PRELIMINARY DRAINAGE REPORT

for

ABERT RANCH SUBDIVISION

Prepared for:

Hannigan and Associates, Inc.
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March 27, 2017
Revised November 16, 2017

Prepared by:

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JPS ENGINEERING

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EXECUTIVE SUMMARY

A. Background

- Abert Ranch is a proposed residential subdivision of a 40.4-acre parcel located northwest of Hodgen Road and Steppler Road in El Paso County.
- The proposed subdivision consists of 10 rural residential lots with 2.5-acre minimum lot sizes.
- Abert Ranch is located within the East Cherry Creek Drainage Basin, which comprises a total drainage area in excess of 30 square miles. The Abert Ranch property represents less than 0.2 percent of the total basin area.

B. General Drainage Concept

- Developed drainage within the site will be conveyed along paved streets with roadside ditches and culverts, as well as grass-lined channels through drainage easements, following historic drainage patterns.
- Developed flows from the subdivision will be detained to historic levels through an on-site private stock pond, which will be upgraded to serve as a stormwater detention pond.
- Subdivision drainage improvements will be designed and constructed to meet El Paso County standards,

C. Drainage Impacts

- The proposed detention pond will detain to historic flows at the downstream property boundary, ensuring no significant adverse developed drainage impact on downstream properties.
- Drainage facilities within public road rights-of-way will be dedicated to the County for maintenance. The proposed stormwater detention pond will be maintained by the subdivision HOA.

DRAINAGE STATEMENT

Engineer's Statement:

Resolved
01/23/2018

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:

____

Resolved
01/23/2018

Printed Name: Eric Leffler Date
BF Ranch Trust 2015
11730 Timberlane Court, 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:

FLOODPLAIN STATEMENT

To the best of my knowledge and belief, no parts of the Abert Ranch Subdivision are located in a FEMA designated floodplain, as shown on FIRM panel No. 08041C0325F, dated March 17, 1997.

____

John P. Schwab, P.E. #29891

I. GENERAL LOCATION AND DESCRIPTION

A. Background

Abert Ranch is a proposed rural residential subdivision located in northeastern El Paso County, Colorado. The Abert Ranch parcel (El Paso County Assessor's Number 61000-00-464) is located between Grandview Subdivision and Settlers Ranch Subdivision, west of Steppler Road, as shown in Figure A1 (Appendix E). Abert Ranch Subdivision will consist of 10 low-density residential lots (2.5-acre minimum size) on a 40.4-acre parcel.

B. Scope

This report is intended to fulfill the El Paso County requirements for a Preliminary Drainage Report (PDR) for submittal with the Preliminary Plan 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 PDR 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 Abert Ranch parcel is located in the Northeast Quarter of Section 24 and the Northwest Quarter of Section 23, Township 11 South, Range 66 West of the 6th Principal Meridian. The site is currently a vacant meadow tract. The property is currently zoned RR-5 (Rural Residential; 5-acre minimum lots), and the proposed subdivision will include re-zoning the property to RR-2.5 (Rural Residential; 2.5-acre minimum lots). The proposed low-density lots will be served by individual wells and septic systems.

The north boundary of the property borders the existing Grandview Subdivision, and the south boundary of the property adjoins the approved Settlers Ranch Subdivision, both of which consist primarily of 2.5-acre lots. The west boundary of the property borders an undeveloped 40-acre ranch property, which is currently in the process of Re-zoning and Preliminary Plat approval for the proposed Settlers View Subdivision, with 2.5-acre minimum lots.

Access to the Abert Ranch Subdivision will be provided by extension of Silver Nell Drive southeasterly through the adjoining Settlers View Subdivision, along with construction of the proposed Abert Ranch Drive extending north and east through the new subdivision. Abert Ranch Drive will connect to Settlers Ranch Drive as Settlers Ranch Filing No. 2 develops to the south.

Subdivision infrastructure improvements will include paving of new public roadways through the site, as well as grading, drainage, and utility service improvements for the proposed residential lots. Local roads will be classified as rural minor residential roads, with 60-feet rights-of-way and paved widths of 28-feet.

Ground elevations within the parcel range from a low point of approximately 7,540 feet above mean sea level at the east boundary of the parcel, to a high point of 7,650 feet near the southwest corner of the property.

This site is located in the East Cherry Creek drainage basin. Surface drainage from the property flows easterly 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 Soil Conservation Service, on-site soils are comprised primarily of the following soil types (see Appendix A):

- Type 67 – "Peyton sandy loam": 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.

JPS Engineering, Inc., "Final Drainage Report for Grandview Subdivision," September 7, 2007 (approved by El Paso County 9/14/07).

JPS Engineering, Inc., "Master Development Drainage Plan (MDDP) and Preliminary Drainage Report for Walden Preserve Subdivision," December 10, 2004 (approved by El Paso County 12/20/04).

JPS Engineering, Inc., "Final Drainage Report for Settlers Ranch Subdivision Filing No. 1," October 18, 2005 (approved by El Paso County 10/19/05).

JPS Engineering, Inc., "Final Drainage Report for Settlers Ranch Subdivision Filing No. 2," May 30, 2008 (approved by El Paso County 3/31/09).

JPS Engineering, Inc., "Final Drainage Report for Settlers View Subdivision," February 17, 2017.

JPS Engineering, Inc., "Final Drainage Report for Walden Pines Subdivision," March 24, 2004.

JPS Engineering, Inc., "Final Drainage Report for Walden Preserve Subdivision Filing No. 1," May 11, 2005.

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 easterly to a tributary of East Cherry Creek, which flows to a confluence with the main channel north of Walker Road. Downstream agricultural areas generally drain northerly towards the main channel of East Cherry Creek.

No drainage planning study has been completed for this drainage basin or any adjacent drainage basins. In the absence of plans for regional drainage facilities, El Paso County generally requires new developments to provide stormwater detention to maintain historic runoff flows leaving developed areas.

The major drainage basins lying in and around the proposed development are depicted in Figure EX1. The Abert Ranch parcel is located near the southerly limit of the East Cherry Creek Drainage Basin, which comprises a total drainage area in excess of 30 square miles. The proposed 40-acre Abert Ranch 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 several sub-basins draining to design points at the north and east and west boundaries of the site.

The developed drainage basins lying within the proposed development are depicted on Figure D1. The developed site layout has been divided into sub-basins based on the proposed road layout within the site. 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. Previous drainage reports for completed subdivision filings have proposed to provide on-site detention for mitigation of developed flows.

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 (2.5-acre lots)	0.17	0.417
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.

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:

Step 1: Employ Runoff Reduction Practices

- Minimize Impacts: The proposed rural residential subdivision development with 2.5-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, 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 and proposed grass-lined drainage swales following historic drainage patterns through the property.

Step 2: Stabilize Drainageways

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

Step 3: Provide Water Quality Capture Volume (WQCV)

- FSD: An existing Stock Pond near the east boundary of the site will be upgraded to serve as a Full-Spectrum Detention Pond. On-site drainage will be routed through the extended detention basin, which will capture and slowly release the WQCV over a 40-hour design release period.

Step 4: Consider Need for Industrial and Commercial BMPs

- No industrial or commercial land uses are proposed within this rural residential subdivision.
- On-site drainage will be routed through the private Full-Spectrum Detention (FSD) basin to minimize introduction of contaminants to the County's public drainage system.

V. DRAINAGE FACILITY DESIGN

A. General Concept

Development of the Abert Ranch Subdivision will require site grading and paving, resulting in additional impervious areas across the site. The general drainage pattern will consist of grading away from home sites to swales and roadside ditches along the internal roads within the subdivision, 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 Abert Ranch development 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.

An existing stock pond near the east boundary of the subdivision will be upgraded to serve as a stormwater detention pond to mitigate the impact of developed flows and maintain historic peak flows downstream of the property.

B. Specific Details

1. Existing Drainage Conditions

Historic drainage conditions within the site are depicted in Figure EX1. The on-site area has been identified as Basin I, which is impacted by upstream off-site drainage basins to the north, west, and south.

Basin OI1 is the off-site area to the north within the existing Grandview Subdivision. Basin A is the off-site area to the west within the proposed Settlers View Subdivision. Basins D11 and D12 are the off-site areas to the south within the proposed Settlers Ranch Subdivision.

Off-site flows from Basins OI1, A, D11, and D12 enter the Abert Ranch property and drain easterly in an existing grass-lined drainage channel, flowing through an existing stock pond, and ultimately crossing Steppler Road in an existing 48-inch RCP culvert at the eastern site boundary.

Flows from Basins OI1, A, D11, D12, and I combine at Design Pont #I, with historic peak flows calculated as Q_5 = 13.9 cfs and Q_{100} = 102.2 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, B, and C represent developed basins within the adjoining Settlers View Subdivision, and these basins will continue to sheet flow easterly through the proposed Abert Ranch Subdivision.

Basin C will flow easterly along the south side of Silver Nell Drive, combining with Basin E at Design Point #E, with developed peak flows calculated as Q_5 = 2.5 cfs and Q_{100} = 10.2 cfs. An 18-inch RCP culvert will convey flows at Design Point #E northerly across Silver Nell Drive on the west side of Abert Ranch Drive.

Basins G, D11, and H will flow northeasterly to the low point in the roadway profile at Design Point #H, combining with upstream flows from DP-F, with total developed peak flows calculated as Q_5 = 14.6 cfs and Q_{100} = 64.4 cfs. A 30-inch RCP culvert will convey flows from Design Point #H northerly across Abert Ranch Drive.

Basins A, D12, OI1, and I combine with flows from DP-H at Design Point #I, with total developed peak flows calculated as Q_5 = 32.8 cfs and Q_{100} = 147.9 cfs.

The existing stock pond within Basin I near the eastern site boundary will be upgraded to serve as "Detention Pond I," mitigating the impact of developed flows from the subdivision. This pond will reduce flows to historic levels prior to discharging to the existing natural drainage swale downstream.

C. Comparison of Developed to Historic Discharges

Based on the hydrologic calculations in Appendix A, the proposed development will result in calculated flows exceeding historic flows from the parcel. The increase in developed flows will be mitigated through on-site stormwater detention facilities. 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 (Q_5%/Q_{100}%)
	Area (ac)	Q_5 (cfs)	Q_{100} (cfs)	Area (ac)	Q_5 (cfs)	Q_{100} (cfs)	
I	95.1	13.9	102.2	95.1	32.8	147.9	236% / 145% (increase)

D. Detention Ponds

The Developed storm runoff downstream of the proposed subdivision will be maintained at historic levels by routing flows through the proposed detention pond at the east boundary of the property. Pond #I will be upgraded to serve as a Full-Spectrum Detention (FSD) Pond to mitigate developed flow impacts from the proposed subdivision. The pond outlet structure has been designed with multiple orifice openings to detain the full spectrum of storm events.

A geotechnical analysis will be performed to confirm the structural stability of the existing pond embankment, and any applicable geotechnical recommendations will be implemented in conjunction with upgrade of the existing pond.

Detailed pond routing calculations have been performed utilizing the Denver Urban Drainage "UD-Detention" software package (see Appendix C). The pond outlet structure configuration has been designed to maintain the calculated pond discharge below the target outflow, while maintaining the maximum water surface elevation below the pond spillway. Detention pond design parameters are summarized as follows:

Pond	Volume (ac-ft)	Outlet Structure
Pond #I	3.3	42-inch RCP w/ orifice plates

The pond spillway will safely convey emergency overflows from the pond northeasterly through a dedicated drainage easement to the existing downstream culvert crossing Steppler Road. The existing downstream culvert is a 48-inch RCP that was installed within the last ten years. The existing culvert has a capacity of approximately 165 cfs (see Appendix B), which is adequate to convey 100-year flows without overtopping Steppler Road.

A 15-foot wide gravel maintenance access road will be provided for the stormwater detention facilities. The proposed detention pond will be privately owned and maintained by the subdivision homeowners association (HOA).

E. On-Site Drainage Facility Design

Developed sub-basins and proposed drainage improvements are depicted in the enclosed Drainage Plan (Sheet D1). In accordance with El Paso County standards, new roadways will be graded with a minimum longitudinal slope of 1.0 percent. The typical local road section will consist of a 28-foot paved width with 2-foot gravel shoulders and 4:1 slopes to 2.5-foot ditches.

On-site drainage facilities will consist of roadside ditches, grass-lined channels, and culverts. Hydraulic calculations for preliminary sizing of major on-site drainage facilities are enclosed in Appendix B, and design criteria are summarized as follows:

1. Culverts

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 D1. Riprap outlet protection will be provided at all culverts.

2. Open Channels

Drainage easements will be dedicated along major drainage channels following historic drainage paths through the subdivision. These channels will generally be grass-lined channels designed to convey 100-year flows, with a trapezoidal cross-section, variable bottom width and depth, 4:1 maximum side slopes, 1-foot freeboard, and a minimum slope of 0.5 percent.

The proposed drainage channels 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, ditch checks, and/or riprap channel lining 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. Detailed channel hydraulic calculations are enclosed in Appendix B.

Primary drainage swales crossing proposed lots have been placed in drainage easements, with variable widths based on the required channel sections.

F. Anticipated Drainage Problems and Solutions

The proposed stormwater Detention Pond I has been designed to mitigate the impacts of developed drainage from this project. 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, culverts, and detention pond facilities. 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, ditch checks, and riprap channel lining will be installed where necessary to minimize erosion concerns. Proper construction and maintenance of the proposed detention facilities will minimize downstream drainage impacts. Public roadway improvements and ditches within the public right-of-way will be owned and maintained by El Paso County. The proposed stormwater detention pond and drainage channels located within open space tracts will be owned and maintained by the subdivision HOA.

VI. EROSION / SEDIMENT CONTROL

The Contractor will be required to implement 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 hay 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. The proposed detention pond will serve as a sediment basin during the construction phase of the project.

VII. COST ESTIMATE AND DRAINAGE FEES

A cost estimate for proposed drainage improvements is enclosed in Appendix D, with a total estimated cost of approximately $54,620 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. Private drainage facilities will be owned and maintained by the subdivision HOA.

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

Abert Ranch is a proposed residential subdivision consisting of 10 lots on a 40.4-acre parcel located between Grandview Subdivision and Settlers Ranch Subdivision on the west side of Steppler Road in northeastern El Paso County. Development of the proposed Abert Ranch Subdivision will generate an increase in developed runoff from the site, which will be mitigated through construction of on-site stormwater detention facilities. The proposed drainage patterns will remain consistent with historic conditions, and new drainage facilities constructed to El Paso County standards will safely convey runoff to suitable outfalls. Based on the on-site stormwater detention concept, no new downstream drainage facilities are proposed.

The proposed detention pond will ensure that overall developed flows from the Abert Ranch Subdivision remain consistent with historic levels. Construction and proper maintenance of the proposed drainage and erosion control facilities will ensure that this subdivision has no significant adverse drainage impact on downstream or surrounding areas.

APPENDIX A

HYDROLOGIC CALCULATIONS

United States Department of Agriculture

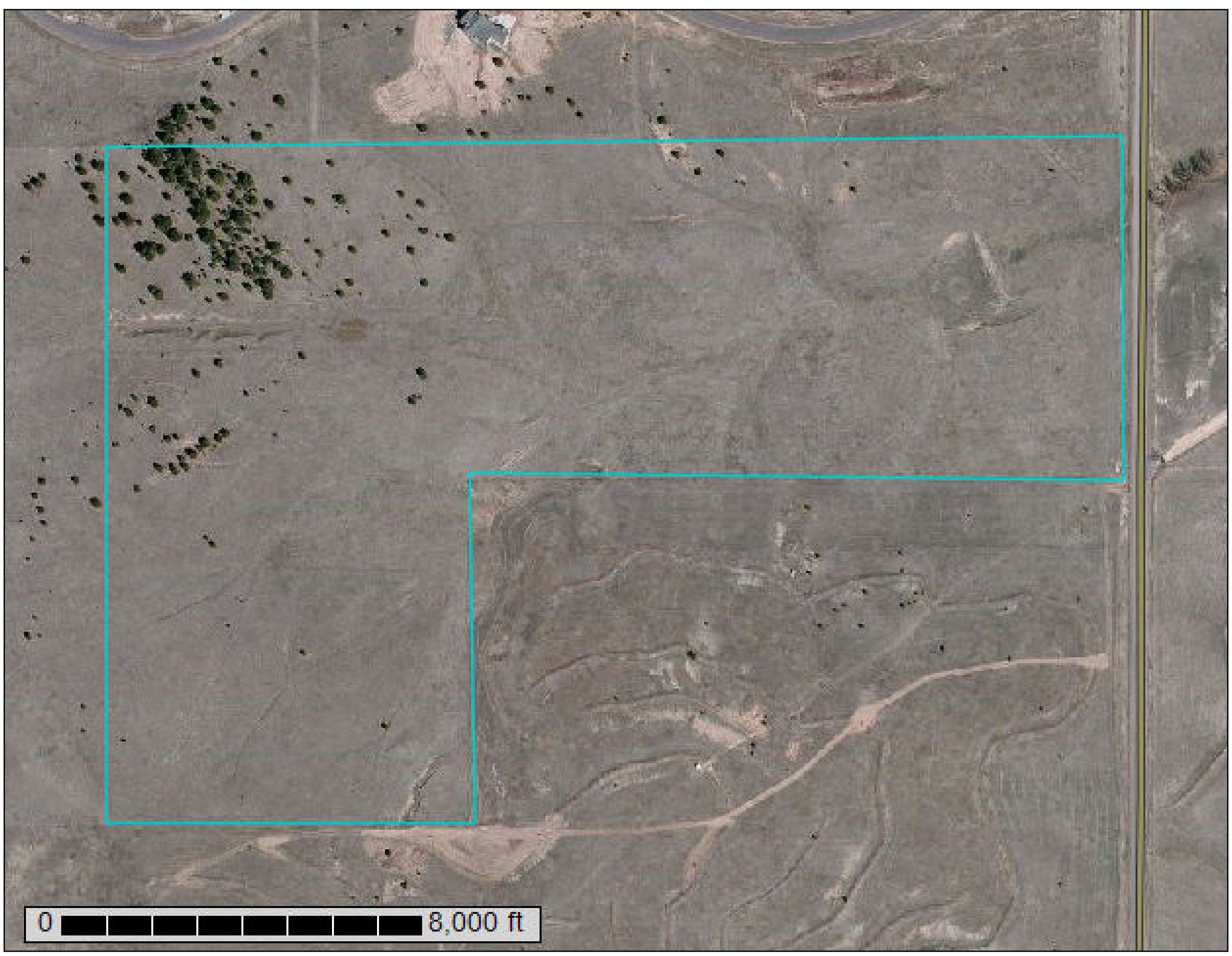
NRCS

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



December 23, 2016

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.

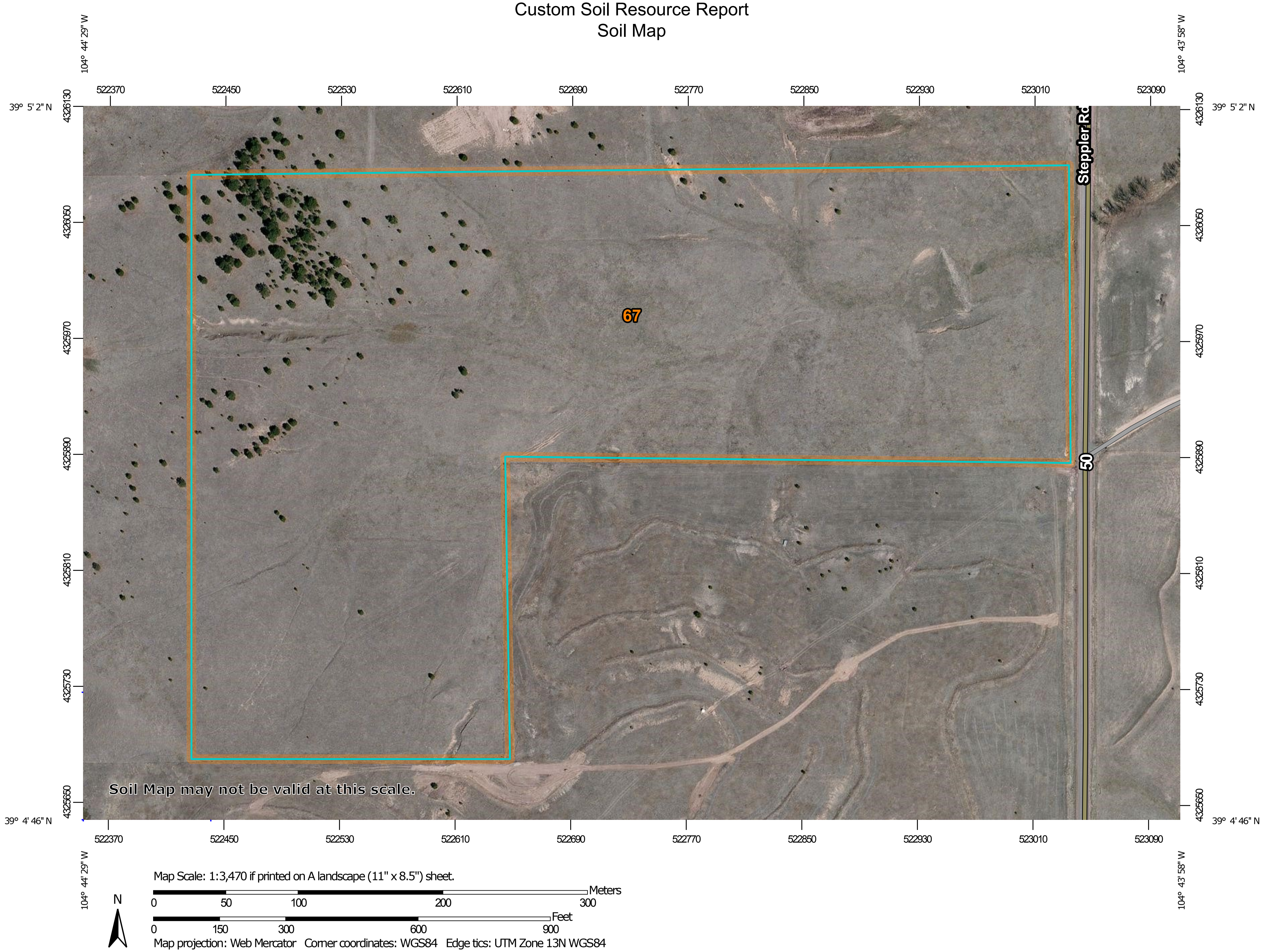
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree 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: 1:3,470 if printed on A landscape (11" x 8.5") sheet.

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 14, Sep 23, 2016

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

Date(s) aerial images were photographed: Apr 15, 2011—Sep 22, 2011

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

El Paso County Area, Colorado (CO625)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
67	Peyton sandy loam, 5 to 9 percent slopes	41.4	100.0%
Totals for Area of Interest		**41.4**	**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

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

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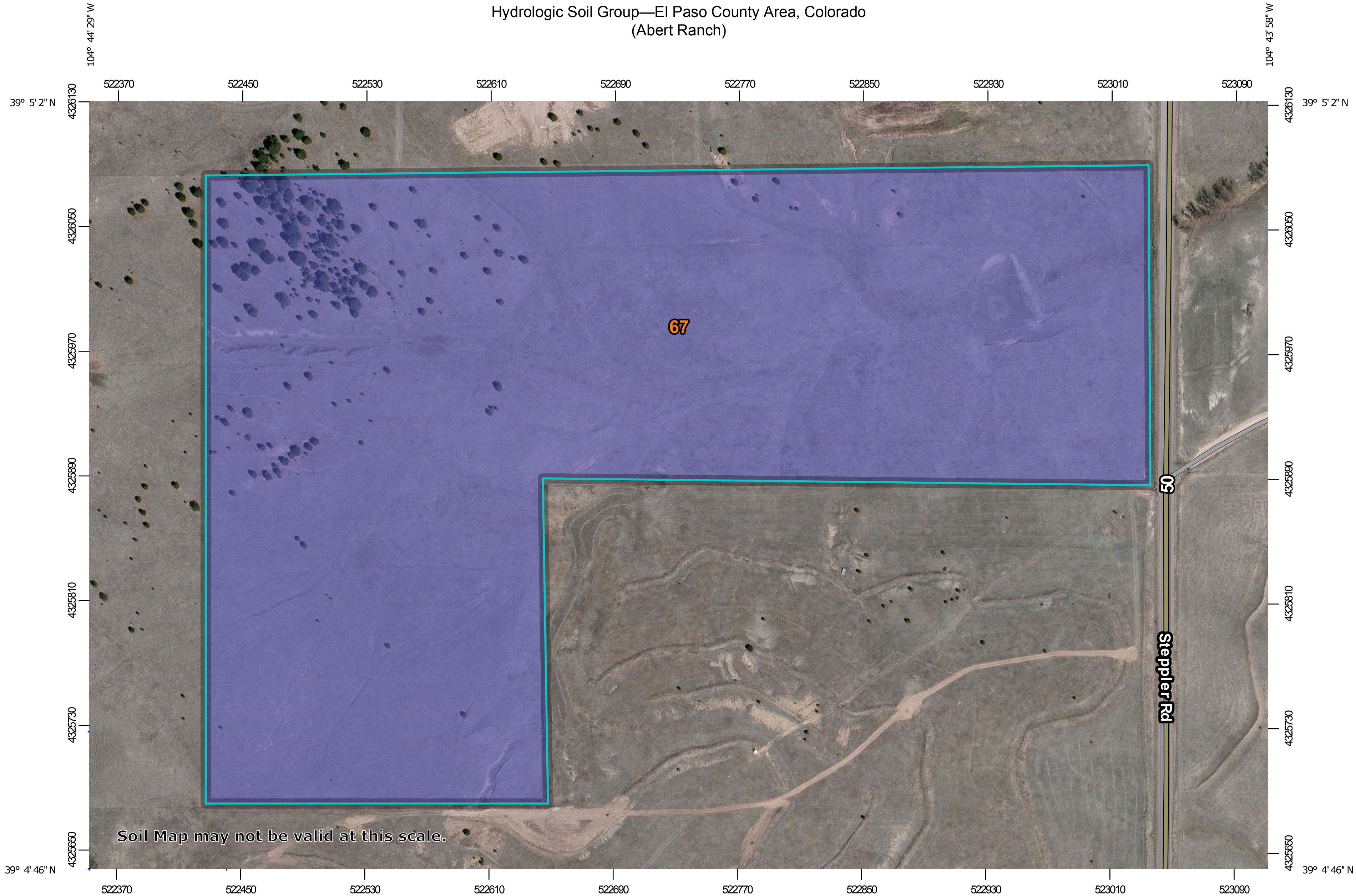
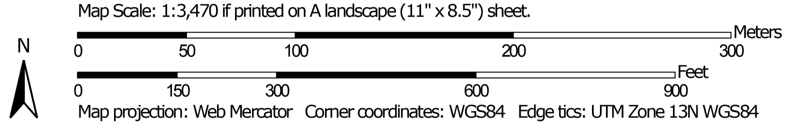
Hydrologic Soil Group—El Paso County Area, Colorado
(Abert Ranch)



Map Scale: 1:3,470 if printed on A landscape (11" x 8.5") sheet.



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 14, Sep 23, 2016

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

Date(s) aerial images were photographed: Apr 15, 2011—Sep 22, 2011

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

Hydrologic Soil Group— Summary by Map Unit — El Paso County Area, Colorado (CO625)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
67	Peyton sandy loam, 5 to 9 percent slopes	B	41.4	100.0%
Totals for Area of Interest			**41.4**	**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

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.

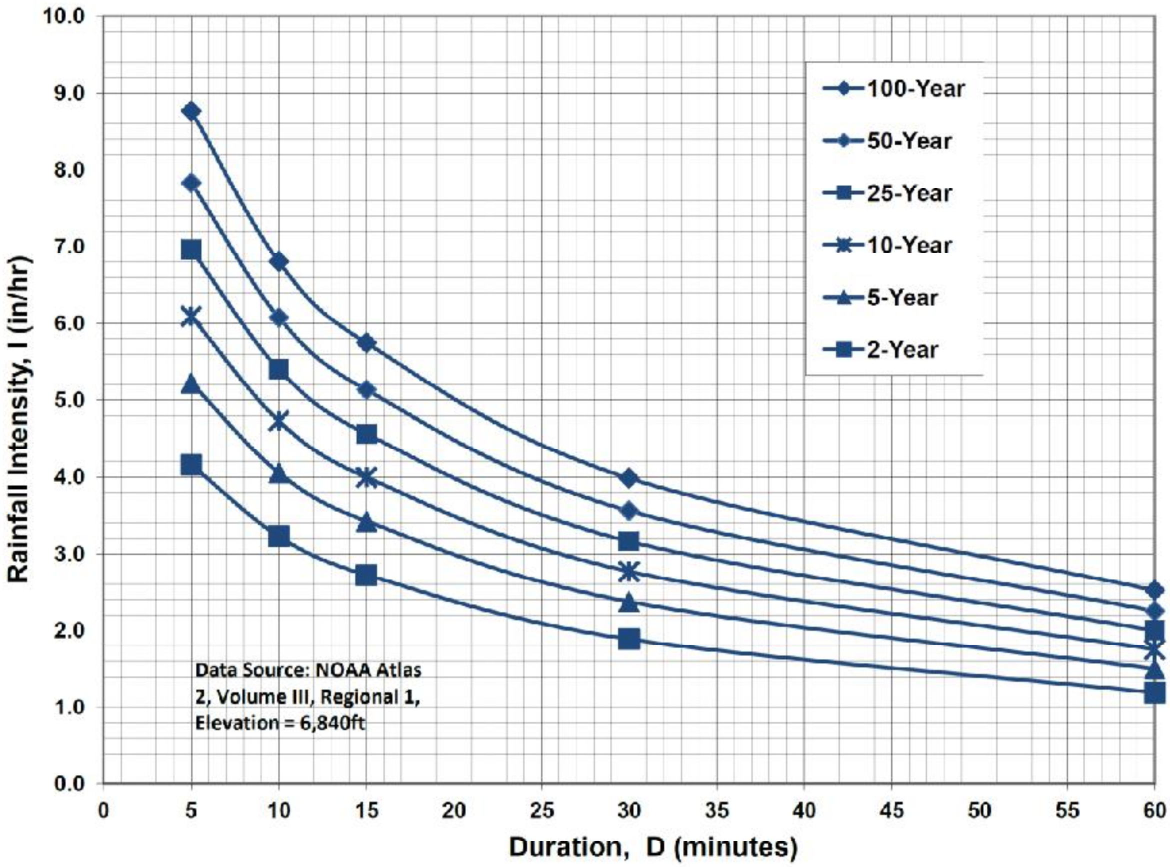
3.2.4 Minimum Time of Concentration

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.

ABERT RANCH
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)
A (SETTLERS VIEW)	A	14.95	0.080	0.350	750	0.048	30.3	0				0.0	30.3	30.3	2.46	4.14	2.95	21.64
D11 (SETT. RANCH)	D11	15.60	0.080	0.350	300	0.037	20.9	1100	15.00	0.072	4.02	4.6	25.5	25.5	2.73	4.58	3.40	24.99
D12 (SETT. RANCH)	D12	11.00	0.080	0.350	300	0.040	20.4	450	15.00	0.089	4.47	1.7	22.1	22.1	2.94	4.94	2.59	19.01
OI1 (GRANDVIEW)	OI1	13.12	0.080	0.350	300	0.020	25.7	1750	15.00	0.042	3.07	9.5	35.2	35.2	2.24	3.76	2.35	17.28
I		40.46	0.080	0.350	0		0.0	1300	15.00	0.0338	2.76	7.9	7.9	7.9	4.49	7.54		
A,D11,D12,OI1, I	I	95.13	0.080	0.350									46.3	46.3	1.83	3.07	13.92	102.18

1) OVERLAND FLOW Tco = (0.395*(1.1-RUNOFF 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

ABERT RANCH 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
2.5-ACRE LOTS	2.50	11.00	BUILDING / PAVEMENT	0.90	89.00	LANDSCAPED	0.08				0.170
5-ACRE LOTS	2.50	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
2.5-ACRE LOTS	2.50	11.00	BUILDING / PAVEMENT	0.96	89.00	LANDSCAPED	0.35				0.417
5-ACRE LOTS	2.50	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
2.5-ACRE LOTS	2.50	11.00	BUILDING / PAVEMENT	100	89.00	LANDSCAPED	0				11.000
5-ACRE LOTS	2.50	7.00	BUILDING / PAVEMENT	100	93.00	LANDSCAPED	0				7.000

ABERT RANCH SUBDIVISION
COMPOSITE RUNOFF COEFFICIENTS

DEVELOPED CONDITIONS

5-YEAR C VALUES

BASIN	TOTAL AREA (AC)	(AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	(AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
C	1.28	1.28	2.5-AC LOTS	0.17							0.170
E	3.12	3.12	2.5-AC LOTS	0.17							0.170
C,E	4.40										0.170
B	2.93	2.93	2.5-AC LOTS	0.17							0.170
F	3.78	3.78	2.5-AC LOTS	0.17							0.170
C,E,B,F	11.11										0.170
G	2.27	2.27	2.5-AC LOTS	0.17							0.170
D11	15.60	15.60	5-AC LOTS	0.137							0.137
H	5.69	5.69	2.5-AC LOTS	0.17							0.170
DPF,G,D11,H	34.67										0.155
A	10.74	10.74	2.5-AC LOTS	0.17							0.170
D12	11.00	11.00	5-AC LOTS	0.137							0.137
OI1	13.12	13.12	5-AC LOTS	0.137							0.137
I	25.60	16.60	5-AC LOTS	0.137	9.00	2.5-AC LOTS	0.17				0.149
DPH,D12,OI1,I	95.13										0.150

100-YEAR C VALUES

BASIN	TOTAL AREA (AC)	(AC)	SUB-AREA 1 DEVELOPMENT/ COVER	C	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	C	(AC)	SUB-AREA 3 DEVELOPMENT/ COVER	C	WEIGHTED C VALUE
C	1.28	1.28	2.5-AC LOTS	0.417							0.417
E	3.12	3.12	2.5-AC LOTS	0.417							0.417
C,E	4.40										0.417
B	2.93	2.93	2.5-AC LOTS	0.417							0.417
F	3.78	3.78	2.5-AC LOTS	0.417							0.417
C,E,B,F	11.11										0.417
G	2.27	2.27	2.5-AC LOTS	0.417							0.417
D11	15.60	15.60	5-AC LOTS	0.393							0.393
H	5.69	5.69	2.5-AC LOTS	0.417							0.417
DPF,G,D11,H	34.67										0.406
A	10.74	10.74	2.5-AC LOTS	0.417							0.417
D12	11.00	11.00	5-AC LOTS	0.393							0.393
OI1	13.12	13.12	5-AC LOTS	0.393							0.393
I	25.60	16.60	5-AC LOTS	0.393	9.00	2.5-AC LOTS	0.417				0.401
DPH,D12,OI1,I	95.13										0.403

ABERT RANCH SUBDIVISION
RATIONAL METHOD

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)
EAST CHERRY CREEK BASIN																		
C	C	1.28	0.170	0.417	300	0.067	15.7	0				0.0	15.7	15.7	3.45	5.80	0.75	3.10
E		3.12	0.170	0.417	300	0.060	16.2	250	15.00	0.056	3.55	1.2	17.4	17.4	3.30	5.54	1.75	7.20
C,E	E	4.40	0.170	0.417									17.4	17.4	3.30	5.54	2.47	10.16
B	B	2.93	0.170	0.417	300	0.050	17.3	0				0.0	17.3	17.3	3.31	5.56	1.65	6.79
F		3.78	0.170	0.417			0.0	400	15.00	0.048	3.27	2.0	2.0	5.0				
C,E,B,F	F	11.11	0.170	0.417									19.3	19.3	3.14	5.28	5.94	24.45
G		2.27	0.170	0.417	0		0.0	300	15.00	0.067	3.87	1.3	1.3	5.0	5.17	8.68	1.99	8.22
D11 (SETT. RANCH)	D11	15.60	0.137	0.393	300	0.037	19.8	1100	15.00	0.072	4.02	4.6	24.3	24.3	2.80	4.69	5.98	28.78
H		5.69	0.170	0.417	0		0.0	300	15.00	0.077	4.15	1.2	1.2	5.0				
DPF+G,D11,H	H	34.67	0.155	0.406									25.5	25.5	2.72	4.57	14.64	64.36
A	A	10.74	0.170	0.417	300	0.033	19.8	400	15.00	0.075	4.11	1.6	21.4	21.4	2.99	5.01	5.45	22.44
D12 (SETT. RANCH)	D12	11.00	0.137	0.393	300	0.040	19.2	450	15.00	0.089	4.47	1.7	20.9	20.9	3.02	5.07	4.55	21.93
OI1 (GRANDVIEW)	OI1	13.12	0.137	0.393	300	0.020	24.2	1750	15.00	0.042	3.07	9.5	33.7	33.7	2.31	3.87	4.14	19.95
I		25.60	0.149	0.401	0		0.0	2100	15.00	0.035	2.81	12.4	12.4	12.4				
DPH+A,D12,OI1,I	I	95.13	0.150	0.403									33.9	33.9	2.30	3.86	32.81	147.90

1) OVERLAND FLOW Tco = (0.395*(1.1-RUNOFF 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

7) WEIGHTED AVERAGE C VALUES FOR COMBINED BASINS

APPENDIX B

HYDRAULIC CALCULATIONS

ABERT RANCH
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
SILVER NELL DRIVE	1040	1425	N	3.76	4:1/3:1	2.5	0.030	60	F	24.5	10	2.5	0.45	3.5	GRASS
SILVER NELL DRIVE	1040	1425	S	3.76	4:1/3:1	2.5	0.030	60	E	10.2	70	7.1	0.67	4.5	GRASS
ABERT RANCH DRIVE	1058	1315	E	6.25	4:1/3:1	2.5	0.030	60	G	8.2	10	0.8	0.27	3.2	GRASS
ABERT RANCH DRIVE	1058	1315	W	6.25	4:1/3:1	2.5	0.030	60	E	10.2	30	3.1	0.45	4.4	GRASS
ABERT RANCH DRIVE	1355	1622	E	4.60	4:1/3:1	2.5	0.030	60	H	64.4	5	3.2	0.48	4.0	GRASS
ABERT RANCH DRIVE	1355	1622	W	4.60	4:1/3:1	2.5	0.030	60	F	24.5	40	9.8	0.73	5.3	**GRASS / ECB**
ABERT RANCH DRIVE	1622	1739	E	2.00	4:1/3:1	2.5	0.030	60	H	64.4	5	3.2	0.56	2.9	GRASS
ABERT RANCH DRIVE	1622	1739	W	2.00	4:1/3:1	2.5	0.030	60	F	24.5	25	6.1	0.71	3.4	GRASS
ABERT RANCH DRIVE	1739	2599	N	5.00	4:1/3:1	2.5	0.030	60	I	147.9	25	37.0	1.18	7.6	**GRASS / ECB**
ABERT RANCH DRIVE	1739	2599	S	5.00	4:1/3:1	2.5	0.030	60	H	64.4	10	6.4	0.61	4.9	GRASS
ABERT RANCH DRIVE	2599	2841	N	2.00	4:1/3:1	2.5	0.030	60	I	147.9	5	7.4	0.77	3.6	GRASS
ABERT RANCH DRIVE	2599	2841	S	2.00	4:1/3:1	2.5	0.030	60	H	64.4	5	3.2	0.56	2.9	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)

ABERT RANCH
CHANNEL CALCULATIONS
DEVELOPED FLOWS

EXISTING / PROPOSED CHANNELS

CHANNEL	DESIGN POINT	EXISTING SLOPE (%)	PROPOSED SLOPE (%)	BOTTOM WIDTH (B, FT)	SIDE SLOPE (Z)	CHANNEL DEPTH (FT)	FRICTION FACTOR (n)	Q100 FLOW (CFS)	Q100 DEPTH (FT)	Q100 VELOCITY (FT/S)	CHANNEL LINING
H	F	0.069	0.069	20	4:1	2.0	0.030	24.5	0.24	4.9	GRASS
I	H	0.032	0.032	40	4:1	2.0	0.030	64.4	0.36	4.4	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 = 0.035 for riprap-lined channels
5) Vmax = 5.0 fps for 100-year flows w/ grass-lined channels
6) Vmax = 8.0 fps for 100-year flows w/ Erosion Control Blankets (NAG C150 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/ft^2 (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 ft^2 (0.73 kg/100 m^2) approx wt	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft^2 (0.73 kg/100 m^2) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft^2 (0.73 kg/100 m^2) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft^2 (0.73 kg/100 m^2) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft^2 (1.47 kg/100 m^2) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft^2 (1.47 kg/100 m^2) approx wt	Leno woven. 100% biodegradable jute fiber 9.30 lbs/1000 ft^2 (4.53 kg/100 m^2) 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/yd^2 (0.27 kg/m^2)	Straw fiber 0.50 lbs/yd^2 (0.27 kg/m^2)	Straw fiber 0.50 lbs/yd^2 (0.27 kg/m^2)	Straw fiber 0.50 lbs/yd^2 (0.27 kg/m^2)	Straw/coconut matrix 70% Straw 0.35 lbs/yd^2 (0.19 kg/m^2) 30% Coconut 0.15 lbs/yd^2 (0.08 kg/m^2)	Coconut fiber 0.50 lbs/yd^2 (0.27 kg/m^2)	Straw fiber 0.50 lbs/yd^2 (0.27 kg/m^2)
Bottom Net	N/A	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft^2 (0.73 kg/100 m^2) approx wt	N/A	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft^2 (0.73 kg/100 m^2) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft^2 (0.73 kg/100 m^2) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft^2 (1.47 kg/100 m^2) approx wt	N/A
Thread	Accelerated degradable	Accelerated degradable	Degradable	Degradable	Degradable	UV-stabilized polypropylene	Biodegradable

Hydraulic Analysis Report

Project Data

Project Title: Abert Ranch

Designer: JPS

Project Date: Sunday, March 26, 2017

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Silver-Nell-Dr-1040-1425-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: 0.0376 ft/ft

Manning's n: 0.0300

Flow: 2.5000 cfs

Result Parameters

Depth: 0.4533 ft

Area of Flow: 0.7191 ft^2

Wetted Perimeter: 3.3023 ft

Hydraulic Radius: 0.2178 ft

Average Velocity: 3.4765 ft/s

Top Width: 3.1729 ft

Froude Number: 1.2869

Critical Depth: 0.5035 ft

Critical Velocity: 2.8179 ft/s

Critical Slope: 0.0215 ft/ft

Critical Top Width: 3.60 ft

Calculated Max Shear Stress: 1.0635 lb/ft^2

Calculated Avg Shear Stress: 0.5109 lb/ft^2

Channel Analysis: SND-1040-1425-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: 0.0376 ft/ft

Manning's n: 0.0300

Flow: 7.1000 cfs

Result Parameters

Depth: 0.6704 ft

Area of Flow: 1.5732 ft^2

Wetted Perimeter: 4.8844 ft

Hydraulic Radius: 0.3221 ft

Average Velocity: 4.5131 ft/s

Top Width: 4.6931 ft

Froude Number: 1.3737

Critical Depth: 0.7644 ft

Critical Velocity: 3.4721 ft/s

Critical Slope: 0.0187 ft/ft

Critical Top Width: 5.46 ft

Calculated Max Shear Stress: 1.5730 lb/ft^2

Calculated Avg Shear Stress: 0.7557 lb/ft^2

Channel Analysis: Abert-Ranch-Dr-1058-1315-E

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0625 ft/ft

Manning's n: 0.0300

Flow: 0.8000 cfs

Result Parameters

Depth: 0.2688 ft

Area of Flow: 0.2529 ft^2

Wetted Perimeter: 1.9582 ft

Hydraulic Radius: 0.1291 ft

Average Velocity: 3.1637 ft/s

Top Width: 1.8815 ft

Froude Number: 1.5208

Critical Depth: 0.3192 ft

Critical Velocity: 2.2436 ft/s

Critical Slope: 0.0250 ft/ft

Critical Top Width: 2.28 ft

Calculated Max Shear Stress: 1.0483 lb/ft^2

Calculated Avg Shear Stress: 0.5036 lb/ft^2

Channel Analysis: ARD-1058-1315-W

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0625 ft/ft

Manning's n: 0.0300

Flow: 3.1000 cfs

Result Parameters

Depth: 0.4467 ft

Area of Flow: 0.6984 ft^2

Wetted Perimeter: 3.2544 ft

Hydraulic Radius: 0.2146 ft

Average Velocity: 4.4387 ft/s

Top Width: 3.1269 ft

Froude Number: 1.6552

Critical Depth: 0.5487 ft

Critical Velocity: 2.9418 ft/s

Critical Slope: 0.0209 ft/ft

Critical Top Width: 3.92 ft

Calculated Max Shear Stress: 1.7421 lb/ft^2

Calculated Avg Shear Stress: 0.8369 lb/ft^2

Channel Analysis: ARD-1355-1622-E

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0460 ft/ft

Manning's n: 0.0300

Flow: 3.2000 cfs

Result Parameters

Depth: 0.4788 ft

Area of Flow: 0.8024 ft^2

Wetted Perimeter: 3.4882 ft

Hydraulic Radius: 0.2300 ft

Average Velocity: 3.9883 ft/s

Top Width: 3.3516 ft

Froude Number: 1.4365

Critical Depth: 0.5557 ft

Critical Velocity: 2.9605 ft/s

Critical Slope: 0.0208 ft/ft

Critical Top Width: 3.97 ft

Calculated Max Shear Stress: 1.3743 lb/ft^2

Calculated Avg Shear Stress: 0.6602 lb/ft^2

Channel Analysis: ARD-1355-1622-W

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0460 ft/ft

Manning's n: 0.0300

Flow: 9.8000 cfs

Result Parameters

Depth: 0.7285 ft

Area of Flow: 1.8575 ft^2

Wetted Perimeter: 5.3074 ft

Hydraulic Radius: 0.3500 ft

Average Velocity: 5.2760 ft/s

Top Width: 5.0995 ft

Froude Number: 1.5406

Critical Depth: 0.8695 ft

Critical Velocity: 3.7032 ft/s

Critical Slope: 0.0179 ft/ft

Critical Top Width: 6.21 ft

Calculated Max Shear Stress: 2.0911 lb/ft^2

Calculated Avg Shear Stress: 1.0046 lb/ft^2

Channel Analysis: ARD-1622-1739-E

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0200 ft/ft

Manning's n: 0.0300

Flow: 3.2000 cfs

Result Parameters

Depth: 0.5597 ft

Area of Flow: 1.0965 ft^2

Wetted Perimeter: 4.0778 ft

Hydraulic Radius: 0.2689 ft

Average Velocity: 2.9184 ft/s

Top Width: 3.9181 ft

Froude Number: 0.9722

Critical Depth: 0.5557 ft

Critical Velocity: 2.9605 ft/s

Critical Slope: 0.0208 ft/ft

Critical Top Width: 3.97 ft

Calculated Max Shear Stress: 0.6985 lb/ft^2

Calculated Avg Shear Stress: 0.3356 lb/ft^2

Channel Analysis: ARD-1622-1739-W

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0200 ft/ft

Manning's n: 0.0300

Flow: 6.1000 cfs

Result Parameters

Depth: 0.7129 ft

Area of Flow: 1.7789 ft^2

Wetted Perimeter: 5.1939 ft

Hydraulic Radius: 0.3425 ft

Average Velocity: 3.4291 ft/s

Top Width: 4.9904 ft

Froude Number: 1.0122

Critical Depth: 0.7193 ft

Critical Velocity: 3.3682 ft/s

Critical Slope: 0.0191 ft/ft

Critical Top Width: 5.14 ft

Calculated Max Shear Stress: 0.8897 lb/ft^2

Calculated Avg Shear Stress: 0.4274 lb/ft^2

Channel Analysis: ARD-1739-2599-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: 37.0000 cfs

Result Parameters

Depth: 1.1803 ft

Area of Flow: 4.8761 ft^2

Wetted Perimeter: 8.5991 ft

Hydraulic Radius: 0.5670 ft

Average Velocity: 7.5880 ft/s

Top Width: 8.2623 ft

Froude Number: 1.7407

Critical Depth: 1.4794 ft

Critical Velocity: 4.8303 ft/s

Critical Slope: 0.0150 ft/ft

Critical Top Width: 10.57 ft

Calculated Max Shear Stress: 3.6826 lb/ft^2

Calculated Avg Shear Stress: 1.7692 lb/ft^2

Channel Analysis: ARD-1739-2599-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: 6.4000 cfs

Result Parameters

Depth: 0.6113 ft

Area of Flow: 1.3078 ft^2

Wetted Perimeter: 4.4535 ft

Hydraulic Radius: 0.2937 ft

Average Velocity: 4.8935 ft/s

Top Width: 4.2790 ft

Froude Number: 1.5599

Critical Depth: 0.7333 ft

Critical Velocity: 3.4007 ft/s

Critical Slope: 0.0189 ft/ft

Critical Top Width: 5.24 ft

Calculated Max Shear Stress: 1.9072 lb/ft^2

Calculated Avg Shear Stress: 0.9163 lb/ft^2

Channel Analysis: ARD-2599-2841-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: 0.0200 ft/ft

Manning's n: 0.0300

Flow: 7.4000 cfs

Result Parameters

Depth: 0.7665 ft

Area of Flow: 2.0562 ft^2

Wetted Perimeter: 5.5841 ft

Hydraulic Radius: 0.3682 ft

Average Velocity: 3.5988 ft/s

Top Width: 5.3654 ft

Froude Number: 1.0245

Critical Depth: 0.7771 ft

Critical Velocity: 3.5009 ft/s

Critical Slope: 0.0186 ft/ft

Critical Top Width: 5.55 ft

Calculated Max Shear Stress: 0.9566 lb/ft^2

Calculated Avg Shear Stress: 0.4596 lb/ft^2

Channel Analysis: ARD-2599-2841-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: 0.0200 ft/ft

Manning's n: 0.0300

Flow: 3.2000 cfs

Result Parameters

Depth: 0.5597 ft

Area of Flow: 1.0965 ft^2

Wetted Perimeter: 4.0778 ft

Hydraulic Radius: 0.2689 ft

Average Velocity: 2.9184 ft/s

Top Width: 3.9181 ft

Froude Number: 0.9722

Critical Depth: 0.5557 ft

Critical Velocity: 2.9605 ft/s

Critical Slope: 0.0208 ft/ft

Critical Top Width: 3.97 ft

Calculated Max Shear Stress: 0.6985 lb/ft^2

Calculated Avg Shear Stress: 0.3356 lb/ft^2

Channel Analysis: Channel Analysis-H

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 20.0000 ft

Longitudinal Slope: 0.0690 ft/ft

Manning's n: 0.0300

Flow: 24.5000 cfs

Result Parameters

Depth: 0.2400 ft

Area of Flow: 5.0307 ft^2

Wetted Perimeter: 21.9792 ft

Hydraulic Radius: 0.2289 ft

Average Velocity: 4.8701 ft/s

Top Width: 21.9201 ft

Froude Number: 1.7915

Critical Depth: 0.3511 ft

Critical Velocity: 3.2600 ft/s

Critical Slope: 0.0191 ft/ft

Critical Top Width: 22.81 ft

Calculated Max Shear Stress: 1.0334 lb/ft^2

Calculated Avg Shear Stress: 0.9855 lb/ft^2

Channel Analysis: Channel Analysis-I

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 40.0000 ft

Longitudinal Slope: 0.0320 ft/ft

Manning's n: 0.0300

Flow: 64.4000 cfs

Result Parameters

Depth: 0.3570 ft

Area of Flow: 14.7890 ft^2

Wetted Perimeter: 42.9437 ft

Hydraulic Radius: 0.3444 ft

Average Velocity: 4.3546 ft/s

Top Width: 42.8559 ft

Froude Number: 1.3063

Critical Depth: 0.4257 ft

Critical Velocity: 3.6272 ft/s

Critical Slope: 0.0177 ft/ft

Critical Top Width: 43.41 ft

Calculated Max Shear Stress: 0.7128 lb/ft^2

Calculated Avg Shear Stress: 0.6877 lb/ft^2

Channel Analysis: Channel Analysis-A

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 20.0000 ft

Longitudinal Slope: 0.0500 ft/ft

Manning's n: 0.0300

Flow: 22.4000 cfs

Result Parameters

Depth: 0.2506 ft

Area of Flow: 5.2640 ft^2

Wetted Perimeter: 22.0668 ft

Hydraulic Radius: 0.2385 ft

Average Velocity: 4.2553 ft/s

Top Width: 22.0051 ft

Froude Number: 1.5332

Critical Depth: 0.3312 ft

Critical Velocity: 3.1715 ft/s

Critical Slope: 0.0195 ft/ft

Critical Top Width: 22.65 ft

Calculated Max Shear Stress: 0.7820 lb/ft^2

Calculated Avg Shear Stress: 0.7443 lb/ft^2

Channel Analysis: Channel Analysis-Pond-I-Outlet

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 6.0000 ft

Longitudinal Slope: 0.0200 ft/ft

Manning's n: 0.0300

Flow: 120.4000 cfs

Result Parameters

Depth: 1.4761 ft

Area of Flow: 17.5728 ft^2

Wetted Perimeter: 18.1726 ft

Hydraulic Radius: 0.9670 ft

Average Velocity: 6.8515 ft/s

Top Width: 17.8091 ft

Froude Number: 1.2155

Critical Depth: 1.6336 ft

Critical Velocity: 5.8799 ft/s

Critical Slope: 0.0132 ft/ft

Critical Top Width: 19.07 ft

Calculated Max Shear Stress: 1.8422 lb/ft^2

Calculated Avg Shear Stress: 1.2068 lb/ft^2

ABERT RANCH
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
E	E	7615.69	7613.00	7612.36	64.0	1	1.5	2.5	2.5	7614.50	7613.8	10.20	10.20	7616.4	7615.1
F	F	7606.99	7604.00	7603.36	64.0	1	1.5	5.9	5.9	7605.50	7605.4	24.50	24.50	7607.7	7607.1
H	H	7572.05	7569.00	7568.36	64.0	1	2.5	16.3	16.3	7571.50	7570.8	64.40	64.40	7572.7	7572.3

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 2.5 cfs
Design Flow: 10.2 cfs
Maximum Flow: 15 cfs

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

Headwater Elevatio	Total Discharge (c	Culvert E Discharg (cfs)	Roadway Discharg (cfs)	Iterations
7613.83	2.50	2.50	0.00	1
7614.05	3.75	3.75	0.00	1
7614.24	5.00	5.00	0.00	1
7614.42	6.25	6.25	0.00	1
7614.60	7.50	7.50	0.00	1
7614.81	8.75	8.75	0.00	1
7615.04	10.00	10.00	0.00	1
7615.08	10.20	10.20	0.00	1
7615.61	12.50	12.50	0.00	1
7615.71	13.75	12.84	0.79	11
7615.73	15.00	12.88	2.04	4
7615.69	12.78	12.78	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert E

Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2.50	2.50	7613.83	0.828	0.0*	1-S2	0.494	0.596	0.499	0.176	4.847	3.022
3.75	3.75	7614.05	1.050	0.265	1-S2	0.617	0.740	0.617	0.222	5.472	3.461
5.00	5.00	7614.24	1.239	0.509	1-S2	0.727	0.856	0.727	0.261	5.896	3.799
6.25	6.25	7614.42	1.416	0.779	1-S2	0.832	0.961	0.832	0.296	6.209	4.080
7.50	7.50	7614.60	1.602	1.078	5-S2	0.936	1.057	0.936	0.327	6.469	4.319
8.75	8.75	7614.81	1.806	1.579	5-S2	1.046	1.141	1.048	0.356	6.643	4.530
10.00	10.00	7615.04	2.040	1.892	5-S2	1.172	1.218	1.172	0.383	6.763	4.718
10.20	10.20	7615.08	2.080	1.945	5-S2	1.194	1.229	1.194	0.387	6.774	4.747
12.50	12.50	7615.61	2.609	2.599	7-M2	1.500	1.333	1.333	0.432	7.533	5.046
13.75	12.84	7615.71	2.696	2.710	7-M2	1.500	1.345	1.345	0.455	7.682	5.191
15.00	12.88	7615.73	2.707	2.727	7-M2	1.500	1.347	1.347	0.477	7.700	5.327

* Full Flow Headwater elevation is below inlet invert.

****
Straight Culvert
Inlet Elevation (invert): 7613.00 ft,   Outlet Elevation (invert): 7612.36 ft
Culvert Length: 64.00 ft,   Culvert Slope: 0.0100
****

Site Data - Culvert E

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 7613.00 ft
Outlet Station: 64.00 ft
Outlet Elevation: 7612.36 ft
Number of Barrels: 1

Culvert Data Summary - Culvert E

Barrel Shape: Circular
Barrel Diameter: 1.50 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: Culvert-E)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
2.50	7612.54	0.18	3.02	0.50	1.36
3.75	7612.58	0.22	3.46	0.64	1.41
5.00	7612.62	0.26	3.80	0.75	1.44
6.25	7612.66	0.30	4.08	0.85	1.47
7.50	7612.69	0.33	4.32	0.94	1.49
8.75	7612.72	0.36	4.53	1.02	1.50
10.00	7612.74	0.38	4.72	1.10	1.52
10.20	7612.75	0.39	4.75	1.11	1.52
12.50	7612.79	0.43	5.05	1.24	1.54
13.75	7612.82	0.46	5.19	1.31	1.55
15.00	7612.84	0.48	5.33	1.37	1.56

Tailwater Channel Data - Culvert-E

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 4.00 ft
Side Slope (H:V): 4.00 (_:1)
Channel Slope: 0.0460
Channel Manning's n: 0.0300
Channel Invert Elevation: 7612.36 ft

Roadway Data for Crossing: Culvert-E

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 7615.69 ft
Roadway Surface: Paved
Roadway Top Width: 32.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 5.9 cfs
Design Flow: 24.5 cfs
Maximum Flow: 35 cfs

Table 4 - Summary of Culvert Flows at Crossing: Culvert-F

Headwater Elevatio	Total Discharge (c	Culvert F Discharg (cfs)	Roadway Discharg (cfs)	Iterations
7605.37	5.90	5.90	0.00	1
7605.82	8.81	8.81	0.00	1
7606.42	11.72	11.72	0.00	1
7607.01	14.63	13.72	0.79	34
7607.04	17.54	13.81	3.61	5
7607.07	20.45	13.89	6.46	4
7607.09	23.36	13.95	9.36	4
7607.10	24.50	13.98	10.46	3
7607.13	29.18	14.05	15.00	3
7607.14	32.09	14.10	17.93	3
7607.16	35.00	14.15	20.82	3
7606.99	13.66	13.66	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert F

Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
5.90	5.90	7605.3	1.367	0.0*	1-S2	0.803	0.934	0.807	0.360	6.089	3.008
8.81	8.81	7605.8	1.817	1.593	5-S2	1.052	1.144	1.054	0.448	6.650	3.395
11.72	11.72	7606.4	2.416	2.300	7-M2	1.500	1.302	1.302	0.522	7.193	3.691
14.63	13.72	7607.0	2.938	3.009	7-M2	1.500	1.374	1.374	0.586	8.092	3.934
17.54	13.81	7607.0	2.964	3.043	7-M2	1.500	1.376	1.376	0.644	8.135	4.142
20.45	13.89	7607.0	2.985	3.069	7-M2	1.500	1.378	1.378	0.697	8.171	4.325
23.36	13.95	7607.0	3.003	3.090	7-M2	1.500	1.380	1.380	0.745	8.201	4.488
24.50	13.98	7607.1	3.012	3.098	7-M2	1.500	1.381	1.381	0.764	8.216	4.548
29.18	14.05	7607.1	3.034	3.127	7-M2	1.500	1.383	1.383	0.834	8.253	4.772
32.09	14.10	7607.1	3.048	3.144	7-M2	1.500	1.384	1.384	0.874	8.278	4.898
35.00	14.15	7607.1	3.062	3.161	7-M2	1.500	1.385	1.385	0.912	8.301	5.015

* Full Flow Headwater elevation is below inlet invert.

****
Straight Culvert
Inlet Elevation (invert): 7604.00 ft,   Outlet Elevation (invert): 7603.36 ft
Culvert Length: 64.00 ft,   Culvert Slope: 0.0100
****

Site Data - Culvert F

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 7604.00 ft
Outlet Station: 64.00 ft
Outlet Elevation: 7603.36 ft
Number of Barrels: 1

Culvert Data Summary - Culvert F

Barrel Shape: Circular
Barrel Diameter: 1.50 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 6 - Downstream Channel Rating Curve (Crossing: Culvert-F)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
5.90	7603.72	0.36	3.01	0.45	0.99
8.81	7603.81	0.45	3.39	0.56	1.02
11.72	7603.88	0.52	3.69	0.65	1.04
14.63	7603.95	0.59	3.93	0.73	1.06
17.54	7604.00	0.64	4.14	0.80	1.07
20.45	7604.06	0.70	4.32	0.87	1.08
23.36	7604.11	0.75	4.49	0.93	1.09
24.50	7604.12	0.76	4.55	0.95	1.10
29.18	7604.19	0.83	4.77	1.04	1.11
32.09	7604.23	0.87	4.90	1.09	1.12
35.00	7604.27	0.91	5.01	1.14	1.12

Tailwater Channel Data - Culvert-F

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 4.00 ft
Side Slope (H:V): 4.00 (_:1)
Channel Slope: 0.0200
Channel Manning's n: 0.0300
Channel Invert Elevation: 7603.36 ft

Roadway Data for Crossing: Culvert-F

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 7606.99 ft
Roadway Surface: Paved
Roadway Top Width: 32.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow
Minimum Flow: 14.6 cfs
Design Flow: 64.4 cfs
Maximum Flow: 80 cfs

Table 7 - Summary of Culvert Flows at Crossing: Crossing H

Headwater Elevatio	Total Discharge (c	Culvert H Discharg (cfs)	Roadway Discharg (cfs)	Iterations
7570.83	14.60	14.60	0.00	1
7571.28	21.14	21.14	0.00	1
7571.73	27.68	27.68	0.00	1
7572.08	34.22	32.26	1.79	19
7572.14	40.76	32.91	7.62	5
7572.18	47.30	33.39	13.68	4
7572.22	53.84	33.81	19.91	4
7572.25	60.38	34.18	26.14	4
7572.27	64.40	34.39	29.88	3
7572.31	73.46	34.83	38.46	3
7572.33	80.00	35.12	44.80	3
7572.05	31.85	31.85	0.00	Overtopping

Table 8 - Culvert Summary Table: Culvert H

Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
14.60	14.60	7570.8	1.835	0.892	1-S2	1.026	1.287	1.049	0.226	7.462	3.090
21.14	21.14	7571.2	2.276	1.434	1-S2	1.270	1.560	1.300	0.282	8.194	3.554
27.68	27.68	7571.7	2.726	2.034	5-S2	1.503	1.792	1.536	0.330	8.756	3.930
34.22	32.26	7572.0	3.083	2.774	5-S2	1.671	1.932	1.699	0.375	9.093	4.250
40.76	32.91	7572.1	3.138	2.832	5-S2	1.696	1.950	1.723	0.415	9.133	4.532
47.30	33.39	7572.1	3.179	2.876	5-S2	1.714	1.964	1.741	0.453	9.163	4.785
53.84	33.81	7572.2	3.216	2.914	5-S2	1.730	1.975	1.756	0.489	9.187	5.013
60.38	34.18	7572.2	3.248	2.948	5-S2	1.744	1.985	1.770	0.523	9.208	5.226
64.40	34.39	7572.2	3.266	2.967	5-S2	1.752	1.991	1.778	0.543	9.220	5.348
73.46	34.83	7572.3	3.305	3.008	5-S2	1.769	2.002	1.794	0.587	9.244	5.604
80.00	35.12	7572.3	3.332	3.036	5-S2	1.780	2.010	1.805	0.617	9.261	5.776

****

Straight Culvert

Inlet Elevation (invert): 7569.00 ft,   Outlet Elevation (invert): 7568.36 ft

Culvert Length: 64.00 ft,   Culvert Slope: 0.0100

****

Site Data - Culvert H

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 7569.00 ft
Outlet Station: 64.00 ft
Outlet Elevation: 7568.36 ft
Number of Barrels: 1

Culvert Data Summary - Culvert H

Barrel Shape: Circular
Barrel Diameter: 2.50 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 9 - Downstream Channel Rating Curve (Crossing: Crossing H)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
14.60	7568.59	0.23	3.09	0.42	1.17
21.14	7568.64	0.28	3.55	0.53	1.21
27.68	7568.69	0.33	3.93	0.62	1.24
34.22	7568.73	0.37	4.25	0.70	1.27
40.76	7568.78	0.42	4.53	0.78	1.29
47.30	7568.81	0.45	4.78	0.85	1.30
53.84	7568.85	0.49	5.01	0.92	1.32
60.38	7568.88	0.52	5.23	0.98	1.33
64.40	7568.90	0.54	5.35	1.02	1.34
73.46	7568.95	0.59	5.60	1.10	1.36
80.00	7568.98	0.62	5.78	1.15	1.37

Tailwater Channel Data - Crossing H

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 20.00 ft
Side Slope (H:V): 4.00 (_:1)
Channel Slope: 0.0300
Channel Manning's n: 0.0300
Channel Invert Elevation: 7568.36 ft

Roadway Data for Crossing: Crossing H

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 7572.05 ft
Roadway Surface: Paved
Roadway Top Width: 32.00 ft

Culvert E

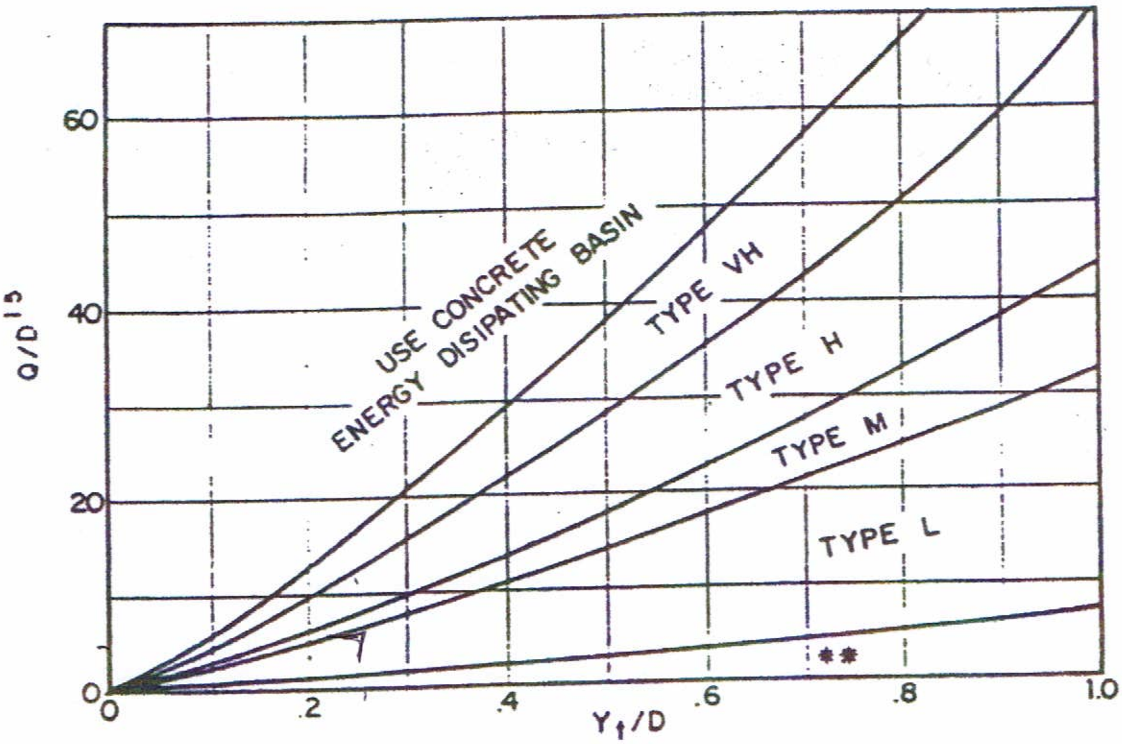
$Q_{100} = 10.2$ cfs

$\Delta = 1.5'$

$$\frac{Q}{\Delta^{1.5}} = \frac{10.2}{(1.5)^{1.5}} = 5.6$$

$Y_t = 0.39'$

$$\frac{Y_t}{\Delta} = \frac{0.39}{1.5} = 0.26$$



Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

→ Use Type M (min.)

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

Culvert F

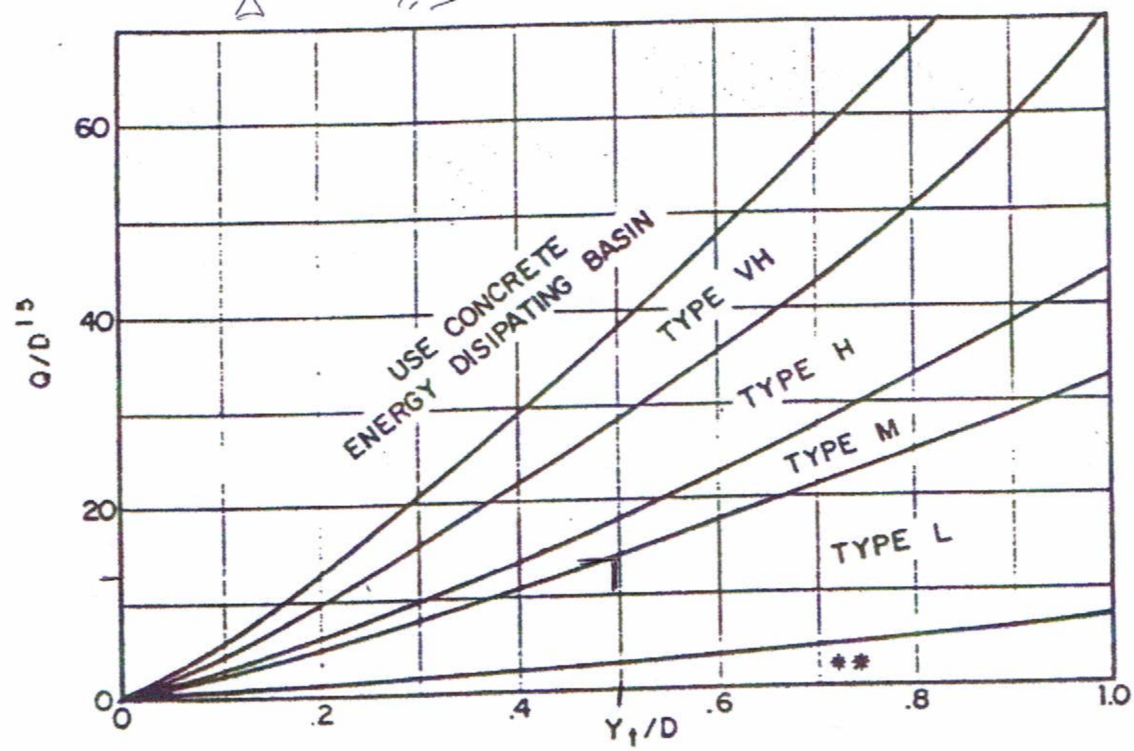
$Q_{100} = 24.5$ cfs

$\Delta = 1.5'$

$\frac{Q}{\Delta^{1.5}} = \frac{24.5}{(1.5)^{1.5}} = 13.3$

$Y_t = 0.76'$

$\frac{Y_t}{\Delta} = \frac{0.76}{1.5} = 0.5$



Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

→ Use Type M

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

Culvert H

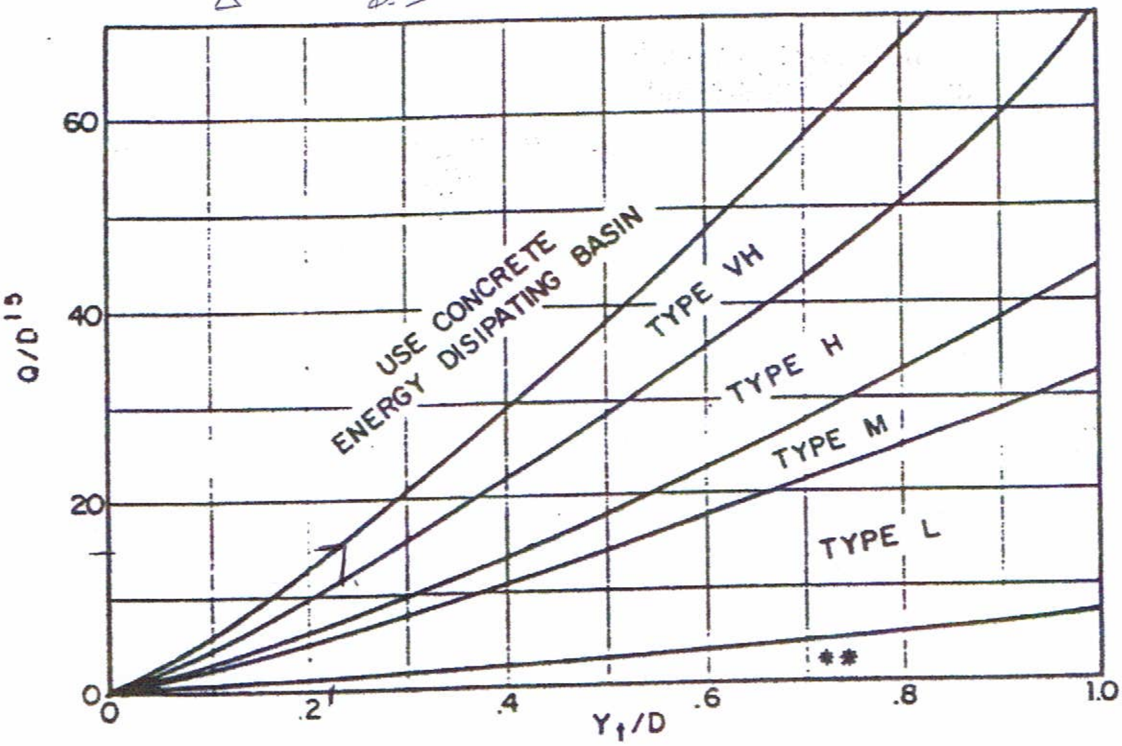
$Q_{100} = 64.4$ cfs

$\Delta = 2.5'$

$$\frac{Q}{\Delta^{1.5}} = \frac{64.4}{(2.5)^{1.5}} = 16.3$$

$Y_t = 0.54'$

$$\frac{Y_t}{\Delta} = \frac{0.54}{2.5} = 0.22$$



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

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

→ Use Type VH

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

Detention Pond I - Outlet Pipe

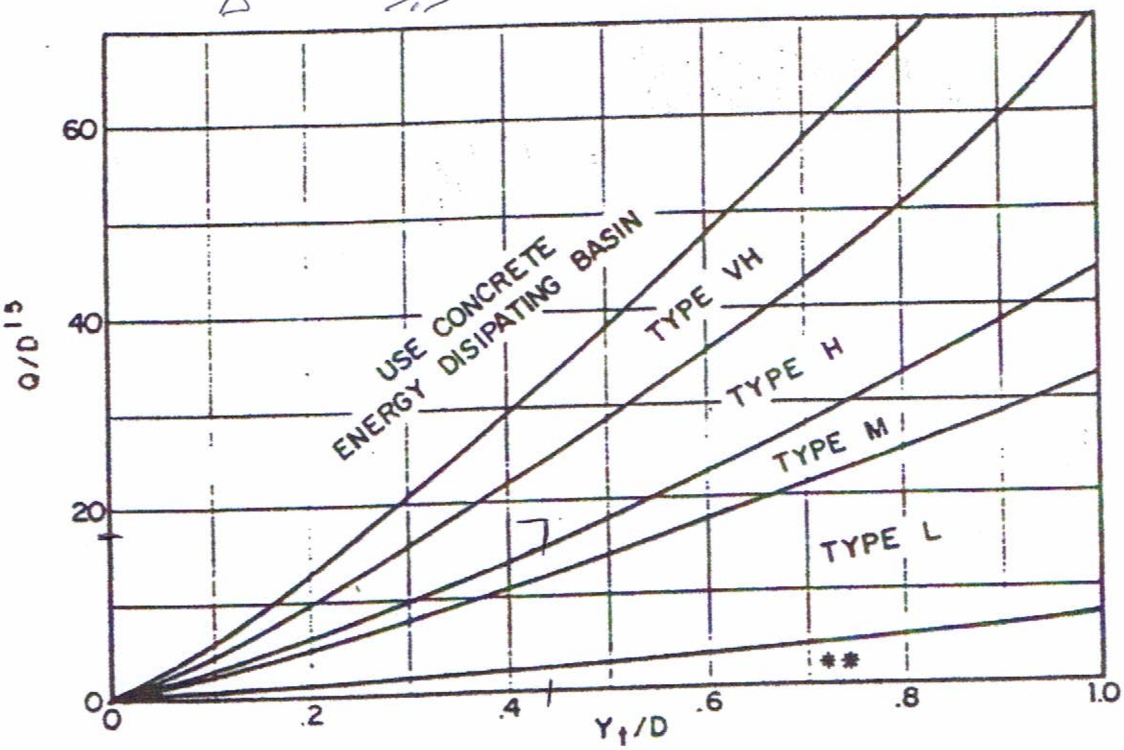
$Q_{100} = 120.4$ cfs

$D = 3.5'$

$$\frac{Q}{D^{1.5}} = \frac{120.4}{(3.5)^{1.5}} = 18.4$$

$Y_t = 1.5'$

$$\frac{Y_t}{D} = \frac{1.5}{3.5} = 0.43$$

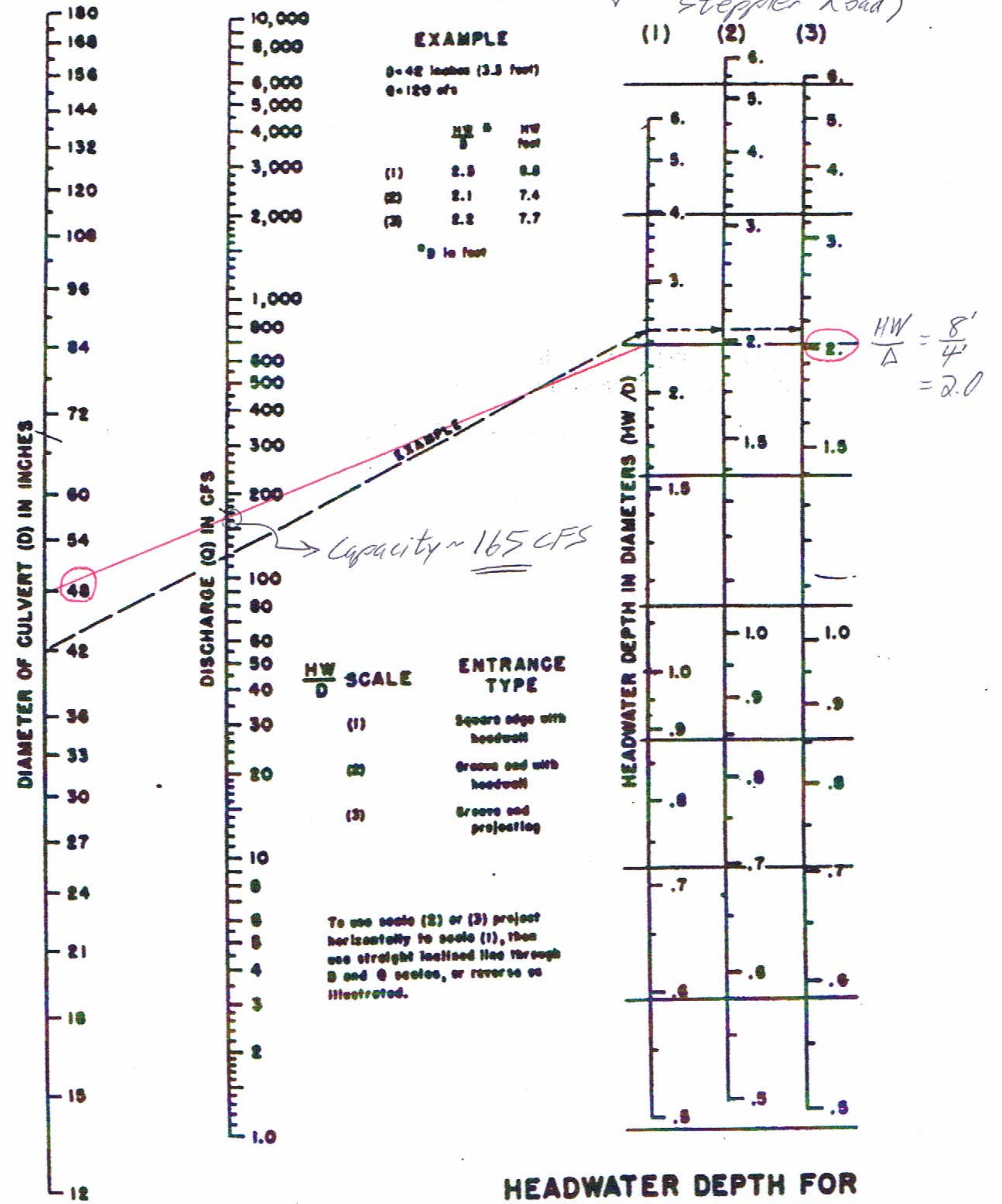


Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

→ Use Type H

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

Culvert I Analysis
(Existing 48" RCP crossing
Steppler Road)



HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HDR Infrastructure, Inc.
A Centerra Company

The City of Colorado Springs / El Paso County
Drainage Criteria Manual

Date
OCT. 1987

Figure
9 - 32

APPENDIX C

DETENTION POND CALCULATIONS

ABERT RANCH SUBDIVISION
COMPOSITE IMPERVIOUS AREAS

IMPERVIOUS AREAS

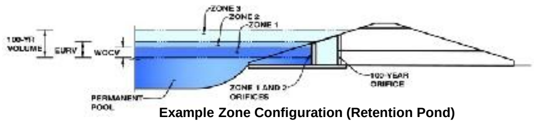
BASIN	TOTAL AREA (AC)	SUB-AREA 1 (AC)	SUB-AREA 1 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	SUB-AREA 2 AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	SUB-AREA 3 (AC)	SUB-AREA 3 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	WEIGHTED % IMP
C	1.28	1.28	2.5-AC LOTS	11.0							11.000
E	3.12	3.12	2.5-AC LOTS	11.0							11.000
C,E	4.40										11.000
B	2.93	2.93	2.5-AC LOTS	11.0							11.000
F	3.78	3.78	2.5-AC LOTS	11.0							11.000
C,E,B,F	11.11										11.000
G	2.27	2.27	2.5-AC LOTS	11.0							11.000
D11	15.60	15.60	5-AC LOTS	7.0							7.000
H	5.69	5.69	2.5-AC LOTS	11.0							11.000
DPF,G,D11,H	34.67										9.200
A	10.74	10.74	2.5-AC LOTS	11.0							11.000
D12	11.00	11.00	5-AC LOTS	7.0							7.000
OI1	13.12	13.12	5-AC LOTS	7.0							7.000
I	25.60	16.60	5-AC LOTS	7.0	9.00	2.5-AC LOTS	11.0				8.406
DPH,D12,OI1,I	95.13										8.632

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: **ABERT RANCH**

Basin ID: **I**



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	95.10	acres		
Watershed Length =	2,800	ft		
Watershed Slope =	0.041	ft/ft		
Watershed Imperviousness =	8.60%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	100.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.466	acre-feet	Optional User Override	
Excess Urban Runoff Volume (EURV) =	0.759	acre-feet	1-hr Precipitation	
2-yr Runoff Volume (P1 = 1.19 in.) =	0.514	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.810	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	1.991	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	5.595	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	7.841	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	10.774	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.07 in.) =	16.086	acre-feet	3.07	inches
Approximate 2-yr Detention Volume =	0.477	acre-feet		
Approximate 5-yr Detention Volume =	0.758	acre-feet		
Approximate 10-yr Detention Volume =	1.686	acre-feet		
Approximate 25-yr Detention Volume =	2.410	acre-feet		
Approximate 50-yr Detention Volume =	2.510	acre-feet		
Approximate 100-yr Detention Volume =	3.272	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.466	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.293	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	2.512	acre-feet
Total Detention Basin Volume =	3.272	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = 2 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	4,061	0.093		
	--	2.00	--	--	--	9,656	0.222	13,621	0.313
	--	4.00	--	--	--	16,274	0.374	39,647	0.910
	--	6.00	--	--	--	25,480	0.585	81,401	1.869
100-YR WSL	--	8.00	--	--	--	36,000	0.826	142,881	3.280
TOP	--	10.00	--	--	--	40,000	0.918	218,881	5.025
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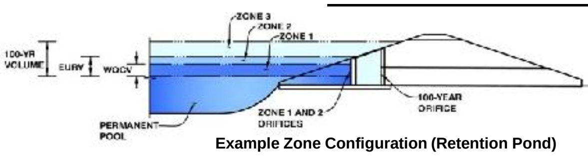
Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: ABERT RANCH

Basin ID: I



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.62	0.466	Orifice Plate
Zone 2 (EURV)	3.58	0.293	Orifice Plate
Zone 3 (100-year)	7.99	2.512	Weir&Pipe (Restrict)
		3.272	Total

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	3.58	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	14.30	inches
Orifice Plate: Orifice Area per Row =	3.47	sq. inches (use rectangular openings)

Calculated Parameters for Plate

WQ Orifice Area per Row =	2.410E-02	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.19	2.39					
Orifice Area (sq. inches)	3.47	3.47	3.47					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

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

Calculated Parameters for Vertical Orifice

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

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	6.00	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	10.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	10.00	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	6.00	N/A	feet
Over Flow Weir Slope Length =	10.00	N/A	feet
Grate Open Area / 100-yr Orifice Area =	9.52	N/A	should be $\geq$ 4
Overflow Grate Open Area w/o Debris =	70.00	N/A	ft^2
Overflow Grate Open Area w/ Debris =	35.00	N/A	ft^2

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

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	42.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	30.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	7.35	N/A	ft^2
Outlet Orifice Centroid =	1.39	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	2.01	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	9.00	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	64.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

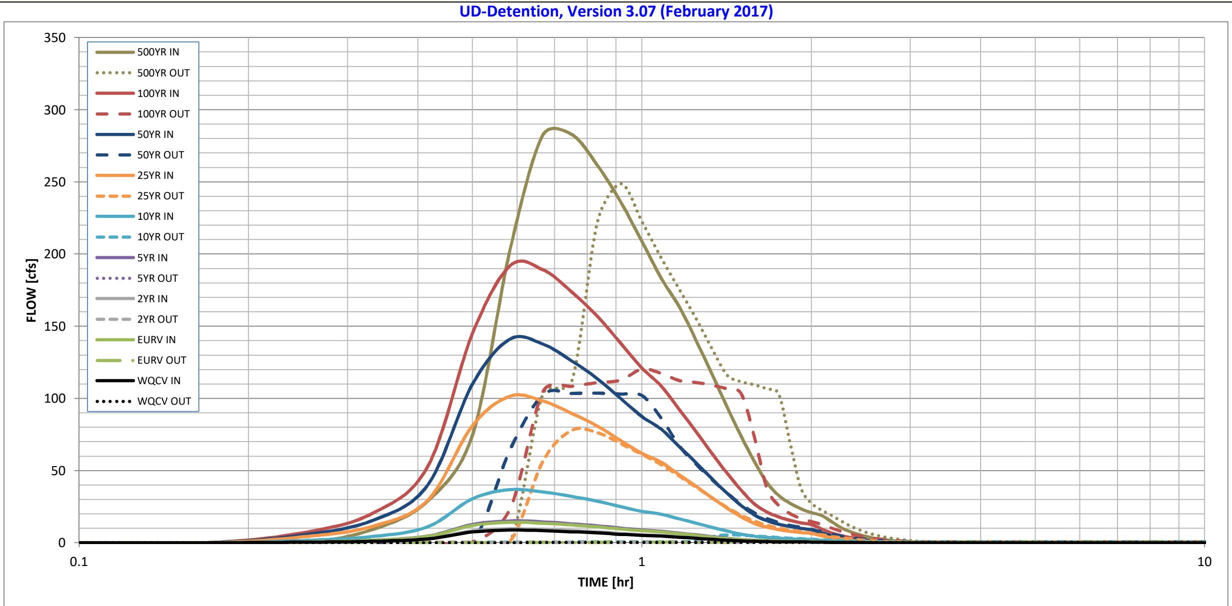
Spillway Design Flow Depth=	0.96	feet
Stage at Top of Freeboard =	10.96	feet
Basin Area at Top of Freeboard =	0.92	acres

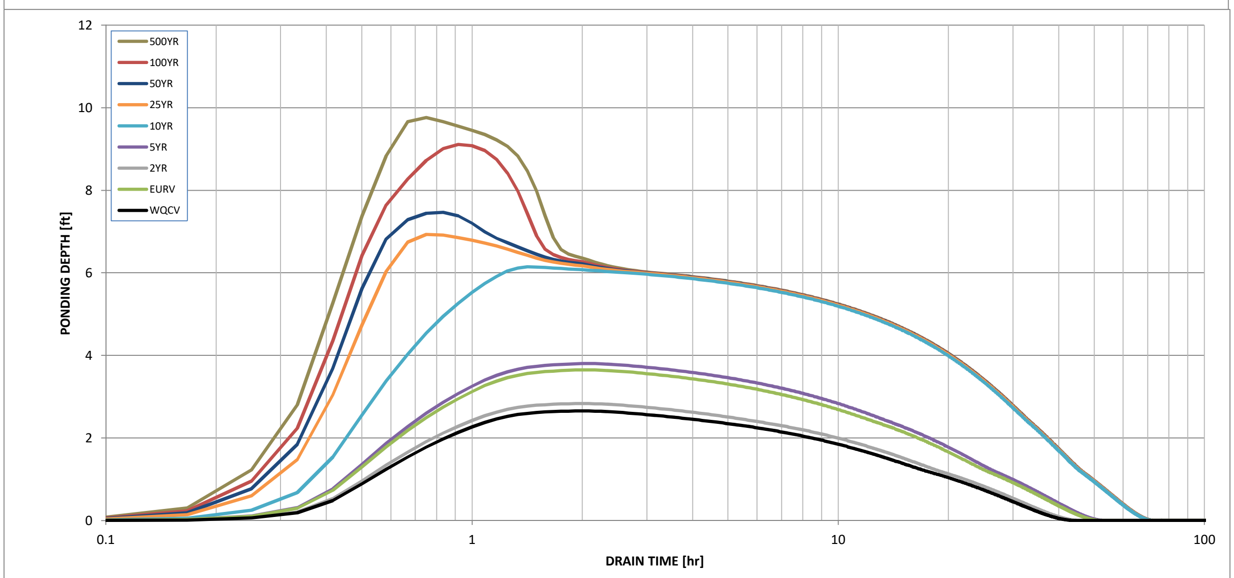
Routed Hydrograph Results

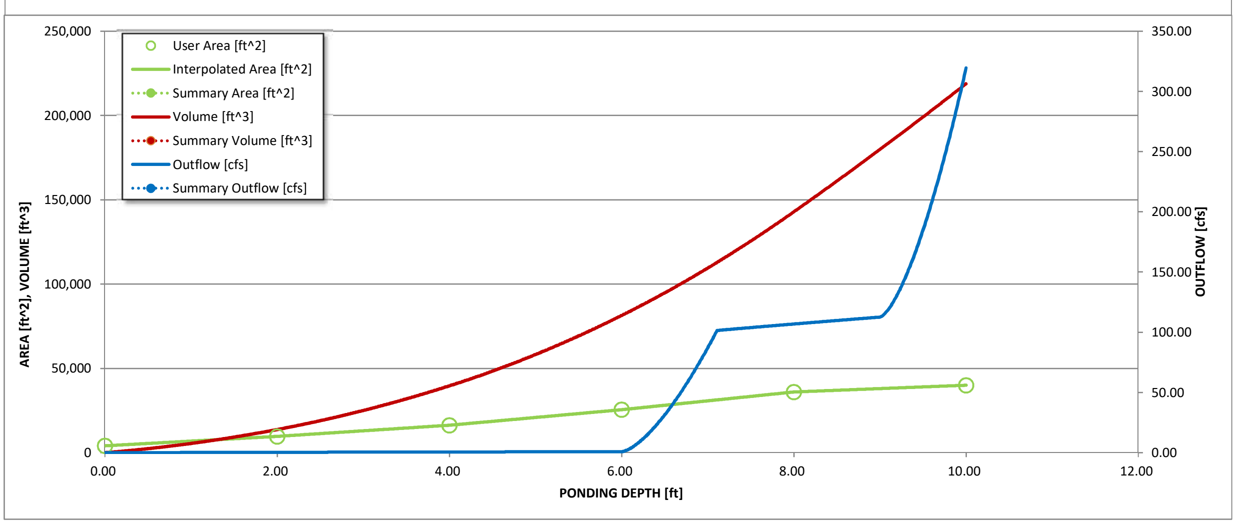
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.07
Calculated Runoff Volume (acre-ft) =	0.466	0.759	0.514	0.810	1.991	5.595	7.841	10.774	16.086
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.526	0.856	0.580	0.913	2.245	6.307	8.842	12.141	18.141
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.24	0.77	1.06	1.42	2.04
Predevelopment Peak Q (cfs) =	0.0	0.0	1.3	2.3	22.6	72.9	100.7	134.7	194.1
Peak Inflow Q (cfs) =	8.8	14.2	9.7	15.1	36.8	101.5	141.1	191.9	283.0
Peak Outflow Q (cfs) =	0.4	0.5	0.4	0.6	5.5	77.9	103.7	120.4	248.9
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.2	0.2	1.1	1.0	0.9	1.3
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Spillway	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.1	1.1	1.5	1.6	1.7
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	37	42	38	43	56	44	40	35	29
Time to Drain 99% of Inflow Volume (hours) =	**40**	47	41	48	63	57	54	50	45
Maximum Ponding Depth (ft) =	2.66	3.65	2.84	3.80	6.14	6.93	7.47	9.11	9.76
Area at Maximum Ponding Depth (acres) =	0.27	0.35	0.28	0.36	0.60	0.70	0.76	0.88	0.91
Maximum Volume Stored (acre-ft) =	0.475	0.784	0.525	0.837	1.952	2.458	2.851	4.226	4.806

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

User-Defined	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrograph	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constant	0:15:00	0.39	0.63	0.43	0.67	1.58	4.09	5.42	6.95	9.29
1.128	0:20:00	1.05	1.69	1.16	1.80	4.32	11.53	15.63	20.63	28.95
	0:25:00	2.70	4.34	2.97	4.62	11.09	29.59	40.13	53.00	74.51
	0:30:00	7.41	11.93	8.16	12.70	30.45	81.08	109.81	144.78	203.02
	0:35:00	8.76	14.19	9.66	15.12	36.78	101.53	141.11	191.89	282.29
	0:40:00	8.35	13.55	9.21	14.44	35.22	98.20	137.65	189.14	282.97
	0:45:00	7.60	12.33	8.38	13.15	32.06	89.65	126.07	173.86	261.57
	0:50:00	6.78	11.02	7.48	11.76	28.79	80.81	113.72	156.93	236.27
	0:55:00	5.84	9.53	6.45	10.16	25.03	70.84	99.95	138.27	208.85
	1:00:00	5.09	8.30	5.62	8.85	21.75	61.93	87.47	121.11	183.07
	1:05:00	4.61	7.52	5.09	8.02	19.72	55.77	78.55	108.42	163.17
	1:10:00	3.79	6.21	4.19	6.63	16.44	46.91	66.40	92.15	139.75
	1:15:00	3.09	5.08	3.42	5.43	13.56	38.93	55.19	76.69	116.50
	1:20:00	2.37	3.92	2.62	4.20	10.63	30.99	44.16	61.68	94.32
	1:25:00	1.75	2.93	1.95	3.14	8.10	24.04	34.40	48.20	74.04
	1:30:00	1.27	2.12	1.41	2.27	5.96	18.05	25.97	36.55	56.57
	1:35:00	0.99	1.64	1.10	1.75	4.52	13.47	19.27	26.98	41.92
	1:40:00	0.82	1.35	0.90	1.44	3.68	10.78	15.34	21.37	32.84
	1:45:00	0.69	1.14	0.77	1.22	3.11	9.06	12.87	17.89	27.33
	1:50:00	0.61	1.00	0.67	1.07	2.71	7.87	11.15	15.46	23.52
	1:55:00	0.55	0.90	0.61	0.96	2.43	7.03	9.94	13.76	20.88
	2:00:00	0.51	0.83	0.56	0.89	2.23	6.43	9.08	12.55	18.99
	2:05:00	0.37	0.61	0.41	0.65	1.65	4.83	6.91	9.68	14.95
	2:10:00	0.27	0.45	0.30	0.48	1.20	3.49	4.98	6.97	10.78
	2:15:00	0.20	0.33	0.22	0.35	0.88	2.58	3.69	5.18	7.98
	2:20:00	0.15	0.24	0.16	0.26	0.66	1.92	2.75	3.84	5.92
	2:25:00	0.10	0.17	0.12	0.19	0.48	1.41	2.02	2.84	4.39
	2:30:00	0.07	0.12	0.08	0.13	0.34	1.02	1.46	2.06	3.19
	2:35:00	0.05	0.09	0.06	0.09	0.25	0.74	1.06	1.49	2.30
	2:40:00	0.03	0.06	0.04	0.06	0.17	0.52	0.75	1.06	1.66
	2:45:00	0.02	0.03	0.02	0.04	0.11	0.34	0.49	0.71	1.12
	2:50:00	0.01	0.02	0.01	0.02	0.06	0.20	0.29	0.42	0.68
	2:55:00	0.00	0.01	0.00	0.01	0.02	0.09	0.14	0.21	0.35
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.07	0.13
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

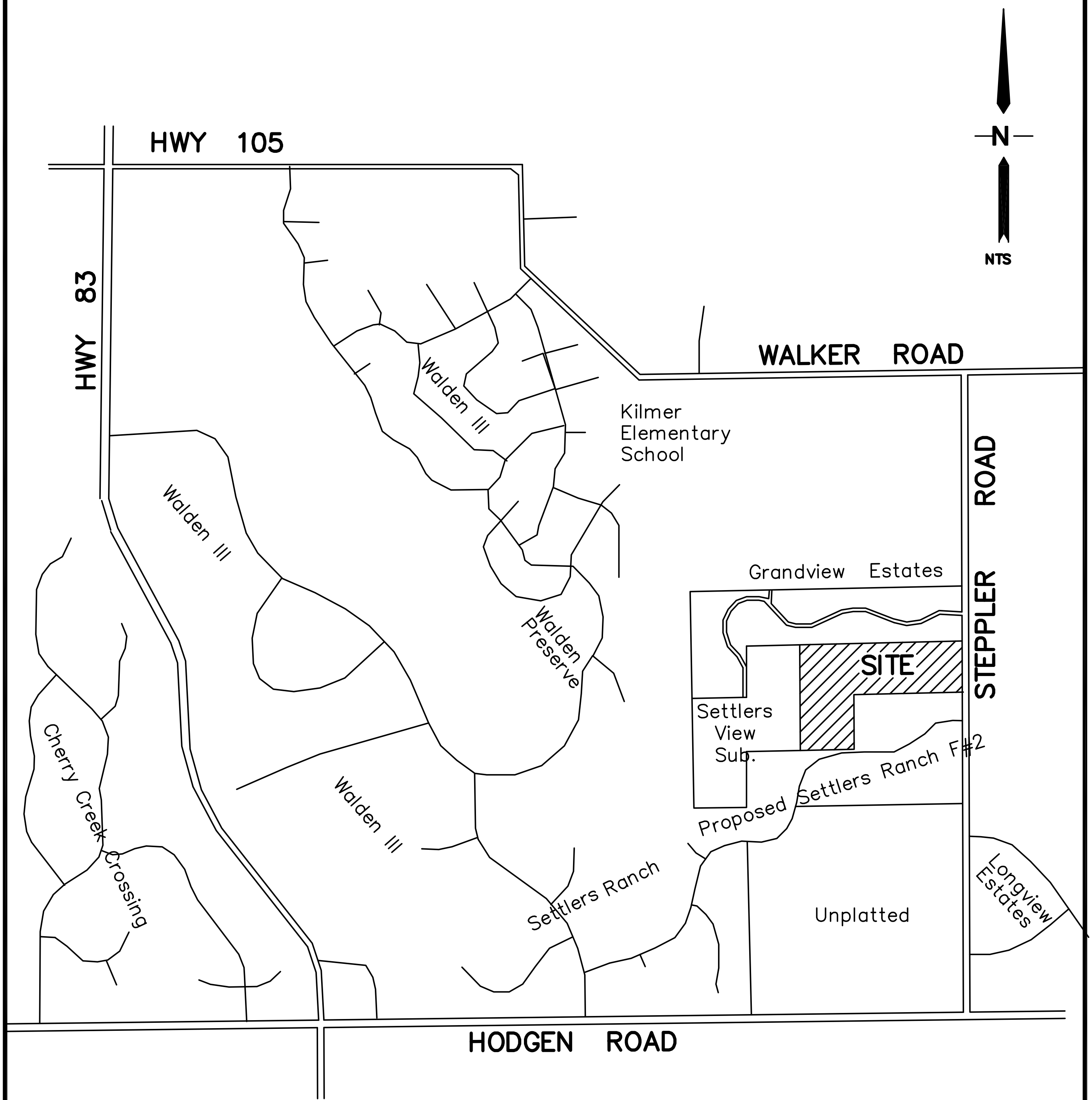
APPENDIX D

DRAINAGE COST ESTIMATE

ABERT RANCH DRAINAGE IMPROVEMENTS COST ESTIMATE					
Item No.	Description	Quantity	Unit	Unit Cost ($$$)	Total Cost ($$$)
	PRIVATE DRAINAGE IMPROVEMENTS				
506	Riprap Aprons (d_{50} = 12")	30	CY	$98	$2,940
603	48" RCP Pond Discharge Pipe w/ FES	80	LF	$178	$14,240
604	Detention Pond Forebay	1	EA	$3,000	$3,000
604	Detention Pond Outlet Structure	1	LS	$8,000	$8,000
604	Detention Pond Spillway	1	LS	$3,000	$3,000
	SUBTOTAL				**$31,180**
	Contingency @ 15%				$4,677
	TOTAL				**$35,857**
	PUBLIC DRAINAGE IMPROVEMENTS (NON-REIMBURSABLE)				
506	Riprap Culvert Aprons (d_{50} = 12")	15	CY	$98	$1,470
603	18" RCP Culvert w/ FES	128	LF	$69	$8,832
603	30" RCP Culvert w/ FES	64	LF	$94	$6,016
	SUBTOTAL				**$16,318**
	Contingency @ 15%				$2,448
	TOTAL				**$18,766**
	TOTAL DRAINAGE IMPROVEMENTS				**$54,623**

APPENDIX E

FIGURES



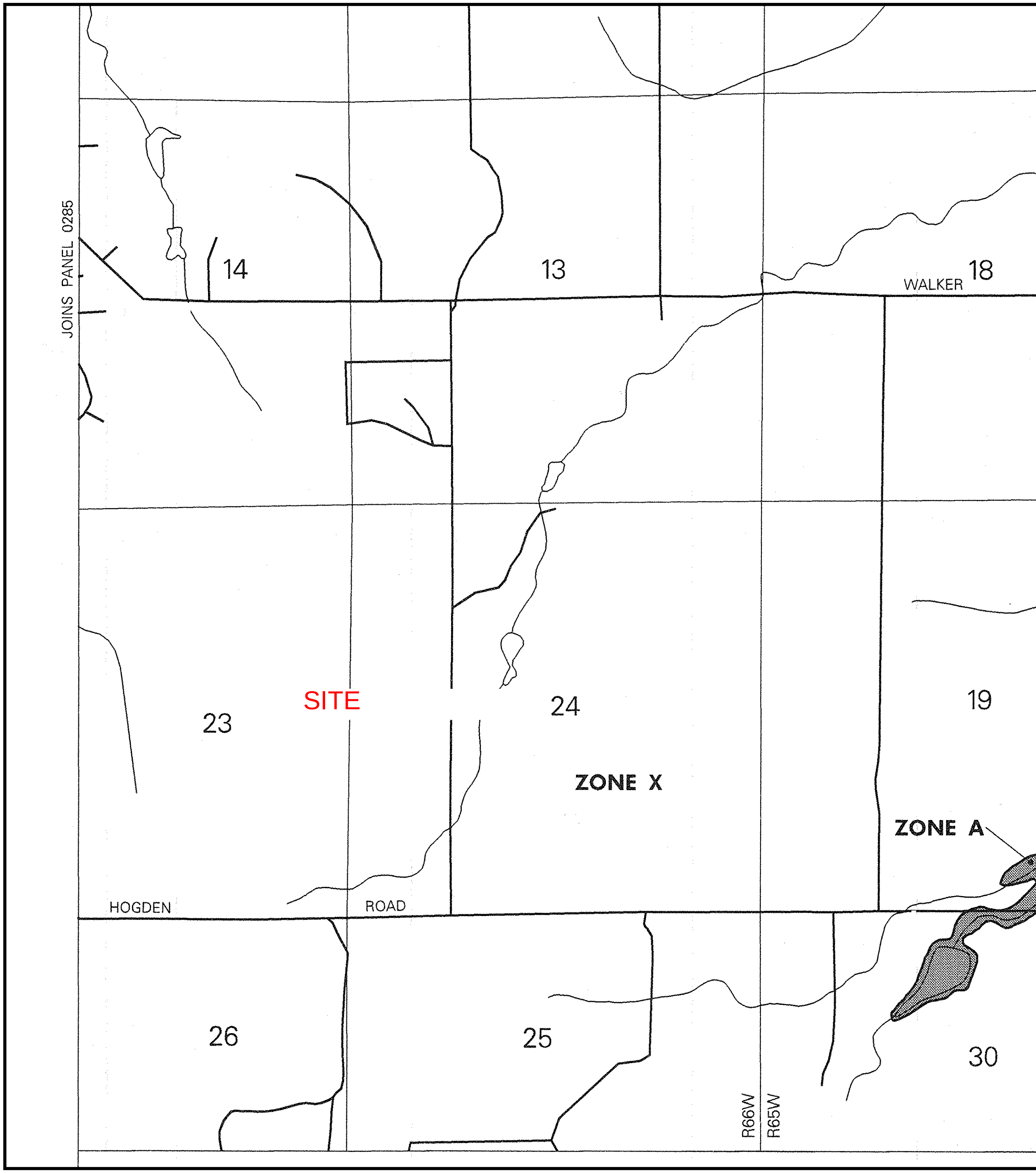
VICINITY MAP

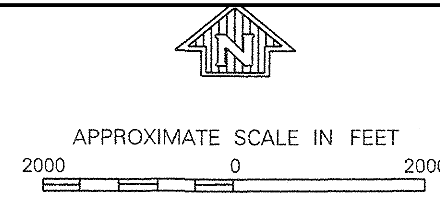
JPS ENGINEERING

ABERT RANCH

FIGURE A1

JPS PROJ NO. 111604





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

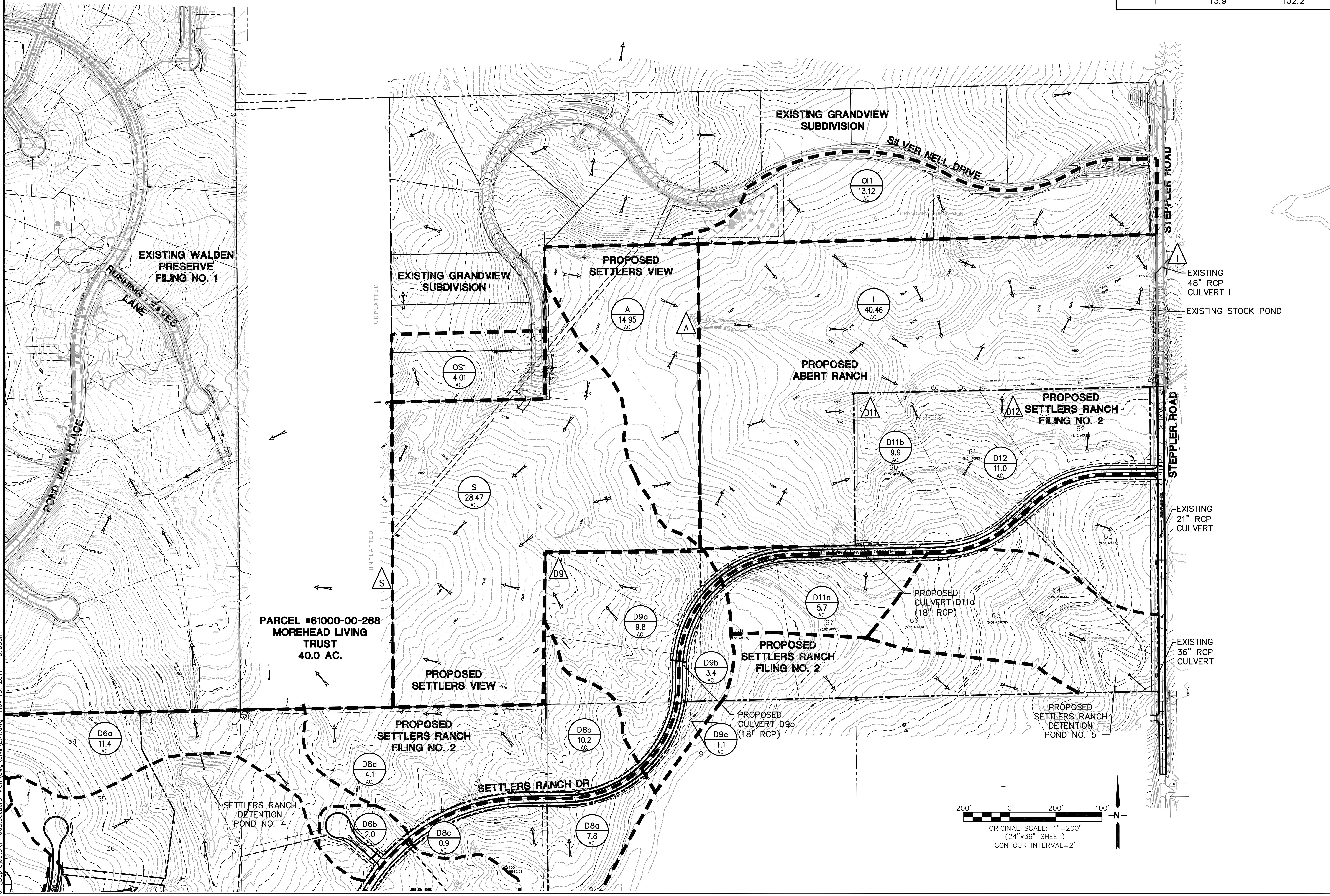
EFFECTIVE DATE:
MARCH 17, 1997

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

SUMMARY HYDROLOGY TABLE

DESIGN POINT	Q_5 (CFS)	Q_{100} (CFS)
A	3.0	21.6
S	10.0	73.1
I	13.9	102.2



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Colorado Springs, CO 80903

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

CALL UTILITY NOTIFICATION CENTER OF COLORADO
1-800-922-1987
CALL 2-BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

NO.	REVISION	BY	DATE

SETTLERS VIEW & ABERT RANCH

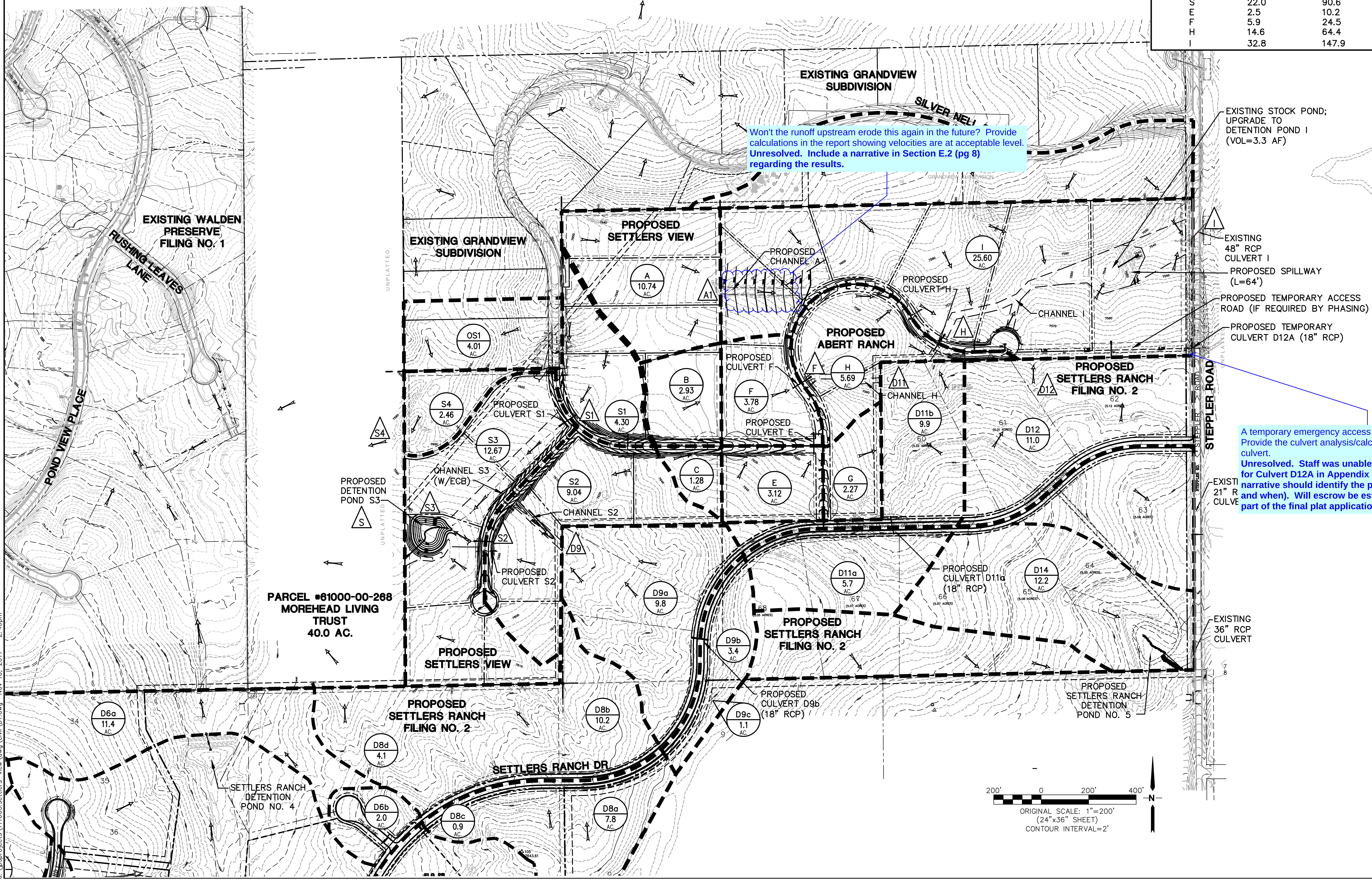
HISTORIC DRAINAGE PLAN

HORZ. SCALE:	1"=200'	DRAWN:	BJJ
VERT. SCALE:	N/A	DESIGNED:	JPS
SURVEYED:	HANNIGAN	CHECKED:	JPS
CREATED:	2/14/17	LAST MODIFIED:	11/16/17
PROJECT NO:	111603	MODIFIED BY:	BJJ

SHEET: EX1

SUMMARY HYDROLOGY TABLE

DESIGN POINT	Q_5 (CFS)	Q_{100} (CFS)
A1	7.6	31.2
D11	6.0	28.8
D12	4.6	21.9
S1	2.3	9.3
S2	12.7	52.5
S3	19.0	78.1
S4	2.8	13.7
S	22.0	90.6
E	2.5	10.2
F	5.9	24.5
H	14.6	64.4
I	32.8	147.9



Won't the runoff upstream erode this again in the future? Provide calculations in the report showing velocities are at acceptable level.
Unresolved. Include a narrative in Section E.2 (pg 8) regarding the results.

A temporary emergency access is required at this location. Provide the culvert analysis/calculations for the temporary culvert.
Unresolved. Staff was unable to locate the calculations for Culvert D12A in Appendix B nor a narrative. The narrative should identify the plan for the removal (who and when). Will escrow be established for the removal as part of the final plat application?

SETTLERS VIEW & ABERT RANCH

DEVELOPED DRAINAGE PLAN

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REVISION	BY	DATE

HORZ. SCALE: 1"=200'	DRAWN: BJJ
VERT. SCALE: N/A	DESIGNED: JPS
SURVEYED: HANNIGAN	CHECKED: JPS
CREATED: 12/26/16	LAST MODIFIED: 11/16/17
PROJECT NO: 111603	MODIFIED BY: BJJ
SHEET:	D1

J:\jpsprojects\111603.settlers-view\dwg\civil\D1.dwg Nov 16, 2017 - 2:46pm

SUMMARY HYDROLOGY TABLE		
DESIGN POINT	Q_5 (CFS)	Q_{100} (CFS)
F	5.9	24.5
H	14.6	64.4
I	32.8	147.9

DATUM IS NAVD '88. BENCHMARK IS THE MONUMENT AT THE SOUTHWEST PROPERTY CORNER, HAVING AN ELEVATION OF 7650.0

ORIGINAL SCALE: 1"=100'
(24"x36" SHEET)
CONTOUR INTERVAL=2'

J:\jpsprojects\111604.abert-ranch\dwg\civil\D1.1.dwg Nov 16, 2017 - 4:28pm

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1-800-922-1987
CALL 2-BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE, OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

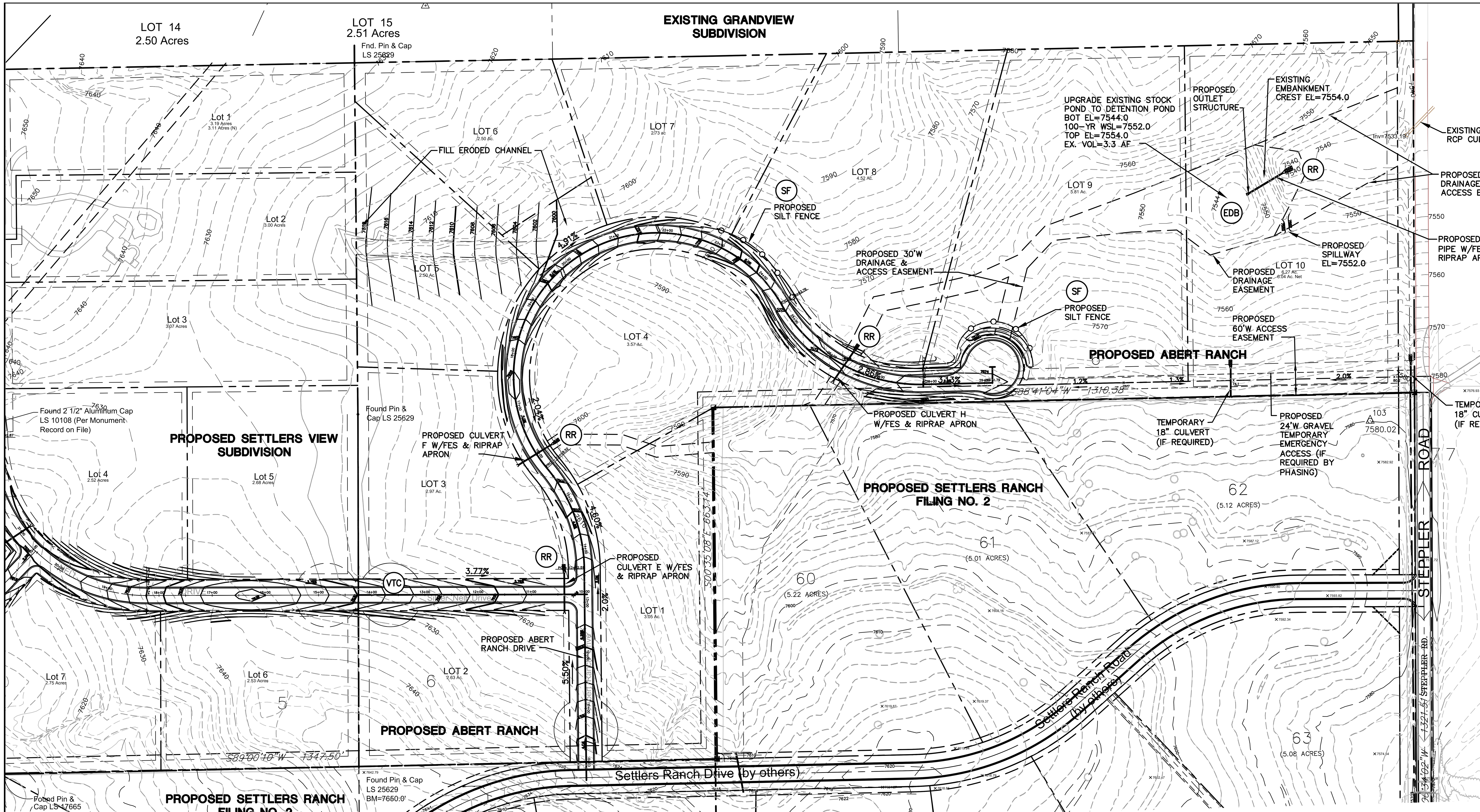
NO.	REVISION	BY	DATE

ABERT RANCH

DEVELOPED DRAINAGE PLAN

HORZ. SCALE:	1"=100'	DRAWN:	BJJ
VERT. SCALE:	N/A	DESIGNED:	JPS
SURVEYED:	HANNIGAN	CHECKED:	JPS
CREATED:	12/27/16	LAST MODIFIED:	11/16/17
PROJECT NO:	111604	MODIFIED BY:	BJJ

SHEET: D1.1



DATUM IS NAVD '88. BENCHMARK IS THE MONUMENT AT THE SOUTHWEST PROPERTY CORNER, HAVING AN ELEVATION OF 7650.0

100' 0 100' 200'

ORIGINAL SCALE: 1"=100'
(24"x36" SHEET)
CONTOUR INTERVAL = 2'

LEGEND:

NEW/EXISTING
SECTION LINE – NEW/EXISTING
EASEMENT LINE – NEW/EXISTING
CONTOUR – NEW/EXISTING
PROPERTY LINE – NEW/EXISTING
FENCE – NEW/EXISTING
OVERHEAD ELECTRIC LINE W/ POWER POLE NEW/EXISTING
UNDERGROUND ELECTRIC LINE NEW/EXISTING
UNDERGROUND ELECTRIC – NEW/EXISTING
TELEPHONE – NEW/EXISTING
GAS – NEW/EXISTING
WATER – NEW/EXISTING
SECTION NUMBER
SHEET ON WHICH SECTION IS SHOWN

EROSION CONTROL:

RR RIPRAP
VTC VEHICLE TRACKING PAD
SF SILT FENCE
EDB EXTENDED DETENTION BASIN

PCD FILE NO. SP-17-007

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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
1	COUNTY SUBMITTAL	JPS	3/28/17
2	COUNTY COMMENTS	JPS	11/16/17

ABERT RANCH

PRELIMINARY GRADING & EROSION CONTROL PLAN

HORZ. SCALE: 1"=100'	DRAWN: BJJ
VERT. SCALE: N/A	DESIGNED: JPS
SURVEYED: RAMPART	CHECKED: JPS
CREATED: 12/27/16	LAST MODIFIED: 11/16/17
PROJECT NO: 111604	MODIFIED BY: BJJ
SHEET:	C1

J:\jpsprojects\111604.abert-ranch\dwg\civil\C1.dwg Nov 16, 2017 - 3:12pm