FINAL DRAINAGE REPORT

for

HUDSON MINOR SUBDIVISION

Prepared for:

Hannigan and Associates, Inc.
19360 Spring Valley Road
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March 7, 2018

Prepared by:

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JPS Project No. 121703

PCD File No. MS-18-002

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FINAL DRAINAGE REPORT
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DRAINAGE STATEMENT

Engineer's Statement:

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for liability caused by negligent acts, errors or omissions on my part in preparing this report.

____

John P. Schwab, P.E. #29891

Developer's Statement:

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

By:

____

Printed Name: Gregory Hudson, Owner   Date

20310 Black Forest Road, Colorado Springs, CO 80908

El Paso County's Statement

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

____

Jennifer Irvine, P.E.   Date

County Engineer / ECM Administrator

Conditions:

I. GENERAL LOCATION AND DESCRIPTION

A. Background

Hudson Minor Subdivision is a proposed rural residential subdivision consisting of four lots on a 38-acre parcel located in northern El Paso County, Colorado. The property is located on the west side of Black Forest Road, south of County Line Road. The parcel (El Paso County Assessor's Parcel No. 51000-00-323) is currently unplatted and vacant, with the exception of one existing single-family residence.

B. Scope

This report is intended to fulfill the El Paso County requirements for a Final Drainage Report (FDR) for submittal with the subdivision Final Plat application. The report provides a summary of site drainage issues impacting the proposed development, including analysis of impacts from upstream drainage areas, site-specific developed drainage patterns, and impacts on downstream facilities. This FDR report has been prepared based on the guidelines and criteria presented in the El Paso County Drainage Criteria Manual.

C. Site Location and Description

The Hudson Minor Subdivision parcel is located in the West Half of the West Half of Section 5, Township 11 South, Range 65 West of the 6th Principal Meridian. The site is currently a vacant ranch and meadow tract, with the exception of a single-family residence. The property is currently zoned RR-5 (Residential Rural; 5-acre minimum lots).

The north and west boundaries of the property border an unplatted 211-acre ranch property, and the south and southwest boundaries of the property border unplatted 53-acre and 60-acre parcels. The east boundary of the property adjoins Black Forest Road, and the existing County Line Estates Subdivision consisting of 5-acre lots is located across Black Forest Road to the east.

The proposed minor subdivision will create four new lots with a minimum lot size of 5 acres. Access to Hudson Minor Subdivision will be provided by construction of Cooper Grove as a gravel public road extending west from Black Forest Road to a proposed cul-de-sac along the north boundary of the site. Access for each lot will be provided by private driveways connecting to the proposed extension of Cooper Grove along the north boundary of the subdivision. The proposed low-density lots will be served by individual wells and septic systems.

Subdivision infrastructure improvements will include gravel paving of Cooper Grove as a new public roadway along the north boundary of the site, as well as grading, drainage, and utility service improvements for the proposed residential lots. Cooper Grove will be classified as a rural minor residential gravel road, with a 60-foot right-of-way and a gravel roadway width of 32-feet.

Ground elevations within the parcel range from a low point of approximately 7,320 feet above mean sea level at the east boundary of the parcel, to a high point of 7,384 feet near the northwest corner of the property.

This site is located in the East Cherry Creek drainage basin. Surface drainage from the property flows southeasterly towards tributaries of East Cherry Creek. The terrain is rolling with slopes ranging from 2% to 8%. Existing vegetation is typical eastern Colorado prairie grass.

D. General Soil Conditions

According to the Soil Survey of El Paso County prepared by the Natural Resources Conservation Service (NRCS), on-site soils are comprised of the following soil types (see Appendix A):

- Type 15 – "Brussett loam": well drained, moderate erosion hazard (Hydrologic Group B)
- Type 67 – "Peyton sandy loam": well drained, moderate erosion hazard (Hydrologic Group B)
- Type 69 – "Peyton-Pring complex": well drained, moderate erosion hazard (Hydrologic Group B)

E. References

City of Colorado Springs & El Paso County "Drainage Criteria Manual, Volumes 1 and 2," revised May, 2014.

El Paso County "Engineering Criteria Manual," January 9, 2006.

FEMA, Flood Insurance Rate Map (FIRM) Number 08041C0325-F, March 17, 1997.

Jeffries Engineering, "Master Development Drainage Plan, County Line Estates," February 18, 1998.

Jeffries Engineering, "Preliminary and Final Drainage Report, County Line Estates Filing No. 3," May 14, 1998.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Description

The proposed development lies within the East Cherry Creek Drainage Basin (CYCY 0200), as classified by El Paso County. Drainage from the site flows southeasterly to a tributary of East Cherry Creek, which flows northeasterly to a confluence with the main channel of East Cherry Creek on the east side of Black Forest Road.

No drainage planning study has been completed for this drainage basin or any adjacent drainage basins.

The major drainage basins lying in and around the proposed development are depicted in Figure EX1. The Hudson Minor Subdivision parcel is located near the southerly limits of the East Cherry Creek Drainage Basin, which comprises a total drainage area in excess of 30 square miles. The proposed 38-acre Hudson Minor Subdivision represents less than 0.2 percent of the total basin area, which is primarily ranch land.

B. Floodplain Impacts

The proposed development area is located beyond the limits of any 100-year floodplain delineated by the Federal Emergency Management Agency (FEMA). The floodplain limits in the vicinity of the site are shown in Flood Insurance Rate Map (FIRM) Number 08041C0325-F, dated March 17, 1997, as shown in Figure FIRM (Appendix E).

C. Sub-Basin Description

The existing drainage basins lying in and around the proposed development are depicted in Figure EX1 (Appendix E). The existing on-site topography has been delineated as three drainage basins flowing to design points at the east and south boundaries of the site.

The site is impacted by one off-site basin north of the property. This basin contributes flow to Basin A, draining southeasterly across the site to an existing culvert crossing Black Forest Road at the east boundary of the property.

The developed drainage basins lying within the proposed development are depicted on Figure D1. The natural drainage patterns will be impacted through development by site grading and concentration of runoff in subdivision roadside ditches and channels. On-site flows will be diverted to the existing natural drainage swales and channels running through the property, following historic drainage paths.

III. DRAINAGE DESIGN CRITERIA

A. Development Criteria Reference

No Drainage Basin Planning Study (DBPS) has been completed for the East Cherry Creek Drainage Basin.

The previously approved subdivision drainage reports for County Line Estates by Jeffries Engineering acknowledge acceptance of the off-site flow from the Hudson property, and County Line Estates did not incorporate any stormwater detention for the rural residential subdivision consisting of 5-acre lots.

B. Hydrologic Criteria

In accordance with the El Paso County Drainage Criteria Manual, Rational Method procedures were utilized for hydrologic calculations since the tributary drainage basins are below 100 acres.

Rational Method hydrologic calculations were based on the following assumptions:

• Design storm (minor)	5-year	
• Design storm (major)	100-year	
• Time of Concentration – Overland Flow	"Airport" equation (300' max. developed)	
• Time of Concentration – Gutter/Ditch Flow	"SCS Upland" equation	
• Rainfall Intensities	El Paso County I-D-F Curve	
• Hydrologic soil type	B	
	<u>C5</u>	<u>C100</u>
• Runoff Coefficients - undeveloped:		
Existing pasture/range areas	0.08	0.35
• Runoff Coefficients - developed:		
Proposed lot areas (5-acre lots)	0.137	0.393

Hydrologic calculations are enclosed in Appendix A, and peak design flows are identified on the drainage basin drawings.

IV. DRAINAGE PLANNING FOUR STEP PROCESS

El Paso County Drainage Criteria require drainage planning to include a Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainageways, and implementing long-term source controls.

Revise the Four Step Process based on the 4-step listed in ECM Appendix I Section I.7.2

As stated in DCM Volume 2, the Four Step Process is applicable to all new and re-development projects with construction activities that disturb 1 acre or greater or that disturb less than 1 acre but are part of a larger common plan of development. The Four Step Process has been implemented as follows in the planning of this project:

<u>Step 1: Employ Runoff Reduction Practices</u>

- Minimize Impacts: The proposed rural residential subdivision development with 5-acre minimum lot sizes provides for inherently minimal drainage impacts based on the limited impervious areas associated with rural residential development.
- Minimize Directly Connected Impervious Areas (MDCIA): The rural residential development will have roadside ditches along all roads and driveways, providing for impervious areas to drain across pervious areas. Based on the roadside ditches throughout the subdivision, the subdivision is classified as MDCIA Level One.

- Grass Swales: The proposed roadside ditches will drain to existing grass-lined drainage swales following historic drainage patterns through the property.

Step 2: Implement BMPs that Provide a Water Quality Capture Volume with Slow Release

- Based on the minimal developed drainage impact associated with this minor subdivision, consisting of only four rural residential lots on 38-acres, no permanent stormwater quality facilities are required.

You may want to also reference ECM I.7.1 that WQCV is not required for development areas of low density (rural) housing (2.5 acre or larger lots).

Step 3: Stabilize Drainageways

- Proper erosion control measures will be implemented along the roadside ditches and grass-lined drainage swales to provide stabilized drainageways within the site.

Step 4: Implement Site Specific and Other Source Control BMPs

- No industrial or commercial land uses are proposed within this rural residential subdivision.

V. DRAINAGE FACILITY DESIGN

A. General Concept

Development of the Hudson Minor Subdivision will include site grading, gravel paving, and residential building improvements, resulting in additional impervious areas across the site. The general drainage plan will consist of grading away from home sites to swales and roadside ditches, conveying runoff flows through the site. Runoff from the site will flow by roadside ditches to cross culverts at low points in the road profiles, and grass-lined channels connecting to existing natural swales at the site boundaries.

The stormwater management concept for the Hudson Minor Subdivision will be to provide roadside ditches and natural swales as required to convey developed drainage through the site to existing natural outfalls. Individual lot grading will provide positive drainage away from building sites, and direct developed flows into the system of roadside ditches and drainage swales running through the subdivision.

B. Specific Details

1. Existing Drainage Conditions

Historic drainage conditions within the site are depicted in Figures EX1 and EX2. The on-site areas have been delineated as Basins A-C, and Basin A is impacted by one upstream off-site drainage basins to the north (Basin OA1).

Basin A comprises the north side of the property, which sheet flows southeasterly to an existing 24-inch CMP culvert crossing Black Forest Road at the east boundary of the property. Off-site flows from Basin OA1 combine with on-site flow within Basin A, and these combined flows drain to Design Point #1, with calculated historic peak flows of Q_5 = 11.0 cfs and Q_{100} = 80.9 cfs.

Basin B comprises the southeast part of the property, which sheet flows southeasterly to an existing 18-inch culvert crossing Black Forest Road at the east boundary of the property. Basin B flows drain to Design Point #2, with calculated historic peak flows of Q_5 = 4.2 cfs and Q_{100} = 30.6 cfs.

Basin C comprises the southwest part of the property, which sheet flows southwesterly to an existing grass swale draining south to an existing pond along the tributary channel of East Cherry Creek on the west side of Black Forest Road. Basin C flows to Design Point #3, with historic peak flows calculated as Q_5 = 2.5 cfs and Q_{100} = 18.5 cfs.

2. Developed Drainage Conditions

The developed drainage basins and projected flows are shown in Figure D1, and hydrologic calculations are enclosed in Appendix A.

Basins A will continue to sheet flow southeasterly to the existing 24-inch CMP culvert crossing Black Forest Road at the east boundary of the property. A proposed 24-inch RCP culvert will be constructed to convey the off-site flows from northerly Basin OA1 across the new extension of Cooper Grove on the west side of Black Forest Road. Flows from Basis OA1 will combine with Basin A at Design Point #1, with developed peak flows calculated as Q_5 = 12.5 cfs and Q_{100} = 82.8 cfs, representing a minor increase in comparison to historic conditions.

The southeast part of the property within Basin B will continue to sheet flow southeasterly to the existing 18-inch culvert crossing Black Forest Road at the east boundary of the property. Basin B will drain to Design Point #2, with calculated developed peak flows of Q_5 = 5.1 cfs and Q_{100} = 31.9 cfs, representing a minor increase in comparison to historic conditions.

The southwest part of the property within Basin C will continue to sheet flow southwesterly to the existing natural swale along the south boundary of the property. Basin C will drain to Design Point #3, with developed peak flows calculated as Q_5 = 3.5 cfs and Q_{100} = 20.0 cfs, representing a minor increase in comparison to historic conditions.

Basin C comprises the southwest part of the property, which sheet flows southwesterly to an existing grass swale draining south to an existing pond along the tributary channel of East Cherry Creek on the west side of Black Forest Road. Basin C flows to Design Point #3, with historic peak flows calculated as Q_5 = 3.5 cfs and Q_{100} = 20.0 cfs, representing a minor increase in comparison to historic conditions.

Based on the large size of the proposed rural residential lots, the developed flow impact will be insignificant.

C. Comparison of Developed to Historic Discharges

Based on the hydrologic calculations in Appendix A, the proposed development will result in a minor increase in developed flows in comparison to historic flows from the parcel. The comparison of developed to historic discharges at key design points is summarized as follows:

Design Point	Historic Flow			Developed Flow			Comparison of Developed to Historic Flow
	Area (ac)	Q_5 (cfs)	Q_{100} (cfs)	Area (ac)	Q_5 (cfs)	Q_{100} (cfs)	
1	54.0	11.0	80.9	54.0	12.5	82.8	+1.5 cfs / +1.8 cfs
2	17.1	4.2	30.6	17.1	5.1	31.9	+0.9 cfs / +1.3 cfs
3	9.5	2.5	18.5	9.5	3.5	20.0	+1.0 cfs / +1.5 cfs

D. On-Site Drainage Facility Design

Include a statement with the justification why on-site detention for flood control is not required.

Developed sub-basins and proposed drainage improvements are depicted in the enclosed Drainage Plan (Sheet D1).

On-site drainage facilities will consist of roadside ditches, grass-lined channels, and culverts. Hydraulic calculations for sizing of on-site drainage facilities are enclosed in Appendix B.

The internal road system has been graded to drain roadside ditches to low points along the road profile, where cross-culverts will convey developed flows into grass-lined channels following historic drainage paths. Culvert pipes have been specified as reinforced concrete pipe (RCP) with a minimum diameter of 18-inches.

Culvert sizes have been identified based on a maximum headwater-to-depth ratio (HW/D) of 1.0 for the minor (5-year) design storm. Final culvert design calculations were performed utilizing the FHWA HY-8 software package to perform a detailed analysis of inlet and outlet control conditions, meeting El Paso County criteria for allowable overtopping. HY8 calculation results are summarized in the "Culvert Sizing Summary" Table in Appendix B. Riprap outlet protection will be provided at all culverts.

Add a narrative regarding the major design storm (100-yr) conditions at the culverts at OA1, DP1 and DP2. From the results it appears that cross flow at OA1 in the major storm does not meet criteria (depth of flow exceeds 6" at the edge of road shoulder). See DCM Table 6-1

The proposed drainage channels and ditches have been sized utilizing Manning's equation for open channel flow, assuming a friction factor ("n") of 0.030 for dry-land grass channels. Maximum allowable velocities will be evaluated based on El Paso County drainage criteria, typically allowing for a maximum 100-year velocity of 5 feet per second. Erosion control mats have been specified for channel segments with maximum 100-year velocities up to 8 feet per second. The proposed channels will generally be seeded with native grasses for erosion control. Erosion control mats will be provided where required based on erosive velocities. Ditch flows will be diverted to drainage channels at the nearest practical location to minimize excessive roadside ditch sizes.

The Developed Drainage Plan includes the following notes for Builders and Property Owners:

1. Individual builders shall provide positive drainage away from structures and account for potential cross-lot drainage impacts within each lot.
2. Builders and property owners shall implement and maintain erosion control best management practices for protection of downstream properties and facilities, including protection of existing grass buffer strips along the downstream property boundaries.

E. Anticipated Drainage Problems and Solutions

The overall drainage plan for the subdivision includes a system of roadside ditches, channels, and culverts to convey developed flows through the site. The primary drainage problems anticipated within this development will consist of maintenance of these drainage channels and culverts. Care will need to be taken to implement proper erosion control measures in the proposed roadside ditches, channels, and swales. Ditches will be designed to meet allowable velocity criteria. Erosion control mats will be installed where necessary to minimize erosion concerns. Public roadway improvements, culverts, and ditches within the public right-of-way will be owned and maintained by El Paso County.

The extreme low density of the proposed development will result in a minimal impact to existing downstream drainage facilities.

VI. EROSION / SEDIMENT CONTROL

The Contractor will be required to implement proper Best Management Practices (BMP's) for erosion control through the course of construction. Sediment control measures will include installation of silt fence at the toe of disturbed slopes and straw bales protecting drainage ditches. Cut slopes will be stabilized during excavation as necessary and vegetation will be established for stabilization of disturbed areas as soon as possible. All ditches will be designed to meet El Paso County criteria for slope and velocity.

VII. COST ESTIMATE AND DRAINAGE FEES

A cost estimate for proposed drainage improvements is enclosed in Appendix E, with a total estimated cost of approximately $6,800 for subdivision drainage improvements. The developer will finance all construction costs for proposed roadway and drainage improvements, and public facilities will be owned and maintained by El Paso County upon final acceptance.

This parcel is located in the East Cherry Creek Drainage Basin. No drainage and bridge fees will be due at time of recordation of the final plat as the subject site is not located in a fee basin.

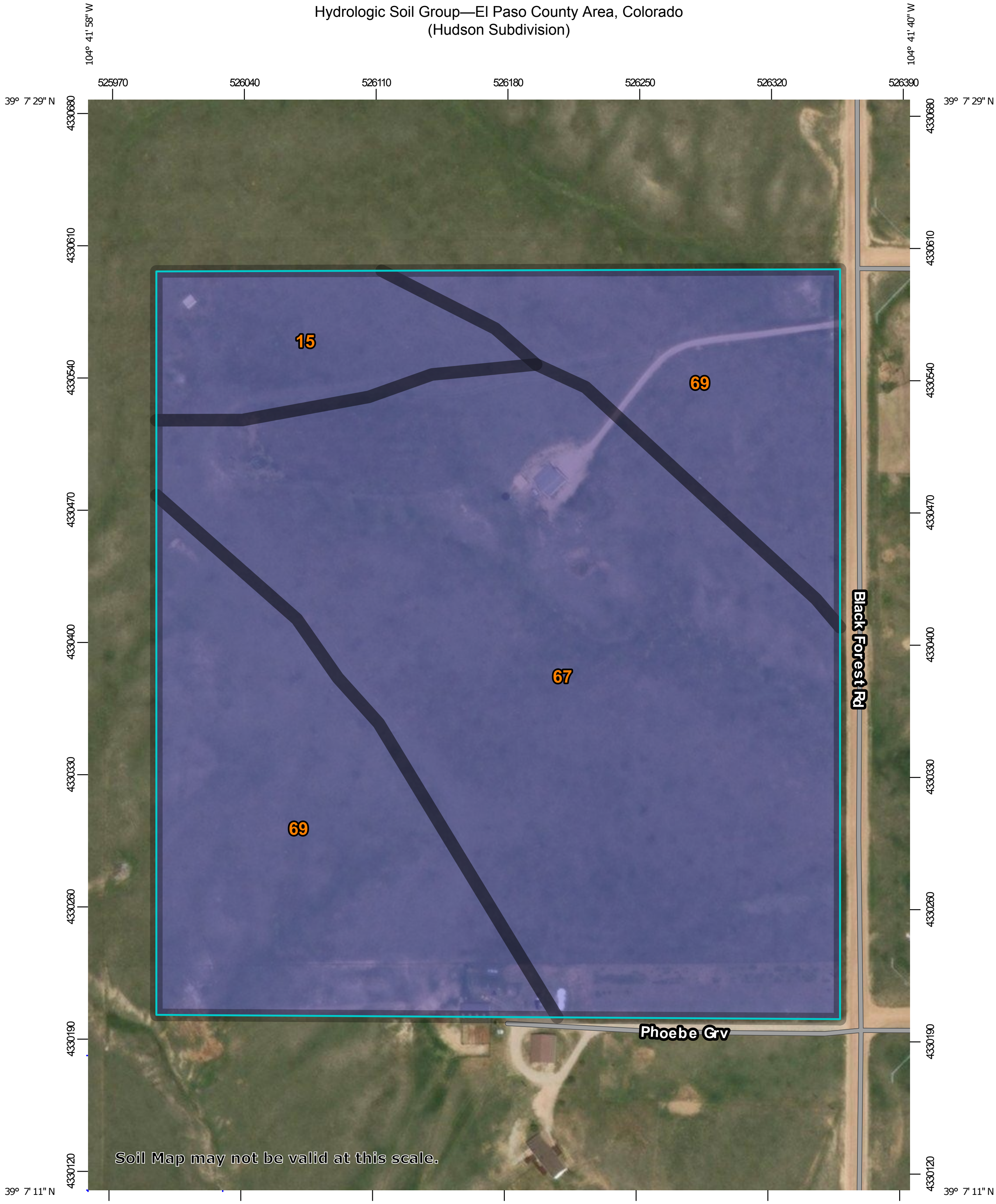
VIII. SUMMARY

Hudson Minor Subdivision is a proposed rural residential subdivision located on the west side of Black Forest Road in northern El Paso County. The proposed drainage patterns for Hudson Minor Subdivision will remain consistent with historic conditions and the overall drainage plan for this area. The proposed rural residential minor subdivision, with four proposed lots on 38-acres, will result in a minimal impact on downstream drainage facilities. Installation and maintenance of proper erosion control practices during and after construction will ensure that this subdivision has no significant adverse drainage impact on downstream or surrounding areas.

APPENDIX A

HYDROLOGIC CALCULATIONS

Hydrologic Soil Group—El Paso County Area, Colorado
(Hudson Subdivision)



Map Scale: 1:2,810 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 40, 80, 160, 240

Feet: 0, 100, 200, 400, 600

N

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

MAP LEGEND

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

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 15, Oct 10, 2017

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

Date(s) aerial images were photographed: May 22, 2016—Mar 9, 2017

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
15	Brussett loam, 3 to 5 percent slopes	B	2.9	8.1%
67	Peyton sandy loam, 5 to 9 percent slopes	B	19.5	54.7%
69	Peyton-Pring complex, 8 to 15 percent slopes	B	13.2	37.2%
Totals for Area of Interest			**35.6**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

United States Department of Agriculture

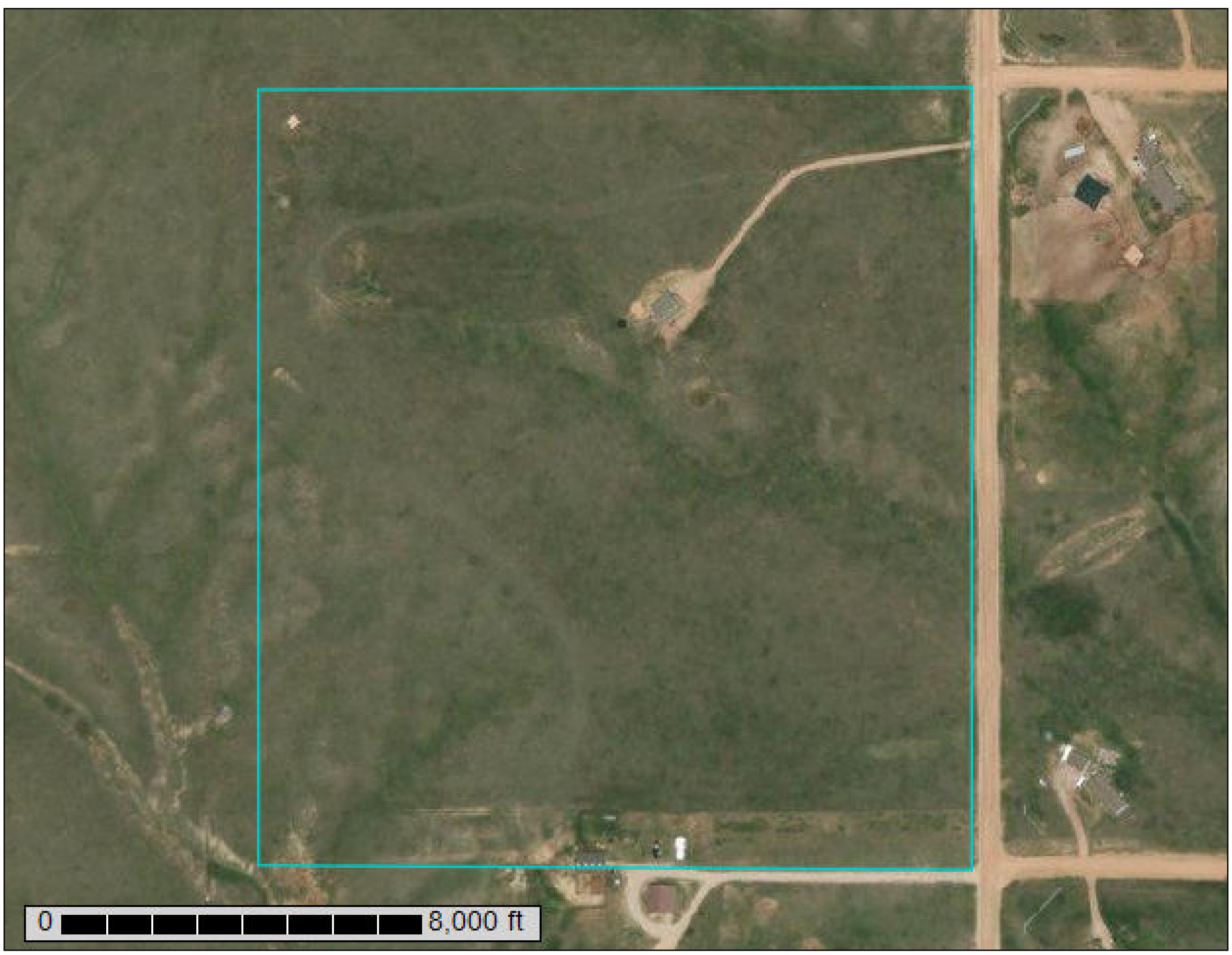
NRCS

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



January 23, 2018

Preface

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).

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.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

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 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

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.

Soil Map

Map Scale: 1:2,810 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 40, 80, 160, 240

Feet: 0, 100, 200, 400, 600

N

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 15, Oct 10, 2017

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

Date(s) aerial images were photographed: May 22, 2016—Mar 9, 2017

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
15	Brussett loam, 3 to 5 percent slopes	2.9	8.1%
67	Peyton sandy loam, 5 to 9 percent slopes	19.5	54.7%
69	Peyton-Pring complex, 8 to 15 percent slopes	13.2	37.2%
Totals for Area of Interest		**35.6**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

El Paso County Area, Colorado

15—Brussett loam, 3 to 5 percent slopes

Map Unit Setting

National map unit symbol: 367k
Elevation: 7,200 to 7,500 feet
Frost-free period: 115 to 125 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

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

Description of Brussett

Setting

Landform: Hills
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits

Typical profile

A - 0 to 8 inches: loam
BA - 8 to 12 inches: loam
Bt - 12 to 26 inches: clay loam
Bk - 26 to 60 inches: silt loam

Properties and qualities

Slope: 3 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 9.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Loamy Park (R048AY222CO)
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit:
Hydric soil rating: No

67—Peyton sandy loam, 5 to 9 percent slopes

Map Unit Setting

National map unit symbol: 369d
Elevation: 6,800 to 7,600 feet
Mean annual air temperature: 43 to 45 degrees F
Frost-free period: 115 to 125 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Peyton

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 and/or arkosic residuum weathered from sedimentary rock

Typical profile

A - 0 to 12 inches: sandy loam
Bt - 12 to 25 inches: sandy clay loam
BC - 25 to 35 inches: sandy loam
C - 35 to 60 inches: sandy loam

Properties and qualities

Slope: 5 to 9 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy Divide (R049BY216CO)
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit:
Hydric soil rating: No

Pleasant

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

69—Peyton-Pring complex, 8 to 15 percent slopes

Map Unit Setting

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

Map Unit Composition

Peyton and similar soils: 40 percent
Pring and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Peyton

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 and/or arkosic residuum weathered from sedimentary rock

Typical profile

A - 0 to 12 inches: sandy loam
Bt - 12 to 25 inches: sandy clay loam
BC - 25 to 35 inches: sandy clay loam
C - 35 to 60 inches: sandy loam

Properties and qualities

Slope: 8 to 9 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy Divide (R049BY216CO)
Hydric soil rating: No

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: 8 to 15 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): 6e
Hydrologic Soil Group: B
Ecological site: Loamy Park (R049BY222CO)
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit:
Hydric soil rating: No

Pleasant

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

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

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

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.

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

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).

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

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.

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

Where:

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

L = waterway length (ft)

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

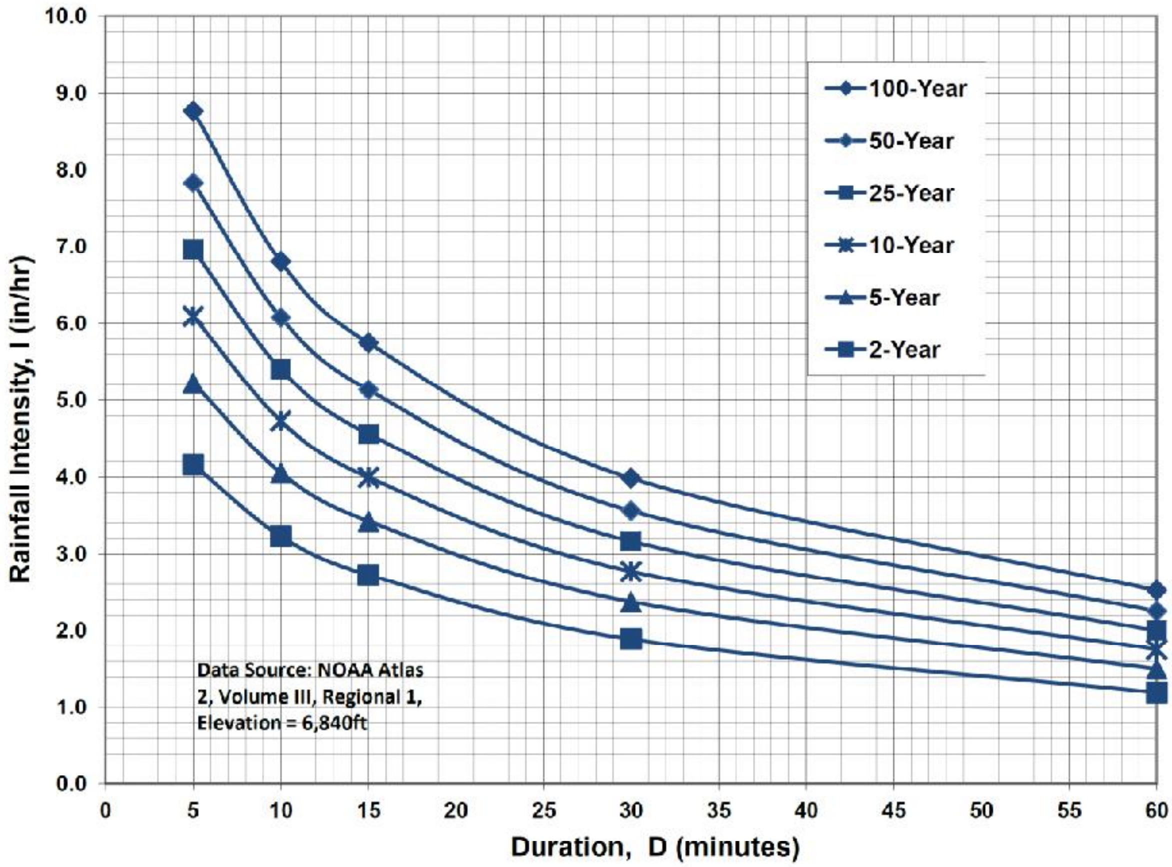
3.2.4 Minimum Time of Concentration

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

3.2.5 Post-Development Time of Concentration

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

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.

HUDSON MINOR SUBDIVISION
COMPOSITE RUNOFF COEFFICIENTS - TYPICAL RURAL RESIDENTIAL LOTS

DEVELOPED CONDITIONS

5-YEAR C VALUES

BASIN	TOTAL AREA (AC)	AREA (%)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (%)	SUB-AREA 2 DEVELOPMENT/ COVER	C	AREA (%)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
5-ACRE LOTS	5.00	7.00	BUILDING / PAVEMENT	0.90	93.00	LANDSCAPED	0.08				0.137

100-YEAR C VALUES

BASIN	TOTAL AREA (AC)	AREA (%)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	AREA (%)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
5-ACRE LOTS	5.00	7.00	BUILDING / PAVEMENT	0.96	93.00	LANDSCAPED	0.35				0.393

IMPERVIOUS AREAS

BASIN	TOTAL AREA (AC)	AREA (%)	SUB-AREA 1 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	AREA (%)	SUB-AREA 2 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	AREA (%)	SUB-AREA 3 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	WEIGHTED % IMP
5-ACRE LOTS	5.00	7.00	BUILDING / PAVEMENT	100	93.00	LANDSCAPED	0				7.000

HUDSON MINOR SUBDIVISION
COMPOSITE RUNOFF COEFFICIENTS

5-YEAR C-VALUES

BASIN	TOTAL AREA (AC)	AREA (AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
OA1	43.37	43.37	MEADOW	0.080							0.080
A1	10.60	10.60	5-AC LOTS	0.137							0.137
OA1,A1	53.97										0.091
B	17.10	5.00	5-AC LOTS	0.14	12.10	MEADOW	0.08				0.097
C	9.50	5.00	5-AC LOTS	0.14	4.50	MEADOW	0.08				0.110

100-YEAR C-VALUES

BASIN	TOTAL AREA (AC)	AREA (AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
OA1	43.37	43.37	MEADOW	0.350							0.350
A1	10.60	10.60	5-AC LOTS	0.393							0.393
OA1,A1	53.97										0.358
B	17.10	5.00	5-AC LOTS	0.393	12.10	MEADOW	0.35				0.363
C	9.50	5.00	5-AC LOTS	0.393	4.50	MEADOW	0.35				0.373

HUDSON MINOR SUBDIVISION
RATIONAL METHOD

HISTORIC FLOWS

BASIN	DESIGN POINT	AREA (AC)	C 5-YEAR(7)	C 100-YEAR(7)	Overland Flow LENGTH (FT)	Overland Flow SLOPE (FT/FT)	Overland Flow Tco(1) (MIN)	Channel flow CHANNEL LENGTH (FT)	Channel flow CONVEYANCE COEFFICIENT C	Channel flow SLOPE (FT/FT)	Channel flow SCS(2) VELOCITY (FT/S)	Channel flow Tt(3) (MIN)	TOTAL Tc(4) (MIN)	TOTAL Tc(4) (MIN)	INTENSITY(5) 5-YR (IN/HR)	INTENSITY(5) 100-YR (IN/HR)	PEAK FLOW Q5(6) (CFS)	PEAK FLOW Q100(6) (CFS)
OA1	OA1	43.37	0.080	0.350	300	0.050	18.9	1650	15.00	0.0552	3.52	7.8	26.7	26.7	2.65	4.46	9.21	67.63
A		10.60	0.080	0.350			0.0	350	15.00	0.0429	3.11	1.9	1.9	5.0	5.17	8.68	4.38	32.20
OA1,A	1	53.97	0.080	0.350									28.6	28.6	2.55	4.28	11.02	80.92
B		17.10	0.080	0.350	300	0.077	16.4	850	15.00	0.0506	3.37	4.2	20.6	20.6	3.04	5.11	4.16	30.58
C	3	9.50	0.080	0.350	300	0.080	16.2	300	15.00	0.10	4.74	1.1	17.2	17.2	3.31	5.56	2.52	18.49

DEVELOPED FLOWS

BASIN	DESIGN POINT	AREA (AC)	C 5-YEAR(7)	C 100-YEAR(7)	Overland Flow LENGTH (FT)	Overland Flow SLOPE (FT/FT)	Overland Flow Tco(1) (MIN)	Channel flow CHANNEL LENGTH (FT)	Channel flow CONVEYANCE COEFFICIENT C	Channel flow SLOPE (FT/FT)	Channel flow SCS(2) VELOCITY (FT/S)	Channel flow Tt(3) (MIN)	TOTAL Tc(4) (MIN)	TOTAL Tc(4) (MIN)	INTENSITY(5) 5-YR (IN/HR)	INTENSITY(5) 100-YR (IN/HR)	PEAK FLOW Q5(6) (CFS)	PEAK FLOW Q100(6) (CFS)
OA1	OA1	43.37	0.080	0.350	300	0.050	18.9	1650	15.00	0.0552	3.52	7.8	26.7	26.7	2.65	4.46	9.21	67.63
A		10.60	0.137	0.393			0.0	350	15.00	0.0429	3.11	1.9	1.9	5.0	5.17	8.68	7.51	36.16
OA1,A	1	53.97	0.091	0.358									28.6	28.6	2.55	4.28	12.54	82.77
B		17.10	0.097	0.363	300	0.077	16.1	850	15.00	0.0506	3.37	4.2	20.3	20.3	3.06	5.14	5.08	31.93
C	3	9.50	0.110	0.373	300	0.080	15.7	300	15.00	0.10	4.74	1.1	16.8	16.8	3.35	5.63	3.51	19.95

DP 2

1) OVERLAND FLOW Tco = (0.39[illegible] NOFF COEFFICIENT)*(OVERLAND FLOW LENGTH^(0.5)/(SLOPE^(0.333))
2) SCS VELOCITY = C * ((SLOPE(FT/FT)^0.5)
C = 2.5 FOR HEAVY MEADOW
C = 5 FOR TILLAGE/FIELD
C = 7 FOR SHORT PASTURE AND LAWNS
C = 10 FOR NEARLY BARE GROUND
C = 15 FOR GRASSED WATERWAY
C = 20 FOR PAVED AREAS AND SHALLOW PAVED SWALES

3) MANNING'S CHANNEL TRAVEL TIME = L/V (WHEN CHANNEL VELOCITY IS KNOWN)
4) Tc = Tco + Tt
*** IF TOTAL TIME OF CONCENTRATION IS LESS THAN 5 MINUTES, THEN 5 MINUTES IS USED
5) INTENSITY BASED ON I-D-F EQUATIONS IN CITY OF COLORADO SPRINGS DRAINAGE CRITERIA MANUAL
$I_5 = -1.5 * \ln(Tc) + 7.583$
$I_{100} = -2.52 * \ln(Tc) + 12.735$
6) Q = CiA

APPENDIX B

HYDRAULIC CALCULATIONS

HUDSON MINOR SUBDIVISION
DITCH CALCULATION SUMMARY

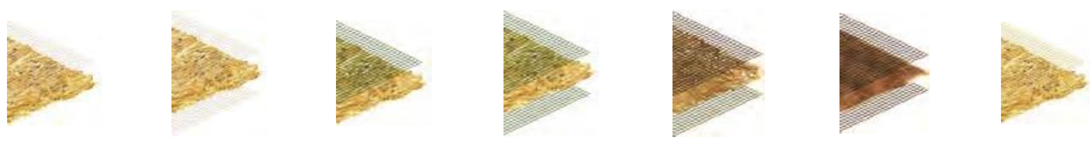
PROPOSED ROADSIDE DITCHES

ROADWAY	FROM STA	TO STA	SIDE	PROPOSED SLOPE (%)	SIDE SLOPE (Z)	CHANNEL DEPTH (FT)	FRICTION FACTOR (n)	ROW WIDTH (ft)	BASIN	Q100 FLOW (CFS)	DITCH FLOW % OF BASIN	DITCH FLOW (CFS)	Q100 DEPTH (FT)	Q100 VELOCITY (FT/S)	DITCH LINING
COOPER GROVE (W)	150	350	N	5.00	4:1/3:1	2.5	0.030	60	OA1	67.6	10	6.8	0.6	5.0	**GRASS / ECB**
COOPER GROVE (W)	150	350	S	5.00	4:1/3:1	2.5	0.030	60	A	36.2	30	10.9	0.7	5.6	**GRASS / ECB**
COOPER GROVE (W)	350	585	N	1.75	4:1/3:1	2.5	0.030	60	OA1	67.6	90	60.8	1.7	5.8	**GRASS / ECB**
COOPER GROVE (W)	350	585	S	1.75	4:1/3:1	2.5	0.030	60	A	36.2	60	21.7	1.2	4.5	GRASS

1) Channel flow calculations based on Manning's Equation
2) Channel depth includes 1' minimum freeboard
3) n = 0.03 for grass-lined non-irrigated channels (minimum)
4) n = 0.045 for riprap-lined channels
5) Vmax = 5.0 fps per El Paso County criteria (p. 10-13) for fescue (dry land grass) for 100-year flows
6) Vmax = 8.0 fps with Erosion Control Blankets (Tensar Eronet SC150 or equal)

The complete line of RollMax™ products offers a variety of options for both short-term and permanent erosion control needs. Reference the RollMax Products Chart below to find the right solution for your next project.

RollMax Product Selection Chart



	TEMPORARY						
	ERONET						BIONET
	DS75	**DS150**	**S75**	**S150**	**SC150**	**C125**	**S75BN**
Longevity	45 days	60 days	12 mo.	12 mo.	24 mo.	36 mo.	12 mo.
Applications	Low Flow Channels 4:1-3:1 Slopes	Moderate Flow Channels 3:1-2:1 Slopes	Low Flow Channels 4:1-3:1 Slopes	Moderate Flow Channels 3:1-2:1 Slopes	Medium Flow Channels 2:1-1:1 Slopes	High-Flow Channels 1:1 and Greater Slopes	Low Flow Channels 4:1-3:1 Slopes
Design Permissible Shear Stress lbs/ft² (Pa)	Unvegetated 1.55 (74)	Unvegetated 1.75 (84)	Unvegetated 1.55 (74)	Unvegetated 1.75 (84)	Unvegetated 2.00 (96)	Unvegetated 2.25 (108)	Unvegetated 1.60 (76)
Design Permissible Velocity ft/s (m/s)	Unvegetated 5.00 (1.52)	Unvegetated 6.00 (1.52)	Unvegetated 5.00 (1.2)	Unvegetated 6.00 (1.83)	Unvegetated 8.00 (2.44)	Unvegetated 10.00 (3.05)	Unvegetated 5.00 (1.52)
Top Net	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft² (0.73 kg/100 m²) approx wt	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft² (0.73 kg/100 m²) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft² (0.73 kg/100 m²) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft² (0.73 kg/100 m²) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft² (1.47 kg/100 m²) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft² (1.47 kg/100 m²) approx wt	Leno woven. 100% biodegradable jute fiber 9.30 lbs/1000 ft² (4.53 kg/100 m²) approx wt
Center Net	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fiber Matrix	Straw fiber 0.50 lbs/yd² (0.27 kg/m²)	Straw fiber 0.50 lbs/yd² (0.27 kg/m²)	Straw fiber 0.50 lbs/yd² (0.27 kg/m²)	Straw fiber 0.50 lbs/yd² (0.27 kg/m²)	Straw/coconut matrix 70% Straw 0.35 lbs/yd² (0.19 kg/m²) 30% Coconut 0.15 lbs/yd² (0.08 kg/m²)	Coconut fiber 0.50 lbs/yd² (0.27 kg/m²)	Straw fiber 0.50 lbs/yd² (0.27 kg/m²)
Bottom Net	N/A	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft² (0.73 kg/100 m²) approx wt	N/A	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft² (0.73 kg/100 m²) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft² (0.73 kg/100 m²) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft² (1.47 kg/100 m²) approx wt	N/A
Thread	Accelerated degradable	Accelerated degradable	Degradable	Degradable	Degradable	UV-stabilized polypropylene	Biodegradable

Hydraulic Analysis Report

Project Data

Project Title: Hudson Minor Subdivision

Designer: JPS

Project Date: Tuesday, March 06, 2018

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Ditch-150-350-N

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0500 ft/ft

Manning's n: 0.0300

Flow: 6.8000 cfs

Result Parameters

Depth: 0.6253 ft

Area of Flow: 1.3687 ft^2

Wetted Perimeter: 4.5559 ft

Hydraulic Radius: 0.3004 ft

Average Velocity: 4.9683 ft/s

Top Width: 4.3774 ft

Froude Number: 1.5658

Critical Depth: 0.7513 ft

Critical Velocity: 3.4422 ft/s

Critical Slope: 0.0188 ft/ft

Critical Top Width: 5.37 ft

Calculated Max Shear Stress: 1.9511 lb/ft^2

Calculated Avg Shear Stress: 0.9373 lb/ft^2

Channel Analysis: Ditch-150-350-S

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0500 ft/ft

Manning's n: 0.0300

Flow: 10.9000 cfs

Result Parameters

Depth: 0.7464 ft

Area of Flow: 1.9498 ft^2

Wetted Perimeter: 5.4377 ft

Hydraulic Radius: 0.3586 ft

Average Velocity: 5.5903 ft/s

Top Width: 5.2247 ft

Froude Number: 1.6127

Critical Depth: 0.9073 ft

Critical Velocity: 3.7829 ft/s

Critical Slope: 0.0176 ft/ft

Critical Top Width: 6.48 ft

Calculated Max Shear Stress: 2.3287 lb/ft^2

Calculated Avg Shear Stress: 1.1187 lb/ft^2

Channel Analysis: Ditch-350-585-N

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0175 ft/ft

Manning's n: 0.0300

Flow: 60.8000 cfs

Result Parameters

Depth: 1.7313 ft

Area of Flow: 10.4912 ft^2

Wetted Perimeter: 12.6134 ft

Hydraulic Radius: 0.8318 ft

Average Velocity: 5.7953 ft/s

Top Width: 12.1193 ft

Froude Number: 1.0977

Critical Depth: 1.8045 ft

Critical Velocity: 5.3348 ft/s

Critical Slope: 0.0140 ft/ft

Critical Top Width: 12.89 ft

Calculated Max Shear Stress: 1.8906 lb/ft^2

Calculated Avg Shear Stress: 0.9083 lb/ft^2

Channel Analysis: Ditch-350-585-S

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0175 ft/ft

Manning's n: 0.0300

Flow: 21.7000 cfs

Result Parameters

Depth: 1.1765 ft

Area of Flow: 4.8444 ft^2

Wetted Perimeter: 8.5712 ft

Hydraulic Radius: 0.5652 ft

Average Velocity: 4.4794 ft/s

Top Width: 8.2354 ft

Froude Number: 1.0292

Critical Depth: 1.1950 ft

Critical Velocity: 4.3414 ft/s

Critical Slope: 0.0161 ft/ft

Critical Top Width: 8.54 ft

Calculated Max Shear Stress: 1.2847 lb/ft^2

Calculated Avg Shear Stress: 0.6172 lb/ft^2

HUDSON MINOR SUBDIVISION
CULVERT DESIGN SUMMARY

BASIN	DESIGN POINT	RD CL ELEV	INV IN ELEV	INV OUT ELEV	PIPE LENGTH (FT)	# of CULVERTS	PIPE DIA (FT)	TOTAL Q5 (CFS)	PER PIPE Q5 (CFS)	MAX ALLOWABLE HEADWATER	CALC HW ELEV	TOTAL Q100 (CFS)	PER PIPE Q100 (CFS)	MAX ALLOWABLE HEADWATER	CALC HW ELEV
OA1	OA1	7333.49	7328.72	7328.23	62.0	1	2.0	9.2	9.20	7330.72	7330.27	67.60	67.60	7334.2	7333.89

Provide culvert analysis for the existing culverts at DP1 and DP 2.

Crossing Data - Crossing 1

Crossing Properties

Name: Crossing 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	5.00	cfs
Design Flow	9.20	cfs
Maximum Flow	67.60	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	6.00	ft
Side Slope (H:V)	4.00	_:1
Channel Slope	0.0200	ft/ft
Manning's n (channel)	0.0300	
Channel Invert Elevation	7328.23	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.00	ft
Crest Length	50.00	ft
Crest Elevation	7333.49	ft
Roadway Surface	Gravel	
Top Width	32.00	ft

Culvert Properties

Culvert OA1

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert OA1	
Shape	Circular	
Material	Concrete	
Diameter	2.00	ft
Embedment Depth	0.00	in
Manning's n	0.0130	
Culvert Type	Straight	
Inlet Configuration	Grooved End Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	7328.72	ft
Outlet Station	62.00	ft
Outlet Elevation	7328.23	ft
Number of Barrels	1	

Help

Click on any icon for help on a specific

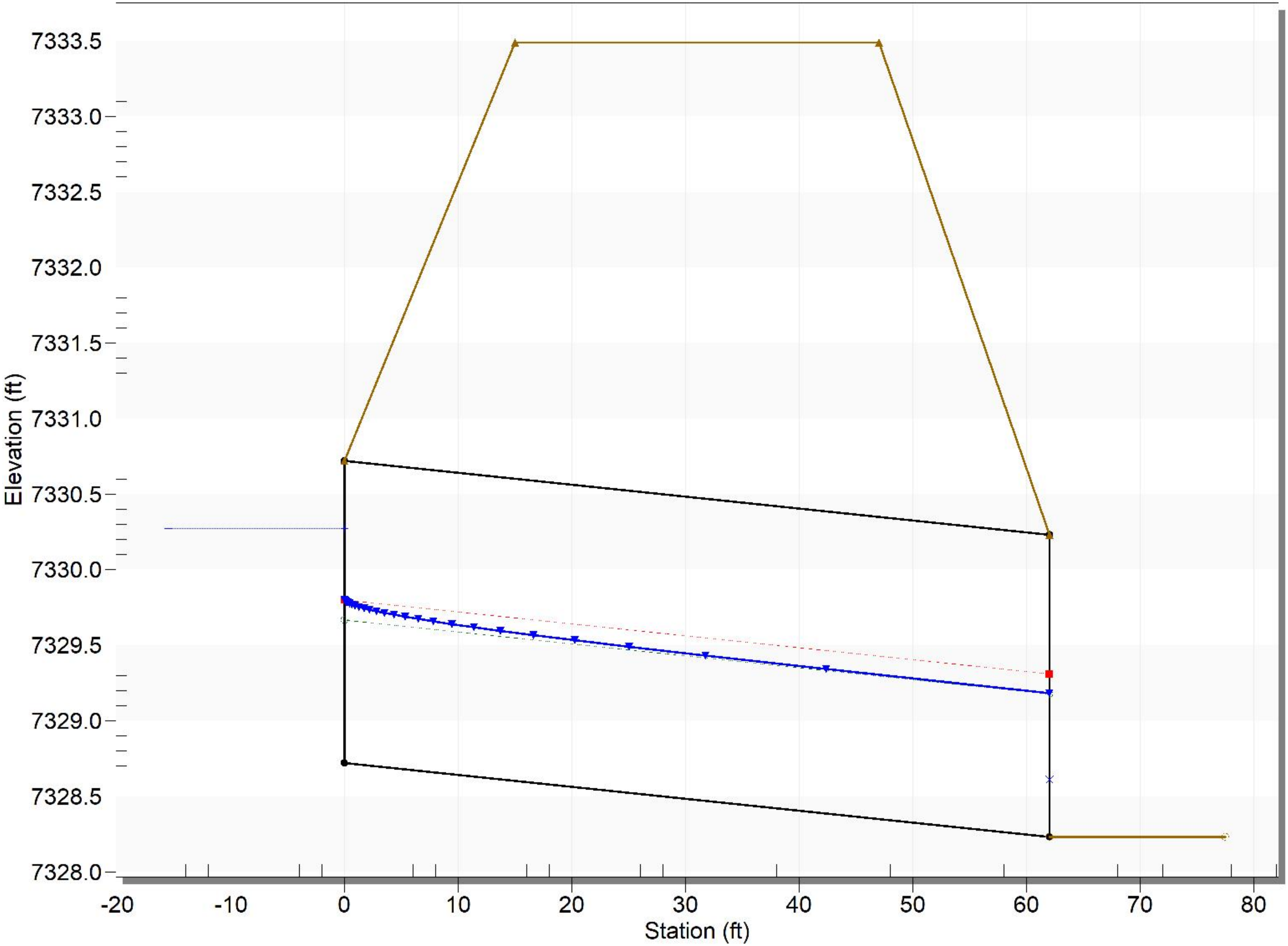
Energy Dissipation

Ana

Type here to search

Crossing - Crossing 1, Design Discharge - 9.2 cfs

Culvert - Culvert OA1, Culvert Discharge - 9.2 cfs



HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 5 cfs

Design Flow: 9.2 cfs

Maximum Flow: 67.6 cfs

Table 1 - Summary of Culvert Flows at Crossing: Crossing 1

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert OA1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
7329.81	5.00	5.00	0.00	1
7330.27	9.20	9.20	0.00	1
7331.08	17.52	17.52	0.00	1
7331.90	23.78	23.78	0.00	1
7333.00	30.04	30.04	0.00	1
7333.58	36.30	32.87	3.37	14
7333.66	42.56	33.26	9.17	5
7333.73	48.82	33.57	15.21	5
7333.79	55.08	33.82	21.19	4
7333.84	61.34	34.06	27.24	4
7333.89	67.60	34.28	33.21	3
7333.49	32.46	32.46	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 1

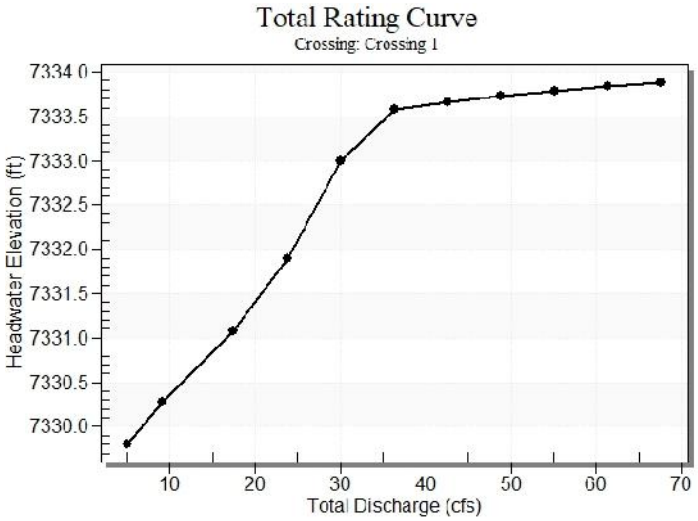


Table 2 - Culvert Summary Table: Culvert OA1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
5.00	5.00	7329.81	1.089	0.0*	1-S2n	0.675	0.783	0.682	0.268	5.274	2.638
9.20	9.20	7330.27	1.553	0.0*	1-S2n	0.948	1.081	0.953	0.379	6.238	3.225
17.52	17.52	7331.08	2.361	2.213	5-S2n	1.443	1.506	1.443	0.543	7.223	3.950
23.78	23.78	7331.90	3.180	3.085	7-M2c	2.000	1.728	1.728	0.641	8.240	4.333
30.04	30.04	7333.00	4.276	4.243	7-M2c	2.000	1.864	1.864	0.726	9.852	4.643
36.30	32.87	7333.58	4.859	4.816	7-M2c	2.000	1.896	1.896	0.803	10.675	4.906
42.56	33.26	7333.66	4.941	4.894	7-M2c	2.000	1.899	1.899	0.873	10.790	5.137
48.82	33.57	7333.73	5.008	4.958	7-M2c	2.000	1.911	1.911	0.937	10.854	5.341
55.08	33.82	7333.79	5.065	5.014	7-M2c	2.000	1.905	1.905	0.998	10.956	5.525
61.34	34.06	7333.84	5.118	5.064	7-M2c	2.000	1.917	1.917	1.054	10.999	5.696
67.60	34.28	7333.89	5.166	5.119	7-M2c	2.000	1.892	1.892	1.108	11.146	5.851

* Full Flow Headwater elevation is below inlet invert.

****

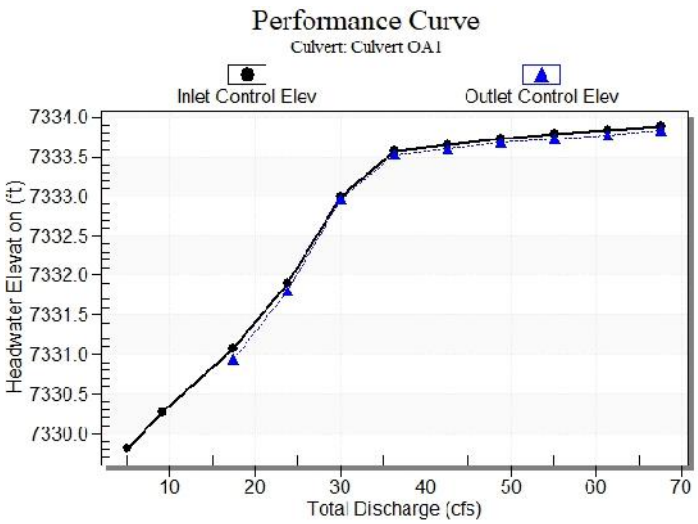
Straight Culvert

Inlet Elevation (invert): 7328.72 ft, Outlet Elevation (invert): 7328.23 ft

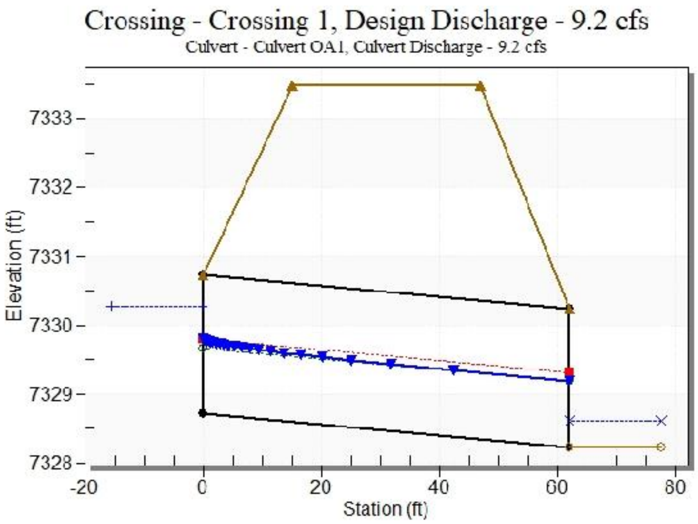
Culvert Length: 62.00 ft, Culvert Slope: 0.0079

****

Culvert Performance Curve Plot: Culvert OA1



Water Surface Profile Plot for Culvert: Culvert OA1



S

Inlet Station: 0.00 ft

Inlet Elevation: 7328.72 ft

Outlet Station: 62.00 ft

Outlet Elevation: 7328.23 ft

Number of Barrels: 1

Culvert Data Summary - Culvert OA1

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0130

Culvert Type: Straight

Inlet Configuration: Grooved End Projecting

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 1)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
5.00	7328.50	0.27	2.64	0.33	0.96
9.20	7328.61	0.38	3.23	0.47	1.01
17.52	7328.77	0.54	3.95	0.68	1.06
23.78	7328.87	0.64	4.33	0.80	1.09
30.04	7328.96	0.73	4.64	0.91	1.11
36.30	7329.03	0.80	4.91	1.00	1.12
42.56	7329.10	0.87	5.14	1.09	1.13
48.82	7329.17	0.94	5.34	1.17	1.14
55.08	7329.23	1.00	5.53	1.25	1.15
61.34	7329.28	1.05	5.70	1.32	1.16
67.60	7329.34	1.11	5.85	1.38	1.17

Tailwater Channel Data - Crossing 1

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 6.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 7328.23 ft

Roadway Data for Crossing: Crossing 1

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 7333.49 ft

Roadway Surface: Gravel

Roadway Top Width: 32.00 ft

Culvert OA1

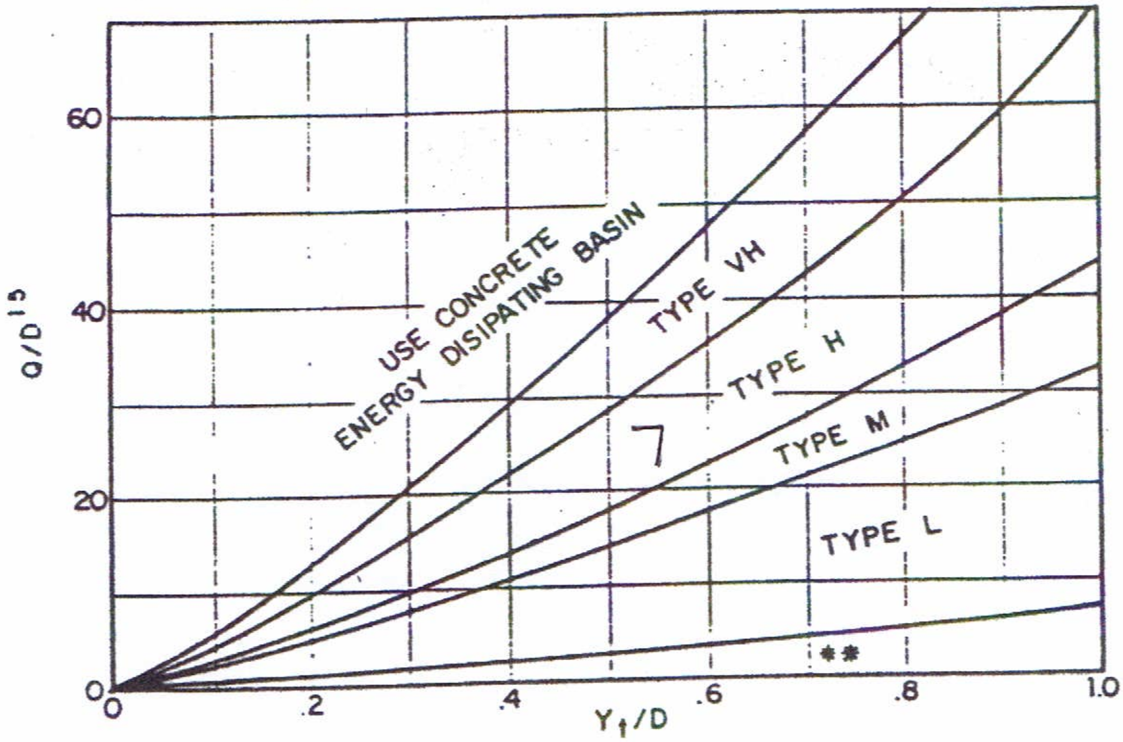
$Q_{100} = 67.6$ cfs

$\Delta = 24'' = 2.0$ ft

$$\frac{Q}{\Delta^{1.5}} = \frac{67.6}{(2)^{1.5}} = 23.9$$

$Y_t = 1.1$ ft (HY8)

$$\frac{Y_t}{\Delta} = \frac{1.1}{2.0} = 0.55$$



Use D_a instead of D whenever flow is supercritical in the barrel.

** Use Type L for a distance of 3D downstream.

→ Use Type H

FIGURE 5-7. RIPRAP EROSION PROTECTION AT CIRCULAR CONDUIT OUTLET.

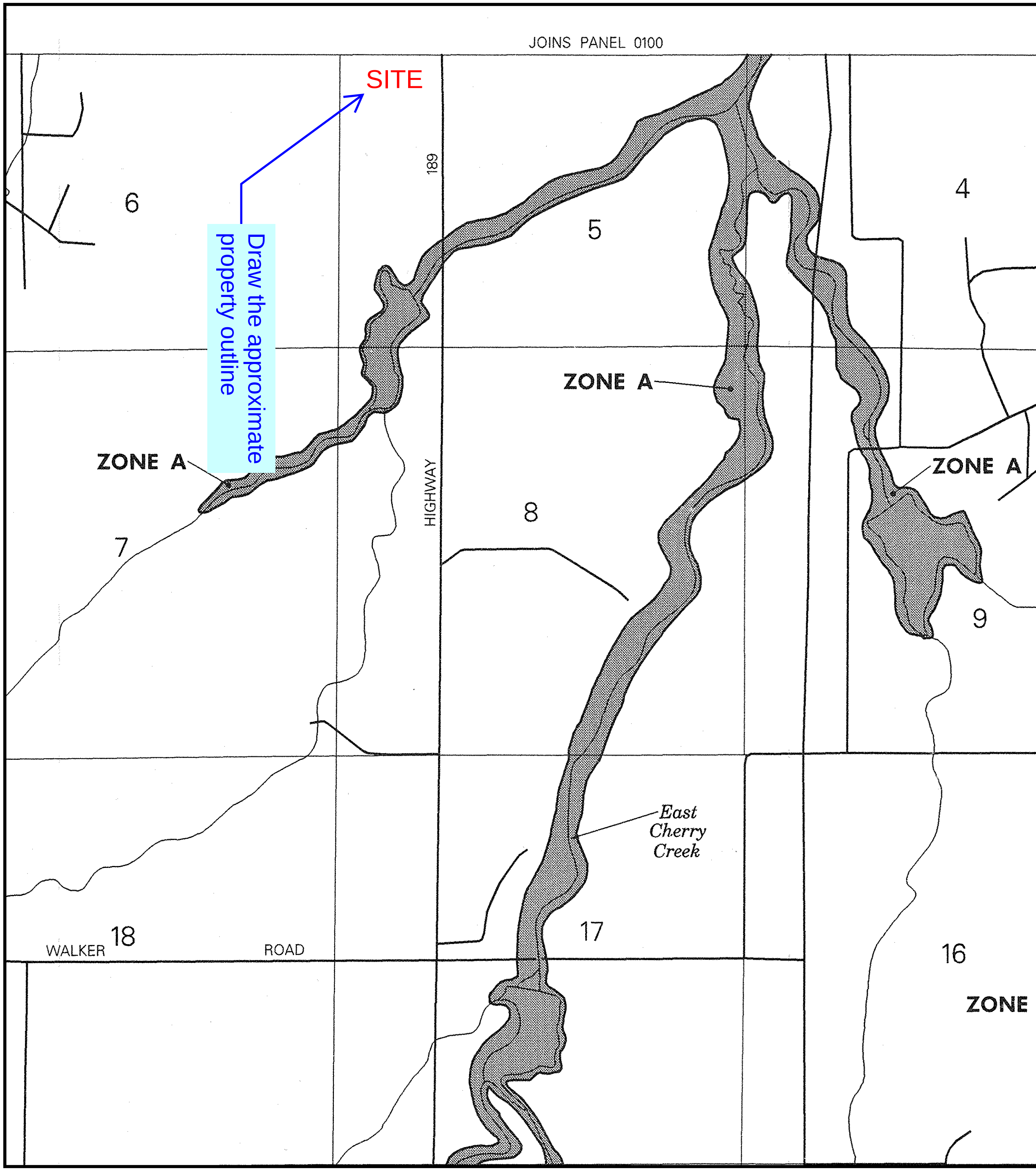
APPENDIX C

DRAINAGE COST ESTIMATE

HUDSON MINOR SUBDIVISION DRAINAGE IMPROVEMENTS COST ESTIMATE					
Item No.	Description	Quantity	Unit	Unit Cost ($$$)	Total Cost ($$$)
	PUBLIC DRAINAGE IMPROVEMENTS (NON-REIMBURSABLE)				
506	Riprap Culvert Aprons (d_{50} = 18")	7	CY	$98	$686
603	24" RCP Culvert w/ FES	62	LF	$84	$5,208
	SUBTOTAL				**$5,894**
	Contingency @ 15%				$884
	TOTAL				**$6,778**

APPENDIX D

FIGURES



APPROXIMATE SCALE IN FEET

2000 0 2000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY,
COLORADO AND
INCORPORATED AREAS

PANEL 325 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

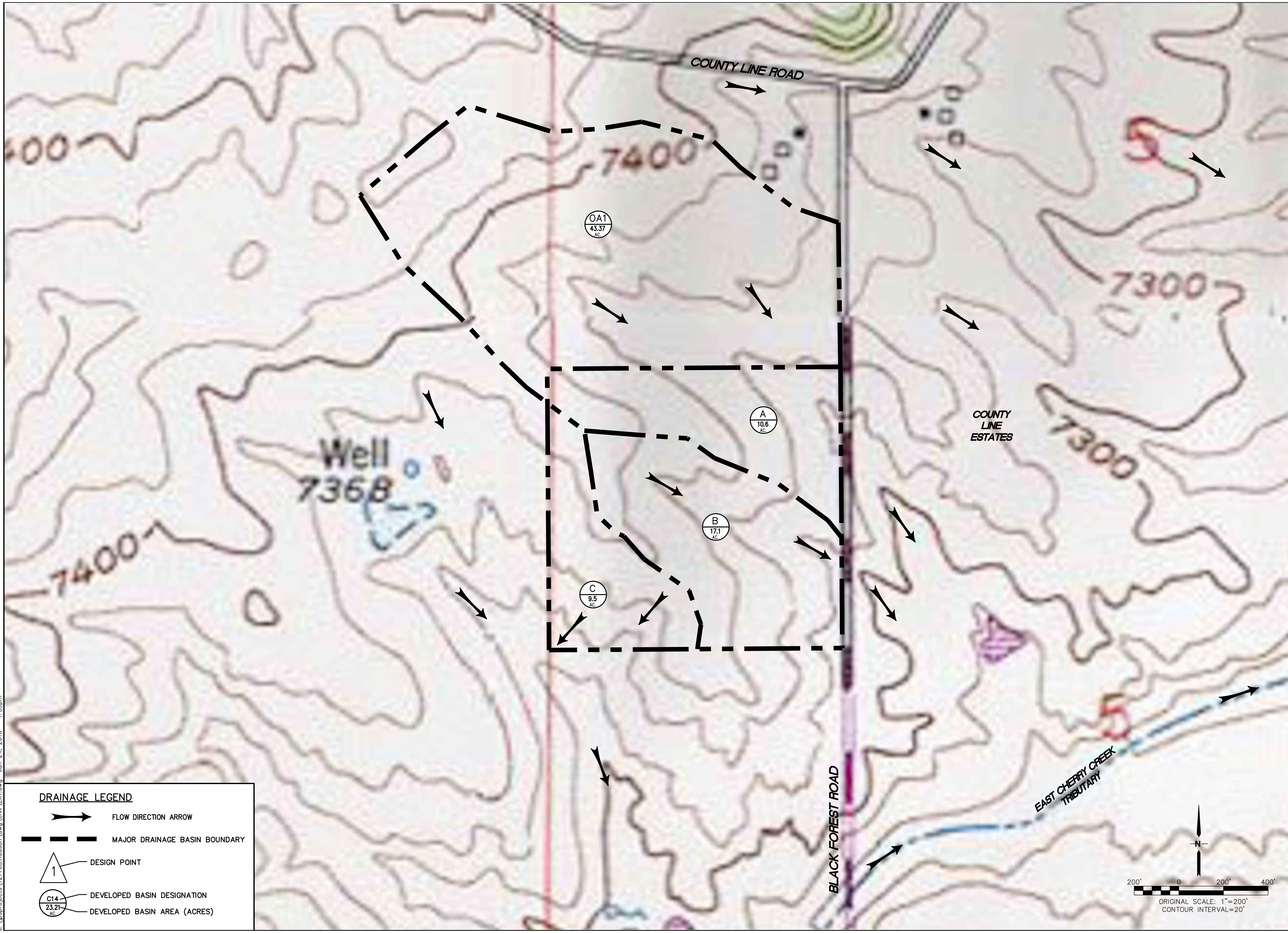
CONTAINS: COMMUNITY	NUMBER	PANEL	SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0325	F

MAP NUMBER
08041C0325 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

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



J:\jpsprojects\121703.hudson\dwg\civil\EX1.dwg Jan 24, 2018 - 1:39pm

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Colorado Springs, CO
80903

PH: 719-477-9429
FAX: 719-471-0766
www.jpsengr.com

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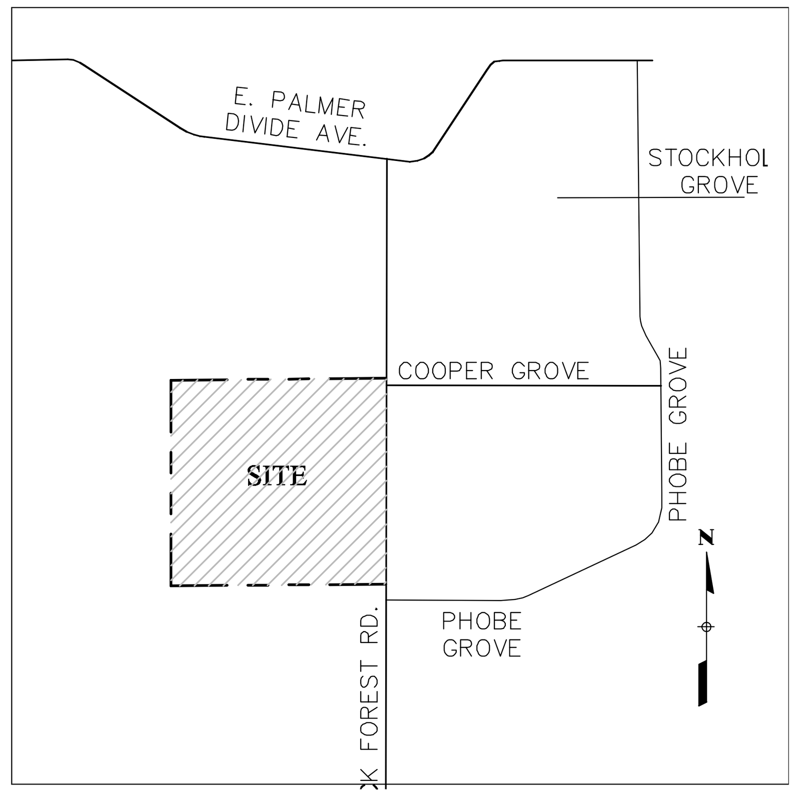
CALL 2-BUSINESS DAYS IN ADVANCE
BEFORE YOU DIG, GRADE, OR EXCAVATE
FOR THE MARKING OF UNDERGROUND
MEMBER UTILITIES.

No.	REVISION	BY	DATE

HUDSON MINOR SUBDIVISION

MAJOR BASIN/HISTORIC DRAINAGE PLAN

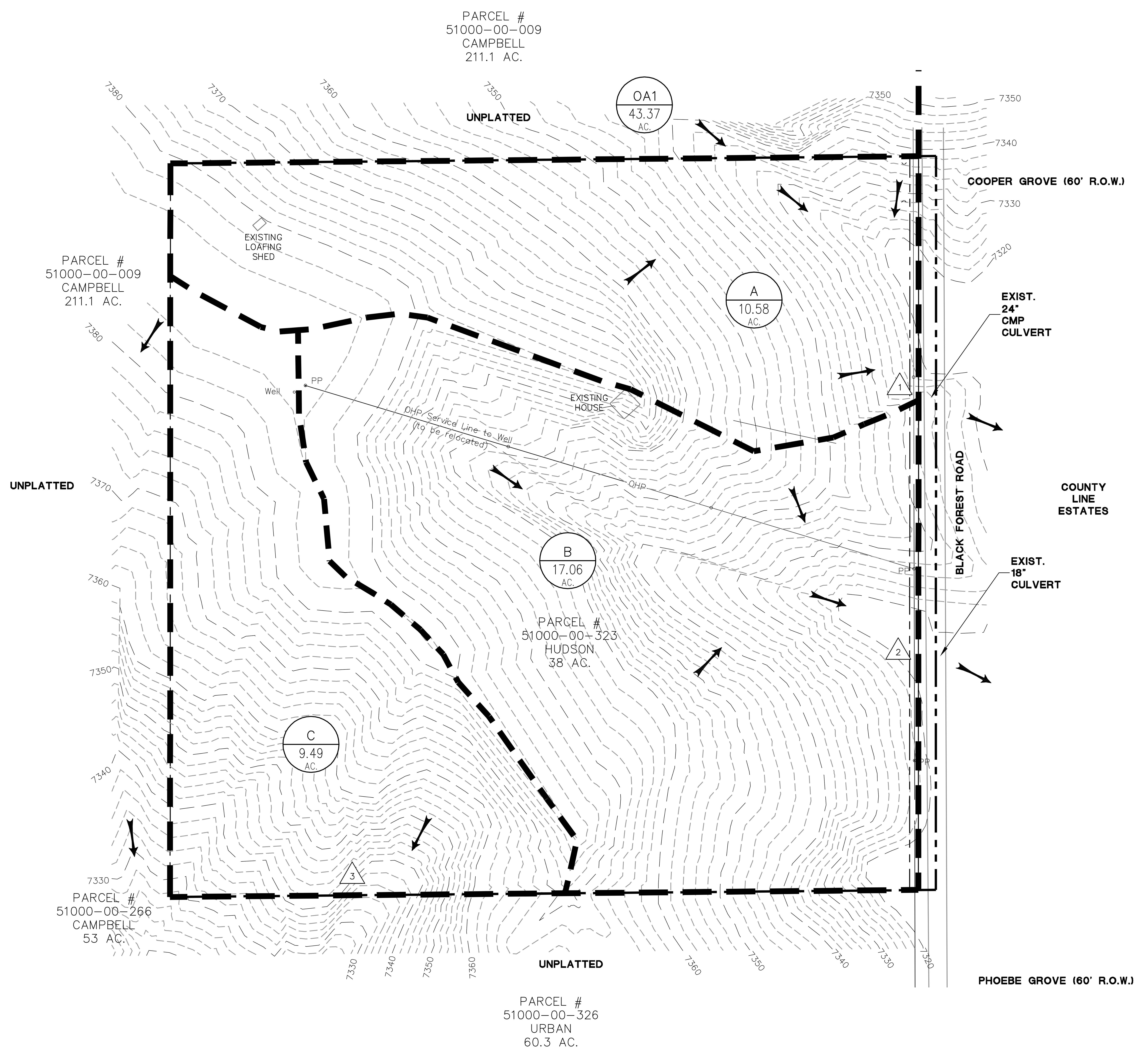
HORZ. SCALE:	1"=200'	DRAWN:	BJJ
VERT. SCALE:	N/A	DESIGNED:	JPS
SURVEYED:	USGS	CHECKED:	JPS
CREATED:	1/23/18	LAST MODIFIED:	1/24/18
PROJECT NO:	121703	MODIFIED BY:	BJJ
SHEET:	EX1		



VICINITY MAP
SCALE 1"=1000'

SUMMARY HYDROLOGY TABLE

DESIGN POINT	Q_5 (CFS)	Q_{100} (CFS)
1	11.0	80.9
2	4.2	30.6
3	2.5	18.5



LEGEND

- FILING LIMITS
- DRAINAGE BASIN BOUNDARY
- 6520 — EXISTING CONTOUR
- × 82.0 EXISTING SPOT ELEVATION (FLOWLINE)
- DRAINAGE CHANNEL
- FLOW DIRECTION ARROW
- 1 / 20.6 / 50.3 — DESIGN POINT; Q_5 (cfs); Q_{100} (cfs)
- A / 26.30 AC. — BASIN DESIGNATION; BASIN AREA (ACRES)

N

GRAPHIC SCALE
100 0 50 100 200
(IN FEET)
Original Scale
1 inch = 100 ft.
Contour Interval = 2 ft.

C:\Civil3D 2018 projects\121703.hudson\dwg\Drainage\EX2.dwg Mar 07, 2018 - 3:52pm

HUDSON MINOR SUBDIVISION

JPS ENGINEERING
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Colorado Springs, CO 80903
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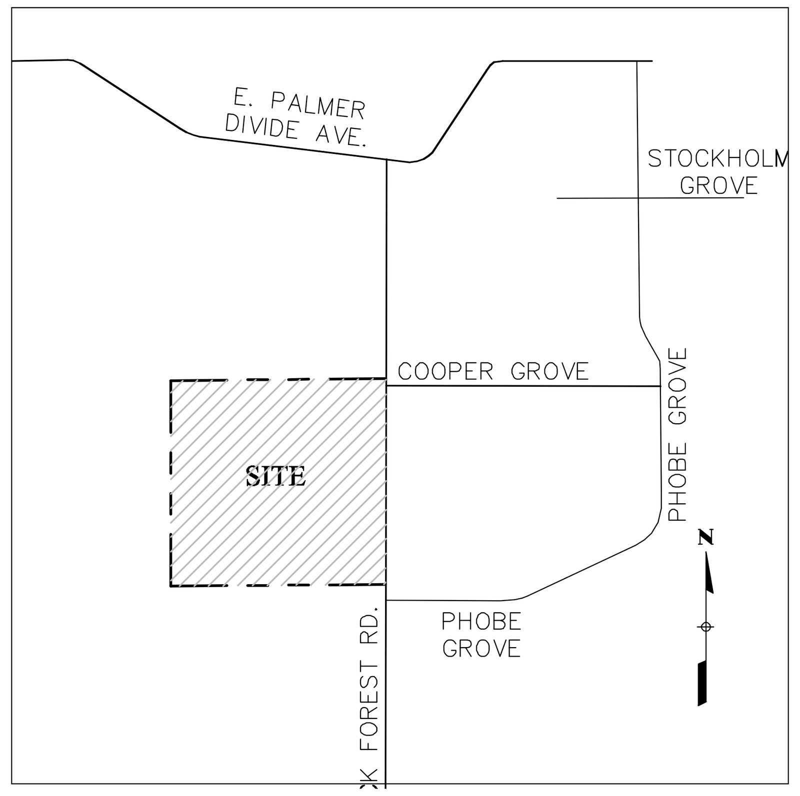
FAX: 719-471-0766

No.	REVISION	BY	DATE
1	COUNTY SUBMITTAL	JPS	3/8/18

HISTORIC DRAINAGE PLAN

HORZ. SCALE:	1" = 100'	DRAWN:	MSP
VERT. SCALE:	N/A	DESIGNED:	JPS
SURVEYED:	HANNIGAN	CHECKED:	JPS
CREATED:	01/08/18	LAST MODIFIED:	3/7/18
PROJECT NO:	121703	MODIFIED BY:	MSP

SHEET: EX2



VICINITY MAP
N.T.S.

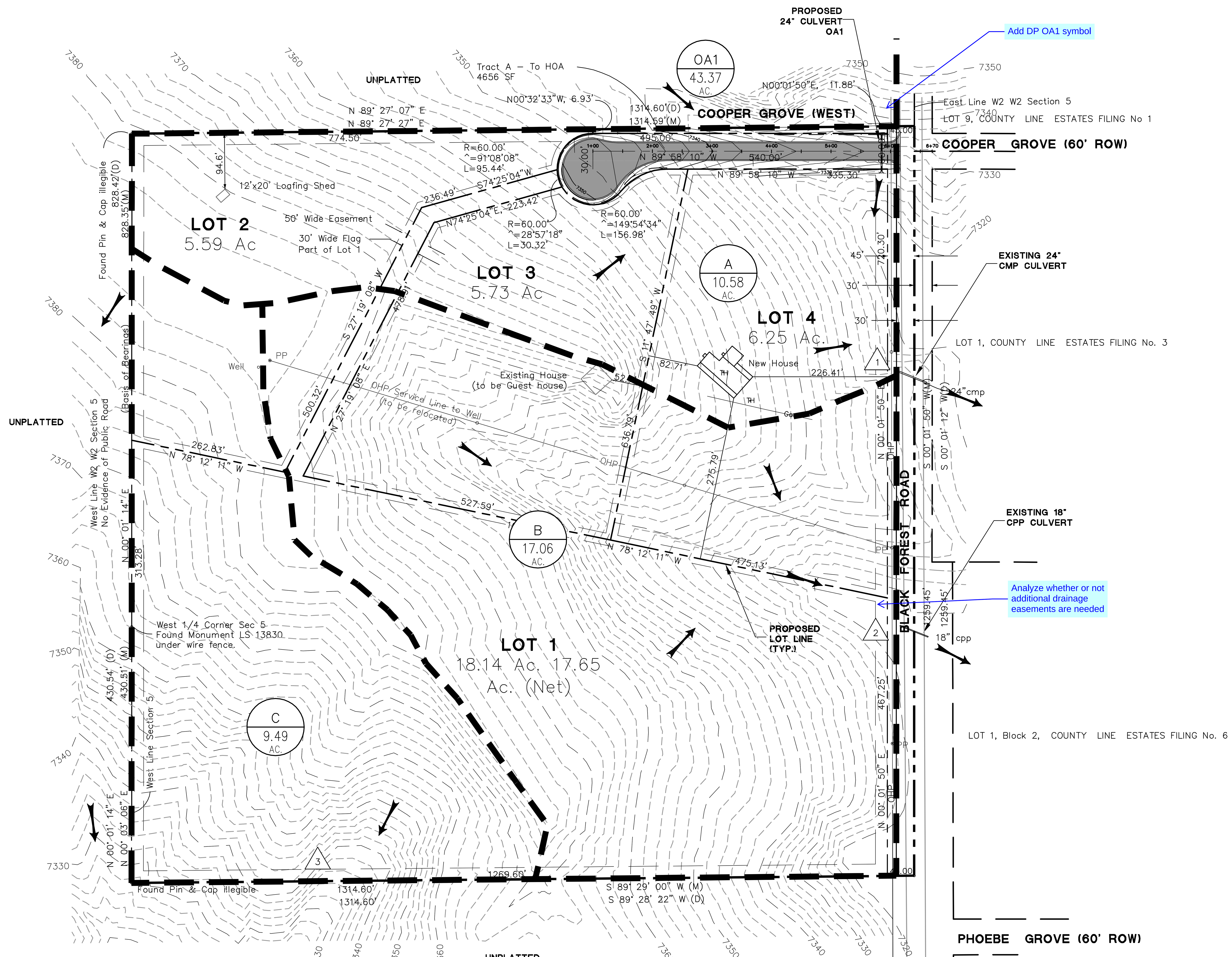
SUMMARY HYDROLOGY TABLE

DESIGN POINT	Q_5 (CFS)	Q_{100} (CFS)
1	12.5	82.8
2	5.1	31.9
3	3.5	20.0

Add DP OA1

LEGEND

- FILING LIMITS
- DRAINAGE BASIN BOUNDARY
- 6520 EXISTING CONTOUR
- 82.0 EXISTING SPOT ELEVATION (FLOWLINE)
- DRAINAGE CHANNEL
- FLOW DIRECTION ARROW
- 1 / 20.6 / 50.3 — DESIGN POINT, Q_5 (cfs), Q_{100}(cfs)
- A / 26.30 AC. — BASIN DESIGNATION, BASIN AREA (ACRES)



GRAPHIC SCALE
(IN FEET)
Original Scale
1 inch = 100 ft.
Contour Interval = 2 ft.

C:\Civil3D 2018 projects\121703.hudson\dwg\Drainage\D1.dwg Mar 07, 2018 – 3:12pm

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HUDSON MINOR SUBDIVISION

No.	REVISION	BY	DATE
1	COUNTY SUBMITTAL	JPS	3/8/18

DEVELOPED DRAINAGE CONDITIONS

HORZ. SCALE:	1" = 100'	DRAWN:	MSP
VERT. SCALE:	N/A	DESIGNED:	JPS
SURVEYED:	HANNIGAN	CHECKED:	JPS
CREATED:	01/08/18	LAST MODIFIED:	3/7/18
PROJECT NO:	121703	MODIFIED BY:	MSP
SHEET:	D1		

Markup Summary

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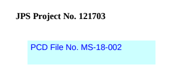

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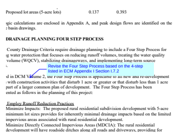
Author: dsdlaforce
Date: 4/19/2018 1:28:06 PM
Color:

PCD File No. MS-18-002

4/19/2018 2:51:30 PM (1)



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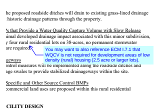
Page Label: 7
Author: dsdlaforce
Date: 4/19/2018 2:51:30 PM
Color:

Revise the Four Step Process based on the 4-step listed in ECM Appendix I Section I.7.2

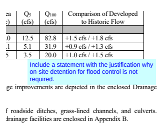
4/19/2018 3:26:20 PM (1)



Subject: Callout
Page Label: 8
Author: dsdlaforce
Date: 4/19/2018 3:26:20 PM
Color:

You may want to also reference ECM I.7.1 that WQCV is not required for development areas of low density (rural) housing (2.5 acre or larger lots).

4/19/2018 3:28:02 PM (1)



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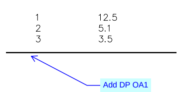
Page Label: 10
Author: dsdlaforce
Date: 4/19/2018 3:28:02 PM
Color:

Include a statement with the justification why on-site detention for flood control is not required.

4/19/2018 3:41:55 PM (1)



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Date: 4/19/2018 3:41:55 PM
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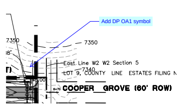
Add DP OA1

4/19/2018 3:42:34 PM (1)



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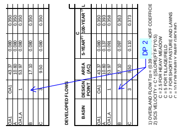
Color:

Add DP OA1 symbol

4/19/2018 3:43:42 PM (1)



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DP 2

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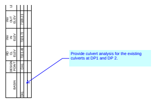

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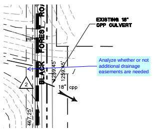
Page Label: 50
Author: dsdlaforce
Date: 4/19/2018 4:34:23 PM
Color:

Provide culvert analysis for the existing culverts at DP1 and DP 2.

4/19/2018 4:35:54 PM (1)



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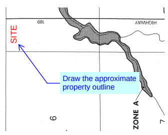
Date: 4/19/2018 4:35:54 PM
Color:

Analyze whether or not additional drainage easements are needed

4/19/2018 4:39:12 PM (1)



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Color:

Draw the approximate property outline

4/23/2018 5:53:01 PM (1)

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Author: dsdlaforce
Date: 4/23/2018 5:53:01 PM
Color:

Add a narrative regarding the major design storm (100-yr) conditions at the culverts at OA1, DP1 and DP2. From the results it appears that cross flow at OA1 in the major storm does not meet criteria (depth of flow exceeds 6" at the edge of road shoulder). See DCM Table 6-1