



# Final Drainage Report

## **Edgewood Subdivision Filing No. 1**

**Minor Subdivision Plat**

**Project Number 61127**

**May 1, 2020**

**PCD File No.: MS199**

# Final Drainage Report

For:

**Edgewood Subdivision Filing 1**

Minor Subdivision Plat

**Project No. 61127**

**August 26, 2019**

**Revised: October 28, 2019**

**Revised: May 1, 2020**

Prepared for:

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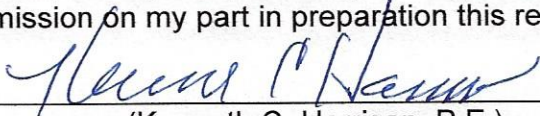
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## CERTIFICATIONS AND APPROVALS

### 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 has been prepared according to the criteria established by El Paso County for drainage reports and said drainage 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



(Kenneth C. Harrison, P.E.)

Registered Professional Engineer State of Colorado No.

23635

Seal



### Owner's Statement

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

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(James Martens)

Address: 8190 Poco Road  
Colorado Springs, Colorado 80908

### El Paso County

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

El Paso County Engineer/ ECM Administrator

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Jennifer Irvine, P.E.)

Date: \_\_\_\_\_



## **I. REPORT PURPOSE**

The purpose of this study is to evaluate the drainage characteristics for the historic and the developed conditions of the Edgewood Subdivision Filing 1 (the site) in accordance the current El Paso County Drainage Criteria. The parameters used for the historic conditions are based on natural conditions with no development. The parameters used for the developed conditions are based on the construction of two (2) residences.

The current site consists of approximately 12.2 acres and is occupied by a single residence. The address is 8190 Poco Road. The site is to be subdivided into two (2) lots, 5.0 acres and 7.2 acres. No changes to the existing drainage characteristics are proposed. The Drainage Plan included in the back of this report shows the existing residence. The second residence is assumed to be constructed near the high point of the 5 acre lot. The location shown on the Drainage Map is approximate. The individual parameters used in the hydrologic and hydraulic evaluation will be discussed in the following sections.

This analysis will demonstrate that there is only a negligible increase in runoff with the development of the site.

## **II. GENERAL DESCRIPTION**

The site is a portion of the southeast quarter of the northwest quarter of Section 28, Township 12 South, Range 65 West of the 6<sup>th</sup> Principal Meridian, El Paso County, Colorado.

The 12.2 acre site is in a natural pasture condition that is regularly mowed. The pasture area surrounds the existing residence. It is assumed that the same will be the case with the 2<sup>nd</sup> residence. The address of the existing residence is 8190 Poco Road.

There are several observable natural drainage and stable corridors that extend from north to south within the boundaries of the site. These will be discussed in the following sections of this report.

No offsite improvements or onsite improvements are proposed for the site except for the installation of an 18" CMP culvert under the driveway to the new residence.

## **III. DESIGN CRITERIA AND METHODOLOGY**

The hydrologic and hydraulic characteristics for both the historic and developed conditions of the site were evaluated using the following resources

- ***Design Manuals***
  - ***El Paso County Drainage Criteria Manual, Volume I.***

The charts and graphs used from this manual are reproduced in Exhibit 4 of the Appendix.

- ***City of Colorado Springs Drainage Criteria Manual (where included with the El Paso County Drainage Criteria Manual).***  
The charts and graphs used from this manual are reproduced in Exhibit 4 of the Appendix.
- **Soil Survey of El Paso County Area, Colorado United States Department of Agriculture, Soil Conservation Service**  
(See Appendix, Exhibit 3)
- ***Flood Insurance Rate Map, Federal Emergency Management Agency***  
(See Appendix, Exhibit 2)
- ***Sand Creek Drainage Basin Planning Study***  
(See Appendix, Exhibit 5)
- **Design storms**
  - Minor storm: 5 year
  - Major storm: 100 year
- **Drainage Areas**
  - Areas for the offsite and onsite sub basins were determined from topographic mapping provided by MVE. This mapping was used as the base for the Drainage Map included in Exhibit 8 at the back of this report.
- **Runoff Methods**
  - ***Rational Method***  
This method is used to determine runoff quantities for sub basins with less than 130 acres. Intensity-Duration-Frequency (IDF) curves were obtained from the Colorado Springs Drainage Criteria Manual (DCM) (Appendix, Exhibit 4).
- **Culvert Evaluation**  
Sizing
  - The 5 year storm was used to evaluate the culverts with a headwater to depth ratio limit of 1.5.
  - The 100 year storm was used to evaluate the over topping conditions at the culverts under Brown Road.
  - The assumptions that were made in the evaluation of these culverts are described in the pertinent sections of the report.
- **Drainage Swale and Borrow Ditch Evaluation**
  - Onsite and offsite drainage swales and the borrow ditches along the northerly roadside of Poco Road were evaluated for erosion potential and depth of flow.

- The assumptions that were made in the evaluation of these culverts are described in the pertinent sections of the report
- The Froude Number was calculated to determine the state of flow, subcritical vs. supercritical. Supercritical flow only became an issue when excessive velocities were calculated for either the minor or major storm events.
- **Detention/ Water Quality**
  - The detention pond/ water quality requirements are addressed in Section XIII.
- **Erosion control**
  - Erosion issues were evaluated based on the estimated velocities in the existing swales.

#### **IV. EXISTING REPORTS, MAPPING AND INFORMATION**

- The project is located at the northwesterly corner of the **Sand Creek Drainage Basin** (Appendix, Exhibit 5).
- No drainage reports have been prepared for any of the tracts that surround the site.

#### **V. FEMA FLOODPLAIN**

The project is within Zone X (other) as shown on the Flood Rate Insurance Map, El Paso County, Colorado and Incorporated Areas, Map Number 08041C0535G, (see Appendix, Exhibit 2). New construction within this zone is subject to minimal flooding hazards.

#### **VI. HYDROLOGIC SOILS INFORMATION**

The hydrologic soils groups were obtained from the USDA National Resource Conservation Service website for soils types in El Paso County, Colorado (see Appendix, Exhibit 3). The soils are identified as follows:

- Pring coarse sandy loam 3-8% (SCS No. 71)

The soils and their characteristics are described in detail in the soils report included in the Appendix, Exhibit 3. The soil group is classified within the B hydrologic group.

#### **VII. DOWNSTREAM DRAINAGE CONDITIONS**

All stormwater runoff drains to the roadside borrow ditch along the northerly side of Poco Road. Two (2) CMP culverts pass the runoff under Poco Road at locations Design Points (DP) 8 and 9 as shown on the Drainage Plan (Exhibit 8, Appendix). A limited evaluation of these culverts was conducted with the parameters and assumptions discussed. A thorough evaluation was not accomplished due to the insignificant increase in design flows created by the developed conditions. Developed flow from the site was used to evaluate the

culverts since there was only a minimal increase in flows from the historic condition.

The culverts discharge into broad grassed lined swales that are natural and not man-made. Based on site observations these swales are stable with only a minor amount of erosion occurring. This is expected with any natural grassed lined swale. Since the increase in runoff for the developed conditions is only negligible it is expected that there will be no change in the existing stability of the downstream swales.

## **VIII. DRAINAGE CONDITIONS FOR OFFSITE SUB-BASINS AND SWALES**

The hydrologic parameters were determined for both the historic and the developed conditions.

Based visual observations and existing vegetative conditions, it is expected that these swales will safely convey the runoff for both the minor and major storms for the historic and developed conditions. It was assumed that the developed conditions for the offsite sub basins with remain unchanged from the existing historic conditions.

- **Basin OS1 and Swale 1**

The analysis performed for this area was only for the historic conditions since no development is anticipated. The runoff from OS1 flows to DP1.

Sub basin OS-1 is the only comparatively large offsite sub basin that drains onto the site. It is approximately 10.3 acres and drains from north to south. The area is predominantly “mowed pasture” in excellent condition. The average slope is between 7% and 10%. OS-1 is drained by a broad grass lined swale noted as Swale 1 on the Drainage Plan. Swale 1 intersects with a smaller swale (not studied) at Design Point 1 approximately 100 feet south of the site’s northerly property line.

### **Hydrologic Characteristics** (calc sheet 1 of 35)

- Area = 10.3 acres
- Runoff Coefficients: 5 year = 0.08, 100 year = 0.35
- Time of Concentration = 27.2 minutes
- Estimated Runoff : 5 year = 1.5 cfs , 100 year = 14.1 cfs

### **Hydraulic Evaluation Swale 1** (calc sheets 18 thru 20 of 35)

- Grassed lined in excellent condition
- Bottom width = 20 feet (average)
- Side Slopes = 10 to 1 (average)
- Slope = 10.7% (average)
- Design flows: 5 year = 1.5 cfs, 100 year = 14.1 cfs
- Depth of flow: 5 year = negligible, 100 year = 0.2 ft.
- Velocity: 5 year = 1.7 fps, 100 year = 3.9 fps

- Erosion potential: negligible based on velocity and visual observation
- **Basin OS2 and Swale 4** (information purposes only)  
The boundary of Offsite Basin OS-2 is shown on the Drainage Plan for information purposes only. The runoff from this area drains from north to south along the easterly side of the site in a large broad grass lined swale. Only a small portion of the site, sub basin C, drains into OS-2. This sub-basin is located at the northeast corner of the site. Stormwater in swale #4 has no impact on the site's drainage conditions. The runoff from OS2 drains to the borrow ditch along the northerly side of Poco Road. Once in the borrow ditch the water flows in an easterly direction, away from the site, to an existing culvert that passes the water under Poco Road. The hydraulic characteristics of the swale were not evaluated since it has no impact on the site.
- **Basin OS3**  
The hydrologic parameters were evaluated for only the historic condition for the evaluation of the driveway culvert. It was assumed that no future development would occur in OS3.

Runoff from OS3 drains to DP 4. Sub-basin OS-3 is approximately 0.6 acres is located offsite at the southeasterly corner of the site. This area drains to the northerly borrow ditch along Poco Road which carries the storm water in a westerly direction to Design Point 4. The water then passes under a driveway to the existing residence through an 18 CMP driveway culvert. This culvert is located approximately 75 west of Design Point 4.

#### **Hydrologic Characteristics** (calc sheet 4 of 35)

- Area 0.6 acres
- Runoff Coefficients  
5 year storm = 0.08  
100 year storm = 0.35
- Time of Concentration: 10 minutes (minimum allowed per criteria)
- Estimated Runoff:  
Minor storm (5 year) = 0.2 cfs  
Major Storm (100 year) = 1.4 cfs

#### **Hydraulic Evaluation Swale 5** (see calc sheets 24 thru 26 of 35)

The hydraulic conditions of the swale upstream of DP#4 were evaluated with Swale #5. Minimal runoff enters the swale upstream of DP #4 since the DP is located so close to the swale's high point.

- **Basin OS4 and Basin B** (references to calc sheets are indicated below)  
The analyses performed for these basins ere for both the historic and developed conditions. The runoff from these sub basins flow to DP6. The total flow at this point was used to evaluate Swale #5.

Runoff from OS-4 and Basin B drains to DP #6 via Swale #5. The total area for basin OS4 and basin B is 4.4 acres. The area includes 2/3 of sub basin B and all of basin OS4. The hydrologic and hydraulic parameters of these basins and roadside borrow ditch were evaluated in combination with the developed flows from basin B since runoff from this sub basin sheet flows into the borrow ditch.

**Hydrologic Characteristics (historic)** (calc sheet 6 of 35)

Basin OS4 and basin B have the following hydrologic characteristics:

- Area 4.4 acres
- Runoff Coefficients (composite): 5 year storm = 0.108 100 year storm = 0.35
- Time of Concentration: 15.8 minutes (same as at design Point 3) (calc sheet 3 of 33)
- Estimated Runoff (historic)(calc sheet 6 of 35): 5 year = 1.6 cfs, 100 year = 9.4 cfs

**Hydrologic Characteristics (developed)** (calc sheet 13, 14 of 35)

Basin OS4 and basin B have the following hydrologic characteristics:

- Area 4.4 acres
- Runoff Coefficients (composite): 5 year storm = 0.17, 100 year storm = 0.41

The composite runoff coefficients were determined based on the following:

Natural: 3.2 acres, C for 5 year = 0.08; C for 100 year = 0.35

House roof area: 8000 sf; C for 5 year = 0.73; C for 100 year = 0.81

Landscaping: 0.4 acres; C for 5 year = 0.12; C for 100 year = 0.39

Gravel Road and driveway: 0.4 acres; C for 5 year = 0.59; C for 100 year = 0.70

- Time of Concentration: 15.8 minutes (same as at design Point 3) (calc sheet 3 of 33)
- Estimated Runoff: 5 year = 2.5 cfs, 100 year = 11.7 cfs

This reflects only a small increase as a result of development.

**Hydraulic Evaluation Swale 5** (calc sheets 24 thru 26 of 35)

Only a limited evaluation of the borrow ditch was performed in order to approximate the condition of the ditch. The evaluation of the culvert at DP#8 will be described in the following sections of this report.

- Grassed lined in excellent condition
- Bottom width = 2 feet (per EPC standard)
- Side Slopes = 3 to 1(per EPC standard)
- Slope = 6.0%
- Design flow: 5 year = 2.5 cfs, 100 year = 11.7 cfs
- Depth of flow: 5 year = 0.2 ft., 100 year = 0.6 ft.
- Velocity: 5 year = 3.1 fps, 100 year = 5.4 fps

- Erosion potential: negligible
- **Basin OS5** (references to calc sheets are indicated below)  
The analysis performed for this area was only for the historic conditions since no development is anticipated.

The total area for basin OS5 and basin OS6 is approximately 0.3 acres is located along the westerly property line of the site immediately north of Poco Road and adjacent to the westerly property line of the site. These basins drain from north to south to the northerly borrow ditch along Poco Road 4 which carries the runoff water in an easterly direction to Design Point 7. Basin OS5 was analyzed in combination with basin OS6. These basins contribute runoff to DP7. The water is then directed to an 18 inch culvert under Poco Road. The culvert is approximately located 20 feet east of the southwesterly corner of the site.

**Hydrologic Characteristics** (calc sheet 7 of 35)

- Area 0.3 acres (OS5 and OS6)
- Runoff Coefficients (composite)
  - 5 year storm = 0.25
  - 100 year storm = 0.47
- Time of Concentration: 10 minutes (minimum allowed for undeveloped conditions)
- Estimated Runoff:
  - Minor storm (5 year) = 0.3 cfs
  - Major Storm (100 year) = 1.0 cfs

The swale was not evaluated since the roadside ditch handles a negligible amount of runoff.

- **Basin OS6**  
The analysis performed for this basin was only for the historic conditions since no development is anticipated.

Basin OS6 is approximately 0.1 and consists of ½ of the Poco Road right of way. Runoff from this basin is negligible since the majority of the runoff from sub basin A enters Swale #7 prior to entering the Poco Road right of way at the upstream end of the culvert at DP9. The area for basin OS-6 was included in the total area contributing runoff to the 18" CMP culvert at DP9. The parameters that were used in the analysis are in the following sections of this report.

- **Basin OS7**  
Basin OS7 is approximately 0.2 and consists of ½ of the Poco Road right of way. Runoff from this basin is negligible since the majority of the runoff from basin B enters Swale #6 that discharges at the upper end of the 24" CMP culvert at DP8. The area in basin OS-7 was included in the total area



contributing runoff to the culvert at DP8. The parameters that were used in the analysis are in the following sections of this report.

## **IX. DRAINAGE CONDITIONS FOR ONSITE SUBBASINS AND SWALES**

The developed conditions reflect the construction of two (2) residences. One (1) residence is already built and is located on the 7.2 acre lot. The other is assumed to be constructed on the 5 acre lot near its high point. The approximate location is shown on the Drainage Plan. Improvements are to consist of the residence, landscaping, and a gravel driveway off of Poco Road. Runoff from basins A and B was determined for both the historic and developed conditions. It has been demonstrated that there is only a negligible increase in runoff from the historic conditions.

Runoff from the developed site was based on the following land use assumptions (Appendix, Exhibit 4):

Natural grassland: C (5 year) = 0.08, C (100 year) = 0.35  
House footprint: 8000 sf; C (5 year) = 0.73, C (100 year) = 0.81  
Landscaping: 0.4 acres; C (5 year) = 0.12, C (100 year) = 0.39  
Gravel Driveway: 6000 sf; C (5 year) = 0.59, C (100 year) = 0.70

- **Basin A and Swale 2** (references to calc sheets are indicated below)  
Basin A is approximately 4.3 acres, and drains north to south along the westerly side of the site. Runoff from basin OS1 enters the site at DP1 via a broad grass lined swale noted as Swale 1 on the drainage plan. The characteristics of Swale #1 are described in Section VIII of this report. The swale that drains basin A is noted as Swale 2 on the drainage plan. This swale directs the runoff in a southerly direction to DP2 and then to an 18 inch culvert under Poco Road at Design Point at DP 9.

**Hydrologic Characteristics** (references to calc sheets are indicated below)  
The hydrologic characteristics were determined based on the total area that contributes runoff to Design Point 2.

Historic Conditions (calc sheet 2 of 35)

- Area = 14.9 acres (includes areas OS1, A, and OS5, and OS6).
- Runoff Coefficients (composite): 5 year = 0.08, 100 year = 0.35
- Time of Concentration: 33.5 minutes
- Estimated Runoff: 5 year = 2.7 cfs, 100 year = 19.8 cfs

Developed Conditions (calc sheet 10 and 11 of 35)

- Area = 14.9 acres (includes areas OS1, A, and OS5, and OS6).
- Runoff Coefficients (composite): 5 year = 0.09, 100 year = 0.36
- Time of Concentration: 33.4 minutes
- Estimated Runoff: 5 year = 3.1 cfs, 100 year = 20.4 cfs

### **Hydraulic Evaluation Swale 2 @ DP9** (calc sheets 21 thru 23 of 35)

Grass lined in excellent condition

- Bottom width = 10 feet
- Side Slopes = 10 to 1
- Slope = 3.6%
- Design Flow: 5 year = 5.8 cfs, 100 year = 23.2 cfs
- Depth of flow: 5 year = 0.2 feet, 100 year = 0.4 feet
- Velocity = 5 year = 2.4 fps, 100 year = 3.8 fps
- Erosion potential: negligible based on velocity and site observation

An existing 18 inch CMP culvert passes the stormwater under Poco Road at Design Point 2. The hydraulic characteristics of the culvert are summarized in Section X of this report.

- **Basin B and Swale 3** (references to calc sheets are indicated below)  
Sub-basin B is approximately 5.9 acres and encompasses the majority of the site. The area slopes to the south at slopes between 8% and 11%. No runoff from offsite basins enters this sub basin. Runoff sheet flows across natural ground to DP 3. The cover is a well-developed grassland and appears to be stable and in excellent condition. The area appears to be mowed on a regular basis. The majority of the runoff enters the northerly roadside borrow ditch along Poco Road. The ditch directs the water to an existing 24 inch culvert at DP8 and was evaluated in a following section of this report.

### **Hydrologic Characteristics** (references to calc sheets are indicated below)

The hydrologic characteristics were determined at DP 3

Historic conditions (calc sheet 3 of 35)

- Area = 5.9 acres
- Runoff Coefficients
  - 5 year storm = 0.08
  - 100 year storm = 0.35
- Time of Concentration: 15.8 minutes
- Estimated Runoff:
  - Minor storm (5 year) = 1.7 cfs
  - Major Storm (100 year) = 12.0 cfs

Developed conditions (calc sheet 12 of 35)

- Area = 5.9 acres
- Runoff Coefficients (composite)
  - 5 year storm = 0.12
  - 100 year storm = 0.42
- Time of Concentration: 15.8 minutes
- Estimated Runoff:
  - Minor storm (5 year) = 2.4 cfs

Major Storm (100 year) = 16.9 cfs

A small swale, noted as Swale 3, drains approximately 1/3 of sub basin B. Due to the small area involved it was assumed that there would be minimal impact on the stability of the soil. Therefore this swale was not evaluated.

An existing 24 inch CMP culvert passes the stormwater under Poco Road at Design Point 8. The hydraulic characteristics are summarized in Section X of this report.

- **Sub-basin C** (references to calc sheets are indicated below)  
The runoff from basin C flows to DP5. Runoff from basin C sheet flows into basin OS2. A DP was located in an arbitrary manner in order to simplify analysis. Also, in order to simplify the analysis for the developed conditions it was assumed that all of the runoff from the existing residence will discharge in basin B

Basin C is approximately 1.5-acres and is located at the northeast section of the property. The area slopes to the east with grades between 10 and 15%. The entire runoff sheet flows into basin OS2.

**Hydrologic Characteristics** (calc sheet 5 of 35)

The following hydrologic characteristics are based on sheet flow since concentrated flow does not occur until the stormwater reaches Swale 4.

- Area = 1.5 acres
- Runoff Coefficients  
Minor storm (5 year): 0.08  
Major Storm (100 year): 0.35
- Time of Concentration: 10 minutes (represents the minimum that is allowed per criteria)
- Estimated Runoff  
Minor storm (5 year): 0.5 cfs  
Major Storm (100 year): 3.6 cfs

**X. EXISTING DRAINAGE FACILITIES**

The existing drainage facilities include culverts under Poco Road located at DP8 and DP9 and an 18" CMP culvert under the driveway at DP4. The culvert at DP8 is a 24" CMP located approximately 500 feet west of the southeasterly property corner of the site. The culvert at DP9 is an 18" CMP and located approximately 20 feet east of the southwesterly property corner of the site. Each culvert was evaluated based on the developed conditions. The hydraulic characteristics of the culvert were not evaluated for historic conditions since there is only a negligible increase in flows from the developed conditions.

The analyses of the culverts were limited in scope. Verification of these assumptions is beyond the scope of this report. Deviation from these

assumptions would be subject to existing field conditions which are subject to change on a frequent basis. The analysis for each culvert was based on the following assumptions:

- The culverts have a minimum of 2 feet of cover.
- The tail water depth at the downstream end of each culvert is minimal and will not affect the culvert's capacity. It was assumed that each culvert was operating under inlet control and in a non-pressurized condition.
- The culvert's inlet and outlet conditions were assumed to be projecting into the roadside and downstream swales. It was also assumed that the borrow ditches are well maintained.
- The culverts were assumed to be clean and not blocked with sediment.
- The allowable headwater to depth ratio (HW/D) is 1.5 for the 5 year storm event and minimum overtopping for the 100 year event in accordance with EPC criteria.

- **Driveway Culvert at Design Point 4**

There is no change from the historic to the developed flows at this design point. Therefore, the hydrologic and hydraulic conditions are the same.

**Hydrologic Characteristics** (calc sheet 4 and 13 of 35)

- Culvert size: 18" CMP
- Contributing drainage area = 0.6
- Runoff Coefficients (composite)
  - 5 year = 0.08
  - 100 year = 0.35
- Time of Concentration = 10 minutes
- Runoff
  - 5 year = 0.2 cfs
  - 100 year = 1.4 cfs

**Culvert Hydraulic Characteristics** (calc sheet 27 of 35)

- Slope = 6% same as slope of Poco Road
- Headwater to depth ratio (HW/D) (see Appendix, Exhibit 4, Figure 3.28)
  - 5 year = no change from the historic to the developed flows
  - 100 year = no change from the historic to the developed flows
- Normal Depth and Velocity (occurs when the water is in the culvert)
  - 5 year = no change from the historic to the developed flows
  - 100 year = no change from the historic to the developed flows
- Recommendations: culvert has sufficient capacity for both the 5 year and the 100 storm event.

- **Driveway Culvert at Design Point 8**

**Hydrologic Characteristics** (calc sheet 15 and 16 of 35)

The following hydrologic characteristics are based the total of all sub-basins that drain to Design Point 8

- Culvert size: 24" CMP
- Contributing drainage area = 7.2 acres (this includes basins B, OS3, OS4, and OS7) (calc sheet 8)
- Runoff Coefficients (composite)
  - 5 year = 0.13
  - 100 year = 0.39
- Time of Concentration = 15.8 minutes
- Runoff
  - 5 year = 3.2 cfs (developed) vs. 2.0 cfs (historic)
  - 100 year = 16.3 cfs (developed) vs. 15.9 cfs (historic)

**Culvert Hydraulic Characteristics** (calc sheet 28 of 35)

- Slope = 1.2% (based on survey information)
- Headwater to depth ratio
  - 5 year = less than 0.5, insignificant
  - 100 year = 1.5 (or depth of 3 feet)
- Normal Depth and Velocity (occurs when the water is in the culvert)
  - 5 year = 0.5 ft, 3.5 fps
  - 100 year = 1.1 ft, 5.6 fps
- Recommendations: culvert has sufficient capacity for both the 5 year and 100 year events.

• **Design Point 9** (calc sheet 17 of 33)

**Hydrologic Characteristics**

- Size: 18" CMP
- Contributing drainage area = 14.9 acres (includes basins A, OS1, OS5, OS6) (calc sheet 9)
- Composite Runoff Coefficients
  - 5 year = 0.10
  - 100 year = 0.37
- Time of Concentration = 33.5 minutes
- Runoff
  - 5 year = 3.4 cfs developed vs. 3.1 cfs historic
  - 100 year = 20.9 cfs developed vs. 19.8 cfs historic

**Culvert Hydraulic Characteristics** (calc sheet 31 thru 33 of 35)

- Slope = 1.2% (based on survey information)
- Headwater to depth ratio (HW/D) (Appendix, Figure 3.28)
  - 5 year = 0.7
  - 100 year = 5.0
- Normal Depth and Velocity (normal flow occurs when the water is in the culvert)
  - 5 year = 0.6 ft, 3.7 fps
  - 100 year = 1.5 ft, 6.1 fps
- Recommendations: the existing culvert is undersized since it cannot handle the historic 100 year event according to current criteria. It

should be replaced with a 24" CMP. The discharge for the developed conditions has minimal effect on the hydraulic characteristics of the culvert since the increase in flow is only 0.3 cfs and 1.1 cfs for the 5 year and 100 year, respectively. Since the existing culvert is undersized for the historic conditions the Owner has no responsibility to replace the culvert.

#### **XI. DEVELOPED DRAINAGE CONDITIONS**

Development is to consist of the construction of a single residential home on the 5 acre lot. There is already an existing residence on the 7.2 acre lot. It is anticipated that the improvements for the new construction will be similar to that of the existing residence. The following land use was assumed in the evaluation of the hydrologic and hydraulic parameters that are presented in the previous sections of this report

- House footprint: 8000 sf
- Landscaping: 0.4 acres (conservative assumption)
- Gravel Driveway: 6000 sf

#### **XII. PROPOSED IMPROVEMENTS**

No drainage improvements are proposed for this site as a result of development except for an 18" CMP culvert under the driveway to the 5 acre lot. It is expected that this culvert will be installed at the upper end of either swale #6 or #7 in basins B and A respectively. It is expected that there will only be a negligible discharge at either of these locations. Therefore, an 18" CMP will have sufficient capacity to accommodate both the 5 year and the 100 year events.

#### **XIII. DETENTION AND WATER QUALITY**

It is expected that the total area to be disturbed with the addition of one (1) residence is as follows;

- House footprint: 8000 sf, 0.18 acres
- Landscaping: 0.4 acres (conservative)
- Gravel Driveway: 6000 sf, 0.14 acres
- Total Area to be disturbed = 0.72 acres (maximum)

Therefore, since the disturbed area is less than 1 acre the proposed development is not an "applicable construction activity and water quality will not be required". Also, detention is not required since the increase in flows as a result of development is minimal. Also, since all of the runoff flows to the design points via natural and well vegetated swales it is expected that water quality will also not be an issue.

#### XIV. EROSION CONTROL

It is advised that the following erosion control measures be applied with the construction of the gravel driveway to the new residence on the 5 acre lot.

- Erosion control logs
- Erosion control blanket
- Seeding and mulching on the disturbed areas

#### XV. FEE CALCULATIONS (calc sheet 35 of 35)

The drainage fee was determined based on the 5 acre lot that is to be disturbed since the 7.2 acre lot has an existing residence. The site is located in the Sand Creek Drainage Basin which has the following fees per impervious acre (Appendix, Exhibit 5):

Drainage Fee per impervious acre	\$	18,940
<u>Bridge Fee per impervious acre</u>	<u>\$</u>	<u>5,559</u>
Total Fees per impervious acre	\$	24,499

% Impervious (see Appendix, Exhibit 5 = 7%)

Impervious Area = 0.35 acres

Fee reduction for 5 acre lots = 25%

Total Impervious area = 0.26 acres

Please delete the highlighted

Total Drainage Fee =	\$	4,924.40
<u>Total Bridge Fees =</u>	<u>\$</u>	<u>1,445.34</u>
Total Fees =	\$	6,369.74

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

#### XVI. FOUR STEP PROCESS

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 since the proposed disturbance is less than one acre.

#### XVII. SUMMARY

The report addresses the hydrologic and hydraulic parameters for both the existing and developed conditions for the entire site even though there are insignificant changes in the runoff for the developed conditions. The two (2) existing culverts under Poco Road were evaluated on a limited basis in order to determine the anticipated hydraulic conditions. The limitations are discussed in the previous sections of this report.



It has been demonstrated that the 24" CMP at DP8 is expected to have sufficient capacity to accommodate both the 5 year and the 100 year design storms in accordance with the EPC criteria.

It has been demonstrated that the existing 18" culvert does not have sufficient capacity even to accommodate the historic conditions. Since the runoff for the developed conditions is only slightly higher than for the existing condition, it can be concluded that the culvert is not sized to accommodate even the historic conditions. It has also been demonstrated that the culvert does not have the capacity to handle the existing flow either. Since the increase in flows, as a result of development, is insignificant, the Owner will have no responsibility to replace this culvert.

The only drainage improvement that is proposed is an 18" CMP under the proposed driveway into the new residence to be constructed on the 5 acre lot.

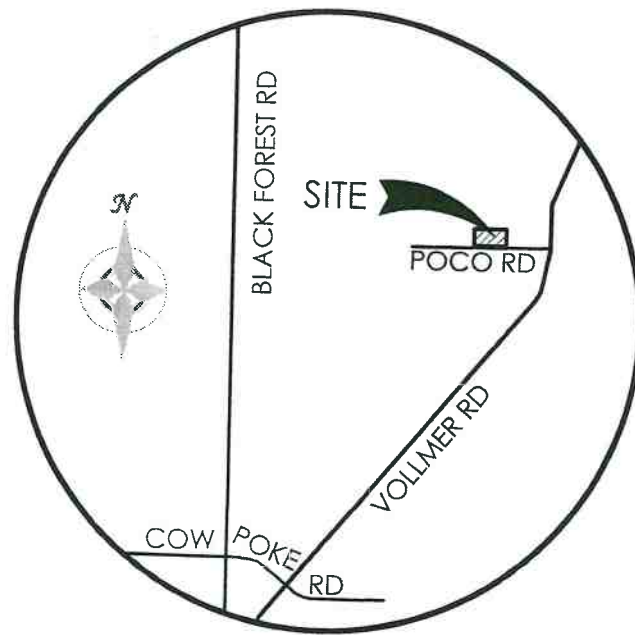
No detention or water quality facilities are required since the area of disturbance is less than 1 acre.

Erosion control facilities are recommended to minimize erosion next to the proposed gravel driveway accessing the new residence on the 5 acre lot.

It is expected that the drainage runoff from this developed site will have no adverse effects to the downstream of surrounding properties.

# APPENDIX

**Exhibit 1**  
**General Location Map**



## VICINITY MAP

NOT TO SCALE

**Exhibit 2**  
**FEMA FIRM Map**

# National Flood Hazard Layer FIRMette



38°58'53.04"N



## 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, AP*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**

- 0.2% Annual Chance Flood Hazard, Area 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**

- Area of Minimal Flood Hazard  
*Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard  
*Zone*

**GENERAL STRUCTURES**

- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**

- Cross Sections with 1% Annual Chance 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

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 8/22/2019 at 7:18:59 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 and Data**





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



August 21, 2019

# Preface

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

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

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

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

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

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

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# How Soil Surveys Are Made

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

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

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

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

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units).

Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

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

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

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

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

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

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

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



## Custom Soil Resource Report

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

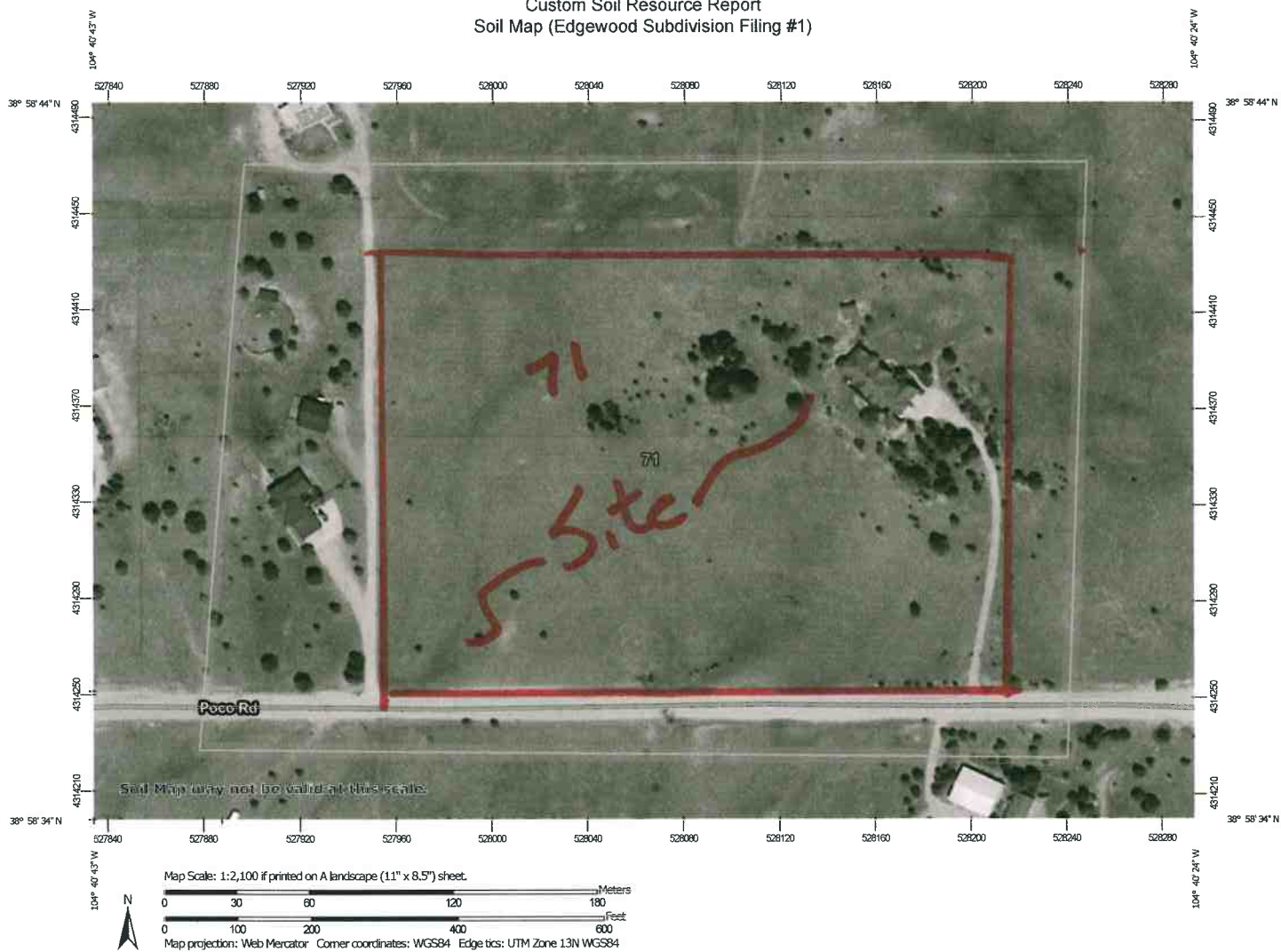


# Soil Map

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

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Soil Map (Edgewood Subdivision Filing #1)



## Custom Soil Resource Report

### MAP LEGEND

<b>Area of Interest (AOI)</b>			Spoil Area
	Area of Interest (AOI)		Stony Spot
<b>Soils</b>			Very Stony Spot
	Soil Map Unit Polygons		Wet Spot
	Soil Map Unit Lines		Other
	Soil Map Unit Points		Special Line Features
<b>Special Point Features</b>		<b>Water Features</b>	
	Blowout		Streams and Canals
	Borrow Pit	<b>Transportation</b>	
	Clay Spot		Rails
	Closed Depression		Interstate Highways
	Gravel Pit		US Routes
	Gravelly Spot		Major Roads
	Landfill		Local Roads
	Lava Flow	<b>Background</b>	
	Marsh or swamp		Aerial Photography
	Mine or Quarry		
	Miscellaneous Water		
	Perennial Water		
	Rock Outcrop		
	Saline Spot		
	Sandy Spot		
	Severely Eroded Spot		
	Sinkhole		
	Slide or Slip		
	Sodic Spot		

### 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 16, Sep 10, 2018

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

Date(s) aerial images were photographed: Sep 8, 2018—May 26, 2019

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 (Edgewood Subdivision Filing #1)



Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
71	Pring coarse sandy loam, 3 to 8 percent slopes	21.8	100.0%
Totals for Area of Interest		21.8	100.0%

## Map Unit Descriptions (Edgewood Subdivision Filing #1)

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

## Custom Soil Resource Report

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

### 71—Pring coarse sandy loam, 3 to 8 percent slopes

#### Map Unit Setting

*National map unit symbol:* 369k  
*Elevation:* 6,800 to 7,600 feet  
*Farmland classification:* Not prime farmland

#### Map Unit Composition

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

#### Description of Pring

##### Setting

*Landform:* Hills  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Arkosic alluvium derived from sedimentary rock


##### Typical profile

*A - 0 to 14 inches:* coarse sandy loam  
*C - 14 to 60 inches:* gravelly sandy loam

##### Properties and qualities

*Slope:* 3 to 8 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Well drained  
*Runoff class:* Low  
*Capacity of the most limiting layer to transmit water (Ksat):* 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 storage in profile:* Low (about 6.0 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 3e  
 *Hydrologic Soil Group:* B  
*Ecological site:* Loamy Park (R048AY222CO)  
*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

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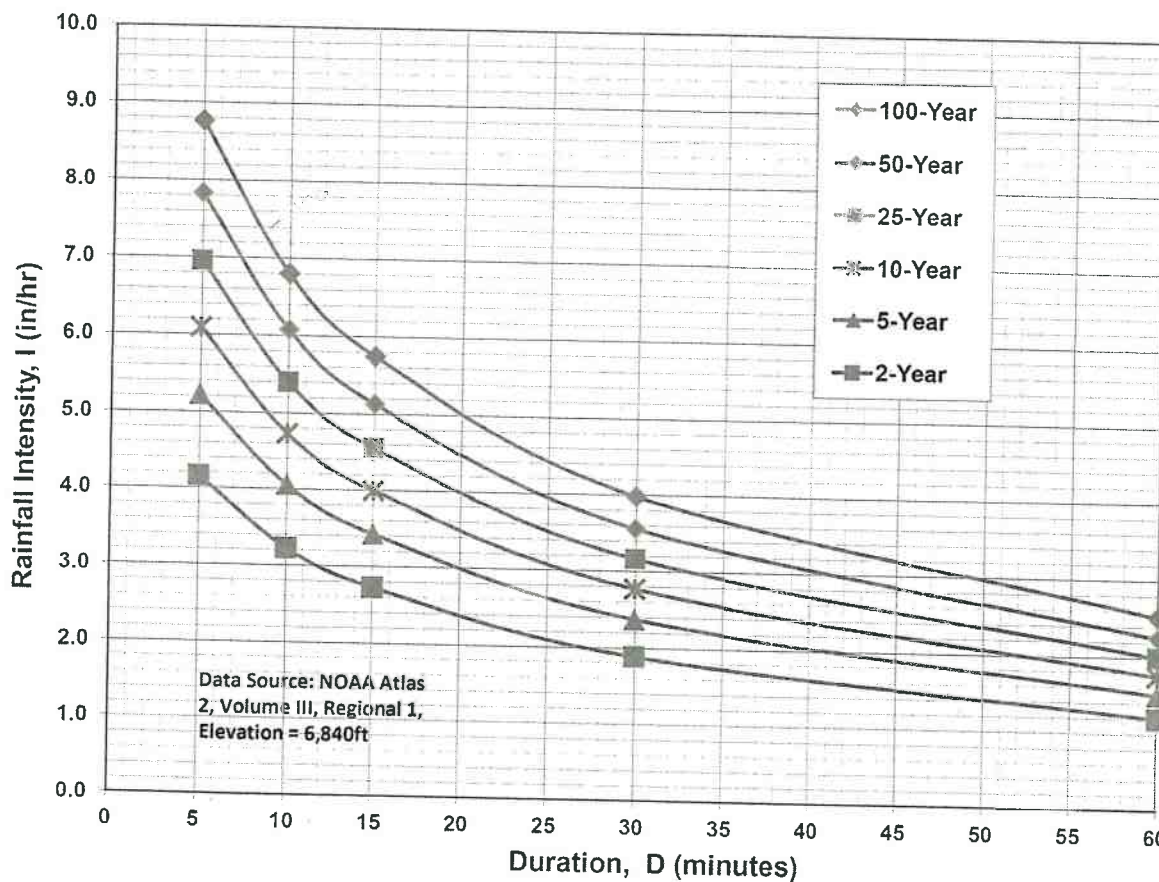
United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. [http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2\\_053624](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624)

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. [http://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs142p2\\_052290.pdf](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf)

## **Exhibit 4**

### **Charts and Tables**

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
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 ( $t_f$ ) 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 ( $t_f$ ) 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.

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

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)

**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.

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

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.

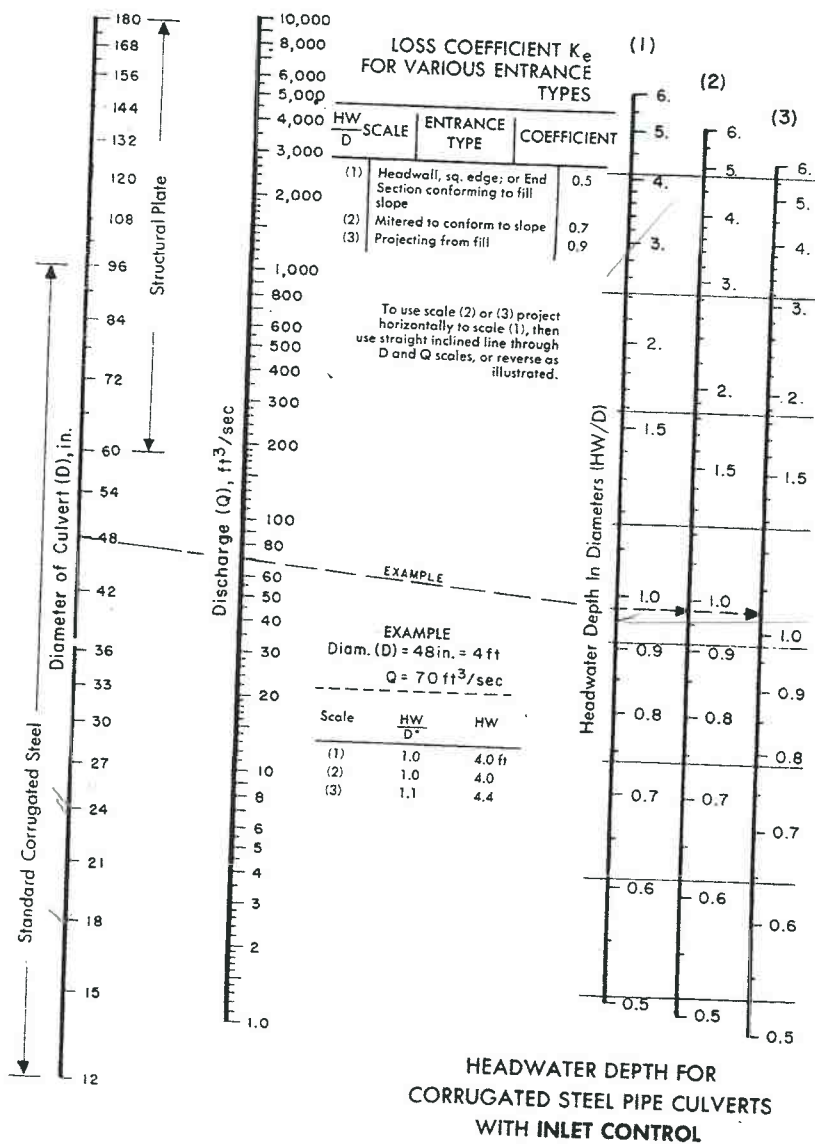
### 3.2.5 Post-Development Time of Concentration

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



### Improved Inlets

Culvert capacity may be increased through the use of special inlet designs. The Federal Highway Administration has developed extensive data<sup>19,20</sup> on these. While these designs increase the flow, their use has not been as expected. The increased costs of the special treatments is apparently responsible.



**Figure 3.28** Inlet control nomograph for corrugated steel pipe culverts.<sup>13</sup> The manufacturers recommend keeping  $HWD$  to a maximum of 1.5 and preferably to no more than 1.0 for diameters greater than 4 to 5 feet.

[Show](#)

## Manning's n Values



Reference tables for Manning's n values for Channels, Closed Conduits Flowing Partially Full, and Corrugated Metal Pipes.

### Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
<b>1. Main Channels</b>			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
<b>2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages</b>			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
<b>3. Floodplains</b>			
a. Pasture, no brush			
1. short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little	0.080	0.100	0.120



undergrowth, flood stage below branches			
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
<b>4. Excavated or Dredged Channels</b>			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.020
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.030
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.030
2. grass, some weeds	0.025	0.030	0.033
3. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. earth bottom and rubble sides	0.028	0.030	0.035
5. stony bottom and weedy banks	0.025	0.035	0.040
6. cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.040
2. jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
<b>5. Lined or Constructed Channels</b>			
a. Cement			
1. neat surface	0.010	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.010	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	

8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

### Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
<b>1. Brass, smooth:</b>	0.009	0.010	0.013
<b>2. Steel:</b>			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
<b>3. Cast Iron:</b>			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
<b>4. Wrought Iron:</b>			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
<b>5. Corrugated Metal:</b>			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
<b>6. Cement:</b>			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015
<b>7. Concrete:</b>			
Culvert, straight and free of debris	0.010	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016

Unfinished, rough wood form	0.015	0.017	0.020
<b>8. Wood:</b>			
Stave	0.010	0.012	0.014
Laminated, treated	0.015	0.017	0.020
<b>9. Clay:</b>			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified Subdrain with open joint	0.014	0.016	0.018
<b>10. Brickwork:</b>			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.013	0.016
Paved invert, sewer, smooth bottom	0.016	0.019	0.020
Rubble masonry, cemented	0.018	0.025	0.030

### Manning's n for Corrugated Metal Pipe (AISI, 1980).

Type of Pipe, Diameter and Corrugation Dimension	n
<b>1. Annular 2.67 x 1/2 inch (all diameters)</b>	0.024
<b>2. Helical 1.50 x 1/4 inch</b>	
8" diameter	0.012
10" diameter	0.014
<b>3. Helical 2.67 x 1/2 inch</b>	
12" diameter	0.011
18" diameter	0.014
24" diameter	0.016
36" diameter	0.019
48" diameter	0.020
60" diameter	0.021
<b>4. Annular 3x1 inch (all diameters)</b>	0.027
<b>5. Helical 3x1 inch</b>	
48" diameter	0.023
54" diameter	0.023
60" diameter	0.024
66" diameter	0.025
72" diameter	0.026
78" diameter and larger	0.027
<b>6. Corrugations 6x2 inches</b>	
60" diameter	0.033
72" diameter	0.032
120" diameter	0.030
180" diameter	0.028



**Table 3-1**  
**Typical Values of Percent Impervious**

<b>Type of Development</b>	<b>Percent Impervious</b>
Commercial	95%
Industrial	85%
Multi-Family	65%
Single Family - 0.1377 acre lots (6,000 SF)	53%
Single-Family – 0.20 acre lots	43%
Single-Family – 0.25 acre lots	40%
Single-Family – 0.33 acre lots	30%
Single-Family – 0.5 acre lots	25%
Single-Family – 1.0 acre lots	20%
Single-Family – 2.5 acre lots	11%
Single-Family – 5 acre lots	7%

The total impervious area may also be determined from direct measurement made by the developer. A developer may wish to do this if the average numbers presented in Table 3-1 do not apply to a specific development. If the developer chooses to do this, all impervious areas within the development should be included. These areas include streets, parking lots, residential, commercial, tax exempt, parks, golf courses, and any other land use within the development. When different land uses are included in a development a composite percent impervious should be used.

### **3.8a Computation of the Basin Fee**

The following example uses the typical impervious area numbers. In the computation of the basin fee, the developer or their representative shall obtain the appropriate basin fee from Exhibit 1 of the September 13, 1999 BOCC Resolution No. 99-383, or more current revision.

#### **Example 1:**

What is the fee for a 40-acre residential development in Dirty Woman Creek basin with 0.5-acre lots? The developer is not required to build any reimbursable stormwater facilities in this example and does not qualify for a low-density reduction or an on-site detention pond credit.

From Table 3-1, the percent impervious is 25%.

Calculate the impervious area for the site:

$$25\% \times 40 \text{ acres} = 10 \text{ acres}$$

Calculate the fee for the entire development:

$$\text{\$14,454 per impervious acre} \times 10 \text{ impervious acres} = \text{\$144,540}$$

Alternatively, the developer in each case could determine impervious area from the property plat, as illustrated in Example 2 below.

**Exhibit 5**  
**Sand Creek Drainage Basin Planning Study**



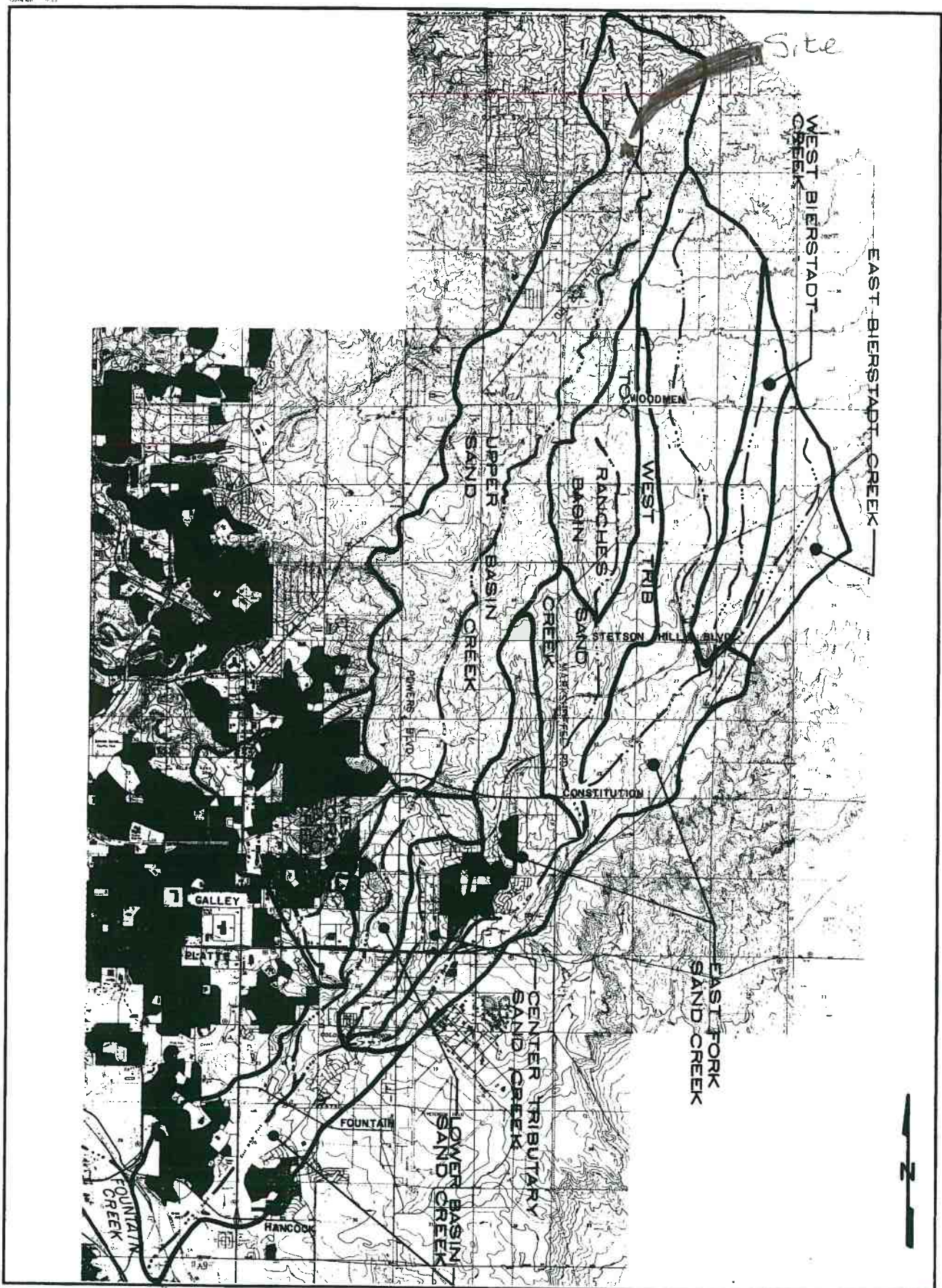


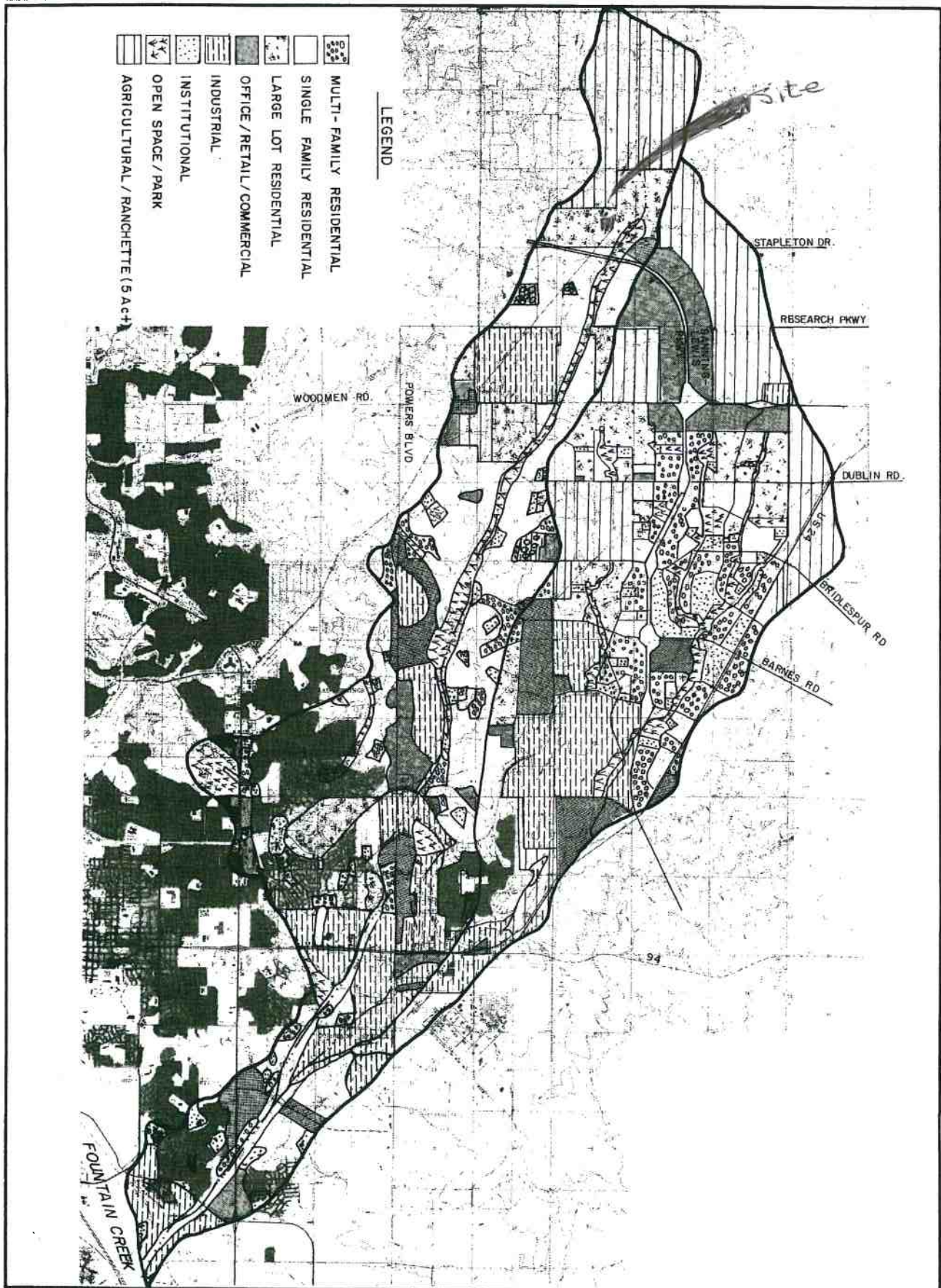
FIG. III-1

PROJECT NO. 90-04-03
DATE: 11/90
DRAWN: EAE
CHECKED: EAE
APPROVED: EAE

# SAND CREEK DRAINAGE BASIN PLANNING STUDY REGIONAL SUB-BASINS

Kiowa Engineering Corporation  
419 W. Bijou Street  
Colorado Springs, Colorado  
80905-1308





# El Paso County Drainage Basin Fees

Resolution No. 18-470

Basin Number	Receiving Waters	Year Studied	Drainage Basin Name	2019 Drainage Fee (per Impervious Acre)	2019 Bridge Fee (per Impervious Acre)
<b><u>Drainage Basins with DBPS's:</u></b>					
CHMS0200	Chico Creek	2013	Haegler Ranch	\$10,324	\$1,524
CHWS1200	Chico Creek	2001	Bennett Ranch	\$11,558	\$4,433
CHWS1400	Chico Creek	2013	Falcon	\$29,622	\$4,069
FOFO2000	Fountain Creek	2001	West Fork Jimmy Camp Creek	\$12,564	\$3,717
FOFO2600	Fountain Creek	1991*	Big Johnson / Crews Gulch	\$18,350	\$2,370
FOFO2800	Fountain Creek	1988*	Widefield	\$18,350	\$0
FOFO2900	Fountain Creek	1988*	Security	\$18,350	\$0
FOFO3000	Fountain Creek	1991*	Windmill Gulch	\$18,350	\$275
FOFO3100 / FOFO3200	Fountain Creek	1988*	Carson Street / Little Johnson	\$11,192	\$0
FOFO3400	Fountain Creek	1984*	Peterson Field	\$13,235	\$1,004
FOFO3600	Fountain Creek	1991*	Fisher's Canyon	\$18,350	\$0
FOFO4000	Fountain Creek	1996	Sand Creek	\$18,940	\$5,559
FOFO4200	Fountain Creek	1977	Spring Creek	\$9,517	\$0
FOFO4600	Fountain Creek	1984*	Southwest Area	\$18,350	\$0
FOFO4800	Fountain Creek	1991	Bear Creek	\$18,350	\$1,004
FOFO5400	Fountain Creek	1977	21st Street	\$5,521	\$0
FOFO5600	Fountain Creek	1964	19th Street	\$3,611	\$0
FOFO5800	Fountain Creek	1964	Camp Creek	\$2,033	\$0
FOMO0400	Monument Creek	1986*	Mesa	\$9,598	\$0
FOMO1000	Monument Creek	1981	Douglas Creek	\$11,540	\$255
FOMO1200	Monument Creek	1977	Templeton Gap	\$11,847	\$275
FOMO1400	Monument Creek	1976	Pope's Bluff	\$3,676	\$627
FOMO1600	Monument Creek	1976	South Rockrimmon	\$4,314	\$0
FOMO1800	Monument Creek	1973	North Rockrimmon	\$5,521	\$0
FOMO2000	Monument Creek	1971	Pulpit Rock	\$6,085	\$0
FOMO2200	Monument Creek	1994	Cottonwood Creek / S. Pine	\$18,350	\$1,004
FOMO2400	Monument Creek	1966	Dry Creek	\$14,486	\$524
FOMO3600	Monument Creek	1989*	Black Squirrel Creek	\$8,331	\$524
FOMO3700	Monument Creek	1987*	Middle Tributary	\$15,312	\$0
FOMO3800	Monument Creek	1987*	Monument Branch	\$18,350	\$0
FOMO4000	Monument Creek	1996	Smith Creek	\$7,481	\$1,004
FOMO4200	Monument Creek	1989*	Black Forest	\$18,350	\$500
FOMO5200	Monument Creek	1993*	Dirty Woman Creek	\$18,350	\$1,004
FOMO5300	Fountain Creek	1993*	Crystal Creek	\$18,350	\$1,004
<b><u>Miscellaneous Drainage Basins: <sup>1</sup></u></b>					
CHBS0800	Chico Creek		Book Ranch	\$17,217	\$2,492
CHEC0400	Chico Creek		Upper East Chico	\$9,380	\$272
CHWS0200	Chico Creek		Telephone Exchange	\$10,306	\$241
CHWS0400	Chico Creek		Livestock Company	\$16,976	\$202
CHWS0600	Chico Creek		West Squirrel	\$8,849	\$3,672
CHWS0800	Chico Creek		Solberg Ranch	\$18,350	\$0
FOFO1200	Fountain Creek		Crooked Canyon	\$5,540	\$0
FOFO1400	Fountain Creek		Calhan Reservoir	\$4,625	\$270
FOFO1600	Fountain Creek		Sand Canyon	\$3,342	\$0
FOFO2000	Fountain Creek		Jimmy Camp Creek <sup>2</sup>	\$18,350	\$858
FOFO2200	Fountain Creek		Fort Carson	\$14,486	\$524
FOFO2700	Fountain Creek		West Little Johnson	\$1,209	\$0
FOFO3800	Fountain Creek		Stratton	\$8,801	\$394
FOFO5000	Fountain Creek		Midland	\$14,486	\$524
FOFO6000	Fountain Creek		Palmer Trail	\$14,486	\$524
FOFO6800	Fountain Creek		Black Canyon	\$14,486	\$524
FOMO4600	Monument Creek		Beaver Creek	\$10,970	\$0
FOMO3000	Monument Creek		Kettle Creek	\$9,909	\$0
FOMO3400	Monument Creek		Elkhorn	\$1,665	\$0
FOMO5000	Monument Creek		Monument Rock	\$7,953	\$0
FOMO5400	Monument Creek		Palmer Lake	\$12,717	\$0
FOMO5600	Monument Creek		Raspberry Mountain	\$4,278	\$0
PLPL0200	Monument Creek		Bald Mountain	\$9,116	\$0
<b><u>Interim Drainage Basins: <sup>2</sup></u></b>					
FOFO1800	Fountain Creek		Little Fountain Creek	\$2,346	\$0
FOMO4400	Monument Creek		Jackson Creek	\$7,263	\$0
FOMO4800	Monument Creek		Teachout Creek	\$5,044	\$758

1. The miscellaneous drainage fee previous to September 1999 resolution was the average of all drainage fees for basins with Basin Planning Studies performed.
2. Interim Drainage Fees are based upon draft Drainage Basin Planning Studies or the Drainage Basin Identification and Fee Estimation Report. (Best available)
3. This is an interim fee and will be adjusted when a DBPS is completed. In addition to the Drainage Fee a surety in the amount of \$7,285 per impervious acre shall be provided. If the DBPS results in a fee greater than the current fee, fees paid in excess of the future revised fee will be reimbursed. See Resolution 06-326 (9/14/06) and Resolution 18-470.



## **Exhibit 6 Photographs**



Looking north from Poco Road  
from DP3



Looking east along Poco Road  
from DP3



18" Drive Culvert at DP4



18" culvert at DP9



Swale #2 looking north

## **Exhibit 7**

### **Calculations**



# KCH Engineering Solutions

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

JOB Edgewood SD  
SHEET NO. 1 OF 35  
CALCULATED BY K. Harrison DATE 10-24-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revisions per FDC comment

Historic Condition  
(natural conditions)

## I. Design Point #1

A Area =  $0.51 = 10.3 \text{ acres}$

B Runoff 'C' (Soil Group = 8)

Pasture / meadow

$C_5 = 0.08$

$C_{100} = 0.35$

## C. Time of Concentration

### 1. Overland

$t_1 = 0.395 (1.1 - C_5) \sqrt{L} / S^{0.33}$

$L = 300 \text{ ft}; S = 10.77\% C_5 = 0.08$

$= 0.395 (1.1 - 0.08) \sqrt{300} / 0.10^{0.33}$

$= 15 \text{ min.}$

$t_1 = 15 \text{ min.}$

### 2. Shallow Concentrated Flow (Not Channelized)

$t_1 = L / 60 * K * \sqrt{S}$

$L = 1000 \text{ ft}; K = 7 \text{ (short pasture)}; S = 3.8\%$

$t_1 = 1000 / 60 * 7 * (0.038)^{1/2}$

$t_1 =$

Total  $T_c =$

$t_c = 12.2 \text{ min}$

$t_T = 27.2 \text{ min}$

## D. Rainfall Intensity

$I_5 = 1.8$

$I_{100} = 3.9$

## E Runoff ( $Q = C I A$ )

$Q_5 = 0.08 * 1.8 * 10.3$

$Q_{100} = 0.35 * 3.9 * 10.3$

$Q_5 = 1.5 \text{ cfs}$

$Q_{100} = 14.1 \text{ cfs}$

# (Historic Conditions)

## II Design Point 2

A. Area (Total of area to the north & west)

$$OS-1 = 10.3$$

$$A = -4.3$$

$$OS-5 = 0.2$$

$$OS-6 = 0.17 \text{ Acres}$$

$$14.9$$

B. Runoff "C"

Soil Group B

Short mowed pasture

$$C_5 = 0.08$$

$$C_{100} = 0.35$$

C. Time of Concentration

$T_c$  at DP#2 is the sum of  $T_c$  at DP#1 & Shallow concn.  
Flow in natural swale from DP#1 to DP#2

$$T_c @ DP\#1 = 27.2 \text{ min}$$

Shallow concn.  $T_c$  DP#1 to DP#2

$$t_c = L / 60 * K * \sqrt{S}$$

$$L = 500; K = 7.0; S = (7230 - 7212) / 500 = 3.6\%$$

$$t_c = 500 / 60 * 7.0 * \sqrt{0.036}$$

$$t_c = 6.3 \text{ min}$$

$$\text{Total } T_c @ DP\#2 = 27.2 + 6.3 = 33.5 \text{ min}$$

D. Rainfall Intensity

$$I_5 = 2.3$$

$$I_{100} = 3.8$$

E. Runoff

$$Q_5 = 0.08 * 2.3 * 14.9$$

$$= 2.7 \text{ cfs}$$

$$Q_{100} = 0.35 * 3.8 * 14.9$$

$$Q_{100} = 19.8 \text{ cfs}$$

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Colorado Springs, CO 80917  
(719) 246-4471

JOB Edgewood SD  
SHEET NO. 3 OF 35  
CALCULATED BY R. Hansen DATE 10-24-19  
CHECKED BY / DATE /  
SCALE Revisions per EPC comments

Historic conditions

## III Design Point 3 & 4

### A. Drainage Area

$$\text{Subbasin B} = 5.9 \text{ acres}$$

### B. Runoff Coef

Soil Group B  
Practice (mowed)

$$C_5 = 0.08$$

$$C_{100} = 0.35$$

### C. Time of Concentration

#### 1. Overland

$$t_o = 0.395(1.1 - C_5) \sqrt{L} / 50.33$$

$$C_5 = 0.08; L = 300, S = (7260 - 7225) / 300 = 1.17\%$$

$$t_1 = 0.395(1.1 - 0.08) \sqrt{300} / (0.117)^{0.33}$$

$$t_1 = 14.2 \text{ min. (corrected)}$$

#### 2. Shallow Concentrated Flow

$$t_c = L / 60 * K * 750$$

$$L = 2000; K = 0.7; S_o = (7205 - 7208) / 200 = 0.015\%$$

$$t_c = 200 / 60 * 7 * 0.015^{1/2} = 1.6 \text{ min}$$

$$3. \text{ Total } T_c = 14.2 + 1.6 = 15.8 \text{ min}$$

### D. Rainfall Intensity

$$I_5 = 3.4$$

$$I_{100} = 5.8$$

### E. Runoff ( $Q = C * I * A$ )

$$Q_5 = 0.08 * 3.4 * 5.9$$

$$Q_5 = 1.7 \text{ cfs}$$

$$Q_{100} = 0.35 * 5.8 * 5.9$$

$$Q_{100} = 12.0 \text{ cfs}$$



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JOB Edgewood SD  
SHEET NO. 4 OF 35  
CALCULATED BY K. Harrison DATE 10-24-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revision per EDC Review

## IV Design Point 4 (SE corner of site)

A. Drainage Area

$$A_{D3} = 0.6 \text{ Acres}$$

B. Runoff Coef

$$S_{d.15} = B$$

Use  $C =$  short pasture

$$C_5 = 0.08$$

$$C_{100} = 0.35$$

C. Time of Concentration

Use minimum allowed per criteria = 10 min.

D. Rainfall Intensity

$$I_5 = 4.0$$

$$I_{100} = 6.8$$

E. Runoff ( $Q = C * I * A$ )

$$Q_5 = 0.08 * 4.0 * 0.6 = 0.2 \text{ cfs}$$

$$Q_{100} = 0.35 * 6.8 * 0.6 = 1.4 \text{ cfs}$$



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JOB Edge wood S/D  
SHEET NO. 5 OF 35  
CALCULATED BY K. Harrison DATE 10-24-17  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

## Historic Conditions

V Design Point #5 (Sheet flows from the ridge,  
no concentrated flow)

A. Area:  $C_s$  1.5 acres

B Coefficients

Soils Group B

Use: short pasture

$$C_5 = 0.08$$

$$C_{100} = 0.35$$

C. Time of Concentration

Use min. allowed = 10 min.

D. Rain Fall Intensity

$$I_5 = 4.0$$

$$I_{100} = 6.8$$

E. Runoff  $Q = C \times I \times A$

$$Q_5 = 0.08 \times 4.0 \times 1.5$$

$$Q_5 = 0.5 \text{ cfs}$$

$$Q_{100} = 0.35 \times 6.8 \times 1.5$$

$$Q_{100} = 3.6 \text{ cfs}$$

# Historic Conditions VI Design Point 6 (used for evaluation of swale #6)

## A. Drainage Area (B)

$$\frac{2}{3} \text{ of } B = 3.9 \text{ acres (Natural)}$$

$$\frac{1}{2} \text{ of Poco Right of Way} = 0.54 = 0.5 \text{ acres}$$

$$\text{Gravel area} = 0.25 \text{ Acres} \approx 0.3 \text{ acres}$$

$$\text{Road side swale } 0.25 \text{ ac (Natural)}$$

$$\text{Total area Runoff to DP6} = 4.4 \text{ acres}$$

## B. Composite "C"

$$\text{Natural Area} = 3.9 + 0.3 = 4.2 \text{ acres}; C_5 = 0.08, C_{100} = 0.35$$

$$\text{Gravel Area} = 0.3 \text{ acres} = C_5 = 0.59, C_{100} = 0.70$$

$$C_5 = \frac{4.2(0.08) + 0.3(0.59)}{4.5} = 0.11$$

$$C_{100} = \frac{4.2(0.35) + 0.3(0.70)}{4.5} = 0.37$$

## C. Time of Concentration

$$\text{Use same as DP 3} = 15.8 \text{ min}$$

## D. Rainfall Intensity ( $Q = C \times I \times A$ )

$$I_5 = 3.4$$

$$I_{100} = 5.8$$

## E. Runoff

$$Q_5 = 0.11 \times 3.4 \times 4.4$$

$$Q_5 = 1.6 \text{ cfs}$$

$$Q_{100} = 0.37 \times 5.8 \times 4.4$$

$$Q_{100} = 9.4 \text{ cfs}$$



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JOB Edgewood S/D  
SHEET NO. 7 OF 35  
CALCULATED BY K. Harrison DATE 10-24-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revision per EPC comments

## Historic Conditions

### VII Design Point 7

#### A. Drainage Area

$$0.55 \pm 0.06 \text{ ac} = 0.3 \text{ Acres}$$

Drainage Area is for  $\frac{1}{2}$  R.O.W of Poco Road for  
array 150 ft  $\therefore 30 \text{ ft} \times 150 \text{ ft} = 0.1 \text{ acres}$

$$\text{Gravel} = 0.05 \text{ Acres}$$

$$\text{Natural Borrow Ditch/Swale} = 0.25 \text{ Acres}$$

$$\text{Total Drainage Area} = 0.3 \text{ ac}$$

#### B. Runoff Coef

Native/Natural

$$C_5 = 0.08$$

$$C_{100} = 0.35$$

Gravel

$$C_5 = 0.59$$

$$C_{100} = 0.70$$

$$C_5 = [0.2(0.08) + 0.1(0.59)] / 0.3 = 0.25 \text{ } C_5 \text{ composite}$$

$$C_{100} = [0.2(0.35) + 0.1(0.70)] / 0.3 = 0.47 \text{ } C_{100} \text{ composite}$$

#### C. Time of Conc

$$\text{Use min. allowed} = 10 \text{ min.}$$

#### D. Rain Fall Intensity

$$I_5 = 4.0$$

$$I_{100} = 6.8$$

#### E. Runoff ( $Q = C \times I \times A$ )

$$Q_5 = 0.25 \times 4 \times 0.3$$
$$= 0.3 \text{ cfs}$$

$$Q_{100} = 0.47 \times 6.8 \times 0.3$$
$$Q_{100} = 1.0 \text{ cfs}$$

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JOB Edgewood S/D  
 SHEET NO. 8 OF 35  
 CALCULATED BY K. Harrison DATE 10-24-19  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

~~SCALE~~ Revision per EPC comments

Historic ConditionsVIII Design Point 8A Drainage Area

<u>I.D</u>	<u>Total</u>	<u>Natural</u>	<u>gravel</u>
B-	5.9	5.9	0.0
OS3	0.6	0.3	0.3
OS4	0.5	0.3	0.2
OS7	0.2	0.1	0.1
	<u>7.2</u>	<u>6.6</u>	<u>0.6</u>

B. Runoff Coeff.

Grassed / Natural  
Gravel

$$C_5 = 0.08$$

$$C_{100} = 0.35$$

$$C_5 = 0.59$$

$$C_{100} = 0.70$$

$$C_5 = \frac{6.6 \times 0.08 + 0.6 \times 0.59}{7.2}$$

$$C_{100} = \frac{6.6 \times 0.35 + 0.6 \times 0.70}{7.2}$$

$$C_5 = 0.12$$

$$C_{100} = 0.38$$

C. Time of Concentration

Same as DP 3 = 15.8 min

D. Rainfall Intensity

$$I_5 = 2.3$$

$$I_{100} = 5.8$$

E Runoff ( $Q = C \times I \times A$ )

$$Q_5 = 0.12 \times 2.3 \times 7.2$$

$$Q_5 = 2.0 \text{ cfs}$$

$$Q_{100} = 0.38 \times 5.8 \times 7.2$$

$$Q_{100} = 15.9 \text{ cfs}$$

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5228 Cracker Barrel Circle  
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(719) 246-4471

JOB Edgewood S/D  
SHEET NO. 9 OF 35  
CALCULATED BY K. Harrison DATE 10-24-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
~~CONF~~ Revisions per EPC comments

## Historic Conditions

IX Design Point #9  
(used to Evaluate 18" Culvert @ SW corner of site)

### A Drainage Area

Area I.D	Total	Natural	Gravel
OS 1	10.3	10.3	0
A	4.3 ✓	4.3	0
OS-6	0.1 ✓	0.05	0.05
OS-5	0.2 ✓	0.1	0.1
	14.9	14.75	0.15

### B Runoff C

Grassed

$$C_5 = 0.08$$

$$C_{100} = 0.35$$

Covered

$$C_5 = 0.59$$

$$C_{100} = 0.70$$

$$C_5 = \frac{14.75 * 0.08 + 0.15 * 0.59}{14.9}$$

$$C_{100} = \frac{14.75 * 0.35 + 0.15 * 0.70}{14.9}$$

$$C_5 = 0.09$$

$$C_{100} = 0.35$$

### C. Time of Conc

Same as DP Z = 33.5 min

### D. Intensity

$$I_5 = 2.3 ✓$$

$$I_{100} = 3.8 ✓$$

### E. Runoff ( $Q = C * I * A$ )

$$Q_5 = 0.09 * 2.3 * 14.9$$

$$Q_5 = 3.1 \text{ cfs}$$

$$Q_{100} = 0.35 * 3.8 * 14.9$$

$$Q_{100} = 19.8 \text{ cfs}$$



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JOB Edgewood S/D  
SHEET NO. 10 OF 35  
CALCULATED BY K. Harrison DATE 10-24-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revisions per EPC comment

Developed Conditions**I Design Point 1**

No changes from the existing conditions

$$C_5 = 1.58$$

$$C_{100} = 14.1 \text{ cfs}$$

**II Design Point 2****A Area**

No change from existing

$$A = 14.9 \text{ acres} = 644,688 \text{ s.f.}$$

Assume a new home will be built on this area

$$\text{House Footprint} = 200 \times 40 = 8000 \text{ s.f.}$$

$$\text{Landscaping/Lawn} = 0.4 \text{ acres} = 17,424 \text{ s.f.}$$

$$\text{Gravel Drive wdy: } 400 \text{ ft by } 15' \text{ wide} = 6,000 \text{ s.f.}$$

10/11

**B Composite "C" (Group B soils)**

Usage	Area	$C_5$	$C_{100}$
Natural	613,264	0.08	0.35
House	8,000	0.73	0.81
Landscaping/Lawn	17,424	0.12	0.39
Gravel Drive	6,000	0.59	0.70
	644,688		

$$C_5 = \frac{613,264(0.08) + 8,000(0.73) + 17,424(0.12) + 6,000(0.59)}{644,688}$$

$$C_5 = 0.09$$

$$C_{100} = \frac{613,264(0.35) + 8,000(0.81) + 17,424(0.39) + 6,000(0.70)}{644,688}$$

$$C_{100} = 0.36$$

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JOB Edgewood S/D  
SHEET NO. 11 OF 35  
CALCULATED BY K. Harrison DATE 10-26-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revisions per EPC comments

## Developed Conditions

### C. Time of Concentration

Even though there is development in this area, it will not affect the applicable  $T_c$  since the majority of the runoff will be contributing to the design point at the same  $T_c$  as the existing condition.

$$T_c = 33.5 \text{ min}$$

### D. Rainfall Intensity

$$I_5 = 2.3$$

$$I_{100} = 3.8$$

### E. Runoff ( $Q = CIA$ )

$$Q_5 = 0.09 * 2.3 * 14.9$$

$$Q_5 = 3.1 \text{ cfs}$$

Compared to ~~3.1~~ cfs for  
existing 2.7 cfs

$$Q_{100} = 0.36 * 3.8 * 14.9$$

$$Q_{100} = 20.4$$

Compared to ~~19.8~~ cfs for  
existing



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JOB Edgewood S/D  
SHEET NO. 12 OF 35  
CALCULATED BY K. Harrison DATE 10-26-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revisions per EPC comments

## Developed Conditions

### III Design Point 3 (used to size Swale #5)

$$A \text{ Area} = 5.9 \times 257,004 \text{ s.f.}$$

Assume same developed conditions as DP #2

$$\begin{aligned} \text{House Footprint} &= 8,000 \text{ s.f.} \\ \text{Landscaping / Lawn} &= 17,424 \text{ s.f.} \\ \text{Gravel Drive} &= 6,000 \text{ s.f.} \end{aligned}$$

### B Composite "C"

Assume all of the water coming off the house flows to DP #3

Usage	Area	C <sub>s</sub>	C <sub>100</sub>
Natural	255,580	0.08	0.35
House	8,000	0.73	0.81
Landscaping	17,424	0.12	0.39
Gravel Drive	6,000	0.59	0.70
	257,004		

$$C_s = \frac{255,580(0.08) + 8,000(0.73) + 17,424(0.12) + 6,000(0.59)}{257,004}$$

$$C_s = 0.124$$

$$C_{100} = \frac{255,580(0.35) + 8,000(0.81) + 17,424(0.39) + 6,000(0.70)}{257,004}$$

$$C_{100} = 0.42$$

### C. Time of Concentration

Same as Existing = 15.8 min

### D. Intensity

$$I_5 = 3.4$$

$$I_{100} = 6.8$$

### E Runoff (Q = CIA)

$$Q_5 = 0.124 \times 3.4 \times 5.9$$

$$Q_5 = 2.4 \text{ cfs}$$

Compared to 1.7 cfs

$$Q_{100} = 0.42 \times 6.8 \times 5.9$$

$$Q_{100} = 16.9 \text{ cfs}$$

Compared to 12.0 cfs



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5228 Cracker Barrel Circle  
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JOB Edge wood site  
SHEET NO. 13 OF 35  
CALCULATED BY K. Harrison DATE 10-26-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revisions per EPC comments

Developed Condition

IV Design Point 4 - No change for Developed Cond

$$Q_5 = 0.1 \text{ cfs}$$

$$Q_{100} = 1.4 \text{ cfs}$$

V Design Point 5 - No change for developed flows

$$Q_5 = 0.5 \text{ cfs}$$

$$Q_{100} = 3.6$$

VI Design Point 6 (used for Evaluating Culvert @ DP8)

A. Drainage Area ( $\frac{2}{3}$  of Area B) +  $\frac{1}{2}$  Porc Rd R.O.W)

Total Area = 182,952 sf (see sheet 6)

House footprint 8,000 ft<sup>2</sup>

Landscaping 17,424 ft<sup>2</sup>

Gravel Drive 6,000 ft<sup>2</sup>

$\frac{1}{2}$  Porc Drive gravel; 0.3 Acres 13,068 ft<sup>2</sup>

$\frac{1}{2}$  Porc Drive R.O.W Natural 0.2 Acre 8,712 ft<sup>2</sup>

B Composite "C"

Use	Area	C <sub>5</sub>	C <sub>100</sub>
Natural	138,460	0.08	0.35
House footprint	8,000	0.73	0.81
Landscaping	17,424	0.12	0.39
Gravel Rd/Drive	19,068	0.59	0.70
	<u>182,952</u>		

$$C_5 = \frac{[138,460(0.08) + 8,000(0.73) + 17,424(0.12) + 19,068(0.59)]}{182,952}$$

$$C_5 = 0.17$$

$$C_{100} = \frac{[138,460(0.35) + 8,000(0.81) + 17,424(0.39) + 19,068(0.70)]}{182,952}$$

$$C_{100} = 0.41$$

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JOB Edge wood s/d  
SHEET NO. 17 OF 3336  
CALCULATED BY K. Harrison DATE 10-26-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revision per EPC comments

Developed Conditions

VI. Continued

C. Time of Concentration

Same as existing @ DP 3 = 15.8 min.

D. Intensity

$$I_5 = 3.5$$

$$I_{100} = 6.8$$

E Runoff ( $Q = CIA$ )

$$Q_5 = 0.17 + 3.5 + 4.2$$

$$= 2.5 \text{ cfs}$$

Compared to 1.6 cfs

$$Q_{100} = 0.41 + 6.8 + 4.2$$

$$Q_{100} = 11.7 \text{ cfs}$$

Compared to 9.4 cfs

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5228 Cracker Barrel Circle  
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JOB Edgewood S/D  
SHEET NO. 15 OF 35  
CALCULATED BY K. Harrison DATE 10-26-19  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE Revisions per EPC comments

## Developed condition

### VII Design Point 7 - No changes from Existing

$$Q_5 = 0.3 \text{ cfs}$$

$$Q_{100} = 1.0 \text{ cfs}$$

### VIII Design Point 8 (used to evaluate existing 24" culvert)

$$A = 7.2 \text{ acres (see sheet 8)} = 313,632 \text{ ft}^2$$

Use		
House Footprint	8,000 ft <sup>2</sup>	} see sheet 13 for area
Landscaping	17,424 ft <sup>2</sup>	
Gravel Drive	6,000 ft <sup>2</sup>	
1/2 Poca in gravel	13,068 ft <sup>2</sup>	
1/2 Poca in natural	8,712 ft <sup>2</sup>	
Natural for Lot	260,428 ft <sup>2</sup>	
	313,632 ft <sup>2</sup>	

### B Composite 'C'

Use		C <sub>5</sub>	C <sub>100</sub>
Natural (Lot)	260,428	0.08	0.35
House Footprint	8,000	0.73	0.81
Landscaping	17,424	0.12	0.39
Gravel Driveway	6,000	0.59	0.70
Poca Rd gravel	13,068	0.59	0.70
Poca Rd Natural	8,712	0.08	0.35

$$C_5 = 0.13 \checkmark$$

$$C_{100} = 0.39 \checkmark$$



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## Developed Condition

### VIII Continued

#### C. Time of Concentration

Same as existing @ DP 3 = 15.8 min  
(see sheet 3)

#### D Intensity

$$I_5 = 3.4$$

$$I_{100} = 5.8$$

#### E. Runoff ( $Q = CIA$ )

$$Q_5 = 0.13 + 3.4 \times 7.2$$
$$= 3.3 \text{ cfs}$$

Compared w/  
DP #8 2.0 cfs

$$Q_{100} = 0.39 + 5.8 \times 7.2$$

$$Q_{100} = 16.3 \text{ cfs}$$

Compared w/ DP #8  
Compared w/ 15.9 cfs  
@ DP #8

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SCALE \_\_\_\_\_

## IX Design Pnt #9 (used to evaluate Culvert)

### A Area

Same as Historic = 14.9 Acres

Total Area = 14.9 Acres	649,044 s.f.
House Footprint	8,000
Landscaping	17,424
Gravel Drive	6,000 s.f.
Gravel 1/2 Poco Drive (1/2 0.36) = 0.05 Acres	2,178
Natural 1/2 Poco Drive (1/2 0.36) = 0.05 Acres	2,178
Natural Ground of Lot	630,688 s.f.

### B Composite 'C'

Natural (Lot)	630,688	0.08	0.35
House Footprint	8,000	0.73	0.81
Landscaping	17,424	0.12	0.39
Gravel Drive	6,000	0.59	0.70
Poco Rd Gravel	2,178	0.59	0.70
Poco Rd Natural	2,178	0.08	0.35

$C_5$  Composite = 0.10

$C_{100}$  Composite = 0.37

### C. Time of Concentration

Same as DP 2 = 33.5

### D Intensity

$I_5 = 2.3$

$I_{100} = 3.8$

### E Runoff ( $Q = C \times I \times A$ )

$$Q_5 = 0.10 \times 2.3 \times 14.9$$
$$= 3.4 \text{ cfs}$$

Compared to 3.1 cfs

$$Q_{100} = 0.37 \times 3.8 \times 14.9$$
$$Q_{100} = 20.9 \checkmark$$

Compared to 19.8 cfs

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SCALE Revisions per FPC comment

## Swoles

### I. Swole #1 (Design Point 1)

Obj: evaluate for stability & erosion potential

#### A. Physical characteristics

BW  $\approx 20'$

SS  $\approx 20/20' = 10/1$

Slope  $\approx 10.7^\circ/2$  (See sheet 1)

Covering pasture

#### B. Hydraulic characteristics (See sheet #19 & #20)

Discharge	$Q_5 = 1.5$	$Q_{100} = 14.1$	(See sheet 10)
Depth	$D_5 = 0.04$	$D_{100} = 0.2$	
Vel.	$V_5 = 1.7$	$V_{100} = 3.9$	
Froude	$Fr = 1.44$	$Fr = 1.75$	Supercritical is unlikely

#### C. Conclusions

The velocity and depths of flow are low enough that it is highly unlikely erosion will occur



The open channel flow calculator <span style="float: right;">Suble #1 5 year</span>			
Select Channel Type: Trapezoid ▼			
Depth from Q ▼		Select unit system: Feet(ft) ▼	
Channel slope: 0.107 ✓ ft/ft	Water depth(y): 0.04 ✓ ft	Bottom width(b) 20 ft	
Flow velocity 1.687436 ✓ ft/s	LeftSlope (Z1): 10 to 1 (H:V) ✓	RightSlope (Z2): 10 to 1 (H:V) ✓	
Flow discharge 1.5 ft <sup>3</sup> /s	Input n value 0.035 or select n clean,uncoated castiron:0.014 ▼		
Calculate!	Status: Calculation finished		Reset
Wetted perimeter 20.87 ft	Flow area 0.89 ft <sup>2</sup>	Top width(T) 20.87 ft	
Specific energy 0.09 ft	Froude number 1.44 ✓	Flow status Supercritical flow	
Critical depth 0.06 ft	Critical slope 0.0456 ft/ft	Velocity head 0.04 ft	

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The open channel flow calculator			
Select Channel Type: Trapezoid ▼			
Depth from Q ▼	Select unit system: Feet(ft) ▼		
Channel slope: .107 ft/ft	Water depth(y): 0.17 ✓ ft	Bottom width(b) 20 ft	
Flow velocity 3.906298 ft/s	LeftSlope (Z1): 10 to 1 (H:V)	RightSlope (Z2): 10 to 1 (H:V)	
Flow discharge 14.1 ✓ ft^3/s	Input n value .035 or select n clean,uncoated castiron:0.014 ▼		
Calculate!	Status: Calculation finished	Reset	
Wetted perimeter 23.35 ft	Flow area 3.61 ft^2	Top width(T) 23.33 ft	
Specific energy 0.4 ft	Froude number 1.75 ✓	Flow status Supercritical flow	
Critical depth 0.24 ft	Critical slope 0.0293 ft/ft	Velocity head 0.24 ft	

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## II Swale #2 (Design Point 2)

### A. Physical Characteristics

BW: 10' to 80ft

SS = 1/10

Slope = 3.6% (see sheet 2)

Treatment: mowed pasture

### B Hydraulic characteristics (Developed) See sheets 22 & 23

	5 yr	100 yr
Design Flow (DP#2)	5.8 ✓	23.2 ✓ (sheet 23)
Depth	0.2 ✓	0.4 ✓
Velocity	2.4 ✓	3.8 ✓
Froude	1.02	1.17

### C. Conclusions

Depth of flow & velocity too low for erosion to be an issue

Swake #2  
Sheet 22 of 35

# The open channel flow calculator

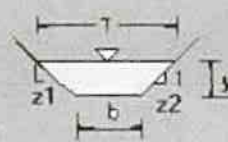
5yr

Select Channel Type:

Trapezoid ▼



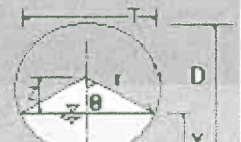
Rectangle



Trapezoid



Triangle



Circle

Depth from Q ▼

Select unit system: Feet(ft) ▼

Channel slope: .036 ✓

ft/ft

Water depth(y): 0.2

ft

Bottom width(b)

10 ✓

ft

Flow velocity 2.404037 ✓

ft/s

LeftSlope (Z1): 10 ✓ to 1 (H:V)

RightSlope (Z2): 10 ✓

to 1 (H:V)

Flow discharge 5.8 ✓

ft^3/s

Input n value 0.035 ✓ or select n

Calculate!

Status: Calculation finished

Reset

Wetted perimeter 14.04

ft

Flow area 2.41

ft^2

Top width(T) 14.02

ft

Specific energy 0.29

ft

Froude number 1.02

Flow status

Supercritical flow

Critical depth 0.21

ft

Critical slope 0.0308

ft/ft

Velocity head 0.09

ft

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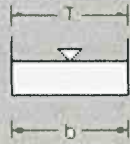
Steel 2005  
Swab #2

## The open channel flow calculator

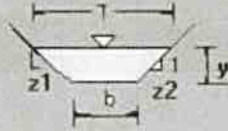
100 yds

Select Channel Type:

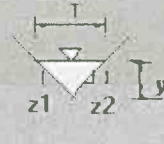
Trapezoid ▾



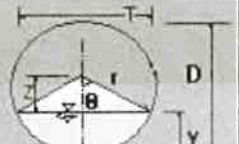
Rectangle



Trapezoid



Triangle



Circle

Depth from Q ▾

Select unit system: Feet(ft) ▾

Channel slope: .036

ft/ft

Water depth(y): 0.43 ft

Bottom width(b) 10

ft

Flow velocity 3.815591

ft/s

LeftSlope (Z1): 10 to 1 (H:V)

RightSlope (Z2): 10

to 1 (H:V)

Flow discharge 23.2

ft<sup>3</sup>/s

Input n value 0.035 or select n

Calculate!

Status: Calculation finished

Reset

Wetted perimeter 18.57

ft

Flow area 6.08 ft<sup>2</sup>

Top width(T) 18.53

ft

Specific energy 0.65

ft

Froude number 1.17

Flow status

Supercritical flow

Critical depth 0.47

ft

Critical slope 0.0248 ft/ft

Velocity head 0.23

ft

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## Swales (Developed)

## III Swale #3 ✓

Only a minimal amount of runoff enters this swale since the majority sheets flows to the ~~bas~~ roadside ditch along Poco Rd.

## IV Swale #4 ✓

This swale drains 0.32 which does not contribute runoff to the site. A very small & insignificant portion of the site drains into Swale #4. Analysis of this swale is beyond the scope.

## V Swale #5 (Poco Rd. borrow pit) (Design Pnt 6)

## A. Physical characteristics (Standard EPC Section)

$$BW = 20' ✓$$

$$SS = 3:1 ✓$$

$$\text{Slope} = 24' \text{ Drop in } 400\text{ft} = 6\% ✓$$

Treatment = Moved grades and

## B. Hydraulic characteristics (see 25 &amp; 26)

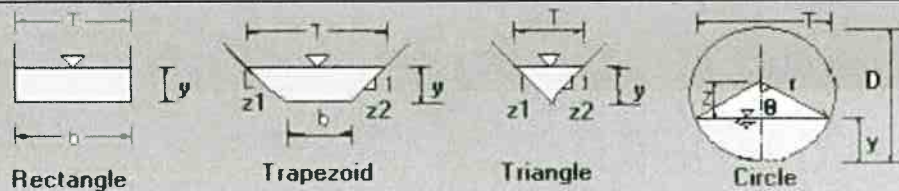
	$\frac{5\text{yr}}$	$\frac{100\text{yr}}$
Design Flow @ DP 6	2.5 ✓	11.7 ✓
Depth	0.2	0.6 ✓
Velocity	3.5	5.4 ✓
Froude #	1.36 ✓	1.52 ✓

## C. Comments

Borrow ditch is stable

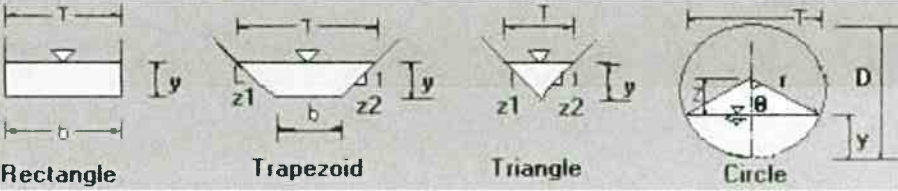


IRCL 200000  
Swale #5  
5 year

The open channel flow calculator			
Select Channel Type: <div style="border: 1px solid black; padding: 2px; display: inline-block;">Trapezoid ▼</div>	 <div style="display: flex; justify-content: space-around; font-size: small;"> <span>Rectangle</span> <span>Trapezoid</span> <span>Triangle</span> <span>Circle</span> </div>		
Depth from Q ▼	Select unit system: Feet(ft) ▼		
Channel slope: .06 ft/ft	Water depth(y): 0.26 ft	Bottom width(b) 2 ft	
Flow velocity 3.463888 ft/s	LeftSlope (Z1): 3 to 1 (H:V)	RightSlope (Z2): 3 to 1 (H:V)	
Flow discharge 2.5 ft <sup>3</sup> /s	Input n value 0.035 or select n		
<div>Calculate!</div>	Status: Calculation finished		<div>Reset</div>
Wetted perimeter 3.64 ft	Flow area 0.72 ft <sup>2</sup>	Top width(T) 3.56 ft	
Specific energy 0.45 ft	Froude number 1.36		Flow status Supercritical flow
Critical depth 0.31 ft	Critical slope 0.0287 ft/ft	Velocity head 0.19 ft	

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Solve H<sub>5</sub>  
100 year

The open channel flow calculator			
Select Channel Type: Trapezoid ▼			
Depth from Q ▼		Select unit system: Feet(ft) ▼	
Channel slope: .06 ft/ft	Water depth(y): 0.58 ft	Bottom width(b): 2 ft	
Flow velocity 5.418 ft/s	LeftSlope (Z1): 3 to 1 (H:V)	RightSlope (Z2): 3 to 1 (H:V)	
Flow discharge 11.7 ft <sup>3</sup> /s	Input n value 0.035 or select n		
Calculate!	Status: Calculation finished		Reset
Wetted perimeter 5.66 ft	Flow area 2.16 ft <sup>2</sup>	Top width(T) 5.47 ft	
Specific energy 1.03 ft	Froude number 1.52	Flow status Supercritical flow	
Critical depth 0.72 ft	Critical slope 0.024 ft/ft	Velocity head 0.46 ft	

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55-

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SCALE Revisions per EDC comments

## Swales

### VI Swale #6

This swale was not evaluated since it handles less than swale #5 which has plenty of capacity.

### VII Swale #7

Same as #6

### VIII Swale #8

This swale was also not evaluated since it is private and only handles an insignificant amount of runoff.

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## Culverts

### I Culvert @ DP #4

This culvert is located under the driveway accessing the existing residence.

#### A Assumed physical characteristics

Size = 18"

Slope = same as the road side slope #6  
= 6%

Depth of cover > 12", Condition: good, sediment

#### B Hydraulic Characteristics

Inlet central

Free outfall

Plain end projecting

Design Flow (Design Pt 4 (sheet 13))

$Q_5 = 0.2 \text{ cfs}$

$Q_{100} = 1.4 \text{ cfs}$

HW/D = insignificant. Plenty of capacity even for 100 year

HW/D 5 year Neg.

HW/D 100 year 'Neg'

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SCALE Revision per EPC comments

## Culvert (cont)

### II Culvert @ DP#8

#### A Physical Characteristics

Size = 24"

Slope Inv. in = 7156.1

Inv out = 7155.5

0.6

Length  $\approx$  50'  $\pm$

Slope =  $0.6/50 = 1.2\%$

#### B Hydraulic Conditions

5yr: Limit HW/D = 1.5 w/o roadway overtopping  
Based on observation there is approximately 2' of  
Cover

100yr: Limited roadway overtopping

Outfall: free w/ minimal tailwater

Culvert operating under inlet control

$Q_{5yr}$  (Sheet 16) = 3.2 cfs  $Q_{100} = 16.3$  cfs

HW/D (5yr) = less than 0.5

HW/D (100yr) = 1.5 or HW =  $1.5(2) = 3.0$  ft

w/ 2 ft of cover (assumed) no overtopping occurs

#### Pipe Flow

Once the water is inside the culvert:

5yr (Sheet 29) Depth = 0.5 ft

Velocity = 3.5 fpm

100yr (Sheet 30) Depth = 1.1 ft

Velocity = 5.6 fpm



29 ab 35  
Culvert @ DP#8  
5yr

# The open channel flow calculator

Select Channel Type: <input type="button" value="Circle"/>			
Depth from Q <input type="button" value="v"/>	Select unit system: <input type="button" value="Feet(ft)"/>		
Channel slope: .012 ft/ft	Water depth(y): 0.51 ft	Radius (r) 2 ft	
Flow velocity 3.456 ft/s	LeftSlope (Z1): <input type="text"/> to 1 (H:V)	RightSlope (Z2): <input type="text"/> to 1 (H:V)	
Flow discharge 3.2 ft^3/s	Input n value 0.022 or select n		
<input type="button" value="Calculate!"/>	Status: Calculation finished	<input type="button" value="Reset"/>	
Wetted perimeter 2.92 ft	Flow area 0.93 ft^2	Top width(T) 2.67 ft	
Specific energy 0.7 ft	Froude number 1.03	Flow status Supercritical flow	
Critical depth 0.52 ft	Critical slope 0.0109 ft/ft	Velocity head 0.19 ft	

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30sf 35  
culvert @ DP#8  
100yr

## The open channel flow calculator

Select Channel Type: <input type="button" value="Circle"/>	<div style="display: flex; justify-content: space-around; font-weight: bold;"> <span>Rectangle</span> <span>Trapezoid</span> <span>Triangle</span> <span>Circle</span> </div>		
Depth from Q <input type="button" value="v"/>	Select unit system: <input type="button" value="Feet(ft)"/>		
Channel slope: .012 ft/ft	Water depth(y): 1.14 ft	Radius (r) 2 ft	
Flow velocity 5.574 ft/s	LeftSlope (Z1): <input type="text"/> to 1 (H:V)	RightSlope (Z2): <input type="text"/> to 1 (H:V)	
Flow discharge 16.3 ft^3/s	Input n value 0.022 or select n		
<input type="button" value="Calculate!"/>	Status: Calculation finished	<input type="button" value="Reset"/>	
Wetted perimeter 4.5 ft	Flow area 2.94 ft^2	Top width(T) 3.61 ft	
Specific energy 1.62 ft	Froude number 1.09	Flow status Supercritical flow	
Critical depth 1.19 ft	Critical slope 0.0101 ft/ft	Velocity head 0.48 ft	

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SCALE \_\_\_\_\_

## Culverts (cont.)

### III Culverts @ DP #9

#### A Physical characteristics

Size = 18" @ MP w/ Project ends

Slope = Inv. in = 7157.7

Inv out = 7157.1

Drop = 0.6 ft

Length = 50 ft

Slope  $0.6/50 = 1.2\%$

Assume Cover = 2'

#### B Hydraulic characteristics

$Q_5 = 3.4 \text{ cfs}$  (see sheet 17)

$Q_{100} = 20.9 \text{ cfs}$  (see sheet 17)

$H_w/D (5 \text{ yr}) \approx 0.7$

$H_w/D (100 \text{ yr}) \approx 5.0$  or  $1.5 = \text{Depth}$

Significant overlapping occurs

Culvert needs to be replaced by EPC since it is undersized for the existing conditions as well

Depth of water prior to overlapping =  $1.5 + 2.0 = 3.5$

$H_w/D (\text{at overlapping}) = 3.5/1.5 \approx 2.3$

may flow in Pipe per criteria  $\neq 12 \text{ cfs}$

#### Pipe Hydraulics

(see sheet 32) 5 yr Depth = 0.6 ft

Velocity = 3.7 fpm

(see sheet 33) 100 yr Depth = 1.5 ft

Velocity = 6.1 fpm



32 & 35  
 Culvert @ DP 9  
 5yr

# The open channel flow calculator

Select Channel Type: <input type="text" value="Circle"/>			
Depth from Q <input type="text"/>	Select unit system: <input type="text" value="Feet(ft)"/>		
Channel slope: .012 ft/ft	Water depth(y): 0.57 <input type="text"/> ft	Radius (r) 1.5 ft	
Flow velocity 3.656 <input type="text"/> ✓ ft/s	LeftSlope (Z1): <input type="text"/> to 1 (H:V)	RightSlope (Z2): <input type="text"/> to 1 (H:V)	
Flow discharge 3.4 <input type="text"/> ✓ ft^3/s	Input n value 0.022 <input type="text"/> or select n		
<input type="button" value="Calculate!"/>	Status: Calculation finished	<input type="button" value="Reset"/>	
Wetted perimeter 2.71 ft	Flow area 0.94 <input type="text"/> ft^2	Top width(T) 2.36 ft	
Specific energy 0.78 ft	Froude number 1.02 <input type="text"/>	Flow status Supercritical flow	
Critical depth 0.58 ft	Critical slope 0.0113 <input type="text"/> ft/ft	Velocity head 0.21 ft	

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# The open channel flow calculator

Culvert @ DF  
100 years

Select Channel Type: Circle ▼			
Depth from Q ▼	Select unit system: Feet(ft) ▼		
Channel slope: 0.012 ft/ft	Water depth(y): 1.47 ft	Radius (r) 1.5 ft	
Flow velocity 6.064 ft/s	LeftSlope (Z1): to 1 (H:V)	RightSlope (Z2): to 1 (H:V)	
Flow discharge 20.9 ft^3/s	Input n value 0.022 or select n		
Calculate!	Status: Calculation finished	Reset	
Wetted perimeter 4.66 ft	Flow area 3.46 ft^2	Top width(T) 3 ft	
Specific energy 2.05 ft	Froude number 1	Flow status Critical flow	
Critical depth 1.47 ft	Critical slope 0.0121 ft/ft	Velocity head 0.57 ft	

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## Proposed Driveway Culvert

### A. Location

- Probably to be located in Sub drain B near the upper end of Swale #6
- The second location would be near the upper end of Swale #7

### B. Design Flow

Since the culvert is to be located at upper end of the swale #6 or #7 there is only a negligible amount of discharge

Therefore an 18" CMP would have plenty of capacity to accommodate the 5 year as well as the 100 year design storm.

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Drainage Basin Fees

A. Percent Impervious for 5 acre lots = 7%  
(Based on Table 3-1)

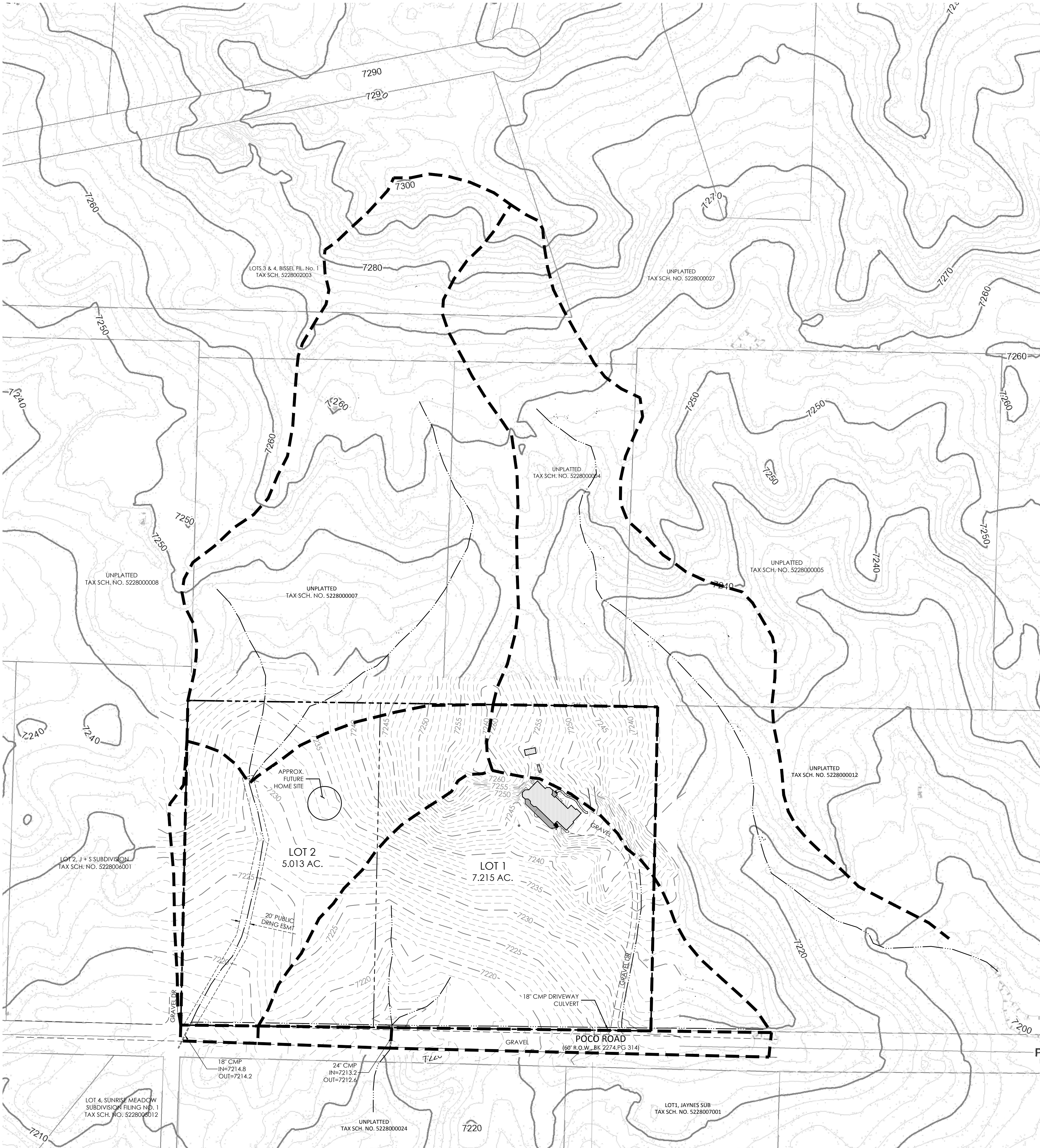
Impervious area for the lot to be disturbed  
 $0.07 * 5 \text{ Acres} = 0.4 \text{ acres}$

Fee Reduction = 25%

$\therefore \text{Impervious Area} = 0.4 \text{ Acres} - 0.25(0.4 \text{ Acres})$   
 $= 0.3 \text{ Acres}$

**Exhibit 8**  
**Drainage Map**  
**(Inside map pocket)**





**LEGEND**

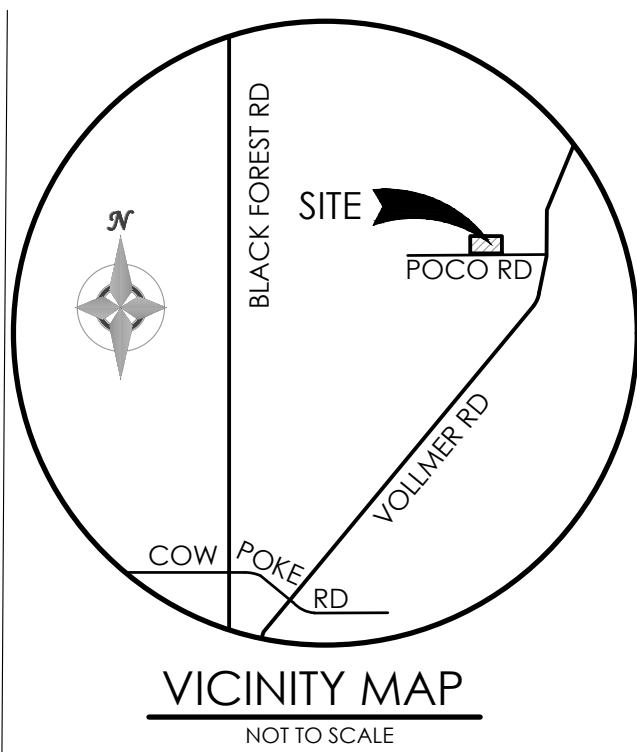
- PROPERTY LINE
- LOT LINE
- INDEX CONTOUR
- INTERMEDIATE CONTOUR
- SWALE
- BASIN BOUNDARY
- GENERAL FLOW/DIRECTION
- BASIN LABEL  
SUB-BASIN ID  
AREA IN ACRES
- DESIGN POINT (DP)

Runoff (historic)										
Design Point	Calc sheet (historic)				Runoff Coefficients			Runoff		Comments
		Sub basin ID	Drainage Area (acres)	5 yr	100 yr	Tc (min)	5 yr (cfs)	100 yr (cfs)		
1	1	OS1	10.3	0.08	0.35	27.2	1.5	14.1		
2	2	OS1, A, OS5, OS6	14.9	0.08	0.35	33.5	2.7	19.8		
3	3	B	5.9	0.08	0.35	15.8	1.7	12.0		
4	4	OS3	0.6	0.08	0.35	10	0.2	1.4	Min. allowable Tc	
5	5	C	1.5	0.08	0.35	10	0.5	3.6	Min. allowable Tc, outfalls into OS2	
6	6	2/3 B, OS4	4.4	0.11	0.37	15.8	1.6	9.4		
7	7	OS6, OS5	0.3	0.25	0.47	10	0.3	1.0		
8	8	B, OS3, OS4, OS7	7.2	0.12	0.38	15.8	2.0	15.9	Composite "C", same Tc as DP3	
9	9	OS1, A, OS6, OS5	14.9	0.09	0.35	33.5	3.1	19.8	same Tc as DP2 & DP7	

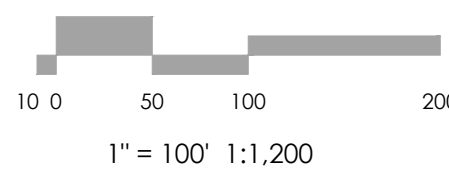
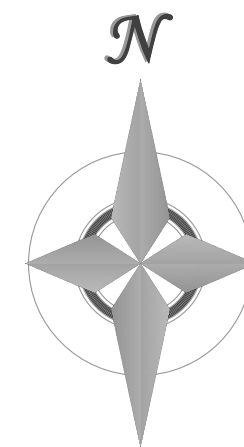
Runoff (developed)									
Design Point	Calc sheet (developed)			Runoff Coefficients		Tc (min)	Runoff		Comments
							developed		
		Sub basin ID	Drainage Area (acres)	5 yr	100 yr		5 yr (cfs)	100 yr (cfs)	
1	10	OS1	10.3	0.08	0.35	27.2	1.5	14.1	no change from existing
2	10-11	OS1, A, OS5, OS6	14.9	0.09	0.36	33.5	5.8	23.2	
3	12	B	5.9	0.12	0.42	15.8	2.4	16.9	
4	13	OS3	0.6	0.08	0.35	10	0.2	1.4	no change from existing
5	13	C	1.5	0.08	0.35	10	0.5	3.6	no change from existing
6	13-14	2/3 B, OS4	4.4	0.17	0.41	15.8	2.5	11.7	Composite "C", same Tc as DP3
7	15	OS6, OS5	0.3	0.25	0.47	10	0.3	1.0	no change from existing
8	15-16	B, OS3, OS4, OS7	7.2	0.13	0.39	15.8	3.4	5.8	no change from existing
9	17	OS1, A, OS6, OS5	14.9	0.10	0.37	33.5	3.4	20.9	

Swale Characteristics (developed conditions)															
Swale #	Hydrologic Calc Design Point	Calc sheet	Design Runoff		Bottom Width	Side slopes	Slope	Treatment	"n"	Depth of Flow		Velocity		Froude #	
			5 year	100 year						5 year	100 year	5 year	100 year		
			cfs	cfs	ft.		%	ft.		ft.	fps	fps	5 year	100 year	
1	1	10,18-20	1.5	14.1	20	10 to 1	10.7	grass lined	0.035	neg	0.2	1.7	3.9	1.44	1.75
2	2	11, 21-23	5.8	20.2	10	10 to 1	3.6	grass lined	0.35	0.2	0.4	2.4	5.8	1.02	1.2
3			Negligible design flow												
4			Negligible design flow												
5	6	13, 24-26	2.5	11.7	2	3 to 1	6	grass lined	0.035	0.2	0.6	3.5	5.4	1.36	1.52
6			Negligible design flow												
7			Negligible design flow												
8			Swale for private driveway, not evaluated												

Culvert Characteristics (developed Conditions)																
Design Point	Calc sheet #	Culvert size	Culvert Material	Design Flow		End Condition	Length	Slope	Tail water condition	Approx. HWD		Culvert depth		Culvert Velocity		Recommendations
				5 year	100 year					5 year	100 year	5 year	100 year			
		inches	cfs	cfs	ft.	%										
4	13, 27	18	CMP	0.1	1.4	proj	30	6	min	<0.5	<0.5	neg	neg	neg	neg	see report assumptions,has capacity to accommodate both storms
8	16, 28-30	24	CMP	3.2	16.3	proj	50	1.2	min	<0.5	1.5	0.5	1.1	3.5	5.6	see report assumptions,has capacity to accommodate both storms
9	17, 31-33	18	CMP	3.4	20.9	proj	50	1.2	min	0.7	5	0.6	1.5	3.7	6.1	Significant overtopping for 100 year occurs even with historic conditions, does not meet EPC criteria



BENCHMARK



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REVISIONS

DESIGNED BY  
DRAWN BY  
CHECKED BY  
AS-BUILT BY  
CHECKED BY

**EDGEWOOD  
SUBDIVISION  
FILING NO. 1**

**EXISTING/  
PROPOSED DRAINAGE  
MAP**

MVE PROJECT **61127**  
MVE DRAWING **-DRN-PP**

**APRIL 29, 2020  
SHEET 1 OF 1**