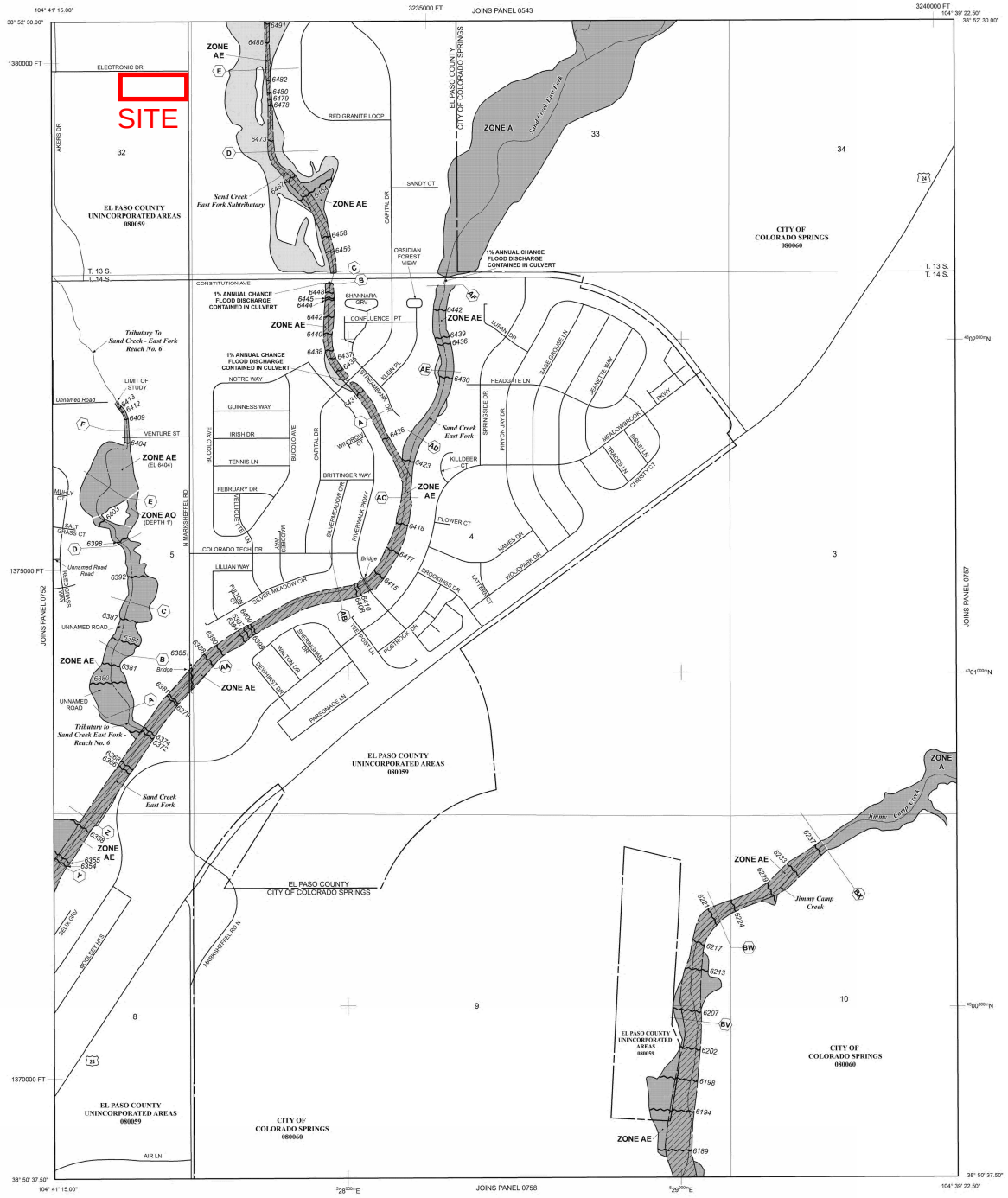
Flooding Source	Vertical Datum Offset (ft)
REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION	

Panel Location Map



This Digital Flood Insurance Rate Map (DFIRM) was produced through a Cooperating Technical Partner (CTP) agreement between the State of Colorado Water Conservation Board (CWCB) and the Federal Emergency Management Agency (FEMA).

Additional Flood Hazard information and resources are available from local communities and the Colorado Water Conservation Board.



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 13 SOUTH, RANGE 65 WEST, AND TOWNSHIP 14 SOUTH, RANGE 65 WEST.

LEGEND

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

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

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area Formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

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

OTHER FLOOD AREAS

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

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

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

Floodplain boundary

Floodway boundary

Zone D Boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

513 — Base Flood Elevation line and value; elevation in feet*

(EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A — A Cross section line

23 - - - - - 23 Transect line

97° 07' 30.00"
32° 22' 30.00" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)

4276000mN 1000-meter Universal Transverse Mercator grid ticks, zone 13

6000000 FT 5000-foot grid ticks: Colorado State Plane coordinate system, central zone (FIPSZONE 0502), Lambert Conformal Conic Projection

DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)

● M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
MARCH 17, 1997

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
DECEMBER 7, 2018 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to update map format, to add roads and road names, and to incorporate previously issued Letters of Map Revision.

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

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

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0756G

FIRM
FLOOD INSURANCE RATE MAP
EL PASO COUNTY, COLORADO
AND INCORPORATED AREAS

PANEL 756 OF 1300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0756	G
EL PASO COUNTY	080059	0756	G

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

MAP NUMBER
08041C0756G

MAP REVISED
DECEMBER 7, 2018

Federal Emergency Management Agency

HYDROLOGIC CALCULATIONS

ELECTRONIC STORAGE
(Area Runoff Coefficient Summary)

EXISTING CONDITIONS

		STREETS / DEVELOPED			*OVERLAND / UNDEVELOPED*			*WEIGHTED*	
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

		STREETS / DEVELOPED			*OVERLAND / UNDEVELOPED*			*WEIGHTED*	
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_t	*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_t	*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

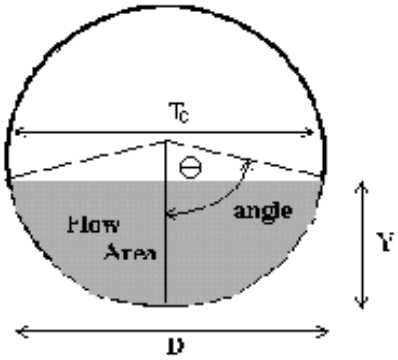
Design Point(s)	*Contributing Basins*	*Area Ac*	*Flow*	
			Q_5	Q_{100}
Z	**OS-Z**	4.01	**7.3**	**16.5**
Y	**OS-Y**	2.55	**2.1**	**8.2**
A	**EX-A**	2.54	**3.2**	**9.5**
B	**EX-B, OS-Y**	4.46	**3.1**	**13.6**
E	**OS-E**	0.44	***0.4***	***1.7***
F	**OS-F**	1.38	***1.2***	***4.6***
G	**OS-G**	0.01	***0.1***	***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)

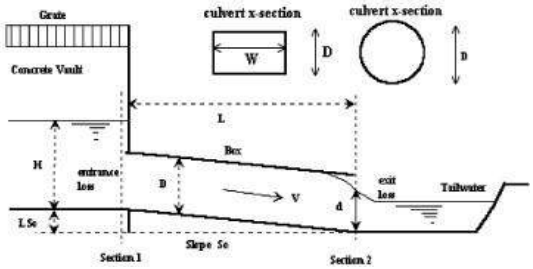
Project: **Electronic Storage**
Pipe ID: **Entrance Culvert**



Design Information (Input)			
Pipe Invert Slope	So =	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	Af =	3.14	sq ft
Full-flow wetted perimeter	Pf =	6.28	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	32.08	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.09	radians
Flow area	An =	0.67	sq ft
Top width	Tn =	1.77	ft
Wetted perimeter	Pn =	2.17	ft
Flow depth	Yn =	0.53	ft
Flow velocity	Vn =	7.42	fps
Discharge	Qn =	5.00	cfs
Percent Full Flow	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	Ac =	1.15	sq ft
Critical top width	Tc =	1.95	ft
Critical flow depth	Yc =	0.79	ft
Critical flow velocity	Vc =	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	D =	24	inches
	Inlet Edge Type (choose from pull-down list)		Grooved End with Headwall	
OR:				
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)		Square Edge w/ 30-78 deg. Flared Wingwall	
	Number of Barrels	No =	1	
	Inlet Elevation at Culvert Invert	Inlet Elev =	6497.5	ft. elev.
	Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	6496.5	ft. elev.
	Culvert Length in Feet	L =	50	ft.
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	K_b =	0	
	Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.20
Friction Loss Coefficient	K_f =	0.62
Sum of All Loss Coefficients	K_s =	1.82
Orifice Inlet Condition Coefficient	C_d =	0.99
Minimum Energy Condition Coefficient	KE_{low} =	-0.0794

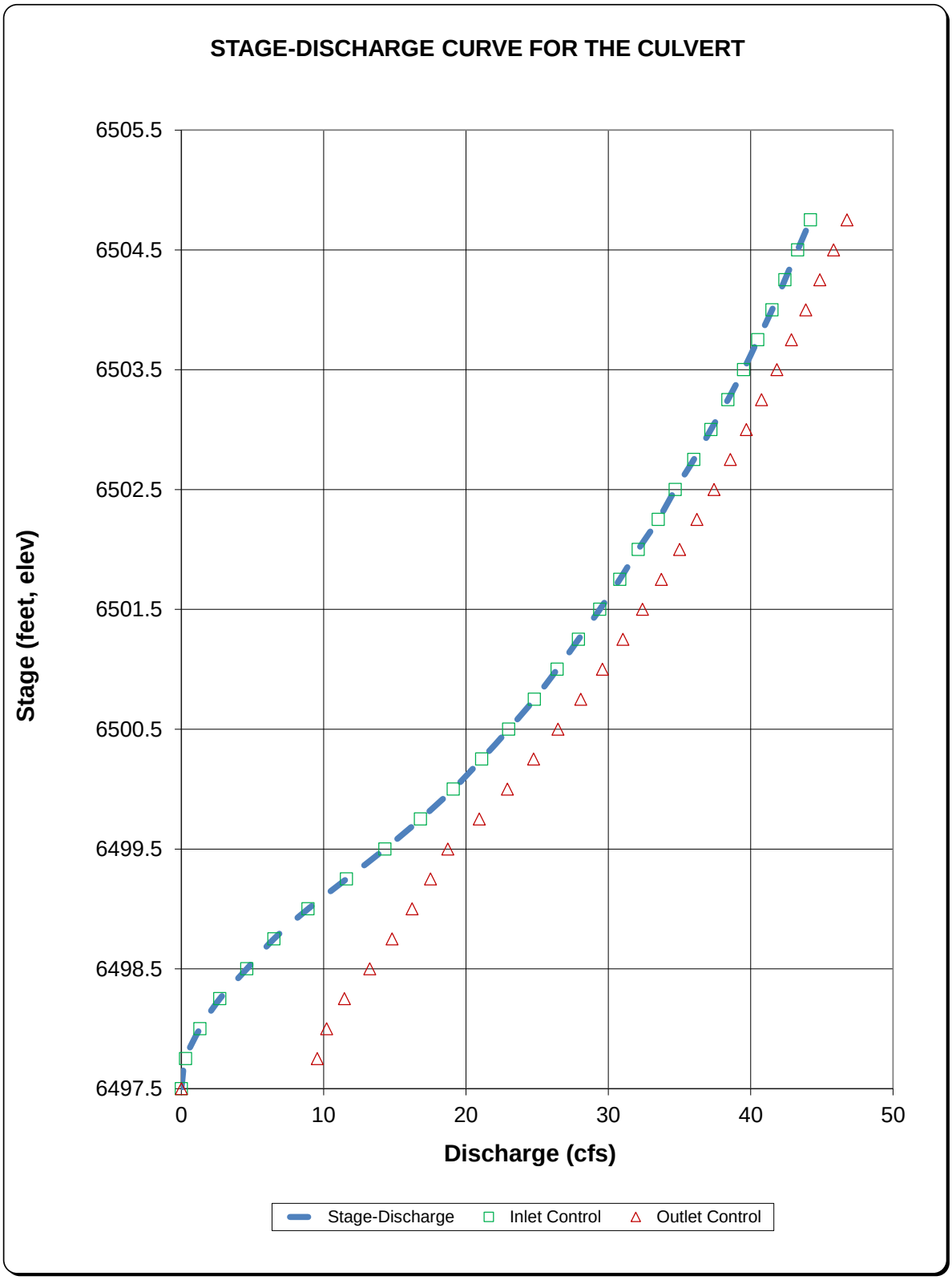
Calculations of Culvert Capacity (output):

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

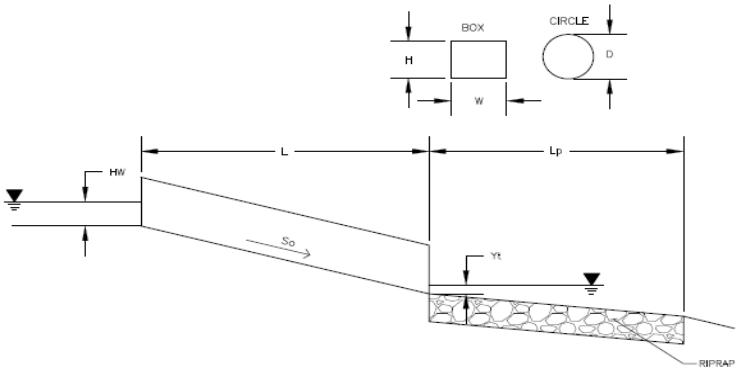
CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

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 Da to calculate protection type.

Design Information (Input):

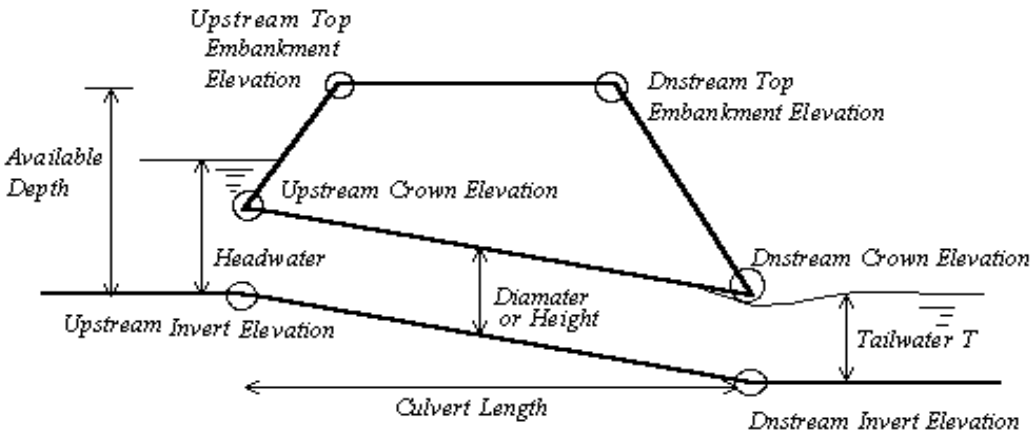
Design Discharge	Q =	5	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	24	inches
Inlet Edge Type (Choose from pull-down list)		Square End with Headwall	
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	Height (Rise) =		ft
Barrel Width (Span) in Feet	Width (Span) =		ft
Inlet Edge Type (Choose 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	ft^2
Culvert Cross Sectional Area Available	A =	3.14	ft^2
Entrance Loss Coefficient	k_e =	0.50	
Friction Loss Coefficient	k_f =	0.62	
Sum of All Losses Coefficients	k_s =	2.12	ft
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(Θ)) =	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	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/D =	0.63	
Inlet Control Headwater	HW_I =	1.09	ft
Outlet Control Headwater	HW_O =	0.48	
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**



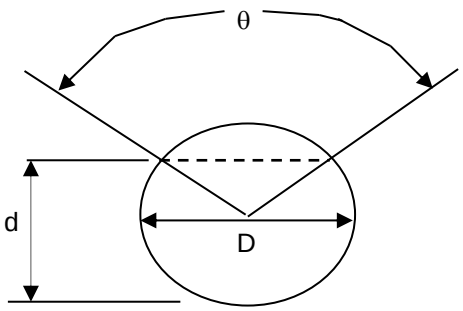
Culvert Information (Input)			
Barrel Diameter or Height	D or H =	24.00	inches
Barrel Length	L =	50.00	ft
Barrel Invert Slope	So =	0.0200	ft/ft
Downstream Invert Elevation	EDI =	6496.50	ft
Downstream Top Embankment Elevation	EDT =	6499.50	ft
Upstream Top Embankment Elevation	EUT =	6501.00	ft
Design Headwater 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	mannings 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 x A

Area,ft^2	Wetted Perimeter, ft	Hydraulic Radius, ft	Solution to Mannings Equation: velocity ft/s	Solution to Mannings Equation: flow, cfs
0.79	3.14	0.25	15.54	12.20

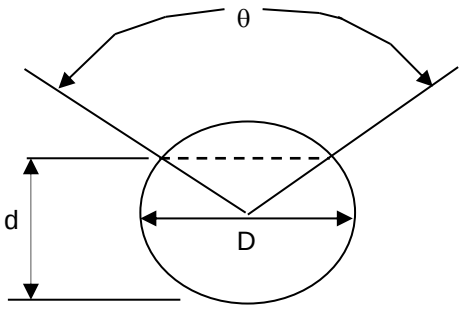
Manning's n-values	
PVC	0.01
PE (<9"dia)	0.015
PE (>12"dia)	0.02
PE(9-12"dia)	0.017
CMP	0.025
ADS N12	0.012
HCMP	0.023
Conc	0.013

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

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

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 x A

Area,ft^2	Wetted Perimeter, ft	Hydraulic Radius, ft	Solution to Mannings Equation: velocity ft/s	Solution to Mannings Equation: flow, cfs
1.23	3.93	0.31	12.62	15.49

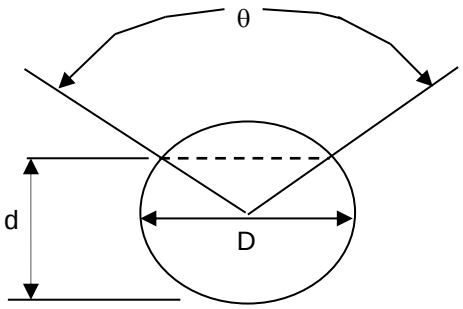
Manning's n-values	
PVC	0.01
PE (<9"dia)	0.015
PE (>12"dia)	0.02
PE(9-12"dia)	0.017
CMP	0.025
ADS N12	0.012
HCMP	0.023
Conc	0.013

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 x A

Area,ft^2	Wetted Perimeter, ft	Hydraulic Radius, ft	Solution to Mannings Equation: velocity ft/s	Solution to Mannings Equation: flow, cfs
0.79	3.14	0.25	10.88	8.54

Manning's n-values	
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

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

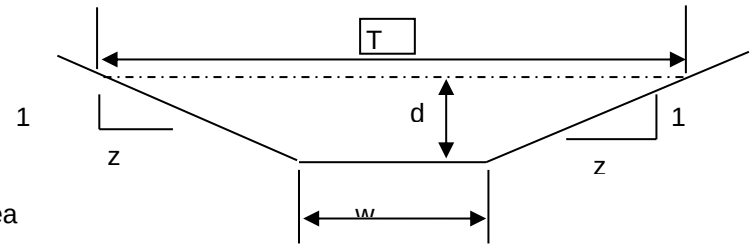
R = A/P

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 x 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

Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Low N Velocity, fps	Low N Flow, cfs	High N Velocity, fps	High N Flow, cfs		
0.6	13.50	45.02	0.30	3.62110768	48.885	3.621108	48.885	T =	45
								Dm =	0.300
				Sc low =	0.0037	Sc high =	0.0037		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.0026	0.0048	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

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

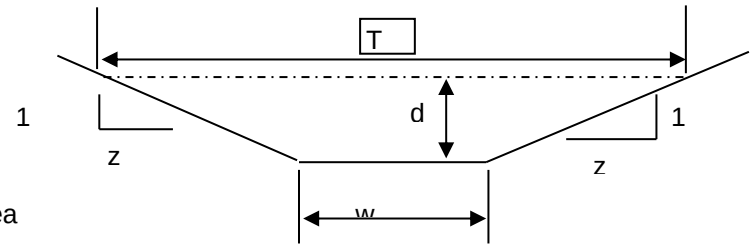
R = A/P

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 x 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

Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Low N Velocity, fps	Low N Flow, cfs	High N Velocity, fps	High N 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	.7 Sc	1.3 Sc		
				0.0026	0.0048	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

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

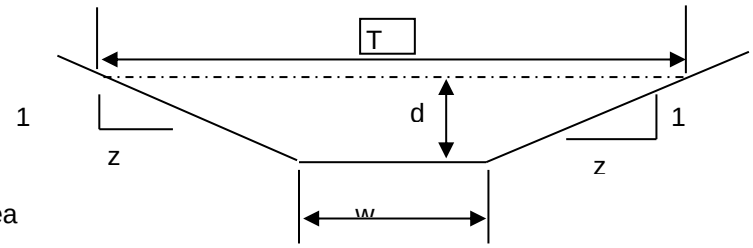
R = A/P

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 x 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, fps	Flow, cfs	Velocity, fps	Flow, cfs		
0.5	6.25	25.50	0.25	4.47601532	27.9751	4.476015	27.9751	T =	25
								Dm =	0.250
				Sc low =	0.0040	Sc high =	0.0040		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				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

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

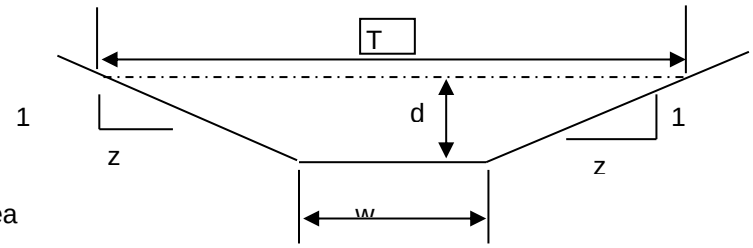
R = A/P

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 x 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

Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Low N Velocity, fps	Low N Flow, cfs	High N Velocity, fps	High N Flow, cfs		
0.5	3.13	13.01	0.24	13.967008	43.6469	13.96701	43.6469	T =	12.5
								Dm =	0.250
				Sc low =	0.0041	Sc high =	0.0041		
				.7 Sc	1.3 Sc	.7 Sc	1.3 Sc		
				0.0029	0.0054	0.0029	0.0054		

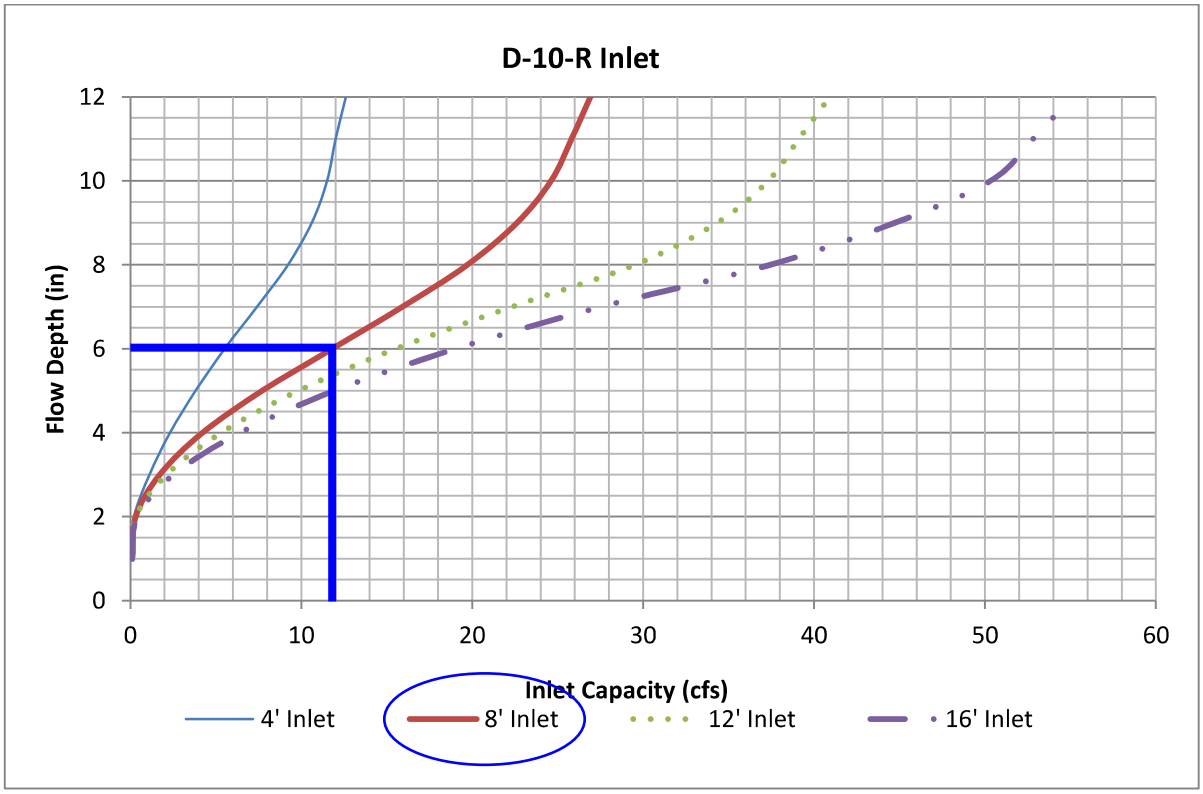
s_c = critical slope ft / ft

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



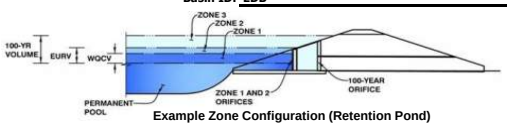
DETENTION CALCULATIONS

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)

Project: **Electronic Storage**

Basin ID: **EDB**



Example Zone Configuration (Retention Pond)

Watershed Information

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

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

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.036	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		

Define Zones and Basin Geometry

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 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 Increement = 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	--	--	--	15	0.000		
	--	0.25	--	--	--	15	0.000	4	0.000
Bottom of Pond	--	0.50	--	--	--	1,174	0.027	152	0.003
	--	0.75	--	--	--	1,339	0.031	466	0.011
	--	1.00	--	--	--	1,504	0.035	822	0.019
	--	1.25	--	--	--	1,668	0.038	1,218	0.028
Top of WQ +/-	--	1.50	--	--	--	1,833	0.042	1,656	0.038
	--	1.75	--	--	--	2,015	0.046	2,137	0.049
	--	2.00	--	--	--	2,197	0.050	2,663	0.061
	--	2.25	--	--	--	2,378	0.055	3,235	0.074
	--	2.50	--	--	--	2,560	0.059	3,852	0.088
	--	2.75	--	--	--	2,771	0.064	4,519	0.104
	--	3.00	--	--	--	2,982	0.068	5,238	0.120
Top of EURV +/-	--	3.25	--	--	--	3,192	0.073	6,009	0.138
	--	3.50	--	--	--	3,403	0.078	6,834	0.157
	--	3.75	--	--	--	3,644	0.084	7,715	0.177
Top of 100 Yr +/-	--	4.00	--	--	--	3,884	0.089	8,656	0.199
	--	4.25	--	--	--	4,125	0.095	9,657	0.222
	--	4.50	--	--	--	4,365	0.100	10,718	0.246
	--	4.75	--	--	--	4,633	0.106	11,843	0.272
	--	5.00	--	--	--	4,901	0.113	13,034	0.299
	--	5.25	--	--	--	5,169	0.119	14,293	0.328
	--	5.50	--	--	--	5,437	0.125	15,619	0.359
	--	5.75	--	--	--	5,737	0.132	17,016	0.391
	--	6.00	--	--	--	6,037	0.139	18,487	0.424
	--	6.25	--	--	--	6,337	0.145	20,034	0.460
Top of Berm	--	6.50	--	--	--	6,637	0.152	21,656	0.497
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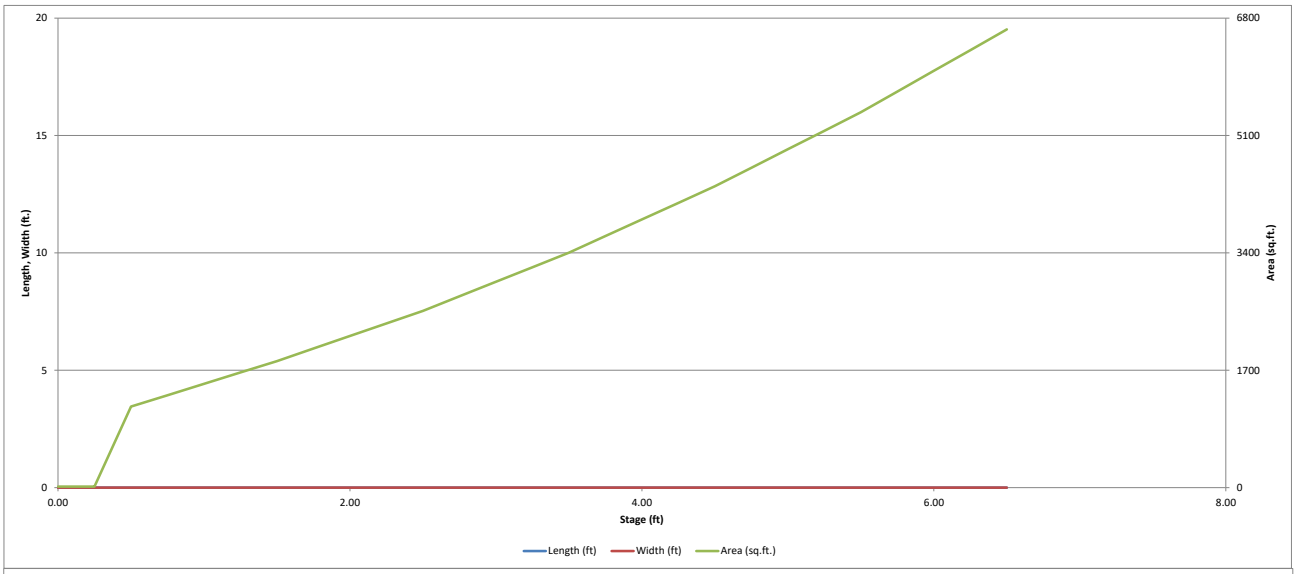
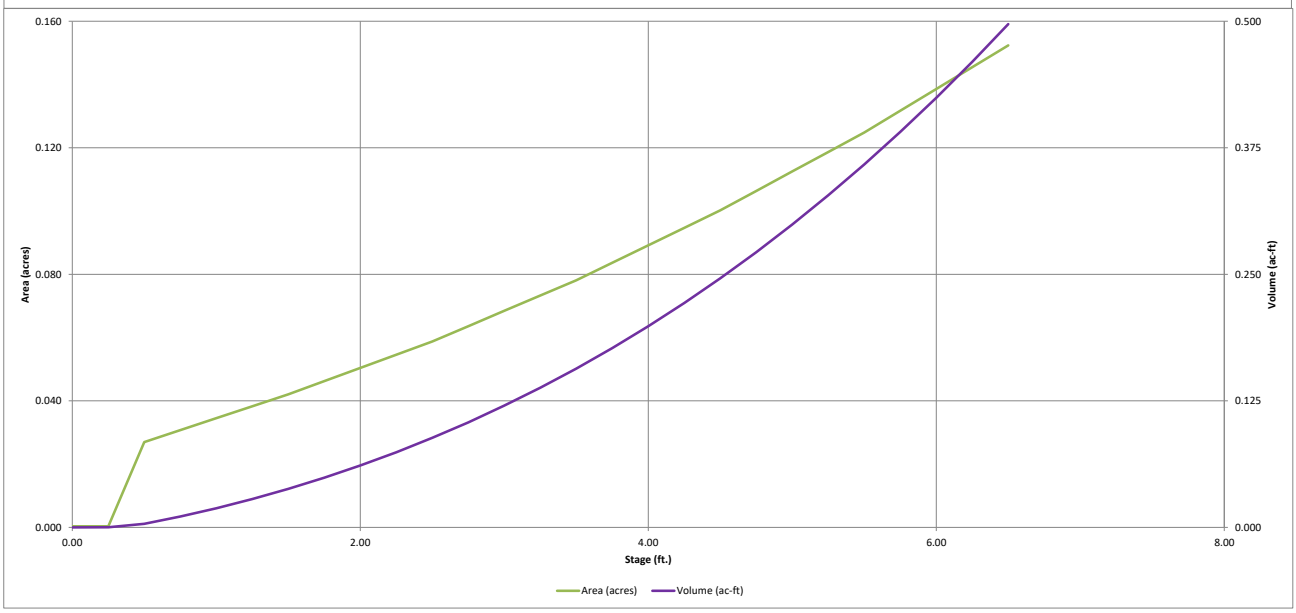

20
15
10
5
0
6800
5100
3400
1700
0
0.00
2.00
4.00
6.00
8.00
Length, Width (ft.)
Area (sq.ft.)
Stage (ft)
Length (ft)
Width (ft)
Area (sq.ft.)

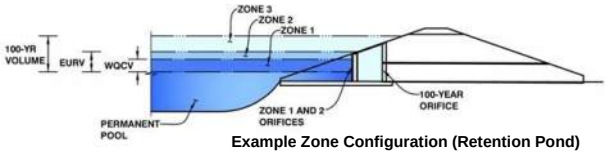

0.160
0.120
0.080
0.040
0.000
0.500
0.375
0.250
0.125
0.000
0.00
2.00
4.00
6.00
8.00
Area (acres)
Volume (ac-ft)
Stage (ft.)
Area (acres)
Volume (ac-ft)

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 =	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 =	2.153E-03	ft^2
Depth at top of Zone using Orifice Plate =	3.20	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	14.60	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.31	sq. inches (diameter = 5/8 inch)	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	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)

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

Calculated Parameters for Vertical Orifice

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

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

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.25	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	2.00	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V
Horiz. Length of Weir Sides =	2.00	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	3.25	N/A	feet
Overflow Weir Slope Length =	2.00	N/A	feet
Grate Open Area / 100-yr Orifice Area =	19.14	N/A	
Overflow Grate Open Area w/o Debris =	2.80	N/A	ft^2
Overflow Grate Open Area w/ Debris =	1.40	N/A	ft^2

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

	Zone 3 Rectangular	Not Selected	
Depth to Invert of Outlet Pipe =	0.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Rectangular Orifice Width =	4.90	N/A	inches
Rectangular Orifice Height =	4.30		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Rectangular	Not Selected	
Outlet Orifice Area =	0.15	N/A	ft^2
Outlet Orifice Centroid =	0.18	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.50	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.42	feet
Spillway Crest Length =	5.00	feet	Stage at Top of Freeboard =	5.92	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.14	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	0.41	acre-ft

Calculated Parameters for Spillway

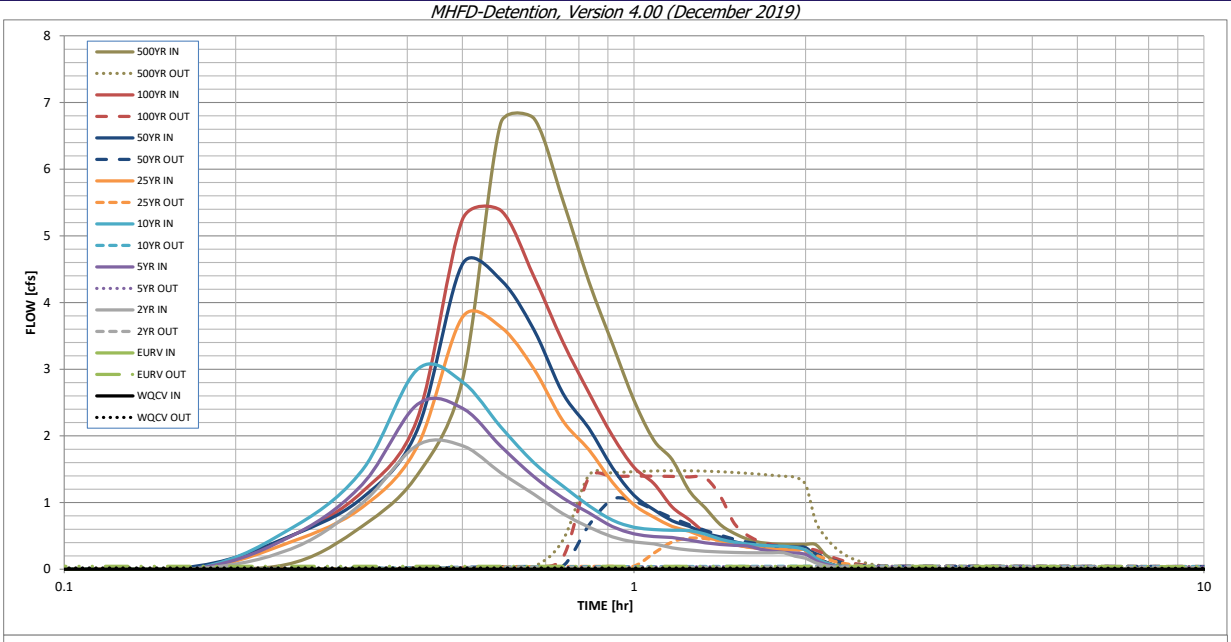
Routed Hydrograph Results

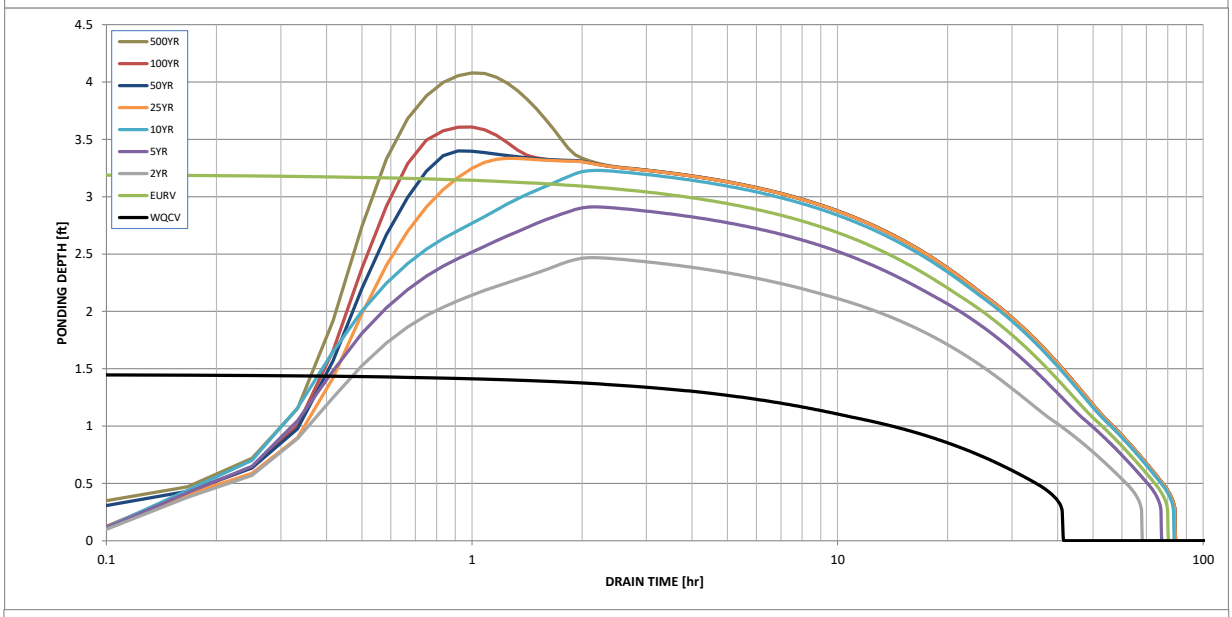
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

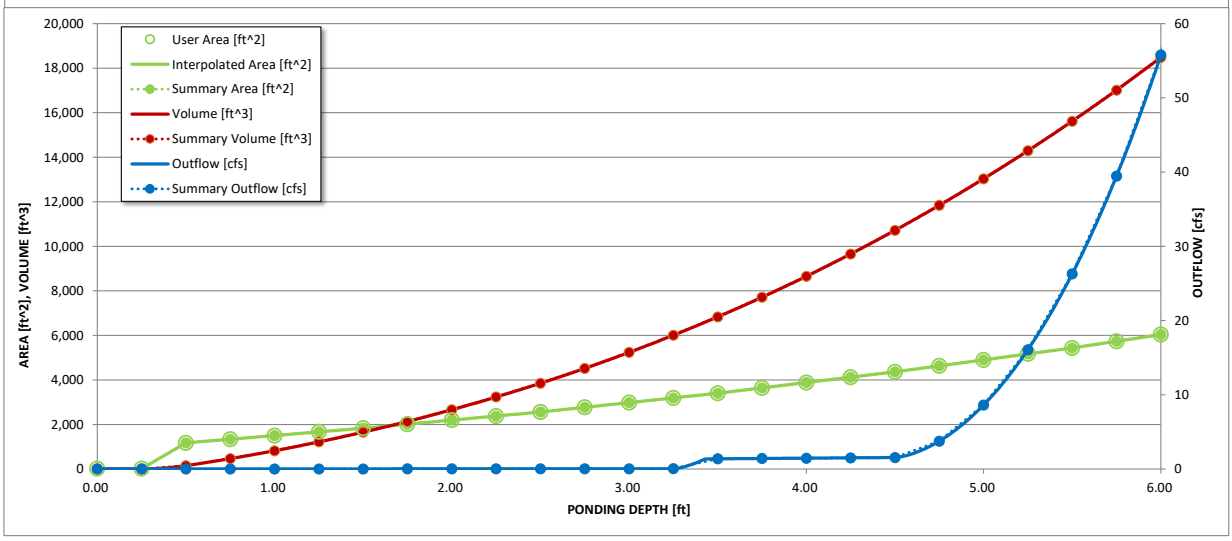
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.00
CUHP Runoff Volume (acre-ft) =	0.036	0.134	0.091	0.120	0.143	0.175	0.205	0.242	0.305
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.091	0.120	0.143	0.175	0.205	0.242	0.305
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.0	0.1	0.5	1.0	1.5	2.4
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

ELEV	***AREA***	***AREA AVG.***	***DELTA ELEV.***	***VOLUME***	***VOLUME TOTAL***
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**	Location:	Forebay Notch - Q=13.9 cfs * 2% = 0.28 cfs	
By:	Dane Frank	Date:	8/31/2020	
Chk By:		Date:		version 12-2004

Mannings Formula

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

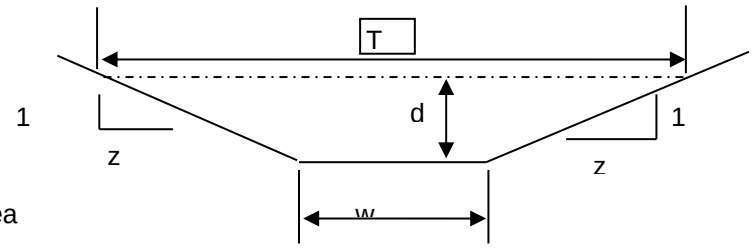
R = A/P

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 x 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 Velocity, fps	Low N Flow, cfs	High N Velocity, fps	High N 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

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

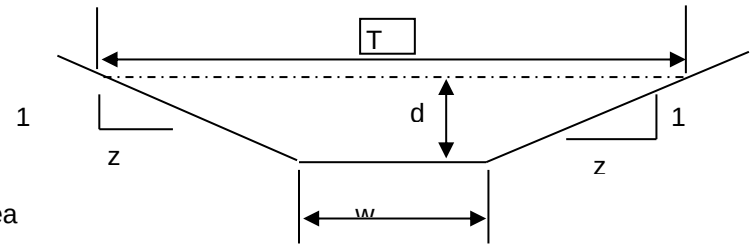
R = A/P

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 x 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 Velocity, fps	Low N Flow, cfs	High N Velocity, fps	High N Flow, cfs		
0.5	0.15	1.30	0.12	1.91555431	0.28733	1.915554	0.28733	T =	0.3
								Dm =	0.500
				Sc low =	0.0219	Sc high =	0.0219		
				.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

DECEMBER 2020

BASIN SUMMARY

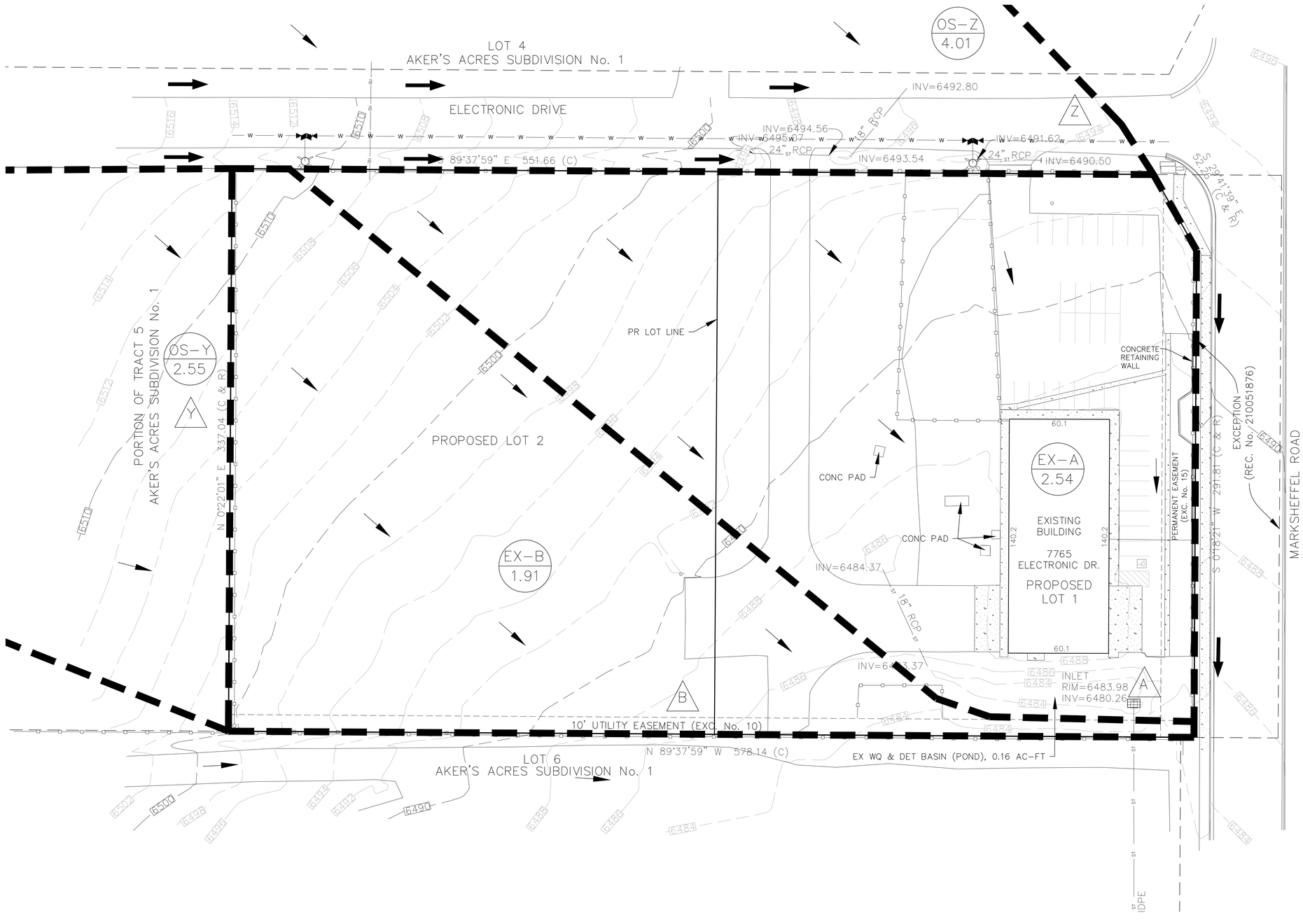
DESIGN POINT	BASIN	AREA (ACRES)	FLOW 5 YR (cfs)	FLOW 100 YR (cfs)
Z	OS–Z	4.01	7.3	16.5
Y	OS–Y	2.55	2.1	8.2
A	EX–A	2.54	3.2	9.5
B	EX–B	1.91	0.9	5.4

LEGEND

- P–7 / 12.22 — BASIN DESIGNATION / AREA IN BASIN (AC)
- D — DESIGN POINT
- BASIN BOUNDARY
- EXISTING 1' CONTOUR
- EXISTING 10' CONTOUR
- GROUND SURFACE FLOW DIRECTION
- ROAD AND DITCH FLOW DIRECTION
- CHAIN–LINK FENCE

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.



REVISIONS		
NO.	DESCRIPTION	DATE

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PREPARED FOR:
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ATTN: DAVID STEFANO
520 W 21ST ST, G–2 #710
NORFOLK, CA 23517
757.333.3144

Terra Nova Engineering, Inc. "Creative Civil Engineering Solutions"
721 S. 23RD STREET
COLORADO SPRINGS, CO 80904
OFFICE: 719–635–6422
FAX: 719–635–6426
www.tnesinc.com

ELECTRONIC STORAGE

EXISTING 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	12/14/20
SHEET NO.	1 OF 4

N:\jobs\1971.00\Drawings\197100 SDP.dwg, 2/4/2021 10:00:24 AM

ELECTRONIC STORAGE

SITE DEVELOPMENT PLAN

EXISTING OFFSITE BASINS

DECEMBER 2020

LEGEND

- P-7 / 12.22 — BASIN DESIGNATION / AREA IN BASIN (AC)
- D — DESIGN POINT
- BASIN BOUNDARY
- EXISTING 1' CONTOUR
- EXISTING 10' CONTOUR
- GROUND SURFACE FLOW DIRECTION
- ROAD AND DITCH FLOW DIRECTION
- CHAIN-LINK FENCE

NOTES

1. ALL FEATURE SHOWN ARE EXISTING.
2. NO GRADING CHANGES ARE INCLUDED IN THIS PLAN.
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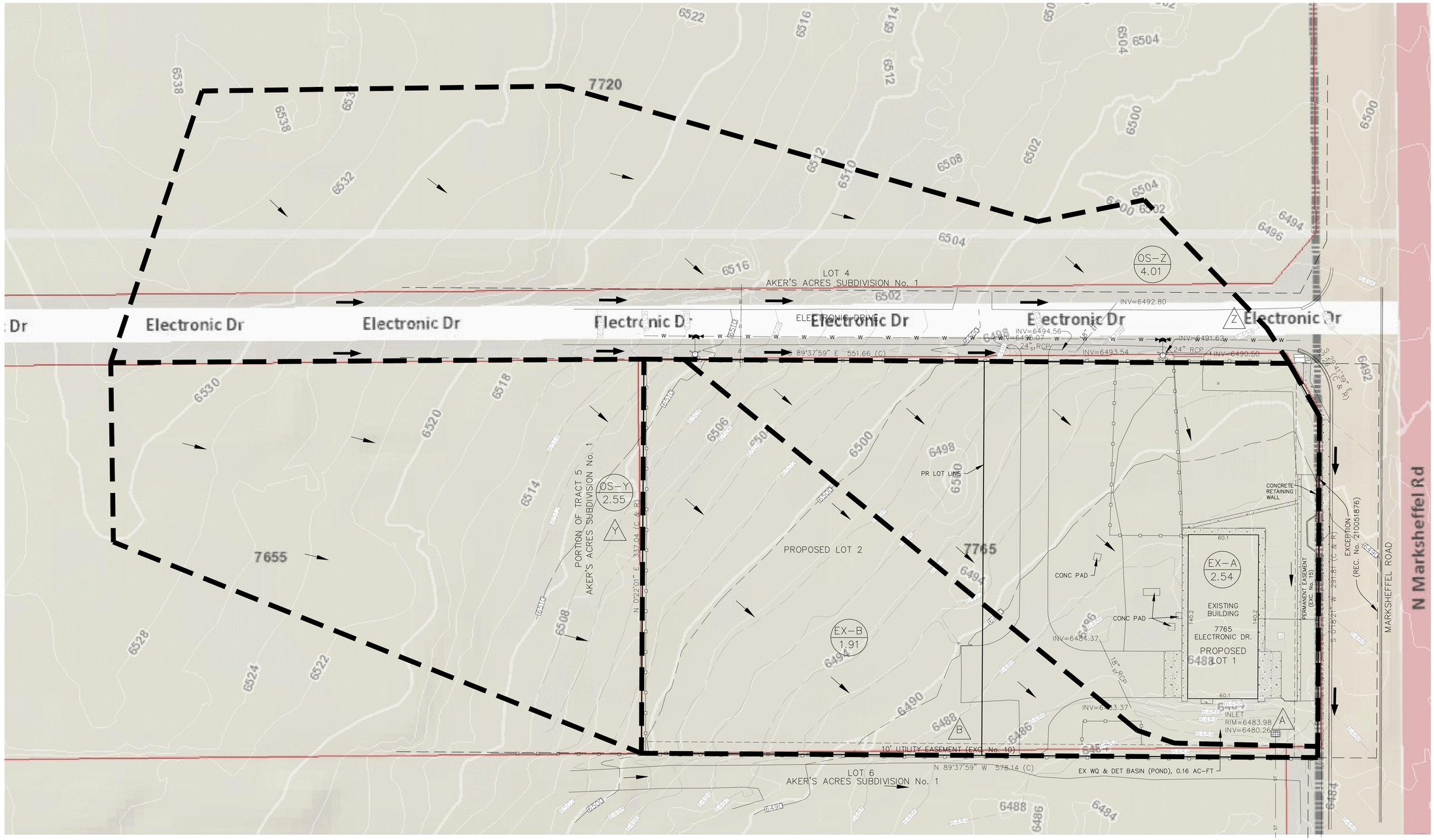
N

40' 0 40' 80'

SCALE: 1"=40'



REVISIONS

NO.	DESCRIPTION	DATE

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www.tnesinc.com

ELECTRONIC STORAGE

EXISTING OFFSITE BASINS

DESIGNED BY DLF
DRAWN BY DLF
CHECKED BY LD
H-SCALE AS SHOWN
V-SCALE N/A
JOB NO. 1971.00
DATE ISSUED 12/14/20
SHEET NO. 2 OF 4

ELECTRONIC STORAGE

SITE DEVELOPMENT PLAN

PROPOSED DRAINAGE MAP

DECEMBER 2020

BASIN SUMMARY

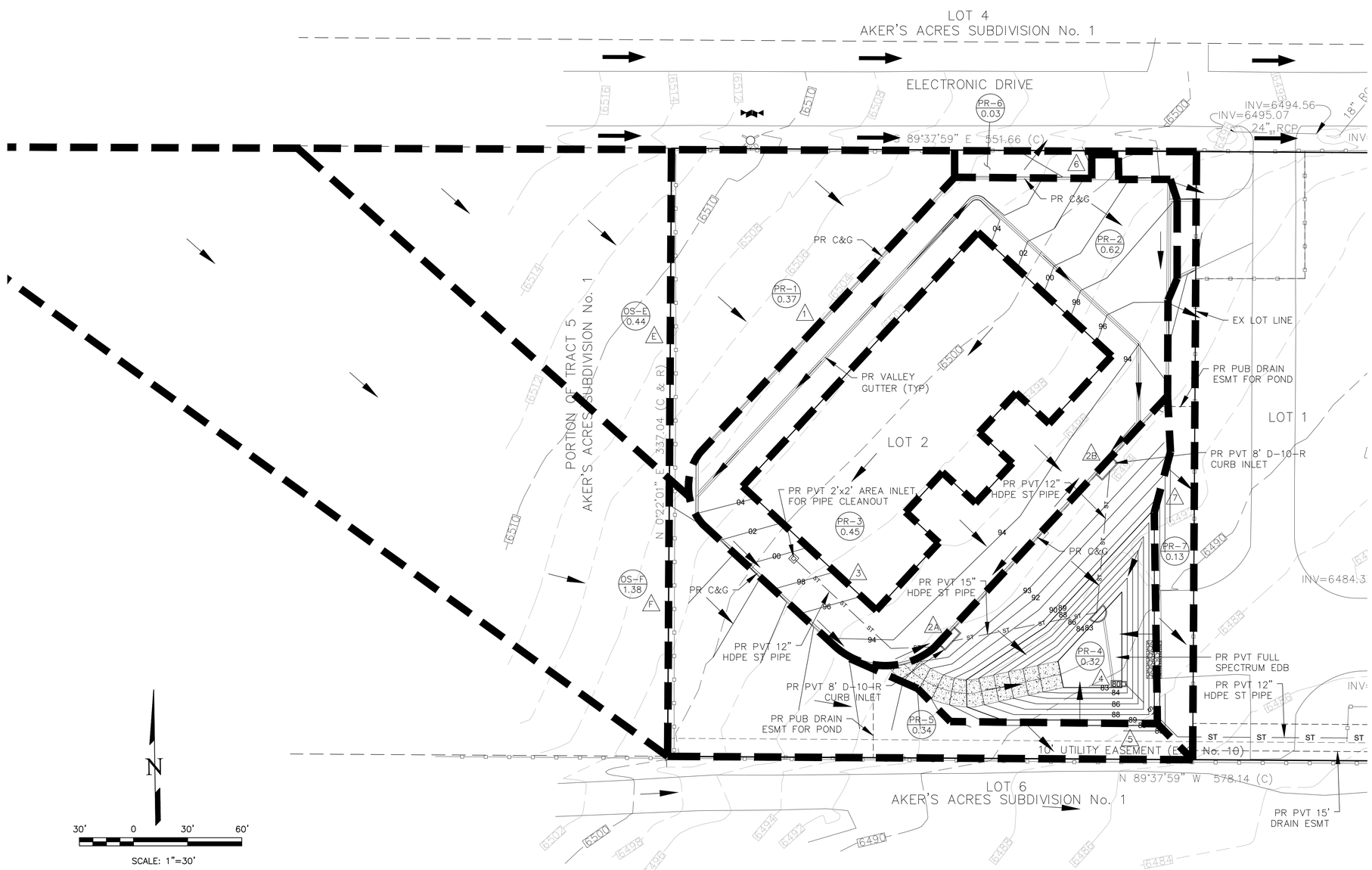
DESIGN POINT	BASIN	AREA (ACRES)	FLOW 5 YR (cfs)	FLOW 100 YR (cfs)
E	OS–E	0.44	0.4	1.7
F	OS–F	1.38	1.2	4.6
1	PR–1	0.37	0.2	1.1
2	PR–2	0.62	3.2	6.5
3	PR–3	0.45	2.3	4.5
4	PR–4	0.32	0.2	1.2
5	PR–5	0.34	0.1	1.0
6	PR–6	0.03	0.0	0.1
7	PR–7	0.13	0.1	0.6

DESIGN POINT SUMMARY

DESIGN POINT	CONTRIBUTING BASINS	AREA (ACRES)	FLOW 5 YR (cfs)	FLOW 100 YR (cfs)
E	OS–E	0.44	0.4	1.7
F	OS–F	1.38	1.2	4.6
1	OS–E,PR–1	0.81	0.6	2.8
2	OS–E,PR–1,PR–2	1.44	3.8	9.3
2A	HALF OF BASIN TOTAL	---	1.9	4.7
2B	HALF OF BASIN TOTAL	---	1.9	4.7
3	PR–3	0.45	2.3	4.5
4	OS–E,PR–1,PR–2, PR–3,PR–4	2.20	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

- P–7 / 12.22 — BASIN DESIGNATION / AREA IN BASIN (AC)
- D — DESIGN POINT
- BASIN BOUNDARY
- EXISTING 1' CONTOUR
- EXISTING 10' CONTOUR
- GROUND SURFACE FLOW DIRECTION
- ROAD AND DITCH FLOW DIRECTION
- CHAIN–LINK FENCE



REVISIONS

NO.	DESCRIPTION	DATE

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ELECTRONIC STORAGE

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 12/14/20
SHEET NO. 3 OF 4

ELECTRONIC STORAGE

SITE DEVELOPMENT PLAN

PROPOSED DETENTION POND

DECEMBER 2020

FOR REFERENCE ONLY
NOT FOR CONSTRUCTION

LEGEND

- P-7 / 12.22 — BASIN DESIGNATION / AREA IN BASIN (AC)
- D — DESIGN POINT
- BASIN BOUNDARY
- EXISTING 1' CONTOUR
- EXISTING 10' CONTOUR
- GROUND SURFACE FLOW DIRECTION
- ROAD AND DITCH FLOW DIRECTION
- CHAIN-LINK FENCE

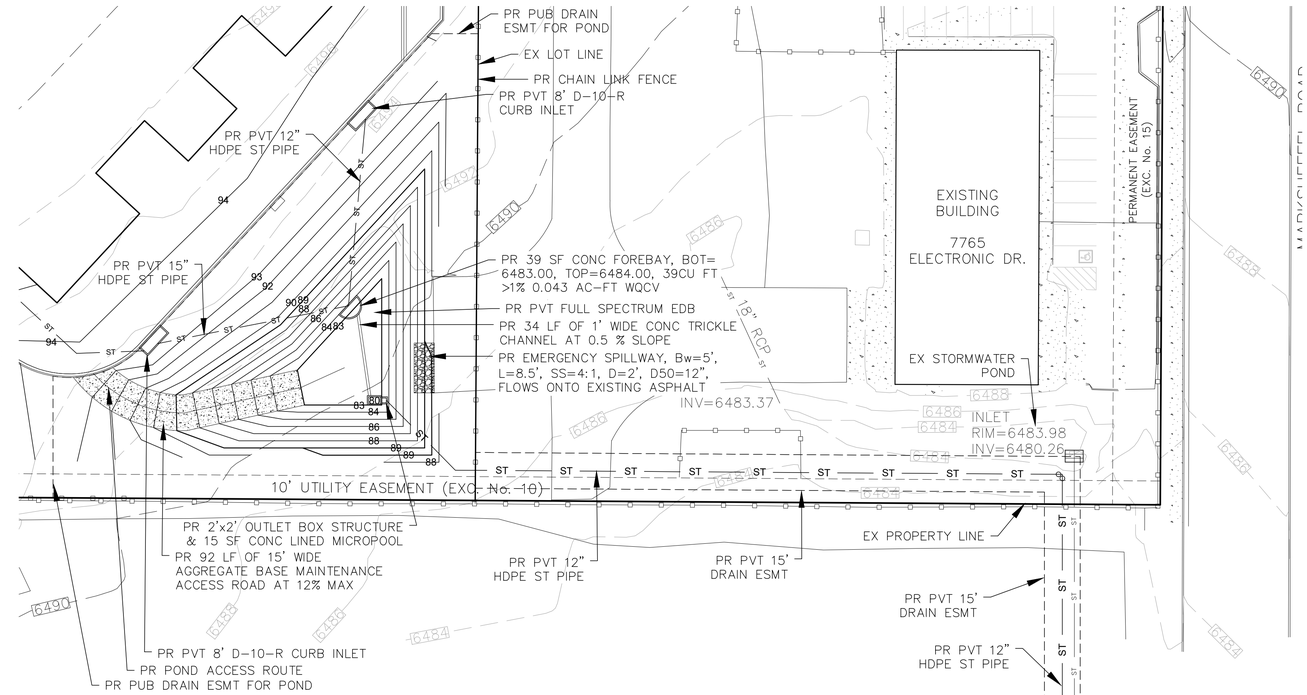
POND WATER LEVEL ELEVS

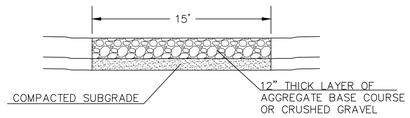
WQCV: 6483.94
EURV: 6485.67
100-YR: 6486.51

N

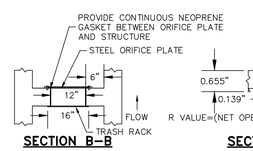
30' 0 30' 60'

SCALE: 1"=30'

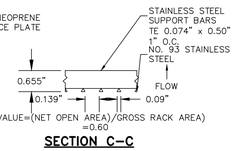




15' MAINTENANCE ACCESS ROAD SECTION
NOT TO SCALE



SECTION B-B
NOT TO SCALE



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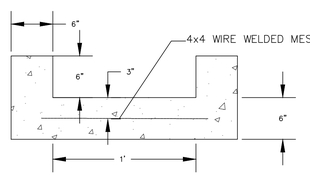
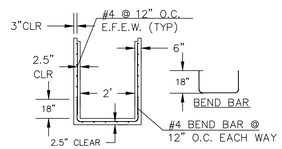
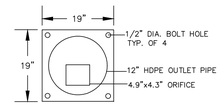
NOT TO SCALE



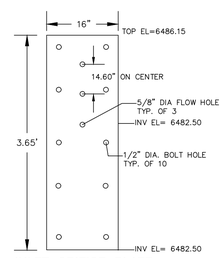
1' CONCRETE TRICKLE CHANNEL
NOT TO SCALE



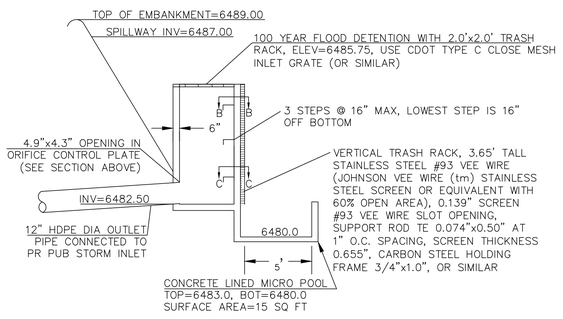
2'x2' OUTLET BOX STRUCTURAL DETAIL
NOT TO SCALE



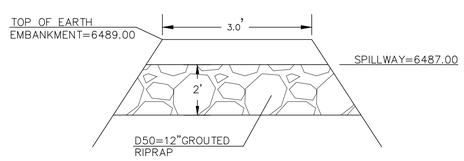
OUTLET ORIFICE PLATE
NOT TO SCALE

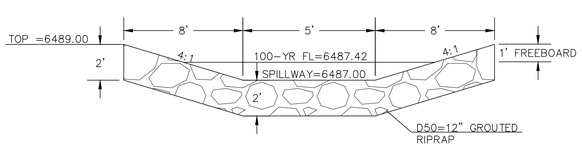


INLET ORIFICE PLATE PERFORATED HOLE PATTERN
NOT TO SCALE

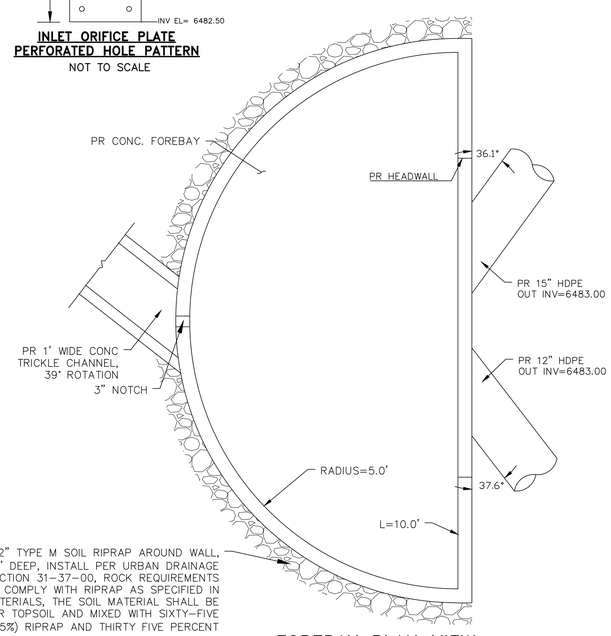


OUTLET STRUCTURE
NOT TO SCALE



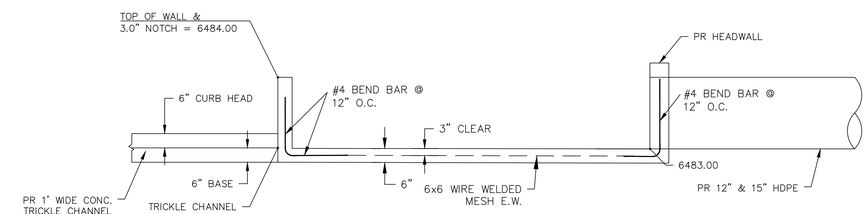


EDB EMERGENCY WEIR
NOT TO SCALE



PR D50=12" TYPE M SOIL RIPRAP AROUND WALL, 2' WIDE, 1' DEEP, INSTALL PER URBAN DRAINAGE SPEC SECTION 31-37-00, ROCK REQUIREMENTS ARE TO COMPLY WITH RIPRAP AS SPECIFIED IN ARTICLE MATERIALS, THE SOIL MATERIAL SHALL BE NATIVE OR TOPSOIL AND MIXED WITH SIXTY-FIVE PERCENT (65%) RIPRAP AND THIRTY FIVE PERCENT (35%) SOIL BY VOLUME. SOIL RIPRAP SHALL CONSIST OF A UNIFORM MIXTURE OF SOIL AND RIPRAP WITHOUT VOIDS

FOREBAY PLAN VIEW
NOT TO SCALE



FOREBAY PROFILE VIEW
NOT TO SCALE

REVISIONS		
NO.	DESCRIPTION	DATE

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ELECTRONIC STORAGE

PROPOSED DETENTION POND

DESIGNED BY	DLF
DRAWN BY	DLF
CHECKED BY	LD
H-SCALE	AS SHOWN
V-SCALE	N/A
JOB NO.	1971.00
DATE ISSUED	12/14/20
SHEET NO.	4 OF 4