Final Drainage Report

For

Canyon Creek Ranch

April, 2022

Prepared for:

Gregg Cawfield
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Colorado Springs, Colorado 80908

Prepared by:

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Job No: 2021-5

TABLE OF CONTENTS

APPENDIX

Certifications and Approvals

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 had been prepared according to the criteria established by El Paso 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 omission on my part in preparation this report

Signature _____ Seal
(Kenneth C. Harrison, P.E.)

Developer/Owner Statement

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

_____
(Business Name)

By: _____
(Signature) (Date)

Print Name and Title _____

Address: _____

El Paso County

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

El Paso County Engineer/ ECM Administrator

Jennifer Irvine P.E. _____
(Print name) *(Signature)*

Date: _____

Flood Plain Statement

See Section V of this report

I. REPORT PURPOSE

The purpose of this report is as follows;

a. Evaluate of offsite conditions both upstream and downstream of the project site.
b. Discuss existing offsite and onsite drainage improvements that impact the site.
c. Conduct a hydrologic analysis for both the minor and major storm events (5 year and 100 year respectively). The main purpose for the analysis of the developed conditions is to demonstrate the negligible increase in runoff.
d. Describe the physical, hydrologic and hydraulic analysis of two (2) of the four (4) ravines that will be crossed by a proposed private driveway.
e. Discuss the impacts that Kettle Creek has on the project as well as any impacts that the project has on Kettle Creek. The report will demonstrate that the impacts are minimal.
f. Locate the Kettle Creek Floodway and Floodplain Discuss and discuss any impacts.

II. GENERAL DESCRIPTION

a. General

The Project Site consists of a total of 24.65 acres. The site is to be subdivided into three (3) lots (17.054 acres) and two (2) tracts (7.60 acres). The southerly portion of the Project Site is divided into three (3) distinct parcels with each bordered on the east and west sides with deep ravines. Each ravine is vegetated with Ponderosa Pines and bushes and appear to be reasonably stable. All of the areas are also bordered on the north by Kettle Creek. These parcels are to be developed as individual residential home sites. A private driveway is to be constructed from the Creek View Lane cul-de-sac located northeast of the site. The driveway will provide access to two (2) lots, Lots 2 and 3. Lot 1 is currently accessed from Mountain View Drive located to the south .

The Project Site also includes 2 Tracts A and B. Tract A encompasses the southerly portion of Kettle Creek and its southerly bank located within the property boundaries. Tract B is a 3.28-acre parcel located in the northwest section of the Project Site. This area is characterized by steep and eroded banks of Kettle Creek and is not suitable for home construction.

b. **Location (Exhibit 1, Appendix)**

The property is located in the SW ¼ of Section 14, Township 12 South, Range 66 West of the 6th P.M., El Paso County, Colorado (*Exhibit 1, Appendix).* The project is located approximately 0.5 miles west of Milam Road, 0.3 miles east of Howells Road, and 0.8 miles north of Old Ranch Road. Currently, the only access to the Project Site is from

Mountain View Drive via a private driveway which provides access to Lot 1.

The other two (2) lots are to be accessed from a private driveway which is to be constructed from the Creek View cul-de-sac in the Kettle Creek Subdivision to the approximate center of Lot 2. The driveway is to be constructed in the 60' access easement located between the Creek View Drive cul de sac and the easterly property line of the project site (*Exhibit 1, Appendix).*

c. Geographic Features

The main geographic features consist of Kettle Creek and the four (4) deep ravines that routes storm water from properties south of the project site to Kettle Creek. The average depth of depth from the high bank along Kettle Creek to the water level varies from 30 to 45 feet. Kettle Creek is heavily vegetated with only minimal signs of erosion. These ravines are shown as Ravine 1 through 4 on the attached Drainage Map (*Exhibit 9 and 10, Appendix*). The slope from the **offsite** sub basins (Sub basins OS1 through OS7) is between 4 and 6 percent. The average slope from the **onsite** sub basins is approximately the same. The average slope of the ravines is approximately 4 to 6 percent. All of the runoff from offsite is collected by the Four (4) ravines prior to entering the project site. Only a minimal amount of storm runoff enters the project site.

d. Existing Improvements

The only existing improvements are located on Lot 1. A residential structure has been built on this lot. The location of the structure is shown on the drainage plan *(Exhibit 9 and 10, Appendix).* The improvement consists of a residential structure with the associated driveway and out buildings. There are no utilities except for those installed to the residence. There are no channels improvement's in either Kettle Creek or in the ravines that cross the property.

e. Adjacent Properties (see Drainage Maps this report)

Properties that are adjacent to the Project Site include the following:

- East of and adjacent:: Kettle Creek Subdivision.
- South of and adjacent: unplatted large acre residential parcels
- West of and adjacent: unplatted large acre residential parcels
- North of and adjacent: Kettle Creek.

III. DESIGN CRITERIA AND METHODOLOGY

a. Design Manuals

Applicable excerpts from the following manuals are included in the Appendix of this report (*Exhibit 4 and 5, Appendix*)

- El Paso County Drainage Criteria Manual (EPCDCM), dated September 30, 1990, Revised July, 2019 when using the Rational Method to determine runoff.
- Colorado Springs Drainage Criteria Manuals, Volume 1 and 2, dated May, 2014 when using the Rational Method to determine runoff.
- Urban Drainage and Flood Control Manual, Volumes 2 and 3, dated August 2018
- TR55 manual when using the TR55 method for determining runoff.

b. Design Storms

- Minor storm: 5 year
- Major storm: 100 year

c. Drainage Areas

Areas for the offsite and onsite sub basins were estimated from available topographic mapping obtained from El Paso County and the Colorado Springs Utilities.

d. Runoff Estimation

Rational Method *(Exhibit 4, Appendix)*
This method was used to determine runoff estimates for areas less than 130 acres. Runoff coefficients and Rainfall Intensities were obtained from the appropriate tables in the El Paso County and City of Colorado Springs Drainage Criteria Manuals. Included in the Appendix are copies of the tables and charts used in this report

- TR55 (*Exhibit 5, Appendix)*
  This method was used to determine runoff estimates from sub basins or combinations of drainage sub basins, with areas greater than 130 acres (per criteria). Included in the Appendix are copies of the tables and charts used in this report

- FEMA Data *(Exhibit 2, Appendix)*
  Data used by FEMA in the preparation of the FIRM maps was obtained to verify the parameters and assumptions used in this report to establish runoff and water surface elevations.

e. Culverts

- Five (5) culverts are proposed for the project. Two (2) are located in Ravine 1 and 2 where the proposed driveway is to cross. The other culverts are to be installed under the proposed driveway at approximate locations shown on the drainage plan. It is expected that a substantial amount of embankment will be required for the driveway crossing due to the depth of the ravines.
- Erosion Control will be provided at the culvert outlets, in roadside borrow ditches, and at locations where the borrow diches enter the Ravines.
- The types of structures at the upstream and downstream ends of each culvert will be determined upon final design of the proposed driveway.

f. Erosion control

It is anticipated that erosion control will be a significant issue due to the amount of sand in the soil. Specific design of the facilities is to be completed once the final location of the driveway once is determined.

It is anticipated that the final erosion control devises will be required/ recommended:

- Seeding and erosion control blankets
- Riprap aprons
- Silt fences
- Staked hay bales
- Erosion control fabric
- Erosion control logs.

The locations of the above facilities will be shown on a Grading and Erosion Control Plan to be prepared at a future date.

IV. EXISTING REPORTS, MAPPING AND INFORMATION

a) Mapping

Topographic mapping was obtained from the GIS Division of El Paso County. The approximate locations of the surrounding parcels were inserted from information obtained from Colorado Springs Utilities (CSU). It is understood that the mapping is only general in nature and therefore is not suitable for the preparation of construction drawings.

b) Surrounding Parcels

The majority of the properties surrounding the Project Site are composed of large acreage tracts that have not been platted. The only platted subdivision, Kettle Creek Subdivision, is located to the east of the Project Site. The plat

was recorded in 1966. A Final Drainage Report was not required for these properties.

c) Kettle Creek Drainage Basin Planning Study
A DBPS was prepared by JR Engineering with the pertinent exhibits included in *Exhibit 6 of the Appendix*.

V. FEMA FLOODPLAIN

The project site is located in FEMA map # (Map 08041CO295G and 08041CO315G. dated 12/7/2018) *(Exhibit 2, Appendix)*.
The majority of the site is located outside the 100-year floodplain in Zone X which is an "Area of Minimal Disturbance" for which there are no special requirements for the construction of commercial or industrial structures. The floodplain extends into at each of the ravines. As a result, a backwater effect will be created. This will be discussed in this report.

VI. HYDROLOGIC SOILS INFORMATION

Geotechnical Studies
The hydrologic soils groups were obtained from the USDA National Resource Conservation Service website for soils types in El Paso County, Colorado (*Appendix, Exhibit 3*). The soils have the following characteristics:

a. **Kettle gravelly loam sand**:
   i. Excessively drained
   ii. Frequency of flooding: none
   iii. Frequency of ponding: none
   iv. Hydrologic Soil Group: B

VII. RUNOFF CHARACTERISTICS FOR EXISTING OFFSITE AREAS

a. General Description
The **offsite** drainage area consists of a total of 421.2 acres. The area slopes from the southeast to the northwest at an average slope of 4%. The area is developed as large acreage homesites. The drainage area extends from Kettle Creek to approximately 2,800 feet southeast of Milam Road. The southerly boundary of the drainage area is approximately 1,200 feet north of Old Ranch Road. The majority of the runoff from the offsite areas enters three (3) ravines that cross the project site and outfall into Kettle Creek. A minimal amount of runoff actually crosses the project site via sheet flow.

b. Ravine Descriptions
There are three (3) ravines that enter the site from the southeast and outfall into Kettle Creek. Each ravine accommodates the majority of the runoff from offsite basins. Only a minimal amount of offsite surface runoff enters the project site. A driveway is to be constructed from the cul-de-sac at the west

end of Creek View Road to about the middle of Lot 2. This will require the crossing of ravines 1 and 2. Runoff values for both the 5-year and 100-year storm will be determined for these ravines in order to size culverts.

- **Ravine 1** is located approximately 100 feet west of the Creek View Lane cul-de-sac. It enters the project site at DP2 and outfalls into Kettle Creek at DP3. The ravine is approximately 20-feet deep at the proposed driveway crossing and 30 feet deep at the outfall into Kettle Creek. The side slopes are approximately 1.5 to 1. The ravine accommodates runoff from OS1 (34.69 acres), OS2 (179.08 acres), and OS3 (18.4 acres) and sub basin A (1.96 acres) for a total of approximately 232.17 acres.

- **Ravine 2** crosses the project site on the west side of Lot 2 and the east side of Lot 1. The ravine enters the Project Site at DP4 and outfalls into Kettle Creek at DP5. It is located approximately 400 feet west of Ravine 1. This ravine extends to the south approximately 400 feet into the offsite drainage areas. The ravine is approximately 35-feet deep at the proposed driveway crossing and 45-feet deep at the outfall into Kettle Creek. The side slopes are approximately 1.5 to 1. It accommodates runoff from offsite basin OS4 (1.39 acres), onsite sub basin OS8 (1.08 acres), onsite sub basin B (3.04 acres), for a total of approximately 5.51 acres.

- **Ravine 3** is the deepest ravine that crosses the project site. It is located on the west side of Lot 2 and on the east side of Lot 3. The ravine enters the Project Site at DP6 and outfalls into Kettle Creek at DP7. It is located approximately 425 feet west of Ravine 2. It extends approximately 1,450 feet into the offsite areas located south of the project site. It is approximately 45- feet deep at the outfall into Kettle Creek. No driveway crossing of Ravine 3 is proposed at this time. The side slopes are approximately 1.5 to 1. It accommodates runoff from OS5 (91.16 acres), OS6 (73.03 acres),and Subbasin D (4.57 acres), for approximately 168.76 acres.

VIII. RUNOFF CHARACTERISTICS FOR OFFSITE BASINS

a. General

The Rational Method was used to estimate runoff from acreage less than 130 acres. The TR55 method was used to determine runoff from areas greater than 130 acres. The following is a description of the various components of each method. The calculations for the **hydrology** are in *Exhibit 7 of the Appendix.* The calculations for the **hydraulic** characteristics are in *Exhibit 8 of the Appendix*.

b. **Rational Method** *(Exhibit 4, Appendix).*

1. Runoff Coefficient: values were obtained from Table 6.2 of the El Paso County DCM
2. Time of Concentration: determined by combining the Initial overland flow, the shallow concentrated flow, and the channel flow. The formulas provided in the El Paso County DCM were used to determine these values.
3. Rainfall: rainfall rates for a specific time of concentration were obtained from Figure 6-5 of the El Paso County DCM.

c. **TR55** ***(Exhibit 5, Appendix)***

1. Runoff Curve Number: The runoff curve number was selected from Table 2-2a of the TR55.
2. Rainfall: The 24-hr. value was obtained from Table 6-2 of the Colorado Springs manual.
3. Rainfall Distribution: Type II
4. Direct Runoff: This value was obtained from Figure 2.1 of the TR55 manual
5. Time of Concentration: this was determined by combining the initial overland flow, the shallow concentrated Flow, and the channel flow. The formulas provided in the El Paso County DCM were used to determine these values
6. Initial Abstraction: These values were obtained from Table 5-1 of the TR55 manual.
7. Unit Peak Discharge: These values were obtained from Exhibit 4-11 of the TR55 manual.

d. **Design Point 1 and 2**

The following is a summary of the hydrologic and hydraulic characteristics for **offsite basins only**. A summary of the hydrologic and hydraulic characteristics for the **onsite basins** is included in Section 9 of this report.

1. **Drainage Area:**
   DP1 is located at the junction of two (2) offsite swales (S1, S2, that collect runoff from OS1, OS2, and OS3. DP2 is located where Swale 1 enters the project site from the southeast. Almost all of the runoff from the offsite basins is collected by ravine 1.

e. **Design Point 4**

1. **Drainage Area:**
   Only a negligible amount of runoff from offsite basin OS4 enters the project site at this DP. The majority of the runoff is generated from **Onsite** Subbasins B. The hydrologic and hydraulic properties of this onsite sub basin is summarized in subsequent sections of this report.

f. Design Point 6

1. Drainage Area:

DP6 is located where runoff from OS5, and OS6, enters the project site from the south. Only a negligible of surface runoff enters the project site DP4.

g. Design Point 8

DP8 is located at the northwest corner of Lot 3 and the southeast corner of Tract B. Runoff from OS7 is collected by Ravine 4 and is routed to Kettle Creek at DP8 and DP12.

IX. RUNOFF CHARACTERISTICS FOR HISTORIC ONSITE CONDITIONS

a. Design Point 3 (Ravine 1 outfall at Kettle Creek)

- **Drainage Area**

  Runoff from offsite basins OS1, OS2, OS3 is collected in Swales 1 and 2 and combine at DP1. From there it is routed to Kettle Creek via Swale 4. Additional runoff is added from onsite basin A before the water is discharged into Kettle Creek. The total acreage drained by Swale 4 is 234.1 acres. The two (2) swales S1 and S2, combine at DP1 and then is routed through the project in Subbasin A before out falling into Kettle Creek. A 48" culvert has been placed at the location where the proposed driveway is to cross. This crossing is approximately 100 feet upstream of the outfall *(Exhibit 8, Appendix)*. The FEMA 100-year flood plain elevation at the outfall of Swale 3 is 6935 and therefore does not encroach into the site.

- **Hydrologic Summary**

  Drainage Area = 234.12 acres
  Runoff Curve #: 58
  Runoff: 5 year = 6.4 cfs, 100 year = 53.1 cfs

- **Ravine 1 Hydraulic Summary**

  Bottom Width: 30 feet
  Side Slopes: 1.5 to 1
  Depth of flow: 5 year = 0.1 feet 100 year = 0.3 feet
  Velocity: 5 year: 2.7 fps, 100 year = 6.2 fps
  Froude #: 5 year = 1.71, 100 year = 2.10 (Super critical)

- **Culvert Hydraulic Summary**

  Size: 48" (existing)
  HW to Depth: 5 yr. = neg, D = neg, 100 yr. = 0.8, 3.7 ft, D=HW = 3.7 ft
  The design of the culvert will be accomplished during the final design of the project. The depth of the ravine requires a lot of fill over the top of

the pipe. The fill is approximated at 28.1 feet. It is recommended that the side slopes of the fill be armored in some manner in order to minimize the erosion potential' The swales that are constructed on both sides of the driveway is to outfall directly into the ravine. Due to the steepness and the erodibility of the soil additional erosion protection is required. One recommendation would be buried riprap.

b. Design Point 5 (Ravine 2 Outfall at Kettle Creek)

- Drainage Area
  DP5 is located at the outfall of Ravine 2 into Kettle Creek. The drainage area consists of OS4, OS8. onsite B, and onsite C (for a total of 7.2 acres. The 100- year flood elevation at the outfall is approximately 6929. A small portion of the floodway extends into the Project Site

- Hydrologic Summary (Rational)
  Drainage Area = 12.2 acres
  Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
  Runoff: 5 year = 1.7 cfs, 100 year = 12.5 cfs

- Hydraulic Summary
  Ravine 2
  Bottom Width: 30 feet
  Slope: 4%
  Side Slopes: 1.5 to 1
  Depth of flow: 5 year = neg, 100 year = 0.1 feet
  Velocity: 5 year: 1.3 fps, 100 year = 0.3.0 fps
  Froude #: 5-year = 1.25, 100 year = 1.67

- Culvert Hydraulic Summary
  Size: 24" (proposed0
  HW to Depth: 5 yr.= neg, 100 yr.1.0, Depth = 2.0 ft.
  The fill depth is approximated at 29.5 feet. It is recommended that the side slopes of the fill be armored in some manner in order to minimize the erosion potential.

c. Design Point 7 (Ravine 3 Outfall at Kettle Creek)

- Drainage Area
  DP7 is located at the outfall of Ravine 3 into Kettle Creek. The drainage area consists of OS5, OS6, onsite D , and onsite C for a total of 172.36 acres. The 100- year flood elevation at the outfall is approximately 6924..

- Hydrologic Summary
  Drainage Area = 172.4 acres
  Runoff Curve #: 58
  Runoff: 5 year = 5.9 cfs, 100 year = 58.7 cfs

- Hydraulic Summary
  Swale 5: Onsite
  Slope: 4%
  Bottom Width: 40 feet
  Side Slopes: 1.5 to 1
  Depth of flow: 5-year = 0.1 feet, 100-year = 0.3 feet
  Velocity: 5 year: 2.5 fps, 100 year = 6.0 fps
  Froude #: 5-year = 1.65, 100 year = 2.04

- Culvert:
  A culvert is not proposed in Ravine 7.

d. Design Point 8

- Drainage Area
  DP8 is located along the southerly bank of Kettle Creek. The majority of the runoff is collected by numerous swales and wash-outs along the south bank of Kettle Creek. The drainage sub basins include onsite sub basins OS7 (1.55 acres), F (4.81), G (1.57) for a total of 7.93 acres.

- Hydraulic Summary
  All of the runoff for this DP outfalls into Kettle Creek per various small "washouts" along the southerly bank of Kettle Creek. The following is shown for information purposes since there is no clearly defined outfalls into Kettle Cr3eek.
  Drainage Area = 7.93 acres
  Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
  Runoff: 5 year = 1.5 cfs, 100 year = 11.5 cfs

e. Design Point 9

- Drainage Area
  DP9 is located along the southerly bank of Kettle Creek at the westerly end of the project site. The majority of the runoff is collected by numerous swales and wash-outs along the south bank of Kettle Creek. The drainage sub basins include sub basins H (5.54 acres) for a total drainage area of 5.54 acres.

- Hydraulic Summary
  The following is shown for information purposes since there is no clearly Drainage Area = 5.54 acres
  Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
  Runoff: 5 year = 2.3 cfs, 100 year = 16.8 cfs

X. RUNOFF CHARACTERISTICS FOR DEVELOPED CONDITIONS FOR ONSITE AREA.

Improvements for the project included the following:

- Main gravel driveway along the project site's northerly property line
  Width: 24 feet
  Average Length: 450'
  TR55 Curve Number 85

  Driveway to each residential location.
  Width: 20 feet
  Average Length: 400 feet
  TR55 Curve Number 85

- Residence roof area: 7,500 square feet
  TR55 Curve Number 85

- Landscaping was assumed to be approximately 0.2 acre.
  TR55 Curve Number 85

A composite CN was determined by included the above in the TR55 entry sheet. There is barely an increase in either the 5 year or 100-year runoff amounts.

XI ENVIRONMENTAL CONSIDERATIONS

A copy of this report will be sent to Colorado State Fish and Wildlife (CSFW) for their review and clearance.

XII. DETENTION AND WATER QUALITY

El Paso County Engineering Criteria Manual, Appendix I, contains the policies and procedures for Stormwater Quality. **Section I.7.1.B** provides for exclusions to the requirements to provide Post Construction Stormwater Quality facilities. All areas of the **Canyon Estates** project qualify for the allowed exemptions. No water quality or detention facilities are required for this site as discussed below.

The project consists of 3 large acreage single-family residential lots and a private gravel driveway. There are no activities or improvements that require permanent water quality facilities for this project based on the exclusions found in **Section I.7.1.5.B.2, Section I.7.1.5.B.3 and Section I.7.1.5.B.5.**

According to **Section I.7.1.B.5**,

"A single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling and having a total lot impervious area of less than 10 percent is excluded."

The total area of the site is 24.65 acres The total lot imperviousness for rural residential lots is less than 10%.

Section I.7.1.B.2 of the ECM provides exclusion for Roadway Redevelopment as follows:

"Redevelopment sites for existing roadways, when 1 of the following criteria is met: 1) The site adds less than 1 acre of paved area per mile of roadway to an existing roadway, or 2) The site does not add more than 8.25 feet of paved width at any location to the existing roadway".

The project involves adding new gravel driveway from the existing cul-de-sac at the westerly end of Creek View Road.
No pavement will be added to the driveway (criteria 1).

Also, **Section I.7.1.B.3** excludes Existing Roadway Areas.

"For redevelopment sites for existing roadways, only the area of the existing roadway is excluded from the requirements of an applicable development site when the site does not increase the width by 2 times or more, on average, of the original roadway area. The *entire site is not excluded from being considered an applicable development site for this exclusion. The area of the site that is part of the added new roadway area is still an applicable development site".*

Again, the project will add a gravel surface to the private driveway which is approximately 630 feet long and 20 feet wide (0.29 acres).

Storm Detention is not required for this site since the resulting flow increases from development is found to be negligible and inconsequential as shown in the above sections.

XIII. FOUR STEP PROCESS

Even though the 4-step process is not required for this project the following are descriptions of the steps that are being taken to address the 4-step process.

a. **Large Lot Single Family Sites.**
A single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling and having a total lot impervious area of less than 10 percent. A total lot imperviousness greater than 10 percent is allowed when a study specific to the watershed and/or MS4 shows that expected soil and vegetation conditions are suitable for infiltration/filtration of the WQCV for a typical site, and the permittee accepts such study as applicable within its MS4 boundaries. The maximum total lot impervious covered under this exclusion shall be 20 percent. In accordance with section 4.0 of chapter 1 of the El Paso County ECM Appendix 1.7.1, the four-step process applies to "projects with construction activities that disturb 1 acre or greater or that disturb less than 1 acre but are part of a larger plan of development or sale". Therefore, the four-step process does not apply to this development.

b. **Step 1: Reduce runoff by disconnecting impervious area, eliminating "unnecessary" impervious area and encouraging infiltration into soils that are suitable**.
The impervious areas for the project include residences, landscaping, concrete patios, sidewalks, and the possibility of asphalt driveways. All of the runoff from the impervious areas drains onto grassed or natural wooded surfaces. All of the downspouts for each residence are planned to discharge either within landscaped areas or natural areas. The majority of the site will remain in its existing natural condition.

c. **Step 2: Treat and slowly release the WQCV.**
A Full Spectrum Water Quality Detention Pond is not required for this site and therefore does not have the WQCV component.

d. **Step 3: Stabilize stream channels.**
All existing swales will remain "as is". The vegetation for each swale includes medium height prairie grasses and small ponderosa pine trees. These area receives very little maintenance. It is not anticipated that any of the ravines will be modified in the future. It can be safely assumed that the negligible increase in flow as a result of development will have minimal negative impacts on downstream facilities.

2. **Step 4: Implement source controls.**

There are no water sources within the project limits or runoff

XIV. EROSION CONTROL

Recommended erosion control measures are to be summarized in the Storm Water Management Permit Application that is being submitted under separate cover.

XV. STORMWATER MANAGEMENT PLAN (SWMP)

a. A **SWMP** is to be submitted separately.

XVI DRAINAGE/ BRIDGE FEES

The drainage fee was determined based on a total of 24.65 acres with the development of 3 lots of greater 5 acres each. The site is located in the Kettle Creek Drainage Basin which has the following fees per each impervious acre (*Exhibit 4, Appendix):*

2021 Drainage Fee per impervious acre	$	10,666
2021 Bridge Fee per impervious acre	$	0
2021 Total Fees per impervious acre	$	10,666

Total Project Area = 24.65 acres
% Impervious = 7% per El Paso County for 5 acre lots
Impervious Area = 1.726 acres
Fee reduction for 5-acre lots = 25%; 0.4315 acres
Total Impervious area = 1.2945 acres
Total Fees = $ 13,807.14

The Drainage Fees are to be paid prior to the recording of the plat.

XVII SUMMARY

This report provides a thorough analysis of the drainage conditions for the proposed project . The property is comprisedof 24.65 acres and is located on the south side of Kettle Creek, east of Howells Road and west of Milam Road. The subdivision is to be subdivided into three (3) lots.

The vegetation consists of primarily Ponderosa Pine trees. There are three (3) main ravines that enter the site from the south that drain a considerable amount of offsite property. All of the offsite property is developed as large acreage residential home sites.

It has been demonstrated that there is only a negligible increase in runoff as a result of development. Also, based on the present engineering criteria for El PasoCounty a water quality/ detention pond is not required

Erosion control facilities include staked hay bales, erosion control check dams,and stone check dams. The location and details for these are included on the Storm Water Management Plan. Included in the map pocket is the drainage map that shows the proposed driveway.

APPENDIX

EXHIBIT 1: LOCATION MAP

62140

EL PASO COUNTY

ONE TOWNSHIP

ASSESSOR

GIS

Geographic Information System

El Paso County
Colorado

Rectangular Survey of One Section

N

December 30, 2020

SCALE OF FEET

0 100 200 400 600 800

ADJOINING 62110

ADJOINING 62000 & 62154

ADJOINING 62130

ADJOINING 62230

SHOUP RD.

LINDSEY SUB. PLAT #2312

J & J SUB. PLAT #1698

CROSSLEN LN.

TERRELL LN.

FORD DR.

LEPRECHAUN LN.

SHADY LN.

MILAM RD.

HOWELLS RD.

TIMBER LAKE ESTATES PLAT #2294

TIMBER LAKE ESTATES NO. 2 PLAT #2498

TIMBERLANE CT.

KETTLE CREEK SUB. PLAT #2692

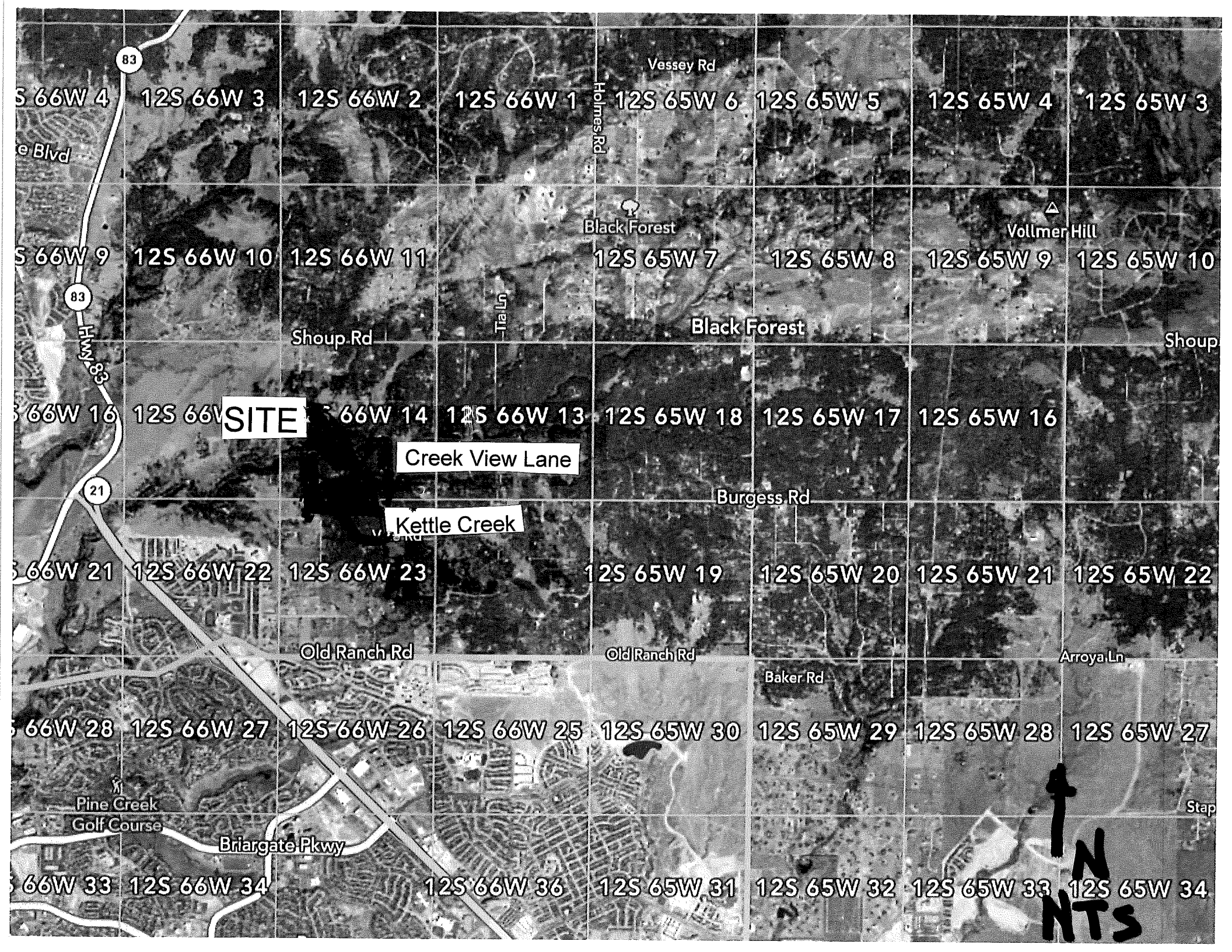
CREEK VIEW RD.

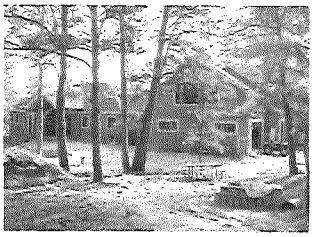
1966 1970

23.96

62140

62140001Z


83
Vessey Rd
Holmes Rd
12S 66W 4
12S 66W 3
12S 66W 2
12S 66W 1
12S 65W 6
12S 65W 5
12S 65W 4
12S 65W 3
Black Forest
Vollmer Hill
12S 66W 9
12S 66W 10
12S 66W 11
12S 65W 7
12S 65W 8
12S 65W 9
12S 65W 10
Tra Ln
Shoup Rd
Black Forest
Shoup
HWY 83
12S 66W 16
12S 66W
SITE
66W 14
12S 66W 13
12S 65W 18
12S 65W 17
12S 65W 16
Creek View Lane
21
Burgess Rd
Kettle Creek
66W 21
12S 66W 22
12S 66W 23
12S 65W 19
12S 65W 20
12S 65W 21
12S 65W 22
Old Ranch Rd
Old Ranch Rd
Arroya Ln
Baker Rd
66W 28
12S 66W 27
12S 66W 26
12S 66W 25
12S 65W 30
12S 65W 29
12S 65W 28
12S 65W 27
Pine Creek
Golf Course
Briargate Pkwy
Stap
66W 33
12S 66W 34
12S 66W 36
12S 65W 31
12S 65W 32
12S 65W 33
12S 65W 34
N
NTS



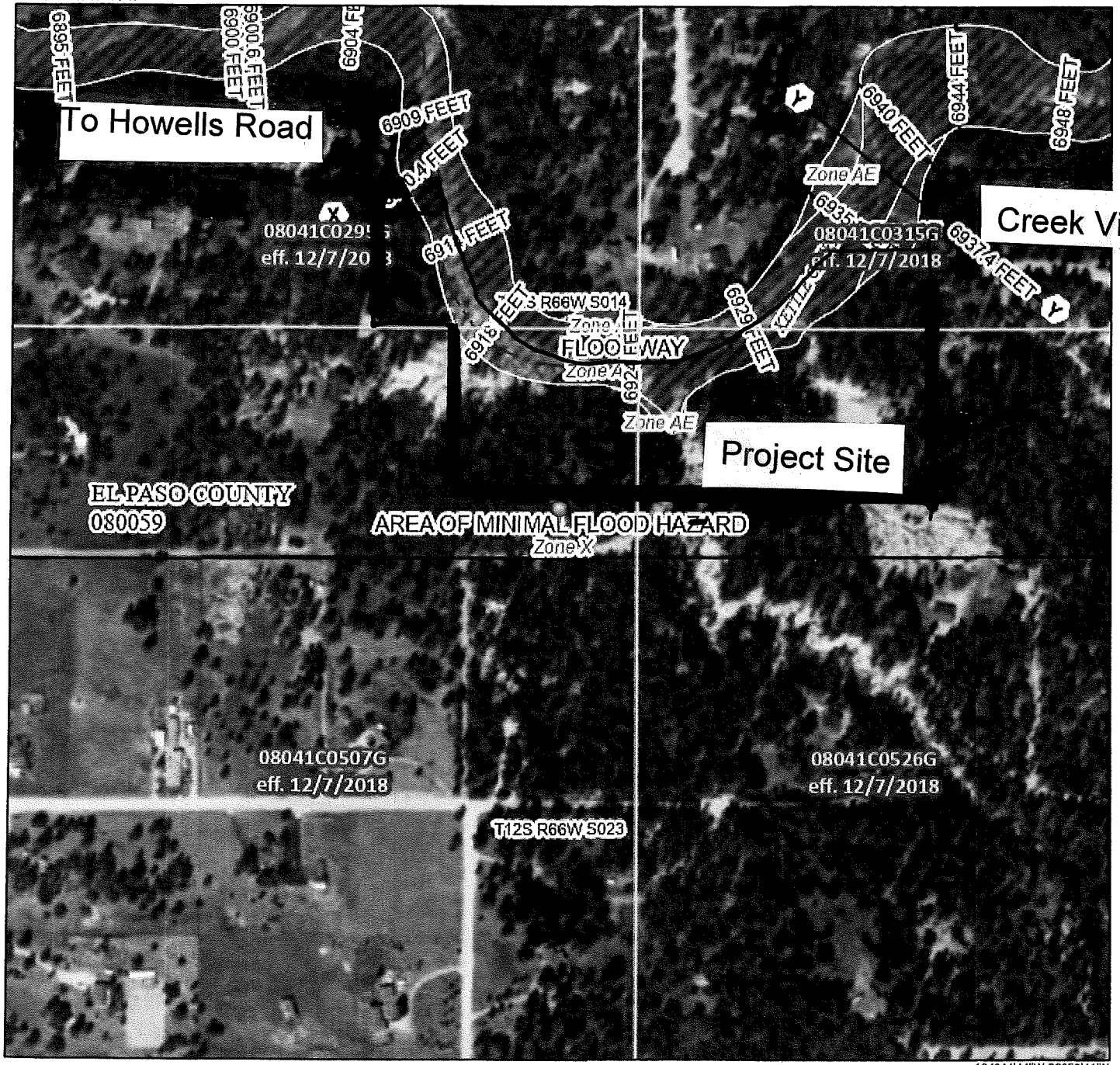
Disclaimer

We have made a good-faith effort to provide you with the most recent and most accurate information available. However, if you need to use this information in any legal or official venue, you will need to obtain official copies from the Assessor's Office. Do be aware that this data is subject to change on a daily basis. If you believe that any of this information is incorrect, please call us at (719) 520-6600.

EXHIBIT 2: FEMA FIRM MAP

National Flood Hazard Layer FIRMette

FEMA



0 250 500 1,000 1,500 2,000 Feet 1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A, V, A99*
	With BFE or Depth *Zone AE, AO, AH, VE, AR*
	Regulatory Floodway
OTHER FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
	Future Conditions 1% Annual Chance Flood Hazard *Zone X*
	Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
	Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN Area of Minimal Flood Hazard *Zone X*
	Effective LOMRs
	Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
OTHER FEATURES	20.2 Cross Sections with 1% Annual Chance
	17.5 Water Surface Elevation
	Coastal Transect
	Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
MAP PANELS	Digital Data Available
	No Digital Data Available
	Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 11/10/2021 at 12:14 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

EXHIBIT 3: SCS SOILS MAP

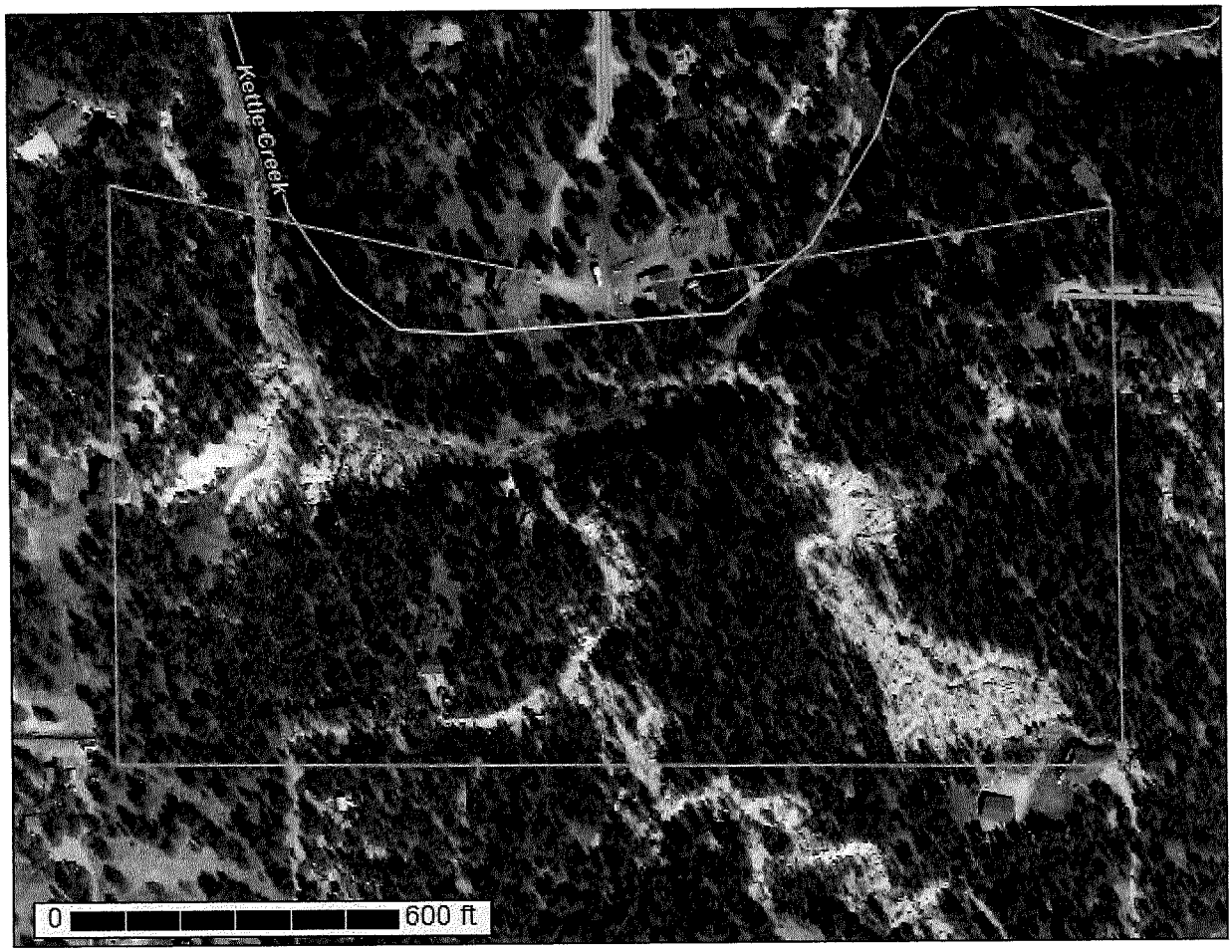
United States Department of Agriculture

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

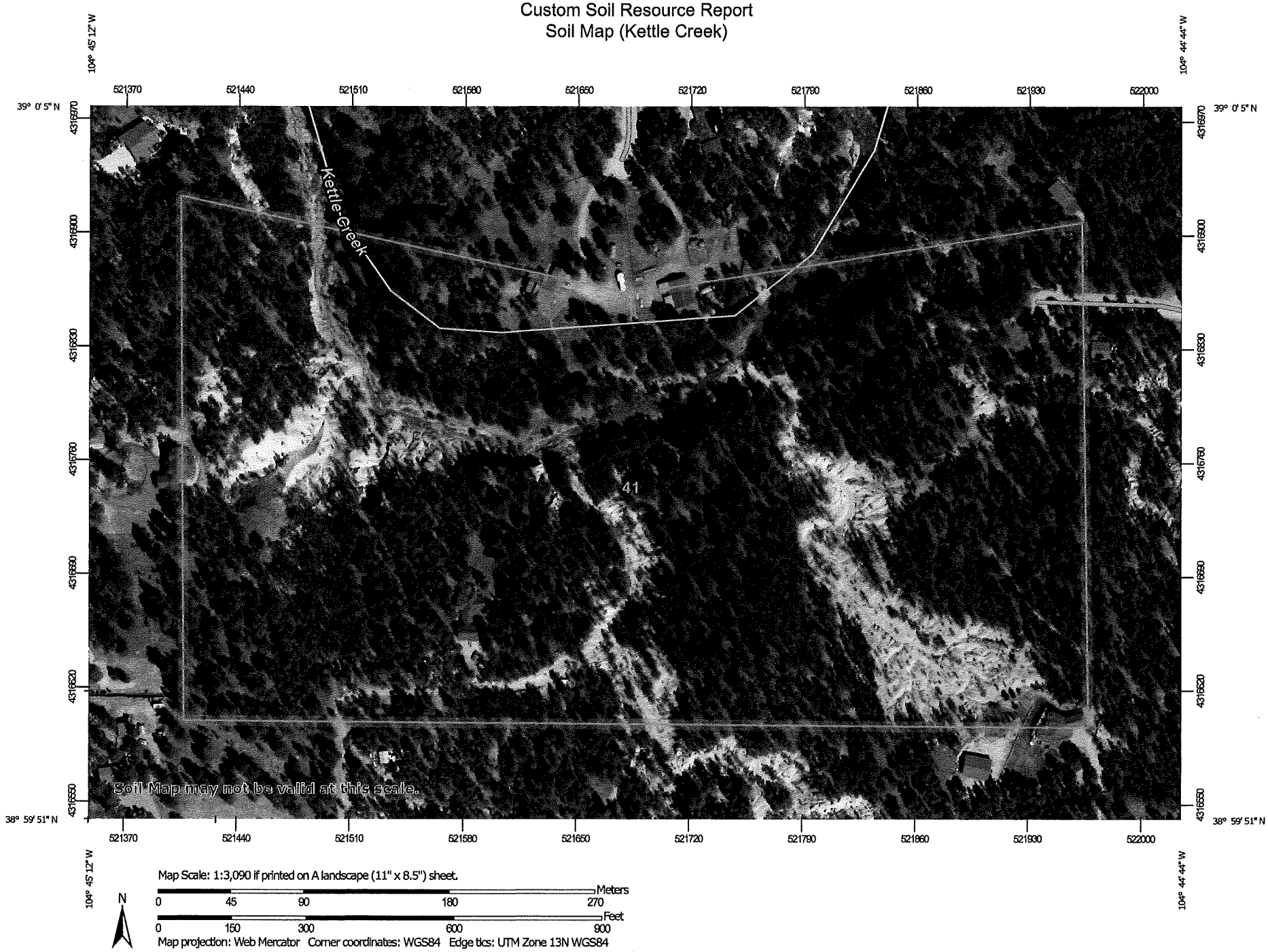


November 10, 2021

Soil Map

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 (Kettle Creek)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 19, Aug 31, 2021

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

Date(s) aerial images were photographed: Aug 19, 2018—Oct 20, 2018

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 (Kettle Creek)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
41	Kettle gravelly loamy sand, 8 to 40 percent slopes	40.4	100.0%
Totals for Area of Interest		**40.4**	**100.0%**

Map Unit Descriptions (Kettle Creek)

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

41—Kettle gravelly loamy sand, 8 to 40 percent slopes

Map Unit Setting

National map unit symbol: 368h
Elevation: 7,000 to 7,700 feet
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Kettle

Setting

Landform: Hills
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy alluvium derived from arkose

Typical profile

E - 0 to 16 inches: gravelly loamy sand
Bt - 16 to 40 inches: gravelly sandy loam
C - 40 to 60 inches: extremely gravelly loamy sand

Properties and qualities

Slope: 8 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Minor Components

Pleasant

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

Other soils

Percent of map unit:
Hydric soil rating: No

EXHIBIT 4: CHARTS AND TABLES FOR RATIONAL METHOD

Table 6-6. Runoff Coefficients for Rational Method
(Source: UDFCD 2001)

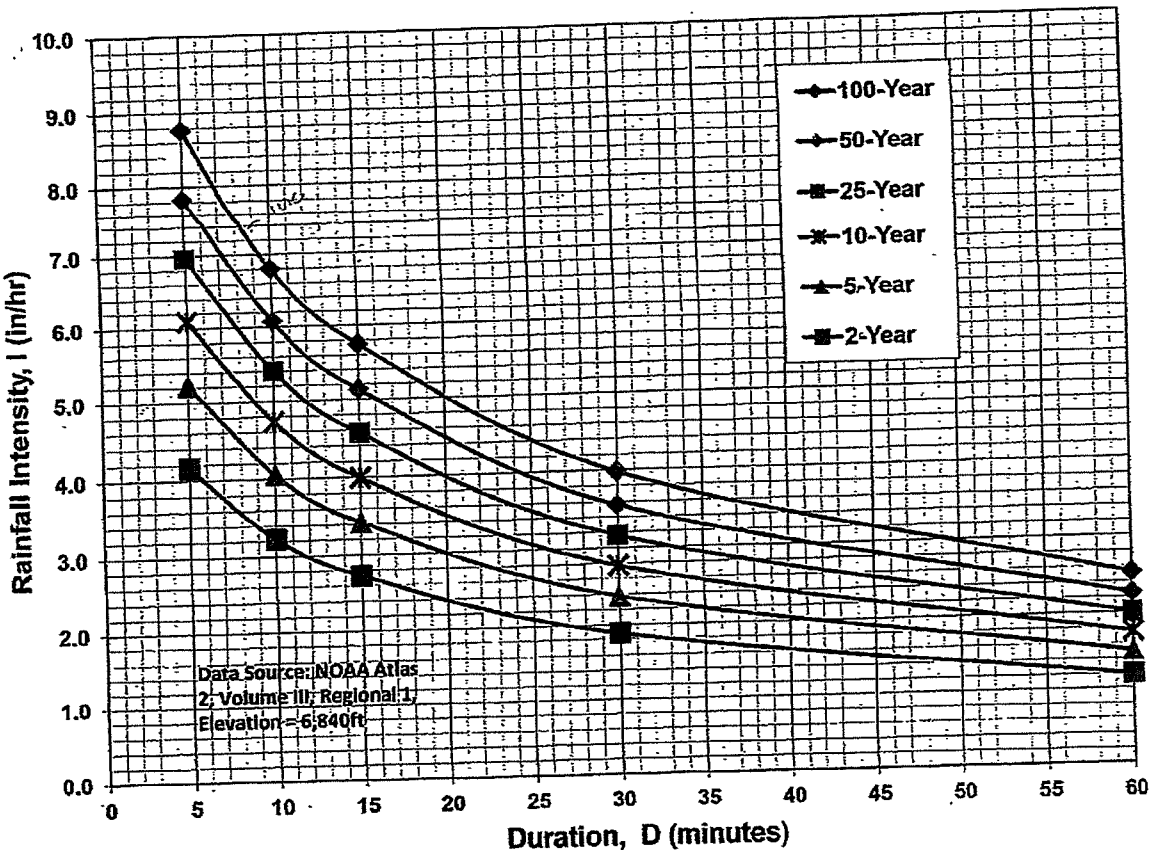
Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
Business													
Commercial Areas	95	0.75	0.80	0.81	0.82	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.89
Neighborhood Areas	70	0.45	0.49	0.49	0.53	0.53	0.57	0.58	0.62	0.60	0.65	0.62	0.68
Residential													
1/8 Acre or less	65	0.41	0.45	0.45	0.49	0.49	0.54	0.54	0.59	0.57	0.62	0.59	0.65
1/4 Acre	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
1/3 Acre	30	0.18	0.22	0.25	0.30	0.32	0.38	0.39	0.47	0.43	0.52	0.47	0.57
1/2 Acre	25	0.15	0.20	0.22	0.28	0.30	0.36	0.37	0.46	0.41	0.51	0.46	0.56
1 Acre	20	0.12	0.17	0.20	0.26	0.27	0.34	0.35	0.44	0.40	0.50	0.44	0.55
Industrial													
Light Areas	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Heavy Areas	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Parks and Cemeteries	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
Playgrounds	13	0.07	0.13	0.16	0.23	0.24	0.31	0.32	0.42	0.37	0.48	0.41	0.54
Railroad Yard Areas	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
Undeveloped Areas													
Historic Flow Analysis—Greenbelts, Agriculture	2	0.03	0.05	0.09	0.16	0.17	0.26	0.26	0.38	0.31	0.45	0.36	0.51
Pasture/Meadow	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Exposed Rock	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Offsite Flow Analysis (when landuse is undefined)	45	0.26	0.31	0.32	0.37	0.38	0.44	0.44	0.51	0.48	0.55	0.51	0.59
Streets													
Paved	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Gravel	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Drive and Walks	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Roofs	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Lawns	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration (t_c) consists of an initial time or overland flow time (t_i) plus the travel time (t_t) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion (t_t) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

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

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

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

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

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

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

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

Table 6-6. Runoff Coefficients for Rational Method
(Source: UDFCD 2001)

Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
Business													
Commercial Areas	95	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.89
Neighborhood Areas	70	0.45	0.49	0.49	0.53	0.53	0.57	0.58	0.62	0.60	0.65	0.62	0.68
Residential													
1/8 Acre or less	65	0.41	0.45	0.45	0.49	0.49	0.54	0.54	0.59	0.57	0.62	0.59	0.65
1/4 Acre	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
1/3 Acre	30	0.18	0.22	0.25	0.30	0.32	0.38	0.39	0.47	0.43	0.52	0.47	0.57
1/2 Acre	25	0.15	0.20	0.22	0.28	0.30	0.36	0.37	0.46	0.41	0.51	0.46	0.56
1 Acre	20	0.12	0.17	0.20	0.26	0.27	0.34	0.35	0.44	0.40	0.50	0.44	0.55
Industrial													
Light Areas	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
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Parks and Cemeteries	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
Playgrounds	13	0.07	0.13	0.16	0.23	0.24	0.31	0.32	0.42	0.37	0.48	0.41	0.54
Railroad Yard Areas	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
Undeveloped Areas													
Historic Flow Analysis-- Greenbelts, Agriculture	2	0.03	0.05	0.09	0.16	0.17	0.26	0.26	0.38	0.31	0.45	0.36	0.51
Pasture/Meadow	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Exposed Rock	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
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Streets													
Paved	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Gravel	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Drive and Walks	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Roofs	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Lawns	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration (t_c) consists of an initial time or overland flow time (t_i) plus the travel time (t_t) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion (t_t) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

The travel time is calculated by dividing the flow distance (in feet) by the velocity calculated using Equation 6-9 and converting units to minutes.

The time of concentration (t_c) is then the sum of the overland flow time (t_i) and the travel time (t_t) per Equation 6-7.

3.2.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (typically the first inlet in the system) in an urbanized catchment should not exceed the time of concentration calculated using Equation 6-10. The first design point is defined as the point where runoff first enters the storm sewer system.

$$t_c = \frac{L}{180} + 10 \qquad \text{(Eq. 6-10)}$$

Where:

t_c = maximum time of concentration at the first design point in an urban watershed (min)

L = waterway length (ft)

Equation 6-10 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method. Normally, Equation 6-10 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

3.2.5 Post-Development Time of Concentration

As Equation 6-8 indicates, the time of concentration is a function of the 5-year runoff coefficient for a drainage basin. Typically, higher levels of imperviousness (higher 5-year runoff coefficients) correspond to shorter times of concentration, and lower levels of imperviousness correspond to longer times of

$$t_c = t_i + t_t \quad \text{(Eq. 6-7)}$$

Where:

t_c = time of concentration (min)

t_i = overland (initial) flow time (min)

t_t = travel time in the ditch, channel, gutter, storm sewer, etc. (min)

3.2.1 Overland (Initial) Flow Time

The overland flow time, t_i, may be calculated using Equation 6-8.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \quad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \quad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)

C_v = conveyance coefficient (from Table 6-7)

S_w = watercourse slope (ft/ft)

EXHIBIT 5: CHARTS AND TABLES FOR TR55 METHOD

Table 4B-2 Runoff curve numbers for selected agricultural, suburban, and rural areas (western Washington).

Cover Type and Hydrologic Condition	CNs for hydrologic soil group A	B	C	D
Curve Numbers for Predevelopment Conditions				
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Curve Numbers for Postdevelopment Conditions				
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):[1]				
Fair condition (grass cover on 50% to 75% of the area)	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds, etc.	100	100	100	100
Paved parking lots, roofs,[2] driveways, etc. (excluding right of way)	98	98	98	98
Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	95	96	97	97
Good lawn condition (weighted average CNs)	94	95	96	97
Paved	98	98	98	98
Gravel (including right of way)	76	85	89	91
Dirt (including right of way)	72	82	87	89
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77

Single Family Residential:[3] Dwelling Unit/Gross Acre	Should only be used for subdivisions >50 acres	Average percent impervious area[3][4]	
1.0 DU/GA		15	Separate curve number must be selected for pervious & impervious portions of the site or basin
1.5 DU/GA		20	
2.0 DU/GA		25	
2.5 DU/GA		30	
3.0 DU/GA		34	
3.5 DU/GA		38	
4.0 DU/GA		42	
4.5 DU/GA		46	
5.0 DU/GA		48	
5.5 DU/GA		50	
6.0 DU/GA		52	
6.5 DU/GA		54	
7.0 DU/GA		56	
7.5 DU/GA		58	
PUDs, condos, apartments, commercial businesses, industrial areas, and subdivisions <50 acres	% impervious must be computed	Separate curve numbers must be selected for pervious and impervious portions of the site	

For a more detailed and complete description of land use curve numbers, refer to Chapter Two (2) of the Soil Conservation Service's Technical Release No. 55 (210-VI-TR-55, Second Ed., June 1986).

[1] Composite CNs may be computed for other combinations of open space cover type.

[2] Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in Chapter 3, the average percent impervious area may be adjusted in accordance with the procedure described under "Flow Credit for Roof Downspout Infiltration" and "Flow Credit for Roof Downspout Dispersion."

[3] Assumes roof and driveway runoff is directed into street/storm system.

[4] All remaining pervious area (lawn) is considered to be in good condition for these curve numbers.

Table 4B-3 Runoff curve numbers for selected agricultural, suburban, and rural areas (eastern Washington).

Cover Type and Hydrologic Condition	CNs for hydrologic soil group A	B	C	D
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):[1]				
Poor condition (grass cover on <50% of the area)	68	79	86	89
Fair condition (grass cover on 50% to 75% of the area)	49	69	79	84
Good condition (grass cover on >75% of the area)	39	61	74	80
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds, etc.	100	100	100	100
Paved parking lots, roofs, driveways, etc. (excluding right of way)	98	98	98	98
Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	95	96	97	97
Gravel (including right of way)	76	85	89	91
Dirt (including right of way)	72	82	87	89
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Cultivated Agricultural Lands:				
Row Crops (good), e.g., corn, sugar beets, soy beans	64	75	82	85
Small Grain (good), e.g., wheat, barley, flax	60	72	80	84
Meadow (continuous grass, protected from grazing, and generally mowed for hay):	30	58	71	78
Brush (brush-weed-grass mixture, with brush the major element):				
Poor (<50% ground cover)	48	67	77	83
Fair (50% to 75% ground cover)	35	56	70	77
Good (>75% ground cover)	30[2]	48	65	73
Woods-Grass Combination (orchard or tree farm):[3]				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods:				
Poor (forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Herbaceous (mixture of grass, weeds, and low-growing brush, with brush the minor element):[4]				
Poor (<30% ground cover)		80	87	93
Fair (30% to 70% ground cover)		71	81	89
Good (>70% ground cover)		62	74	85
Sagebrush With Grass Understory:[4]				
Poor (<30% ground cover)		67	80	85
Fair (30% to 70% ground cover)		51	63	70
Good (>70% ground cover)		35	47	55

For a more detailed and complete description of land use curve numbers, refer to Chapter Two (2) of the Soil Conservation Service's Technical Release No. 55 (210-VI-TR-55, Second Ed., June 1986).

[1] Composite CNs may be computed for other combinations of open space cover type.

[2] Actual curve number is less than 30; use CN = 30 for runoff computations.

[3] CNs shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

[4] Curve numbers have not been developed for Group A soils.

Table 4B-5 "n" and "k" values used in time calculations for hydrographs.

"n_s" Sheet Flow Equation Manning's Values (for the initial 300 ft. of travel)	
Manning's Values for sheet flow only; from Overton and Meadows 1976 (see TR-55, 1986)	**n_s**
Smooth surfaces (concrete, asphalt, gravel, or bare, hand-packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover ≤20%	0.06
Cultivated soil with residue cover >20%	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80
(210-VI-TR-55, Second Ed., June 1986)	
"k" Values Used in Travel Time/Time of Concentration Calculations	
Shallow Concentrated Flow (after the initial 300 ft. of sheet flow, R = 0.1)	**k_s**
1. Forest with heavy ground litter and meadows (n = 0.10)	3
2. Brushy ground with some trees (n = 0.060)	5
3. Fallow or minimum tillage cultivation (n = 0.040)	8
4. High grass (n = 0.035)	9
5. Short grass, pasture, and lawns (n = 0.030)	11
6. Nearly bare ground (n = 0.025)	13
7. Paved and gravel areas (n = 0.012)	27
Channel Flow (intermittent) (at the beginning of visible channels, R = 0.2)	**k_c**
1. Forested swale with heavy ground litter (n = 0.10)	5
2. Forested drainage course/ravine with defined channel bed (n = 0.050)	10
3. Rock-lined waterway (n = 0.035)	15
4. Grassed waterway (n = 0.030)	17
5. Earth-lined waterway (n = 0.025)	20
6. CMP pipe, uniform flow (n = 0.024)	21
7. Concrete pipe, uniform flow (0.012)	42
8. Other waterways and pipe	0.508/n
Channel Flow (continuous stream, R = 0.4)	**k_c**
9. Meandering stream with some pools (n = 0.040)	20
10. Rock-lined stream (n = 0.035)	23
11. Grass-lined stream (n = 0.030)	27
12. Other streams, manmade channels, and pipe	0.807/n

Table 4B-6 Values of the roughness coefficient, "n."

Type of Channel and Description	Manning's "n" (Normal)	Type of Channel and Description	Manning's "n" (Normal)
A. Constructed Channels		6. Sluggish reaches, weedy	
a. *Earth, straight and uniform*		deep pools	0.070
1. Clean, recently completed	0.018	7. Very weedy reaches, deep	
2. Gravel, uniform selection,	0.025	pools, or floodways with	
clean		heavy stand of timber and	
3. With short grass, few	0.027	underbrush	0.100
weeds		b. *Mountain streams, no vegetation*	
b. *Earth, winding and sluggish*		*in channel, banks usually steep,*	
1. No vegetation	0.025	*trees and brush along banks*	
2. Grass, some weeds	0.030	*submerged at high stages*	
3. Dense weeds or aquatic		1. Bottom: gravel, cobbles, and	
plants in deep channels	0.035	few boulders	0.040
4. Earth bottom and rubble		2. Bottom: cobbles with large	
sides	0.030	boulders	0.050
5. Stony bottom and weedy		B-2 Flood plains	
banks	0.035	a. *Pasture, no brush*	
6. Cobble bottom and clean		1. Short grass	0.030
sides	0.040	2. High grass	0.035
c. *Rock-lined*		b. *Cultivated areas*	
1. Smooth and uniform	0.035	1. No crop	0.030
2. Jagged and irregular	0.040	2. Mature row crops	0.035
d. *Channels not maintained,*		3. Mature field crops	0.040
weeds and brush uncut		c. *Brush*	
1. Dense weeds, high as flow		1. Scattered brush, heavy	
depth	0.080	weeds	0.050
2. Clean bottom, brush on		2. Light brush and trees	0.060
sides	0.050	3. Medium to dense brush	0.070
3. Same, highest stage of		4. Heavy, dense brush	0.100
flow	0.070	d. *Trees*	
4. Dense brush, high stage	0.100	1. Dense willows, straight	0.150
B. Natural Streams		2. Cleared land with tree	
B-1 Minor streams (top width at		stumps, no sprouts	0.040
flood stage < 100 ft.)		3. Same as above, but with	
a. *Streams on plain*		heavy growth of sprouts	0.060
1. Clean, straight, full stage,		4. Heavy stand of timber, a few	
no rifts or deep pools	0.030	downed trees, little	
2. Same as above, but more		undergrowth, flood stage	
stones and weeds	0.035	below branches	0.100
3. Clean, winding, some		5. Same as above, but with	
pools and shoals	0.040	flood stage reaching	
4. Same as above, but some		branches	0.120
weeds	0.040		
5. Same as 4, but more stones	0.050		

*Note: These "n" values are "normal" values for use in analysis of channels. For conservative design for channel capacity, the maximum values listed in other references should be considered. For channel bank stability, the minimum values should be considered.

Table 4B-2 Runoff curve numbers for selected agricultural, suburban, and rural areas (western Washington).

Cover Type and Hydrologic Condition	CNs for hydrologic soil group A	B	C	D
Curve Numbers for Predevelopment Conditions				
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Curve Numbers for Postdevelopment Conditions				
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):[1]				
Fair condition (grass cover on 50% to 75% of the area)	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds, etc.	100	100	100	100
Paved parking lots, roofs,[2] driveways, etc. (excluding right of way)	98	98	98	98
Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	95	96	97	97
Good lawn condition (weighted average CNs)	94	95	96	97
Paved	98	98	98	98
Gravel (including right of way)	76	85	89	91
Dirt (including right of way)	72	82	87	89
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77

Single Family Residential:[3] Dwelling Unit/Gross Acre	Should only be used for subdivisions >50 acres	Average percent impervious area[3][4]	
1.0 DU/GA		15	Separate curve number
1.5 DU/GA		20	must be selected for
2.0 DU/GA		25	pervious & impervious
2.5 DU/GA		30	portions of the site or
3.0 DU/GA		34	basin
3.5 DU/GA		38	
4.0 DU/GA		42	
4.5 DU/GA		46	
5.0 DU/GA		48	
5.5 DU/GA		50	
6.0 DU/GA		52	
6.5 DU/GA		54	
7.0 DU/GA		56	
7.5 DU/GA		58	
PUDs, condos, apartments, commercial businesses, industrial areas, and subdivisions <50 acres	% impervious must be computed	Separate curve numbers must be selected for pervious and impervious portions of the site	

For a more detailed and complete description of land use curve numbers, refer to Chapter Two (2) of the Soil Conservation Service's Technical Release No. 55 (210-VI-TR-55, Second Ed., June 1986).

[1] Composite CNs may be computed for other combinations of open space cover type.

[2] Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in Chapter 3, the average percent impervious area may be adjusted in accordance with the procedure described under "Flow Credit for Roof Downspout Infiltration" and "Flow Credit for Roof Downspout Dispersion."

[3] Assumes roof and driveway runoff is directed into street/storm system.

[4] All remaining pervious area (lawn) is considered to be in good condition for these curve numbers.

Table 4B-3 Runoff curve numbers for selected agricultural, suburban, and rural areas (eastern Washington).

Cover Type and Hydrologic Condition	CNs for hydrologic soil group A	B	C	D
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):[1]				
Poor condition (grass cover on <50% of the area)	68	79	86	89
Fair condition (grass cover on 50% to 75% of the area)	49	69	79	84
Good condition (grass cover on >75% of the area)	39	61	74	80
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds, etc.	100	100	100	100
Paved parking lots, roofs, driveways, etc. (excluding right of way)	98	98	98	98
Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	95	96	97	97
Gravel (including right of way)	76	85	89	91
Dirt (including right of way)	72	82	87	89
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Cultivated Agricultural Lands:				
Row Crops (good), e.g., corn, sugar beets, soy beans	64	75	82	85
Small Grain (good), e.g., wheat, barley, flax	60	72	80	84
Meadow (continuous grass, protected from grazing, and generally mowed for hay):	30	58	71	78
Brush (brush-weed-grass mixture, with brush the major element):				
Poor (<50% ground cover)	48	67	77	83
Fair (50% to 75% ground cover)	35	56	70	77
Good (>75% ground cover)	30[2]	48	65	73
Woods-Grass Combination (orchard or tree farm):[3]				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods:				
Poor (forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Herbaceous (mixture of grass, weeds, and low-growing brush, with brush the minor element):[4]				
Poor (<30% ground cover)		80	87	93
Fair (30% to 70% ground cover)		71	81	89
Good (>70% ground cover)		62	74	85
Sagebrush With Grass Understory:[4]				
Poor (<30% ground cover)		67	80	85
Fair (30% to 70% ground cover)		51	63	70
Good (>70% ground cover)		35	47	55

For a more detailed and complete description of land use curve numbers, refer to Chapter Two (2) of the Soil Conservation Service's Technical Release No. 55 (210-VI-TR-55, Second Ed., June 1986).

[1] Composite CNs may be computed for other combinations of open space cover type.

[2] Actual curve number is less than 30; use CN = 30 for runoff computations.

[3] CNs shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

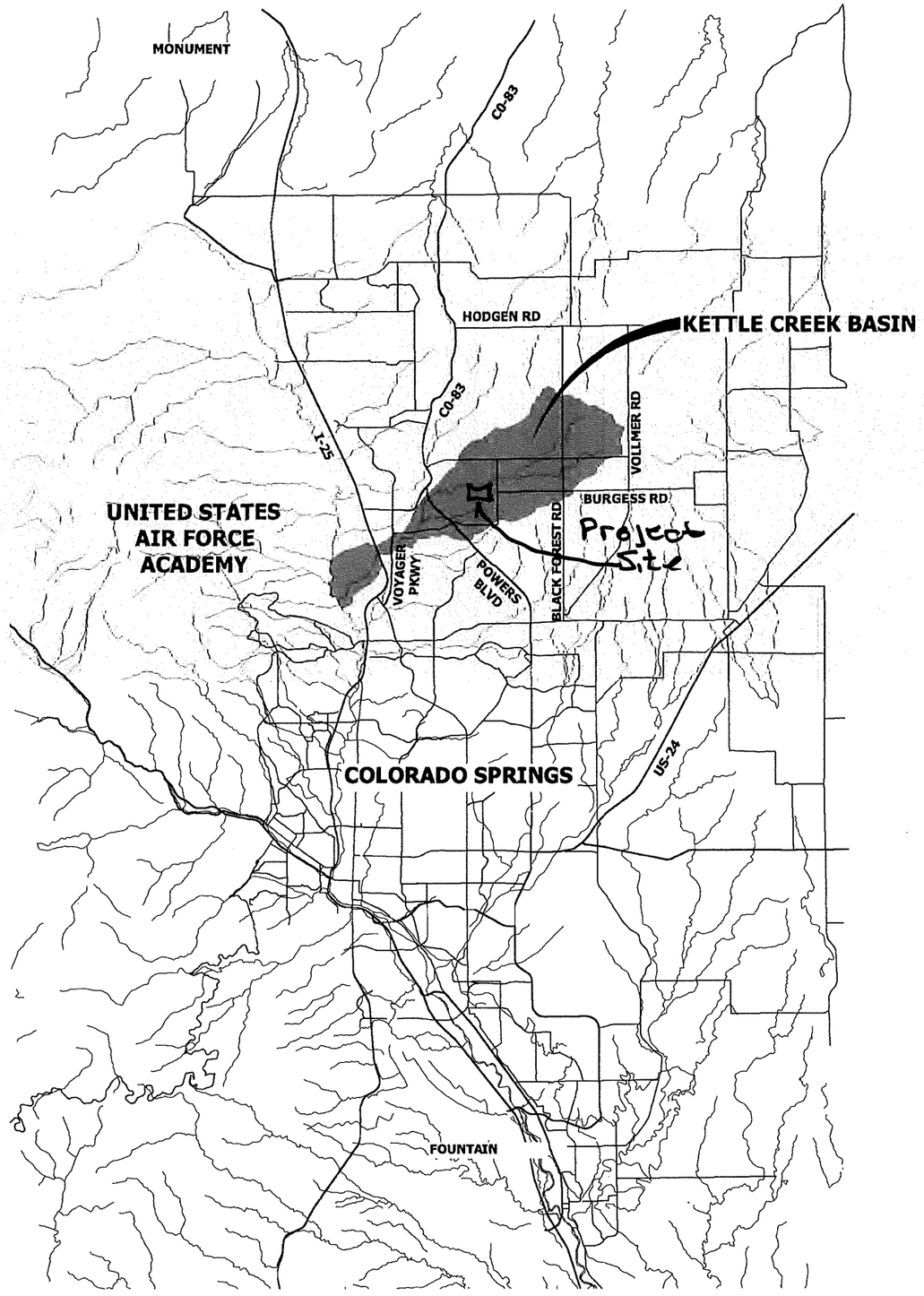
[4] Curve numbers have not been developed for Group A soils.

Table 4B-6 Values of the roughness coefficient, "n."

Type of Channel and Description	Manning's "n" (Normal)	Type of Channel and Description	Manning's "n" (Normal)
A. Constructed Channels		6. Sluggish reaches, weedy	
a. *Earth, straight and uniform*		deep pools	0.070
1. Clean, recently completed	0.018	7. Very weedy reaches, deep	
2. Gravel, uniform selection,	0.025	pools, or floodways with	
clean		heavy stand of timber and	
3. With short grass, few	0.027	underbrush	0.100
weeds		b. *Mountain streams, no vegetation*	
b. *Earth, winding and sluggish*		*in channel, banks usually steep,*	
1. No vegetation	0.025	*trees and brush along banks*	
2. Grass, some weeds	0.030	*submerged at high stages*	
3. Dense weeds or aquatic		1. Bottom: gravel, cobbles, and	
plants in deep channels	0.035	few boulders	0.040
4. Earth bottom and rubble		2. Bottom: cobbles with large	
sides	0.030	boulders	0.050
5. Stony bottom and weedy		B-2 Flood plains	
banks	0.035	a. *Pasture, no brush*	
6. Cobble bottom and clean		1. Short grass	0.030
sides	0.040	2. High grass	0.035
c. *Rock-lined*		b. *Cultivated areas*	
1. Smooth and uniform	0.035	1. No crop	0.030
2. Jagged and irregular	0.040	2. Mature row crops	0.035
d. *Channels not maintained,*		3. Mature field crops	0.040
weeds and brush uncut		c. *Brush*	
1. Dense weeds, high as flow		1. Scattered brush, heavy	
depth	0.080	weeds	0.050
2. Clean bottom, brush on		2. Light brush and trees	0.060
sides	0.050	3. Medium to dense brush	0.070
3. Same, highest stage of		4. Heavy, dense brush	0.100
flow	0.070	d. *Trees*	
4. Dense brush, high stage	0.100	1. Dense willows, straight	0.150
B. Natural Streams		2. Cleared land with tree	
B-1 Minor streams (top width at		stumps, no sprouts	0.040
flood stage < 100 ft.)		3. Same as above, but with	
a. *Streams on plain*		heavy growth of sprouts	0.060
1. Clean, straight, full stage,		4. Heavy stand of timber, a few	
no rifts or deep pools	0.030	downed trees, little	
2. Same as above, but more		undergrowth, flood stage	
stones and weeds	0.035	below branches	0.100
3. Clean, winding, some		5. Same as above, but with	
pools and shoals	0.040	flood stage reaching	
4. Same as above, but some		branches	0.120
weeds	0.040		
5. Same as 4, but more stones	0.050		

*Note: These "n" values are "normal" values for use in analysis of channels. For conservative design for channel capacity, the maximum values listed in other references should be considered. For channel bank stability, the minimum values should be considered.

EXHIBIT 6: DRAINAGE BASIN PLANNING STUDY EXHIBITS



N

2 1 0 2 4

ORIGINAL SCALE: 1" = 4 MILES

FIGURE 1–1 VICINITY MAP
KETTLE CREEK DBPS
JOB NO. 25100.00
MAY 2015

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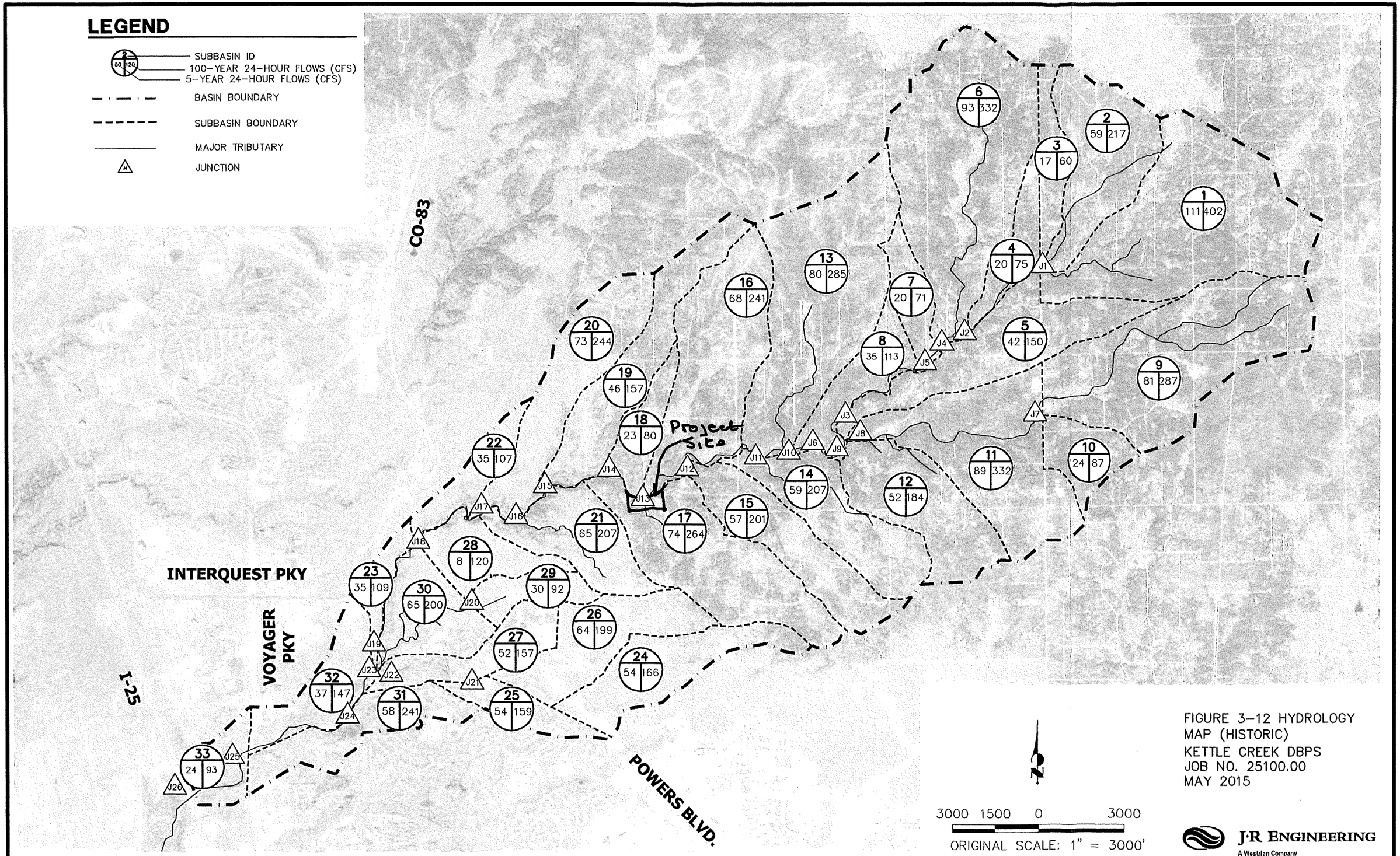
Fort Collins 970–491–9888 • www.jrengineering.com

LEGEND

- SUBBASIN ID
- 100-YEAR 24-HOUR FLOWS (CFS)
- 5-YEAR 24-HOUR FLOWS (CFS)
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- MAJOR TRIBUTARY
- JUNCTION



3000 1500 0 3000

ORIGINAL SCALE: 1" = 3000'

FIGURE 3-12 HYDROLOGY MAP (HISTORIC)
KETTLE CREEK DBPS
JOB NO. 25100.00
MAY 2015

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HISTORIC CONDITIONS MODEL RESULTS (5-YEAR)

5-Year, 24-Hour Storm			
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Volume (In)
Subbasin-1	1.263	111	0.42
Subbasin-2	0.586	59	0.42
Subbasin-3	0.18	17	0.42
Junction-1	2.029	185	0.42
Reach-1	2.029	184	0.42
Subbasin-4	0.195	20	0.4
Junction-2	2.224	202	0.42
Reach-2	2.224	195	0.42
Subbasin-5	0.625	42	0.4
Junction-3	2.849	235	0.41
Reach-3	2.849	235	0.41
Subbasin-6	1.333	93	0.4
Junction-4	4.182	328	0.41
Reach-4	4.182	323	0.41
Subbasin-7	0.183	20	0.42
Junction-5	4.365	333	0.41
Reach-5	4.365	324	0.41
Subbasin-8	0.288	35	0.4
Junction-6	4.653	337	0.41
Reach-6	4.653	336	0.41
Subbasin-9	1.177	81	0.42
Subbasin-10	0.222	24	0.4
Junction-7	1.399	93	0.42
Reach-7	1.399	92	0.42
Subbasin-11	0.88	89	0.4
Junction-8	2.279	152	0.41
Reach-8	2.279	150	0.41
Subbasin-12	0.552	52	0.43
Junction-9	2.831	193	0.41
Reach-9	2.831	191	0.41
Junction-10	7.484	508	0.41
Reach-10	7.484	500	0.41
Subbasin-13	1.156	80	0.42
Subbasin-14	0.516	59	0.45
Junction-11	9.156	578	0.41
Reach-11	9.156	576	0.41
Subbasin-15	0.498	57	0.44
Junction-12	9.654	590	0.42
Reach-12	9.654	589	0.42
Subbasin-16	0.819	68	0.42
Subbasin-17	0.788	74	0.42
Junction-13	11.261	631	0.42

5-Year, 24-Hour Storm			
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Volume (In)
Reach-13	11.261	627	0.42
Subbasin-18	0.192	23	0.42
Junction-14	11.453	631	0.42
Reach-14	11.453	624	0.42
Subbasin-19	0.552	46	0.47
Junction-15	12.005	641	0.42
Reach-15	12.005	640	0.42
Subbasin-20	0.594	73	0.5
Junction-16	12.599	654	0.42
Reach-16	12.599	653	0.42
Subbasin-21	0.417	65	0.52
Junction-17	13.016	661	0.43
Reach-17	13.016	658	0.43
Subbasin-22	0.2	35	0.57
Junction-18	13.216	662	0.43
Reach-18	13.216	660	0.43
Subbasin-23	0.123	35	0.55
Junction-19	13.339	662	0.43
Reach-19	13.339	660	0.43
Subbasin-24	0.453	54	0.57
Subbasin-25	0.169	51	0.57
Subbasin-26	0.48	64	0.57
Junction-21	1.102	128	0.57
Reach-21	1.102	125	0.57
Subbasin-27	0.294	52	0.57
Junction-22	1.396	164	0.57
Reach-22	1.396	161	0.57
Subbasin-28	0.264	38	0.57
Subbasin-29	0.172	30	0.57
Junction-20	0.436	68	0.57
Reach-20	0.436	64	0.57
Subbasin-30	0.364	65	0.57
Junction-23	15.535	702	0.45
Reach-23	15.535	697	0.45
Subbasin-31	0.377	58	0.33
Subbasin-32	0.316	37	0.33
Junction-24	16.228	705	0.44
Reach-24	16.228	702	0.44
Subbasin-33	0.184	24	0.37
Junction-25	16.412	704	0.44
Reach-25	16.412	698	0.44
Junction-26	16.412	698	0.44

EXISTING CONDITIONS MODEL RESULTS (5-YEAR)

5-Year, 24-Hour Storm			
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Volume (In)
Subbasin-1	1.263	315	1.06
Subbasin-2	0.586	173	1.06
Subbasin-3	0.180	56	1.27
Junction-1	2.029	527	1.08
Reach-1	2.029	526	1.08
Subbasin-4	0.195	56	0.97
Junction-2	2.224	572	1.07
Reach-2	2.224	568	1.07
Subbasin-5	0.625	134	1.14
Junction-3	2.849	689	1.08
Reach-3	2.849	689	1.08
Subbasin-6	1.333	240	0.94
Junction-4	4.182	928	1.04
Reach-4	4.182	917	1.04
Subbasin-7	0.183	51	0.97
Junction-5	4.365	940	1.03
Reach-5	4.365	929	1.03
Subbasin-8	0.288	117	1.1
Junction-6	4.653	959	1.04
Reach-6	4.653	944	1.04
Subbasin-9	1.177	223	1.05
Subbasin-10	0.222	62	0.93
Junction-7	1.399	252	1.03
Reach-7	1.399	250	1.03
Subbasin-11	0.880	322	1.23
Junction-8	2.279	484	1.11
Reach-8	2.279	484	1.11
Subbasin-12	0.552	144	1.06
Junction-9	2.831	609	1.1
Reach-9	2.831	594	1.1
Junction-10	7.484	1,444	1.06
Reach-10	7.484	1,428	1.06
Subbasin-13	1.156	212	1
Subbasin-14	0.516	138	0.95
Junction-11	9.156	1,605	1.05
Reach-11	9.156	1,604	1.05
Subbasin-15	0.498	143	1
Junction-12	9.654	1,636	1.05
Reach-12	9.654	1,634	1.05

5-Year, 24-Hour Storm			
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Volume (In)
Subbasin-16	0.819	193	1.06
Subbasin-17	0.788	184	0.95
Junction-13	11.261	1,730	1.04
Reach-13	11.261	1,705	1.04
Subbasin-18	0.192	55	0.95
Junction-14	11.453	1,711	1.04
Reach-14	11.453	1,710	1.04
Subbasin-19	0.552	101	0.95
Junction-15	12.005	1,745	1.03
Reach-15	12.005	1,741	1.03
Subbasin-20	0.594	134	0.86
Junction-16	12.599	1,760	1.03
Reach-16	12.599	1,741	1.03
Subbasin-21	0.417	100	0.79
Junction-17	13.016	1,752	1.02
Reach-17	13.016	1,752	1.02
Subbasin-22	0.200	36	0.59
Junction-18	13.216	1,756	1.01
Reach-18	13.216	1,746	1.01
Subbasin-23	0.123	42	0.66
Junction-19	13.339	1,748	1.01
Reach-19	13.339	1,747	1.01
Source-1	1.396	109	0.58
Subbasin-28	0.264	38	0.57
Subbasin-29	0.172	37	0.7
Junction-20	0.436	75	0.62
Reach-20	0.436	70	0.62
Subbasin-30	0.364	116	1
Junction-23	15.535	1,764	0.96
Reach-23	15.535	1,751	0.96
Subbasin-31	0.377	217	1.05
Subbasin-32	0.316	124	1.01
Junction-24	16.228	1,766	0.96
Reach-24	16.228	1,754	0.96
Subbasin-33	0.184	24	0.37
Junction-25	16.412	1,756	0.96
Reach-25	16.412	1,750	0.96
Junction-26	16.412	1,750	0.96

FUTURE CONDITIONS MODEL RESULTS (5-YEAR)

5-Year, 24-Hour Storm			
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Volume (In)
Subbasin-1	1.263	315	1.06
Subbasin-2	0.586	173	1.06
Subbasin-3	0.180	56	1.27
Junction-1	2.029	527	1.08
Reach-1	2.029	526	1.08
Subbasin-4	0.195	56	0.97
Junction-2	2.224	572	1.07
Reach-2	2.224	568	1.07
Subbasin-5	0.625	134	1.14
Junction-3	2.849	689	1.08
Reach-3	2.849	689	1.08
Subbasin-6	1.333	240	0.94
Junction-4	4.182	928	1.04
Reach-4	4.182	917	1.04
Subbasin-7	0.183	51	0.97
Junction-5	4.365	940	1.03
Reach-5	4.365	929	1.03
Subbasin-8	0.288	117	1.1
Junction-6	4.653	959	1.04
Reach-6	4.653	944	1.04
Subbasin-9	1.177	223	1.05
Subbasin-10	0.222	62	0.93
Junction-7	1.399	252	1.03
Reach-7	1.399	250	1.03
Subbasin-11	0.880	322	1.23
Junction-8	2.279	484	1.11
Reach-8	2.279	484	1.11
Subbasin-12	0.552	144	1.06
Junction-9	2.831	609	1.1
Reach-9	2.831	594	1.1
Junction-10	7.484	1,444	1.06
Reach-10	7.484	1,428	1.06
Subbasin-13	1.156	212	1
Subbasin-14	0.516	138	0.95
Junction-11	9.156	1,605	1.05
Reach-11	9.156	1,604	1.05
Subbasin-15	0.498	143	1
Junction-12	9.654	1,636	1.05
Reach-12	9.654	1,634	1.05

5-Year, 24-Hour Storm			
Hydrologic Element	Drainage Area (mi^2)	Peak Discharge (CFS)	Volume (In)
Subbasin-16	0.819	193	1.06
Subbasin-17	0.788	184	0.95
Junction-13	11.261	1,730	1.04
Reach-13	11.261	1,705	1.04
Subbasin-18	0.192	55	0.95
Junction-14	11.453	1,711	1.04
Reach-14	11.453	1,710	1.04
Subbasin-19	0.552	111	1.03
Junction-15	12.005	1,747	1.04
Reach-15	12.005	1,743	1.04
Subbasin-20	0.594	206	1.29
Junction-16	12.599	1,769	1.05
Reach-16	12.599	1,750	1.05
Subbasin-21	0.417	114	0.9
Junction-17	13.016	1,761	1.04
Reach-17	13.016	1,761	1.04
Subbasin-22	0.200	112	1.76
Junction-18	13.216	1,769	1.06
Reach-18	13.216	1,760	1.06
Subbasin-23	0.123	44	0.68
Junction-19	13.339	1,763	1.05
Reach-19	13.339	1,761	1.05
Source-1	1.396	109	0.58
Subbasin-28	0.264	123	1.74
Subbasin-29	0.172	111	2.06
Junction-20	0.436	230	1.86
Reach-20	0.436	220	1.86
Subbasin-30	0.364	158	1.34
Junction-23	15.535	1,788	1.04
Reach-23	15.535	1,774	1.04
Subbasin-31	0.377	290	1.38
Subbasin-32	0.316	274	2.2
Junction-24	16.228	1,796	1.07
Reach-24	16.228	1,785	1.07
Subbasin-33	0.184	24	0.37
Junction-25	16.412	1,787	1.06
Reach-25	16.412	1,781	1.06
Junction-26	16.412	1,781	1.06

FIGURE 3–10 HYDROLOGY
MINOR STORM RESULTS
KETTLE CREEK DBPS
JOB NO. 25100.00
MAY 2015

NOTE

1. FUTURE AND EXISTING SUBBASIN 24–27 DATA IS REPLACED WITH DATA FROM THE KETTLE CREEK DRAINAGE BASIN OLD RANCH ROAD TRIBUTARY MASTER DEVELOPMENT DRAINAGE PLAN AND LABELED AS SOURCE–1 (S1).

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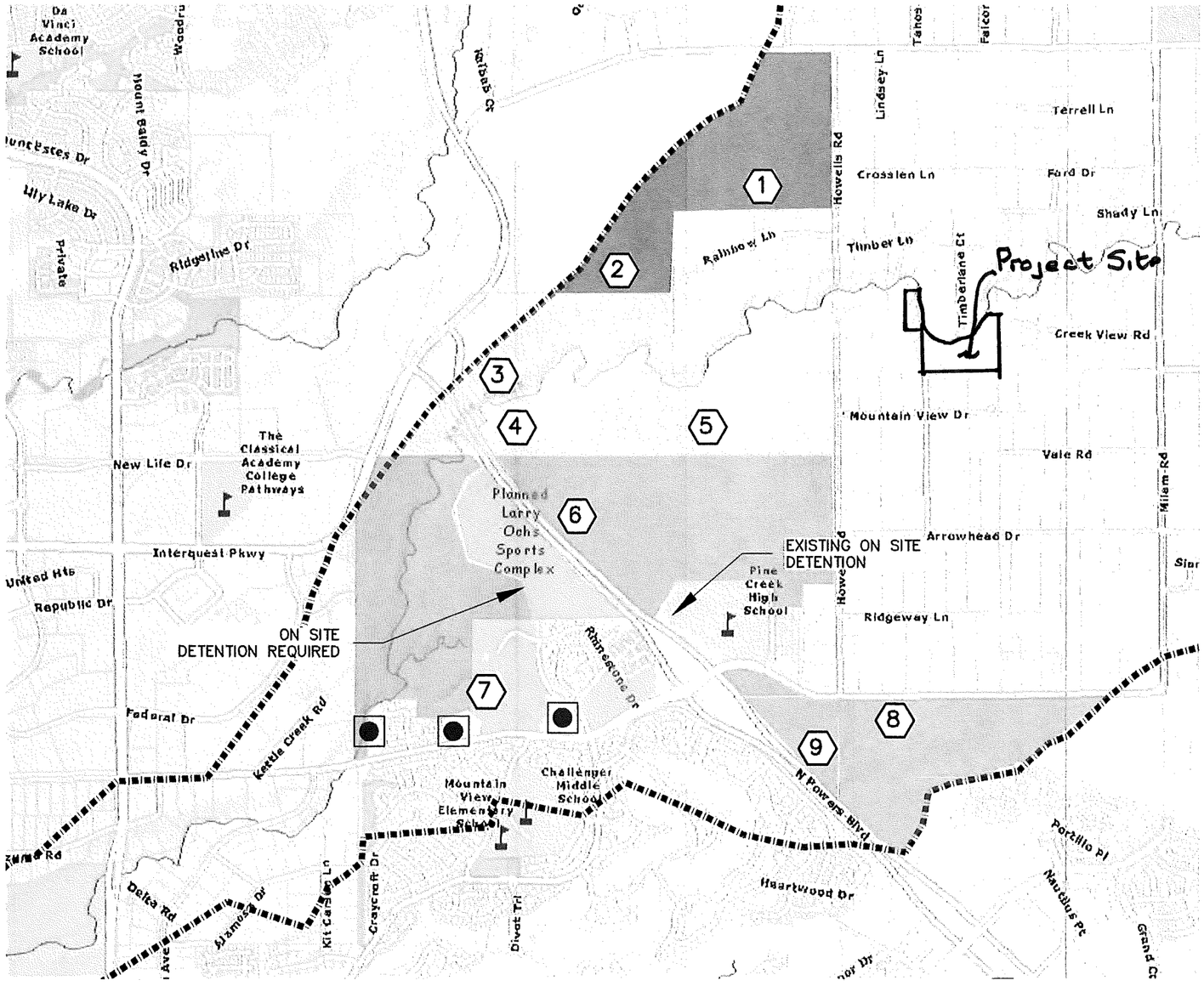
Fort Collins 970–491–9888 • www.jrengineering.com

LEGEND

- JOVENCHI–I LLC
- 260 EB LLC
- HIGH VALLEY LAND COMPANY INC
- KETTLE CREEK LLC & VENEZIA JOHN FAMILY TRUST
- ① ESTIMATED LOCATION OF PROPOSED SUBREGIONAL PONDS
- EXISTING LOCATION OF SUBREGIONAL PONDS
- KETTLE CREEK BASIN BOUNDARY



2000 1000 0 2000

ORIGINAL SCALE: 1" = 2000'

FIGURE 6–1
SUBREGIONAL POND LOCATIONS
KETTLE CREEK DBPS
JOB NO. 25100.00
MAY 2015

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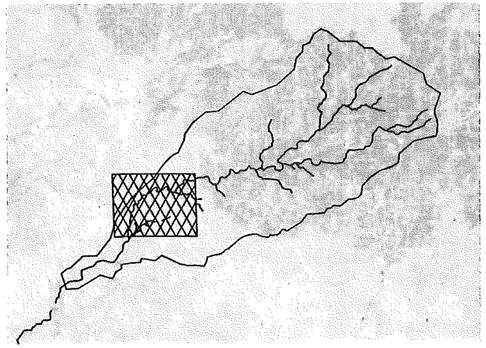

KEY MAP
N.T.S.

N

600 300 0 600

ORIGINAL SCALE: 1" = 600'

LEGEND

- EXISTING INTERMEDIATE CONTOUR
- 6800 EXISTING INDEX CONTOUR
- CROSS-SECTION SAMPLE LINE
- APPROXIMATE FEMA 100-YR FLOODPLAIN EXTENTS
- 100YR EXISTING & FUTURE 100-YR FLOODPLAIN EXTENTS

FIGURE 4-2
KETTLE CREEK DBPS
JOB NO. 25100.00
MAY 2015

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EXHIBIT 7: HYDROLOGY EXHIBITS

Basin Summary

Basin I.D.	Area	Runoff Coefficients (rational method)		TR55	Runoff per Rational Method		Runoff per TR55 method	
					Q5	Q100	Q5	Q100
	(acres)	C5	C100		cfs	cfs	cfs	cfs
A	1.96	0.08	0.35		0.6	4.2		
B	3.04	0.08	0.35		0.7	5.4		
C	1.58	0.8	0.35		0.4	2.8		
D	4.57	0.8	0.31		1.2	9.2		
E	3.63	0.09	0.4		1	7		
F	4.51	0.08	0.36		0.7	5.3		
G	1.57	0..8	0.35		0.6	4.8		
H	5.54	0.01	0.05		2.3	16.8		
I	1.28	0.08	0.35		6.5	33.8		
OS1	34.69	see TR55	see TR55				1.3	12.74
OS2	179.06	see TR55	see TR55				4.94	41.34
OS3	18.41	see TR55	see TR55				0.53	4.53
OS4	1.39	see TR55	see TR55		0.3	2.4		
OS5	91.16	see TR55	see TR55				2.61	22.35
OS6	73.03	see TR55	see TR55				2.98	31.49
OS7	1.56	0.08	0.35		0.2	1.4		
OS8	1.06	0.08	0.35		0.3	1.9		

4/12/22

Canyon Creek Ranch
FINAL DRAINAGE REPORT
Existing Conditions
(Area Drainage Summary)

From Area Runoff Coefficient Summary				*OVERLAND*				*SHALLOW CHANNEL FLOW*				*Time of Travel (T_t)*		*INTENSITY **		*TOTAL FLOWS*	
BASIN	**AREA TOTAL**	**C_5**	**C_{100}**	**C_5**	**Length**	**Height**	**T_C**	**Length**	**Slope**	**Velocity**	**T_t**	**TOTAL**	**CHECK**	**I_5**	**I_{100}**	**Q_5**	**Q_{100}**
	(Acres)				*(ft)*	*(ft)*	*(min)*	*(ft)*	*(%)*	*(fps)*	*(min)*	*(min)*	*(min)*	*(in/hr)*	*(in/hr)*	*(c.f.s.)*	*(c.f.s.)*
A	1.96	0.08	0.35	0.08	100	10	8.6	330	4.0%	1.0	5.5	14.1	12.4	3.6	6.1	*0.6*	*4.2*
B	3.04	0.08	0.35	0.08	100	18	7.1	820	4.0%	1.0	13.7	20.8	15.1	3.0	5.1	*0.7*	*5.4*
C	1.58	0.08	0.35	0.08	100	16	7.4	820	4.0%	1.0	13.7	21.0	15.1	3.0	5.1	*0.4*	*2.8*
D	4.57	0.08	0.35	0.08	100	10	8.6	450	4.0%	1.0	7.5	16.1	13.1	3.4	5.7	*1.2*	*9.2*
E	3.63	0.08	0.35	0.08	100	10	8.6	600	5.0%	1.1	8.9	17.6	13.9	3.3	5.5	*1.0*	*7.0*
F	4.51	0.08	0.36	0.08	20	15	2.0	3850	10.0%	1.6	40.6	42.6	31.5	2.0	3.3	*0.7*	*5.3*
G	1.57	0.08	0.35	0.08			#DIV/0!			0.0	#DIV/0!	5.0	10.0	5.2	8.7	*0.6*	*4.8*
H	5.54	0.08	0.35	0.08			#DIV/0!			0.0	#DIV/0!	5.0	10.0	5.2	8.7	*2.3*	*16.8*
I	1.28	0.80	0.35	0.80			#DIV/0!			0.0	#DIV/0!	5.0	10.0	5.2	8.7	*5.3*	*3.9*
OS1	34.69	0.16	0.52	0.16	100	10	8.0	3800	4.0%	1.0	63.3	71.3	31.7	1.2	2.0	*6.5*	*35.8*
OS2	179.06	0.16	0.41	0.16	100	10	7.9	7800	4.2%	1.0	126.9	134.8	53.9	0.2	0.4	*6.5*	*27.8*
OS3	18.41	0.14	0.40	0.14	200	10	14.4	2600	4.1%	1.0	42.8	57.2	25.6	1.5	2.5	*3.9*	*18.5*
OS4	1.39	0.08	0.35	0.08	100	20	6.9	1000	4.5%	1.1	15.7	22.6	16.1	2.9	4.9	*0.3*	*2.4*
OS5	91.16	0.13	0.38	0.13	100	10	8.2	7350	4.5%	1.1	115.5	123.7	51.4	0.4	0.6	*4.1*	*20.8*
OS6	73.03	0.13	0.39	0.13	200	20	11.6	2300	4.6%	1.1	35.7	47.3	23.9	1.8	3.0	*17.0*	*85.2*
OS7	1.55	0.08	0.35	0.08	300	20	17.0	2500	4.6%	1.1	38.9	55.9	25.6	1.5	2.6	*0.2*	*1.4*
OS8	1.06	0.08	0.35	0.08	100	30	6.0	1200	8.8%	1.5	13.5	19.5	17.2	3.1	5.3	*0.3*	*1.9*

4/12/22

Canyon Creek Ranch
Drainage Calculations
Existing Conditions
(Area Runoff Coefficient Summary)

March 8, 2022

		Large Acreage Lots			*Natural (pasture)*			*Natural (forest, pasture)*			*RUNOFF COEFFICIENT*		
BASIN	**TOTAL AREA** *(Acres)*	**AREA** *(Acres)*	C_5	C_{100}	**AREA** *(Acres)*	C_5	C_{100}	**AREA** *(Acres)*	C_5	C_{100}	C_2	C_5	C_{100}
A	1.96	0.00	0.20	0.44	0.00	0.08	0.35	1.96	0.08	0.35	*0.00*	*0.08*	*0.35*
B	3.04	0.00	0.20	0.44	0.00	0.08	0.35	3.04	0.08	0.35	*0.00*	*0.08*	*0.35*
C	1.58	0.00	0.20	0.44	0.00	0.08	0.35	1.58	0.08	0.35	*0.00*	*0.08*	*0.35*
D	4.57	0.00	0.20	0.44	0.00	0.08	0.35	4.57	0.08	0.35	*0.00*	*0.08*	*0.35*
E	3.63	0.00	0.20	0.44	0.00	0.08	0.35	3.63	0.08	0.35	*0.00*	*0.08*	*0.35*
F	4.51	0.00	0.20	0.44	0.00	0.08	0.35	4.60	0.08	0.35	*0.00*	*0.08*	*0.36*
G	1.57	0.00	0.20	0.44	0.00	0.08	0.35	1.57	0.08	0.35	*0.00*	*0.08*	*0.35*
H	5.54	0.00	0.20	0.44	0.00	0.08	0.35	5.54	0.08	0.35	*0.00*	*0.08*	*0.35*
I	1.28	0.00	0.20	0.44	0.00	0.08	0.35	1.28	0.80	0.35	*0.00*	*0.80*	*0.35*
OS1	34.69	13.40	0.20	0.44	17.69	0.08	0.35	17.00	0.08	0.35	*0.00*	*0.16*	*0.52*
OS2	179.06	120.00	0.20	0.44	59.60	0.08	0.35	0.00	0.08	0.35	*0.00*	*0.16*	*0.41*
OS3	18.41	9.40	0.20	0.44	9.01	0.08	0.35	0.00	0.08	0.35	*0.00*	*0.14*	*0.40*
OS4	1.39	0.00	0.20	0.44	1.39	0.08	0.35	0.00	0.08	0.35	*0.00*	*0.08*	*0.35*
OS5	91.16	35.00	0.20	0.44	56.16	0.08	0.35	0.00	0.08	0.35	*0.00*	*0.13*	*0.38*
OS6	73.03	30.00	0.20	0.44	43.03	0.08	0.35	0.00	0.08	0.35	*0.00*	*0.13*	*0.39*
OS7	1.55	0.00	0.20	0.44	1.56	0.08	0.35	0.00	0.08	0.35	*0.00*	*0.08*	*0.35*
OS8	1.06	0.00	0.20	0.44	1.06	0.08	0.35	0.00	0.08	0.35	*0.00*	*0.08*	*0.35*

DP3

Rdvme #1

Harrison

Canyon Estates
Design Point 3
El Paso County, Colorado

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 5-Yr (cfs)	100-Yr (cfs)
SUBAREAS		
OS1	1.28	12.74
OS2	4.94	41.34
OS3	0.53	4.53
A onsite	0.16	2.08
REACHES		
OUTLET	6.38	53.13

Harrison

Canyon Estates
Design Point 3
El Paso County, Colorado

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 5-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS				
OS1	1.28	12.74		
	13.01	12.75		
OS2	4.94	41.34		
	14.01	13.47		
OS3	0.53	4.53		
	13.83	13.31		
A onsite	0.16	2.08		
	12.13	12.06		
REACHES				
OUTLET	6.38	53.13		

WinTR-55 Current Data Description

--- Identification Data ---

User: Harrison
Project: Canyon Estates
SubTitle: Design Point 3
State: Colorado
County: El Paso
Filename: <new file>

Date: 4/12/2022
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
OS1		Outlet	34.69	58	1.193
OS2		Outlet	179.06	58	2.251
OS3		Outlet	18.41	58	2.062
A onsite		Outlet	1.96	58	0.235

Total area: 234.12 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
2.1	2.7	3.2	3.6	4.2	4.6	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

Harrison

Canyon Estates
Design Point 3
El Paso County, Colorado

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
OS1	34.69	1.193	58	Outlet	
OS2	179.06	2.251	58	Outlet	
OS3	18.41	2.062	58	Outlet	
A onsite	1.96	0.235	58	Outlet	

Total Area: 234.12 (ac)

Harrison

Canyon Estates
Design Point 3
El Paso County, Colorado

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
OS1							
User-provided							1.193
					Time of Concentration		1.193
OS2							
User-provided							2.251
					Time of Concentration		2.251
OS3							
User-provided							2.062
					Time of Concentration		2.062
A onsite							
User-provided							0.235
					Time of Concentration		0.235

Harrison

Canyon Estates
Design Point 3
El Paso County, Colorado

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
OS1	CN directly entered by user	-	34.69	58
	Total Area / Weighted Curve Number		34.69	58
OS2	CN directly entered by user	-	179.06	58
	Total Area / Weighted Curve Number		179.06	58
OS3	CN directly entered by user	-	18.41	58
	Total Area / Weighted Curve Number		18.41	58
A onsite	CN directly entered by user	-	1.96	58
	Total Area / Weighted Curve Number		1.96	58

DP 7
Rawine 3
No Culvert

WinTR-55 Current Data Description

--- Identification Data ---

User: Harrison
Project: Canyon Estates
SubTitle: Design Point 7
State: Colorado
County: El Paso
Filename: <new file>

Date: 4/12/2022
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
OS5		Outlet	91.16	58	2.070
OS6		Outlet	73.03	58	0.955
ONSITE D		Outlet	44.57	58	0.270
ONSITE E		Outlet	3.61	58	0.297

Total area: 212.37 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
2.1	2.7	3.2	3.6	4.2	4.6	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

Harrison

Canyon Estates
Design Point 7
El Paso County, Colorado

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
2.1	2.7	3.2	3.6	4.2	4.6	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

Harrison

Canyon Estates
Design Point 7
El Paso County, Colorado

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 5-Yr (cfs)	100-Yr (cfs)
SUBAREAS		
OS5	2.61	22.35
OS6	2.98	31.49
ONSITE D	3.43	44.24
ONSITE E	0.26	3.41
REACHES		
OUTLET	5.88	58.70

Harrison

Canyon Estates
Design Point 7
El Paso County, Colorado

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 5-Yr (cfs)	(hr)	100-Yr (cfs)	(hr)
SUBAREAS				
OS5	2.61	13.84	22.35	13.32
OS6	2.98	12.78	31.49	12.58
ONSITE D	3.43	12.15	44.24	12.08
ONSITE E	0.26	12.18	3.41	12.10
REACHES				
OUTLET	5.88		58.70	

Harrison

Canyon Estates
Design Point 7
El Paso County, Colorado

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
OS5	91.16	2.070	58	Outlet	
OS6	73.03	0.955	58	Outlet	
ONSITE D	44.57	0.270	58	Outlet	
ONSITE E	3.61	0.297	58	Outlet	

Total Area: 212.37 (ac)

Harrison

Canyon Estates
Design Point 7
El Paso County, Colorado

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
OS5							
User-provided							2.070
					Time of Concentration		2.070
OS6							
User-provided							0.955
					Time of Concentration		0.955
ONSITE D							
User-provided							0.270
					Time of Concentration		0.270
ONSITE E							
User-provided							0.297
					Time of Concentration		0.297

Harrison

Canyon Estates
Design Point 7
El Paso County, Colorado

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
OS5	CN directly entered by user	-	91.16	58
	Total Area / Weighted Curve Number		91.16	58
OS6	CN directly entered by user	-	73.03	58
	Total Area / Weighted Curve Number		73.03	58
ONSITE D	CN directly entered by user	-	44.57	58
	Total Area / Weighted Curve Number		44.57	58
ONSITE E	CN directly entered by user	-	3.61	58
	Total Area / Weighted Curve Number		3.61	58

EXHIBIT 8: HYDRAULICS EXHIBITS

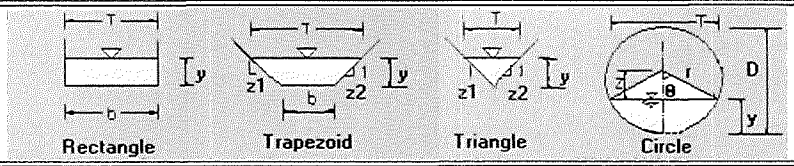
Swale Summary

Ravine #	Outfall DP	Contributing Subbasins	Slope	Design Flow		Depth of Flow		Velocity		Froude #	
				Q5	Q100	Q5	Q100	Q5	Q100		
			%	cfs	cfs	ft	ft	fps	fps	5 year	100 year
1	DP3	OS1, OS2, OS3, A	4.0	6.4	53.1	0.1	0.3	2.7	6.2	1.71	2.10
2	DP5	OS8,, OS4, B,C	4.0	1.7	12.5	neg	0.1	1.3	3.0	1.25	1.67
3	DP7	OS5, OS6, D, E	4.0	5.9	58.7	0.1	0.3	2.5	6.0	1.65	2.04

Swale Summary

The open channel flow calculator

Select Channel Type: Trapezoid



Depth from Q

Select unit system: Feet(ft)

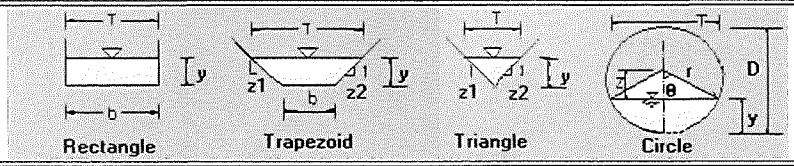
Channel slope: .04 ft/ft	Water depth(y): 0.08 ft	Bottom width(b) 30 ft
Flow velocity 2.710463 ft/s	LeftSlope (Z1): 1.5 to 1 (H:V)	RightSlope (Z2): 1.5 to 1 (H:V)
Flow discharge 6.4 ft^3/s	Input n value .020 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 30.28 ft	Flow area 2.36 ft^2	Top width(T) 30.24 ft
Specific energy 0.19 ft	Froude number 1.71	Flow status Supercritical flow
Critical depth 0.11 ft	Critical slope 0.0119 ft/ft	Velocity head 0.11 ft

Route 1
9 of 7

Rd

The open channel flow calculator

Select Channel Type: Trapezoid



Depth from Q

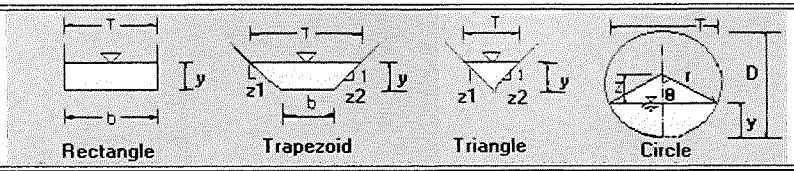
Select unit system: Feet(ft)

Channel slope: .04 ft/ft	Water depth(y): 0.28 ft	Bottom width(b) 30 ft
Flow velocity 6.249991 ft/s	LeftSlope (Z1): 1.5 to 1 (H:V)	RightSlope (Z2): 1.5 to 1 (H:V)
Flow discharge 53.1 ft^3/s	Input n value .020 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 31.01 ft	Flow area 8.5 ft^2	Top width(T) 30.84 ft
Specific energy 0.89 ft	Froude number 2.1	Flow status Supercritical flow
Critical depth 0.46 ft	Critical slope 0.0075 ft/ft	Velocity head 0.61 ft

Rainel
100 YT

The open channel flow calculator

Select Channel Type: Trapezoid



Depth from Q

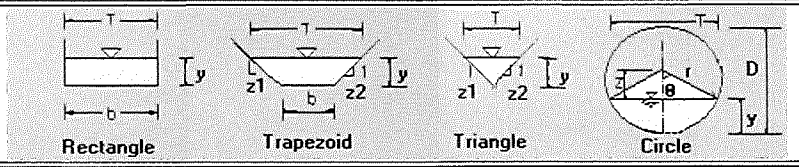
Select unit system: Feet(ft)

Channel slope: .04 ft/ft	Water depth(y): 0.03 ft	Bottom width(b) 40 ft
Flow velocity 1.286287 ft/s	LeftSlope (Z1): 1.5 to 1 (H:V)	RightSlope (Z2): 1.5 to 1 (H:V)
Flow discharge 1.7 ft^3/s	Input n value 0.020 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 40.12 ft	Flow area 1.32 ft^2	Top width(T) 40.1 ft
Specific energy 0.06 ft	Froude number 1.25	Flow status Supercritical flow
Critical depth 0.04 ft	Critical slope 0.017 ft/ft	Velocity head 0.03 ft

Rainez
5 yr.

The open channel flow calculator

Select Channel Type: Trapezoid



Depth from Q

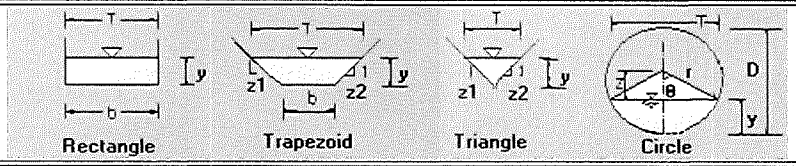
Select unit system: Feet(ft)

Channel slope: .04 ft/ft	Water depth(y): 0.1 ft	Bottom width(b) 40 ft
Flow velocity 3.025255 ft/s	LeftSlope (Z1): 1.5 to 1 (H:V)	RightSlope (Z2): 1.5 to 1 (H:V)
Flow discharge 12.5 ft^3/s	Input n value 0.020 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 40.37 ft	Flow area 4.13 ft^2	Top width(T) 40.31 ft
Specific energy 0.25 ft	Froude number 1.67	Flow status Supercritical flow
Critical depth 0.15 ft	Critical slope 0.0105 ft/ft	Velocity head 0.14 ft

Route 2 100 yr

The open channel flow calculator

Select Channel Type: Trapezoid



Depth from Q

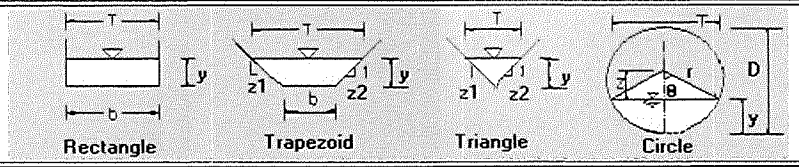
Select unit system: Feet(ft)

Channel slope: .04 ft/ft	Water depth(y): 0.07 ft	Bottom width(b) 35 ft
Flow velocity 2.450106 ft/s	LeftSlope (Z1): 1.5 to 1 (H:V)	RightSlope (Z2): 1.5 to 1 (H:V)
Flow discharge 5.9 ft^3/s	Input n value .020 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 35.25 ft	Flow area 2.41 ft^2	Top width(T) 35.21 ft
Specific energy 0.16 ft	Froude number 1.65	Flow status Supercritical flow
Critical depth 0.1 ft	Critical slope 0.0119 ft/ft	Velocity head 0.09 ft

Rdwy Dr
5yr

The open channel flow calculator

Select Channel Type: Trapezoid



Depth from Q

Select unit system: Feet(ft)

Channel slope: .04 ft/ft	Water depth(y): 0.27 ft	Bottom width(b) 35 ft
Flow velocity 6.040995 ft/s	LeftSlope (Z1): 1.5 to 1 (H:V)	RightSlope (Z2): 1.5 to 1 (H:V)
Flow discharge 58.7 ft^3/s	Input n value .020 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 35.99 ft	Flow area 9.72 ft^2	Top width(T) 35.82 ft
Specific energy 0.84 ft	Froude number 2.04	Flow status Supercritical flow
Critical depth 0.44 ft	Critical slope 0.0078 ft/ft	Velocity head 0.57 ft

Revised
10/04

KCH Engineering Solutions
5228 Cracker Barrel Circle
Colorado Springs, CO 80917
(719) 246-4471

JOB Culvert Design
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____
SCALE _____

A Culvert Design @ Ravine 1 (8%) grade 5% to 10%

1. Top of Rd @ culvert crossing.
   - Elevation @ Creek View Rd Cul-de-sac = 6980.1
   - Road Grade. Use 8% (Both ways)
   - Distance to culvert = 320 ft
   - Distance to Bottom of V.C (Approximate) ≈ 1.5'
   - Top of Road = 6980.1 − 320(0.08) = 6954.5'
   - Flowline of Ravine = 6940
   - Depth of Fill = 698.10 − 6954.5 = 14 + 1.5 = 28.1 ft of fill over Culvert

Culvert Slope = Slope of Ravine 10' fall in 250 ft
Slope = 10/250 = 4%

Ravine 1 = 6.4 Q_5 53.1 Q_{100}

Ravine 2 = 1.7 = Q_5 12.5 = Q_{100}

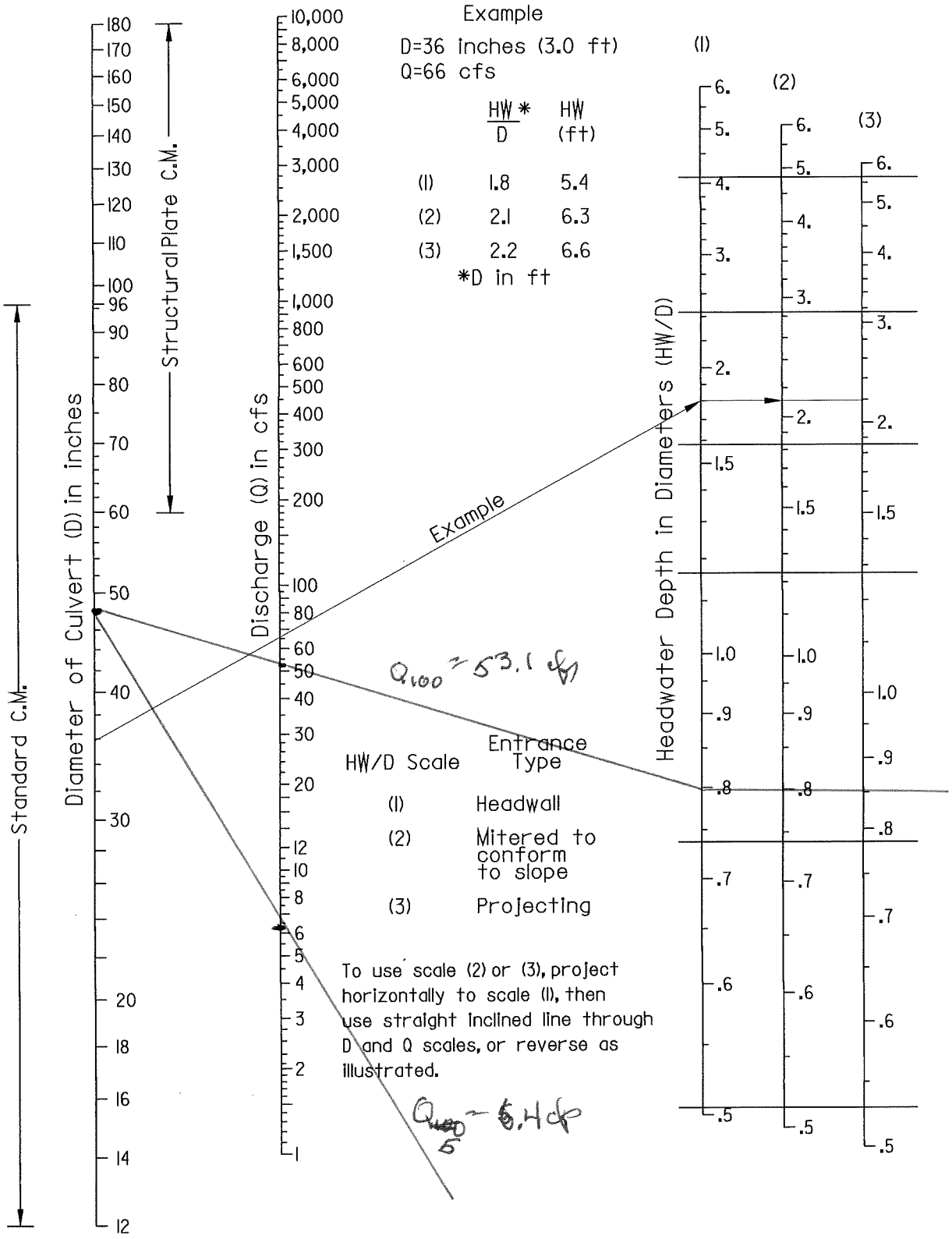


Exhibit F.2 Headwater Depth for CMP Culverts with Inlet Control
(Source: Reference F.1)

Ravine #1
48" CMP

5yr = 6.4 cfs
100yr = 53.1

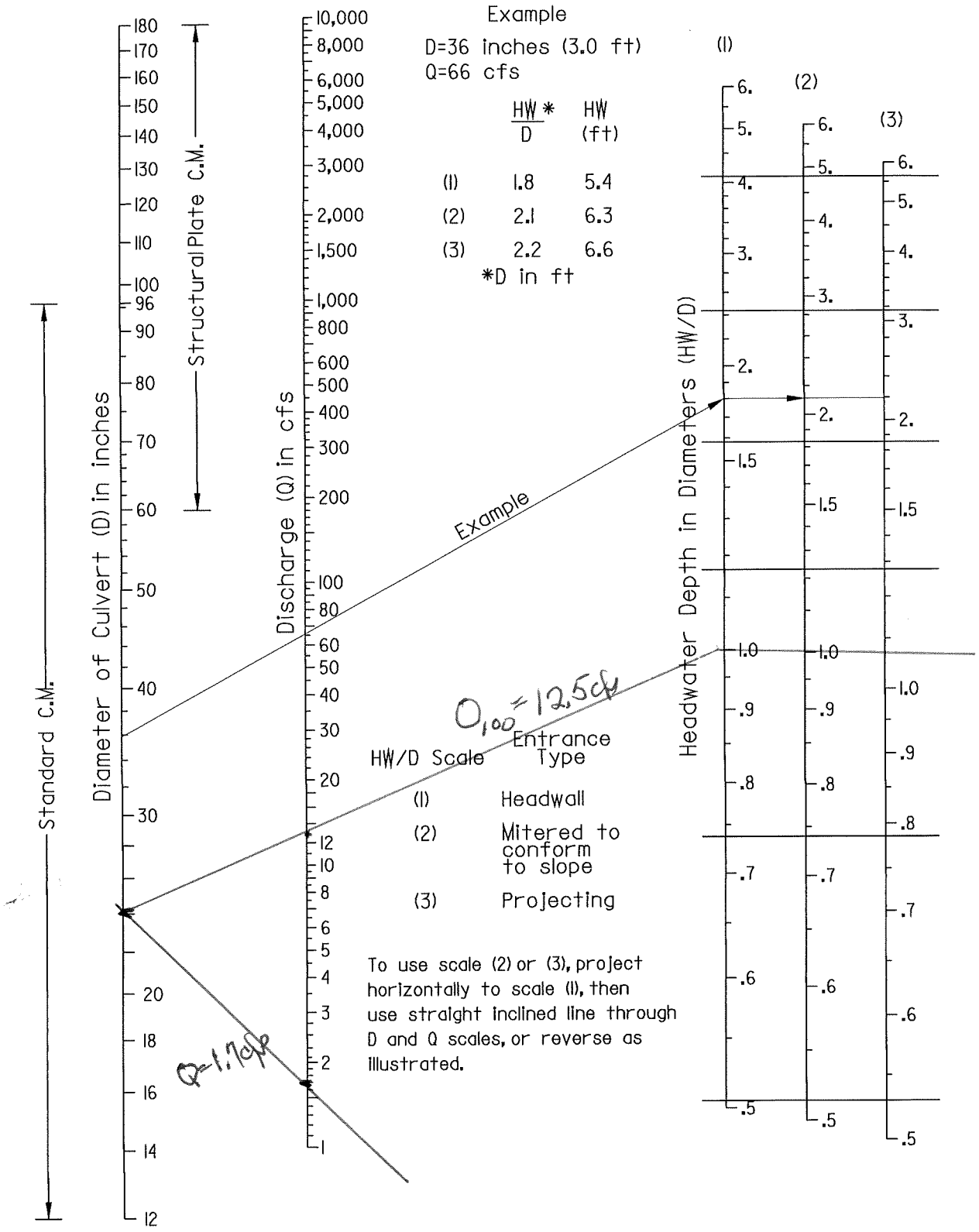


Exhibit F.2 Headwater Depth for CMP Culverts with Inlet Control (Source: Reference F.1)

Ravine 2

$Q_5 = 1.7$ $Q_{100} = 12.5$

EXHIBIT 9: DRAINAGE MAP

CANYON CREEK RANCH

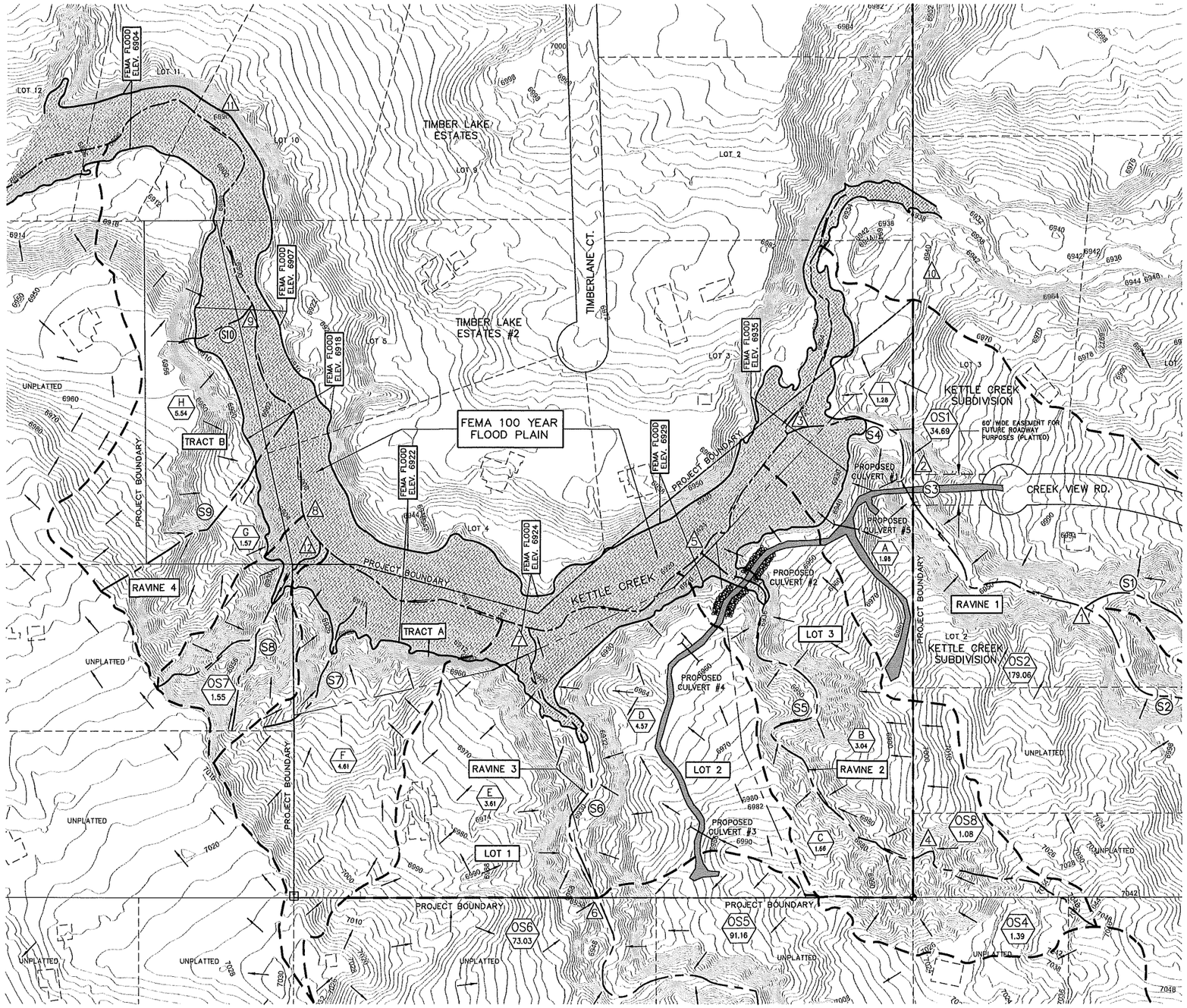
A PORTION OF THE SOUTH HALF OF THE SOUTHWEST QUARTER,
SECTION 14, TOWNSHIP 12 SOUTH, RANGE 66 WEST OF THE 6th P.M.,
COUNTY OF EL PASO, STATE OF COLORADO

SWALE SUMMARY

RAVINE #	OUTFALL DP	CONTRIBUTING SUBBASINS	SLOPE	DESIGN FLOW		DEPTH OF FLOW		VELOCITY		FROUDE #	
				Q5	Q100	Q5	Q100	Q5	Q100		
			%	cfs	cfs	ft	ft	fps	fps	5 year	100 year
1	DP3	OS1, OS2, OS3, A	4.0	6.4	53.1	0.1	0.3	2.7	6.2	1.71	2.10
2	DP5	OS8, OS4, B, C	4.0	1.7	12.8	NEG	0.1	1.3	3.0	1.25	1.67
3	DP7	OS5, OS6, D, E	4.0	5.9	58.7	0.1	0.3	2.5	6.0	1.65	2.04

BASIN SUMMARY

BASIN I.D.	AREA	RUNOFF COEFFICIENTS (existing)		TR55	RUNOFF PER RATIONAL METHOD		RUNOFF PER TR55 METHOD	
					Q5	Q100	Q5	Q100
	(acres)	C5	C100		cfs	cfs	cfs	cfs
A	1.96	0.08	0.35		0.6	4.2	--	--
B	3.04	0.08	0.35		0.7	5.4	--	--
C	1.66	0.8	0.35		0.4	2.8	--	--
D	4.57	0.8	0.31		1.2	9.2	--	--
E	3.61	0.09	0.40		1.0	7.0	--	--
F	4.61	0.08	0.36		0.7	5.3	--	--
G	1.57	0.08	0.35		0.6	4.8	--	--
H	5.54	0.01	0.05		2.3	16.8	--	--
I	1.28	0.08	0.35		6.5	33.8	--	--
OS1	34.69	SEE TR55	SEE TR55		--	--	1.3	12.74
OS2	179.06	SEE TR55	SEE TR55		--	--	4.94	41.34
OS3	18.41	SEE TR55	SEE TR55		--	--	0.53	4.53
OS4	1.39	SEE TR55	SEE TR55		0.3	2.4	--	--
OS5	91.16	SEE TR55	SEE TR55		--	--	2.61	22.35
OS6	73.03	SEE TR55	SEE TR55		--	--	2.98	31.49
OS7	1.55	0.08	0.35		0.2	1.4	--	--
OS8	1.08	0.8	0.35		0.3	1.9	--	--



NOTES:

- SEE SHEET 1 FOR OFF SITE INFORMATION.
- PROPOSED RIPRAP EROSION PROTECTION LOCATION TO BE DETERMINED UPON FINAL DESIGN.

N

100 0 100 200

SCALE: 1" = 100'

LEGEND:

- DIRECTION OF FLOW
- PROJECT BOUNDARY
- FLOWLINE / NATURAL SWALE / SUBBASIN BOUNDARY
- SUBBASIN BOUNDARY
- DESIGN POINT
- SWALE NUMBER
- OSX / XX.X — SUBDIVISION I.D. / AREA (ACRES)
- CULVERT
- STRUCTURE NUMBER
- INDEX CONTOURS (APPROX.)
- INTERMEDIATE CONTOURS
- EXISTING STRUCTURE (APPROX.)
- PROPOSED RIPRAP
- EXISTING LOT LINES
- PROPOSED LOT LINE
- SUBDIVISION/LOT BOUNDARY
- FEMA 100-YEAR FLOOD PLAIN AREA
- PROPOSED ROAD

PRELIMINARY
NOT FOR CONSTRUCTION:
THESE PLANS ARE INTENDED FOR PRELIMINARY REVIEW AND APPROVAL BY CITY/COUNTY PLANNING DEPARTMENTS AND SHOULD NOT BE USED ON SITE FOR CONSTRUCTION OR LAYOUT.

CALL BEFORE YOU DIG ...
811
DIAL 811
48 HOURS BEFORE YOU DIG UTILITY LOCATIONS FOR LOCATING AND MARKING GAS, ELECTRIC, WATER AND WASTEWATER

REVISIONS

No.	Description	By	Date

H-Scale: N/A
V-Scale: 1" = 100'
Designed By: KCH
Drawn By: DAS
Checked By: KCH
Date: 03/22/2022

Land Development Consultants, Inc.
PLANNING · SURVEYING
www.ldc-inc.com · TEL: (719) 528-6133 · FAX: (719) 528-6848
3598 MAIZELAND ROAD · COLORADO SPRINGS, CO 80909

CANYON CREEK RANCH

DRAINAGE PLAN FOR EXISTING CONDITIONS

Project No.: 21002
Sheet: 2 of 3

F_CAD\21002\100Canyon Creek Ranch\Engineering\21002 DRAINAGE PLAN CANYON CREEK RANCH 111721.dwg

CANYON CREEK RANCH

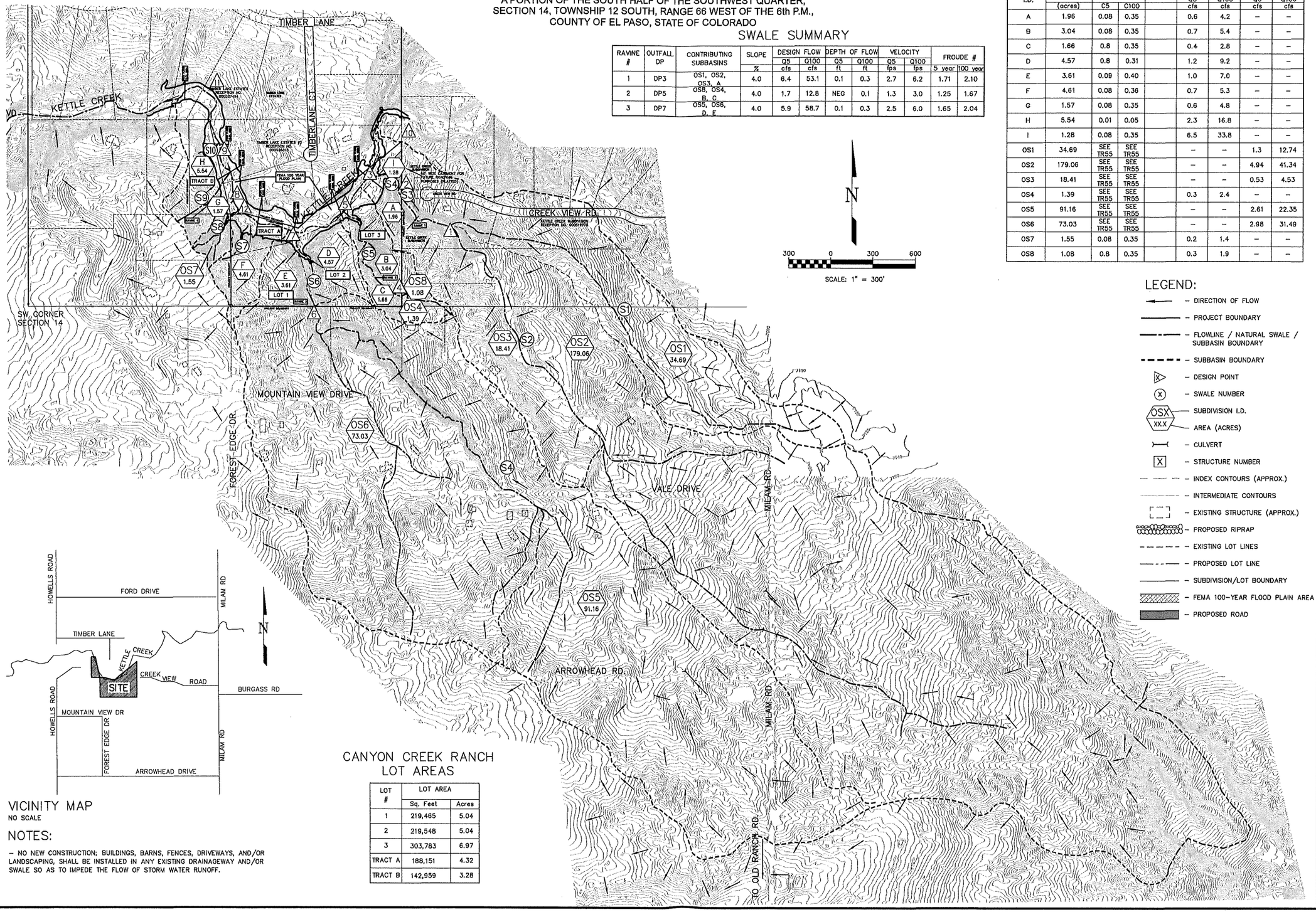
A PORTION OF THE SOUTH HALF OF THE SOUTHWEST QUARTER,
SECTION 14, TOWNSHIP 12 SOUTH, RANGE 66 WEST OF THE 6th P.M.,
COUNTY OF EL PASO, STATE OF COLORADO

SWALE SUMMARY

RAVINE #	OUTFALL DP	CONTRIBUTING SUBBASINS	SLOPE	DESIGN FLOW Q5	DESIGN FLOW Q100	DEPTH OF FLOW Q5	DEPTH OF FLOW Q100	VELOCITY Q5	VELOCITY Q100	FROUDE # 5 year	FROUDE # 100 year
			%	cfs	cfs	ft	ft	fps	fps		
1	DP3	OS1, OS2, OS3, A	4.0	6.4	53.1	0.1	0.3	2.7	6.2	1.71	2.10
2	DP5	OS8, OS4, B, C	4.0	1.7	12.8	NEG	0.1	1.3	3.0	1.25	1.67
3	DP7	OS5, OS6, D, E	4.0	5.9	58.7	0.1	0.3	2.5	6.0	1.65	2.04

BASIN SUMMARY

BASIN I.D.	AREA (acres)	RUNOFF COEFFICIENTS (existing) C5	C100	TR55	RUNOFF PER RATIONAL METHOD Q5 cfs	RUNOFF PER RATIONAL METHOD Q100 cfs	RUNOFF PER TR55 METHOD Q5 cfs	RUNOFF PER TR55 METHOD Q100 cfs
A	1.96	0.08	0.35		0.6	4.2	–	–
B	3.04	0.08	0.35		0.7	5.4	–	–
C	1.66	0.8	0.35		0.4	2.8	–	–
D	4.57	0.8	0.31		1.2	9.2	–	–
E	3.61	0.09	0.40		1.0	7.0	–	–
F	4.61	0.08	0.36		0.7	5.3	–	–
G	1.57	0.08	0.35		0.6	4.8	–	–
H	5.54	0.01	0.05		2.3	16.8	–	–
I	1.28	0.08	0.35		6.5	33.8	–	–
OS1	34.69	SEE TR55	SEE TR55		–	–	1.3	12.74
OS2	179.06	SEE TR55	SEE TR55		–	–	4.94	41.34
OS3	18.41	SEE TR55	SEE TR55		–	–	0.53	4.53
OS4	1.39	SEE TR55	SEE TR55		0.3	2.4	–	–
OS5	91.16	SEE TR55	SEE TR55		–	–	2.61	22.35
OS6	73.03	SEE TR55	SEE TR55		–	–	2.98	31.49
OS7	1.55	0.08	0.35		0.2	1.4	–	–
OS8	1.08	0.8	0.35		0.3	1.9	–	–



LEGEND:

- DIRECTION OF FLOW
- PROJECT BOUNDARY
- FLOWLINE / NATURAL SWALE / SUBBASIN BOUNDARY
- SUBBASIN BOUNDARY
- DESIGN POINT
- SWALE NUMBER
- SUBDIVISION I.D.
- AREA (ACRES)
- CULVERT
- STRUCTURE NUMBER
- INDEX CONTOURS (APPROX.)
- INTERMEDIATE CONTOURS
- EXISTING STRUCTURE (APPROX.)
- PROPOSED RIPRAP
- EXISTING LOT LINES
- PROPOSED LOT LINE
- SUBDIVISION/LOT BOUNDARY
- FEMA 100-YEAR FLOOD PLAIN AREA
- PROPOSED ROAD

VICINITY MAP

NO SCALE

NOTES:

– NO NEW CONSTRUCTION; BUILDINGS, BARNS, FENCES, DRIVEWAYS, AND/OR LANDSCAPING, SHALL BE INSTALLED IN ANY EXISTING DRAINAGEWAY AND/OR SWALE SO AS TO IMPEDE THE FLOW OF STORM WATER RUNOFF.

CANYON CREEK RANCH LOT AREAS

LOT #	LOT AREA Sq. Feet	Acres
1	219,465	5.04
2	219,548	5.04
3	303,783	6.97
TRACT A	188,151	4.32
TRACT B	142,959	3.28

PRELIMINARY
NOT FOR CONSTRUCTION:
THESE PLANS ARE INTENDED FOR SUBMITTAL, REVIEW AND APPROVAL BY CITY/COUNTY PLANNING DEPARTMENT. THEY SHOULD NOT BE USED ON SITE FOR CONSTRUCTION OR LAYOUT.

CALL BEFORE YOU DIG ...
811
DIAL 811
48 HOURS BEFORE YOU DIG, CALL UTILITY LOCATORS FOR LOCATING OF UNDERGROUND ELECTRIC, WATER AND WASTEWATER

No.	Description	By	Date
	REVISIONS		

H Scale: N/A
V Scale: 1" = 300'
Designed By: KDH
Drawn By: DAS
Checked By: KDH
Date: 03/23/2022

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www.ldc-inc.com • TEL: (719) 528-6133 • FAX: (719) 528-6848
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CANYON CREEK RANCH

DRAINAGE MAP FOR OFFSITE DRAINAGE AREAS

Project No.: 21002

Sheet: 1 of 3

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