



Final Drainage Report

# Palmer Solar Facility El Paso County, Colorado

Prepared for:

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Project #: 096495003

Prepared: December 20, 2018

**Kimley»Horn**



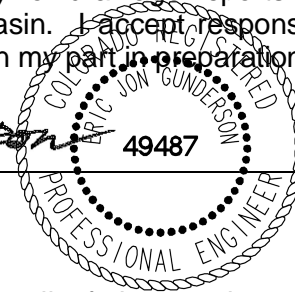
## CERTIFICATION

### 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 master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparation of this report.

SIGNATURE (Affix Seal):

*Eric Gunderson*  
Colorado P.E. No. 49487



1/16/19

Date

### OWNER/DEVELOPER'S STATEMENT

I, the developer, have read and will comply with all of the requirements specified in this Drainage Report and Plan.

\_\_\_\_\_  
Name of Developer

\_\_\_\_\_  
Authorized Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed Name

\_\_\_\_\_  
Title

\_\_\_\_\_  
Address:

### EL PASO COUNTY STATEMENT

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

\_\_\_\_\_  
Director of Public Works

\_\_\_\_\_  
Date

Conditions:

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## **PURPOSE AND SCOPE OF STUDY**

The purpose of this Final Drainage Report (FDR) is to provide the hydrologic and hydraulic calculations and to document and finalize the drainage design methodology in support of the proposed Palmer Solar Facility (“the Project”) for JSI Construction Group LLC. The Project is located within the jurisdictional limits of El Paso County (“the County”). Thus, the guidelines for the hydrologic and hydraulic design components were based on the criteria for the County and City of Colorado Springs, described below.

## **GENERAL LOCATON AND DESCRIPTION**

### ***LOCATION***

The Project is located approximately 3.5 miles southeast of Fountain, Colorado within Township 16 South, Range 65 West of the 6<sup>th</sup> Principal Meridian, County of El Paso, State of Colorado (the “Site”). More specifically, the Site is located north of Birdsall Road, approximately 1 mile east of Old Pueblo Road. The surrounding platted developments include Coalson Farms to the west, Woodmoor Water and Sanitation District land to the north, City of Colorado Springs land to the east, and State of Colorado land to the south. A vicinity map has been provided in the Appendix of this report.

The Site is split into two primary array areas, the first being Birdsall Road Site located along the west boundary of the Site and the second being Squirrel Creek Site located along the east boundary of the Site. The west side of the Site, or Birdsall Road Site, is located within El Paso County’s Calhan Reservoir basin. The east side of the Site, or Squirrel Creek Site, is located within El Paso County’s Lower Williams Creek basin.

The Site is currently owned by the Woodmoor Water and Sanitation District (the “District”) and will be leased to JSI Construction Group LLC to develop the Project.

### ***DESCRIPTION OF PROPERTY***

The Project is located on approximately 523 acres of land consisting of vacant land with native vegetation and is classified as “Pasture and Meadow” per Table 6-6 of the City of Colorado Springs Drainage Criteria Manual. The Site does not currently provide water quality or detention for the Project area. The existing land use is undeveloped vacant land. The proposed land use is a solar facility with native ground cover.

Birdsall Road Site, consists of slopes ranging from 2% to 4:1. Squirrel Creek Site, consists of slopes ranging from 2% to 4:1.

NRCS soil data is available for this Site and it has been noted that soils onsite are generally USCS Type C and D. Reference the Geotechnical Engineering Report for CO404 Palmer Solar Facility prepared by Terracon Consultants, Inc. dated May 21, 2018 for additional information on specific soil types and other geotechnical information. There are no major drainage ways or irrigation facilities within the Site.

Improvements will consist of mowing, clearing and grubbing, weed control, native seeding, gravel access road construction, overlot grading, solar array installation, roadside ditches,



culverts, drainage swales and a proposed channel to convey off-site flows through Squirrel Creek Site.

The Project proposes to install underground electric lines connecting power stations for the solar panels to a larger sub-station located on the northeast corner of the Site. There will also be a proposed transmission line that connects the two sites together.

ALTA and topographic field survey was completed for the Project by Clark Land Surveying Inc. dated April 23<sup>rd</sup>, 2018 and is the basis for design for the drainage improvements.

## **DRAINAGE BASINS AND SUB-BASINS**

### ***MAJOR BASIN DESCRIPTIONS***

There are no previous drainage studies, master plans or site constraints for this Site.

No portion of the Project is located within the 100-year floodplain as determined by the Flood Insurance Rate Map (FIRM) numbers 08041C0970F and 08041C1160F effective date, March 17, 1997 (see Appendix).

Birdsall Road Site, is located within El Paso County's Calhan Reservoir basin. Squirrel Creek Site, is located within El Paso County's Lower Williams Creek basin.

### ***EXISTING SUB-BASIN DESCRIPTIONS***

Birdsall Road Site, has been divided into 4 drainage sub-basins (W1-W4). Existing drainage patterns are split by a ridge that runs north-south and generally divides the drainage areas in half. Drainage along the west side flows west overland to existing agricultural land which ultimately drains southward to Fountain Creek (sub-basins W1 and W3). Drainage along the east side flows overland to the east. More specifically, sub-basin W2 flows east to Calhan Reservoir and sub-basin W4 flows east and eventually south, beneath Birdsall Road ultimately to Fountain Creek. Fountain Creek is a part of the Arkansas River Basin.

The west sub-basin areas, minor 5-year storm event runoffs, and major 100-year storm event runoffs are provided in Table 1.

Basin	Basin Area (Acres)	Direct 5-Year Runoff (cfs)	Direct 100-Year Runoff (cfs)
W1	94.49	24.99	115.43
W2	151.66	25.17	115.88
W3	91.27	45.72	196.20
W4	303.81	129.49	563.91

**Table 1. Existing West Sub-Basin Data**

Squirrel Creek Site, has been divided into 3 drainage sub-basins (E1-E3). Existing drainage patterns are split by a ridge that runs east-west along the southern 1/3 of the area. Drainage along the north side flows south, through the Site and eventually southeast outside of the property limits. Ultimately drainage from this area reaches Fountain Creek (sub-basin E1). Drainage along the southern 1/3 of the areas flows south overland to existing unnamed drainageways and ultimately southward to Fountain Creek (sub-basins E2 and E3).

The east sub-basin areas, minor 5-year storm event runoffs, and major 100-year storm event runoffs are provided Table 2.

Basin	Basin Area (Acres)	Direct 5-Year Runoff (cfs)	Direct 100-Year Runoff (cfs)
E1	776.17	115.86	530.57
E2	24.35	5.99	27.66
E3	90.83	24.02	110.95

**Table 2. Existing East Sub-Basin Data**

Offsite flows entering the Site will be conveyed through the Site following existing and historical drainage paths and outfall to Fountain Creek or the unnamed drainage ditches which ultimately outfall to Fountain Creek. Offsite flows will not be detained on site.

An Existing Drainage Conditions Map and hydrologic calculations are included in the Appendix of this report for reference.

## **DRAINAGE DESIGN CRITERIA**

### **DEVELOPMENT CRITERIA REFERENCE**

The proposed storm facilities are designed to be in compliance with the City of Colorado Springs and El Paso County "Drainage Criteria Manual (DCM)" dated November 1991 ("the MANUAL"), El Paso County "Engineering Criteria Manual" ("the Engineering Manual"), Chapter

6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs Drainage Criteria Manual dated May 2014 (“the Colorado Springs MANUAL”). Site drainage is not significantly impacted by such constraints as utilities or existing development.

There are no previous drainage studies, master plans or site constraints for this Site.

### **HYDROLOGIC CRITERIA**

The 5-year and 100-year design storm events were used in determining rainfall and runoff for the proposed drainage analysis per the MANUAL. Table 6-2 of the Colorado Springs MANUAL is the source for rainfall data for the 5-year and 100-year design storm events. Design runoff was calculated using the Soil Conservation Service (SCS) method for developed conditions as established in the MANUAL. The SCS Method was used for existing conditions and proposed conditions due to the on-site and off-site basins containing more than 130 acres. Runoff curve numbers for the proposed development were determined using Table 5-4 of the MANUAL by determining the land use of the Site.

The Project does not provide water quality or detention as the Project is not significantly increasing the imperviousness of the Site or developed flows.

There are no additional provisions selected or deviations from the criteria in both the MANUAL and Colorado Springs MANUAL.

### **HYDRAULIC CRITERIA**

Applicable design methods were utilized to size the proposed culverts and drainage channel, which includes the use of the UDFCD UD Culvert spreadsheet and FlowMaster, V8i software.

The culverts and drainage channel hydraulic analysis of design intervals as outlined by the following design storm events:

- Major Storm: 100-year Storm Event

## **DRAINAGE FACILITY DESIGN**

### **GENERAL CONCEPT**

The proposed drainage patterns will match the existing drainage conditions and historic patterns. Overlot grading of specific areas within the Site will be required to facilitate the construction of the solar arrays on adequate slopes. The overlot grading will follow the existing topography and will not alter the historic drainage patterns. Areas that are overlot graded will be revegetated with native seeding. Native seeding and vegetation will be established beneath the solar arrays such that the overall impervious area of the Site will not increase except for the addition of gravel access roads throughout the Site. Additionally, the solar arrays provide a level of shade to the underlying vegetation to facilitate growth. Mowing operations are included as part of the operations and maintenance plan for the facility.

Water quality and detention are not provided for the Site per justification provided in the “Hydrologic Response of Solar Farms” ASCE white paper prepared by Lauren M. Cook and Richard H. McCuen at the University of Maryland, dated May 2013 (the “white paper”). The white paper outlines the hydrologic effects of solar panels and the applicability of stormwater management on solar sites to control runoff volumes and rates. The white paper concluded that

“The addition of solar panels over a grassy field does not have much of an effect on the volume of runoff, the peak discharge, nor the time to peak. With each analysis, the runoff volume increased slightly but not enough to require storm-water management facilities.” The white paper then goes on to emphasize the impact that ground cover plays on the runoff volume, peak discharge, and time to peak. Gravel or pavement underneath the solar panels will increase the volume of runoff significantly. However, ground cover plays a significant role regardless of the type of development. “The solar panels are impervious to rain water; however, they are mounted on metal rods and placed over pervious land,” as stated in the white paper. Therefore, water quality and detention are not provided for the Site.

Provided in the Appendix are hydrologic calculations utilizing the SCS method for the existing and proposed conditions, Flowmaster details and cross sections for proposed hydraulic drainage features, and existing and proposed drainage maps of Array 1 and Array 2.

### **SPECIFIC DETAILS**

Runoff conditions for the Site were developed utilizing the previously referenced Hydrologic Criteria. Birdsall Road Site, has been divided into 4 proposed drainage sub-basins (W1-W4). The proposed west drainage basins extents match the existing drainage basins due to the site grading matching existing conditions except for the proposed grading of roadways and roadside ditches. The proposed basins are split by a ridge that runs north-south. The west side of the ridge consists of sub-Basins W1 and W3. The east side of the ridge consists of sub-basins W2 and W4.

Sub-basins W1 and W3 consist of solar panels, native vegetation, permanent check dams, and roadways. The basins follow historic drainage patterns and drain to the west to existing agricultural land which ultimately drains to Fountain Creek. Check dams are to be installed to help dissipate flow velocities draining to the west. Sub-basin W2 consists of offsite native vegetation. Sub-basin W4 consists of solar panels, roadside ditches, and roadways. Sub-basins W2 and W4 follow historic drainage patterns and flow east to either Calhan Reservoir or southward to Fountain Creek.

The west sub-basin areas, minor 5-year storm event runoffs, and major 100-year storm event runoffs are provided in Table 3.

Basin	Basin Area (Acres)	Direct 5-Year Runoff (cfs)	Direct 100-Year Runoff (cfs)
W1	94.49	28.23	121.88
W2	151.66	25.17	115.86
W3	91.27	45.72	196.20
W4	303.81	129.49	563.91

**Table 3. Proposed West Sub-Basin Data**

Squirrel Creek Site, is divided into 5 drainage sub-basins (E1-E5). Existing drainage patterns are split by a ridge that runs east-west along the southern 1/3 of the area. The proposed drainage patterns will remain split by the east-west ridge. The north side of the ridge consists of sub-basins E1-E4. The south 1/3 of the ridge consists of sub-basin E5.

Sub-Basin E1 consists of offsite native vegetation north of the Site. Sub-basins E2 through E4 consist of solar panels, native vegetation, drainage channel, and roadways. Sub-basins E1-E4 follow historic drainage patterns and flow south overland to existing unnamed drainage ditches, eastward and ultimately southward to Fountain Creek. Sub-basin E5 consists of solar panels, native vegetation, and roadways. Sub-Basin E5 follows historic drainage patterns and flows south overland to existing unnamed drainage ditches, and ultimately southward to Fountain Creek.

The east sub-basin areas, minor 5-year storm event runoffs, and major 100-year storm event runoffs are provided in Table 4.

Basin	Basin Area (Acres)	Direct 5-Year Runoff (cfs)	Direct 100-Year Runoff (cfs)
E1	508.33	95.16	388.01
E2	207.96	44.02	191.18
E3	24.35	5.98	27.66
E4	59.88	13.08	60.65
E5	90.83	27.13	117.15

**Table 4. Proposed East Sub-Basin Data**

A Proposed Drainage Conditions Map and hydrologic calculations are included in the Appendix of this report for reference.

The Project utilizes a proposed drainage channel within Squirrel Creek Site to convey offsite and minimal onsite flows through the Site for the protection of the solar panels. The proposed designed to carry the minor and major storm events and will run dry for most of the year. The channel has an average depth of approximately 2 feet, a 55-foot bottom width, a left-side slope of 4:1, and a right-side slope of 4:1. The channel was sized to convey the 100-year storm event of 762.73 cfs. Channel calculations are provided in the Appendix.

The Project also utilizes check dams on the west perimeter of the Site. Two neighborhood meetings were held prior to completion of this report. The neighborhood meetings were hosted by JSI Construction Group LLC and the neighboring public was invited to attend to comment on the Project. During those meetings, existing home owners along the west side of the Site raised concerns about existing drainage issues relative to the hillside that drains westward, towards their property. These areas are shown on the Existing Drainage Conditions Map. Based upon this public comment, proposed check dams were provided to decrease the velocity of offsite and onsite flows going west. The check dams are three feet earthen berms with a maximum length

of 300'. The check dams are designed with a high point in the center which slopes outward at a minimum of 1% each direction. There are breaks in the check dams that contain riprap pads.

Roadside ditches are provided on the uphill side of the proposed roadways to route flows to the proposed culverts. The roadside ditches were sized to convey 23.25 cfs. The roadside ditches have an average depth of approximately 1 foot, a 4-foot bottom width, a left-side slope of 6:1, and a right-side slope of 4:1. Roadside ditch calculations are provided in the Appendix.

Culverts were sized to convey flows from the ditches, underneath the site access roads. The proposed culverts are 18" or 24" in diameter and have been designed to convey the 100-year storm event. Culvert calculations are provided in the Appendix and culvert locations are provided in the Proposed Drainage Maps.

The Site will disturb more than 1 acre and will require a Colorado Discharge Permit System (CDPS) General Permit for Stormwater Discharge Associated with Construction Activities from the Colorado Department of Public Health and Environment (CDPHE).

The estimated opinion of probable cost for the stormwater infrastructure is \$202,708. An opinion of cost is provided in the Appendix.

There are no drainage and bridge fees for the Project. The Project is leasing two parcels of land from Woodmoor Water and Sanitation District and the Site does not require platting.

## **SUMMARY**

The proposed drainage design is to maintain the historic drainage patterns, the overall imperviousness and release rates for the Site. Runoff from the Site will flow overland to existing El Paso County drainage basins: the Calhan Reservoir Basin and the Lower Williams Creek Basin. Both basins ultimately discharge to Fountain Creek. The drainage design presented within this report conforms to the criteria presented in both the MANUAL and the Colorado Springs MANUAL. Additionally, the Site runoff and storm drain facilities will not adversely affect the downstream and surrounding developments, including Fountain Creek.

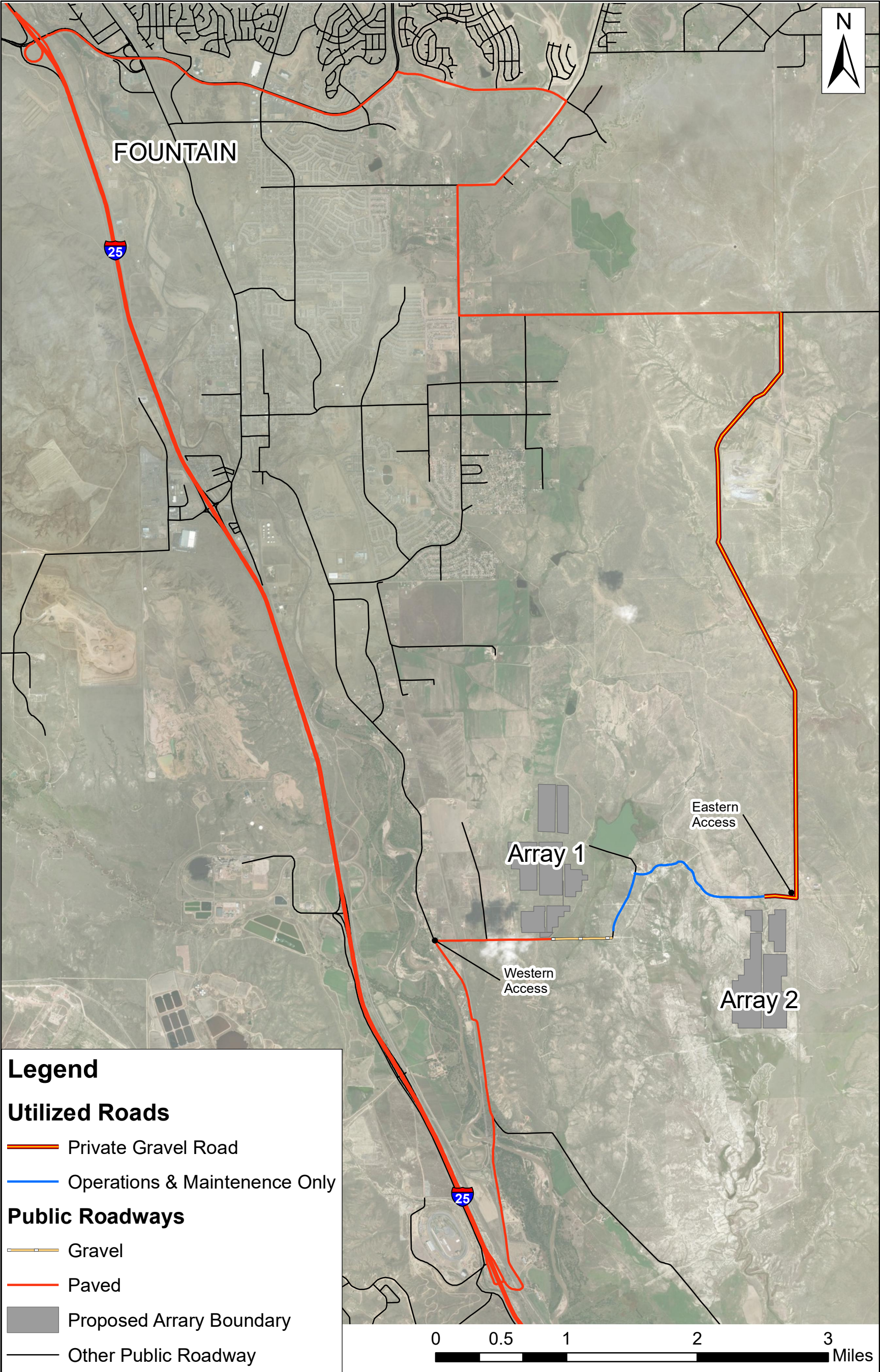
## **REFERENCES**

1. City of Colorado Springs and El Paso County "Drainage Criteria Manual (DCM)", dated November 1991
2. El Paso County "Engineering Criteria Manual" Revision 6, dated December 13, 2016
3. Chapter 6 and Section 3.2.1. of Chapter 13-City of Colorado Springs Drainage Criteria Manual, May 2014.
4. Urban Drainage and Flood Control District Drainage Criteria Manual (UDFCD CM), Vol. 1, prepared by Wright-McLaughlin Engineers, June 2001, with latest revisions.
5. Flood Insurance Rate Map, El Paso County, Colorado and Incorporated Areas, Map Number 08041C0970F and 08041C1160F, Effective Date March 17, 1997, prepared by the Federal Emergency Management Agency (FEMA).
6. Hydrologic Response of Solar Farms, prepared by Lauren M. Cook and Richard H. McCuen, University of Maryland, May 2013.

## APPENDIX

***VICINITY MAP AND FEMA FIRM MAP***



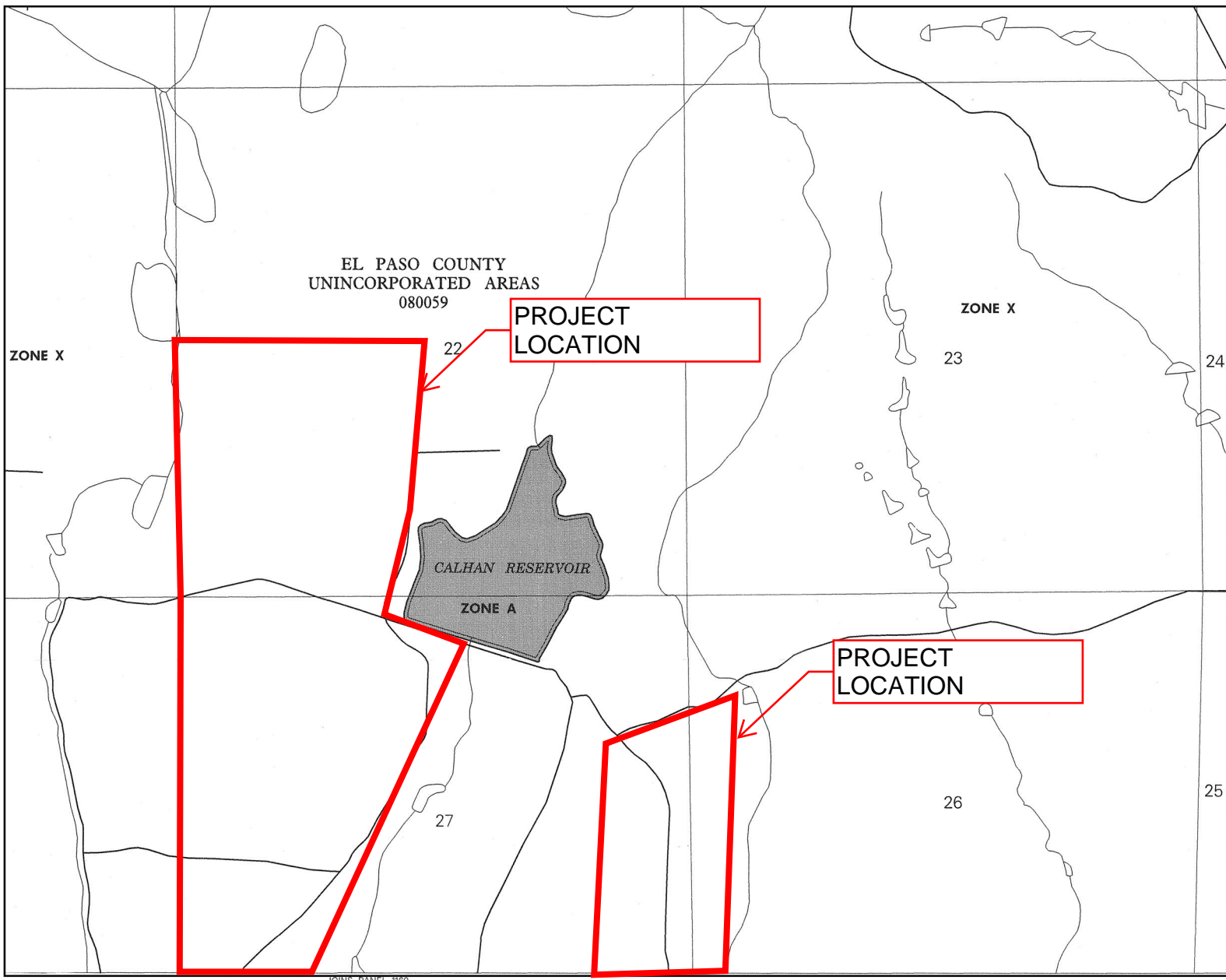


**Figure 1**

Vicinity Map

El Paso County, Colorado





APPROXIMATE SCALE IN FEET  
1000 0 1000

**NATIONAL FLOOD INSURANCE PROGRAM**

**FIRM  
FLOOD INSURANCE RATE MAP**

**EL PASO COUNTY,  
COLORADO AND  
INCORPORATED AREAS**

**PANEL 970 OF 1300**  
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:  
COMMUNITY

NUMBER	PANEL	SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0970 F

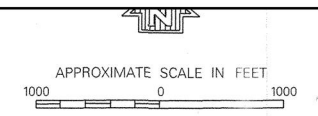
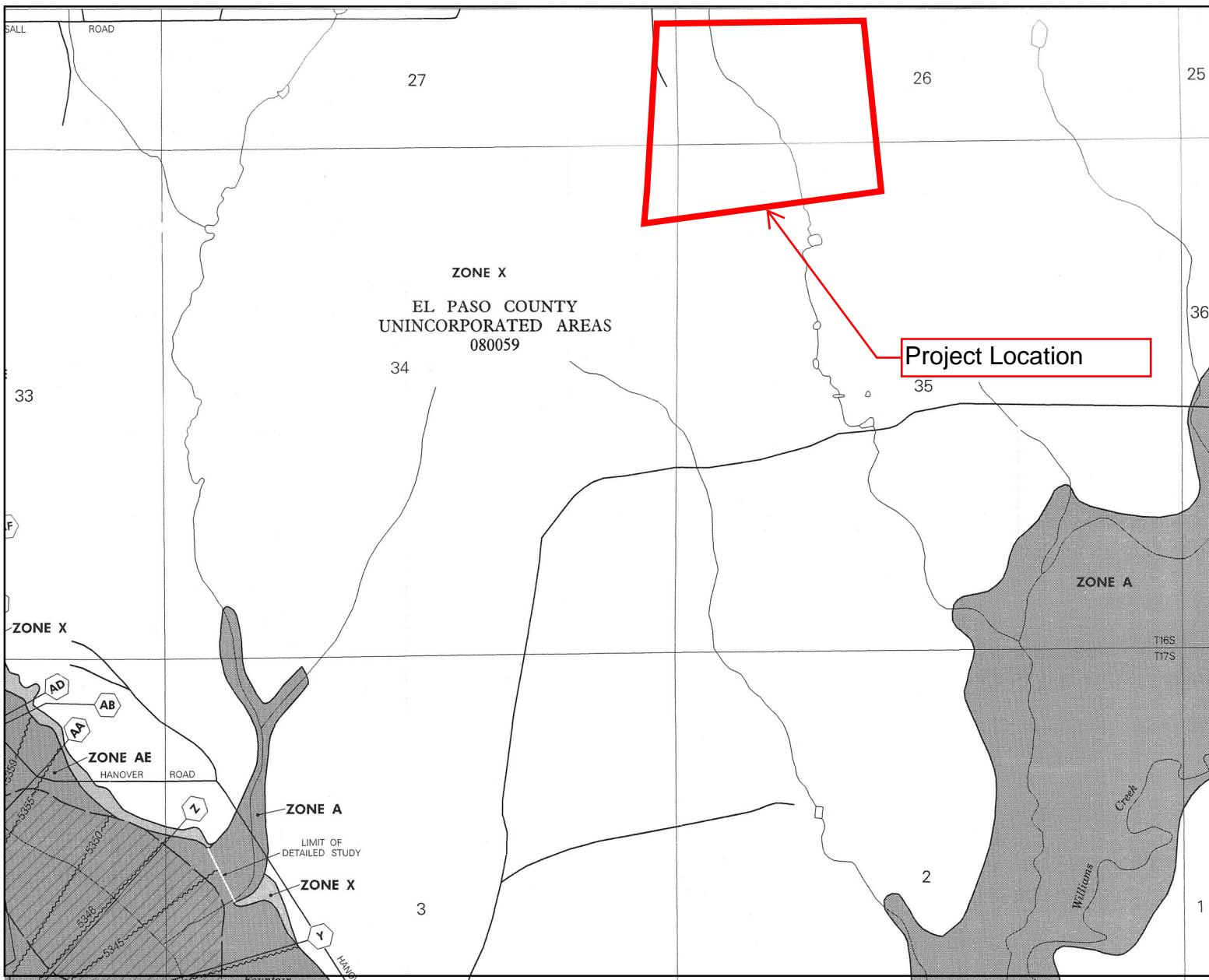
**MAP NUMBER  
08041C0970 F**

**EFFECTIVE DATE:  
MARCH 17, 1997**



Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at [www.msc.fema.gov](http://www.msc.fema.gov)



**NATIONAL FLOOD INSURANCE PROGRAM**

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

**PANEL 1160 OF 1300**  
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:	NUMBER	PANEL	SUFFIX
COMMUNITY			
EL PASO COUNTY	080059	1160	F
UNINCORPORATED AREAS	080081	1160	F
FOUNTAIN, CITY OF			

**MAP NUMBER**  
**08041C1160 F**

**EFFECTIVE DATE:**  
**MARCH 17, 1997**



Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at [www.msc.fema.gov](http://www.msc.fema.gov)

***SOILS MAP***





United States  
Department of  
Agriculture

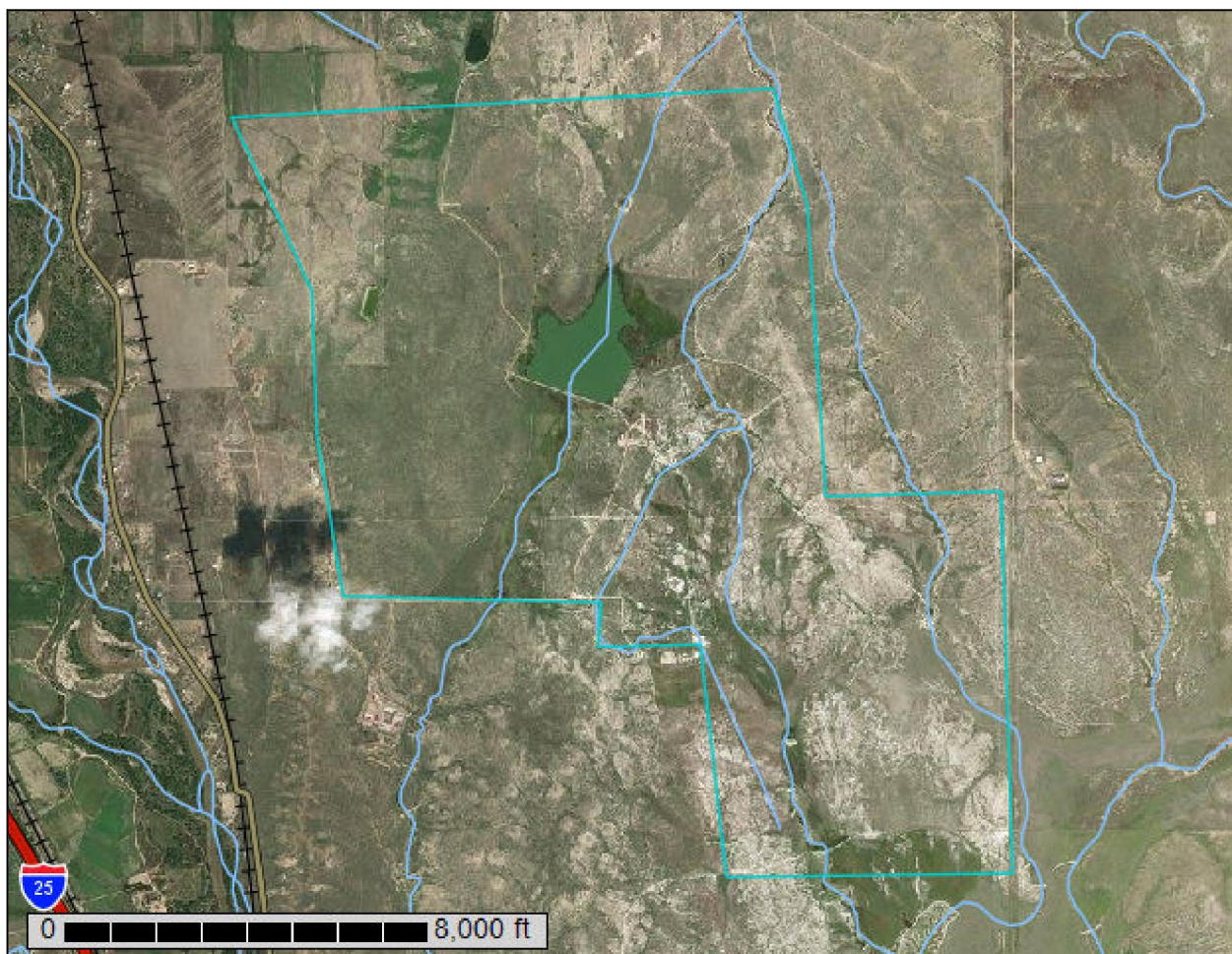
**NRCS**

Natural  
Resources  
Conservation  
Service

A product of the National  
Cooperative Soil Survey,  
a joint effort of the United  
States Department of  
Agriculture and other  
Federal agencies, State  
agencies including the  
Agricultural Experiment  
Stations, and local  
participants

# Custom Soil Resource Report for **El Paso County Area, Colorado**

**Palmer Solar**



June 13, 2018

# Preface

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Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist ([http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2\\_053951](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951)).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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# How Soil Surveys Are Made

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Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

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scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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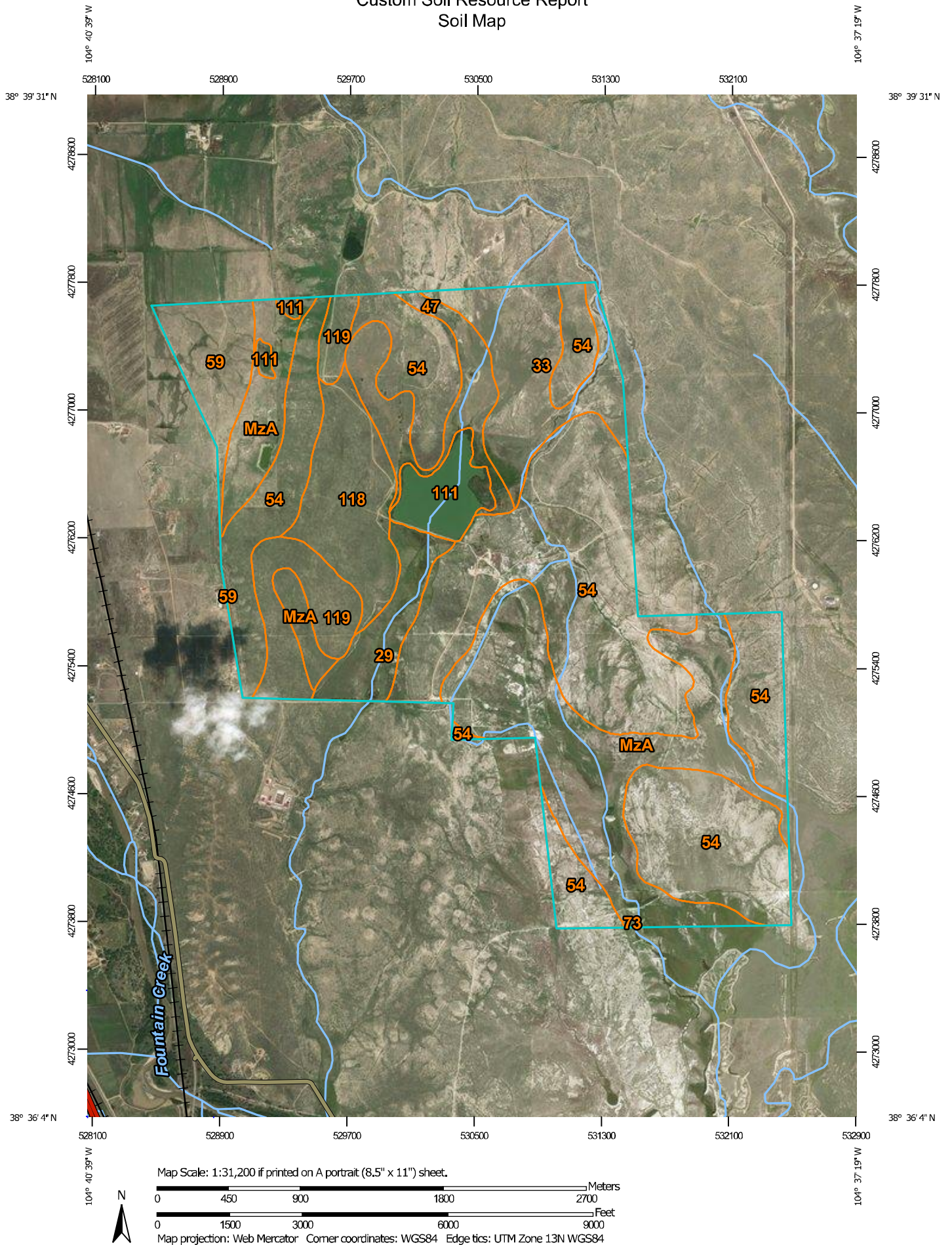
identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

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The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

# Custom Soil Resource Report Soil Map



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

**Water Features**

 Streams and Canals

**Transportation**

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

**Background**

 Aerial Photography

 Spoil Area

 Stony Spot

 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

MAP INFORMATION

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

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 15, Oct 10, 2017

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

Date(s) aerial images were photographed: Nov 7, 2015—Mar 9, 2017

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
29	Fluvaquentic Haplaquolls, nearly level	82.3	3.5%
33	Heldt clay loam, 0 to 3 percent slopes	177.2	7.5%
47	Limon clay, 0 to 3 percent slopes	111.5	4.7%
54	Midway clay loam, 3 to 25 percent slopes	1,040.4	44.2%
59	Nunn clay loam, 0 to 3 percent slopes	93.3	4.0%
73	Razor clay loam, 3 to 9 percent slopes	1.2	0.1%
111	Water	72.2	3.1%
118	Fort loam, 1 to 5 percent slopes, cool	154.8	6.6%
119	Fort sandy loam, 1 to 8 percent slopes, cool	121.6	5.2%
MzA	Manzanola silty clay loam, saline, 0 to 2 percent slopes	497.1	21.1%
<b>Totals for Area of Interest</b>		<b>2,351.5</b>	<b>100.0%</b>

## Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different

management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.



## El Paso County Area, Colorado

### 29—Fluvaquentic Haplaquolls, nearly level

#### Map Unit Setting

*National map unit symbol:* 3681  
*Elevation:* 5,000 to 7,800 feet  
*Mean annual precipitation:* 13 to 15 inches  
*Mean annual air temperature:* 46 to 52 degrees F  
*Frost-free period:* 110 to 165 days  
*Farmland classification:* Not prime farmland

#### Map Unit Composition

*Fluvaquentic haplaquolls and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Fluvaquentic Haplaquolls

##### Setting

*Landform:* Flood plains, marshes, swales  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Alluvium

##### Properties and qualities

*Slope:* 0 to 2 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Poorly drained  
*Runoff class:* Very high  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.20 to 6.00 in/hr)  
*Depth to water table:* About 0 to 24 inches  
*Frequency of flooding:* Frequent  
*Frequency of ponding:* None  
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)

##### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 5w  
*Hydrologic Soil Group:* D  
*Ecological site:* Sandy Meadow (R067BY029CO)  
*Hydric soil rating:* Yes

#### Minor Components

##### Haplaquolls

*Percent of map unit:*  
*Landform:* Domes  
*Hydric soil rating:* Yes

##### Other soils

*Percent of map unit:*  
*Hydric soil rating:* No

### 33—Heldt clay loam, 0 to 3 percent slopes

#### Map Unit Setting

*National map unit symbol:* 3686  
*Elevation:* 5,200 to 6,500 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 48 to 52 degrees F  
*Frost-free period:* 135 to 155 days  
*Farmland classification:* Prime farmland if irrigated

#### Map Unit Composition

*Heldt and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Heldt

##### Setting

*Landform:* Alluvial fans, stream terraces  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Clayey alluvium derived from shale

##### Typical profile

*Ap - 0 to 8 inches:* clay loam  
*Bw - 8 to 41 inches:* silty clay  
*Bk - 41 to 60 inches:* silty clay 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 low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 10 percent  
*Gypsum, maximum in profile:* 4 percent  
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 10.0  
*Available water storage in profile:* High (about 10.4 inches)

##### Interpretive groups

*Land capability classification (irrigated):* 3e  
*Land capability classification (nonirrigated):* 4c  
*Hydrologic Soil Group:* C  
*Ecological site:* Alkaline Plains LRU's A & B (R069XY047CO)  
*Other vegetative classification:* ALKALINE PLAINS (069BY047CO)

*Hydric soil rating:* No

#### **Minor Components**

##### **Other soils**

*Percent of map unit:*

*Hydric soil rating:* No

##### **Pleasant**

*Percent of map unit:*

*Landform:* Depressions

*Hydric soil rating:* Yes

### **47—Limon clay, 0 to 3 percent slopes**

#### **Map Unit Setting**

*National map unit symbol:* 368p

*Elevation:* 5,200 to 6,200 feet

*Mean annual precipitation:* 12 to 14 inches

*Mean annual air temperature:* 48 to 52 degrees F

*Frost-free period:* 135 to 155 days

*Farmland classification:* Not prime farmland

#### **Map Unit Composition**

*Limon, occasionally flooded, and similar soils:* 85 percent

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

#### **Description of Limon, Occasionally Flooded**

##### **Setting**

*Landform:* Alluvial fans, flood plains

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Clayey alluvium derived from shale

##### **Typical profile**

*A - 0 to 4 inches:* clay

*AC - 4 to 12 inches:* silty clay

*C - 12 to 60 inches:* silty clay 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 low to moderately high (0.06 to 0.20 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* Occasional

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 10 percent

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*Gypsum, maximum in profile:* 2 percent

*Salinity, maximum in profile:* Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)

*Sodium adsorption ratio, maximum in profile:* 10.0

*Available water storage in profile:* High (about 9.9 inches)

### Interpretive groups

*Land capability classification (irrigated):* 3e

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* C

*Ecological site:* Salt Flat LRU's A & B (R069XY033CO)

*Hydric soil rating:* No

### Minor Components

#### Other soils

*Percent of map unit:*

*Hydric soil rating:* No

#### Pleasant

*Percent of map unit:*

*Landform:* Depressions

*Hydric soil rating:* Yes

## 54—Midway clay loam, 3 to 25 percent slopes

### Map Unit Setting

*National map unit symbol:* 368y

*Elevation:* 5,200 to 6,200 feet

*Mean annual precipitation:* 12 to 14 inches

*Mean annual air temperature:* 48 to 52 degrees F

*Frost-free period:* 135 to 155 days

*Farmland classification:* Not prime farmland

### Map Unit Composition

*Midway and similar soils:* 85 percent

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

### Description of Midway

#### Setting

*Landform:* Hills

*Landform position (three-dimensional):* Side slope

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Slope alluvium over residuum weathered from shale

#### Typical profile

*A - 0 to 4 inches:* clay loam

*C - 4 to 13 inches:* clay

*Cr - 13 to 17 inches:* weathered bedrock

**Properties and qualities**

*Slope:* 3 to 25 percent  
*Depth to restrictive feature:* 6 to 20 inches to paralithic bedrock  
*Natural drainage class:* Well drained  
*Runoff class:* Medium  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent  
*Gypsum, maximum in profile:* 15 percent  
*Salinity, maximum in profile:* Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 15.0  
*Available water storage in profile:* Very low (about 2.2 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 7e  
*Hydrologic Soil Group:* D  
*Ecological site:* Shaly Plains LRU's A & B (R069XY046CO)  
*Other vegetative classification:* SHALY PLAINS (069AY046CO)  
*Hydric soil rating:* No

**Minor Components**

**Other soils**

*Percent of map unit:*  
*Hydric soil rating:* No

**Pleasant**

*Percent of map unit:*  
*Landform:* Depressions  
*Hydric soil rating:* Yes

**59—Nunn clay loam, 0 to 3 percent slopes**

**Map Unit Setting**

*National map unit symbol:* 3693  
*Elevation:* 5,400 to 6,500 feet  
*Mean annual precipitation:* 13 to 15 inches  
*Mean annual air temperature:* 46 to 50 degrees F  
*Frost-free period:* 135 to 155 days  
*Farmland classification:* Prime farmland if irrigated

**Map Unit Composition**

*Nunn and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*



## Description of Nunn

### Setting

*Landform:* Terraces, fans  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Mixed alluvium

### Typical profile

*A - 0 to 12 inches:* clay loam  
*Bt - 12 to 26 inches:* clay loam  
*BC - 26 to 30 inches:* clay loam  
*Bk - 30 to 58 inches:* sandy clay loam  
*C - 58 to 72 inches:* clay

### 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 low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent  
*Gypsum, maximum in profile:* 2 percent  
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)  
*Available water storage in profile:* High (about 9.8 inches)

### Interpretive groups

*Land capability classification (irrigated):* 2e  
*Land capability classification (nonirrigated):* 3c  
*Hydrologic Soil Group:* C  
*Ecological site:* Clayey Plains LRU's A & B (R069XY042CO)  
*Other vegetative classification:* CLAYEY PLAINS (069AY042CO)  
*Hydric soil rating:* No

## Minor Components

### Other soils

*Percent of map unit:*  
*Hydric soil rating:* No

### Pleasant

*Percent of map unit:*  
*Landform:* Depressions  
*Hydric soil rating:* Yes

## 73—Razor clay loam, 3 to 9 percent slopes

### Map Unit Setting

*National map unit symbol:* 369m  
*Elevation:* 5,300 to 6,100 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 48 to 52 degrees F  
*Frost-free period:* 135 to 155 days  
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Razor and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Razor

#### Setting

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Clayey slope alluvium over residuum weathered from shale

#### Typical profile

*A - 0 to 3 inches:* clay loam  
*Bw - 3 to 9 inches:* clay loam  
*Bk - 9 to 31 inches:* clay  
*Cr - 31 to 35 inches:* weathered bedrock

#### Properties and qualities

*Slope:* 3 to 9 percent  
*Depth to restrictive feature:* 20 to 40 inches to paralithic bedrock  
*Natural drainage class:* Well drained  
*Runoff class:* Medium  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent  
*Gypsum, maximum in profile:* 5 percent  
*Salinity, maximum in profile:* Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 15.0  
*Available water storage in profile:* Low (about 5.5 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 6e  
*Land capability classification (nonirrigated):* 6e  
*Hydrologic Soil Group:* D

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*Ecological site:* Alkaline Plains LRU's A & B (R069XY047CO)  
*Other vegetative classification:* ALKALINE PLAINS (069AY047CO)  
*Hydric soil rating:* No

### Minor Components

#### Other soils

*Percent of map unit:*  
*Hydric soil rating:* No

#### Pleasant

*Percent of map unit:*  
*Landform:* Depressions  
*Hydric soil rating:* Yes

## 111—Water

### Map Unit Composition

*Water:* 100 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

## 118—Fort loam, 1 to 5 percent slopes, cool

### Map Unit Setting

*National map unit symbol:* 2rgqs  
*Elevation:* 5,500 to 6,500 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 48 to 54 degrees F  
*Frost-free period:* 125 to 160 days  
*Farmland classification:* Prime farmland if irrigated

### Map Unit Composition

*Fort and similar soils:* 85 percent  
*Minor components:* 15 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Fort

#### Setting

*Landform:* Interfluves, fans  
*Landform position (two-dimensional):* Backslope, footslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Convex  
*Across-slope shape:* Linear  
*Parent material:* Loamy alluvium and/or eolian deposits

#### Typical profile

*A - 0 to 4 inches:* loam  
*Bt - 4 to 12 inches:* clay loam

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*Btk - 12 to 33 inches:* clay loam  
*Bk1 - 33 to 47 inches:* loam  
*Bk2 - 47 to 79 inches:* sandy loam

### Properties and qualities

*Slope:* 1 to 5 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 (0.20 to 0.60 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 25 percent  
*Gypsum, maximum in profile:* 2 percent  
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.5 to 2.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 3.0  
*Available water storage in profile:* Moderate (about 8.5 inches)

### Interpretive groups

*Land capability classification (irrigated):* 3e  
*Land capability classification (nonirrigated):* 4c  
*Hydrologic Soil Group:* C  
*Ecological site:* Loamy Plains, LRU's A & B 10-14 Inches, P.Z. (R069XY006CO)  
*Forage suitability group:* Loamy (G069XW017CO)  
*Other vegetative classification:* Loamy Plains #6 (069XY006CO\_2)  
*Hydric soil rating:* No

### Minor Components

#### Wilid

*Percent of map unit:* 10 percent  
*Landform:* Interfluves  
*Landform position (two-dimensional):* Summit  
*Landform position (three-dimensional):* Interfluve  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Ecological site:* Loamy Plains, LRU's A & B 10-14 Inches, P.Z. (R069XY006CO)  
*Other vegetative classification:* Loamy Plains #6 (069XY006CO\_2)  
*Hydric soil rating:* No

#### Oterodry

*Percent of map unit:* 5 percent  
*Landform:* Hillslopes  
*Landform position (two-dimensional):* Backslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Convex  
*Across-slope shape:* Linear  
*Ecological site:* Sandy Plains LRU's A & B (R069XY026CO)  
*Hydric soil rating:* No

## 119—Fort sandy loam, 1 to 8 percent slopes, cool

### Map Unit Setting

*National map unit symbol:* 2t50n

*Elevation:* 4,500 to 6,000 feet

*Mean annual precipitation:* 12 to 14 inches

*Mean annual air temperature:* 48 to 54 degrees F

*Frost-free period:* 125 to 170 days

*Farmland classification:* Not prime farmland

### Map Unit Composition

*Fort, cool, and similar soils:* 85 percent

*Minor components:* 15 percent

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

### Description of Fort, Cool

#### Setting

*Landform:* Hills, interfluves

*Landform position (two-dimensional):* Footslope, backslope

*Landform position (three-dimensional):* Side slope, head slope

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Alluvium and/or eolian deposits

#### Typical profile

*A - 0 to 5 inches:* sandy loam

*Bt - 5 to 13 inches:* clay loam

*Btk - 13 to 28 inches:* clay loam

*Bk1 - 28 to 36 inches:* loam

*Bk2 - 36 to 79 inches:* sandy loam

#### Properties and qualities

*Slope:* 1 to 8 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*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:* 25 percent

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)

*Sodium adsorption ratio, maximum in profile:* 2.0

*Available water storage in profile:* Moderate (about 8.2 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 4e

*Land capability classification (nonirrigated):* 6e

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*Hydrologic Soil Group:* B  
*Ecological site:* Sandy Plains LRU's A & B (R069XY026CO)  
*Forage suitability group:* Loamy (G069XW017CO)  
*Other vegetative classification:* Sandy Plains #26 (069XY026CO\_2)  
*Hydric soil rating:* No

### Minor Components

#### Wilid

*Percent of map unit:* 5 percent  
*Landform:* Interfluves  
*Landform position (two-dimensional):* Summit  
*Landform position (three-dimensional):* Interfluve  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Ecological site:* Loamy Plains, LRU's A & B 10-14 Inches, P.Z. (R069XY006CO)  
*Other vegetative classification:* Loamy Plains #6 (069XY006CO\_2)  
*Hydric soil rating:* No

#### Vonid

*Percent of map unit:* 5 percent  
*Landform:* Ridges, hills  
*Landform position (two-dimensional):* Backslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Convex, linear  
*Across-slope shape:* Convex  
*Ecological site:* Sandy Plains LRU's A & B (R069XY026CO)  
*Hydric soil rating:* No

#### Kimera

*Percent of map unit:* 5 percent  
*Landform:* Interfluves, fan remnants  
*Landform position (two-dimensional):* Shoulder, backslope  
*Landform position (three-dimensional):* Interfluve, side slope  
*Down-slope shape:* Convex, linear  
*Across-slope shape:* Linear  
*Ecological site:* Loamy Plains, LRU's A & B 10-14 Inches, P.Z. (R069XY006CO)  
*Hydric soil rating:* No

## MzA—Manzanola silty clay loam, saline, 0 to 2 percent slopes

### Map Unit Setting

*National map unit symbol:* 2rgrg  
*Elevation:* 3,900 to 6,000 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 48 to 54 degrees F  
*Frost-free period:* 130 to 170 days  
*Farmland classification:* Not prime farmland



### Map Unit Composition

*Manzanola and similar soils:* 90 percent

*Minor components:* 10 percent

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

### Description of Manzanola

#### Setting

*Landform:* Fan remnants, interfluves, terraces, drainageways

*Landform position (two-dimensional):* Footslope, summit

*Landform position (three-dimensional):* Side slope, tread

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Alluvium derived from shale

#### Typical profile

*A - 0 to 4 inches:* silty clay loam

*Bt1 - 4 to 11 inches:* silty clay loam

*Bt2 - 11 to 26 inches:* silty clay loam

*Bk1 - 26 to 38 inches:* silty clay loam

*Bk2 - 38 to 79 inches:* silty clay loam

#### Properties and qualities

*Slope:* 0 to 2 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 14 percent

*Gypsum, maximum in profile:* 3 percent

*Salinity, maximum in profile:* Moderately saline (8.0 to 15.0 mmhos/cm)

*Sodium adsorption ratio, maximum in profile:* 13.0

*Available water storage in profile:* Very high (about 12.1 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3e

*Land capability classification (nonirrigated):* 4c

*Hydrologic Soil Group:* C

*Ecological site:* Saline Overflow LRU's A & B (R069XY037CO)

*Other vegetative classification:* Saline Overflow (069XY037CO\_1)

*Hydric soil rating:* No

### Minor Components

#### Aguilar

*Percent of map unit:* 5 percent

*Landform:* Fan remnants

*Landform position (two-dimensional):* Footslope

*Landform position (three-dimensional):* Side slope

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Ecological site:* Salt Flat LRU's A & B (R069XY033CO)

*Other vegetative classification:* Salt Flat #33 (069AY033CO\_2)

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*Hydric soil rating:* No

### **Haversid**

*Percent of map unit:* 5 percent

*Landform:* Terraces, drainageways

*Landform position (three-dimensional):* Tread

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Ecological site:* Saline Overflow LRU's A & B (R069XY037CO)

*Hydric soil rating:* No

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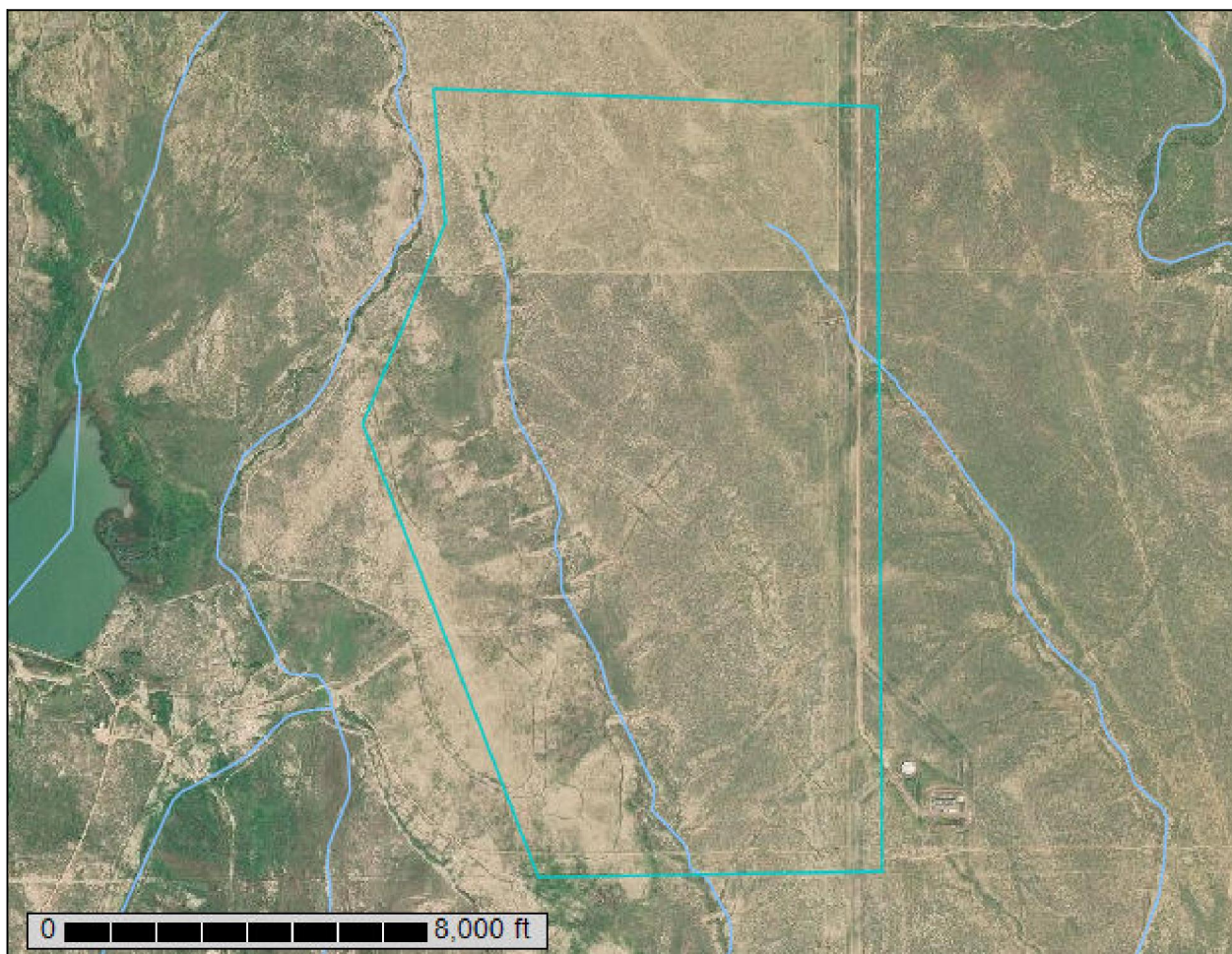
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**NRCS**

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a joint effort of the United  
States Department of  
Agriculture and other  
Federal agencies, State  
agencies including the  
Agricultural Experiment  
Stations, and local  
participants

# Custom Soil Resource Report for **El Paso County Area, Colorado**



October 31, 2018

# Preface

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Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist ([http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2\\_053951](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951)).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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# How Soil Surveys Are Made

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Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

## Custom Soil Resource Report

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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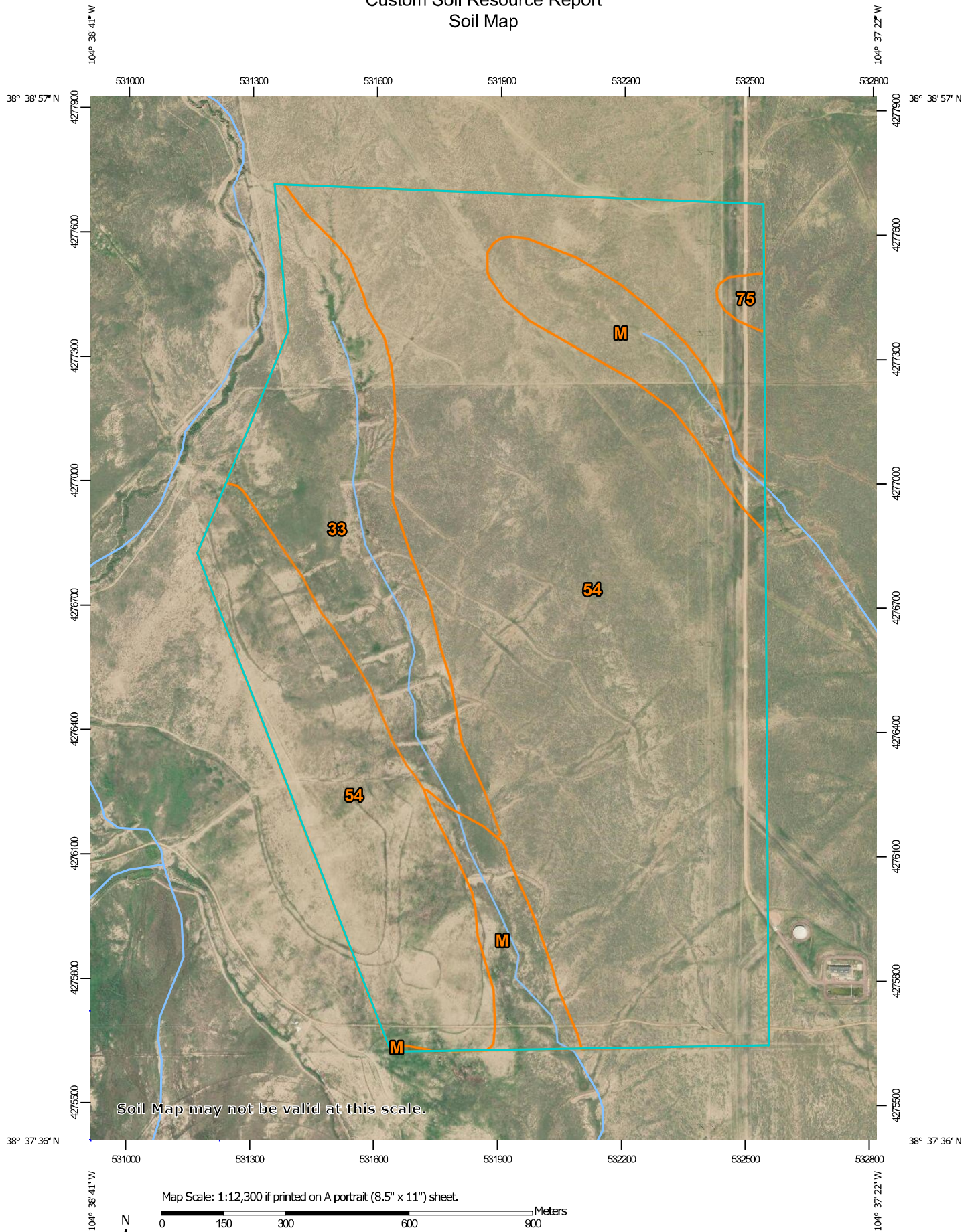
identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

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The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

# Custom Soil Resource Report Soil Map









## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
33	Heldt clay loam, 0 to 3 percent slopes	88.7	14.7%
54	Midway clay loam, 3 to 25 percent slopes	459.0	76.1%
75	Razor-Midway complex	2.9	0.5%
MzA	Manzanola silty clay loam, saline, 0 to 2 percent slopes	52.5	8.7%
<b>Totals for Area of Interest</b>		<b>603.2</b>	<b>100.0%</b>

## Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate

## Custom Soil Resource Report

pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

## El Paso County Area, Colorado

### 33—Heldt clay loam, 0 to 3 percent slopes

#### Map Unit Setting

*National map unit symbol:* 3686  
*Elevation:* 5,200 to 6,500 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 48 to 52 degrees F  
*Frost-free period:* 135 to 155 days  
*Farmland classification:* Prime farmland if irrigated

#### Map Unit Composition

*Heldt and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Heldt

##### Setting

*Landform:* Alluvial fans, stream terraces  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Clayey alluvium derived from shale

##### Typical profile

*Ap - 0 to 8 inches:* clay loam  
*Bw - 8 to 41 inches:* silty clay  
*Bk - 41 to 60 inches:* silty clay 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 low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 10 percent  
*Gypsum, maximum in profile:* 4 percent  
*Salinity, maximum in profile:* Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 10.0  
*Available water storage in profile:* High (about 10.4 inches)

##### Interpretive groups

*Land capability classification (irrigated):* 3e  
*Land capability classification (nonirrigated):* 4c  
*Hydrologic Soil Group:* C  
*Ecological site:* Alkaline Plains LRU's A & B (R069XY047CO)  
*Other vegetative classification:* ALKALINE PLAINS (069BY047CO)  
*Hydric soil rating:* No

## Minor Components

### Other soils

*Percent of map unit:*  
*Hydric soil rating:* No

### Pleasant

*Percent of map unit:*  
*Landform:* Depressions  
*Hydric soil rating:* Yes

## 54—Midway clay loam, 3 to 25 percent slopes

### Map Unit Setting

*National map unit symbol:* 368y  
*Elevation:* 5,200 to 6,200 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 48 to 52 degrees F  
*Frost-free period:* 135 to 155 days  
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Midway and similar soils:* 85 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Midway

#### Setting

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Slope alluvium over residuum weathered from shale

#### Typical profile

*A - 0 to 4 inches:* clay loam  
*C - 4 to 13 inches:* clay  
*Cr - 13 to 17 inches:* weathered bedrock

#### Properties and qualities

*Slope:* 3 to 25 percent  
*Depth to restrictive feature:* 6 to 20 inches to paralithic bedrock  
*Natural drainage class:* Well drained  
*Runoff class:* Medium  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent

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*Gypsum, maximum in profile:* 15 percent  
*Salinity, maximum in profile:* Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 15.0  
*Available water storage in profile:* Very low (about 2.2 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 7e  
*Hydrologic Soil Group:* D  
*Ecological site:* Shaly Plains LRU's A & B (R069XY046CO)  
*Other vegetative classification:* SHALY PLAINS (069AY046CO)  
*Hydric soil rating:* No

### Minor Components

#### Other soils

*Percent of map unit:*  
*Hydric soil rating:* No

#### Pleasant

*Percent of map unit:*  
*Landform:* Depressions  
*Hydric soil rating:* Yes

## 75—Razor-Midway complex

### Map Unit Setting

*National map unit symbol:* 369p  
*Elevation:* 5,300 to 6,100 feet  
*Mean annual precipitation:* 12 to 14 inches  
*Mean annual air temperature:* 48 to 52 degrees F  
*Frost-free period:* 135 to 155 days  
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Razor and similar soils:* 50 percent  
*Midway and similar soils:* 30 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Razor

#### Setting

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Concave, linear  
*Across-slope shape:* Linear  
*Parent material:* Clayey slope alluvium over residuum weathered from shale

#### Typical profile

*A - 0 to 4 inches:* stony clay loam

## Custom Soil Resource Report

*Bw - 4 to 22 inches:* cobbly clay loam  
*Bk - 22 to 29 inches:* cobbly clay  
*Cr - 29 to 33 inches:* weathered bedrock

### Properties and qualities

*Slope:* 3 to 15 percent  
*Depth to restrictive feature:* 20 to 40 inches to paralithic bedrock  
*Natural drainage class:* Well drained  
*Runoff class:* Medium  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent  
*Gypsum, maximum in profile:* 5 percent  
*Salinity, maximum in profile:* Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 15.0  
*Available water storage in profile:* Low (about 4.7 inches)

### Interpretive groups

*Land capability classification (irrigated):* 6e  
*Land capability classification (nonirrigated):* 6e  
*Hydrologic Soil Group:* D  
*Ecological site:* Alkaline Plains LRU's A & B (R069XY047CO)  
*Other vegetative classification:* ALKALINE PLAINS (069AY047CO)  
*Hydric soil rating:* No

## Description of Midway

### Setting

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Slope alluvium over residuum weathered from shale

### Typical profile

*A - 0 to 4 inches:* clay loam  
*C - 4 to 13 inches:* clay  
*Cr - 13 to 17 inches:* weathered bedrock

### Properties and qualities

*Slope:* 3 to 25 percent  
*Depth to restrictive feature:* 6 to 20 inches to paralithic bedrock  
*Natural drainage class:* Well drained  
*Runoff class:* Medium  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent  
*Gypsum, maximum in profile:* 15 percent  
*Salinity, maximum in profile:* Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)

## Custom Soil Resource Report

*Sodium adsorption ratio, maximum in profile:* 15.0

*Available water storage in profile:* Very low (about 2.2 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 7e

*Hydrologic Soil Group:* D

*Ecological site:* Shaly Plains LRU's A & B (R069XY046CO)

*Other vegetative classification:* SHALY PLAINS (069AY045CO)

*Hydric soil rating:* No

### Minor Components

#### Other soils

*Percent of map unit:*

*Hydric soil rating:* No

#### Pleasant

*Percent of map unit:*

*Landform:* Depressions

*Hydric soil rating:* Yes

## MzA—Manzanola silty clay loam, saline, 0 to 2 percent slopes

### Map Unit Setting

*National map unit symbol:* 2rgrg

*Elevation:* 3,900 to 6,000 feet

*Mean annual precipitation:* 12 to 14 inches

*Mean annual air temperature:* 48 to 54 degrees F

*Frost-free period:* 130 to 170 days

*Farmland classification:* Not prime farmland

### Map Unit Composition

*Manzanola and similar soils:* 90 percent

*Minor components:* 10 percent

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

### Description of Manzanola

#### Setting

*Landform:* Terraces, drainageways, fan remnants, interfluves

*Landform position (two-dimensional):* Footslope, summit

*Landform position (three-dimensional):* Side slope, tread

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Alluvium derived from shale

#### Typical profile

*A - 0 to 4 inches:* silty clay loam

*Bt1 - 4 to 11 inches:* silty clay loam



## Custom Soil Resource Report

*Bt2 - 11 to 26 inches:* silty clay loam  
*Bk1 - 26 to 38 inches:* silty clay loam  
*Bk2 - 38 to 79 inches:* silty clay loam

### Properties and qualities

*Slope:* 0 to 2 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Well drained  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 14 percent  
*Gypsum, maximum in profile:* 3 percent  
*Salinity, maximum in profile:* Moderately saline (8.0 to 15.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 13.0  
*Available water storage in profile:* Very high (about 12.1 inches)

### Interpretive groups

*Land capability classification (irrigated):* 3e  
*Land capability classification (nonirrigated):* 4c  
*Hydrologic Soil Group:* C  
*Ecological site:* Saline Overflow LRU's A & B (R069XY037CO)  
*Other vegetative classification:* Saline Overflow (069XY037CO\_1)  
*Hydric soil rating:* No

### Minor Components

#### Haversid

*Percent of map unit:* 5 percent  
*Landform:* Drainageways, terraces  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Ecological site:* Saline Overflow LRU's A & B (R069XY037CO)  
*Hydric soil rating:* No

#### Aguilar

*Percent of map unit:* 5 percent  
*Landform:* Fan remnants  
*Landform position (two-dimensional):* Footslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Ecological site:* Salt Flat LRU's A & B (R069XY033CO)  
*Other vegetative classification:* Salt Flat #33 (069AY033CO\_2)  
*Hydric soil rating:* No

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## Custom Soil Resource Report

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***HYDROLOGIC CALCULATIONS***

Weighted Curve Number-Existing Conditions

SUB-BASIN	AREA (SF)	AREA (Acres)	PASTURE AREA (AC)	HSG C PERCENTAGE	HSG D PERCENTAGE	HSG C AREA	HSG D AREA	NEWLY GRADED AREA	HSG C PERCENTAGE	HSG D PERCENTAGE	HSG C AREA	HSG D AREA	GRAVEL ROAD AREA	HSG C PERCENTAGE	HSG D PERCENTAGE	HSG C AREA	HSG D AREA	WEIGHTED CN
W1	4,116,201	94.49	94	20%	80%	18.90	75.60	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67
W2	6,606,512	151.66	152	20%	80%	30.33	121.33	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67
W3	3,975,782	91.27	91	20%	80%	18.25	73.02	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67
W4	13,234,172	303.81	304	20%	80%	60.76	243.05	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67
E1	33,810,096	776.17	776	20%	80%	155.23	620.94	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67
E2	1,060,550	24.35	24	20%	80%	4.87	19.48	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67
E3	3,956,372	90.83	91	20%	80%	18.17	72.66	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67
TOTAL	62,643,484	1438.10	1,438	20%	80%	287.62	1150.48	0	20%	80%	0.00	0.00	0	20%	80%	0.00	0.00	67

Curve Numbers	Pre Development (ARC I)		Post Development (ARC II)	
	HSG C	HSG D	HSG C	HSG D
Pasture, grassland, rande -FAIR	61	69	79	84
Newly Graded Area (Pervious, no vegeation)			91	94
Gravel Streets			89	91

\*Curve Numbers are based on on Table 6-9 and Table 6-10 of the Colorado Springs DCM

Existing Runoff							
BASIN	BASIN AREA (ACRES)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 10- YR RUNOFF (CFS)	DIRECT 25- YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)	Time of Concentration (min)	Notes
W1	94.49	24.99	44.55	62.95	115.43	32.10	
W2	151.66	25.17	44.52	62.79	115.88	62.00	
W3	91.27	45.72	80.19	110.79	196.20	10.60	
W4	303.81	129.49	228.69	317.03	563.91	15.40	
E1	776.17	115.86	203.95	287.26	530.57	74.30	
E2	24.35	5.99	10.67	15.07	27.66	34.00	
E3	90.83	24.02	42.82	60.50	110.95	32.60	
TOTAL	1532.59	371.24	655.39	916.39	1660.60		

Weighted Curve Number-Proposed Conditions

SUB-BASIN	AREA (SF)	AREA (Acres)	PASTURE AREA (AC)	HSG C PERCENTAGE	HSG D PERCENTAGE	HSG C AREA	HSG D AREA	NEWLY GRADED AREA*	HSG C PERCENTAGE	HSG D PERCENTAGE	HSG C AREA	HSG D AREA	GRAVEL ROAD AREA	HSG C PERCENTAGE	HSG D PERCENTAGE	HSG C AREA	HSG D AREA	PAVED AREA	HSG C PERCENTAGE	HSG D PERCENTAGE	HSG C AREA	HSG D AREA	WEIGHTED CN
W1	4,116,201	94.49	92.91	20%	80%	18.58	74.33	0.00	20%	80%	0.00	0.00	1.58	0%	100%	0.00	1.58	0.00	0%	100%	0.00	0.00	68
W2	6,606,512	151.66	151.58	20%	80%	30.32	121.26	0.00	20%	80%	0.00	0.00	0.09	0%	100%	0.00	0.09	0.00	0%	100%	0.00	0.00	67
W3	3,975,782	91.27	90.91	20%	80%	18.18	72.73	0.00	20%	80%	0.00	0.00	0.36	0%	100%	0.00	0.36	0.00	0%	100%	0.00	0.00	67
W4	13,234,172	303.81	303.81	20%	80%	60.76	243.05	0.00	20%	80%	0.00	0.00	0.00	0%	100%	0.00	0.00	0.00	0%	100%	0.00	0.00	67
E1	22,142,797	508.33	483.58	20%	80%	96.72	386.86	22.20	20%	80%	4.44	17.76	2.43	0%	100%	0.00	2.43	0.12	0%	100%	0.00	0.12	69
E2	9,058,841	207.96	204.97	20%	80%	40.99	163.98	0.00	20%	80%	0.00	0.00	2.70	0%	100%	0.00	2.70	0.29	0%	100%	0.00	0.29	68
E3	1,060,549	24.35	24.35	20%	80%	4.87	19.48	0.00	20%	80%	0.00	0.00	0.00	0%	100%	0.00	0.00	0.00	0%	100%	0.00	0.00	67
E4	2,608,459	59.88	59.88	20%	80%	11.98	47.91	0.00	20%	80%	0.00	0.00	0.00	0%	100%	0.00	0.00	0.00	0%	100%	0.00	0.00	67
E5	3,956,372	90.83	89.14	20%	80%	17.83	71.31	0.00	20%	80%	0.00	0.00	0.84	0%	100%	0.00	0.84	0.84	0%	100%	0.00	0.84	67
TOTAL	56,078,653	1287.39																					

\*Newly Graded Area represnts the substation pads.

Curve Numbers	Pre Developement (ARC I)		Post Developement (ARC II)	
	HSG C	HSG D	HSG C	HSG D
Pasture, grassland, rande -FAIR	61	69	79	84
Newly Graded Area (Pervious, no vegetation)			91	94
Paved-Open Ditches			92	93
Gravel Streets			89	91

Curve Numbers are based on on Table 6-9 and Table 6-10 of the Colorado Springs DCM



Proposed Runoff							
BASIN	BASIN AREA (ACRES)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 10-YR RUNOFF (CFS)	DIRECT 25-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)	Time of Concentration (min)	Notes
W1	94.49	28.23	48.86	68.03	121.88	33.30	Check Dam increases TC
W2	151.66	25.17	44.51	62.78	115.86	62.00	
W3	91.27	45.72	80.19	110.79	196.20	11.50	Check Dam increases TC
W4	303.81	129.49	228.69	317.03	563.91	15.80	
E1	508.33	95.16	159.65	219.14	388.01	72.00	
E2	207.96	44.02	76.17	105.93	191.18	51.70	
E3	24.35	5.98	10.67	15.07	27.66	33.90	
E4	59.88	13.08	23.34	32.90	60.65	43.80	
E5	90.83	27.13	46.96	65.39	117.15	32.60	
TOTAL	1532.59	413.98	719.04	997.06	1782.50		

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

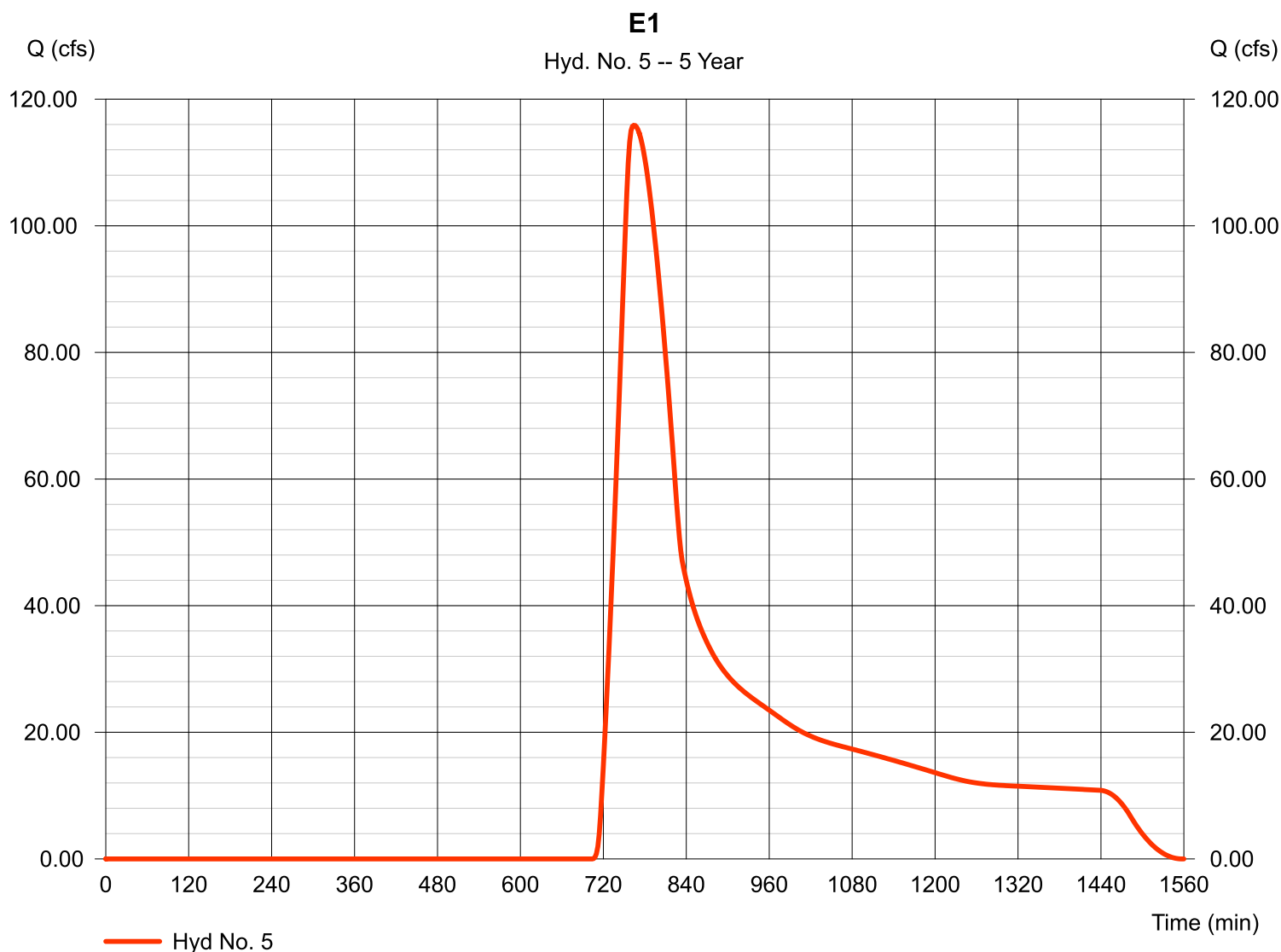
Tuesday, 12 / 18 / 2018

## Hyd. No. 5

E1

Hydrograph type	= SCS Runoff	Peak discharge	= 115.86 cfs
Storm frequency	= 5 yrs	Time to peak	= 764 min
Time interval	= 2 min	Hyd. volume	= 1,254,490 cuft
Drainage area	= 776.170 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 74.30 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(155.230 \times 61) + (620.940 \times 69)] / 776.170$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 5

E1

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 2.10	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 25.47</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 25.47</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 6410.00	0.00	0.00	
Watercourse slope (%)	= 2.10	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=2.34	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 45.69</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 45.69</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 1440.00	0.00	0.00	
Wetted perimeter (ft)	= 117.00	0.00	0.00	
Channel slope (%)	= 1.80	0.00	0.00	
Manning's n-value	= 0.030	0.015	0.015	
Velocity (ft/s)	=35.82	0.00	0.00	
Flow length (ft)	(\{0\})6640.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 3.09</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 3.09</b>
<b>Total Travel Time, Tc .....</b>				<b>74.30 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

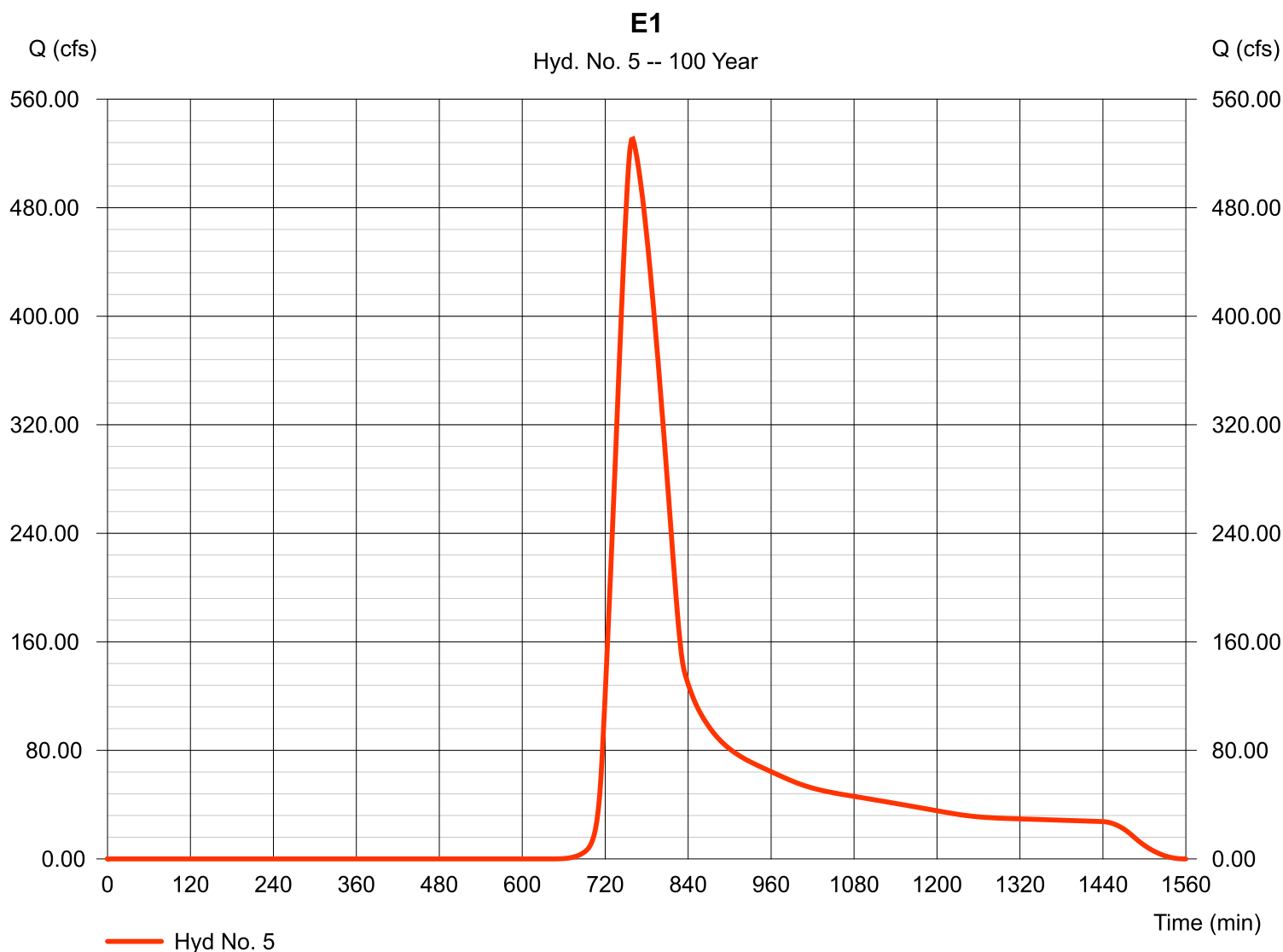
Tuesday, 12 / 18 / 2018

## Hyd. No. 5

E1

Hydrograph type	= SCS Runoff	Peak discharge	= 530.57 cfs
Storm frequency	= 100 yrs	Time to peak	= 760 min
Time interval	= 2 min	Hyd. volume	= 4,335,597 cuft
Drainage area	= 776.170 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 74.30 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = [(155.230 x 61) + (620.940 x 69)] / 776.170



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

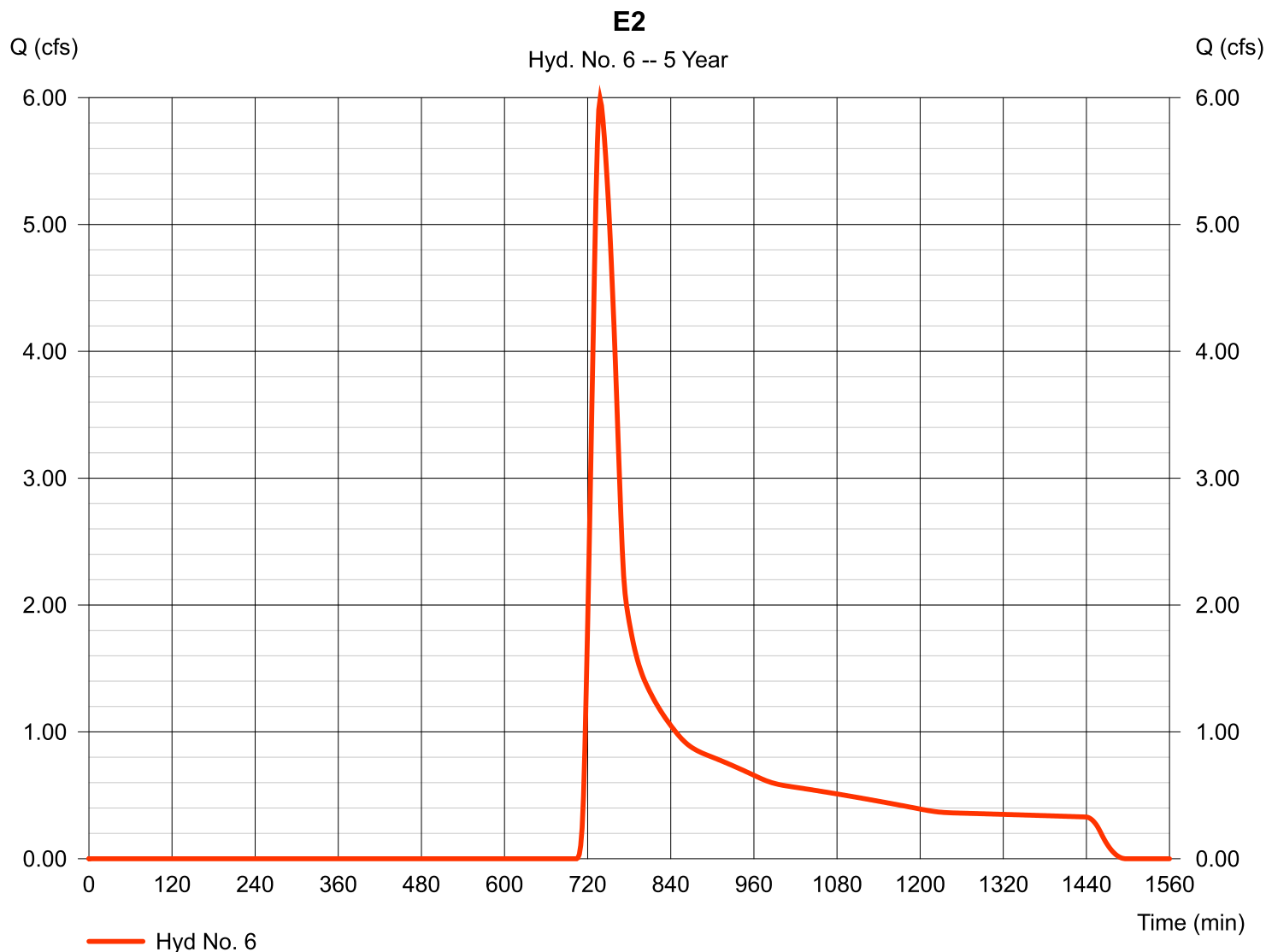
Tuesday, 12 / 18 / 2018

## Hyd. No. 6

E2

Hydrograph type	= SCS Runoff	Peak discharge	= 5.989 cfs
Storm frequency	= 5 yrs	Time to peak	= 738 min
Time interval	= 2 min	Hyd. volume	= 38,689 cuft
Drainage area	= 24.350 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 34.00 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(4.870 \times 61) + (19.480 \times 69)] / 24.350$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No. 6

E2

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 1.50	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 29.14</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 29.14</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 570.00	0.00	0.00	
Watercourse slope (%)	= 1.50	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=1.98	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 4.81</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 4.81</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 0.00	0.00	0.00	
Wetted perimeter (ft)	= 0.00	0.00	0.00	
Channel slope (%)	= 0.00	0.00	0.00	
Manning's n-value	= 0.015	0.015	0.015	
Velocity (ft/s)	=0.00	0.00	0.00	
Flow length (ft)	(0)0.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>34.00 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

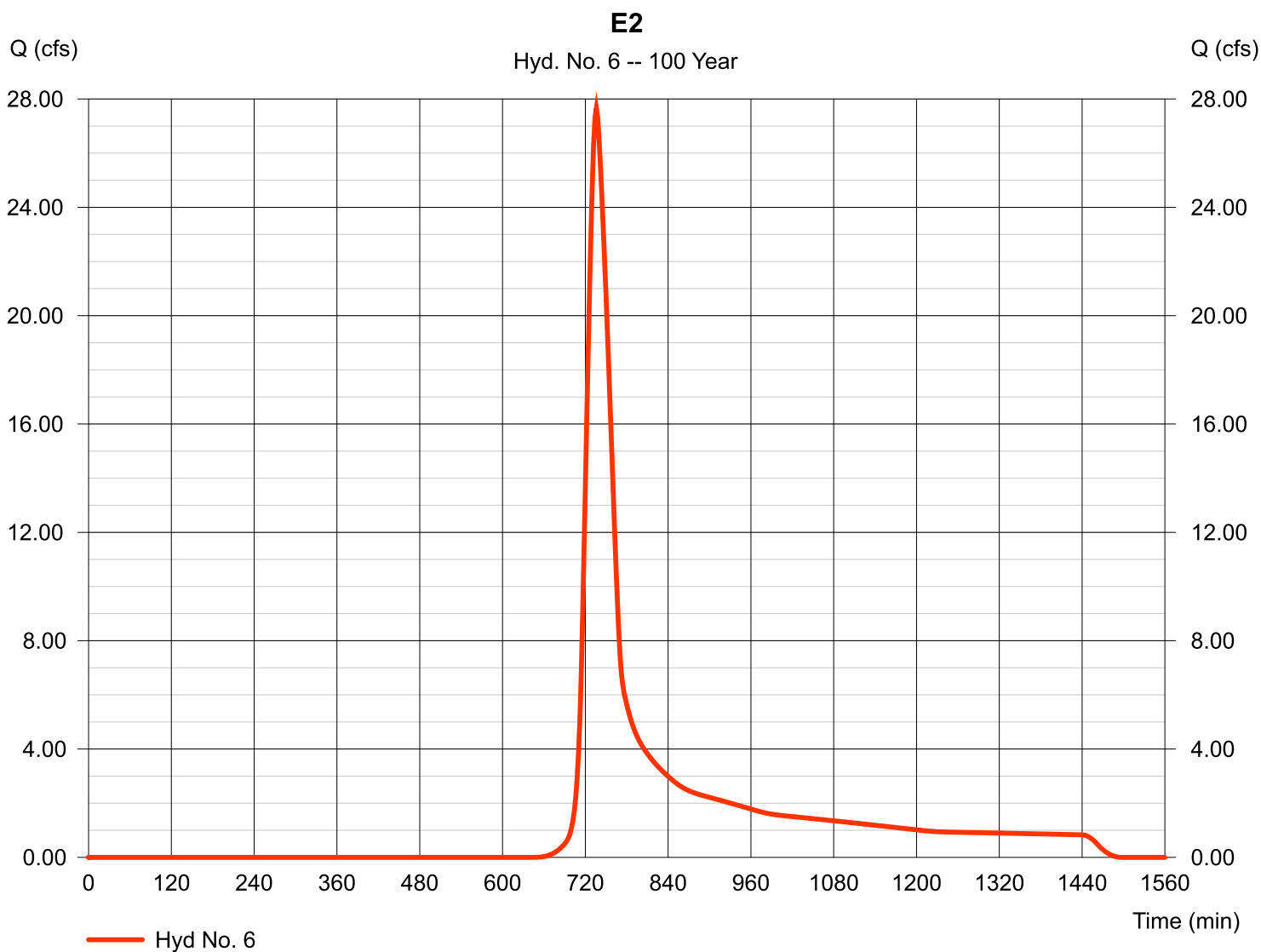
Tuesday, 12 / 18 / 2018

## Hyd. No. 6

E2

Hydrograph type	= SCS Runoff	Peak discharge	= 27.66 cfs
Storm frequency	= 100 yrs	Time to peak	= 736 min
Time interval	= 2 min	Hyd. volume	= 133,711 cuft
Drainage area	= 24.350 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 34.00 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(4.870 \times 61) + (19.480 \times 69)] / 24.350$





# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

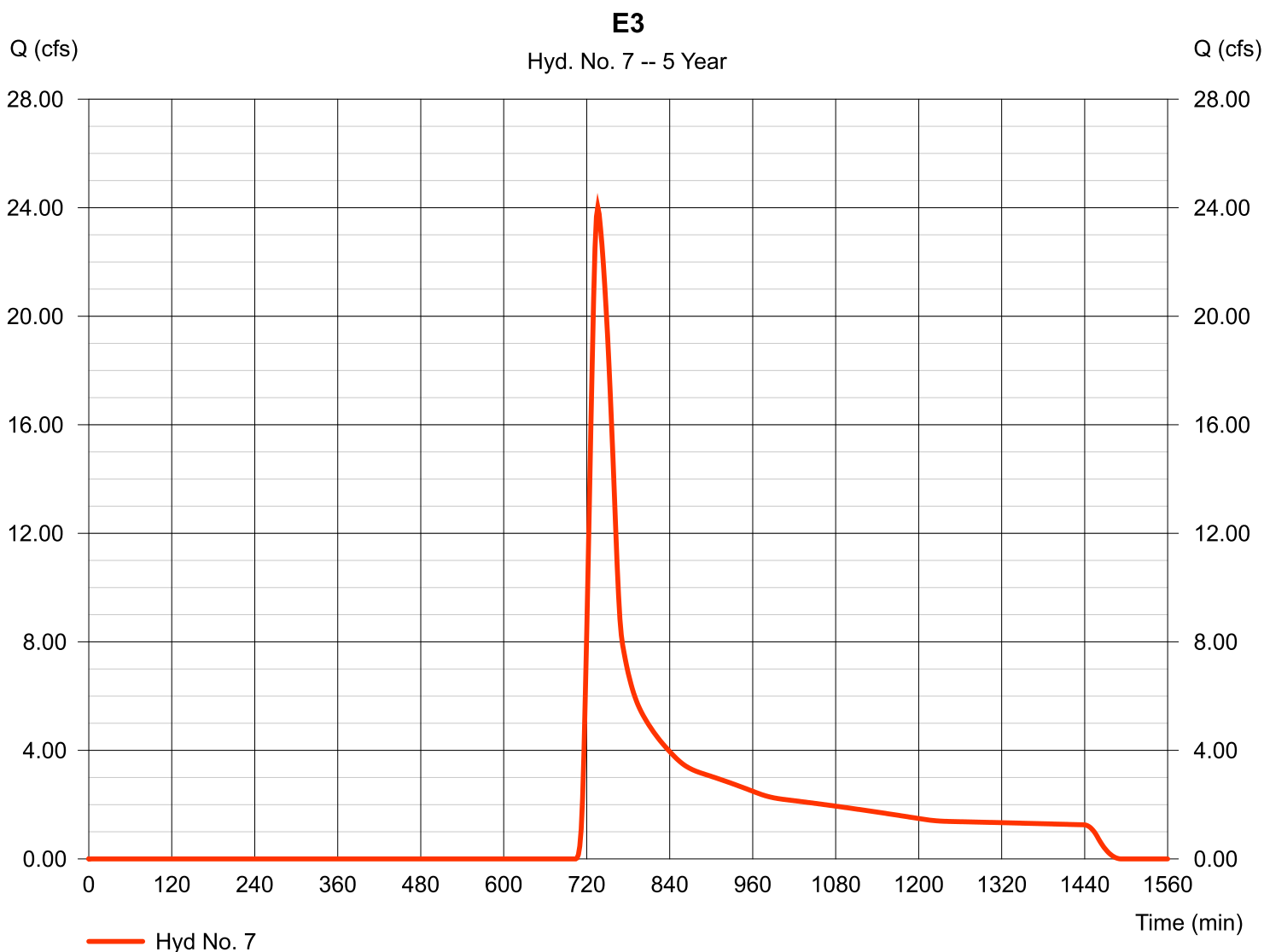
Tuesday, 12 / 18 / 2018

## Hyd. No. 7

E3

Hydrograph type	= SCS Runoff	Peak discharge	= 24.02 cfs
Storm frequency	= 5 yrs	Time to peak	= 736 min
Time interval	= 2 min	Hyd. volume	= 147,800 cuft
Drainage area	= 90.830 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 32.60 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.170 \times 61) + (72.660 \times 69)] / 90.830$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 7

E3

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>			
<b>Sheet Flow</b>							
Manning's n-value	= 0.130	0.011	0.011				
Flow length (ft)	= 300.0	0.0	0.0				
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00				
Land slope (%)	= 2.50	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 23.76</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>23.76</b>
<b>Shallow Concentrated Flow</b>							
Flow length (ft)	= 1350.00	0.00	0.00				
Watercourse slope (%)	= 2.50	0.00	0.00				
Surface description	= Unpaved	Paved	Paved				
Average velocity (ft/s)	=2.55	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 8.82</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>8.82</b>
<b>Channel Flow</b>							
X sectional flow area (sqft)	= 0.00	0.00	0.00				
Wetted perimeter (ft)	= 0.00	0.00	0.00				
Channel slope (%)	= 0.00	0.00	0.00				
Manning's n-value	= 0.015	0.015	0.015				
Velocity (ft/s)	=0.00	0.00	0.00				
Flow length (ft)	((0})0.0	0.0	0.0				
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>32.60 min</b>			

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

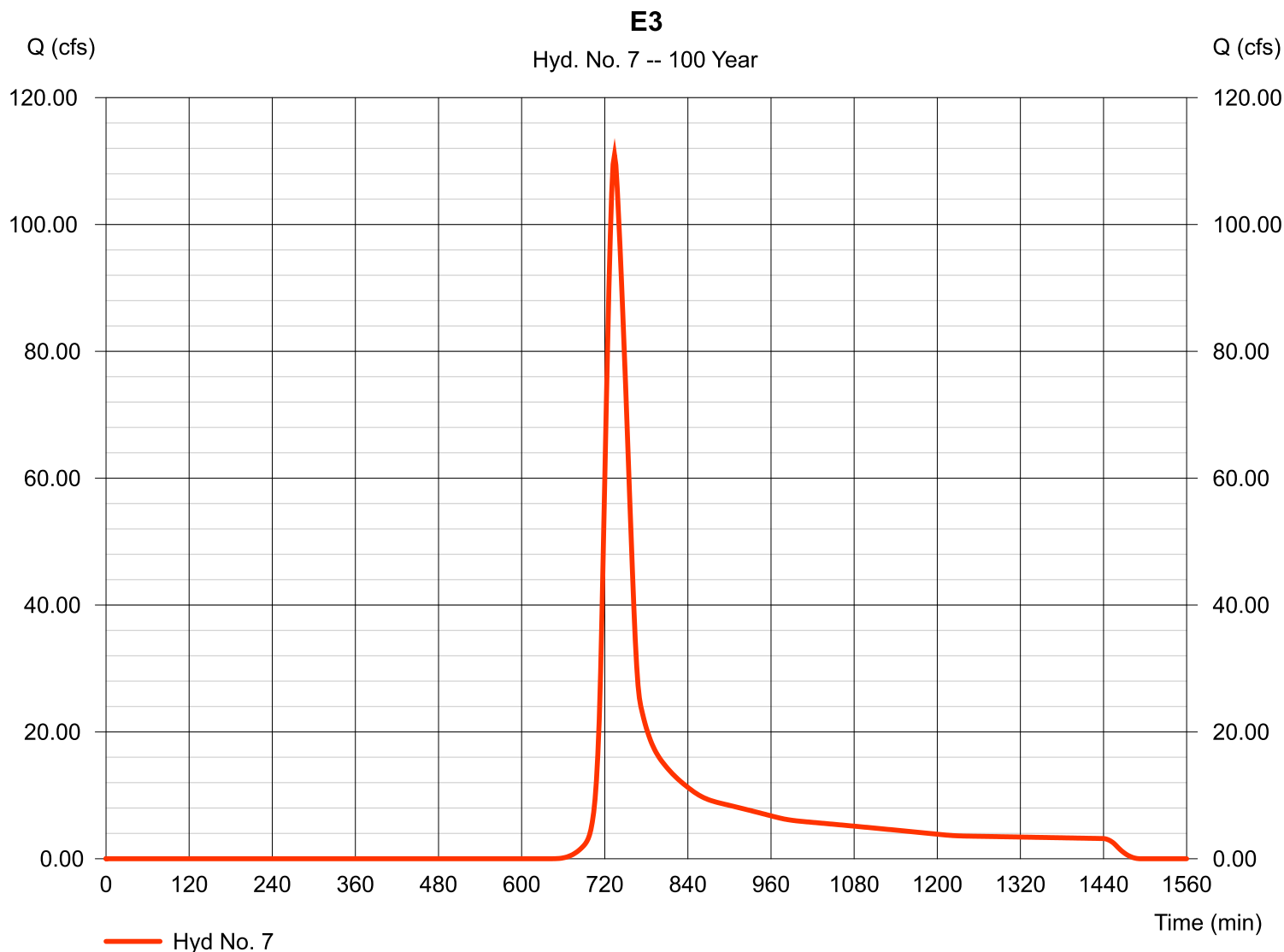
Tuesday, 12 / 18 / 2018

## Hyd. No. 7

E3

Hydrograph type	= SCS Runoff	Peak discharge	= 110.95 cfs
Storm frequency	= 100 yrs	Time to peak	= 734 min
Time interval	= 2 min	Hyd. volume	= 510,806 cuft
Drainage area	= 90.830 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 32.60 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.170 \times 61) + (72.660 \times 69)] / 90.830$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

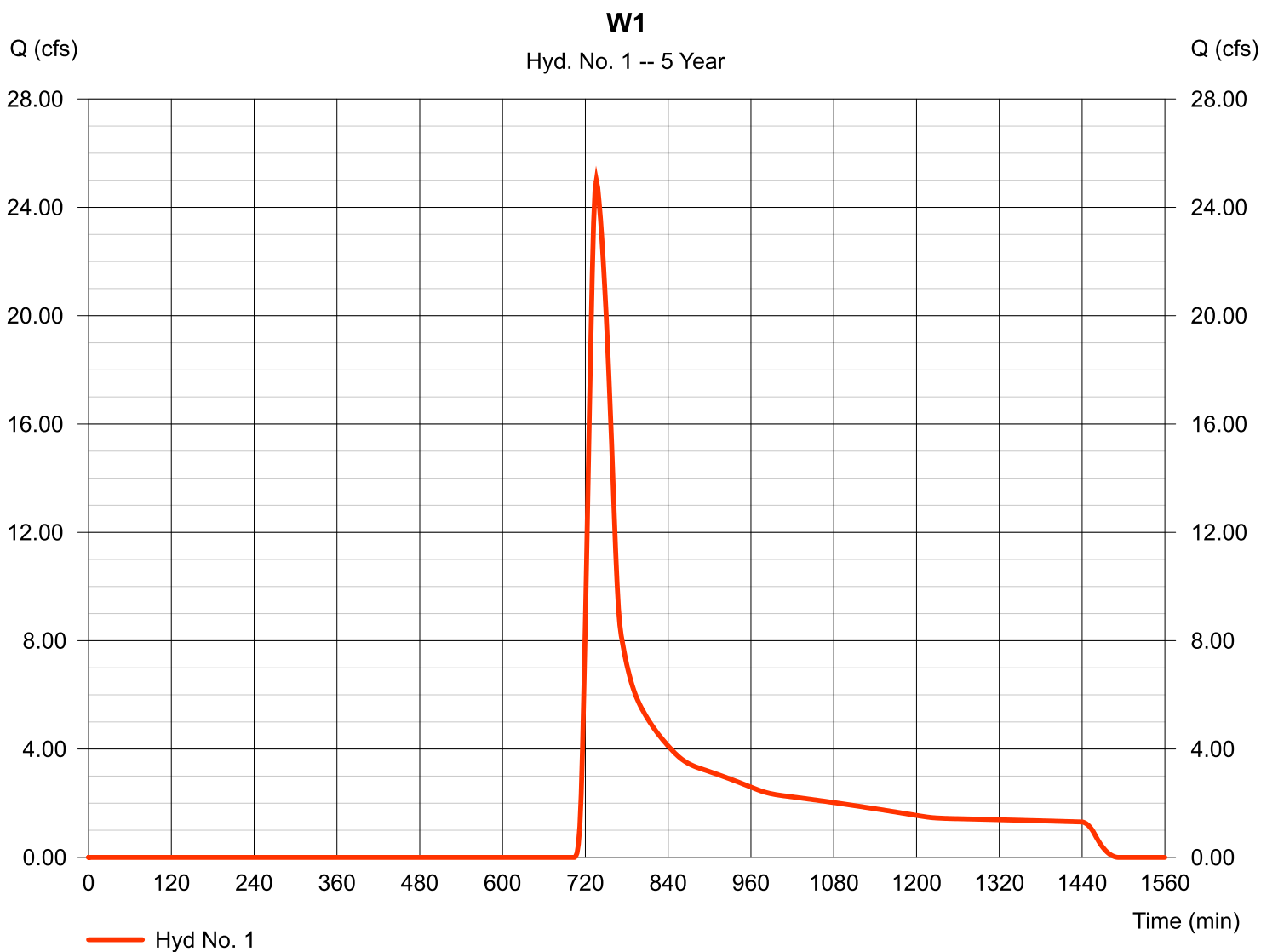
Tuesday, 12 / 18 / 2018

## Hyd. No. 1

W1

Hydrograph type	= SCS Runoff	Peak discharge	= 24.99 cfs
Storm frequency	= 5 yrs	Time to peak	= 736 min
Time interval	= 2 min	Hyd. volume	= 153,772 cuft
Drainage area	= 94.500 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 32.10 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.900 \times 61) + (75.600 \times 69)] / 94.500$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 1

W1

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 2.30	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 24.56</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 24.56</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 1100.00	0.00	0.00	
Watercourse slope (%)	= 2.30	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=2.45	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 7.49</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 7.49</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 0.00	0.00	0.00	
Wetted perimeter (ft)	= 0.00	0.00	0.00	
Channel slope (%)	= 0.00	0.00	0.00	
Manning's n-value	= 0.025	0.015	0.015	
Velocity (ft/s)	=0.00	0.00	0.00	
Flow length (ft)	(0)0.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>32.10 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

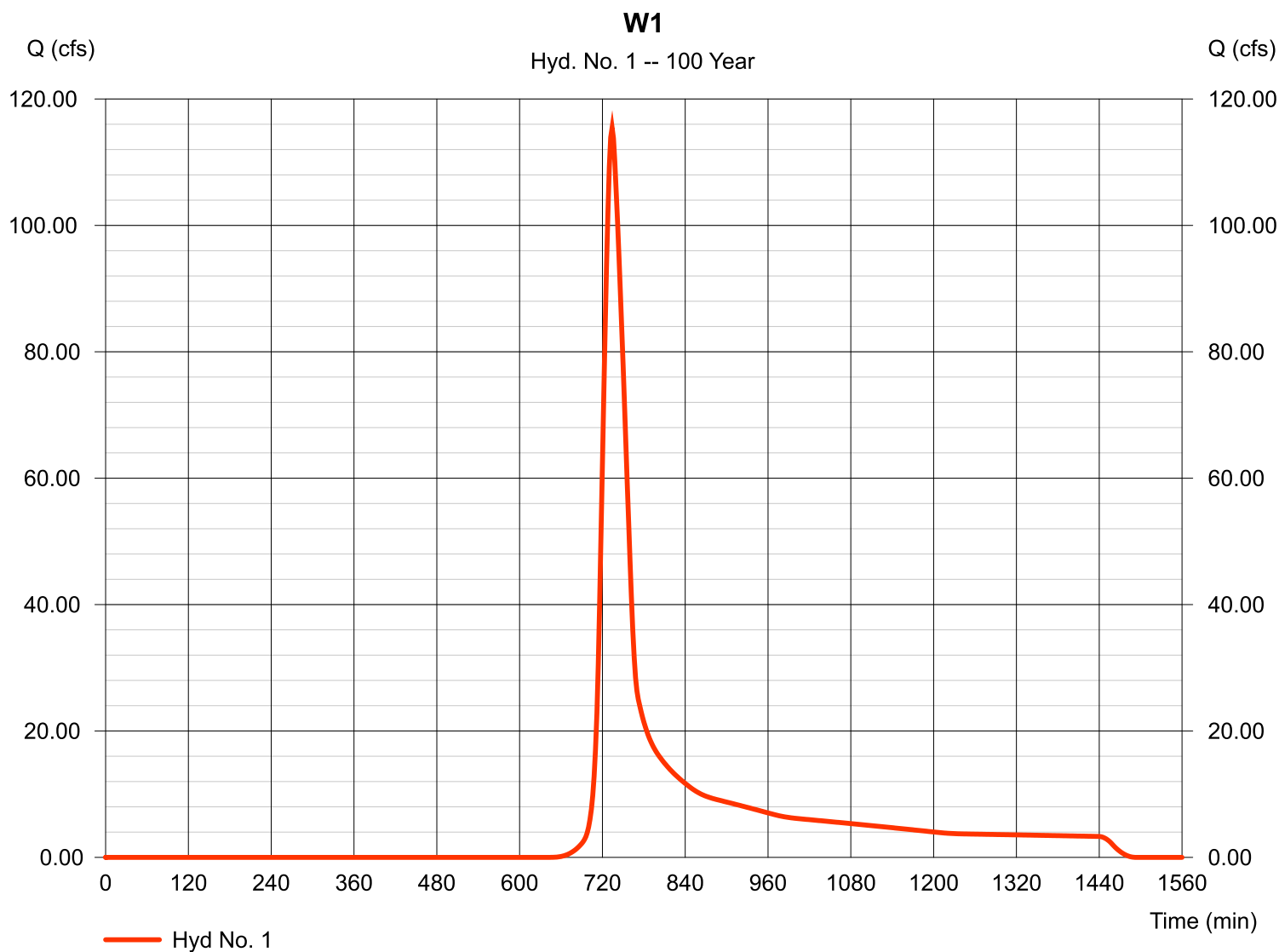
Tuesday, 12 / 18 / 2018

## Hyd. No. 1

W1

Hydrograph type	= SCS Runoff	Peak discharge	= 115.43 cfs
Storm frequency	= 100 yrs	Time to peak	= 734 min
Time interval	= 2 min	Hyd. volume	= 531,444 cuft
Drainage area	= 94.500 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 32.10 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.900 \times 61) + (75.600 \times 69)] / 94.500$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

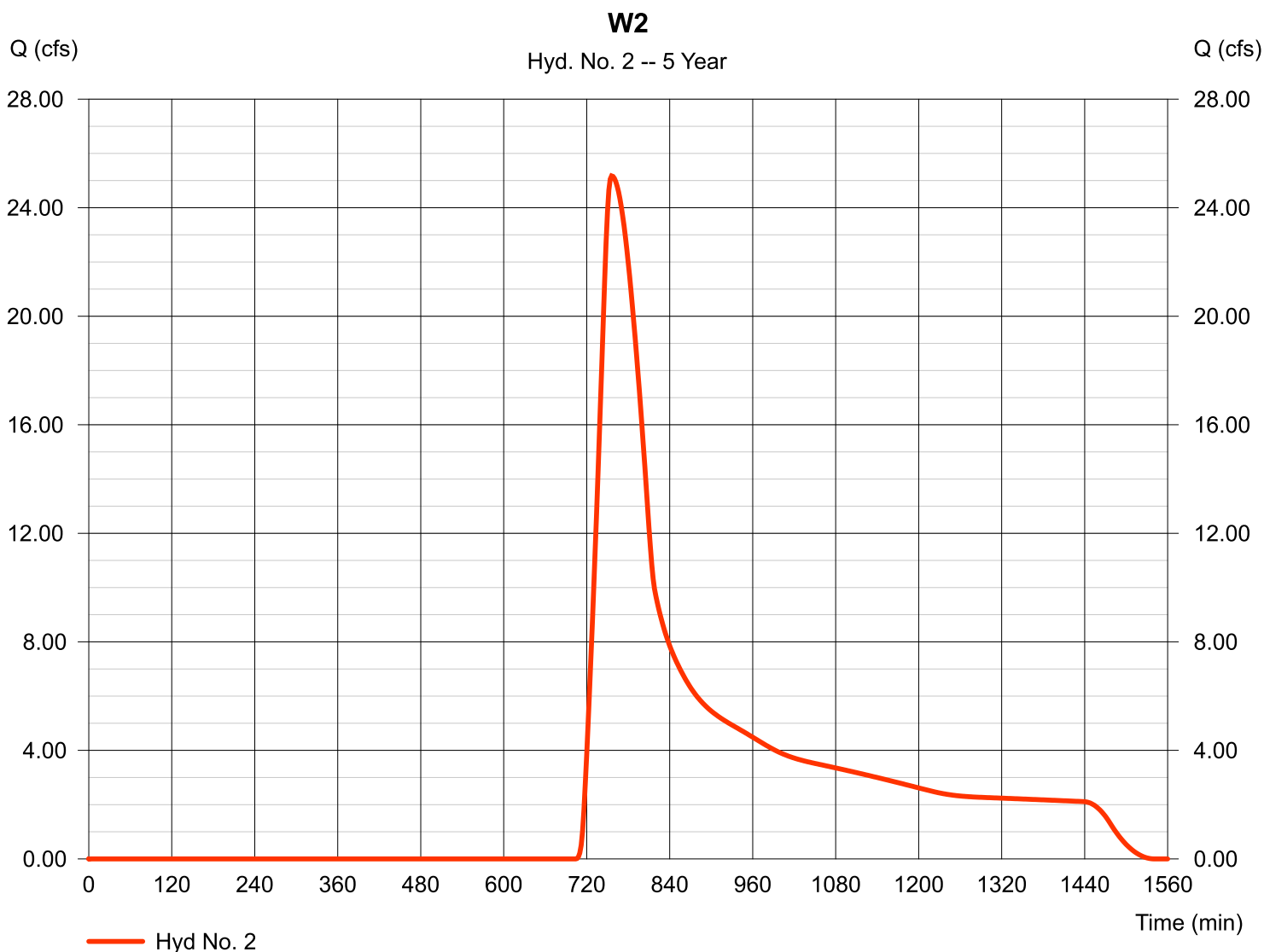
Tuesday, 12 / 18 / 2018

## Hyd. No. 2

W2

Hydrograph type	= SCS Runoff	Peak discharge	= 25.17 cfs
Storm frequency	= 5 yrs	Time to peak	= 756 min
Time interval	= 2 min	Hyd. volume	= 245,405 cuft
Drainage area	= 151.700 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 62.00 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(30.300 \times 61) + (121.400 \times 69)] / 151.700$





# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 2

W2

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 2.00	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 25.98</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 25.98</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 3485.00	0.00	0.00	
Watercourse slope (%)	= 1.00	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=1.61	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 36.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 36.00</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 0.00	0.00	0.00	
Wetted perimeter (ft)	= 0.00	0.00	0.00	
Channel slope (%)	= 0.00	0.00	0.00	
Manning's n-value	= 0.015	0.015	0.015	
Velocity (ft/s)	=0.00	0.00	0.00	
Flow length (ft)	(0)0.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>62.00 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

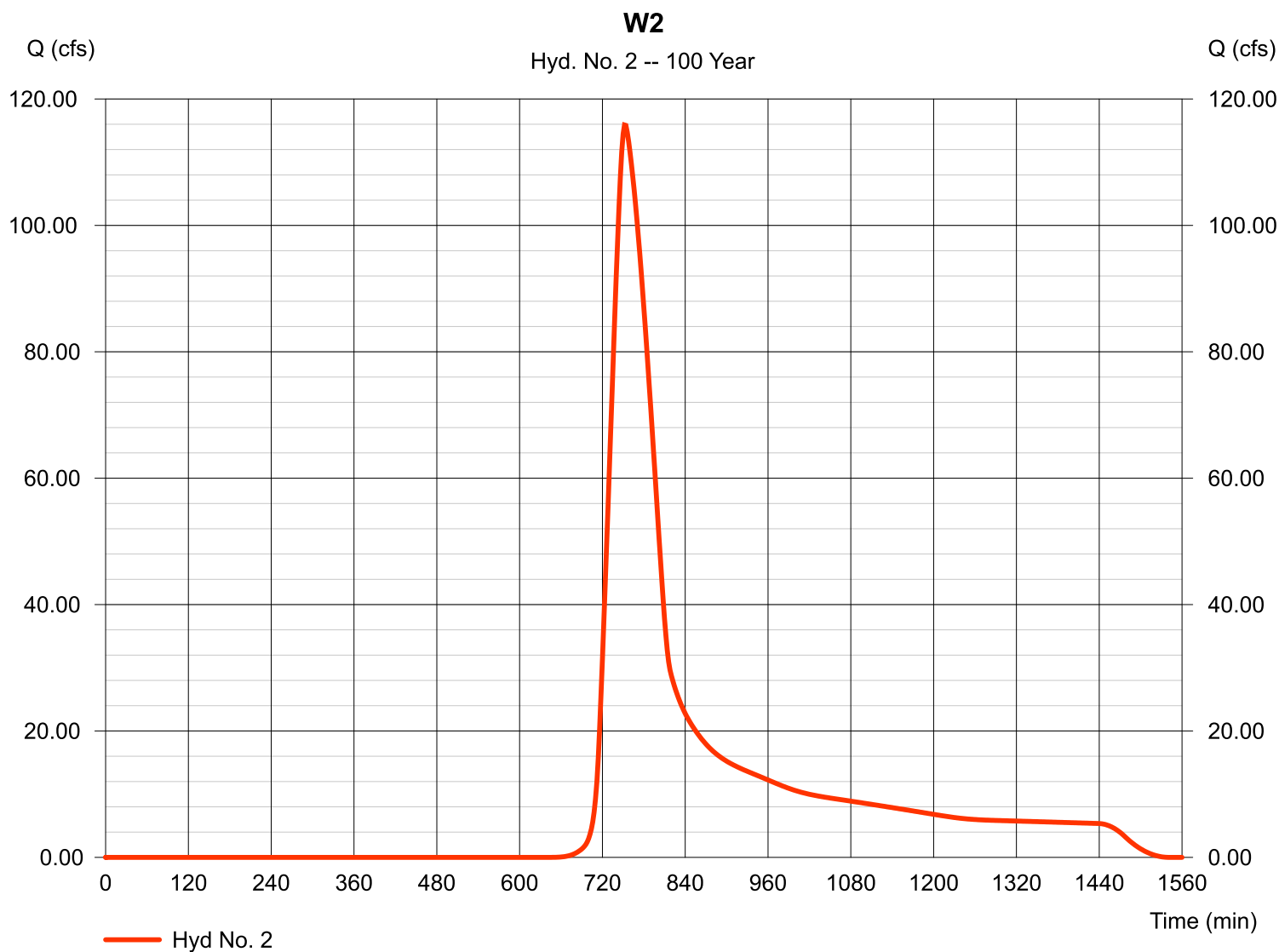
Tuesday, 12 / 18 / 2018

## Hyd. No. 2

W2

Hydrograph type	= SCS Runoff	Peak discharge	= 115.88 cfs
Storm frequency	= 100 yrs	Time to peak	= 752 min
Time interval	= 2 min	Hyd. volume	= 848,135 cuft
Drainage area	= 151.700 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 62.00 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(30.300 \times 61) + (121.400 \times 69)] / 151.700$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

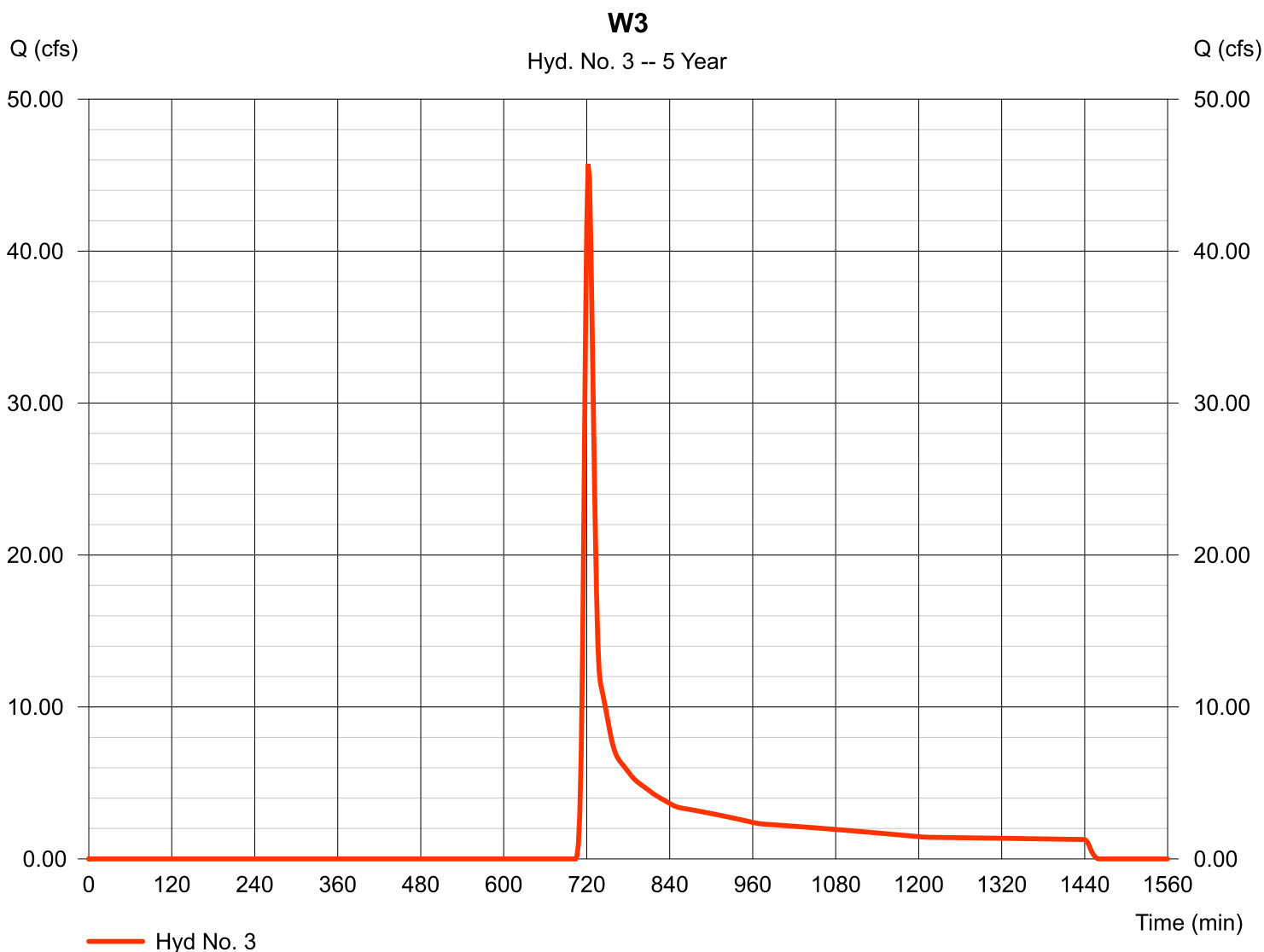
Tuesday, 12 / 18 / 2018

## Hyd. No. 3

W3

Hydrograph type	= SCS Runoff	Peak discharge	= 45.72 cfs
Storm frequency	= 5 yrs	Time to peak	= 722 min
Time interval	= 2 min	Hyd. volume	= 151,266 cuft
Drainage area	= 91.270 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.250 \times 61) + (73.020 \times 69)] / 91.270$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 3

W3

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>			
<b>Sheet Flow</b>							
Manning's n-value	= 0.013	0.011	0.011				
Flow length (ft)	= 300.0	0.0	0.0				
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00				
Land slope (%)	= 4.60	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 2.95</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>2.95</b>
<b>Shallow Concentrated Flow</b>							
Flow length (ft)	= 1585.00	0.00	0.00				
Watercourse slope (%)	= 4.60	0.00	0.00				
Surface description	= Unpaved	Paved	Paved				
Average velocity (ft/s)	=3.46	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 7.63</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>7.63</b>
<b>Channel Flow</b>							
X sectional flow area (sqft)	= 0.00	0.00	0.00				
Wetted perimeter (ft)	= 0.00	0.00	0.00				
Channel slope (%)	= 0.00	0.00	0.00				
Manning's n-value	= 0.015	0.015	0.015				
Velocity (ft/s)	=0.00	0.00	0.00				
Flow length (ft)	(0)0.0	0.0	0.0				
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>10.60 min</b>			

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

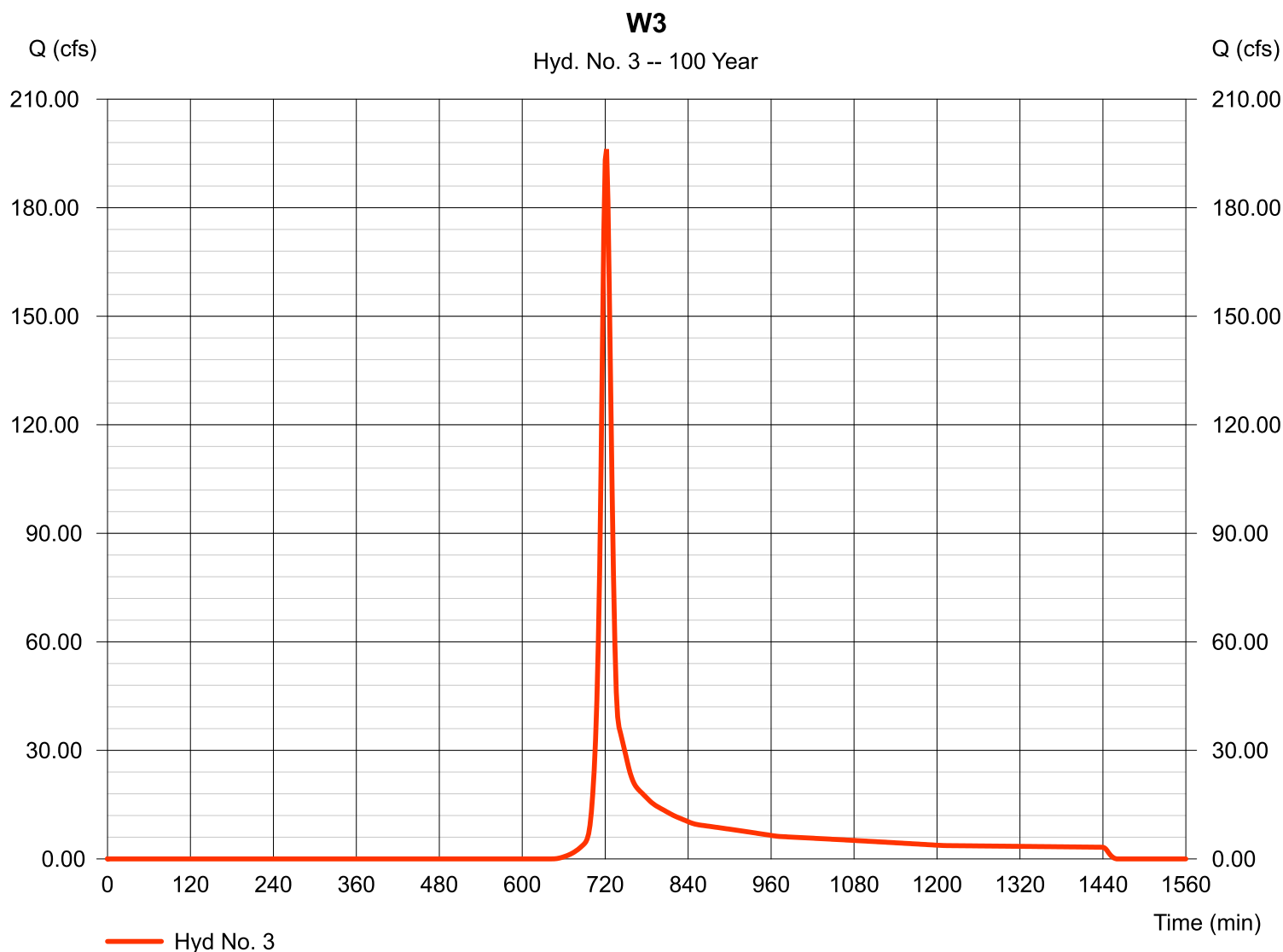
Tuesday, 12 / 18 / 2018

## Hyd. No. 3

W3

Hydrograph type	= SCS Runoff	Peak discharge	= 196.20 cfs
Storm frequency	= 100 yrs	Time to peak	= 722 min
Time interval	= 2 min	Hyd. volume	= 522,786 cuft
Drainage area	= 91.270 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.250 \times 61) + (73.020 \times 69)] / 91.270$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

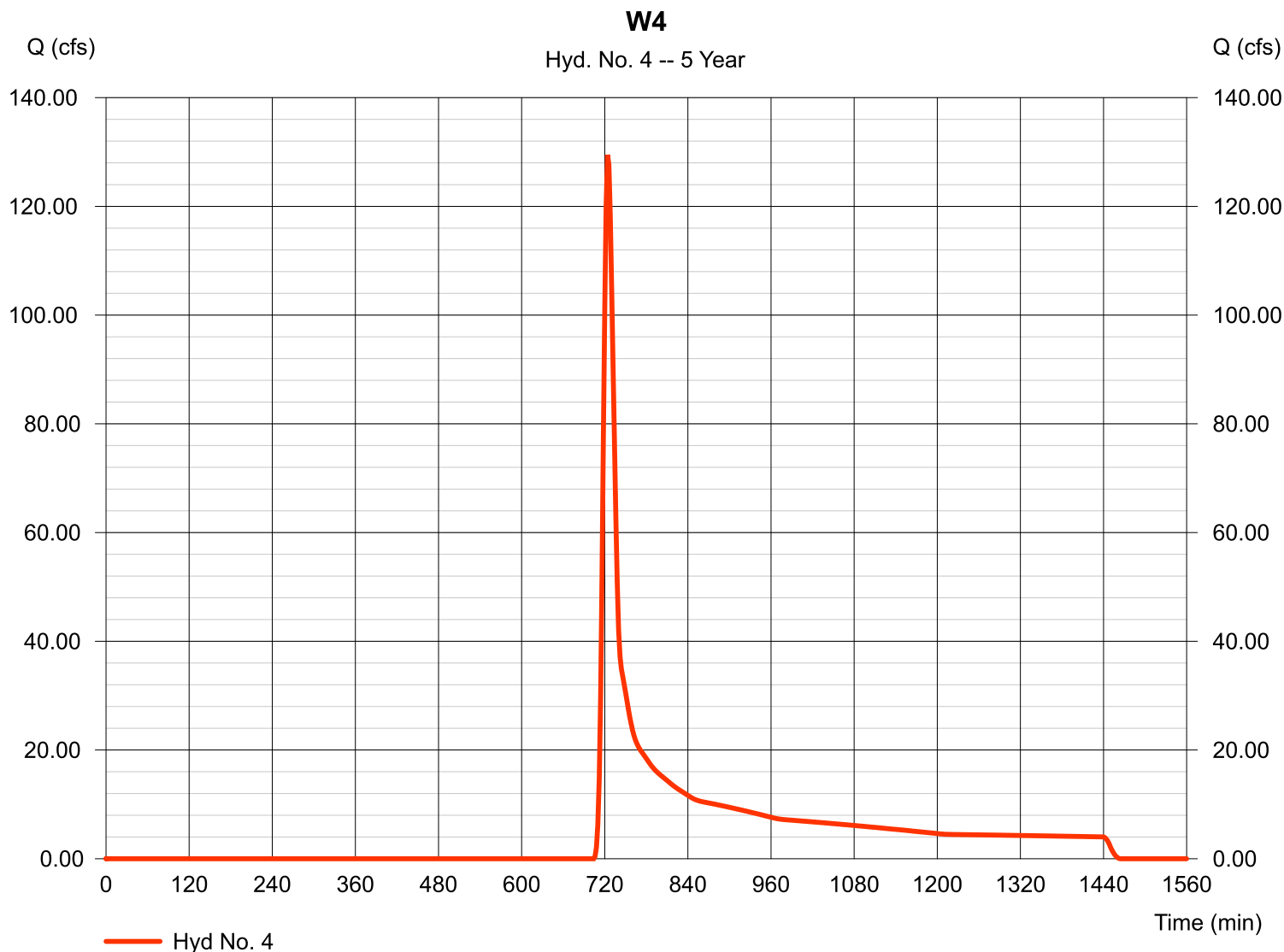
Tuesday, 12 / 18 / 2018

## Hyd. No. 4

W4

Hydrograph type	= SCS Runoff	Peak discharge	= 129.49 cfs
Storm frequency	= 5 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 476,054 cuft
Drainage area	= 303.810 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.40 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(60.760 \times 61) + (243.050 \times 69)] / 303.810$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 4

W4

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>			
<b>Sheet Flow</b>							
Manning's n-value	= 0.011	0.011	0.011				
Flow length (ft)	= 300.0	0.0	0.0				
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00				
Land slope (%)	= 3.90	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 2.76</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>2.76</b>
<b>Shallow Concentrated Flow</b>							
Flow length (ft)	= 2400.00	0.00	0.00				
Watercourse slope (%)	= 3.90	0.00	0.00				
Surface description	= Unpaved	Paved	Paved				
Average velocity (ft/s)	=3.19	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 12.55</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>12.55</b>
<b>Channel Flow</b>							
X sectional flow area (sqft)	= 874500.00	0.00	0.00				
Wetted perimeter (ft)	= 1275.00	0.00	0.00				
Channel slope (%)	= 1.00	0.00	0.00				
Manning's n-value	= 0.030	0.015	0.015				
Velocity (ft/s)	=394.78	0.00	0.00				
Flow length (ft)	(0)2700.0	0.0	0.0				
<b>Travel Time (min)</b>	<b>= 0.11</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>0.11</b>
<b>Total Travel Time, Tc .....</b>					<b>15.40 min</b>		



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

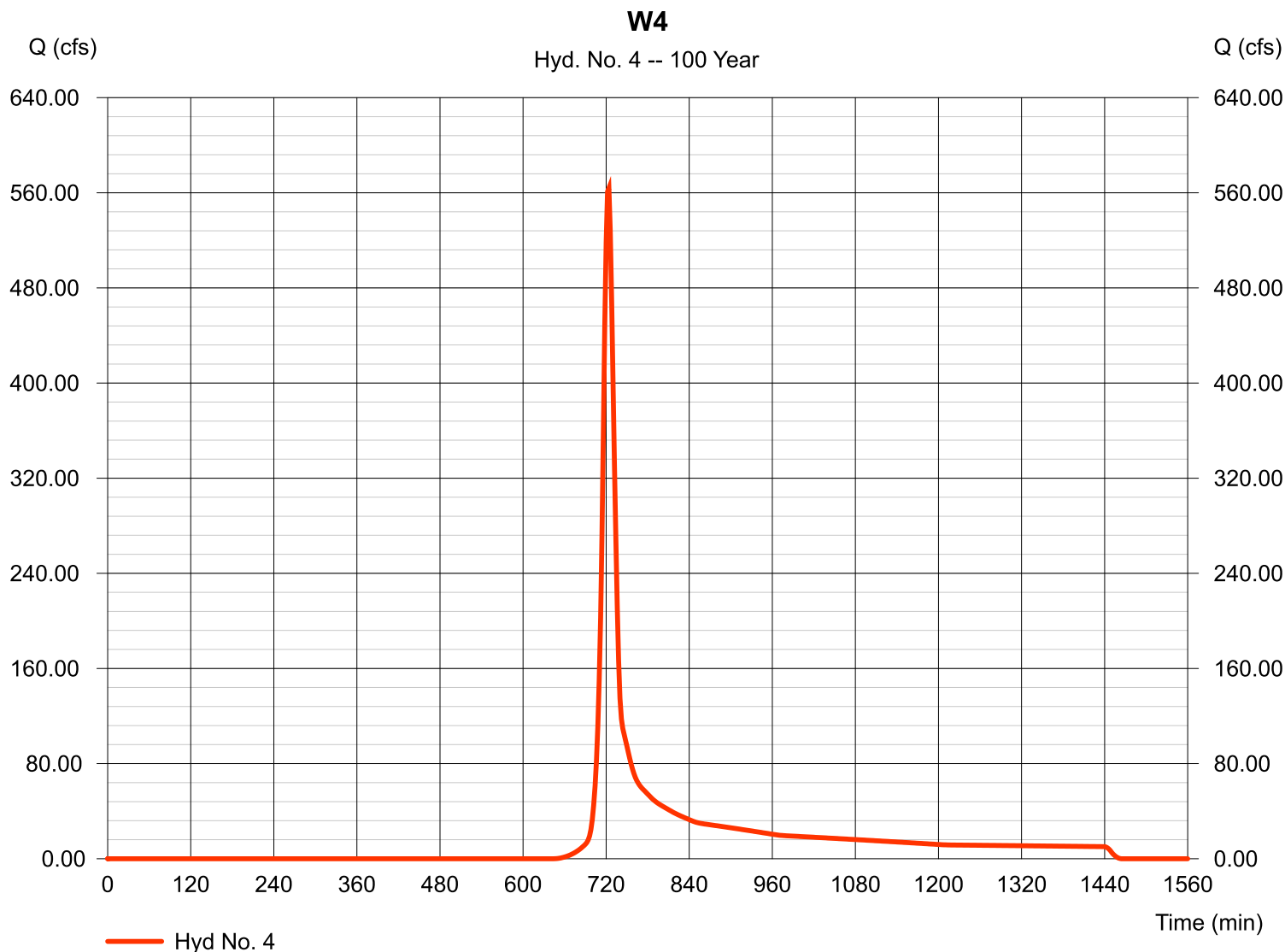
Tuesday, 12 / 18 / 2018

## Hyd. No. 4

W4

Hydrograph type	= SCS Runoff	Peak discharge	= 563.91 cfs
Storm frequency	= 100 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 1,645,272 cuft
Drainage area	= 303.810 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.40 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(60.760 \times 61) + (243.050 \times 69)] / 303.810$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

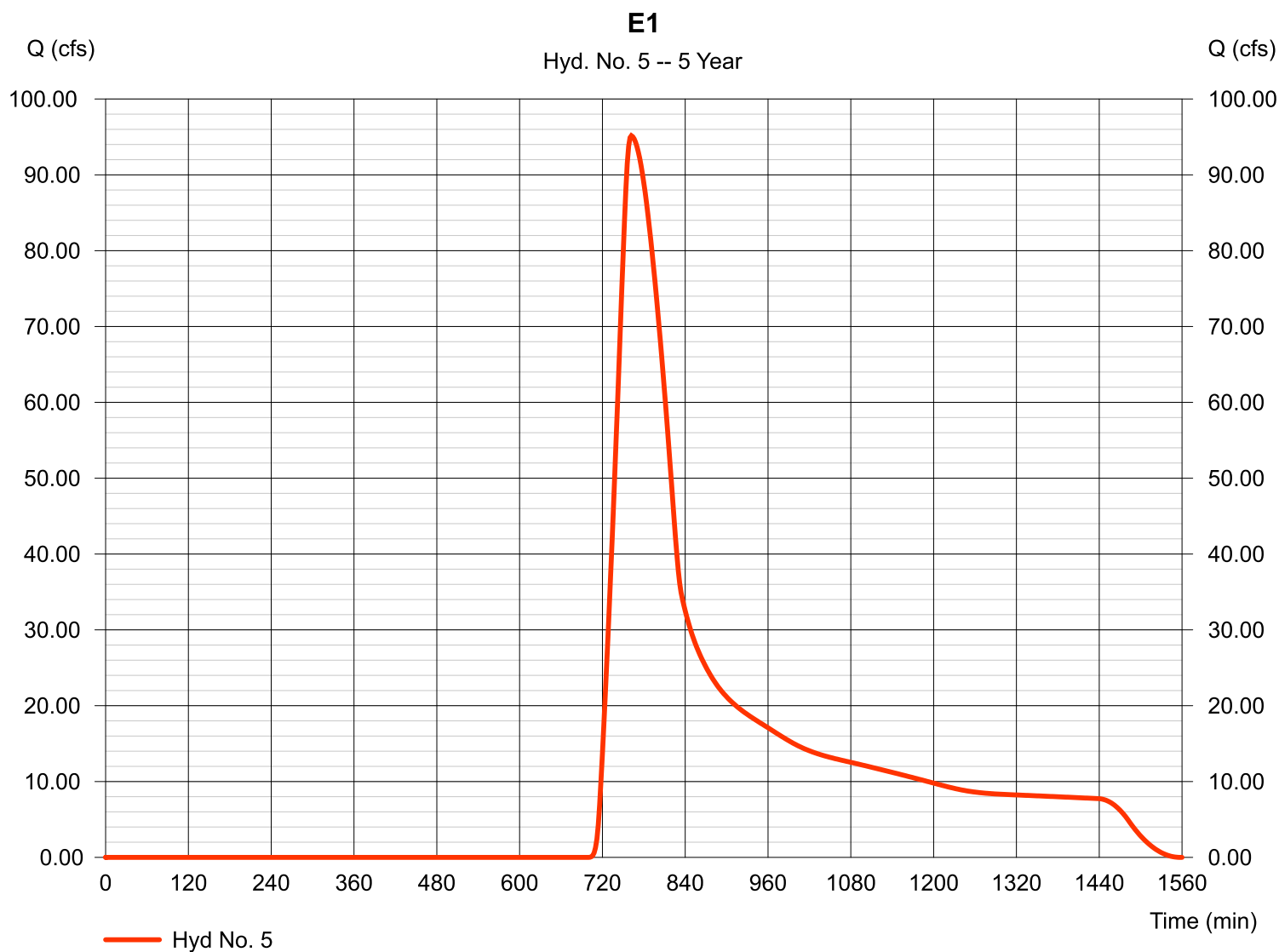
Wednesday, 01 / 16 / 2019

## Hyd. No. 5

E1

Hydrograph type	= SCS Runoff	Peak discharge	= 95.16 cfs
Storm frequency	= 5 yrs	Time to peak	= 762 min
Time interval	= 2 min	Hyd. volume	= 956,761 cuft
Drainage area	= 508.330 ac	Curve number	= 69*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 72.00 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $+(22.320 \times 94) + (2.430 \times 91) + (96.720 \times 61) + (386.860 \times 69) / 508.330$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 5

E1

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 2.10	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 25.47</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 25.47</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 6410.00	0.00	0.00	
Watercourse slope (%)	= 2.10	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=2.34	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 45.69</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 45.69</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 1440.00	0.00	0.00	
Wetted perimeter (ft)	= 117.00	0.00	0.00	
Channel slope (%)	= 1.80	0.00	0.00	
Manning's n-value	= 0.030	0.015	0.015	
Velocity (ft/s)	=35.82	0.00	0.00	
Flow length (ft)	(\{0\})1745.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.81</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 0.81</b>
<b>Total Travel Time, Tc .....</b>				<b>72.00 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

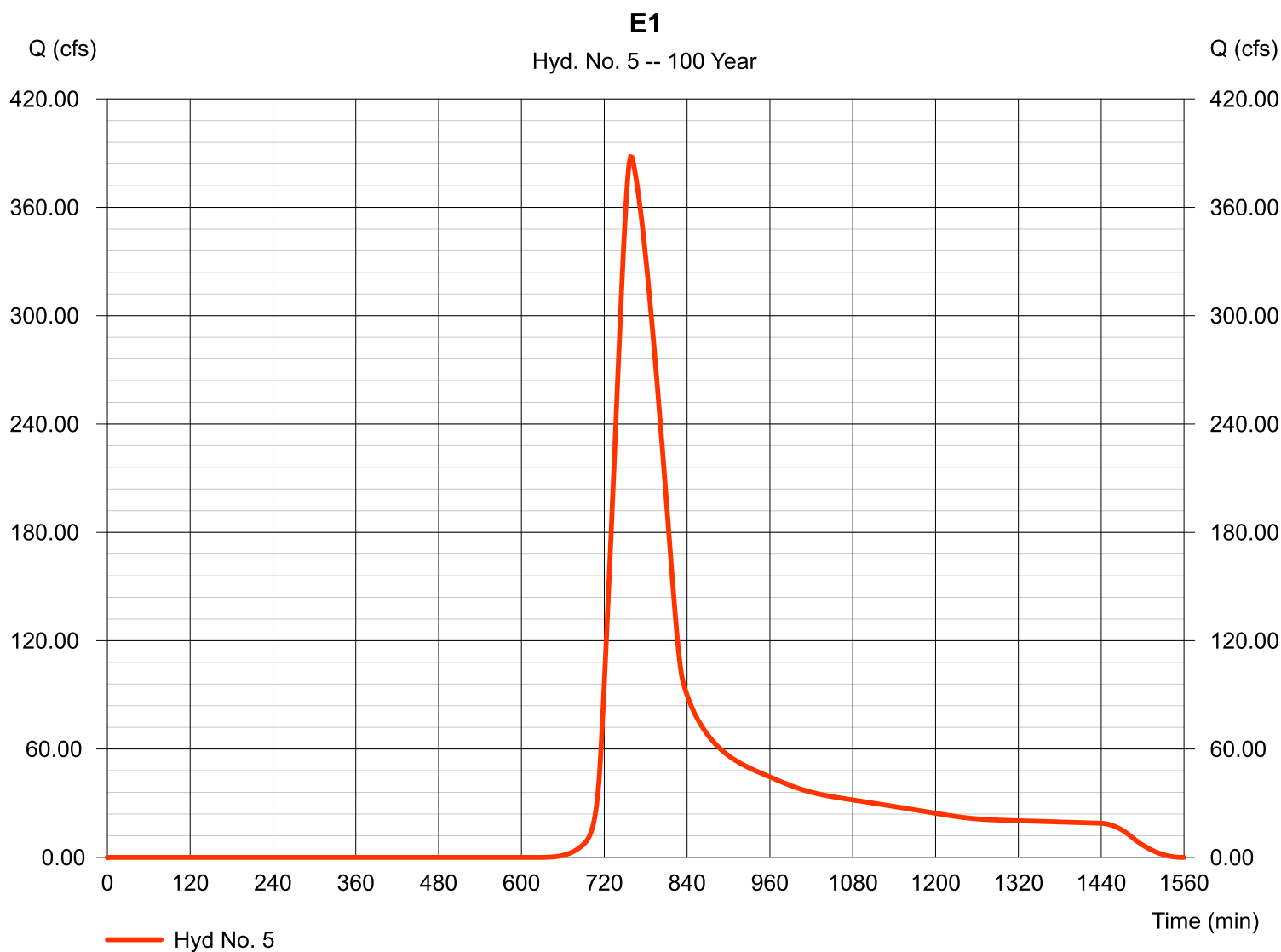
Wednesday, 01 / 16 / 2019

## Hyd. No. 5

E1

Hydrograph type	= SCS Runoff	Peak discharge	= 388.01 cfs
Storm frequency	= 100 yrs	Time to peak	= 758 min
Time interval	= 2 min	Hyd. volume	= 3,102,772 cuft
Drainage area	= 508.330 ac	Curve number	= 69*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 72.00 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = + (22.320 x 94) + (2.430 x 91) + (96.720 x 61) + (386.860 x 69)] / 508.330



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

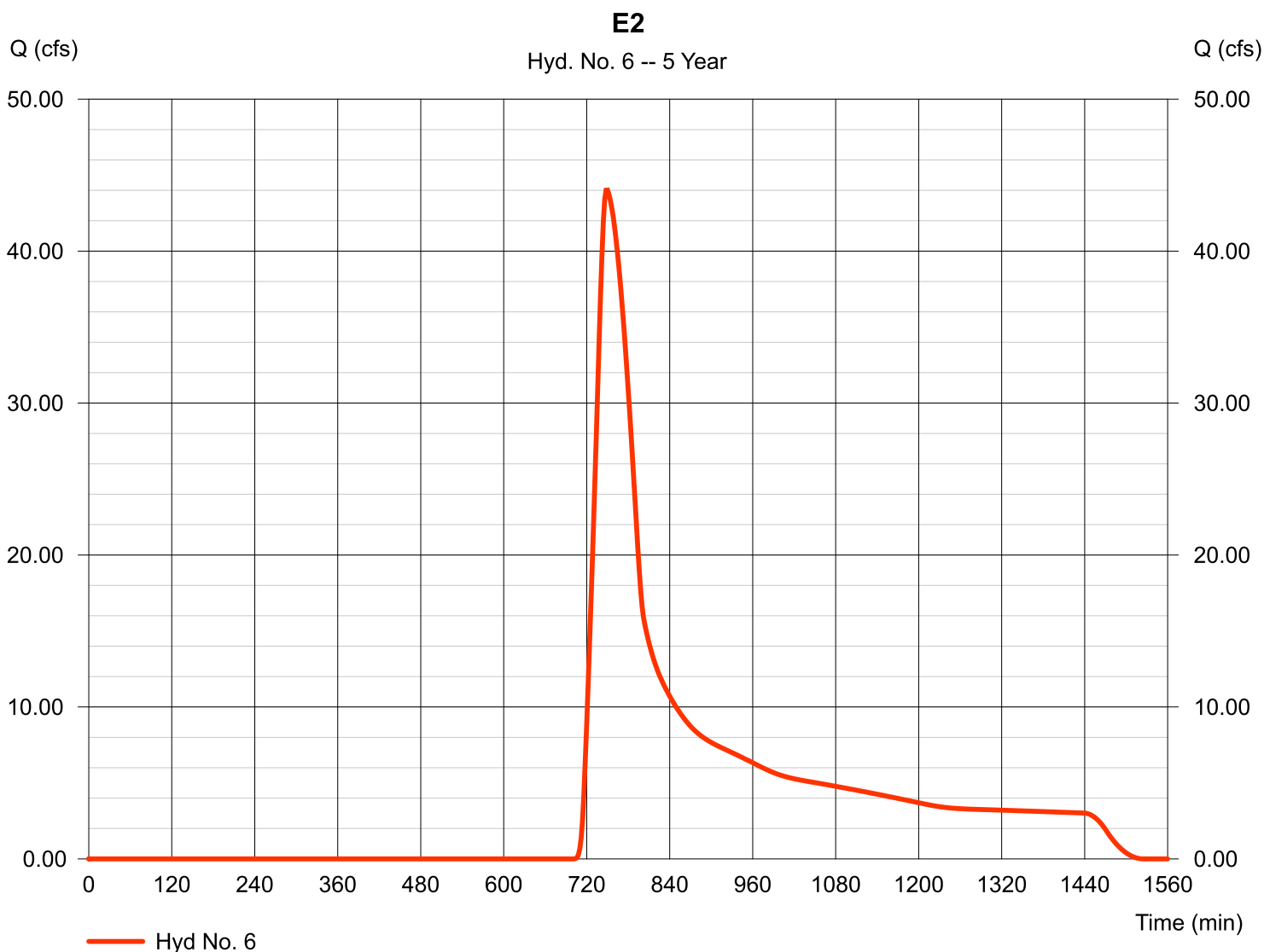
Wednesday, 01 / 16 / 2019

## Hyd. No. 6

E2

Hydrograph type	= SCS Runoff	Peak discharge	= 44.02 cfs
Storm frequency	= 5 yrs	Time to peak	= 750 min
Time interval	= 2 min	Hyd. volume	= 364,012 cuft
Drainage area	= 207.960 ac	Curve number	= 68*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 51.70 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = + (2.700 x 91) + (0.290 x 93) + (40.990 x 61) + (163.980 x 69)] / 207.960



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

**Hyd. No. 6**

E2

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 1.50	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 29.14</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 29.14</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 1700.00	0.00	0.00	
Watercourse slope (%)	= 2.10	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=2.34	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 12.12</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 12.12</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 126.00	0.00	0.00	
Wetted perimeter (ft)	= 71.00	0.00	0.00	
Channel slope (%)	= 0.70	0.00	0.00	
Manning's n-value	= 0.030	0.015	0.015	
Velocity (ft/s)	=6.10	0.00	0.00	
Flow length (ft)	(0)3810.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 10.41</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 10.41</b>
<b>Total Travel Time, Tc .....</b>				<b>51.70 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

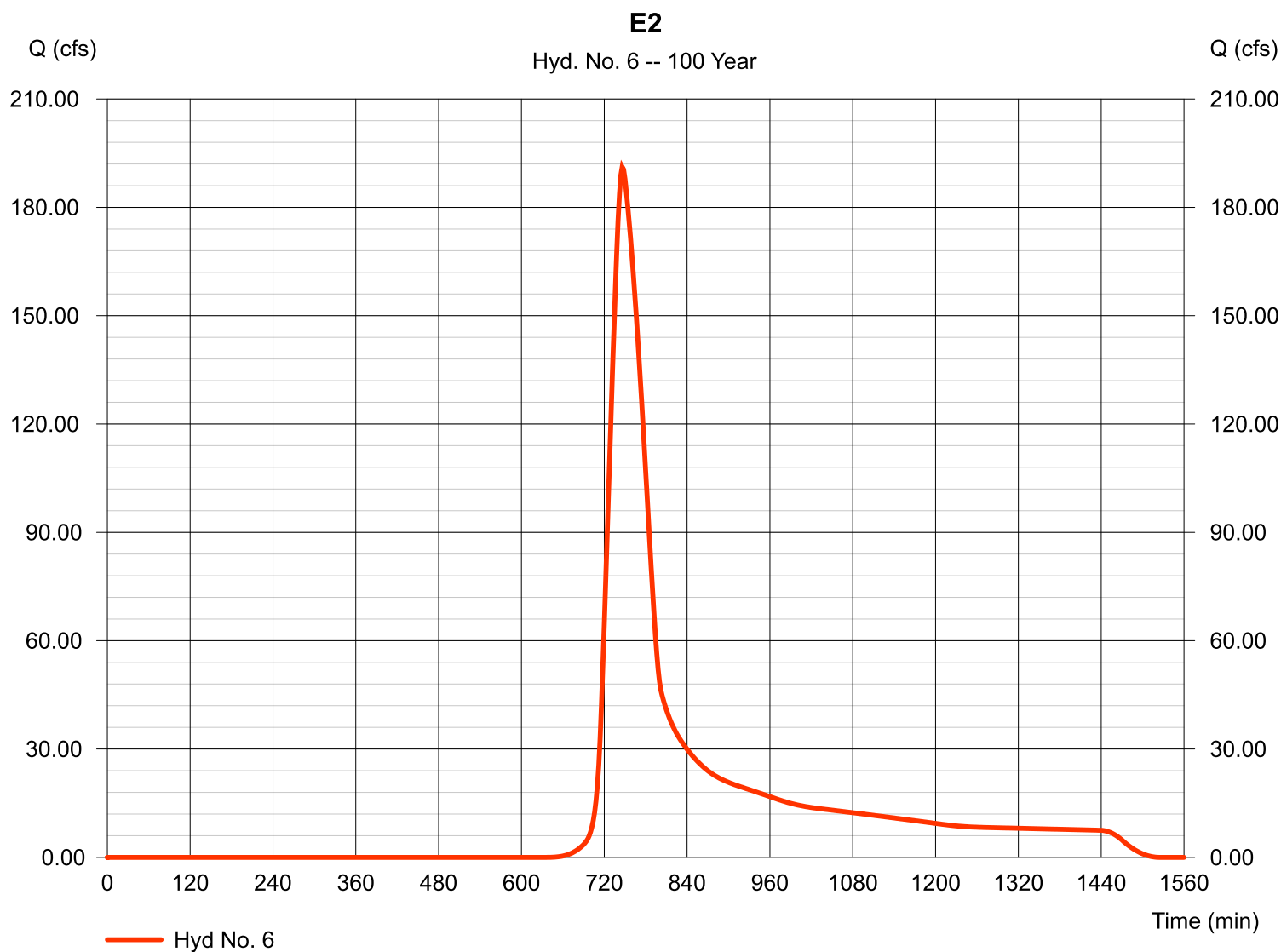
Wednesday, 01 / 16 / 2019

## Hyd. No. 6

E2

Hydrograph type	= SCS Runoff	Peak discharge	= 191.18 cfs
Storm frequency	= 100 yrs	Time to peak	= 746 min
Time interval	= 2 min	Hyd. volume	= 1,217,582 cuft
Drainage area	= 207.960 ac	Curve number	= 68*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 51.70 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $+(2.700 \times 91) + (0.290 \times 93) + (40.990 \times 61) + (163.980 \times 69) / 207.960$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

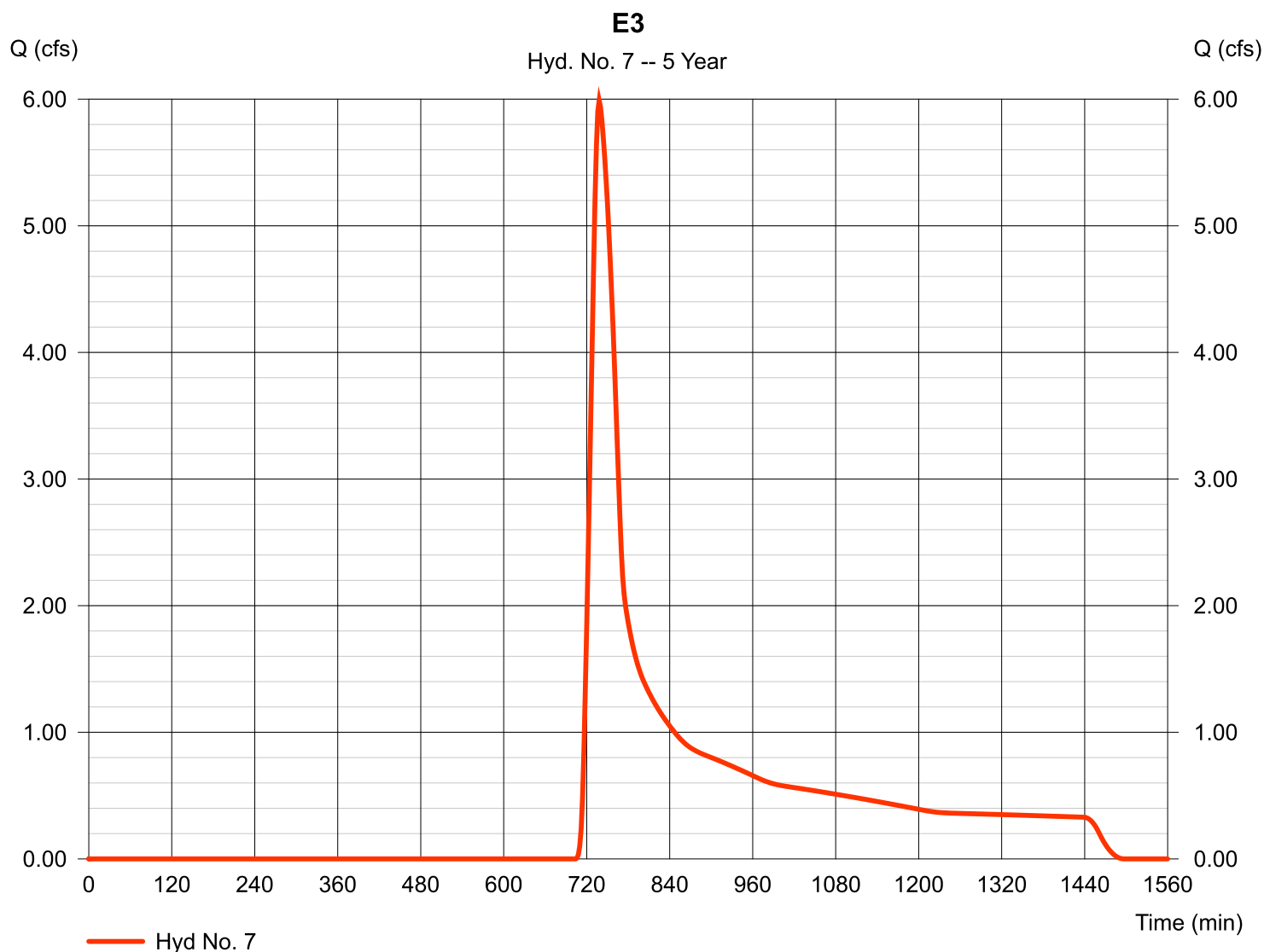
Wednesday, 01 / 16 / 2019

## Hyd. No. 7

E3

Hydrograph type	= SCS Runoff	Peak discharge	= 5.989 cfs
Storm frequency	= 5 yrs	Time to peak	= 738 min
Time interval	= 2 min	Hyd. volume	= 38,689 cuft
Drainage area	= 24.350 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 33.90 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $+(4.870 \times 61) + (19.480 \times 69) / 24.350$





# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No. 7

E3

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 1.50	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 29.14</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 29.14</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 565.00	0.00	0.00	
Watercourse slope (%)	= 1.50	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=1.98	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 4.77</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 4.77</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 0.00	0.00	0.00	
Wetted perimeter (ft)	= 0.00	0.00	0.00	
Channel slope (%)	= 0.00	0.00	0.00	
Manning's n-value	= 0.015	0.015	0.015	
Velocity (ft/s)	=0.00	0.00	0.00	
Flow length (ft)	(0)0.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>33.90 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

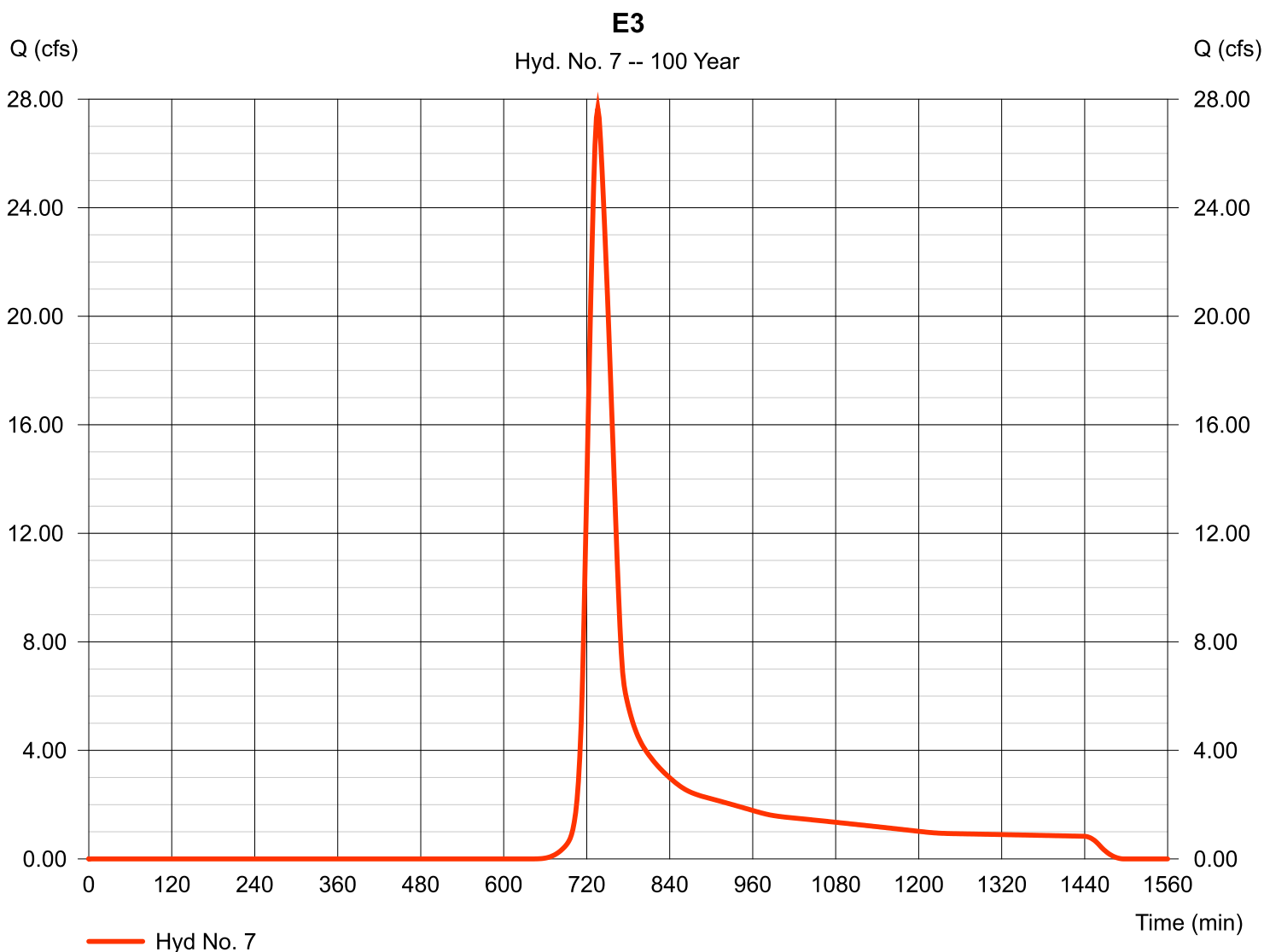
Wednesday, 01 / 16 / 2019

## Hyd. No. 7

E3

Hydrograph type	= SCS Runoff	Peak discharge	= 27.66 cfs
Storm frequency	= 100 yrs	Time to peak	= 736 min
Time interval	= 2 min	Hyd. volume	= 133,711 cuft
Drainage area	= 24.350 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 33.90 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $+(4.870 \times 61) + (19.480 \times 69) / 24.350$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

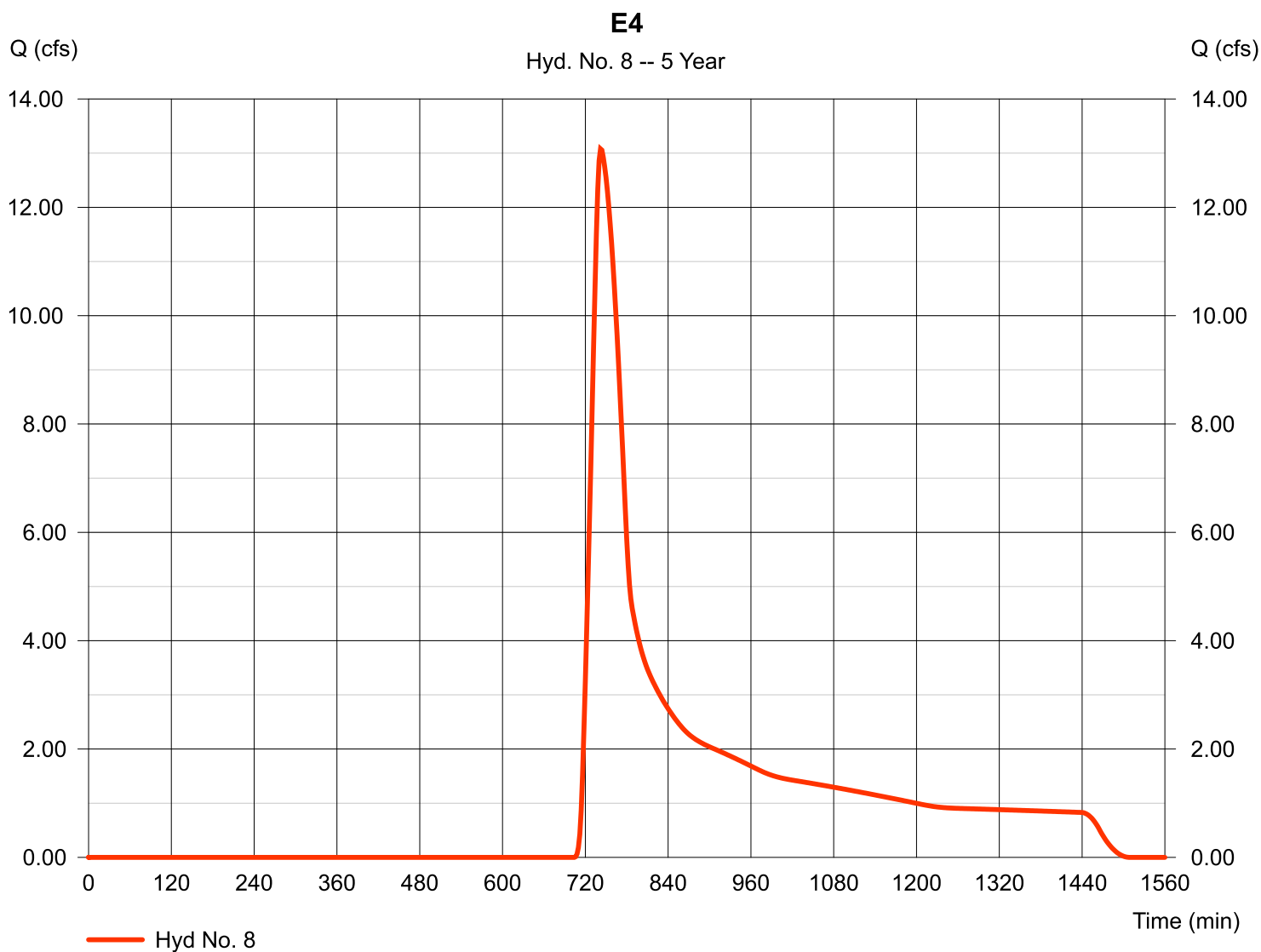
Wednesday, 01 / 16 / 2019

## Hyd. No. 8

E4

Hydrograph type	= SCS Runoff	Peak discharge	= 13.08 cfs
Storm frequency	= 5 yrs	Time to peak	= 742 min
Time interval	= 2 min	Hyd. volume	= 97,176 cuft
Drainage area	= 59.890 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 43.80 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = + (11.980 x 61) + (47.910 x 69)] / 59.890



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No. 8

E4

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 3.25	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 21.39</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 21.39</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 2825.00	0.00	0.00	
Watercourse slope (%)	= 1.70	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=2.10	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 22.38</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 22.38</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 0.00	0.00	0.00	
Wetted perimeter (ft)	= 0.00	0.00	0.00	
Channel slope (%)	= 0.00	0.00	0.00	
Manning's n-value	= 0.015	0.015	0.015	
Velocity (ft/s)	=0.00	0.00	0.00	
Flow length (ft)	(0)0.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>43.80 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

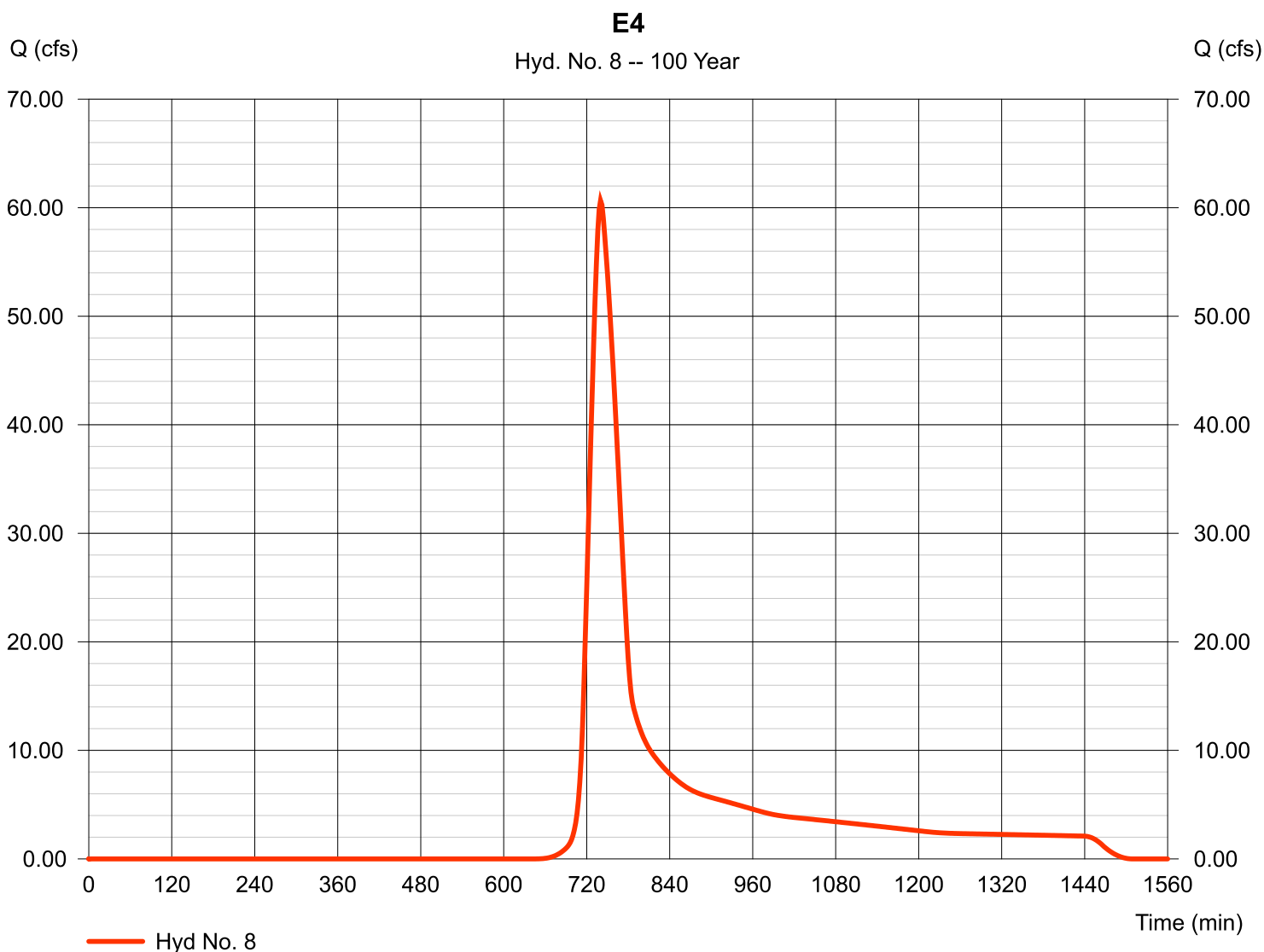
Wednesday, 01 / 16 / 2019

## Hyd. No. 8

E4

Hydrograph type	= SCS Runoff	Peak discharge	= 60.65 cfs
Storm frequency	= 100 yrs	Time to peak	= 740 min
Time interval	= 2 min	Hyd. volume	= 335,847 cuft
Drainage area	= 59.890 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 43.80 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = + (11.980 x 61) + (47.910 x 69)] / 59.890



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

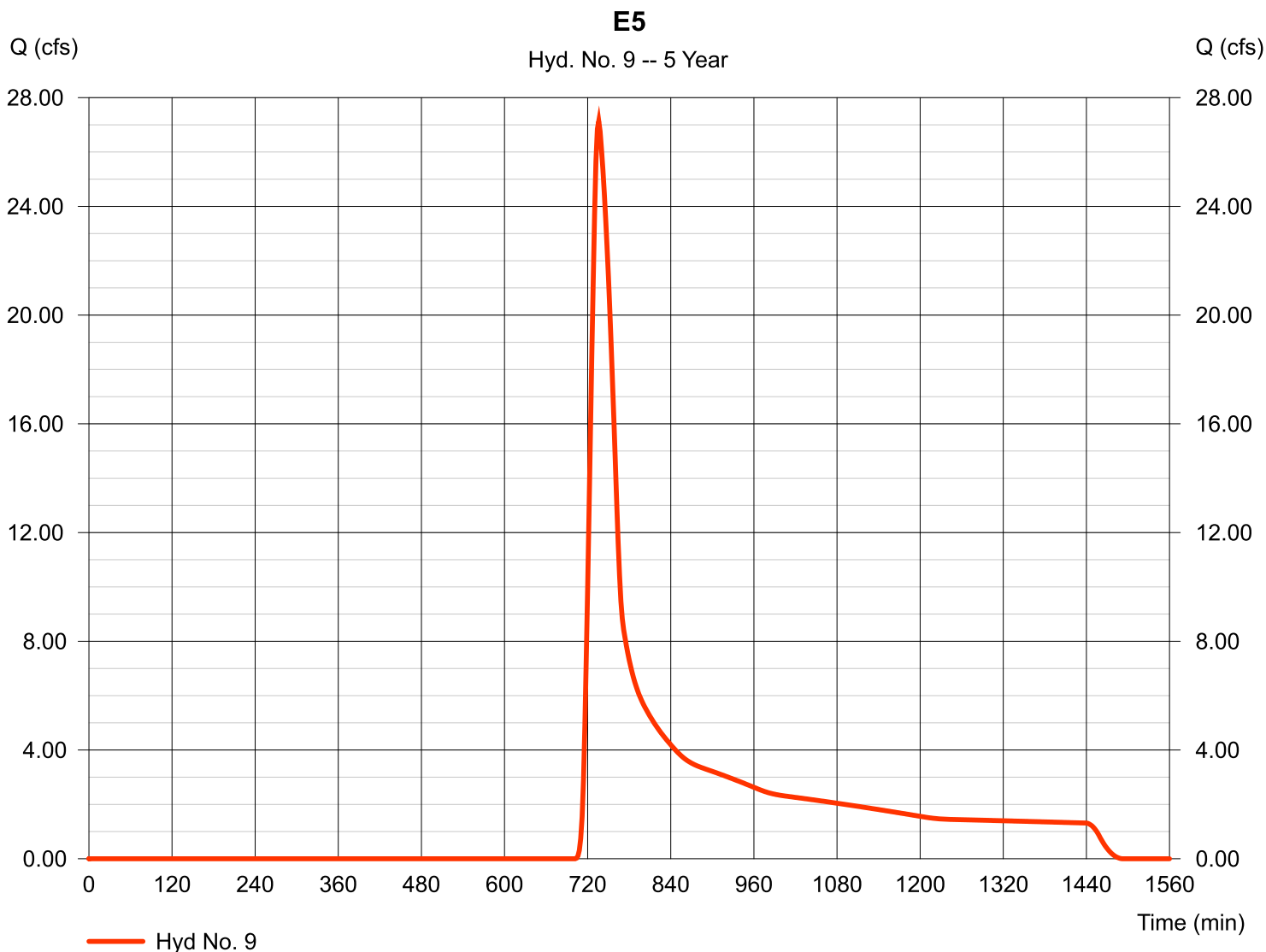
Wednesday, 01 / 16 / 2019

## Hyd. No. 9

E5

Hydrograph type	= SCS Runoff	Peak discharge	= 27.13 cfs
Storm frequency	= 5 yrs	Time to peak	= 736 min
Time interval	= 2 min	Hyd. volume	= 159,710 cuft
Drainage area	= 90.820 ac	Curve number	= 68*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 32.60 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(0.840 \times 93) + (0.840 \times 91) + (17.830 \times 61) + (71.310 \times 69)] / 90.820$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

**Hyd. No. 9**

E5

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 2.50	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 23.76</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 23.76</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 1350.00	0.00	0.00	
Watercourse slope (%)	= 2.50	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=2.55	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 8.82</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 8.82</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 0.00	0.00	0.00	
Wetted perimeter (ft)	= 0.00	0.00	0.00	
Channel slope (%)	= 0.00	0.00	0.00	
Manning's n-value	= 0.015	0.015	0.015	
Velocity (ft/s)	=0.00	0.00	0.00	
Flow length (ft)	(0)0.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>
			<b>0.00</b>	<b>= 0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>32.60 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

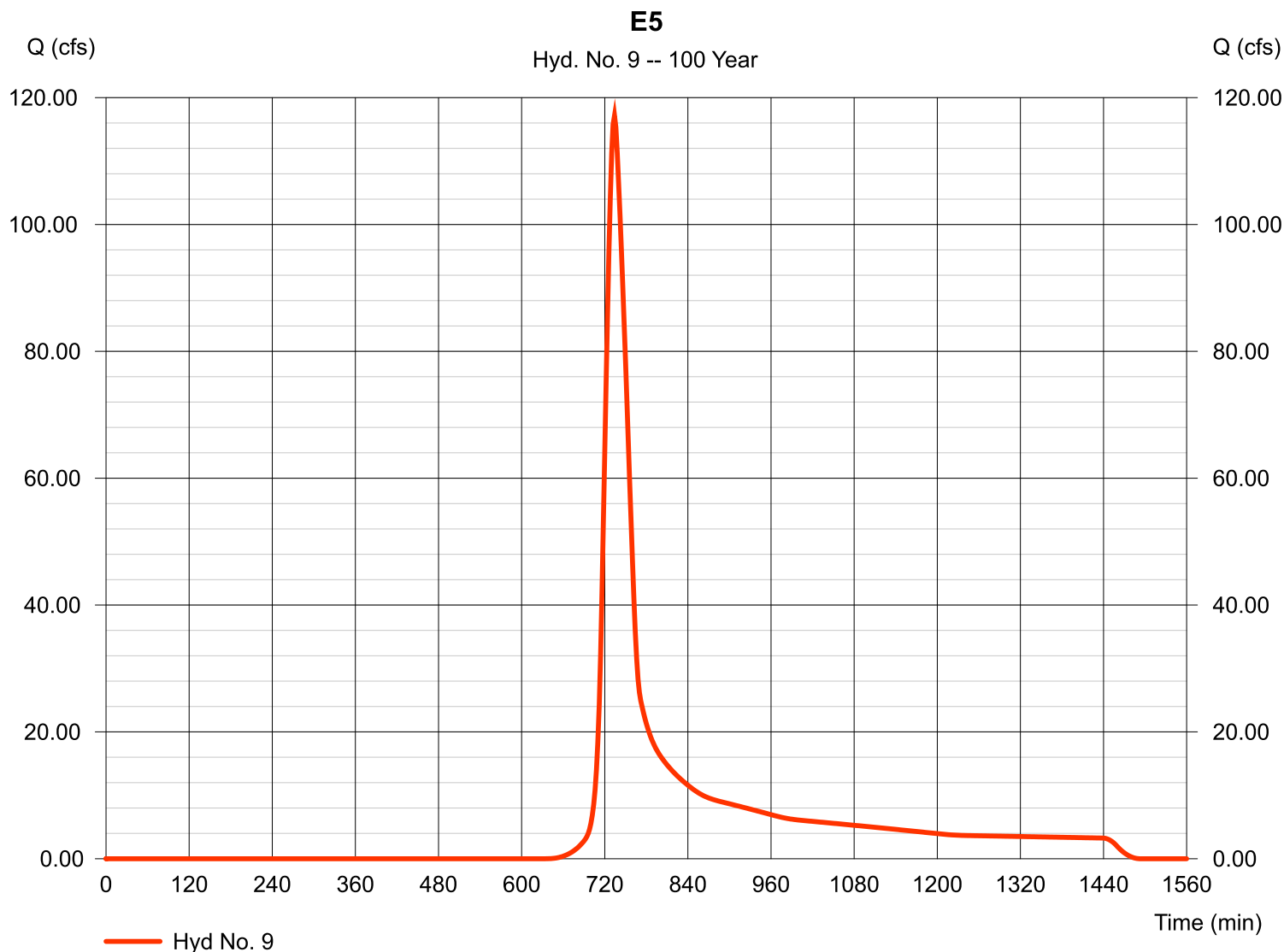
Wednesday, 01 / 16 / 2019

## Hyd. No. 9

E5

Hydrograph type	= SCS Runoff	Peak discharge	= 117.15 cfs
Storm frequency	= 100 yrs	Time to peak	= 734 min
Time interval	= 2 min	Hyd. volume	= 534,213 cuft
Drainage area	= 90.820 ac	Curve number	= 68*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 32.60 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(0.840 \times 93) + (0.840 \times 91) + (17.830 \times 61) + (71.310 \times 69)] / 90.820$





# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

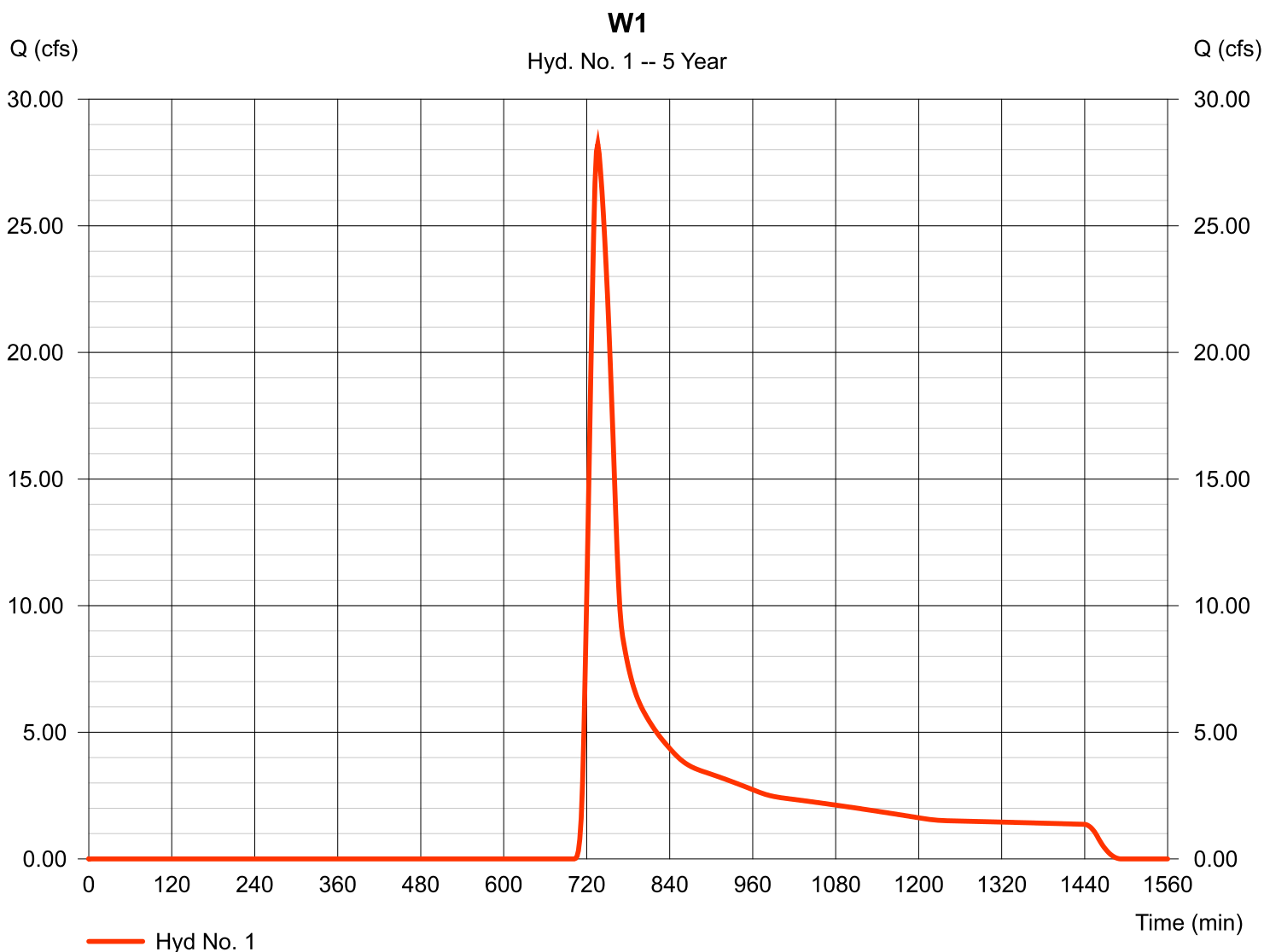
Wednesday, 01 / 16 / 2019

## Hyd. No. 1

W1

Hydrograph type	= SCS Runoff	Peak discharge	= 28.23 cfs
Storm frequency	= 5 yrs	Time to peak	= 736 min
Time interval	= 2 min	Hyd. volume	= 166,164 cuft
Drainage area	= 94.490 ac	Curve number	= 68*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 33.30 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $+(1.580 \times 91) + (18.580 \times 61) + (74.330 \times 69)] / 94.490$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 1

W1

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>			
<b>Sheet Flow</b>							
Manning's n-value	= 0.130	0.011	0.011				
Flow length (ft)	= 300.0	0.0	0.0				
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00				
Land slope (%)	= 2.30	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 24.56</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>24.56</b>
<b>Shallow Concentrated Flow</b>							
Flow length (ft)	= 1280.00	0.00	0.00				
Watercourse slope (%)	= 2.30	0.00	0.00				
Surface description	= Unpaved	Paved	Paved				
Average velocity (ft/s)	=2.45	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 8.72</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>8.72</b>
<b>Channel Flow</b>							
X sectional flow area (sqft)	= 0.00	0.00	0.00				
Wetted perimeter (ft)	= 0.00	0.00	0.00				
Channel slope (%)	= 0.00	0.00	0.00				
Manning's n-value	= 0.025	0.015	0.015				
Velocity (ft/s)	=0.00	0.00	0.00				
Flow length (ft)	((0})0.0	0.0	0.0				
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>33.30 min</b>			

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

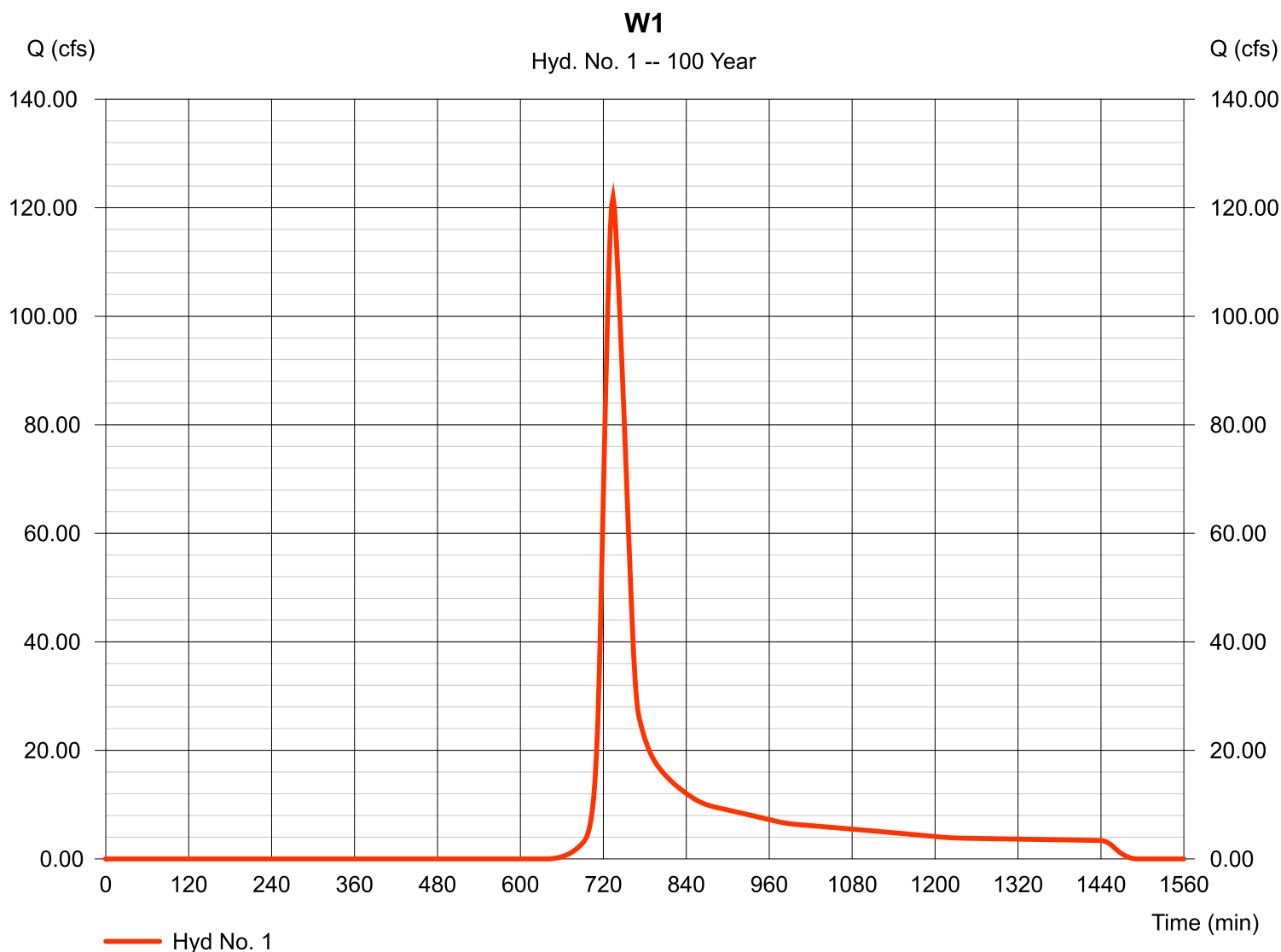
Wednesday, 01 / 16 / 2019

## Hyd. No. 1

W1

Hydrograph type	= SCS Runoff	Peak discharge	= 121.88 cfs
Storm frequency	= 100 yrs	Time to peak	= 734 min
Time interval	= 2 min	Hyd. volume	= 555,801 cuft
Drainage area	= 94.490 ac	Curve number	= 68*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 33.30 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $+(1.580 \times 91) + (18.580 \times 61) + (74.330 \times 69) / 94.490$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

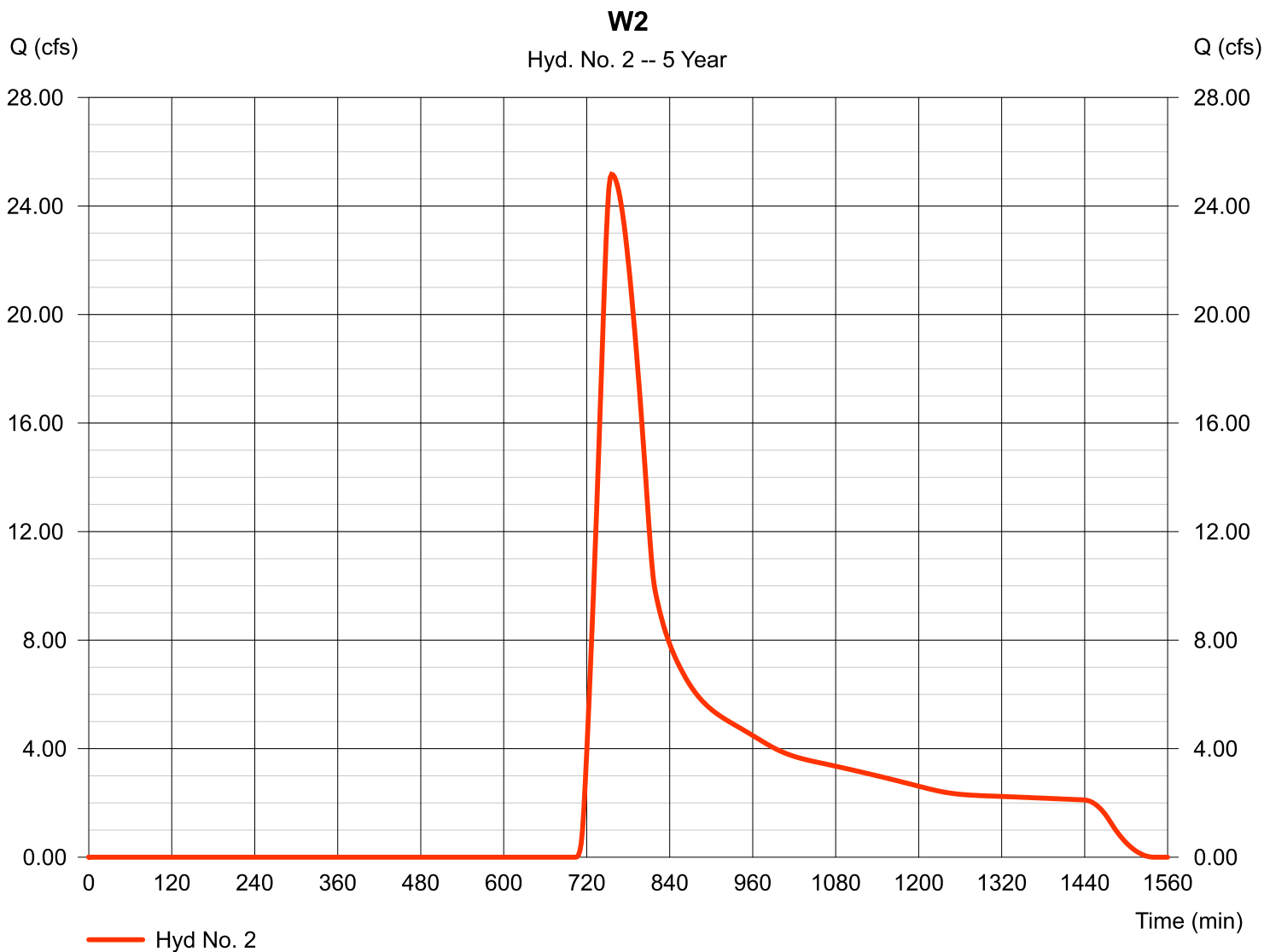
Wednesday, 01 / 16 / 2019

## Hyd. No. 2

W2

Hydrograph type	= SCS Runoff	Peak discharge	= 25.17 cfs
Storm frequency	= 5 yrs	Time to peak	= 756 min
Time interval	= 2 min	Hyd. volume	= 245,356 cuft
Drainage area	= 151.670 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 62.00 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $+(0.090 \times 91) + (30.320 \times 61) + (121.260 \times 69) / 151.670$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 2

W2

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>
<b>Sheet Flow</b>				
Manning's n-value	= 0.130	0.011	0.011	
Flow length (ft)	= 300.0	0.0	0.0	
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00	
Land slope (%)	= 2.00	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 25.98</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 25.98</b>
<b>Shallow Concentrated Flow</b>				
Flow length (ft)	= 3485.00	0.00	0.00	
Watercourse slope (%)	= 1.00	0.00	0.00	
Surface description	= Unpaved	Paved	Paved	
Average velocity (ft/s)	=1.61	0.00	0.00	
<b>Travel Time (min)</b>	<b>= 36.00</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 36.00</b>
<b>Channel Flow</b>				
X sectional flow area (sqft)	= 0.00	0.00	0.00	
Wetted perimeter (ft)	= 0.00	0.00	0.00	
Channel slope (%)	= 0.00	0.00	0.00	
Manning's n-value	= 0.015	0.015	0.015	
Velocity (ft/s)	=0.00	0.00	0.00	
Flow length (ft)	(0)0.0	0.0	0.0	
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b> <b>0.00</b>	<b>+</b> <b>0.00</b>	<b>= 0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>62.00 min</b>

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

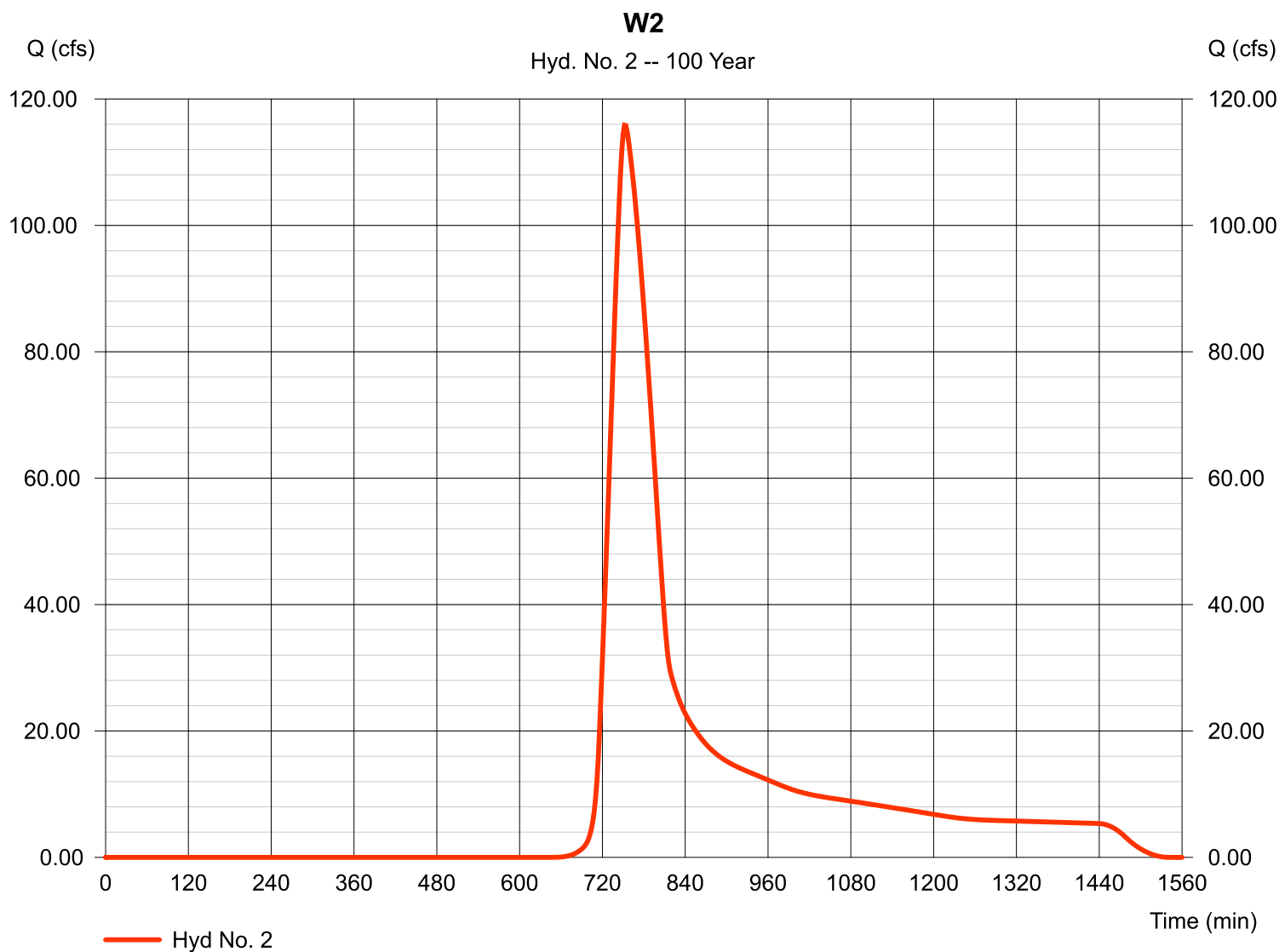
Wednesday, 01 / 16 / 2019

## Hyd. No. 2

W2

Hydrograph type	= SCS Runoff	Peak discharge	= 115.86 cfs
Storm frequency	= 100 yrs	Time to peak	= 752 min
Time interval	= 2 min	Hyd. volume	= 847,966 cuft
Drainage area	= 151.670 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 62.00 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = + (0.090 x 91) + (30.320 x 61) + (121.260 x 69)] / 151.670



# Hydrograph Report

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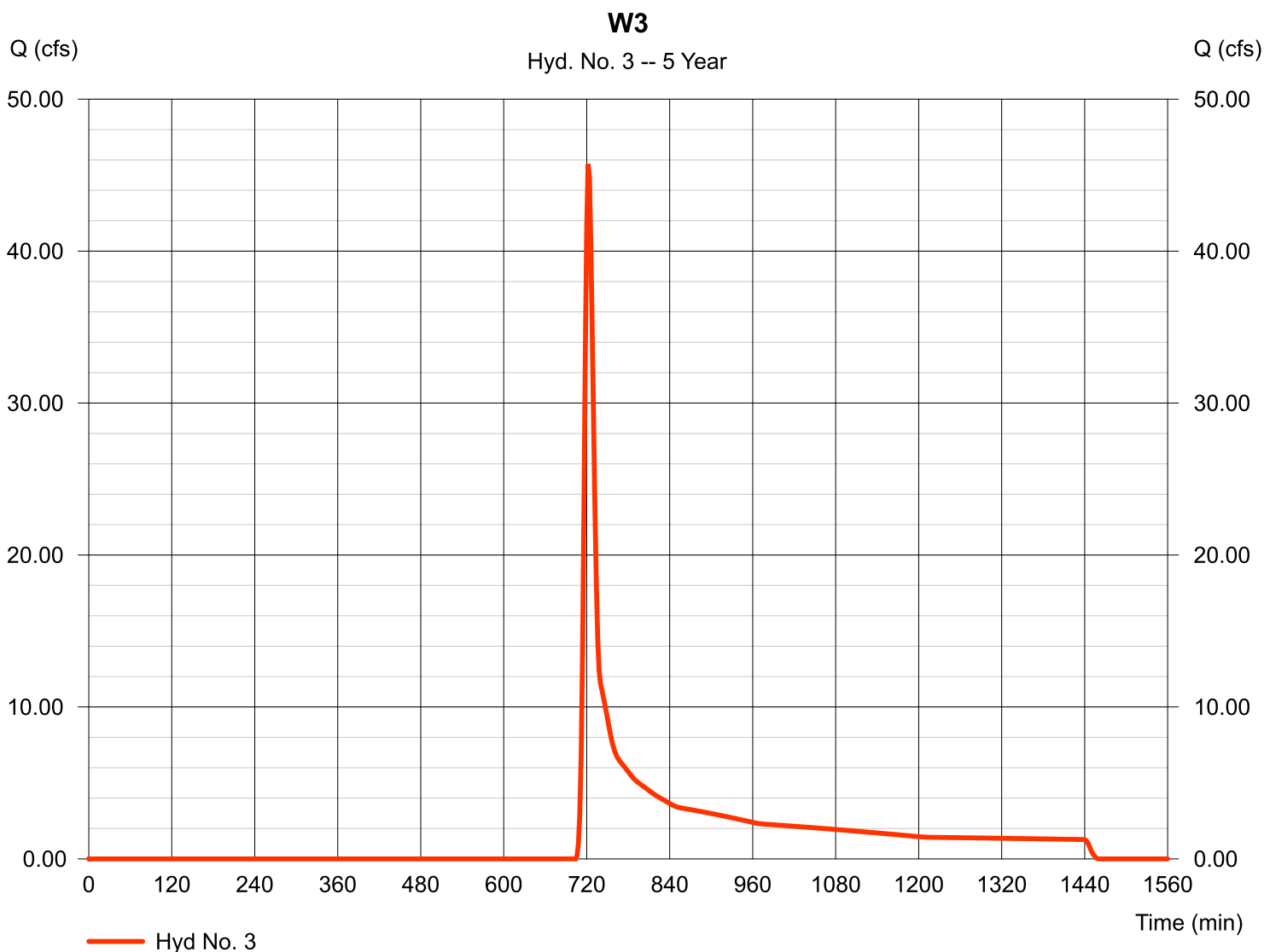
Wednesday, 01 / 16 / 2019

## Hyd. No. 3

W3

Hydrograph type	= SCS Runoff	Peak discharge	= 45.72 cfs
Storm frequency	= 5 yrs	Time to peak	= 722 min
Time interval	= 2 min	Hyd. volume	= 151,266 cuft
Drainage area	= 91.270 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.50 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.180 \times 61) + (72.730 \times 69) + (0.360 \times 91)] / 91.270$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 3

W3

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>			
<b>Sheet Flow</b>							
Manning's n-value	= 0.013	0.011	0.011				
Flow length (ft)	= 300.0	0.0	0.0				
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00				
Land slope (%)	= 4.60	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 2.95</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>2.95</b>
<b>Shallow Concentrated Flow</b>							
Flow length (ft)	= 1770.00	0.00	0.00				
Watercourse slope (%)	= 4.60	0.00	0.00				
Surface description	= Unpaved	Paved	Paved				
Average velocity (ft/s)	=3.46	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 8.52</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>8.52</b>
<b>Channel Flow</b>							
X sectional flow area (sqft)	= 0.00	0.00	0.00				
Wetted perimeter (ft)	= 0.00	0.00	0.00				
Channel slope (%)	= 0.00	0.00	0.00				
Manning's n-value	= 0.015	0.015	0.015				
Velocity (ft/s)	=0.00	0.00	0.00				
Flow length (ft)	(0)0.0	0.0	0.0				
<b>Travel Time (min)</b>	<b>= 0.00</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>0.00</b>
<b>Total Travel Time, Tc .....</b>				<b>11.50 min</b>			



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

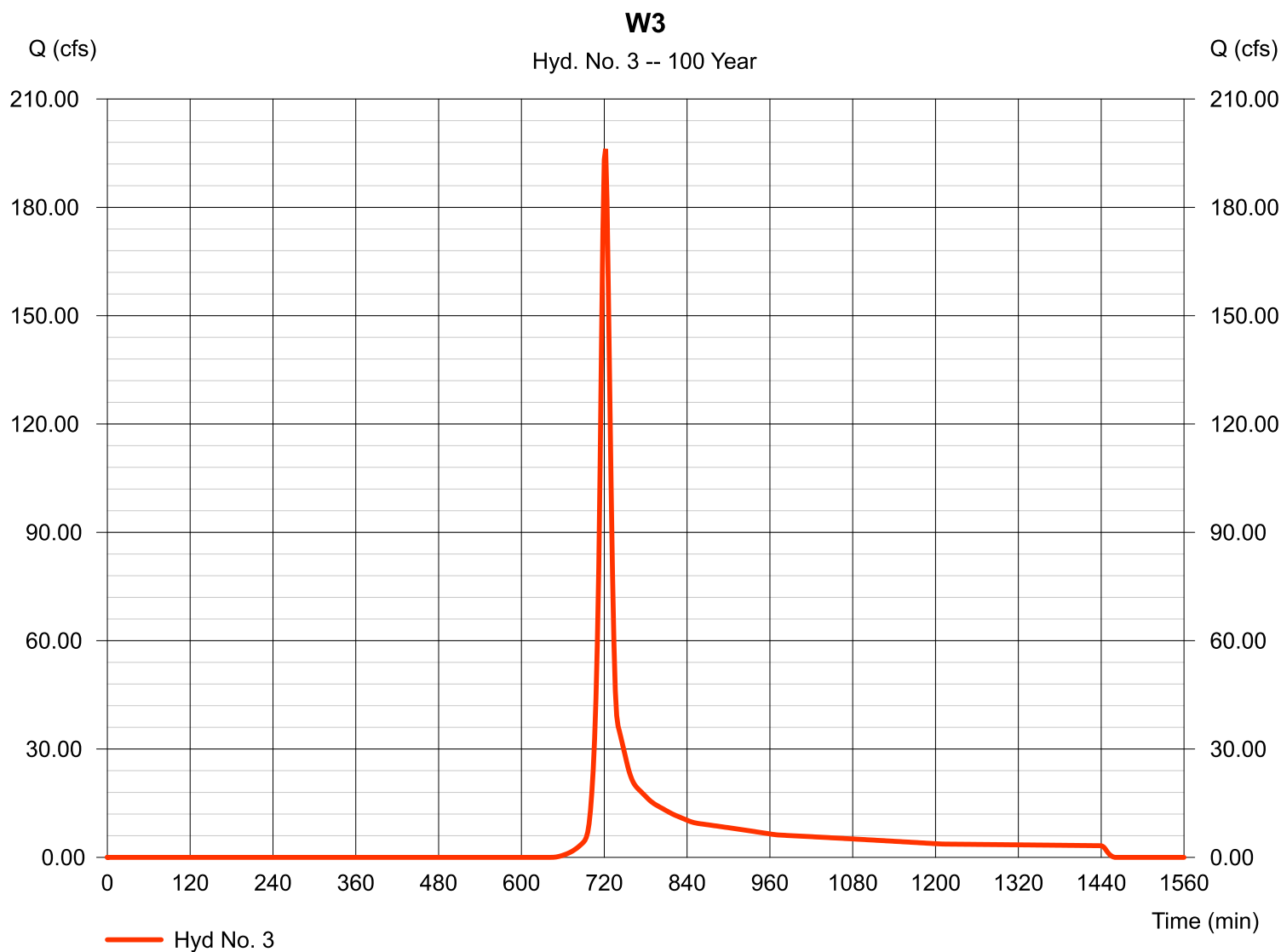
Wednesday, 01 / 16 / 2019

## Hyd. No. 3

W3

Hydrograph type	= SCS Runoff	Peak discharge	= 196.20 cfs
Storm frequency	= 100 yrs	Time to peak	= 722 min
Time interval	= 2 min	Hyd. volume	= 522,786 cuft
Drainage area	= 91.270 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.50 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(18.180 \times 61) + (72.730 \times 69) + (0.360 \times 91)] / 91.270$



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

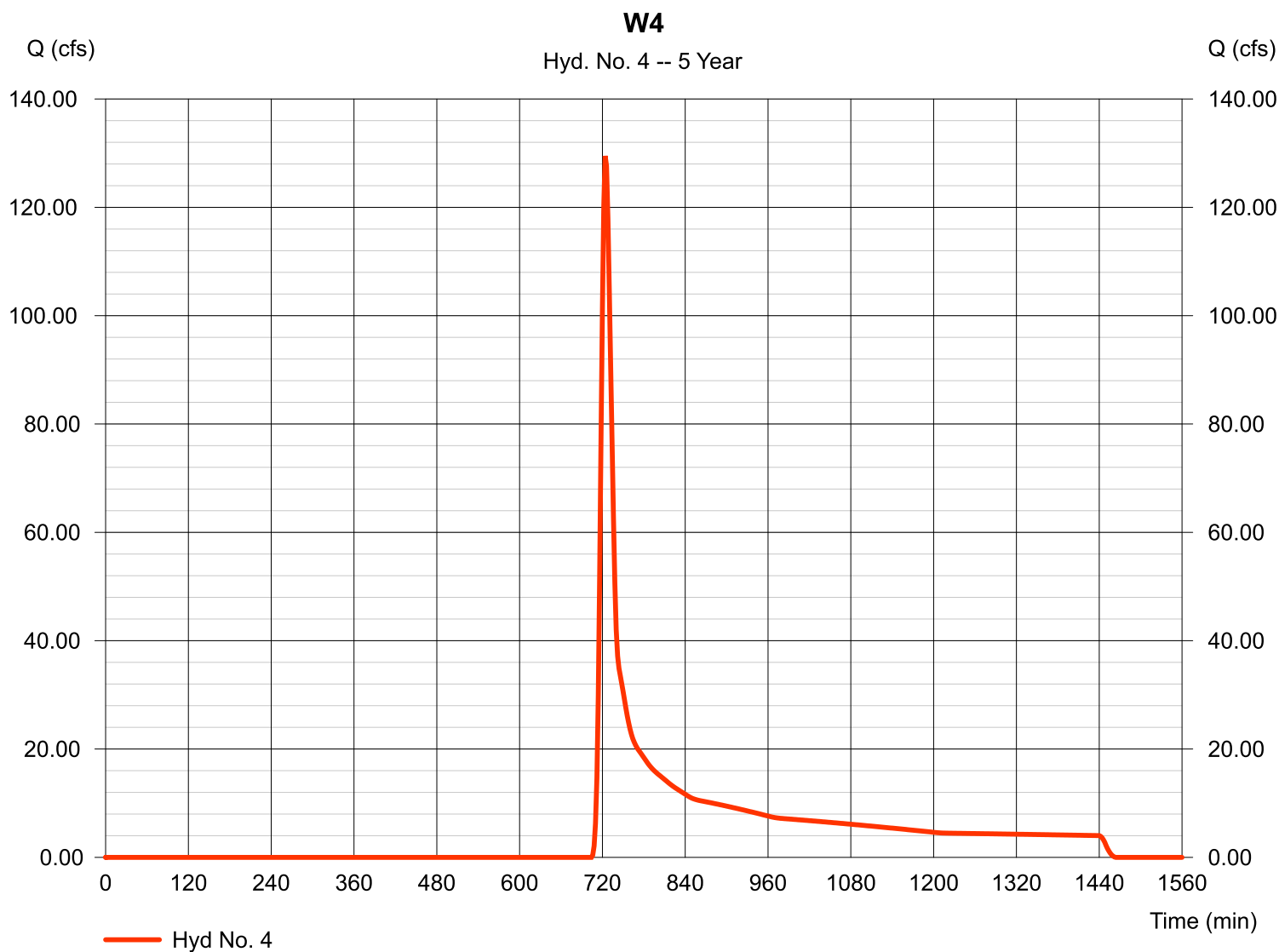
Wednesday, 01 / 16 / 2019

## Hyd. No. 4

W4

Hydrograph type	= SCS Runoff	Peak discharge	= 129.49 cfs
Storm frequency	= 5 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 476,054 cuft
Drainage area	= 303.810 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.80 min
Total precip.	= 2.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(60.760 \times 61) + (243.050 \times 69)] / 303.810$



# TR55 Tc Worksheet

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

## Hyd. No. 4

W4

<u>Description</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>Totals</u>			
<b>Sheet Flow</b>							
Manning's n-value	= 0.011	0.011	0.011				
Flow length (ft)	= 300.0	0.0	0.0				
Two-year 24-hr precip. (in)	= 2.10	0.00	0.00				
Land slope (%)	= 3.90	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 2.76</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>2.76</b>
<b>Shallow Concentrated Flow</b>							
Flow length (ft)	= 2400.00	0.00	0.00				
Watercourse slope (%)	= 3.90	0.00	0.00				
Surface description	= Unpaved	Paved	Paved				
Average velocity (ft/s)	=3.19	0.00	0.00				
<b>Travel Time (min)</b>	<b>= 12.55</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>12.55</b>
<b>Channel Flow</b>							
X sectional flow area (sqft)	= 87450.00	0.00	0.00				
Wetted perimeter (ft)	= 1275.00	0.00	0.00				
Channel slope (%)	= 1.00	0.00	0.00				
Manning's n-value	= 0.030	0.015	0.015				
Velocity (ft/s)	=84.40	0.00	0.00				
Flow length (ft)	(0)2700.0	0.0	0.0				
<b>Travel Time (min)</b>	<b>= 0.53</b>	<b>+</b>	<b>0.00</b>	<b>+</b>	<b>0.00</b>	<b>=</b>	<b>0.53</b>
<b>Total Travel Time, Tc .....</b>					<b>15.80 min</b>		

# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

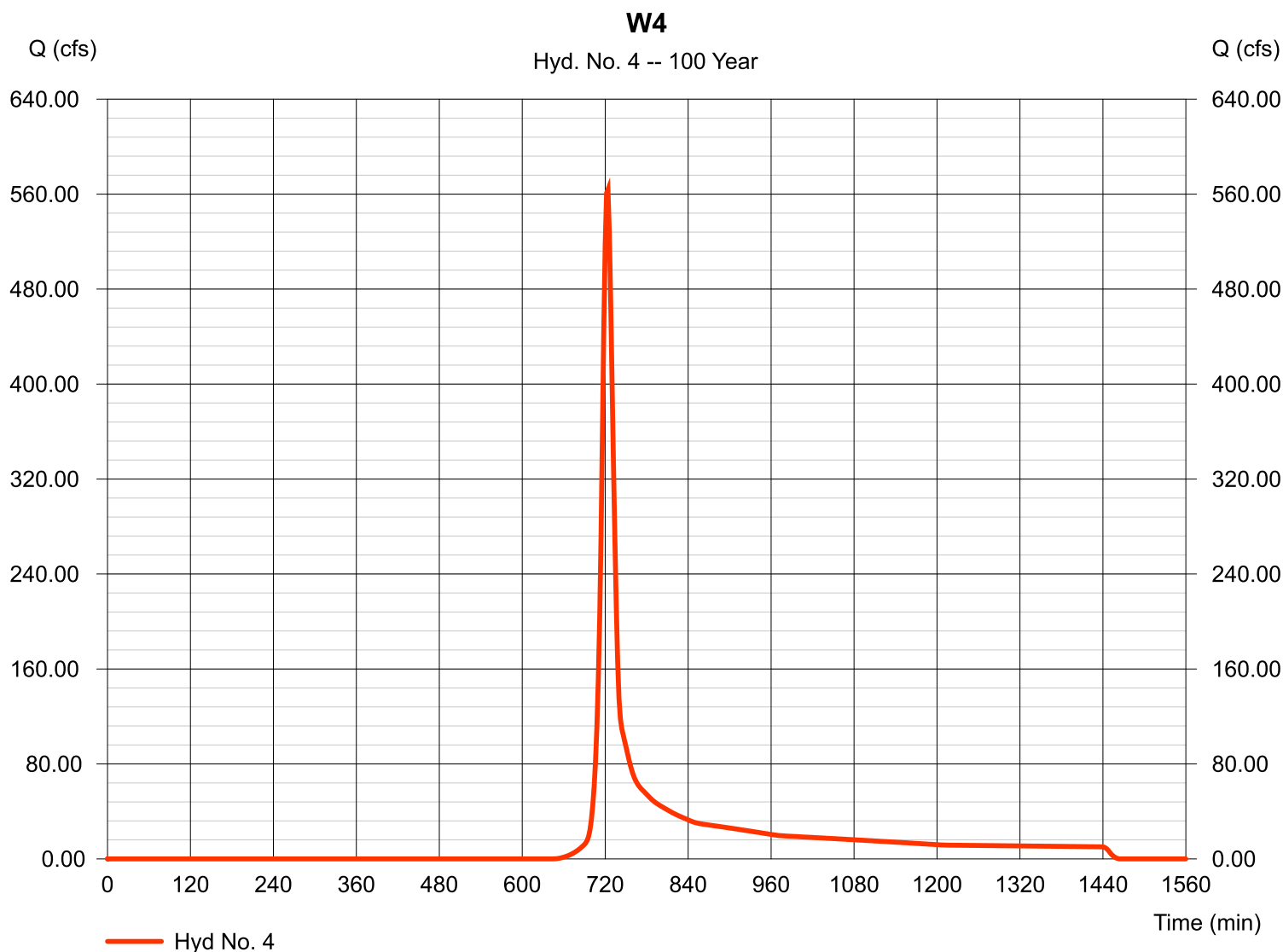
Wednesday, 01 / 16 / 2019

## Hyd. No. 4

W4

Hydrograph type	= SCS Runoff	Peak discharge	= 563.91 cfs
Storm frequency	= 100 yrs	Time to peak	= 724 min
Time interval	= 2 min	Hyd. volume	= 1,645,272 cuft
Drainage area	= 303.810 ac	Curve number	= 67*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.80 min
Total precip.	= 4.60 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = [(60.760 x 61) + (243.050 x 69)] / 303.810



***HYDRAULIC CALCULATIONS***

## Cross Section for Drainage Channel

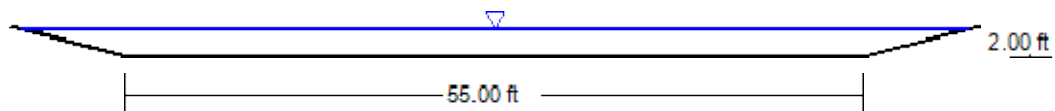
### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00700	ft/ft
Normal Depth	2.00	ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	55.00	ft
Discharge	762.73	ft <sup>3</sup> /s

### Cross Section Image



V: 1  
H: 1

## Worksheet for Drainage Channel

### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00700	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	55.00	ft
Discharge	762.73	ft³/s

### Results

Normal Depth	2.00	ft
Flow Area	126.11	ft²
Wetted Perimeter	71.51	ft
Hydraulic Radius	1.76	ft
Top Width	71.01	ft
Critical Depth	1.74	ft
Critical Slope	0.01140	ft/ft
Velocity	6.05	ft/s
Velocity Head	0.57	ft
Specific Energy	2.57	ft
Froude Number	0.80	
Flow Type	Subcritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.00	ft
Critical Depth	1.74	ft
Channel Slope	0.00700	ft/ft

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Worksheet for Drainage Channel

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GVF Output Data

Critical Slope 0.01140 ft/ft



## Cross Section for Trapezoidal Roadside Ditch

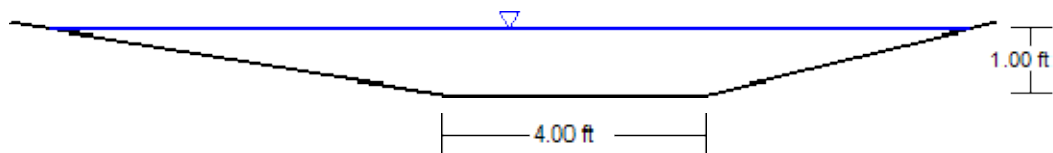
### Project Description

Friction Method	Manning Formula
Solve For	Discharge

### Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	1.00	ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	4.00	ft
Discharge	23.25	ft <sup>3</sup> /s

### Cross Section Image



V: 1  
H: 1

## Worksheet for Trapezoidal Roadside Ditch

### Project Description

Friction Method	Manning Formula
Solve For	Discharge

### Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Normal Depth	1.00	ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Bottom Width	4.00	ft

### Results

Discharge	23.25	ft <sup>3</sup> /s
Flow Area	9.00	ft <sup>2</sup>
Wetted Perimeter	14.21	ft
Hydraulic Radius	0.63	ft
Top Width	14.00	ft
Critical Depth	0.75	ft
Critical Slope	0.01678	ft/ft
Velocity	2.58	ft/s
Velocity Head	0.10	ft
Specific Energy	1.10	ft
Froude Number	0.57	
Flow Type	Subcritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.00	ft
Critical Depth	0.75	ft
Channel Slope	0.00500	ft/ft

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# Worksheet for Trapezoidal Roadside Ditch

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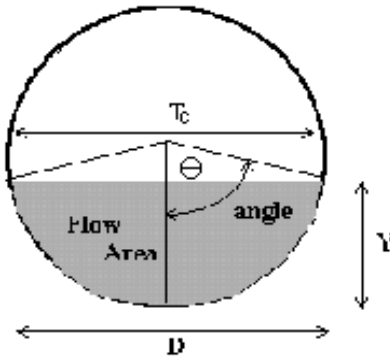
## GVF Output Data

Critical Slope 0.01678 ft/ft

## CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

Project: **Palmer Solar Facility**

Pipe ID: **18" Culvert**



### Design Information (Input)

Pipe Invert Slope	$S_o =$	<input type="text" value="0.0100"/>	ft/ft
Pipe Manning's n-value	$n =$	<input type="text" value="0.0130"/>	
Pipe Diameter	$D =$	<input type="text" value="18.00"/>	inches
<b>Design discharge</b>	<b><math>Q =</math></b>	<b><input type="text" value="10.53"/></b>	<b>cfs</b>

### Full-flow Capacity (Calculated)

Full-flow area	$A_f =$	<input type="text" value="1.77"/>	sq ft
Full-flow wetted perimeter	$P_f =$	<input type="text" value="4.71"/>	ft
Half Central Angle	$\theta =$	<input type="text" value="3.14"/>	radians
Full-flow capacity	$Q_f =$	<input type="text" value="10.53"/>	cfs

### Calculation of Normal Flow Condition

Half Central Angle ( $0 < \theta < 3.14$ )	$\theta =$	<input type="text" value="2.26"/>	radians
Flow area	$A_n =$	<input type="text" value="1.55"/>	sq ft
Top width	$T_n =$	<input type="text" value="1.15"/>	ft
Wetted perimeter	$P_n =$	<input type="text" value="3.40"/>	ft
Flow depth	$Y_n =$	<input type="text" value="1.23"/>	ft
Flow velocity	$V_n =$	<input type="text" value="6.79"/>	fps
Discharge	$Q_n =$	<input type="text" value="10.53"/>	cfs
Percent Full Flow	$\text{Flow} =$	<input type="text" value="100.0%"/>	of full flow
Normal Depth Froude Number	$Fr_n =$	<input type="text" value="1.03"/>	supercritical

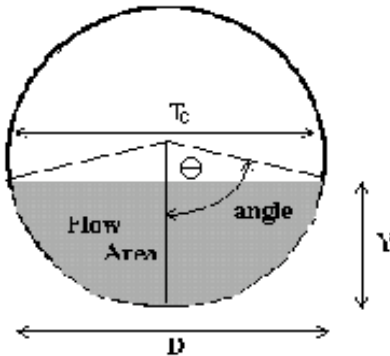
### Calculation of Critical Flow Condition

Half Central Angle ( $0 < \theta < 3.14$ )	$\theta_c =$	<input type="text" value="2.29"/>	radians
Critical flow area	$A_c =$	<input type="text" value="1.57"/>	sq ft
Critical top width	$T_c =$	<input type="text" value="1.12"/>	ft
Critical flow depth	$Y_c =$	<input type="text" value="1.25"/>	ft
Critical flow velocity	$V_c =$	<input type="text" value="6.71"/>	fps
Critical Depth Froude Number	$Fr_c =$	<input type="text" value="1.00"/>	

## CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

Project: **Palmer Solar Facility**

Pipe ID: **24" Culvert Maximum Capacity**



### Design Information (Input)

Pipe Invert Slope	$S_o =$	0.0100	ft/ft
Pipe Manning's n-value	$n =$	0.0130	
Pipe Diameter	$D =$	24.00	inches
Design discharge	$Q =$	22.68	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	$Q_f =$	22.68	cfs

### Calculation of Normal Flow Condition

Half Central Angle ( $0 < \theta < 3.14$ )	$\theta =$	2.26	radians
Flow area	$A_n =$	2.76	sq ft
Top width	$T_n =$	1.54	ft
Wetted perimeter	$P_n =$	4.53	ft
Flow depth	$Y_n =$	1.64	ft
Flow velocity	$V_n =$	8.23	fps
Discharge	$Q_n =$	22.68	cfs
Percent Full Flow	$\text{Flow} =$	100.0%	of full flow
Normal Depth Froude Number	$Fr_n =$	1.08	supercritical

### Calculation of Critical Flow Condition

Half Central Angle ( $0 < \theta < 3.14$ )	$\theta_c =$	2.34	radians
Critical flow area	$A_c =$	2.84	sq ft
Critical top width	$T_c =$	1.44	ft
Critical flow depth	$Y_c =$	1.70	ft
Critical flow velocity	$V_c =$	7.98	fps
Critical Depth Froude Number	$Fr_c =$	1.00	

## Rip-Rap Calculation DRAINAGE CHANNEL

### Applicable Equations:

$L_p = (1/2 \tan \theta)(A_t/Y_t - D)$	Equation 9-11 per USDCM
$A_t = Q/V$	Equation 9-12 per USDCM
$\theta = \tan^{-1}(1/(2 * \text{ExpansionFactor}))$	Equation 9-13 per USDCM
$W = 2(L_p \tan \theta) + D$	Equation 9-14 per USDCM
$T = 2D_{50}$	Equation 9-15 per USDCM

### Assumptions

Maximum Major Event Velocity is 7fps for FES outletting into trickle channels

### Input parameters:

Description	Variable	Input	Unit
Width of the conduit (use diameter for circular conduits),	D:	55.00	ft
HGL Elevation		1.74	ft
Invert Elevation		0.00	ft
Tailwater depth (ft),	$Y_t$ :	1.74	ft
Expansion angle of the culvert flow	$\theta$ :	0.79	radians
Design discharge (cfs)*	Q:	762.73	cfs
Froude Number	$F_r$	0.04	Subcritical
Unitless Variables for Tables:			
	For Figure 9-35 $Q/D^{2.5}$	0.03	
	For Figure 9-35 $Y_t/D$	0.03	
	For Figure 9-38 $Q/D^{1.5}$	1.87	
	For Figure 9-38 $Y_t/D$	0.03	
Allowable non-eroding velocity in the downstream channel (ft/sec)	V:	2	ft/sec
Expansion Factor (Figure 9-35), $1/(2 \tan \theta)$		0.5	

### Solve for:

Description	Variable	Output	Unit
1. Required area of flow at allowable velocity (ft <sup>2</sup> )	$A_t$ :	381.37	ft <sup>2</sup>
2. Length of Protection	$L_p$ :	82.09	ft
	$L_p < 3D$ ?	Yes	
	$L_{pmin}$ :	165.00	ft
3. Width of downstream riprap protection	W:	385.00	ft
4. Rip Rap Type (Figure 9-38)	-	H	
5. Rip Rap Size (Figure 8-34)	$D_{50}$ :	18	inches

### Rip Rap Summary

Length	$L_p$	165.00	ft
Width	W	385.00	ft
Size	$D_{50}$	18	inches
Type	-	H	-
Thickness	T	36	inches

## Rip-Rap Calculation CULVERT OUTFALL

### Applicable Equations:

$L_p = (1/2 \tan \theta)(A_t/Y_t - D)$	Equation 9-11 per USDCM
$A_t = Q/V$	Equation 9-12 per USDCM
$\theta = \tan^{-1}(1/(2 * \text{ExpansionFactor}))$	Equation 9-13 per USDCM
$W = 2(L_p \tan \theta) + D$	Equation 9-14 per USDCM
$T = 2D_{50}$	Equation 9-15 per USDCM

### Assumptions

Maximum Major Event Velocity is 7fps for FES outletting into trickle channels

### Input parameters:

Description	Variable	Input	Unit
Width of the conduit (use diameter for circular conduits),	D:	2.00	ft
HGL Elevation		1.64	ft
Invert Elevation		0.00	ft
Tailwater depth (ft),	$Y_t$ :	1.64	ft
Expansion angle of the culvert flow	$\theta$ :	0.07	radians
Design discharge (cfs)*	Q:	22.68	cfs
Froude Number	$F_r$	0.99	Subcritical
Unitless Variables for Tables:			
	For Figure 9-35 $Q/D^{2.5}$	4.01	
	For Figure 9-35 $Y_t/D$	0.82	
	For Figure 9-38 $Q/D^{1.5}$	8.02	
	For Figure 9-38 $Y_t/D$	0.82	
Allowable non-eroding velocity in the downstream channel (ft/sec)	V:	2	ft/sec
Expansion Factor (Figure 9-35), $1/(2 \tan(\theta))$		6.7	

### Solve for:

Description	Variable	Output	Unit
1. Required area of flow at allowable velocity (ft <sup>2</sup> )	$A_t$ :	11.34	ft <sup>2</sup>
2. Length of Protection	$L_p$ :	32.93	ft
	$L_p < 3D$ ?	No	
	$L_{pmin}$ :	32.93	ft
3. Width of downstream riprap protection	W:	7.00	ft
4. Rip Rap Type (Figure 9-38)	-	L	
5. Rip Rap Size (Figure 8-34)	$D_{50}$ :	9	inches

### Rip Rap Summary

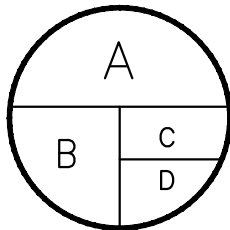
Length	$L_p$	33.00	ft
Width	W	7.00	ft
Size	$D_{50}$	9	inches
Type	-	L	-
Thickness	T	18	inches

***DRAINAGE MAPS***

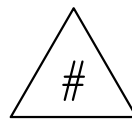


K:\COS\_Civil\096495003\_Palmer Solar\CADD\Exhibits\Existing Drainage Map.dwg 12/20/2018 2:08 PM  
THIS DOCUMENT, TOGETHER WITH THE CONCEPTS AND DESIGN PRESENTED HEREIN, IS AN INSTRUMENT OF SERVICE. IT IS INTENDED ONLY FOR THE SPECIFIC PURPOSE AND CLIENT FOR WHICH IT WAS PREPARED. REUSE OF AND IMPROPER RELIANCE ON THIS DOCUMENT WITHOUT WRITTEN AUTHORIZATION AND ADAPTATION BY KIMLEY-HORN AND ASSOCIATES, INC. SHALL BE WITHOUT LIABILITY TO KIMLEY-HORN AND ASSOCIATES, INC.

LEGEND



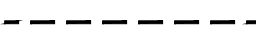
- A = BASIN DESIGNATION  
B = AREA (ACRES)  
C = CURVE NUMBER  
D = 100YR DESIGN STORM RUNOFF (CFS)



# = DESIGN POINT



FLOW DIRECTION



DRAINAGE BASIN BOUNDARY



EXISTING MAJOR CONTOUR (25 FT)



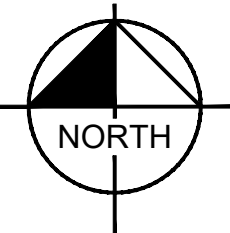
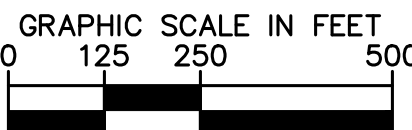
EXISTING MINOR CONTOUR (5 FT)

Existing Runoff			
BASIN	BASIN AREA (ACRES)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)
W1	94.49	24.99	115.43
W2	151.66	25.17	115.88
W3	91.27	45.72	196.20
W4	303.81	129.49	563.91
E1	776.17	115.86	530.57
E2	24.35	5.99	27.66
E3	90.83	24.02	110.95
TOTAL	1532.59	371.24	1660.60

KEYMAP



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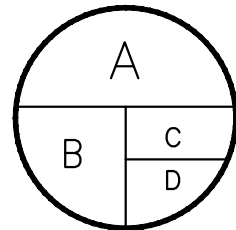
PALMER SOLAR-EXISTING DRAINAGE MAP



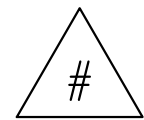


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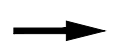
LEGEND



- A = BASIN DESIGNATION
- B = AREA (ACRES)
- C = CURVE NUMBER
- D = 100YR DESIGN STORM RUNOFF (CFS)



- # = DESIGN POINT



- FLOW DIRECTION

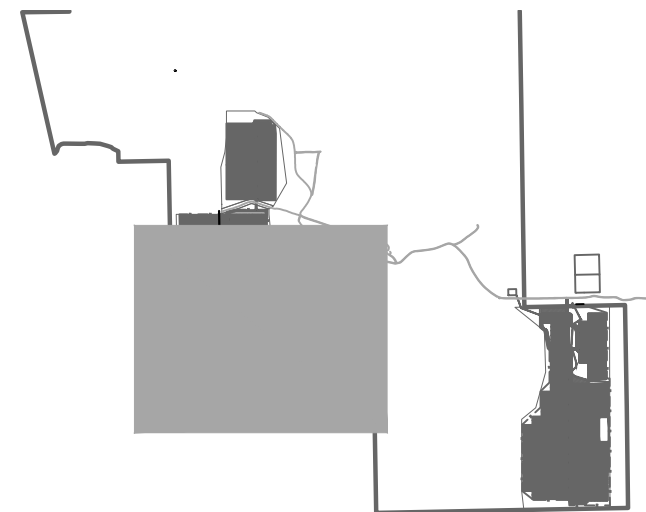
- DRAINAGE BASIN BOUNDARY

- - - - - EXISTING MAJOR CONTOUR (25 FT)

- - - - - EXISTING MINOR CONTOUR (5 FT)

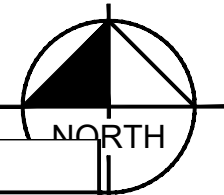
Existing Runoff			
BASIN	BASIN AREA (ACRES)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)
W1	94.49	24.99	115.43
W2	151.66	25.17	115.88
W3	91.27	45.72	196.20
W4	303.81	129.49	563.91
E1	776.17	115.86	530.57
E2	24.35	5.99	27.66
E3	90.83	24.02	110.95
TOTAL	1532.59	371.24	1660.60

KEYMAP



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GRAPHIC SCALE IN FEET  
0 125 250 500



Existing Runoff

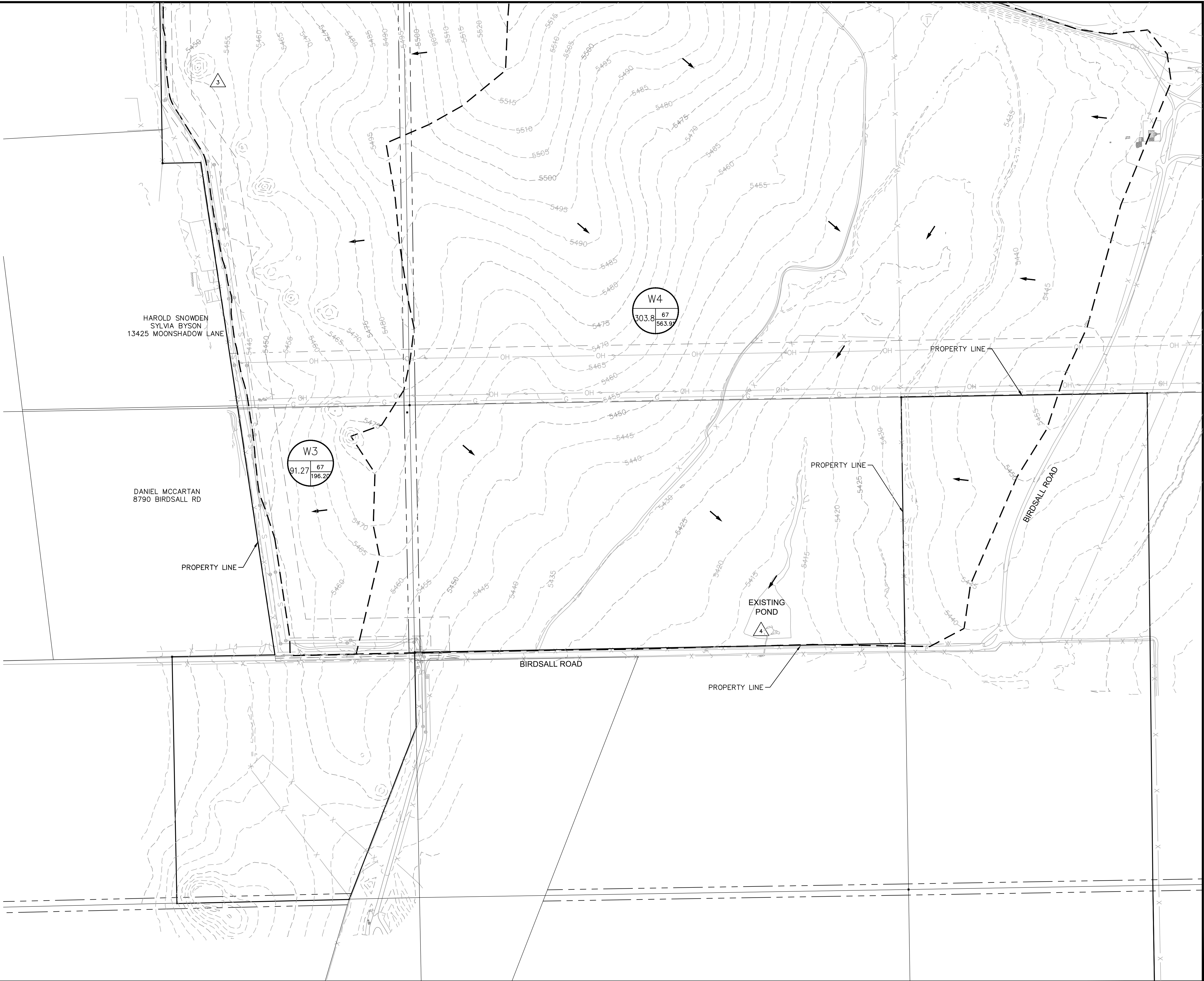
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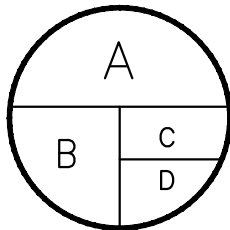
STING DRAINAGE MAP



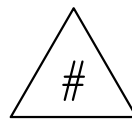


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LEGEND



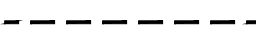
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- FLOW DIRECTION



- DRAINAGE BASIN BOUNDARY



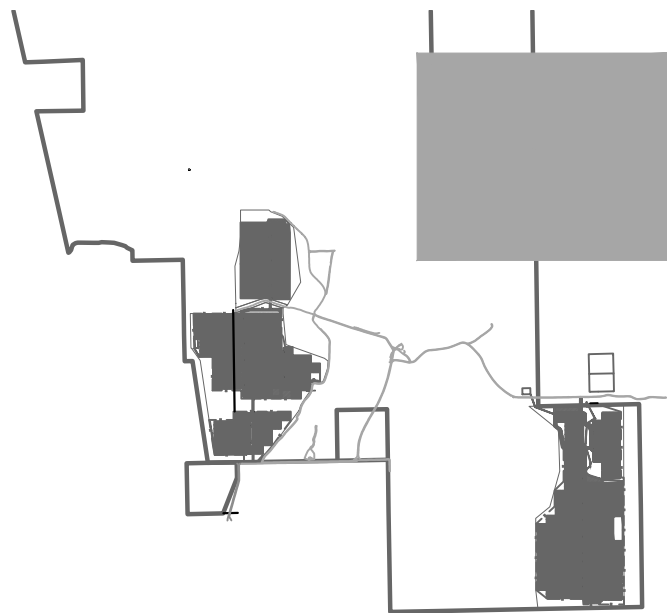
- EXISTING MAJOR CONTOUR (25 FT)



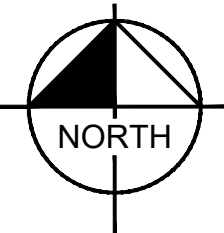
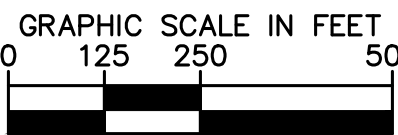
- EXISTING MINOR CONTOUR (5 FT)

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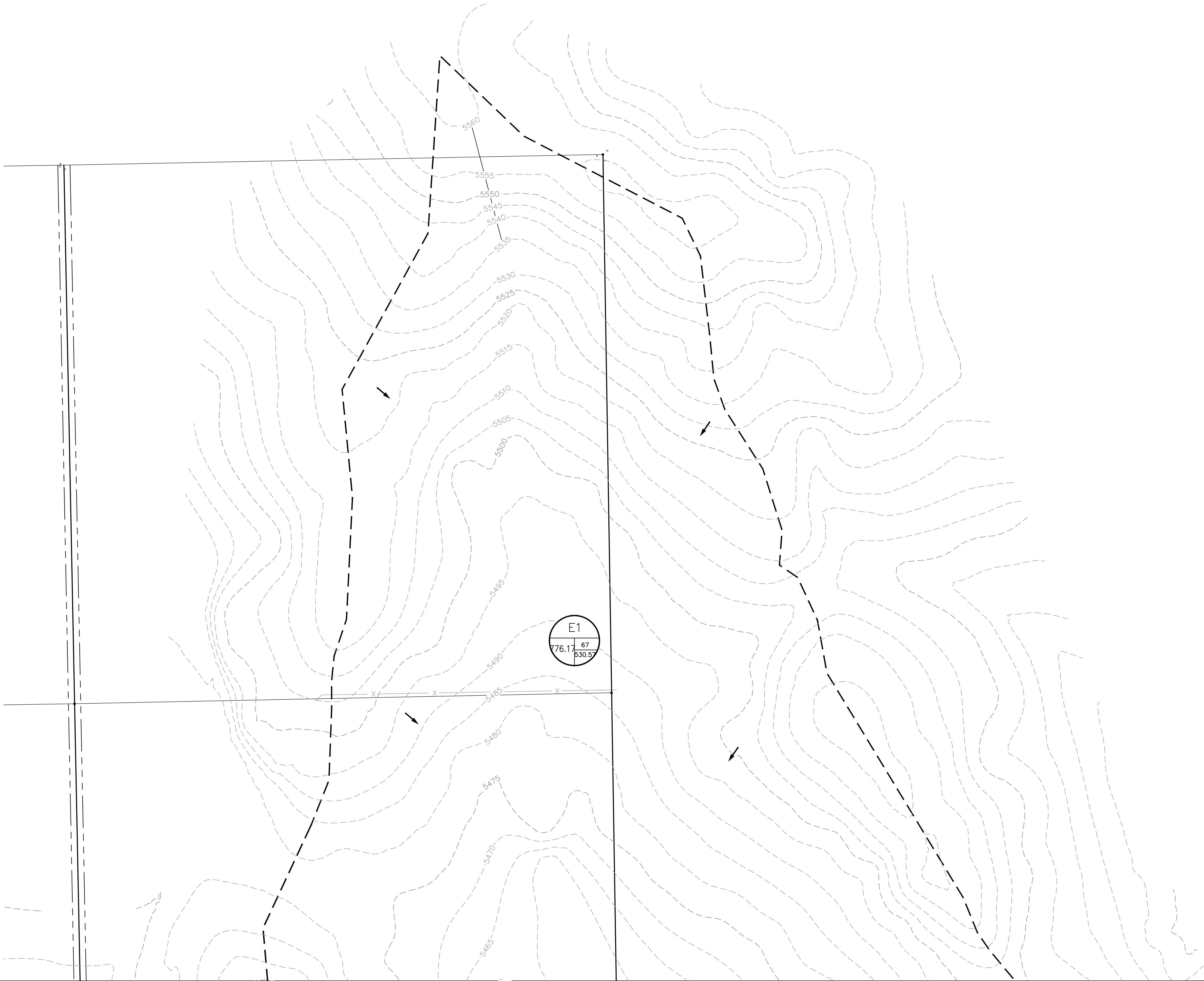
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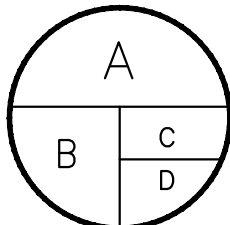
PALMER SOLAR-EXISTING DRAINAGE MAP



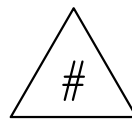


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- FLOW DIRECTION



- DRAINAGE BASIN BOUNDARY



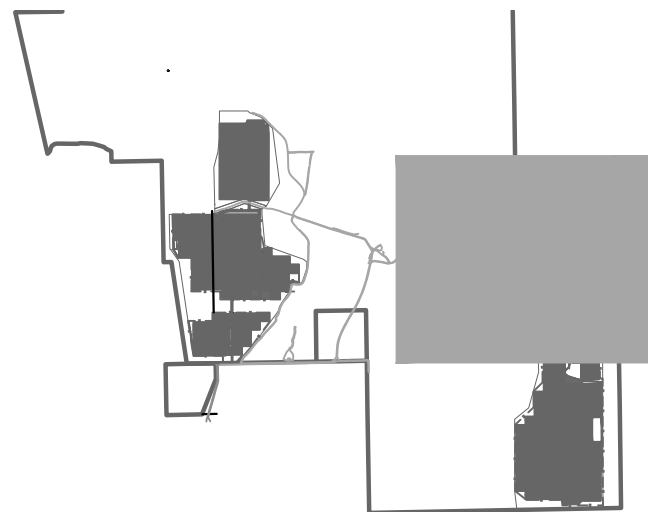
- EXISTING MAJOR CONTOUR (25 FT)



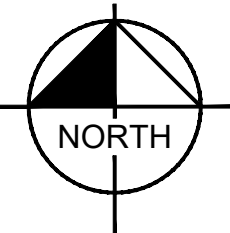
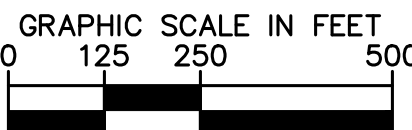
- EXISTING MINOR CONTOUR (5 FT)

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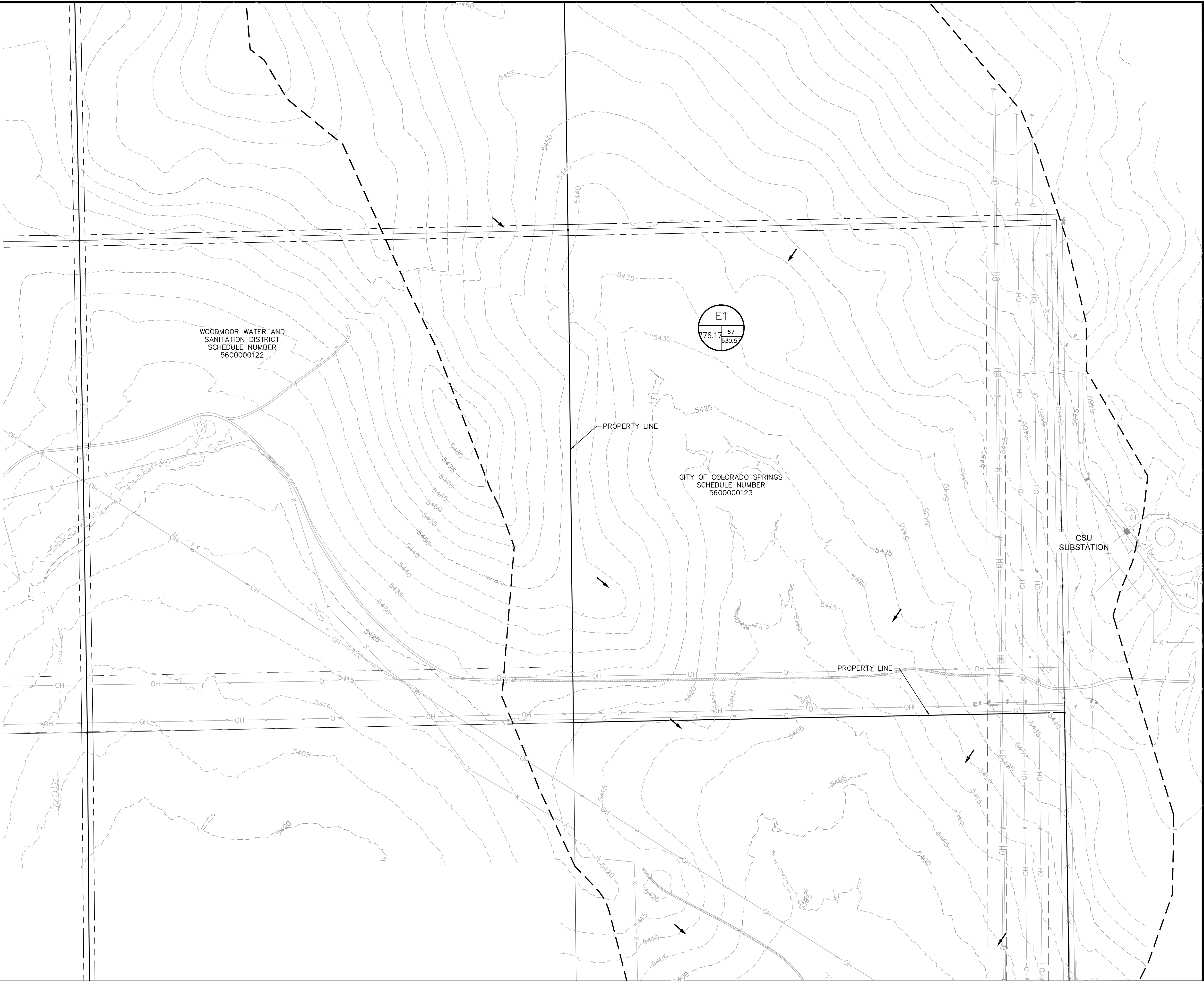
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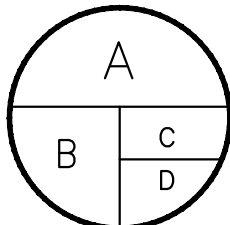
PALMER SOLAR-EXISTING DRAINAGE MAP



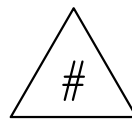


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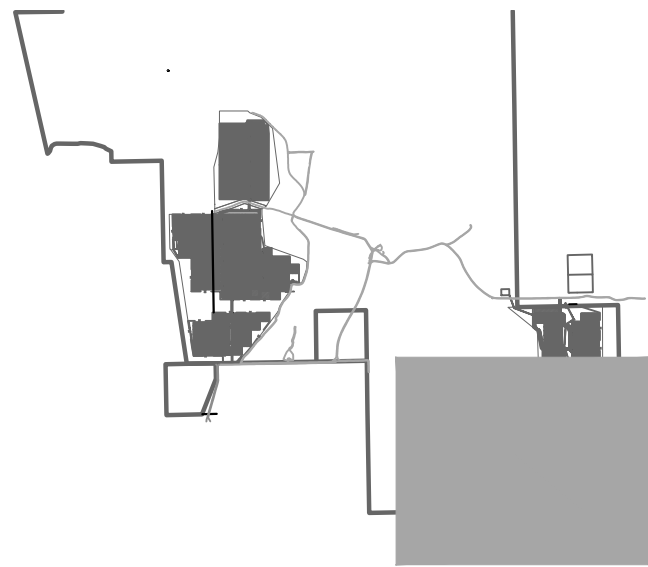
- DRAINAGE BASIN BOUNDARY

- - - - - EXISTING MAJOR CONTOUR (25 FT)

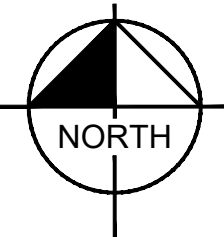
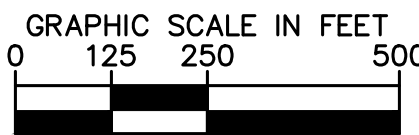
- - - - - EXISTING MINOR CONTOUR (5 FT)

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KEYMAP



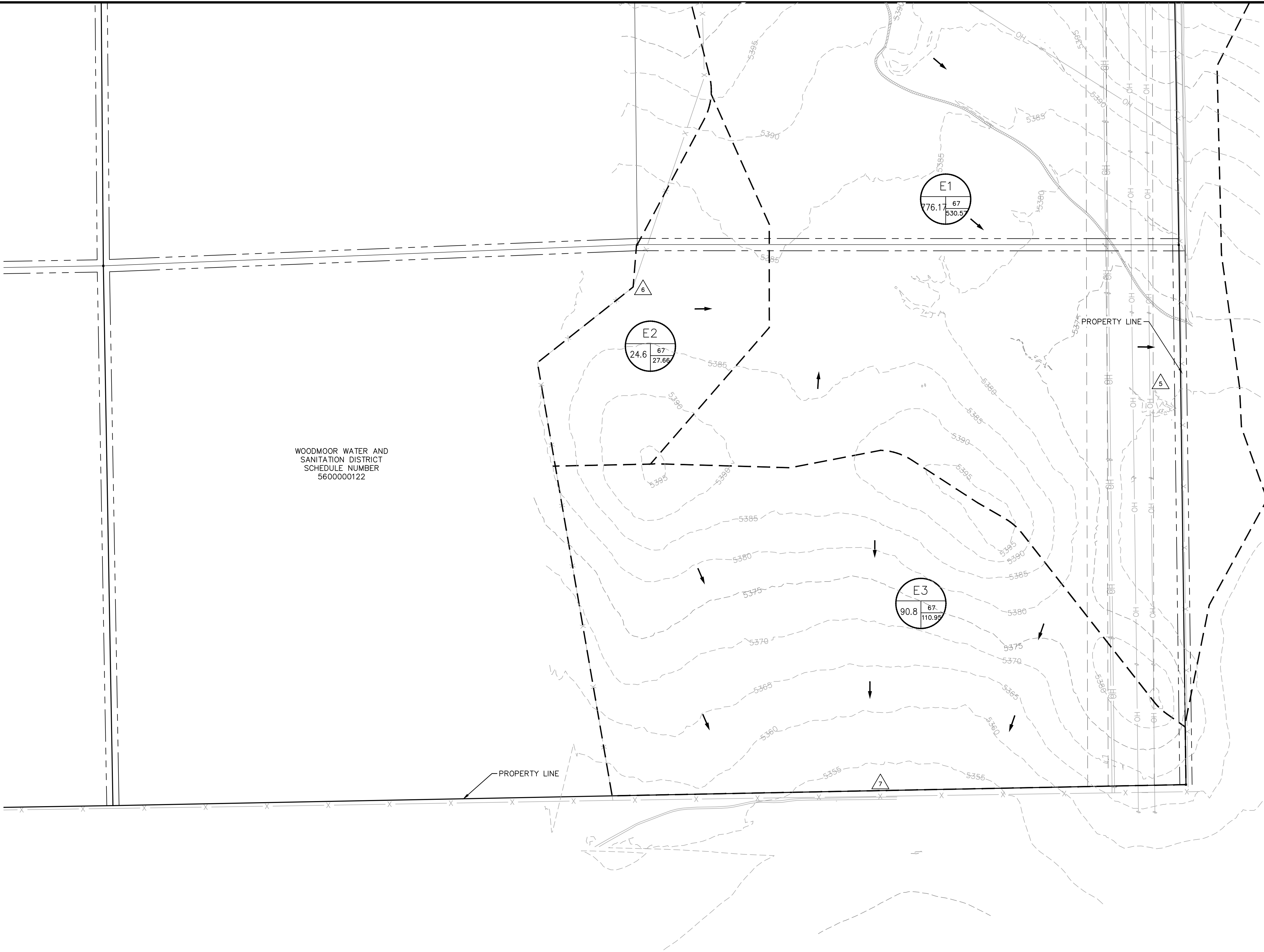
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PALMER SOLAR-EXISTING DRAINAGE MAP





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→

FLOW DIRECTION

-----

DRAINAGE BASIN BOUNDARY

→

EMERGENCY OVERFLOW PATH

-----

PROPOSED MAJOR CONTOUR

-----

PROPOSED MINOR CONTOUR

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EXISTING MAJOR CONTOUR

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EXISTING MINOR CONTOUR

→

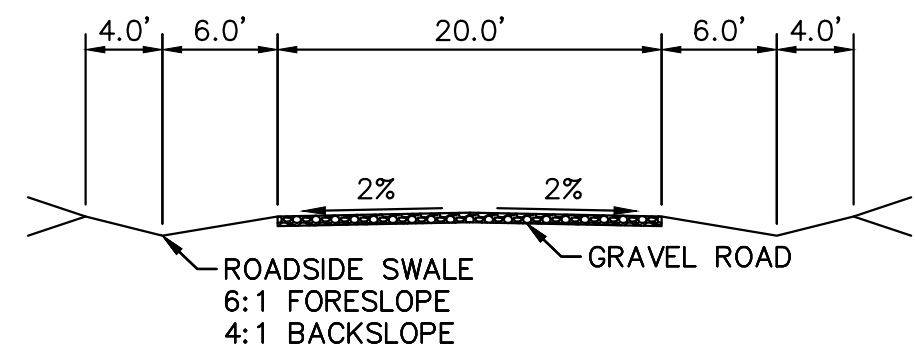
ROADSIDE SWALE/DITCH

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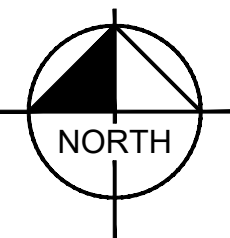
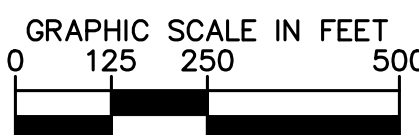
PROPOSED CULVERT

Proposed Runoff			
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E3	24.35	5.98	27.66
E4	59.88	13.08	60.65
E5	90.83	27.13	117.15
TOTAL	1532.58	413.98	1782.50

TYPICAL ACCESS ROAD SECTION



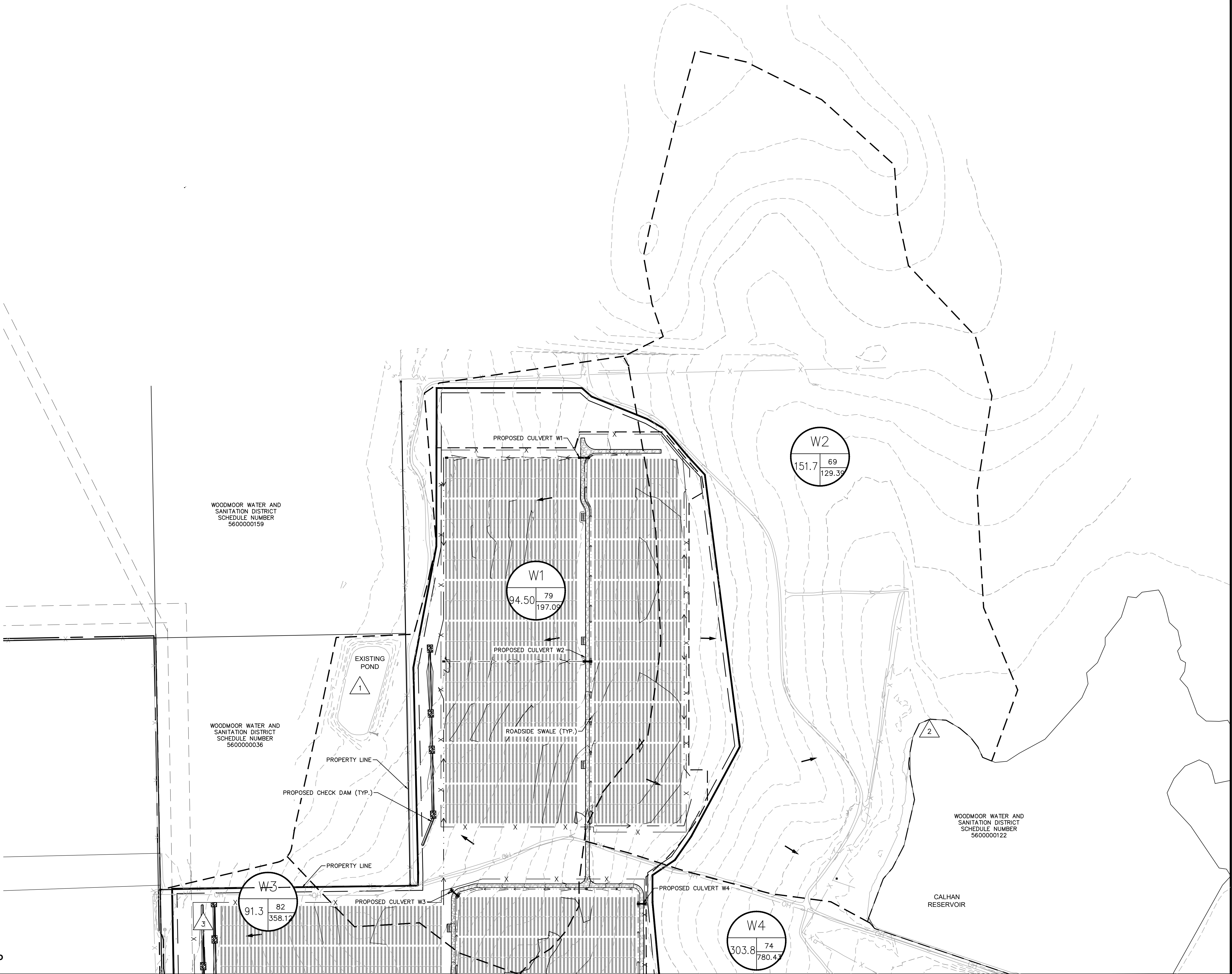
KEYMAP



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PALMER SOLAR-PROPOSED DRAINAGE MAP









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B

C

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#

# = DESIGN POINT

→

FLOW DIRECTION

-----

DRAINAGE BASIN BOUNDARY

→

EMERGENCY OVERFLOW PATH

-----XXXX-----

PROPOSED MAJOR CONTOUR

-----XXXX-----

PROPOSED MINOR CONTOUR

-----XXXX-----

EXISTING MAJOR CONTOUR

-----XXXX-----

EXISTING MINOR CONTOUR

→.....

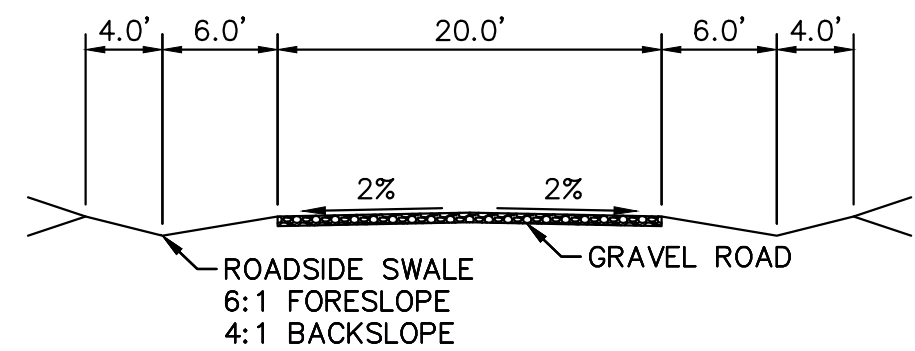
ROADSIDE SWALE/DITCH

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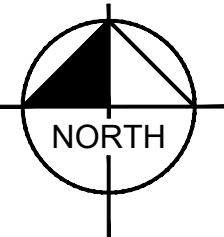
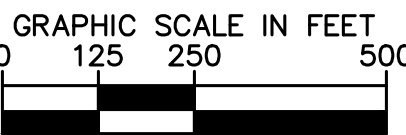
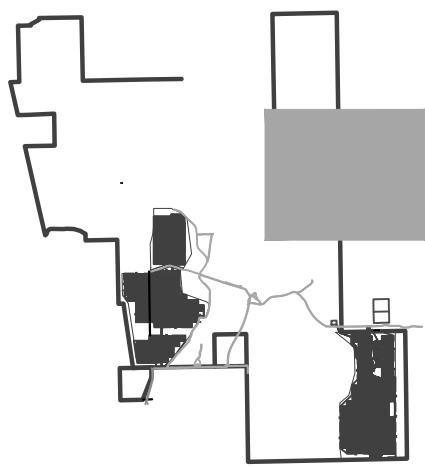
PROPOSED CULVERT

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TYPICAL ACCESS ROAD SECTION

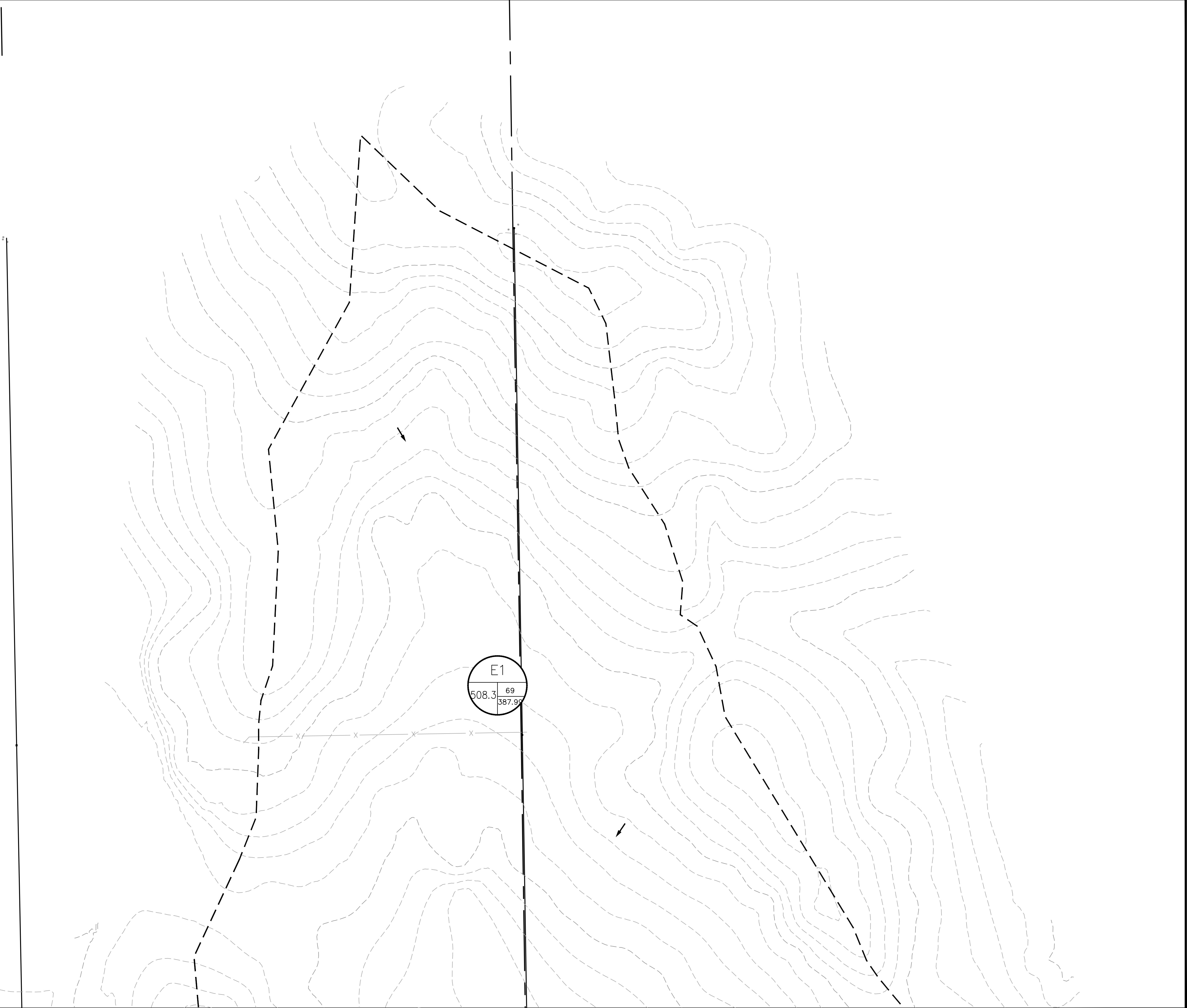


KEYMAP



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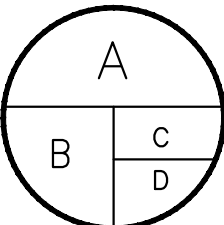
PALMER SOLAR-PROPOSED DRAINAGE MAP



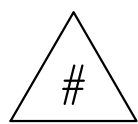


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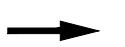
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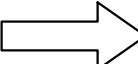
# = DESIGN POINT



FLOW DIRECTION



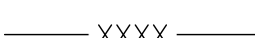
DRAINAGE BASIN BOUNDARY



EMERGENCY OVERFLOW PATH



PROPOSED MAJOR CONTOUR



PROPOSED MINOR CONTOUR



EXISTING MAJOR CONTOUR



EXISTING MINOR CONTOUR



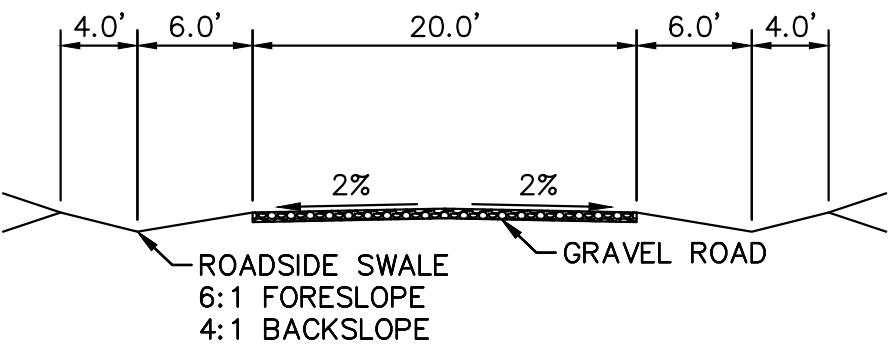
ROADSIDE SWALE/DITCH



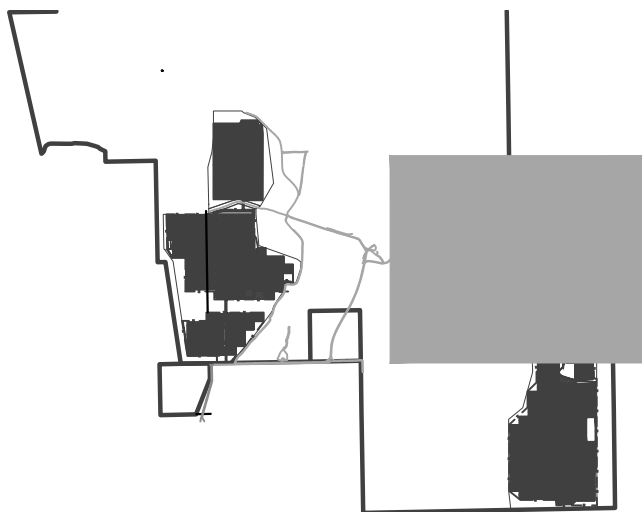
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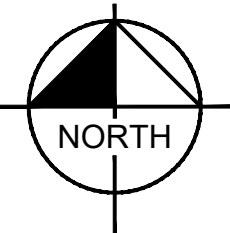
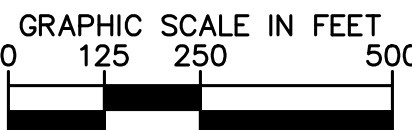
TYPICAL ACCESS ROAD SECTION



KEYMAP



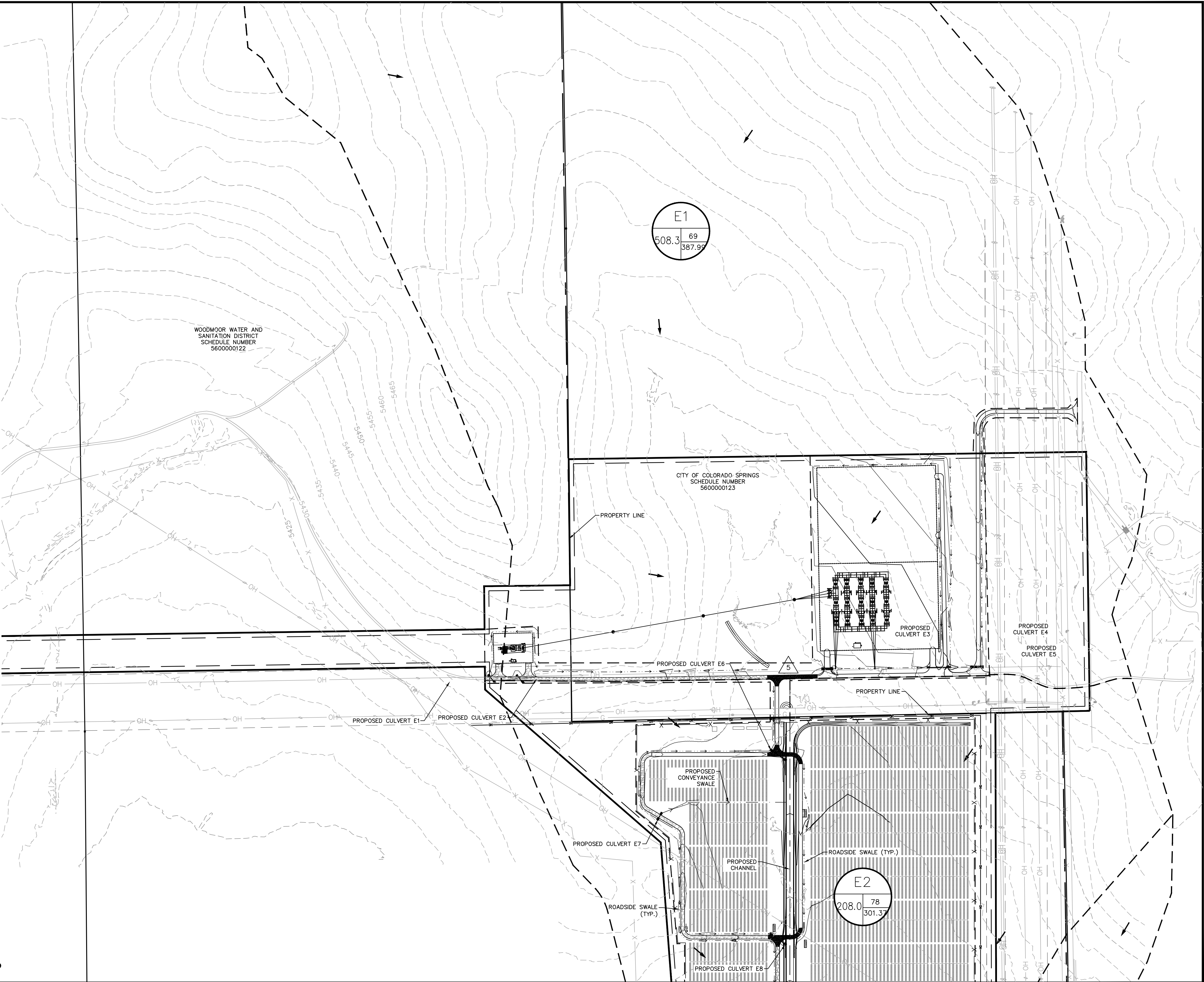
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PALMER SOLAR-PROPOSED DRAINAGE MAP





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→

FLOW DIRECTION

-----

DRAINAGE BASIN BOUNDARY

→

EMERGENCY OVERFLOW PATH

-----XXXX-----

PROPOSED MAJOR CONTOUR

-----XXXX-----

PROPOSED MINOR CONTOUR

-----XXXX-----

EXISTING MAJOR CONTOUR

-----XXXX-----

EXISTING MINOR CONTOUR

→-----

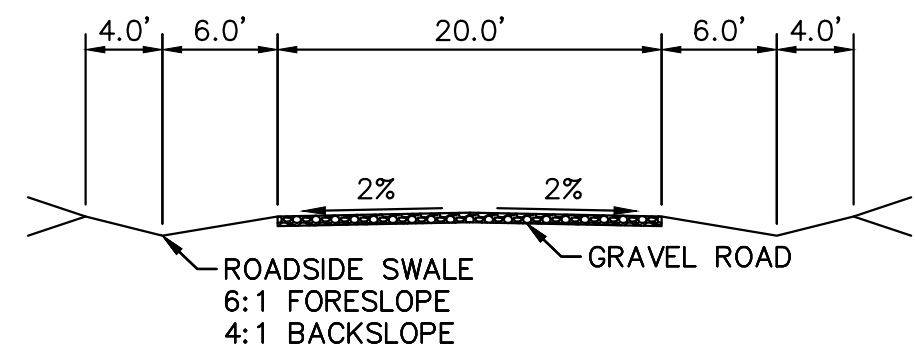
ROADSIDE SWALE/DITCH

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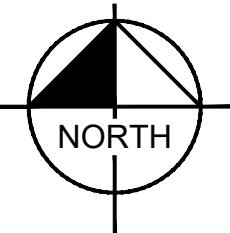
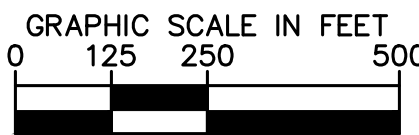
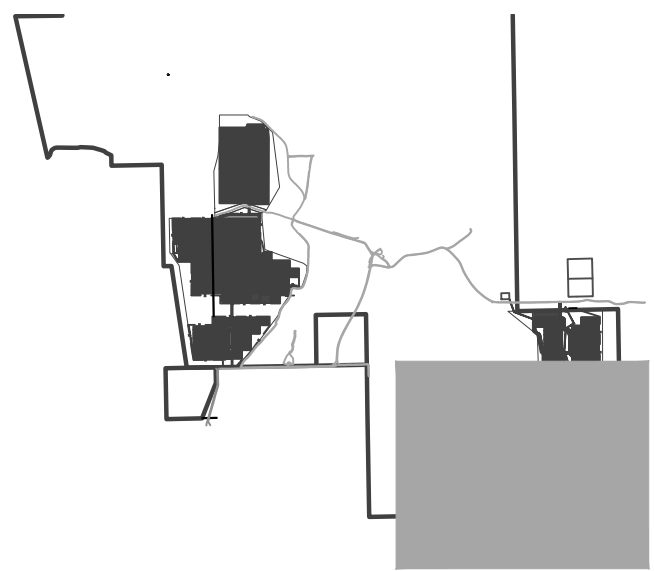
PROPOSED CULVERT

Proposed Runoff			
BASIN	BASIN AREA (ACRES)	DIRECT 5-YR RUNOFF (CFS)	DIRECT 100-YR RUNOFF (CFS)
W1	94.49	28.23	121.88
W2	151.66	25.17	115.86
W3	91.27	45.72	196.20
W4	303.81	129.49	563.91
E1	508.33	95.16	388.01
E2	207.96	44.02	191.18
E3	24.35	5.98	27.66
E4	59.88	13.08	60.65
E5	90.83	27.13	117.15
TOTAL	1532.58	413.98	1782.50

TYPICAL ACCESS ROAD SECTION

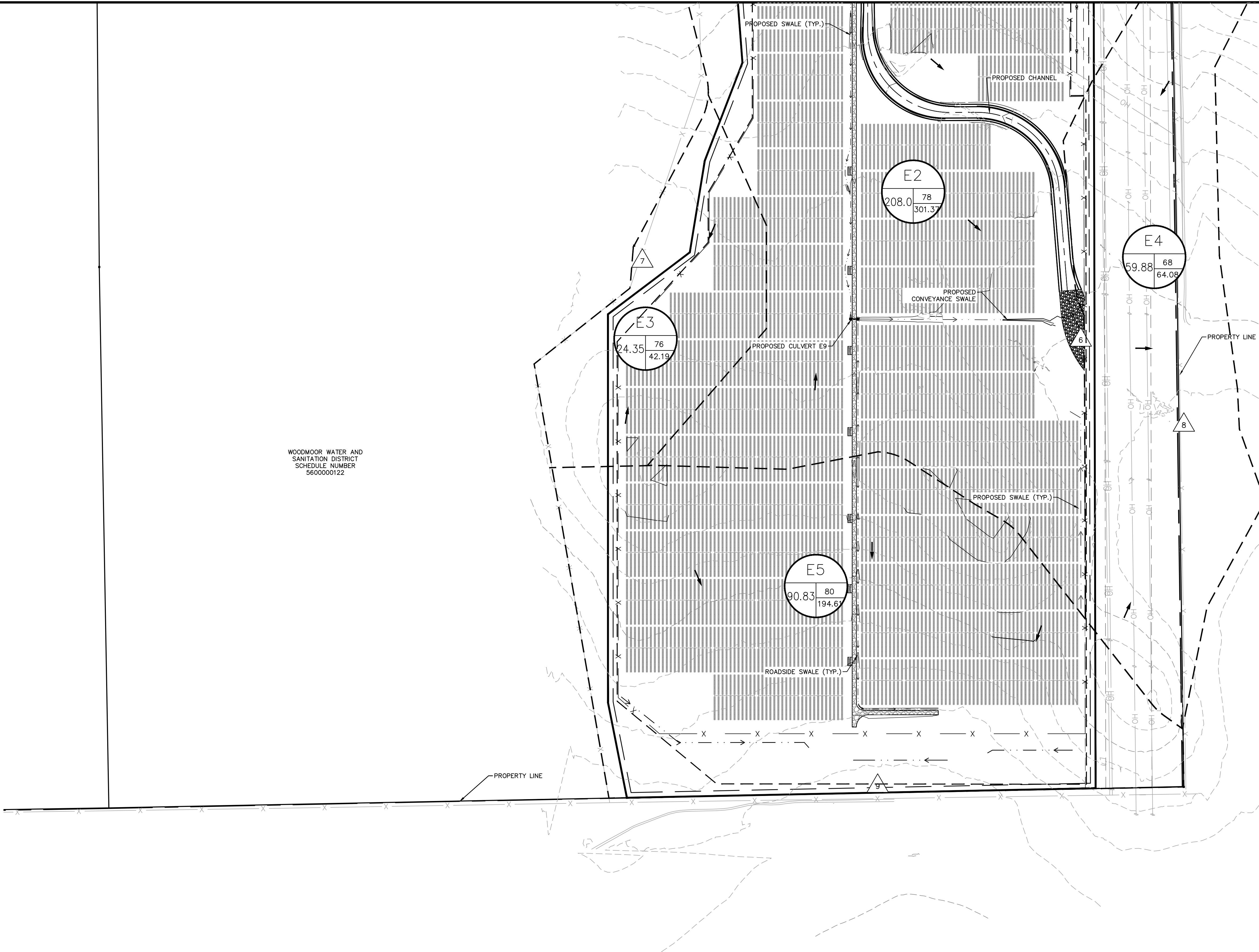


KEYMAP



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2 North Nevada Avenue, Suite 300  
Colorado Springs, Colorado 80903 (719) 453-0180

PALMER SOLAR-PROPOSED DRAINAGE MAP



***OPINION OF PROBABLE COST***



Kimley-Horn & Associates, Inc.

Opinion of Probable Construction Cost

Client: JSI Construction Group LLC	Date: 12/20/2018
Project: Palmer Solar Facility	Prepared By: JJM
KHA No.: 096495003	Checked By: EJG

No:	Sheet: 1 of 1
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Kimley-Horn & Associates, Inc. has not prepared fully engineered construction drawings for this site; therefore, the final quantities are subject to change. Additionally, the final land plan could change significantly through the development process. This OPC is not intended for basing financial decisions, or securing funding. Review all notes and assumptions. Since Kimley-Horn & Associates, Inc. has no control over the cost of labor, materials, equipment, or services furnished by others, or over methods of determining price, or over competitive bidding or market conditions, any and all opinions as to the cost herein, including but not limited to opinions as to the costs of construction materials, shall be made on the basis of experience and best available data. Kimley-Horn & Associates, Inc. cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinions on costs shown herein. The total costs and other numbers in this Opinion of Probable Cost have been rounded.

Item No.	Item Description	Quantity	Unit	Unit Price	Item Cost
	<b>Permanent BMP Costs (Private)</b>				
1	24" CMP Culvert	892	LF	\$90.00	\$80,280
2	24" Culvert End Section	40	EA	\$2,600.00	\$104,000
Subtotal:					\$184,280
Contingency (%,+/-) 10%					\$18,428
<b>Project Total:</b>					<b>\$202,708</b>

Basis for Cost Projection:

- ☐ No Design Completed  
☐ Preliminary Design  
☒ Final Design

Design Engineer:

*Eric J. Gunderson*

Eric J. Gunderson  
Registered Professional Engineer, State of Colorado No. 49487

