

# FINAL DRAINAGE REPORT

for

## ABERT RANCH SUBDIVISION

Rename to  
Preliminary  
Drainage Report.

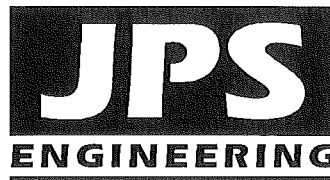
Prepared for:

**Hannigan and Associates, Inc.**  
19360 Spring Valley Road  
Monument, Colorado 80132

March 27, 2017

The Stormwater Detention and Infiltration (SDI) design data sheet and EPC MS4 post construction form (attached) will be required with the final plat application.

Prepared by:



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Include the riprap sizing calculations for the culvert and pond outlet.

JPS Project No. 111604

Add: PCD File No.: SP-17-007

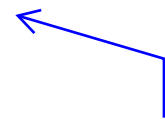
**ABERT RANCH SUBDIVISION  
FINAL DRAINAGE REPORT  
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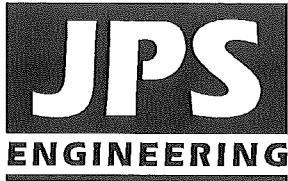
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Extract the O&M Manual from the drainage report. This item will be a required standalone submittal document with the final plat application.





## ABERT RANCH SUBDIVISION– FINAL DRAINAGE REPORT EXECUTIVE SUMMARY

### A. Background

- Abert Ranch is a proposed residential subdivision of a 40.4-acre parcel located northwest of Hodgen Road and Stepler 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:

Remove "City"

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 City/County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for liability caused by negligent acts, errors or omissions on my part in preparing this report.

---

John P. Schwab, P.E. #29891

Developer's Statement:

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

By:

---

Printed Name:

Date

Type the name, title, business name and address.

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.  
County Engineer / ECM Administrator

Date

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

Remove the FDR. The applicant has only submitted for preliminary plan.

## **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 Stepler Road, as shown in Figure A1 (Appendix F). 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 and Final Drainage Report (FDR) for submittal with the Preliminary Plan and Final Plat applications. The report provides a summary of site drainage issues impacting the proposed development, including analysis of impacts from upstream drainage areas, site-specific developed drainage patterns, and impacts on downstream facilities. This FDR report has been prepared based on the guidelines and criteria presented in the El Paso County Drainage Criteria Manual.

### **C. Site Location and Description**

The 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-foot 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 F).

### **C. Sub-Basin Description**

The existing drainage basins lying in and around the proposed development are depicted in Figure EX1 (Appendix F). 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.

Update the 4 step process based on the steps identified in Appendix I Section I.7.2 which are different from the city.

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

- **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 3: 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 4: Implement Site Specific and Other Source Control 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 Stepler 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)

Discuss the emergency overflow condition. Is it overtopping Stepler Road? If so what is the depth on the road.

**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 #1 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 #1	3.3	48-inch RCP w/ multiple orifices

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 E, 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**

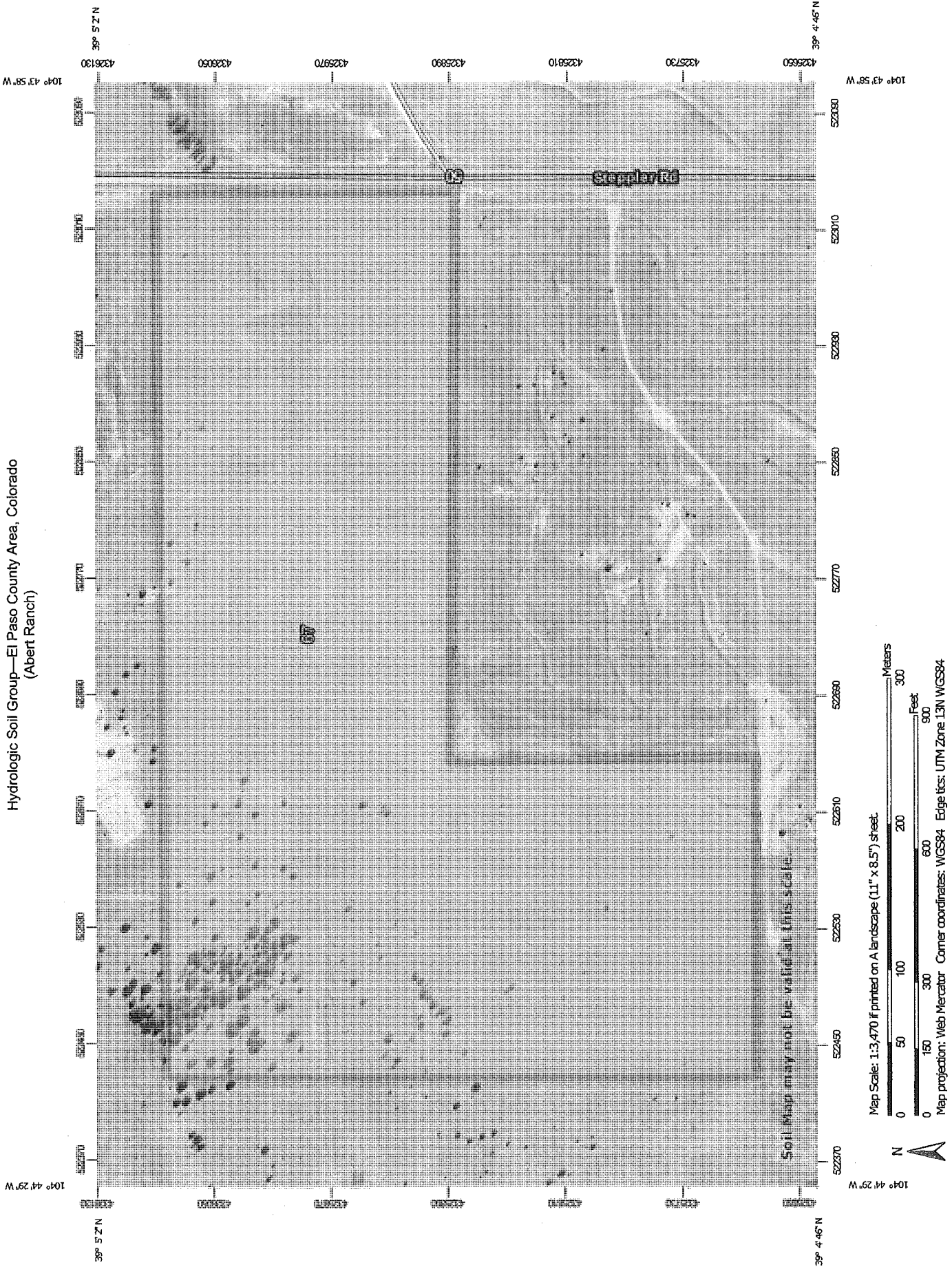
Abert Ranch is a proposed residential subdivision consisting of 10 lots on a 40.4-acre parcel located between Grandview Subdivision and Settlers Ranch Subdivision on the west side of Stepler Road in northeastern El Paso County. Development of the proposed Abert Ranch Subdivision will generate an increase 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**



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



Soil Map may not be valid at this scale.

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

*Tie-break Rule: Higher*

## 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 ACI	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

## 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
- 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.



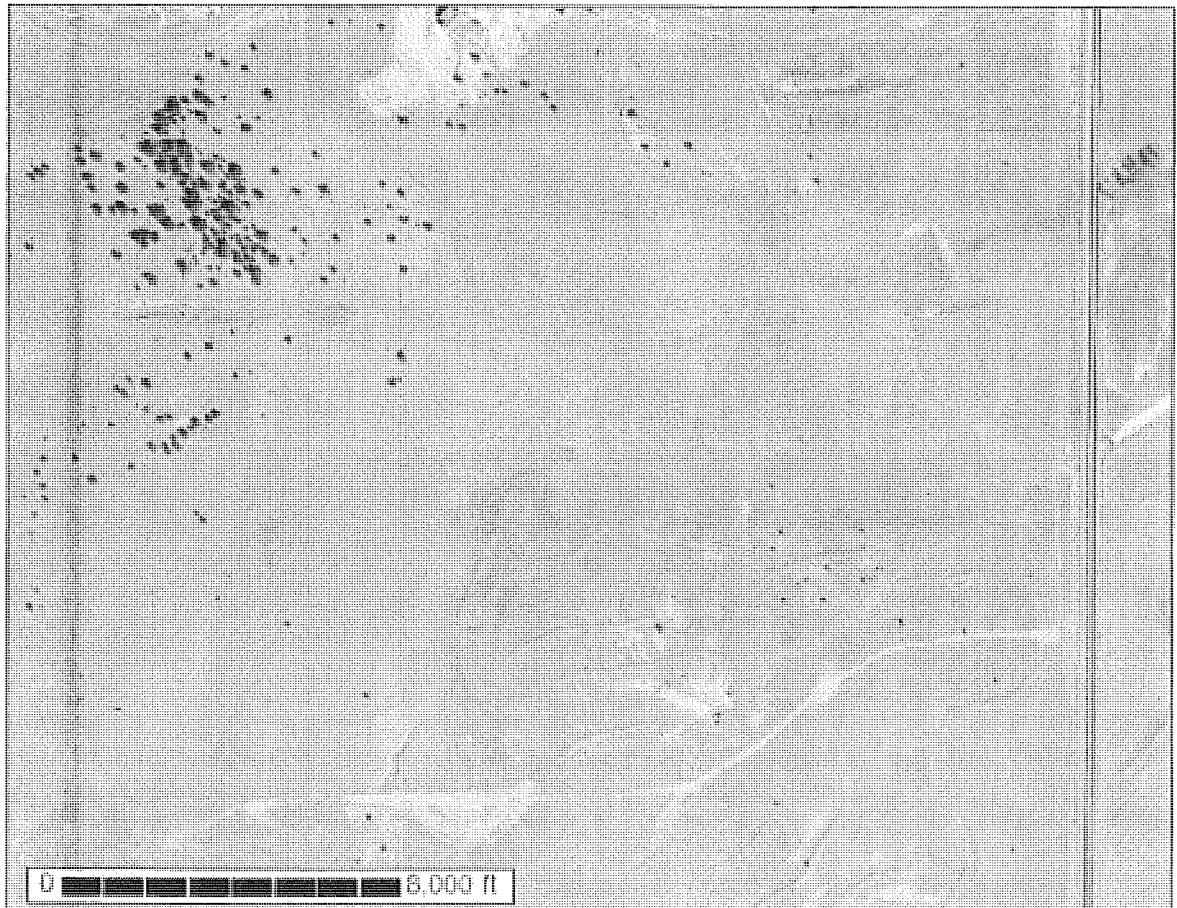
United States  
Department of  
Agriculture

**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**



# Preface

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

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

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

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

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

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

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# How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

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

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

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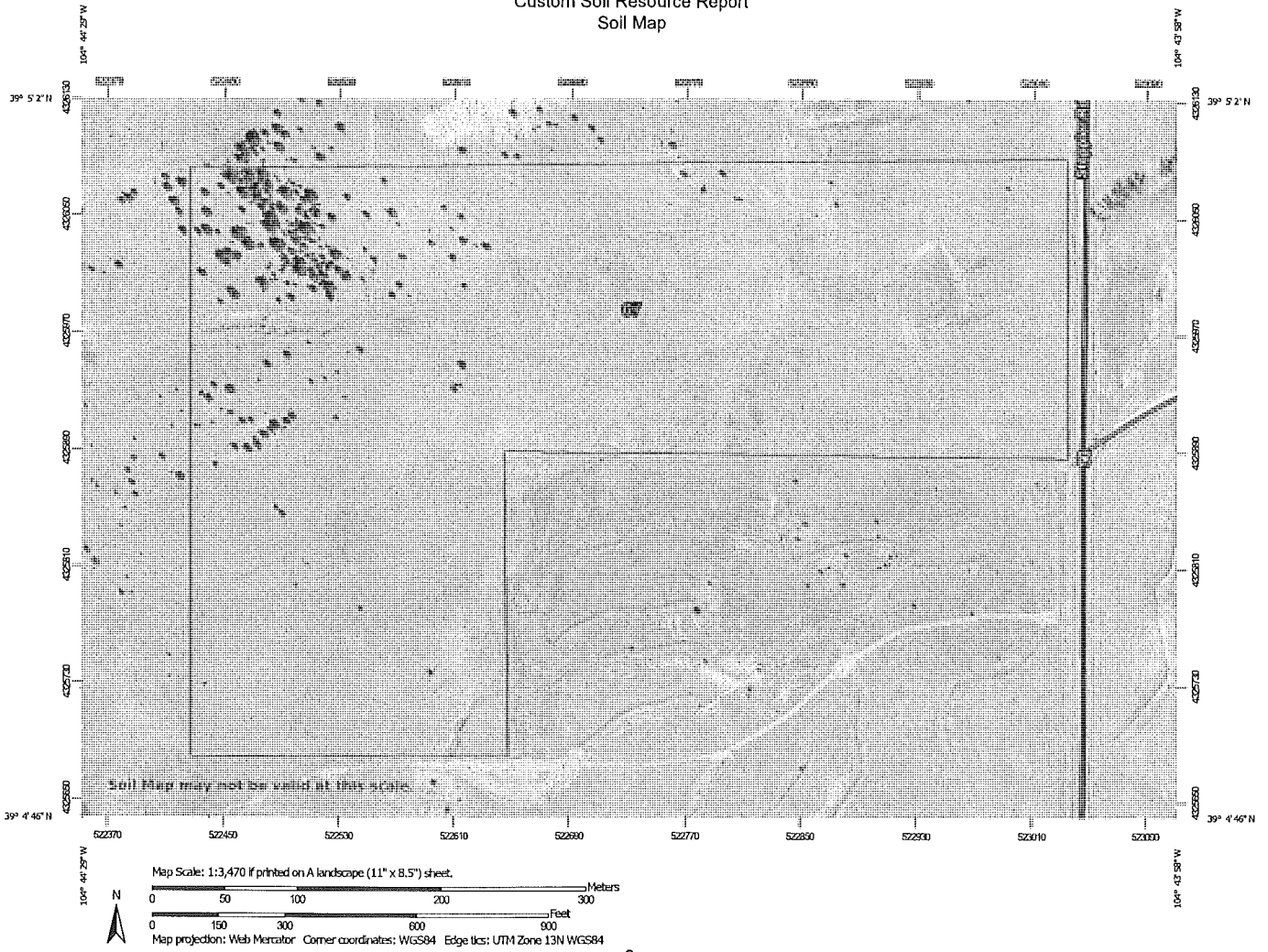
identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

## Soil Map

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



































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

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Soil Map



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**MAP LEGEND**

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

**MAP INFORMATION**

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

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

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

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

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

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

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

Soil Survey Area: El Paso County Area, Colorado  
 Survey Area Data: Version 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,

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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

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**Pleasant**

*Percent of map unit:*

*Landform:* Depressions

*Hydric soil rating:* Yes

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

Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
<b>Business</b>													
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
<b>Residential</b>													
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
<b>Industrial</b>													
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
<b>Parks and Cemeteries</b>													
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
<b>Undeveloped Areas</b>													
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
<b>Streets</b>													
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
<b>Drive and Walks</b>													
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.

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

Where:

$t_c$  = time of concentration (min)

$t_i$  = overland (initial) flow time (min)

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

### 3.2.1 Overland (Initial) Flow Time

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

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

Where:

$t_i$  = overland (initial) flow time (min)

$C_5$  = runoff coefficient for 5-year frequency (see Table 6-6)

$L$  = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)

$S$  = average basin slope (ft/ft)

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

### 3.2.2 Travel Time

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

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

Where:

$V$  = velocity (ft/s)

$C_v$  = conveyance coefficient (from Table 6-7)

$S_w$  = watercourse slope (ft/ft)

**Table 6-7. Conveyance Coefficient,  $C_v$** 

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

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

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

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

### 3.2.3 First Design Point Time of Concentration in Urban Catchments

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

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

Where:

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

$L$  = waterway length (ft)

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

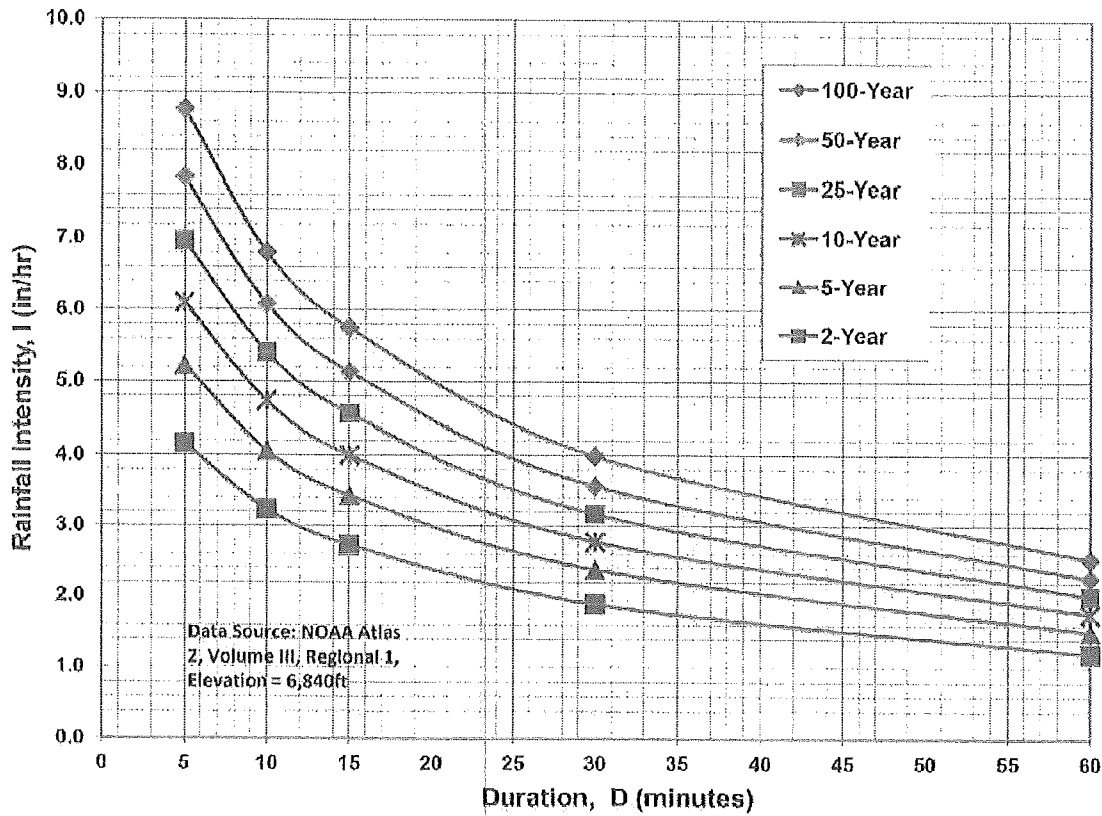
### 3.2.4 Minimum Time of Concentration

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		Overland Flow			Channel flow				TOTAL		PEAK FLOW			
			5-YEAR <sup>(1)</sup>	100-YEAR <sup>(1)</sup>	LENGTH (FT)	SLOPE (FT/FT)	T <sub>co</sub> <sup>(1)</sup> (MIN)	CHANNEL LENGTH (FT)	CONVEYANCE COEFFICIENT C	SLOPE (FT/FT)	SCS <sup>(2)</sup> VELOCITY (FT/S)	T <sub>t</sub> <sup>(3)</sup> (MIN)	T <sub>c</sub> <sup>(4)</sup> (MIN)	5-YR (IN/HR)	100-YR (IN/HR)	Q <sub>5</sub> <sup>(6)</sup> (CFS)	Q <sub>100</sub> <sup>(6)</sup> (CFS)
A (SETTLERS VIEW)	A	14.95	0.080	0.350	750	0.048	30.3	0						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	4.5	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	2.94	4.94	2.59	19.01
O11 (GRANDVIEW)	O11	13.12	0.080	0.350	300	0.020	25.7	1750	15.00	0.042	3.07	9.5	35.2	2.24	3.76	2.35	17.28
I		40.45	0.080	0.350	0		0.0	1300	15.00	0.0338	2.76	7.9	7.9	4.49	7.54		
A, D11, D12, O11, I	I	95.13	0.080	0.350									46.3	1.83	3.07	13.92	102.18

1) OVERLAND FLOW T<sub>co</sub> = (0.395\*(1.1-RUNOFF COEFFICIENT)\*(OVERLAND FLOW LENGTH\*(0.5)/(SLOPE)<sup>0.333</sup>))

2) SCS VELOCITY = C \* ((SLOPE/(FT/FT))<sup>0.5</sup>)

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 = LV (WHEN CHANNEL VELOCITY IS KNOWN)

4) T<sub>c</sub> = T<sub>co</sub> + T<sub>t</sub>

\*\*\* 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

$$I_5 = -1.5 * \ln(T_c) + 7.583$$

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

$$Q = C_i A$$

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	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	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
O11	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,O11,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
O11	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,O11,I	95.13										0.403

ABERT RANCH SUBDIVISION  
RATIONAL METHOD

DEVELOPED FLOWS

Revise to DP D12

BASIN	DESIGN POINT	AREA (AC)	C			Overland Flow			Channel flow				INTENSITY <sup>(6)</sup>			PEAK FLOW		
			5-YEAR <sup>(7)</sup>	100-YEAR <sup>(7)</sup>	T <sub>co</sub> <sup>(1)</sup>	LENGTH (FT)	SLOPE (FT/FT)	T <sub>co</sub> <sup>(1)</sup> (MIN)	CHANNEL LENGTH (FT)	CONVEYANCE C	SLOPE (FT/FT)	SCS <sup>(2)</sup> VELOCITY (FT/S)	T <sub>t</sub> <sup>(3)</sup> (MIN)	T <sub>c</sub> <sup>(4)</sup> (MIN)	TOTAL T <sub>c</sub> <sup>(4)</sup> (MIN)	5-YR (IN/HR)	100-YR (IN/HR)	Q <sub>5</sub> <sup>(6)</sup> (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	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	F	3.78	0.170	0.417	0.0			400	15.00	0.048	3.27	2.0	2.0					
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			300	15.00	0.067	3.87	1.3	1.3	5.17	8.68	1.99	8.22	
D11 (SETT. RANCH)	D11	15.90	0.137	0.393	300	0.037	19.8	1100	15.00	0.072	4.02	4.6	24.3	2.80	4.69	5.98	28.78	
H		5.69	0.170	0.417	0			300	15.00	0.077	4.15	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	2.99	5.01	5.45	22.44	
D12 (SETT. RANCH)	D11	11.00	0.137	0.393	300	0.040	19.2	450	15.00	0.089	4.47	1.7	20.9	3.02	5.07	4.55	21.93	
O11 (GRANDVIEW)	O11	13.12	0.137	0.393	300	0.020	24.2	1750	15.00	0.042	3.07	9.5	33.7	2.31	3.87	4.14	19.95	
I		25.60	0.149	0.401	0			2100	15.00	0.035	2.81	12.4	12.4					
DPH+A,D12,O11,I	I	95.13	0.150	0.403								33.9	33.9	2.30	3.86	32.81	147.90	

1) OVERLAND FLOW T<sub>co</sub> = (0.395\*(1.1-RUNOFF COEFFICIENT)\*(OVERLAND FLOW LENGTH<sup>(0.5)</sup>)/(SLOPE<sup>(0.333)</sup>)

2) SCS VELOCITY = C \* ((SLOPE(FT/FT)<sup>0.5</sup>)

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 = LV (WHEN CHANNEL VELOCITY IS KNOWN)

4) T<sub>c</sub> = T<sub>co</sub> + T<sub>t</sub>

\*\*\* 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<sub>5</sub> = -1.5 \* ln(Tc) + 7.583

I<sub>100</sub> = -2.52 \* ln(Tc) + 12.735

6) Q = C<sub>i</sub>A

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	<b>GRASS / ECB</b>
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	<b>GRASS / ECB</b>
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)

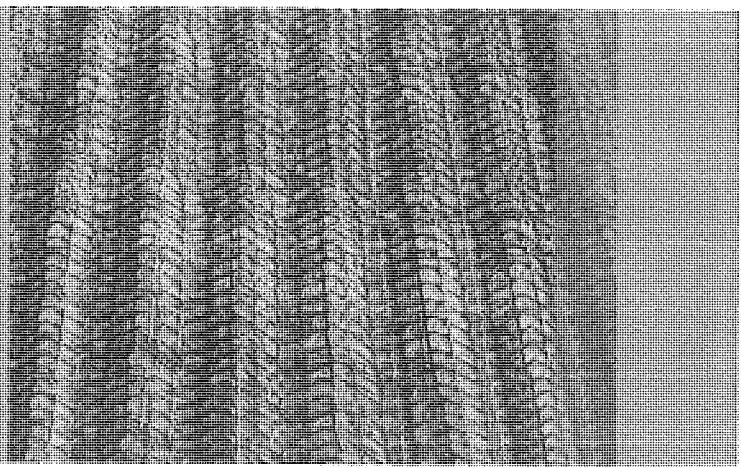
ABERT RANCH  
CHANNEL CALCULATIONS  
DEVELOPED FLOWS

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
<b>Longevity</b>	45 days	60 days	12 mo.	12 mo.	24 mo.	36 mo.	12 mo.
<b>Applications</b>	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
<b>Design Permissible Shear Stress</b> lbs/ft <sup>2</sup> (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)
<b>Design Permissible Velocity</b> 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)
<b>Top Net</b>	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft <sup>2</sup> (0.73 kg/100 m <sup>2</sup> ) approx wt	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft <sup>2</sup> (0.73 kg/100 m <sup>2</sup> ) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft <sup>2</sup> (0.73 kg/100 m <sup>2</sup> ) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft <sup>2</sup> (0.73 kg/100 m <sup>2</sup> ) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft <sup>2</sup> (1.47 kg/100 m <sup>2</sup> ) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft <sup>2</sup> (1.47 kg/100 m <sup>2</sup> ) approx wt	Leno woven, 100% biodegradable jute fiber 9.30 lbs/1000 ft <sup>2</sup> (4.53 kg/100 m <sup>2</sup> ) approx wt
<b>Center Net</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Fiber Matrix</b>	Straw fiber 0.50 lbs/yd <sup>2</sup> (0.27 kg/m <sup>2</sup> )	Straw fiber 0.50 lbs/yd <sup>2</sup> (0.27 kg/m <sup>2</sup> )	Straw fiber 0.50 lbs/yd <sup>2</sup> (0.27 kg/m <sup>2</sup> )	Straw fiber 0.50 lbs/yd <sup>2</sup> (0.27 kg/m <sup>2</sup> )	Straw/coconut matrix 70% Straw 0.35 lbs/yd <sup>2</sup> (0.19 kg/m <sup>2</sup> ) 30% Coconut 0.15 lbs/yd <sup>2</sup> (0.08 kg/m <sup>2</sup> )	Coconut fiber 0.50 lbs/yd <sup>2</sup> (0.27 kg/m <sup>2</sup> )	Straw fiber 0.50 lbs/yd <sup>2</sup> (0.27 kg/m <sup>2</sup> )
<b>Bottom Net</b>	N/A	Lightweight accelerated photodegradable polypropylene 1.50 lbs/1000 ft <sup>2</sup> (0.73 kg/100 m <sup>2</sup> ) approx wt	N/A	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft <sup>2</sup> (0.73 kg/100 m <sup>2</sup> ) approx wt	Lightweight photodegradable polypropylene 1.50 lbs/1000 ft <sup>2</sup> (0.73 kg/100 m <sup>2</sup> ) approx wt	Heavyweight UV-stabilized polypropylene 2.9 lbs/1000 ft <sup>2</sup> (1.47 kg/100 m <sup>2</sup> ) approx wt	N/A
<b>Thread</b>	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: Ditch Analysis

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.5109 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.7557 lb/ft<sup>2</sup>

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

Notes: Ditch Analysis

### 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.5036 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.8369 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.6602 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 1.0046 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.3356 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.4274 lb/ft<sup>2</sup>



## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 1.7692 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.9163 lb/ft<sup>2</sup>

## 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<sup>2</sup>

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<sup>2</sup>

Calculated Avg Shear Stress: 0.4596 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.3356 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.9855 lb/ft<sup>2</sup>

## 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<sup>2</sup>  
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<sup>2</sup>  
Calculated Avg Shear Stress: 0.6877 lb/ft<sup>2</sup>

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 Elevation (ft)	Total Discharge (cfs)	Culvert E Discharge (cfs)	Roadway Discharge (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 Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2.50	2.50	7613.83	0.828	0.0*	1-S2n	0.494	0.596	0.499	0.176	4.847	3.022
3.75	3.75	7614.05	1.050	0.265	1-S2n	0.617	0.740	0.617	0.222	5.472	3.461
5.00	5.00	7614.24	1.239	0.509	1-S2n	0.727	0.856	0.727	0.261	5.896	3.799
6.25	6.25	7614.42	1.416	0.779	1-S2n	0.832	0.961	0.832	0.296	6.209	4.080
7.50	7.50	7614.60	1.602	1.078	5-S2n	0.936	1.057	0.936	0.327	6.469	4.319
8.75	8.75	7614.81	1.806	1.579	5-S2n	1.046	1.141	1.048	0.356	6.643	4.530
10.00	10.00	7615.04	2.040	1.892	5-S2n	1.172	1.218	1.172	0.383	6.763	4.718
10.20	10.20	7615.08	2.080	1.945	5-S2n	1.194	1.229	1.194	0.387	6.774	4.747
12.50	12.50	7615.61	2.609	2.599	7-M2c	1.500	1.333	1.333	0.432	7.533	5.046
13.75	12.84	7615.71	2.696	2.710	7-M2c	1.500	1.345	1.345	0.455	7.682	5.191
15.00	12.88	7615.73	2.707	2.727	7-M2c	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

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**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 Surface 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 (1:1)

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 Elevation (ft)	Total Discharge (cfs)	Culvert F Discharge (cfs)	Roadway Discharge (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 Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
5.90	5.90	7605.37	1.367	0.0*	1-S2n	0.803	0.934	0.807	0.360	6.089	3.008
8.81	8.81	7605.82	1.817	1.593	5-S2n	1.052	1.144	1.054	0.448	6.650	3.395
11.72	11.72	7606.42	2.416	2.300	7-M2c	1.500	1.302	1.302	0.522	7.193	3.691
14.63	13.72	7607.01	2.938	3.009	7-M2c	1.500	1.374	1.374	0.586	8.092	3.934
17.54	13.81	7607.04	2.964	3.043	7-M2c	1.500	1.376	1.376	0.644	8.135	4.142
20.45	13.89	7607.07	2.985	3.069	7-M2c	1.500	1.378	1.378	0.697	8.171	4.325
23.36	13.95	7607.09	3.003	3.090	7-M2c	1.500	1.380	1.380	0.745	8.201	4.488
24.50	13.98	7607.10	3.012	3.098	7-M2c	1.500	1.381	1.381	0.764	8.216	4.548
29.18	14.05	7607.13	3.034	3.127	7-M2c	1.500	1.383	1.383	0.834	8.253	4.772
32.09	14.10	7607.14	3.048	3.144	7-M2c	1.500	1.384	1.384	0.874	8.278	4.898
35.00	14.15	7607.16	3.062	3.161	7-M2c	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 Surface 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 Elevation (ft)	Total Discharge (cfs)	Culvert H Discharge (cfs)	Roadway Discharge (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 Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
14.60	14.60	7570.83	1.835	0.892	1-S2n	1.026	1.287	1.049	0.226	7.462	3.090
21.14	21.14	7571.28	2.276	1.434	1-S2n	1.270	1.560	1.300	0.282	8.194	3.554
27.68	27.68	7571.73	2.726	2.034	5-S2n	1.503	1.792	1.536	0.330	8.756	3.930
34.22	32.26	7572.08	3.083	2.774	5-S2n	1.671	1.932	1.699	0.375	9.093	4.250
40.76	32.91	7572.14	3.138	2.832	5-S2n	1.696	1.950	1.723	0.415	9.133	4.532
47.30	33.39	7572.18	3.179	2.876	5-S2n	1.714	1.964	1.741	0.453	9.163	4.785
53.84	33.81	7572.22	3.216	2.914	5-S2n	1.730	1.975	1.756	0.489	9.187	5.013
60.38	34.18	7572.25	3.248	2.948	5-S2n	1.744	1.985	1.770	0.523	9.208	5.226
64.40	34.39	7572.27	3.266	2.967	5-S2n	1.752	1.991	1.778	0.543	9.220	5.348
73.46	34.83	7572.31	3.305	3.008	5-S2n	1.769	2.002	1.794	0.587	9.244	5.604
80.00	35.12	7572.33	3.332	3.036	5-S2n	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 Surface 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 (1:1)

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

## **APPENDIX C**

### **DETENTION POND CALCULATIONS**

ABERT RANCH SUBDIVISION COMPOSITE IMPERVIOUS AREAS											
IMPERVIOUS AREAS											
BASIN	TOTAL AREA (AC)	(AC)	SUB-AREA 1 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	AREA (AC)	SUB-AREA 2 DEVELOPMENT/ COVER	PERCENT IMPERVIOUS	(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
O11	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.O11.I	95.13										8.632

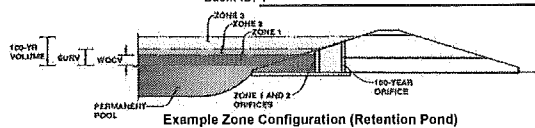


# DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD- Detention, Version 3.07 (February 2017)

Project: **ABERT RANCH**

Basin ID: **I**



**Example Zone Configuration (Retention Pond)**

### Required Volume Calculation

Selected BMP Type =		<b>EDB</b>
Watershed Area =	<b>95.10</b>	acres
Watershed Length =	<b>2,900</b>	ft
Watershed Slope =	<b>0.041</b>	ft/ft
Watershed Imperviousness =	<b>8.60%</b>	percent
Percentage Hydrologic Soil Group A =	<b>0.0%</b>	percent
Percentage Hydrologic Soil Group B =	<b>100.0%</b>	percent
Percentage Hydrologic Soil Groups C/D =	<b>0.0%</b>	percent
Desired WQCV Drain Time =	<b>40.0</b>	hours
Location for 1-hr Rainfall Depths = User Input		
Water Quality Capture Volume (WQCV) =	<b>0.466</b>	acre-feet
Excess Urban Runoff Volume (EURV) =	<b>0.759</b>	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	<b>0.514</b>	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	<b>0.810</b>	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	<b>1.991</b>	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	<b>5.595</b>	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	<b>7.841</b>	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	<b>10.774</b>	acre-feet
600-yr Runoff Volume (P1 = 3.07 in.) =	<b>16.086</b>	acre-feet
Approximate 2-yr Detention Volume =	<b>0.477</b>	acre-feet
Approximate 5-yr Detention Volume =	<b>0.759</b>	acre-feet
Approximate 10-yr Detention Volume =	<b>1.696</b>	acre-feet
Approximate 25-yr Detention Volume =	<b>2.410</b>	acre-feet
Approximate 50-yr Detention Volume =	<b>2.510</b>	acre-feet
Approximate 100-yr Detention Volume =	<b>3.272</b>	acre-feet

Optional User Override 1-hr Precipitation	
<b>1.19</b>	inches
<b>1.50</b>	inches
<b>1.75</b>	inches
<b>2.00</b>	inches
<b>2.25</b>	inches
<b>2.52</b>	inches
<b>3.07</b>	inches

### Stage-Storage Calculation

Zone 1 Volume (WQCV) =	<b>0.466</b>	acre-feet
Zone 2 Volume (100-year Zone 1) =	<b>2.805</b>	acre-feet
Select Zone 3 Storage Volume (Optional) =	<b>0.000</b>	acre-feet
<b>Total Detention Basin Volume =</b>	<b>3.272</b>	<b>acre-feet</b>
Initial Surcharge Volume (ISV) =	<b>user</b>	ft <sup>3</sup>
Initial Surcharge Depth (ISD) =	<b>user</b>	ft
<b>Total Available Detention Depth (H<sub>total</sub>) =</b>	<b>user</b>	<b>ft</b>
Depth of Trickle Channel (H <sub>tc</sub> ) =	<b>user</b>	ft
Slope of Trickle Channel (S <sub>tc</sub> ) =	<b>user</b>	ft/ft
Slopes of Main Basin Sides (S <sub>main</sub> ) =	<b>user</b>	H:V
Basin Length-to-Width Ratio (R <sub>L/W</sub> ) =	<b>user</b>	

Initial Surcharge Area (A <sub>ISV</sub> ) =	<b>user</b>	ft <sup>2</sup>
Surcharge Volume Length (L <sub>ISV</sub> ) =	<b>user</b>	ft
Surcharge Volume Width (W <sub>ISV</sub> ) =	<b>user</b>	ft
Depth of Basin Floor (H <sub>floor</sub> ) =	<b>user</b>	ft
Length of Basin Floor (L <sub>floor</sub> ) =	<b>user</b>	ft
Width of Basin Floor (W <sub>floor</sub> ) =	<b>user</b>	ft
Area of Basin Floor (A <sub>floor</sub> ) =	<b>user</b>	ft <sup>2</sup>
Volume of Basin Floor (V <sub>floor</sub> ) =	<b>user</b>	ft <sup>3</sup>
Depth of Main Basin (H <sub>main</sub> ) =	<b>user</b>	ft
Length of Main Basin (L <sub>main</sub> ) =	<b>user</b>	ft
Width of Main Basin (W <sub>main</sub> ) =	<b>user</b>	ft
Area of Main Basin (A <sub>main</sub> ) =	<b>user</b>	ft <sup>2</sup>
Volume of Main Basin (V <sub>main</sub> ) =	<b>user</b>	ft <sup>3</sup>
<b>Calculated Total Basin Volume (V<sub>total</sub>) =</b>	<b>user</b>	<b>acre-feet</b>

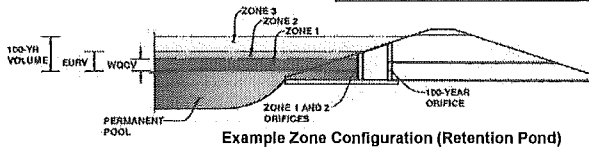
Depth increment = <b>2</b> ft									
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft <sup>2</sup> )	Optional Override Area (ft <sup>2</sup> )	Area (acre)	Volume (ft <sup>3</sup> )	Volume (ac-ft)
<b>Top of Micropool</b>	--	<b>0.00</b>	--	--	--	<b>4,061</b>	<b>0.093</b>		
	--	<b>2.00</b>	--	--	--	<b>9,656</b>	<b>0.222</b>	<b>13,621</b>	<b>0.313</b>
	--	<b>4.00</b>	--	--	--	<b>16,274</b>	<b>0.374</b>	<b>39,647</b>	<b>0.910</b>
	--	<b>6.00</b>	--	--	--	<b>25,480</b>	<b>0.585</b>	<b>81,401</b>	<b>1.869</b>
<b>100-YR WSL</b>	--	<b>8.00</b>	--	--	--	<b>35,000</b>	<b>0.803</b>	<b>141,681</b>	<b>3.257</b>
<b>TOP</b>	--	<b>10.00</b>	--	--	--	<b>40,000</b>	<b>0.918</b>	<b>216,881</b>	<b>4.979</b>

Three different volumes are associated with the design of a full spectrum detention facility: WQCV, EURV, and 100-yr. Revise Zone 2 and 3 in the worksheet

# Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: **ABERT RANCH**  
Basin ID: **1**



	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.62	0.466	Orifice Plate
Zone 2 (100-year)	8.02	2.805	Weir & Pipe (Restrict)
Zone 3			
		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 <sup>2</sup>
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 =	2.62	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	10.50	Inches
Orifice Plate: Orifice Area per Row =	2.95	sq. inches (diameter = 1-15/16 Inches)

Calculated Parameters for Plate

WQ Orifice Area per Row =	2.049E-02	ft <sup>2</sup>
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft <sup>2</sup>

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	0.67	1.75					
Orifice Area (sq. inches)	2.95	2.95	2.95					

	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 =			ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =			ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =			inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =			ft <sup>2</sup>
Vertical Orifice Centroid =			feet

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

	Zone 2 Weir	Not Selected	
Overflow Weir Front Edge Height, H <sub>o</sub> =	6.00		ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	10.00		feet
Overflow Weir Slope =	0.00		H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	6.00		feet
Overflow Grate Open Area % =	70%		% , grate open area/total area
Debris Clogging % =	50%		%

Calculated Parameters for Overflow Weir

	Zone 2 Weir	Not Selected	
Height of Grate Upper Edge, H <sub>1</sub> =	6.00		feet
Over Flow Weir Slope Length =	6.00		feet
Grate Open Area / 100-yr Orifice Area =	3.60		should be ≥ 4
Overflow Grate Open Area w/o Debris =	42.00		ft <sup>2</sup>
Overflow Grate Open Area w/ Debris =	21.00		ft <sup>2</sup>

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

	Zone 2 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.50		ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	48.00		inches
Restrictor Plate Height Above Pipe Invert =	42.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 2 Restrictor	Not Selected	
Outlet Orifice Area =	11.66		ft <sup>2</sup>
Outlet Orifice Centroid =	1.87		feet
Half-Central Angle of Restrictor Plate on Pipe =	2.42	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

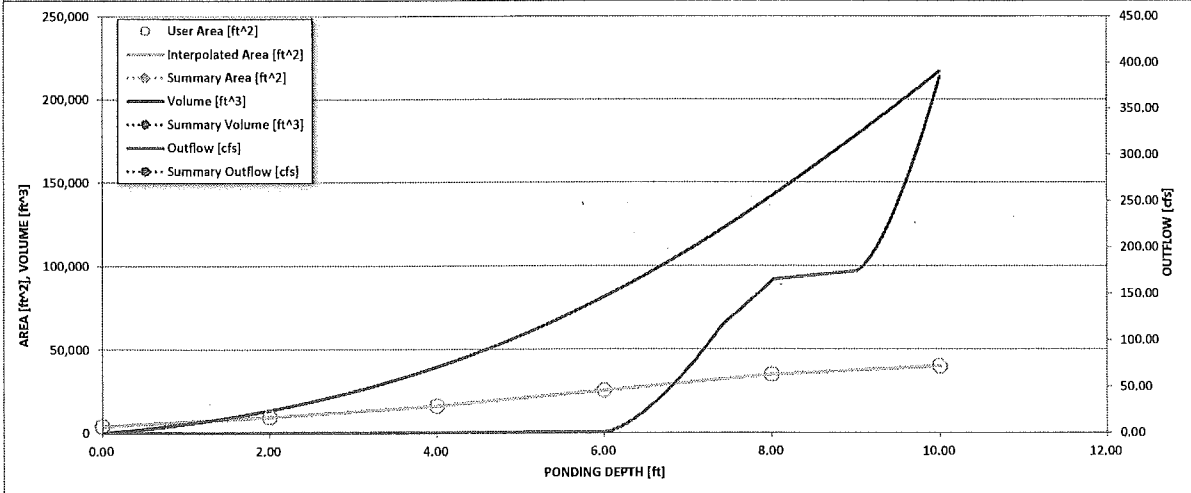
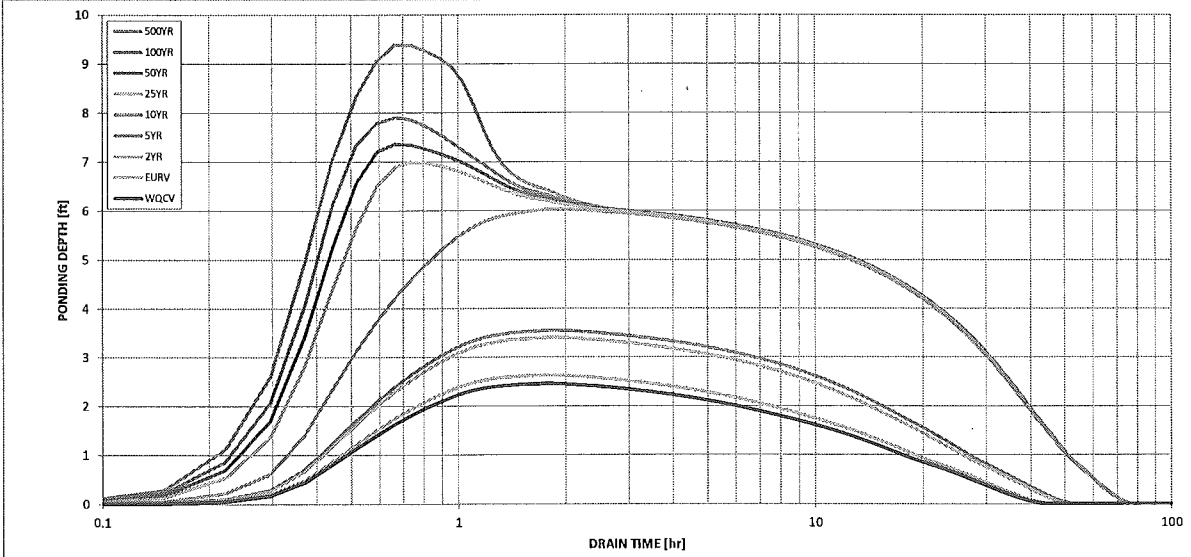
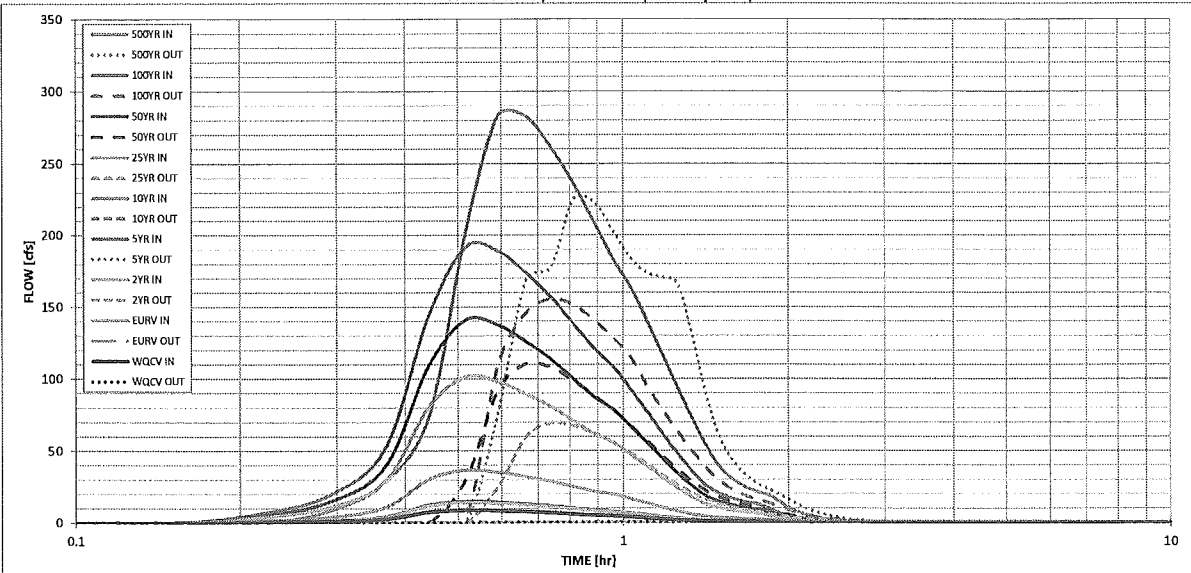
Spillway Design Flow Depth =	0.96	feet
Stage at Top of Freeboard =	10.96	feet
Basin Area at Top of Freeboard =	0.92	acres

## Routed Hydrograph Results

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =									
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) =	0.466	0.758	0.514	0.809	1.989	5.588	7.834	10.756	16.073
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	0.5	1.1	69.5	110.4	155.4	225.1
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.2	0.0	1.0	1.1	1.2	1.2
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.0	1.6	2.6	3.7	4.2
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) =	36	42	37	43	59	48	43	39	34
Time to Drain 99% of Inflow Volume (hours) =	40	47	41	48	67	60	57	53	48
Maximum Ponding Depth (ft) =	2.46	3.40	2.63	3.55	6.03	7.00	7.36	7.90	9.39
Area at Maximum Ponding Depth (acres) =	0.26	0.33	0.27	0.34	0.59	0.69	0.73	0.79	0.88
Maximum Volume Stored (acre-ft) =	0.422	0.700	0.467	0.746	1.886	2.501	2.765	3.177	4.421

# 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			



**APPENDIX D**

**DETENTION POND OPERATION & MAINTENANCE MANUAL**

Operation and Maintenance Manual  
for

Extended Detention Basins  
(EDBs)

June, 2009

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## **EDB-1 BACKGROUND**

Extended Detention Basins (EDBs) are one of the most common types of Stormwater BMPs utilized within the Front Range of Colorado. An EDB is a sedimentation basin designed to “extend” the runoff detention time, but to drain completely dry sometime after stormwater runoff ends. The EDB’s drain time for the water quality portion of the facility is typically 40 hours. The basins are considered to be “dry” because the majority of the basin is designed not to have a significant permanent pool of water remaining between runoff events.

EDBs are an adaptation of a detention basin used for flood control, with the primary difference is the addition of forebays, micropools and a slow release outlet design. Forebays are shallow concrete “pans” located at the inflow point to the basin and are provided to facilitate sediment removal within a contained area prior to releasing into the pond. These forebays collect and briefly hold stormwater runoff resulting in a process called sedimentation, dropping sediment out of the stormwater. The stormwater is then routed from the forebay into the concrete trickle channel and upper basin, the large grassy portion of the basin. The EDB uses a much smaller outlet that extends the emptying time of the more frequently occurring runoff events to facilitate pollutant removal. An EDB should have a small micropool just upstream of the outlet. This micropool is designed to hold a small amount of water to keep sediment and floatables from blocking the outlet orifices.

## **EDB-2 INSPECTING EXTENDED DETENTION BASINS (EDBs)**

### **EDB-2.1 Access and Easements**

Inspection or maintenance personnel may utilize the figures located in the approved Final Drainage Report for the project and recorded subdivision plat containing the location(s) of the access points and potential maintenance easements of the EDB(s) within this development.

### **EDB-2.2 Stormwater Best Management Practice (BMP) Locations**

Inspection or maintenance personnel may utilize the figures located in the approved Final Drainage Report for the project and recorded subdivision plat containing the location(s) of the EDB(s) within this development.

### **EDB-2.3 Extended Detention Basin (EDB) Features**

EDBs have a number of features that are designed to serve a particular function. Many times the proper function of one feature depends on another. For example, if a forebay is not properly maintained, it could negatively affect the performance of a feature downstream (trickle channel, micropool, etc.).



Therefore, it is critical that each feature of the EDB is properly inspected and maintained to ensure that the overall facility functions as it was intended. Below is a list and description of the most common features within an EDB and the corresponding maintenance inspection items that can be anticipated:

**Table EDB-1  
Typical Inspection & Maintenance Requirements Matrix**

EDB Features	Sediment Removal	Mowing/ Weed control	Trash & Debris Removal	Erosion	Overgrown Vegetation Removal	Standing Water (mosquito/ algae control)	Structure Repair
Inflow Points (outfalls)	X		X				X
Forebay	X		X				X
Low-flow channel	X		X	X	X		X
Bottom Stage	X	X	X	X	X	X	
Micropool	X		X		X	X	X
Outlet Works	X		X				X
Emergency Spillway			X	X	X		X
Upper Stage			X	X			
Embankment		X		X	X		

### EDB-2.3.1 Inflow Points

Inflow Points or Outfalls into EDBs are the point source of the stormwater discharge into the facility. An inflow point is commonly a storm sewer pipe with a flared end section that discharges into the EDB. In some instances, an inflow point could be a drainage channel or ditch that flows into the facility.

An energy dissipater (riprap or hard armor protection) is typically immediately downstream of the discharge point into the EDB to protect from erosion. In some cases, the storm sewer outfall can have a toe-wall or cut-off wall immediately below the structure to prevent undercutting of the outfall from erosion.

*The typical maintenance items that are found with inflow points are as follows:*

*a. Riprap Displaced* – Many times, because the repeated impact/force of water, the riprap can shift and settle. If any portion of the riprap apron appears to have settled, soil is present between the riprap, or

the riprap has shifted, maintenance may be required to ensure future erosion is prevented.

*b. Erosion Present/Outfall Undercut* – In some situations, the energy dissipater may not have been sized, constructed, or maintained appropriately and erosion has occurred. Any erosion within the vicinity of the inflow point will require maintenance to prevent damage to the structure(s) and sediment transport within the facility.

*c. Sediment Accumulation* – Because of the turbulence in the water created by the energy dissipater, sediment often deposits immediately downstream of the inflow point. To prevent a loss in hydraulic performance of the upstream infrastructure, sediment that accumulates in this area must be removed in a timely manner.

*d. Structural Damage* – Structural damage can occur at anytime during the life of the facility. Typically, for an inflow, the structural damage occurs to the pipe flared end section (concrete or steel). Structural damage can lead to additional operating problems with the facility, including loss of hydraulic performance.

*e. Woody Growth/Weeds Present* – Undesirable vegetation can grow in and around the inflow area to an EDB that can significantly affect the performance of the drainage facilities discharging into the facility. This type of vegetation includes trees (typically cottonwoods) and dense areas of shrubs (willows). If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate, resulting in blockage of the discharge. Also, tree roots can cause damage to the structural components of the inflow. Routine maintenance is essential for trees (removing a small tree/sapling is much cheaper and “quieter” than a mature tree). In addition, noxious weeds growing in the facility can result in the loss of desirable native vegetation and impact adjacent open spaces/land.

### EDB-2.3.2 Forebay

A forebay is a solid surface (pad), typically constructed of concrete, immediately downstream of the inflow point. The forebay is designed to capture larger particles and trash to prevent them from entering the main portion of the EDB. The solid surface is designed to facilitate mechanical sediment removal (skid steer). The forebay typically includes a small diameter discharge pipe or v-notch weir on the downstream end and designed to drain the forebay in a specified period of time to promote sedimentation. The forebays vary in size and depth depending on the design and site constraints.

*The typical maintenance items that are found with forebays are as follows:*

*a. Sediment/Debris Accumulation* – Because this feature of the EDB is designed to provide the initial sedimentation, debris and sediment frequently accumulate in this area. If the sediment and debris is not removed from the forebay on a regular basis, it can significantly affect the function of other features within the EDB. Routine sediment removal from the forebay can **significantly** reduce the need for dredging of the main portion of the EDB using specialized equipment (long reach excavators). Routine removal of sediment from the forebay can **substantially** decrease the long-term sediment removal costs of an EDB.

*b. Concrete Cracking/Failing* – The forebay is primarily constructed of concrete, which cracks, spalls, and settles. Damage to the forebay can result in decreased performance and impact maintenance efforts.

*c. Drain Pipe/Weir Clogged* – Many times the drainpipe or weir can be clogged with debris, and prevent the forebay from draining properly. If standing water is present in the forebay (and there is not a base flow), the forebay is most likely not draining properly. This can result in a decrease in performance and create potential nuisances with stagnant water (mosquitoes).

*d. Weir/Drain Pipe Damaged* – Routine maintenance activities, vandalism, or age may cause the weir or drain pipe in the forebay to become damaged. Weirs are typically constructed of concrete, which cracks and spalls. The drainpipe is typically smaller in diameter and constructed with plastic, which can fracture.

### EDB-2.3.3 Trickle Channel (Low-Flow)

The trickle channel conveys stormwater from the forebay to the micro-pool of the EDB. The trickle channel is typically made of concrete. However, grass lined (riprap sides protected) is also common and can provide for an additional means of water quality within the EDB. The trickle channel is typically 6-9 inches in depth and can vary in width.

*The typical maintenance items that are found with trickle channels are as follows:*

*a. Sediment/Debris Accumulation* – Trickle channels are typically designed with a relatively flat slope that can promote sedimentation and the collection of debris. Also, if a trickle channel is grass lined it can accumulate sediment and debris at a much quicker rate. Routine

removal of accumulated sediment and debris is essential in preventing flows from circumventing the trickle channel and affecting the dry storage portion of the pond.

*b. Concrete/Riprap Damage* – Concrete can crack, spall, and settle and must be repaired to ensure proper function of the trickle channel. Riprap can also shift over time and must be replaced/repared as necessary.

*c. Woody Growth/Weeds Present* – Because of the constant moisture in the area surrounding the trickle channel, woody growth (cottonwoods/willows) can become a problem. Trees and dense shrub type vegetation can affect the capacity of the trickle channel and can allow flows to circumvent the feature.

*d. Erosion Outside of Channel* – In larger precipitation events, the trickle channel capacity will likely be exceeded. This can result in erosion immediately adjacent to the trickle channel and must be repaired to prevent further damage to the structural components of the EDB.

#### EDB-2.3.4 Bottom Stage

The bottom stage is at least 1.0 to 2.0 feet deeper than the upper stage and is located in front of the outlet works structure. The bottom stage is designed to store the smaller runoff events, assists in keeping the majority of the basin bottom dry resulting in easier maintenance operations, and enhances the facilities pollutant removal capabilities. This area of the EDB may develop wetland vegetation.

*The typical maintenance items that are found with the bottom stage are as follows:*

*a. Sediment/Debris Accumulation* – The micro-pool can frequently accumulate sediment and debris. This material must be removed to maintain pond volume and proper function of the outlet structure.

*b. Woody Growth/Weeds Present* - Because of the constant moisture in the soil surrounding the micro-pool, woody growth (cottonwoods/willows) can create operational problems for the EDB. If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate outside of the micro-pool, which can cause problems with other EDB features. Also, tree roots can cause damage to the structural components of the outlet works. Routine management is essential for trees (removing a small tree/sapling is much cheaper and “quieter” than a mature tree).

*c. Bank Erosion* – The micro-pool is usually a couple feet deeper than the other areas of the ponds. Erosion can be caused by water dropping into the micro-pool if adequate protection/armor is not present. Erosion in this area must be mitigated to prevent sediment transport and other EDB feature damage.

*d. Mosquitoes/Algae Treatment* – Nuisance created by stagnant water can result from improper maintenance/treatment of the micro-pool. Mosquito larvae can be laid by adult mosquitoes within the permanent pool. Also, aquatic vegetation that grows in shallow pools of water can decompose causing foul odors. Chemical/mechanical treatment of the micro-pool may be necessary to reduce these impacts to adjacent homeowners.

*e. Petroleum/Chemical Sheen* – Many indicators of illicit discharges into the storm sewer systems will be present in the micro-pool area of the EDB. These indicators can include sheens, odors, discolored soil, and dead vegetation. If it is suspected that an illicit discharge has occurred, contact the supervisor immediately. Proper removal/mitigation of contaminated soils and water in the EDB is necessary to minimize any environmental impacts downstream.

#### EDB-2.3.5 Micro-pool

The micro-pool is a concrete or grouted boulder walled structure directly in front of the outlet works. At a minimum, the micropool is 2.5 feet deep and is designed to hold water. The micro-pool is critical in the proper function of the EDB; it allows suspended sediment to be deposited at the bottom of the micro-pool and prevents these sediments from being deposited in front of the outlet works causing clogging of the outlet structure, which results in marshy areas within the top and bottom stages.

*The typical maintenance items that are found with micro-pools are as follows:*

*a. Sediment/Debris Accumulation* – The micro-pool can frequently accumulate sediment and debris. This material must be removed to maintain pond volume and proper function of the outlet structure.

*b. Woody Growth/Weeds Present* - Because of the constant moisture in the soil surrounding the micro-pool, woody growth (cottonwoods/willows) can create operational problems for the EDB. If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate outside of the micro-pool, which

can cause problems with other EDB features. Also, tree roots can cause damage to the structural components of the outlet works. Routine management is essential for trees (removing a small tree/sapling is much cheaper and “quieter” than a mature tree).

*c. Mosquitoes/Algae Treatment* – Nuisance created by stagnant water can result from improper maintenance/treatment of the micro-pool. Mosquito larvae can be laid by adult mosquitoes within the permanent pool. Also, aquatic vegetation that grows in shallow pools of water can decompose causing foul odors. Chemical/mechanical treatment of the micro-pool may be necessary to reduce these impacts to adjacent homeowners.

*d. Petroleum/Chemical Sheen* – Many indicators of illicit discharges into the storm sewer systems will be present in the micro-pool area of the EDB. These indicators can include sheens, odors, discolored soil, and dead vegetation. If it is suspected that an illicit discharge has occurred, contact the supervisor immediately. Proper removal/mitigation of contaminated soils and water in the EDB is necessary to minimize any environmental impacts downstream.

#### EDB-2.3.6 Outlet Works

The outlet works is the feature that drains the EDB in specified quantities and periods of time. The outlet works is typically constructed of reinforced concrete into the embankment of the EDB. The concrete structure typically has steel orifice plates anchored/embedded into it to control stormwater release rates. The larger openings (flood control) on the outlet structure typically have trash racks over them to prevent clogging. The water quality orifice plate (smaller diameter holes) will typically have a well screen covering it to prevent smaller materials from clogging it. The outlet structure is the single most important feature in the EDB operation. Proper inspection and maintenance of the outlet works is essential in ensuring the long-term operation of the EDB.

*The typical maintenance items that are found with the outlet works are as follows:*

*a. Trash Rack/Well Screen Clogged* – Floatable material that enters the EDB will most likely make its way to the outlet structure. This material is trapped against the trash racks and well screens on the outlet structure (which is why they are there). This material must be removed on a routine basis to ensure the outlet structure drains in the specified design period.

*b. Structural Damage* - The outlet structure is primarily constructed of concrete, which can crack, spall, and settle. The steel trash racks and well screens are also susceptible to damage.

*c. Orifice Plate Missing/Not Secure* – Many times residents, property owners, or maintenance personnel will remove or loosen orifice plates if they believe the pond is not draining properly. Any modification to the orifice plate(s) will significantly affect the designed discharge rates for water quality and/or flood control. Modification of the orifice plates is not allowed without approval from the County.

*d. Manhole Access* – Access to the outlet structure is necessary to properly inspect and maintain the facility. If access is difficult or not available to inspect the structure, chances are it will be difficult to maintain as well.

*e. Woody Growth/Weeds Present* - Because of the constant moisture in the soil surrounding the outlet works, woody growth (cottonwoods/willows) can create operational problems for the EDB. If woody vegetation is not routinely mowed/removed, the growth can cause debris/sediment to accumulate around the outlet works, which can cause problems with other EDB features. Also, tree roots can cause damage to the structural components of the outlet works. Routine management is essential for trees (removing a small tree/sapling is much cheaper and “quieter” than a mature tree).

#### EDB-2.3.7 Emergency Spillway

An emergency spillway is typical of all EDBs and designed to serve as the overflow in the event the volume of the pond is exceeded. The emergency spillway is typically armored with riprap (or other hard armor) and is sometimes buried with soil. The emergency spillway is typically a weir (notch) in the pond embankment. Proper function of the emergency spillway is essential to ensure flooding does not affect adjacent properties.

*The typical maintenance items that are found with emergency spillways are as follows:*

*a. Riprap Displaced* – As mentioned before, the emergency spillway is typically armored with riprap to provide erosion protection. Over the life of an EDB, the riprap may shift or dislodge due to flow.

*b. Erosion Present* – Although the spillway is typically armored, stormwater flowing through the spillway can cause erosion damage.

Erosion must be repaired to ensure the integrity of the basin embankment, and proper function of the spillway.

*c. Woody Growth/Weeds Present* – Management of woody vegetation is essential in the proper long-term function of the spillway. Larger trees or dense shrubs can capture larger debris entering the EDB and reduce the capacity of the spillway.

*d. Obstruction Debris* – The spillway must be cleared of any obstruction (man made or natural) to ensure the proper design capacity.

#### EDB-2.3.8 Upper Stage (Dry Storage)

The upper stage of the EDB provides the majority of the water quality flood detention volume. This area of the EDB is higher than the micro-pool and typically stays dry, except during storm events. The upper stage is the largest feature/area of the basin. Sometimes, the upper stage can be utilized for park space and other uses in larger EDBs. With proper maintenance of the micro-pool and forebay(s), the upper stage should not experience much sedimentation; however, bottom elevations should be monitored to ensure adequate volume.

*The typical maintenance items that are found with upper stages are as follows:*

*a. Vegetation Sparse* – The upper basin is the most visible part of the EDB, and therefore aesthetics is important. Adequate and properly maintained vegetation can greatly increase the overall appearance and acceptance of the EDB by the public. In addition, vegetation can reduce the potential for erosion and subsequent sediment transport to the other areas of the pond.

*b. Woody Growth/Undesirable Vegetation* – Although some trees and woody vegetation may be acceptable in the upper basin, some thinning of cottonwoods and willows may be necessary. Remember, the basin will have to be dredged to ensure volume, and large trees and shrubs will be difficult to protect during that operation.

*c. Standing Water/Boggy Areas* – Standing water or boggy areas in the upper stage is typically a sign that some other feature in the pond is not functioning properly. Routine maintenance (mowing, trash removal, etc) can be extremely difficult for the upper stage if the ground is saturated. If this inspection item is checked, make sure you have identified the root cause of the problem.



*d. Sediment Accumulation* – Although other features within the EDB are designed to capture sediment, the upper storage area will collect sediment over time. Excessive amounts of sedimentation will result in a loss of storage volume. It may be more difficult to determine if this area has accumulated sediment without conducting a field survey.

Below is a list of indicators:

1. Ground adjacent to the trickle channel appears to be several inches higher than concrete/riprap
2. Standing water or boggy areas in upper stage
3. Uneven grades or mounds
4. Micro-pool or Forebay has excessive amounts of sediment

*e. Erosion (banks and bottom)* – The bottom grades of the dry storage are typically flat enough that erosion should not occur. However, inadequate vegetative cover may result in erosion of the upper stage. Erosion that occurs in the upper stage can result in increased dredging/maintenance of the micro-pool.

*f. Trash/Debris* – Trash and debris can accumulate in the upper area after large events, or from illegal dumping. Over time, this material can accumulate and clog the EDB outlet works.

*g. Maintenance Access* – Most EDBs typically have a gravel/concrete maintenance access path to either the upper stage or forebay. This access path should be inspected to ensure the surface is still drivable. Some of the smaller EDBs may not have maintenance access paths; however, the inspector should verify that access is available from adjacent properties.

#### EDB-2.3.9 Miscellaneous

There are a variety of inspection/maintenance issues that may not be attributed to a single feature within the EDB. This category on the inspection form is for maintenance items that are commonly found in the EDB, but may not be attributed to an individual feature.

*a. Access* – Access needs to be maintained.

*b. Graffiti/Vandalism* – Damage to the EDB infrastructure can be caused by vandals. If criminal mischief is evident, the inspector should forward this information to the local enforcement agency.

*c. Public Hazards* – Public hazards include items such as vertical drops of greater than 4-feet, containers of unknown/suspicious

substances, exposed metal/jagged concrete on structures. **If any hazard is found within the facility area that poses an immediate threat to public safety, contact the local emergency services at 911 immediately!**

*d. Burrowing Animals/Pests* – Prairie dogs and other burrowing rodents may cause damage to the EDB features and negatively affect the vegetation within the EDB.

*e. Other* – Any miscellaneous inspection/maintenance items not contained on the form should be entered here.

#### **EDB-2.4 Inspection Forms**

Inspection forms shall be completed by the person(s) conducting the inspection activities. These inspection forms shall be kept a minimum of 5 years and made available to the County upon request.

### **EDB-3 MAINTAINING EXTENDED DETENTION BASINS (EDBS)**

#### **EDB-3.1 Maintenance Personnel**

Maintenance personnel must be qualified to properly maintain EDBs. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs.

#### **EDB-3.2 Equipment**

It is imperative that the appropriate equipment and tools are taken to the field with the operations crew. The types of equipment/tools will vary depending on the task at hand. Below is a list of tools, equipment, and material(s) that may be necessary to perform maintenance on an EDB:

- 1.) Loppers/Tree Trimming Tools
- 2.) Mowing Tractors
- 3.) Trimmers (extra string)
- 4.) Shovels
- 5.) Rakes
- 6.) All Surface Vehicle (ASVs)
- 7.) Skid Steer
- 8.) Back Hoe
- 9.) Track Hoe/Long Reach Excavator
- 10.) Dump Truck

- 11.) Jet-Vac Machine
- 12.) Engineers Level (laser)
- 13.) Riprap (Minimum - Type M)
- 14.) Filter Fabric
- 15.) Erosion Control Blanket(s)
- 16.) Seed Mix (Native Mix)
- 17.) Illicit Discharge Cleanup Kits
- 18.) Trash Bags
- 19.) Tools (wrenches, screw drivers, hammers, etc)
- 20.) Chain Saw
- 21.) Confined Space Entry Equipment
- 22.) Approved Inspection and Maintenance Plan

Some of the items identified above may not be needed for every maintenance operation. However, this equipment should be available to the maintenance operations crews should the need arise.

### **EDB-3.3 Safety**

Vertical drops may be encountered in areas located within and around the facility. Avoid walking on top of retaining walls or other structures that have a significant vertical drop. If a vertical drop is identified within the EDB that is greater than 48" in height, make the appropriate note/comment on the maintenance inspection form.

### **EDB-3.4 Maintenance Forms**

An EDB Maintenance Form provides a record of each maintenance operation performed by maintenance contractors. An EDB Maintenance Form shall be filled out in the field after the completion of the maintenance operation.

### **EDB-3.5 Maintenance Categories and Activities**

A typical EDB Maintenance Program will consist of three broad categories of work: Routine, Restoration (minor), and Rehabilitation (major). Within each category of work, a variety of maintenance activities can be performed on an EDB. A maintenance activity can be specific to each feature within the EDB, or general to the overall facility. This section of the SOP explains each of the categories and briefly describes the typical maintenance activities for an EDB.

A variety of maintenance activities are typical of EDBs. The maintenance activities range in magnitude from routine trash pickup to the reconstruction of

drainage infrastructure. Below is a description of each maintenance activity, the objectives, and frequency of actions:

### EDB-3.6 Routine Maintenance Activities

The majority of this work consists of regularly scheduled mowing and trash and debris pickups for stormwater management facilities during the growing season. This includes items such as the removal of debris/material that may be clogging the outlet structure well screens and trash racks. It also includes activities such as weed control, mosquito treatment, and algae treatment. These activities normally will be performed numerous times during the year. These items can be completed without any prior correspondence with the County; however, completed inspection and maintenance forms shall be kept on file.

The Maintenance Activities are summarized below, and further described in the following sections.

**TABLE – EDB-2  
Summary of Routine Maintenance Activities**

MAINTENANCE ACTIVITY	MINIMUM FREQUENCY	LOOK FOR:	MAINTENANCE ACTION
Mowing	Twice annually	Excessive grass height/aesthetics	Mow grass to a height of 4" to 6"
Trash/Debris Removal	Twice annually	Trash & debris in EDB	Remove and dispose of trash and debris
Outlet Works Cleaning	As needed - after significant rain events – twice annually min.	Clogged outlet structure; ponding water	Remove and dispose of debris/trash/sediment to allow outlet to function properly
Weed control	Minimum twice annually	Noxious weeds; Unwanted vegetation	Treat w/ herbicide or hand pull; Consult the local weed specialist
Mosquito Treatment	As needed	Standing water/mosquito habitat	Treat w/ EPA approved chemicals
Algae Treatment	As needed	Standing water/ Algal growth/green color	Treat w/ EPA approved chemicals

#### EDB-3.6.1 Mowing

Occasional mowing is necessary to limit unwanted vegetation and to improve the overall appearance of the EDB. Native vegetation should

be mowed to a height of 4-to-6 inches tall. Grass clippings should be collected and disposed of properly.

*Frequency* – Routine - Minimum of twice annually or depending on aesthetics.

#### EDB-3.6.2 Trash/Debris Removal

Trash and debris must be removed from the entire EDB area to minimize outlet clogging and to improve aesthetics. This activity must be performed prior to mowing operations.

*Frequency* – Routine – Prior to mowing operations and minimum of twice annually.

#### EDB-3.6.3 Outlet Works Cleaning

Debris and other materials can clog the outlet work's well screen, orifice plate(s) and trash rack. This activity must be performed anytime other maintenance activities are conducted to ensure proper operation.

*Frequency* - Routine – After significant rainfall event or concurrently with other maintenance activities.

#### EDB-3.6.4 Weed Control

Noxious weeds and other unwanted vegetation must be treated as needed throughout the EDB. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with the local Weed Inspector is highly recommended prior to the use of herbicide.

*Frequency* – Routine – As needed based on inspections.

#### EDB-3.6.5 Mosquito/Algae Treatment

Treatment of permanent pools is necessary to control mosquitoes and undesirable aquatic vegetation that can create nuisances. Only EPA approved chemicals/materials can be used in areas that are warranted.

*Frequency* – As needed.

### EDB- 3.7 Restoration Maintenance Activities

This work consists of a variety of isolated or small-scale maintenance or operational problems. Most of this work can be completed by a small crew, tools, and small equipment. These items do not require prior correspondence with the County require completed inspection and maintenance forms to be kept on file.

**Table – EDB-3  
Summary of Restoration Maintenance Activities**

MAINTENANCE ACTIVITY	MINIMUM FREQUENCY	LOOK FOR:	MAINTENANCE ACTION
<b>Sediment Removal</b>	As needed; typically every 1 –2 years	Sediment build-up; decrease in pond volume	Remove and dispose of sediment
<b>Erosion Repair</b>	As needed, based upon inspection	Rills/gullies forming on side slopes, trickle channel, other areas	Repair eroded areas Revegetate; address source of erosion
<b>Vegetation Removal/Tree Thinning</b>	As needed, based upon inspection	Large trees/wood vegetation in lower chamber of pond	Remove vegetation; restore grade and surface
<b>Drain Cleaning/Jet Vac</b>	As needed, based upon inspection	Sediment build-up /non draining system	Clean drains; Jet Vac if needed

#### EDB-3.7.1 Sediment Removal

Sediment removal is necessary to maintain the original design volume of the EDB and to ensure proper function of the infrastructure. Regular sediment removal (minor) from the forebay, inflow(s), and trickle channel can significantly reduce the frequency of major sediment removal activities (dredging) in the upper and lower stages. The minor sediment removal activities can typically be addressed with shovels and smaller equipment. Major sediment removal activities will require larger and more specialized equipment. The major sediment activities may also require surveying with an engineer's level, and consultation with the Consulting Engineer or County staff to ensure design volumes/grades are achieved.

Stormwater sediments removed from EDBs do not meet the criteria of "hazardous waste". However, these sediments are contaminated with a wide array of organic and inorganic pollutants and handling must be done with care. Sediments from permanent pools must be carefully removed to minimize turbidity, further sedimentation, or other adverse

water quality impacts. Sediments should be transported by motor vehicle only after they are dewatered. All sediments must be taken to a landfill for proper disposal. Prompt and thorough cleanup is important should a spill occur during transportation.

*Frequency* – Nonroutine – As necessary based upon inspections. Sediment removal in the forebay and trickle channel may be necessary as frequently as every 1-2 years.

#### EDB-3.7.2 Erosion Repair

The repair of eroded areas is necessary to ensure the proper function of the EDB, minimize sediment transport, and to reduce potential impacts to other features. Erosion can vary in magnitude from minor repairs to trickle channels, energy dissipaters, and rilling to major gullies in the embankments and spillways. The repair of eroded areas may require the use of excavators, earthmoving equipment, riprap, concrete, erosion control blankets, and turf reinforcement mats. Major erosion repair to the pond embankments, spillways, and adjacent to structures will require consultation with the Consulting Engineer or County Engineering staff.

*Frequency* – Nonroutine – As necessary based upon inspections.

#### EDB-3.7.3 Vegetation Removal/Tree Thinning

Dense stands of woody vegetation (willows, shrubs, etc) or trees can create maintenance problems for the infrastructure within an EDB. Tree roots can damage structures and invade pipes/channels thereby blocking flows. Also, trees growing in the upper and lower stages of the EDB will most likely have to be removed when sediment/dredging operations occur. A small tree is easier to remove than a large tree, therefore, regular removal/thinning is imperative. All trees and woody vegetation that is growing in the bottom of the EDB or near structures (inflows, trickle channels, outlet works, emergency spillways, etc) should be removed. Any trees or woody vegetation in the EDB should be limited to the upper portions of the pond banks.

*Frequency* – Nonroutine – As necessary based upon inspections.

#### EDB-3.7.4 Clearing Drains/Jet-Vac

An EDB contains many structures, openings, and pipes that can be frequently clogged with debris. These blockages can result in a decrease of hydraulic capacity and create standing water in areas outside of the micro-pool. Many times the blockage to this

infrastructure can be difficult to access and/or clean. Specialized equipment (jet-vac machines) may be necessary to clear debris from these difficult areas.

*Frequency* – Nonroutine – As necessary based upon inspections.

**EDB-3.8 Rehabilitation Maintenance Activities**

This work consists of larger maintenance/operational problems and failures within the stormwater management facilities. All of this work requires consultation with the Consulting Engineer or County Engineering staff to ensure the proper maintenance is performed. This work requires that the engineering staff review the original design and construction drawings to assess the situation and assign the necessary maintenance. This work may also require more specialized maintenance equipment, design/details, surveying, or assistance through private contractors and consultants. Any proper permits required for this activity must be obtained.

**Table – EDB-4  
Summary of Rehabilitation Maintenance Activities**

<b>MAINTENANCE ACTIVITY</b>	<b>MINIMUM FREQUENCY</b>	<b>LOOK FOR:</b>	<b>MAINTENANCE ACTION</b>
Major Sediment Removal	As needed – based upon scheduled inspections	Large quantities of sediment; reduced pond capacity	Remove and dispose of sediment. Repair vegetation as needed
Major Erosion Repair	As needed – based upon scheduled inspections	Severe erosion including gullies, excessive soil displacement, areas of settlement, holes	Repair erosion – find cause of problem and address to avoid future erosion
Structural Repair	As needed – based upon scheduled inspections	Deterioration and/or damage to structural components – broken concrete, damaged pipes, outlet works	Structural repair to restore the structure to its original design

**EDB-3.8.1 Major Sediment Removal**

Major sediment removal consists of removal of large quantities of sediment or removal of sediment from vegetated areas. Care shall be given when removing large quantities of sediment and sediment deposited in vegetated areas. Large quantities of sediment need to be carefully removed, transported and disposed of. Vegetated areas



need special care to ensure design volumes and grades are preserved.

*Frequency* – Nonroutine – Repair as needed based upon inspections.

#### EDB-3.8.2 Major Erosion Repair

Major erosion repair consist of filling and revegetating areas of severe erosion. Determining the cause of the erosion as well as correcting the condition that caused the erosion should also be part of the erosion repair. Care should be given to ensure design grades and volumes are preserved.

*Frequency* – Nonroutine – Repair as needed based upon inspections.

#### EDB-3.8.3 Structural Repair

An EDB includes a variety of structures that can deteriorate or be damaged during the course of routine maintenance. These structures are constructed of steel and concrete that can degrade or be damaged and may need to be repaired or re-constructed from time to time. These structures include items like outlet works, trickle channels, forebays, inflows and other features. In-house operations staff can perform some of the minor structural repairs. Major repairs to structures may require input from a structural engineer and specialized contractors. Consultation with the Consulting Engineer or County Engineering staff should take place prior to all structural repairs.

*Frequency* – Nonroutine – Repair as needed based upon inspections.

**Reference:**

This Manual is adapted from City of Colorado Springs O&M Procedures, which are adapted from SEMSWA (2007) and from the Town of Parker, Colorado (2004), STORMWATER PERMANENT BEST MANAGEMENT PRACTICES (PBMP) LONG-TERM OPERATION AND MAINTENANCE MANUAL

**APPENDIX E**

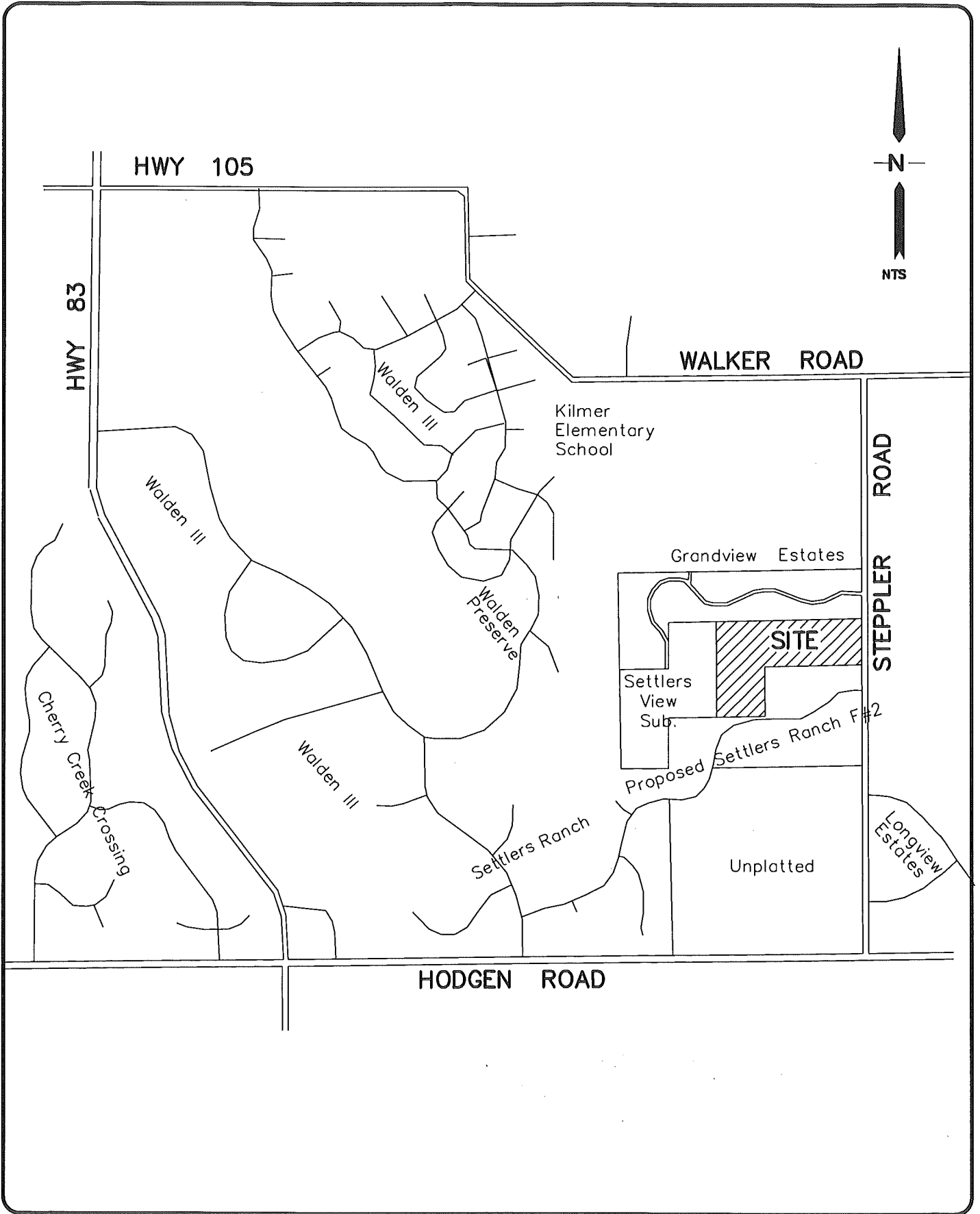
**DRAINAGE COST ESTIMATE**

<b>ABERT RANCH DRAINAGE IMPROVEMENTS COST ESTIMATE</b>					
Item No.	Description	Quantity	Unit	Unit Cost (\$\$)	Total Cost (\$\$)
<b>PRIVATE DRAINAGE IMPROVEMENTS</b>					
506	Riprap Aprons (d <sub>50</sub> = 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
<b>SUBTOTAL</b>					<b>\$31,180</b>
Contingency @ 15%					\$4,677
<b>TOTAL</b>					<b>\$35,857</b>
<b>PUBLIC DRAINAGE IMPROVEMENTS (NON-REIMBURSABLE)</b>					
506	Riprap Culvert Aprons (d <sub>50</sub> = 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
<b>SUBTOTAL</b>					<b>\$16,318</b>
Contingency @ 15%					\$2,448
<b>TOTAL</b>					<b>\$18,766</b>
<b>TOTAL DRAINAGE IMPROVEMENTS</b>					<b>\$54,623</b>

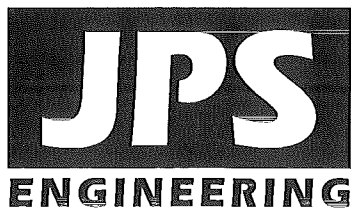
**APPENDIX F**

**FIGURES.**

J:\jpsprojects\111604.abert-ranch\dwg\civil\FIGURE A1.dwg, 3/27/2017 3:06:55 PM



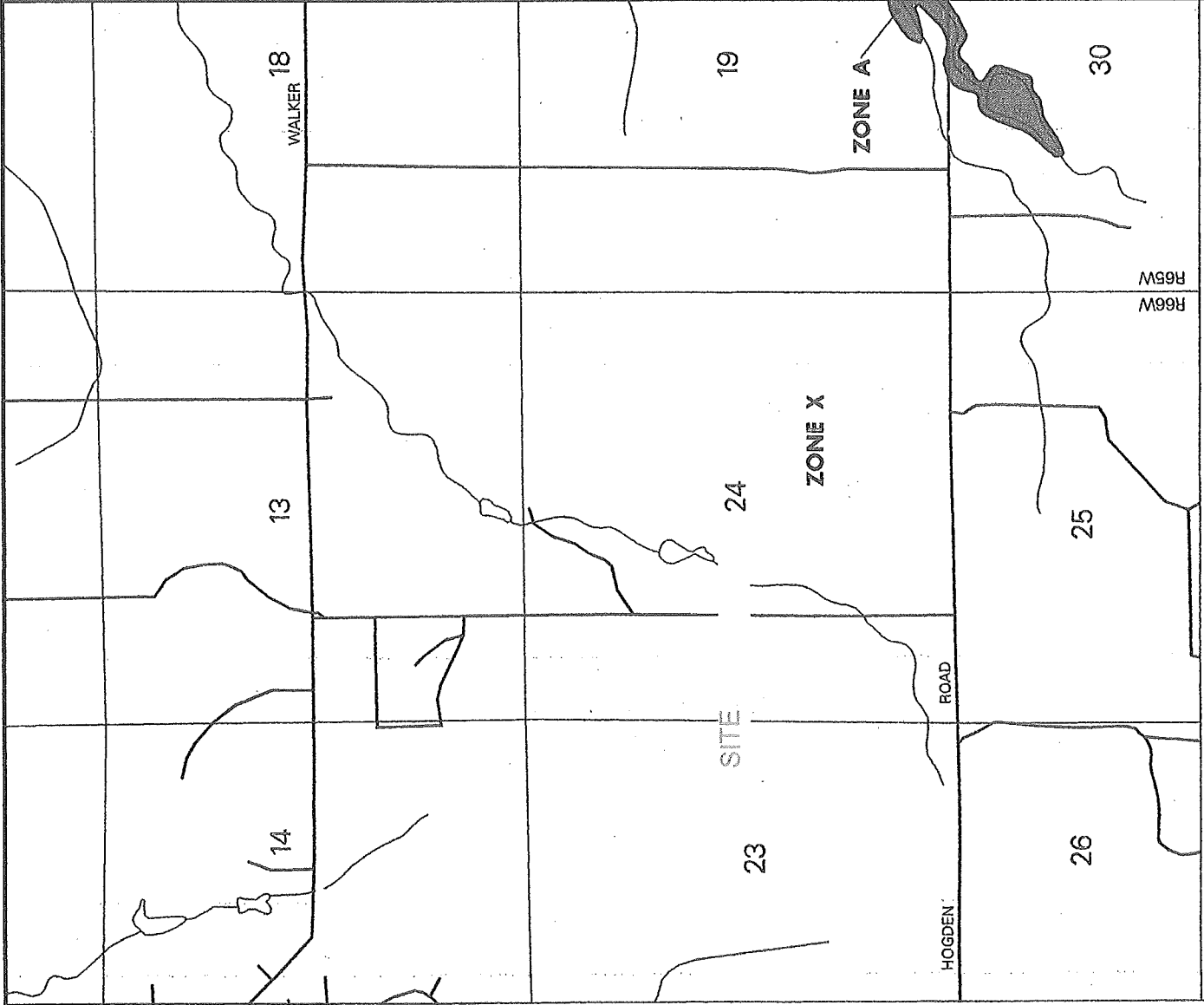
VICINITY MAP



ABERT RANCH

FIGURE A1  
JPS PROJ NO. 111604

JOINS PANEL 0285



**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 08069 0025 F

MAP NUMBER  
 08041C0325 F

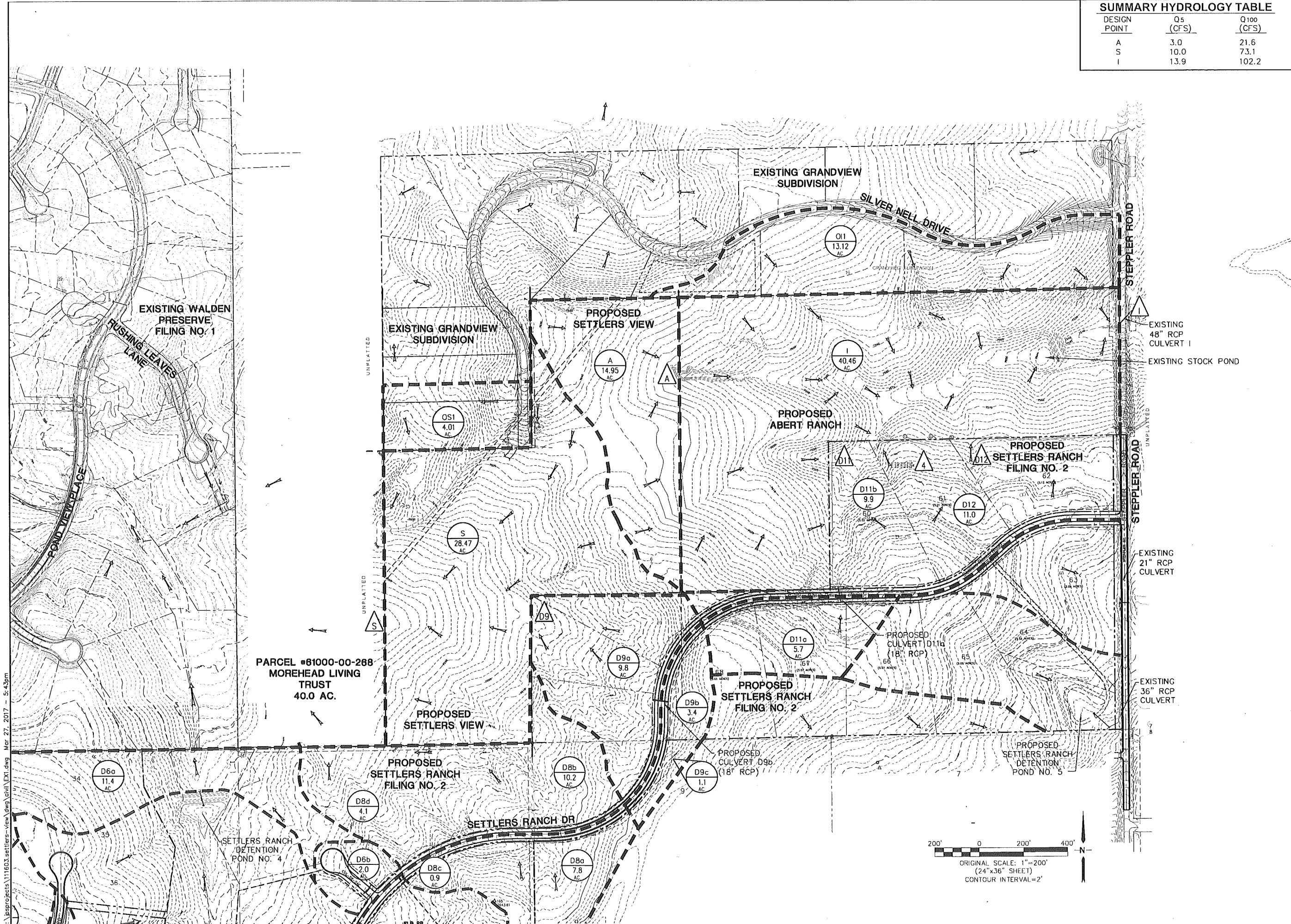
EFFECTIVE DATE:  
 MARCH 17, 1997



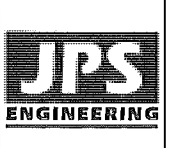
Federal Emergency Management Agency

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](http://www.msc.fema.gov)

SUMMARY HYDROLOGY TABLE		
DESIGN POINT	Q <sub>5</sub> (CFS)	Q <sub>100</sub> (CFS)
A	3.0	21.6
S	10.0	73.1
I	13.9	102.2



# SETTLEERS VIEW & ABERT RANCH



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Colorado Springs, CO  
80903  
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FAX: 719-471-0766  
www.jpsegr.com



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CENTER OF COLORADO  
1-800-922-1987  
BEFORE YOU DIG IN ADVANCE  
BEFORE YOU DIG OR EXCAVATE  
FOR THE MARKING OF UNDERGROUND  
MEMBER UTILITIES.

NO.	REVISION	BY	DATE

## HISTORIC DRAINAGE PLAN

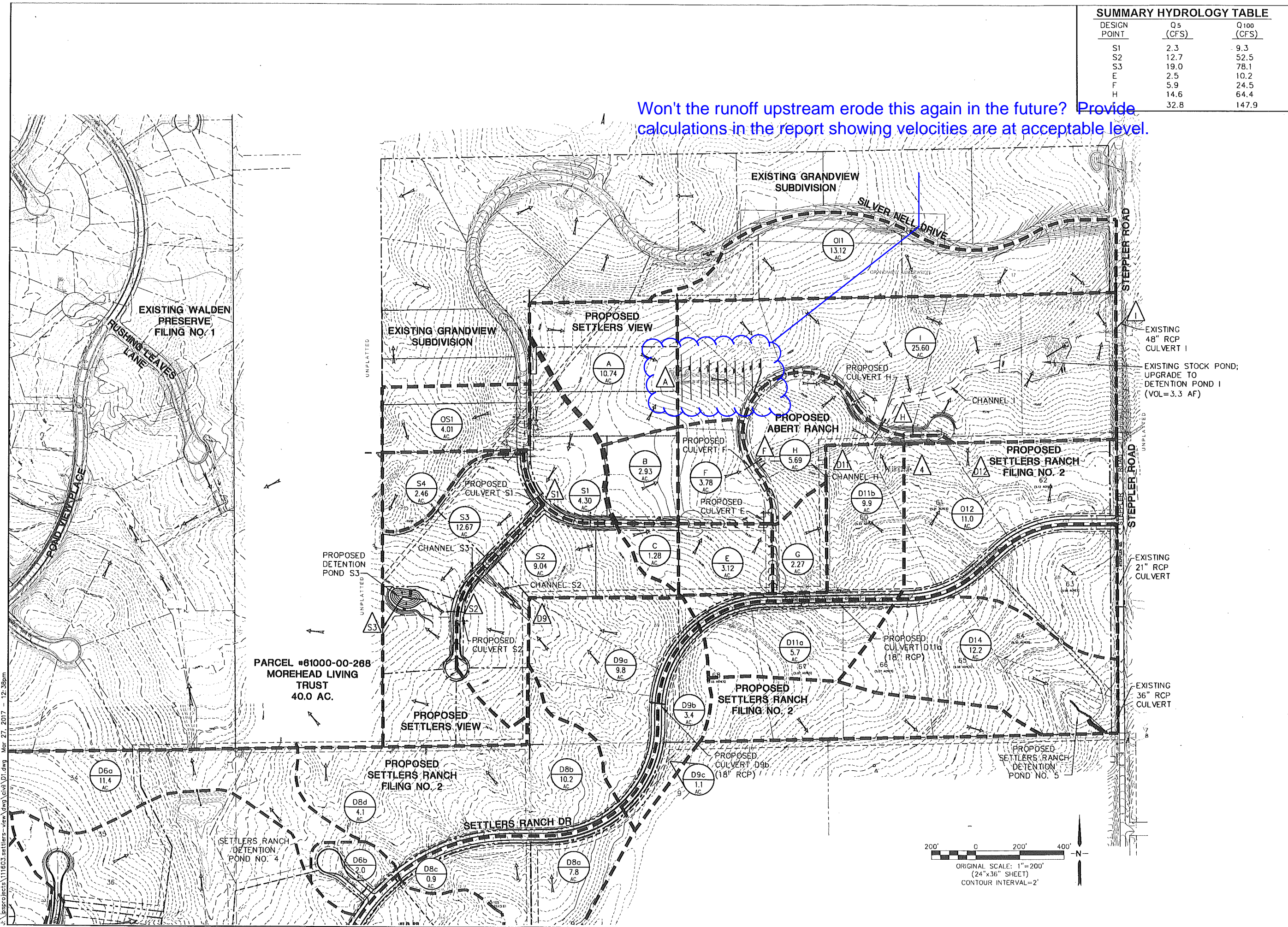
HORZ. SCALE: 1"=200'	DRAWN: BJJ
VERT. SCALE: N/A	DESIGNED: JPS
SURVEYED: HANNIGAN	CHECKED: JPS
CREATED: 2/14/17	LAST MODIFIED: 3/27/17
PROJECT NO: 111603	MODIFIED BY: BJJ
SHEET:	

EX1

J:\psprojects\111603.settlers-view.dwg Civil EX1.dwg Mar 27, 2017 - 5:43pm

SUMMARY HYDROLOGY TABLE		
DESIGN POINT	Q5 (CFS)	Q100 (CFS)
S1	2.3	9.3
S2	12.7	52.5
S3	19.0	78.1
E	2.5	10.2
F	5.9	24.5
H	14.6	64.4
	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.



# SETTLERS VIEW & ABERT RANCH

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 Colorado Springs, CO 80903  
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 FAX: 719-471-0766  
 www.jpsegr.com

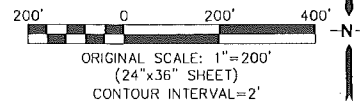
CALL UTILITY NOTIFICATION CENTER OF COLORADO  
 1-800-922-1987  
 BEFORE YOU DIG, GRADE OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

NO.	REVISION	BY	DATE

DEVELOPED DRAINAGE PLAN

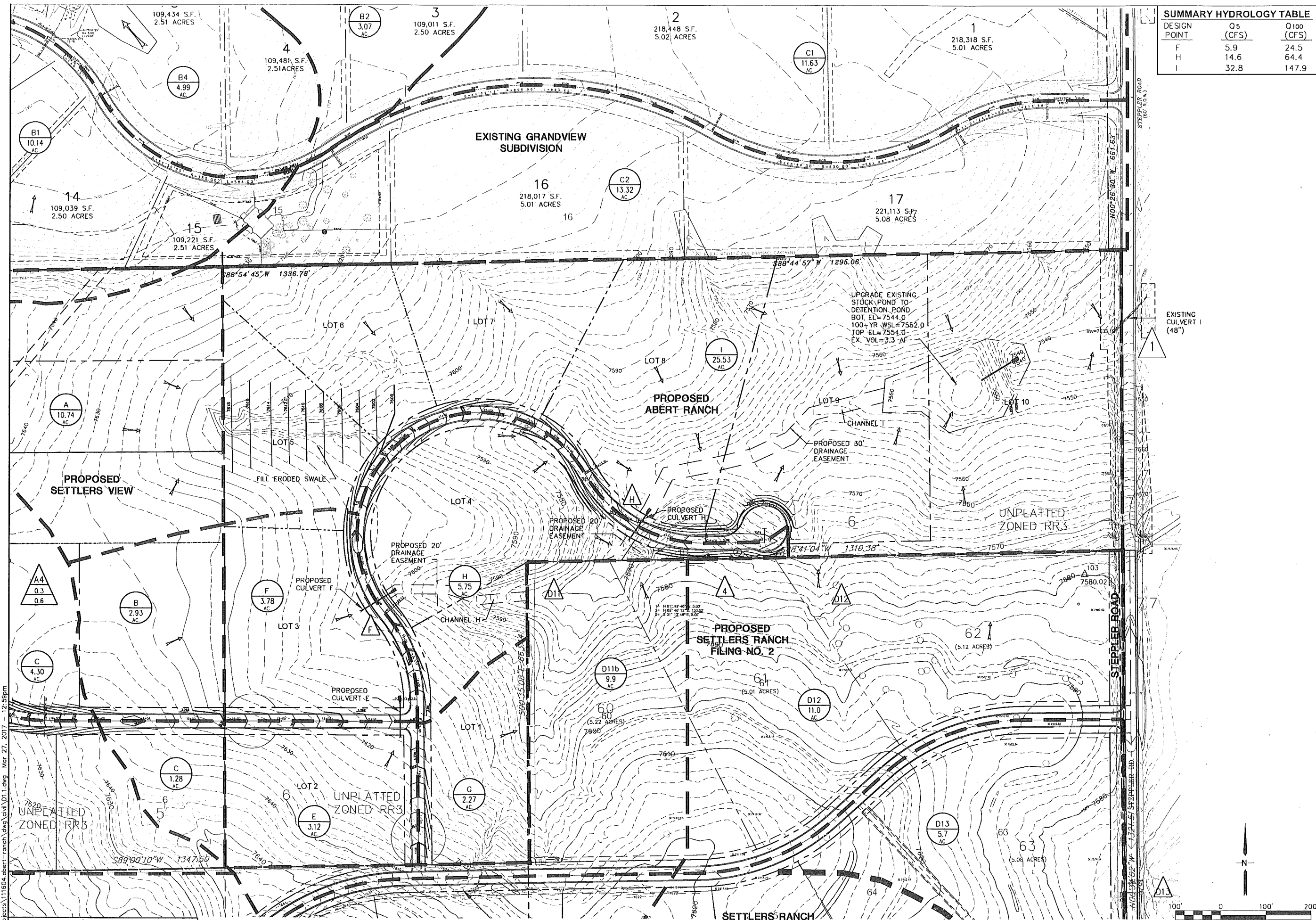
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 VERT. SCALE: N/A  
 SURVEYED: HANNIGAN  
 CREATED: 12/26/16  
 PROJECT NO: 111603  
 SHEET: D1

DRAWN: BJJ  
 DESIGNED: JPS  
 CHECKED: JPS  
 LAST MODIFIED: 3/27/17  
 MODIFIED BY: BJJ



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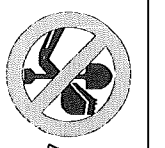




SUMMARY HYDROLOGY TABLE		
DESIGN POINT	Q5 (CFS)	Q100 (CFS)
F	5.9	24.5
H	14.6	64.4
I	32.8	147.9



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 1-800-922-1987  
 2-BUSINESS DAYS IN ADVANCE  
 BEFORE ANY EXCAVATION  
 FOR THE MARKING OF UNDERGROUND  
 MEMBER UTILITIES.

NO.	REVISION	BY	DATE

# ABERT RANCH

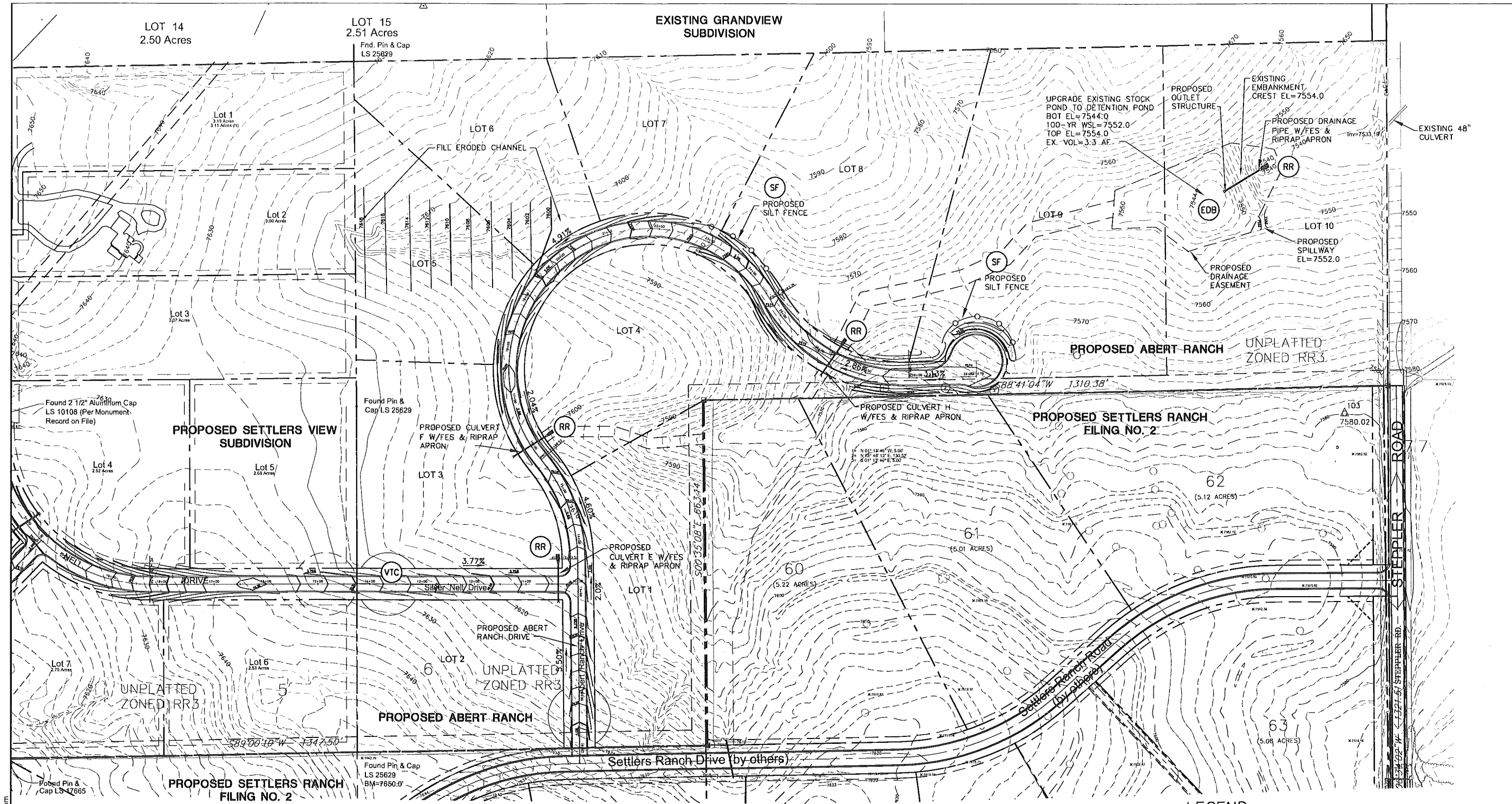
## DEVELOPED DRAINAGE PLAN

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

HORZ. SCALE: 1"=100'  
 VERT. SCALE: N/A  
 SURVEYED: HANNIGAN  
 CREATED: 12/27/16  
 PROJECT NO: 111604  
 SHEET: D1.1

DRAWN: BJJ  
 DESIGNED: JPS  
 CHECKED: JPS  
 LAST MODIFIED: 3/27/17  
 MODIFIED BY: BJJ

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



LOT 14  
2.50 Acres  
 LOT 15  
2.51 Acres  
 Fnd. Pin & Cap  
LS 25629  
 Found 2 1/2" Aluminum Cap  
LS 10108 (Per Monument  
Record on File)  
 Found Pin &  
Cap LS 25629  
 Found Pin &  
Cap LS 47665  
 Found Pin & Cap  
LS 25629  
BM=7650.0'

PROPOSED SETTLERS VIEW  
SUBDIVISION  
 PROPOSED SETTLERS RANCH  
FILING NO. 2  
 UNPLATTED  
ZONED RR3  
 UNPLATTED  
ZONED RR3  
 UNPLATTED  
ZONED RR3

EXISTING GRANDVIEW  
SUBDIVISION  
 PROPOSED ABERT RANCH  
 PROPOSED SETTLERS RANCH  
FILING NO. 2  
 Settlers Ranch Drive (by others)

**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

**EROSION CONTROL:**

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

1  
P1  
 SHEET ON WHICH  
SECTION IS SHOWN

**ABERT RANCH**

**PRELIMINARY GRADING  
& EROSION CONTROL PLAN**

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ENGINEERING  
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Colorado Springs, CO  
80903  
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BEFORE WORKING IN UNDERGROUND  
FOR THE MEMBER UTILITIES.

NO.	REVISION	BY	DATE

HORZ. SCALE: 1"=100'  
 VERT. SCALE: N/A  
 SURVEYED: N/A  
 RAMPART  
 CREATED: 12/27/16  
 PROJECT NO: 111604  
 SHEET:

DRAWN: BJJ  
 DESIGNED: JPS  
 CHECKED: JPS  
 LAST MODIFIED: 3/27/17  
 MODIFIED BY: BJJ

**C1**

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

SUMMARY HYDROLOGY TABLE		
DESIGN POINT	Q5 (CFS)	Q100 (CFS)
S1	2.3	9.3
S2	12.7	52.5
S3	19.0	78.1
F	2.5	10.2
H	5.9	24.5
I	14.6	64.4
	32.8	147.9

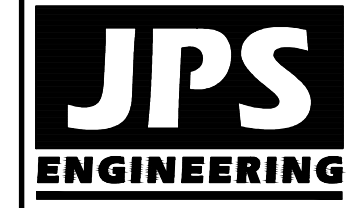
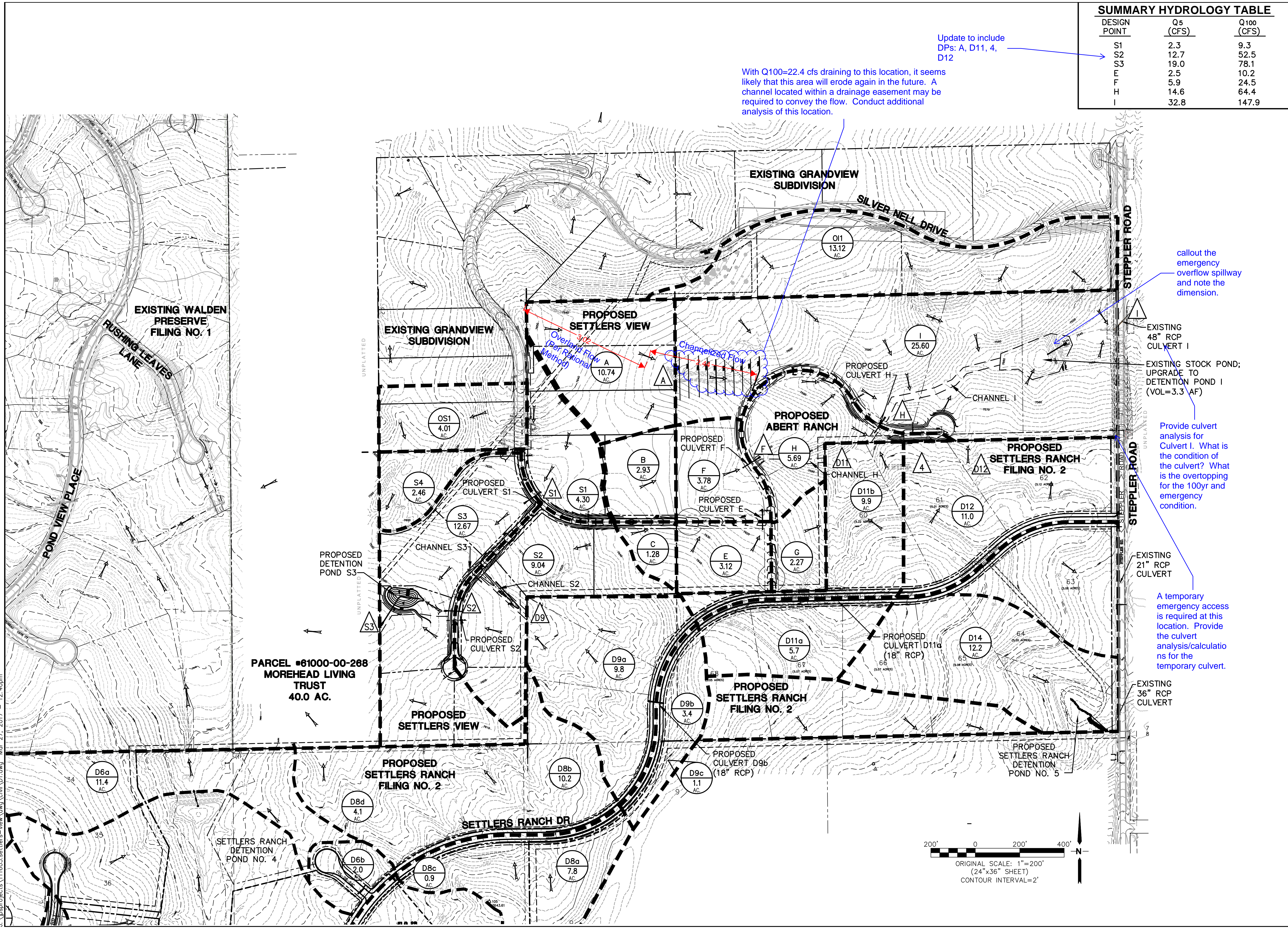
Update to include DPs: A, D11, 4, D12

With Q100=22.4 cfs draining to this location, it seems likely that this area will erode again in the future. A channel located within a drainage easement may be required to convey the flow. Conduct additional analysis of this location.

callout the emergency overflow spillway and note the dimension.

Provide culvert analysis for Culvert I. What is the condition of the culvert? What is the overtopping for the 100yr and emergency condition.

A temporary emergency access is required at this location. Provide the culvert analysis/calculations for the temporary culvert.



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NO.	REVISION	BY	DATE

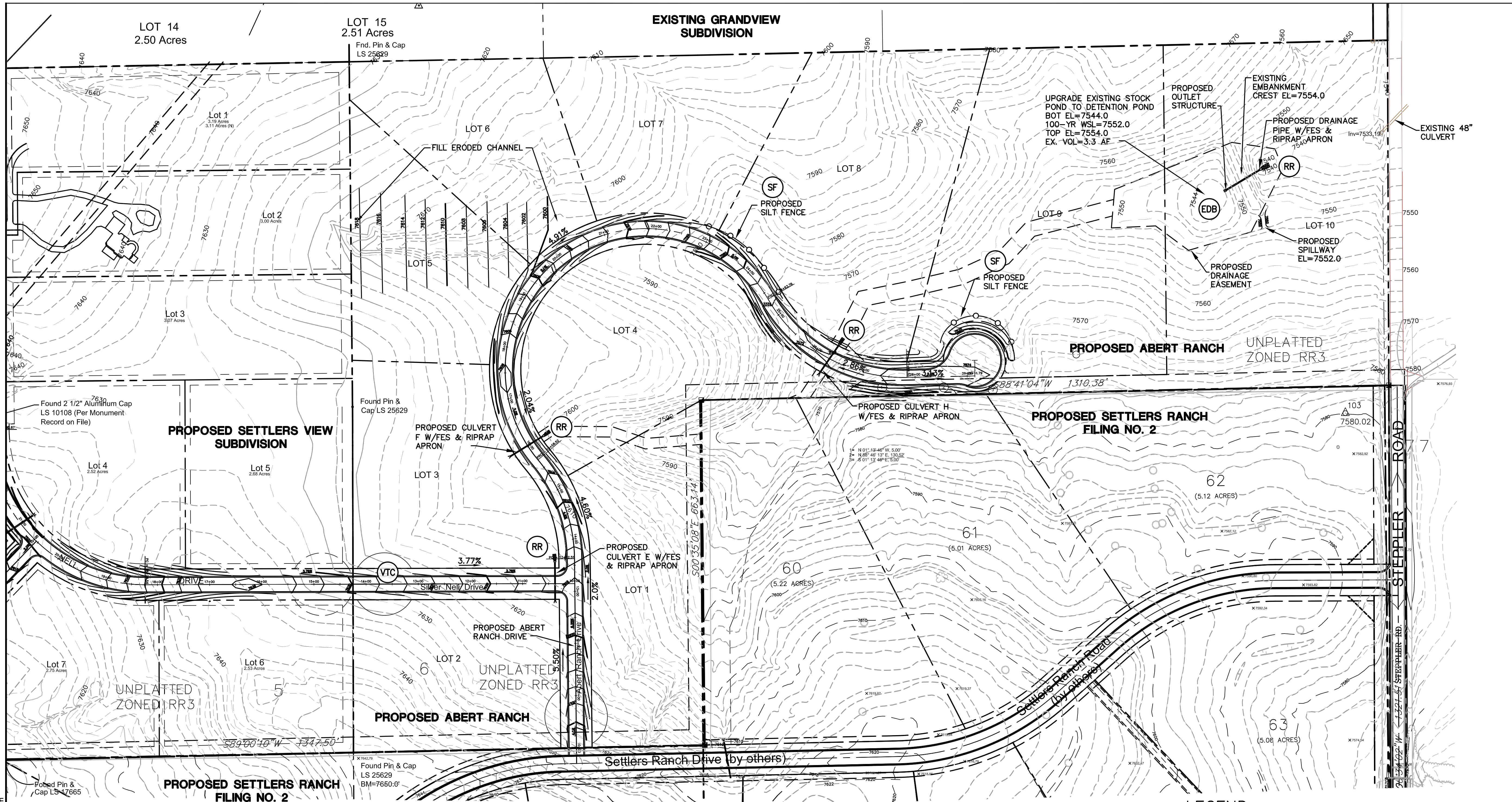
# SETTLERS VIEW & ABERT RANCH

## DEVELOPED DRAINAGE PLAN

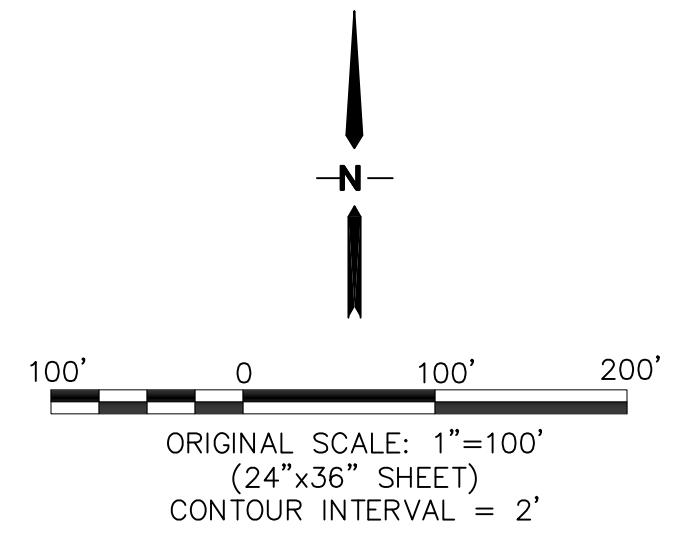
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VERT. SCALE: N/A	DESIGNED: JPS
SURVEYED: HANNIGAN	CHECKED: JPS
CREATED: 12/26/16	LAST MODIFIED: 3/27/17
PROJECT NO: 111603	MODIFIED BY: BJJ

SHEET: D1

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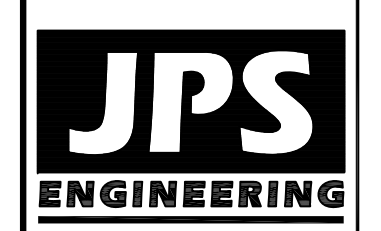


DATUM IS NAVD '88. BENCHMARK IS THE MONUMENT AT THE SOUTHWEST PROPERTY CORNER, HAVING AN ELEVATION OF 7650.0



- LEGEND:**
- NEW/EXISTING
  - SECTION LINE -- NEW/EXISTING
  - EASEMENT LINE -- NEW/EXISTING
  - 6230 --- 6230 --- CONTOUR -- NEW/EXISTING
  - PROPERTY LINE -- NEW/EXISTING
  - FENCE -- NEW/EXISTING
  - OHE --- OHE --- OVERHEAD ELECTRIC LINE W/ POWER POLE NEW/EXISTING
  - UGE --- UGE --- UNDERGROUND ELECTRIC LINE NEW/EXISTING
  - UGE --- UGE --- UNDERGROUND ELECTRIC -- NEW/EXISTING
  - TEL --- TEL --- TELEPHONE -- NEW/EXISTING
  - GAS --- GAS --- GAS -- NEW/EXISTING
  - WT --- WT --- WATER -- NEW/EXISTING
- EROSION CONTROL:**
- RR RIPRAP
  - VTC VEHICLE TRACKING PAD
  - SF SILT FENCE
  - EDB EXTENDED DETENTION BASIN
- SECTION NUMBER**  
1  
P1  
SHEET ON WHICH SECTION IS SHOWN

# ABERT RANCH



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No.	REVISION	DATE

## 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: 3/27/17
PROJECT NO: 111604	MODIFIED BY: BJJ

SHEET: C1

# Markup Summary

dsdlaforce (23)

Add: PCD File No.: SP-17-007

**Subject:** Text Box  
**Page Label:** 1  
**Lock:** Unlocked  
**Status:**  
**Checkmark:** Unchecked  
**Author:** dsdlaforce  
**Date:** 8/28/2017 8:40:10 AM  
**Color:** ■

Add: PCD File No.: SP-17-007

Include the riprap sizing calculations for the culvert and pond outlet.

**Subject:** Text Box  
**Page Label:** 1  
**Lock:** Unlocked  
**Status:**  
**Checkmark:** Unchecked  
**Author:** dsdlaforce  
**Date:** 8/28/2017 12:52:46 PM  
**Color:** ■

Include the riprap sizing calculations for the culvert and pond outlet.

The Stormwater Detention and Infiltration (SDI) design data sheet and EPC MS4 post construction form (attached) will be required with the final plat application.



**Subject:** Text Box  
**Page Label:** 1  
**Lock:** Unlocked  
**Status:**  
**Checkmark:** Unchecked  
**Author:** dsdlaforce  
**Date:** 8/28/2017 8:39:37 AM  
**Color:** ■

The Stormwater Detention and Infiltration (SDI) design data sheet and EPC MS4 post construction form (attached) will be required with the final plat application.

FINAL D  
ABERT R  
Rename to Preliminary Drainage Report.  
Hansig 1926

**Subject:** Callout  
**Page Label:** 1  
**Lock:** Unlocked  
**Status:**  
**Checkmark:** Unchecked  
**Author:** dsdlaforce  
**Date:** 8/28/2017 8:37:21 AM  
**Color:** ■

Rename to Preliminary Drainage Report.

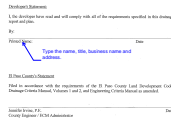


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**Lock:** Unlocked  
**Status:**  
**Checkmark:** Unchecked  
**Author:** dsdlaforce  
**Date:** 8/28/2017 8:39:46 AM  
**Color:** ■

Extract the O&M Manual from the drainage report. This item will be a required standalone submittal document with the final plat application.

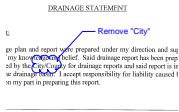
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Extract the O&M Manual from the drainage report. This item will be a required standalone submittal document with the final plat application.



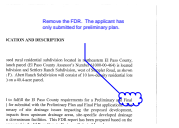
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**Author:** dsdlaforce  
**Date:** 8/28/2017 8:49:06 AM  
**Color:** ■

Type the name, title, business name and address.



**Subject:** Cloud+  
**Page Label:** 4  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 8:48:44 AM  
**Color:** ■

Remove "City"



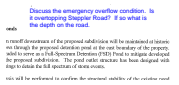
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**Date:** 8/28/2017 8:53:41 AM  
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Remove the FDR. The applicant has only submitted for preliminary plan.



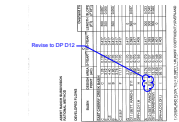
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**Author:** dsdlaforce  
**Date:** 8/28/2017 9:05:34 AM  
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Update the 4 step process based on the steps identified in Appendix I Section 1.7.2 which are different from the city.



**Subject:** Text Box  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 12:59:31 PM  
**Color:** ■

Discuss the emergency overflow condition. Is it overtopping Stepler Road? If so what is the depth on the road.



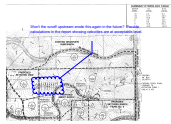
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Revise to DP D12



**Subject:** Cloud+  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 11:53:15 AM  
**Color:** ■

Three different volumes are associated with the design of a full spectrum detention facility: WQCV, EURV, and 100-yr. Revise Zone 2 and 3 in the worksheet



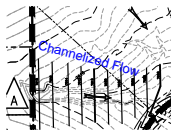
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**Author:** dsdlaforce  
**Date:** 8/28/2017 9:19:13 AM  
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Won't the runoff upstream erode this again in the future? Provide calculations in the report showing velocities are at acceptable level.



**Subject:** Callout  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 1:30:53 PM  
**Color:** ■

A temporary emergency access is required at this location. Provide the culvert analysis/calculations for the temporary culvert.



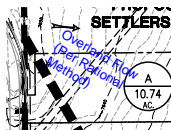
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**Page Label:** 115  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 10:18:01 AM  
**Color:** ■

Channelized Flow



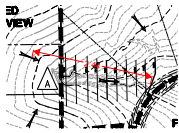
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**Page Label:** 115  
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**Status:**  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 11:53:19 AM  
**Color:** ■

With  $Q_{100}=22.4$  cfs draining to this location, it seems likely that this area will erode again in the future. A channel located within a drainage easement may be required to convey the flow. Conduct additional analysis of this location.



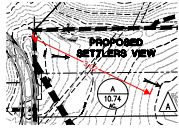
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Overland Flow  
(Per Rational Method)



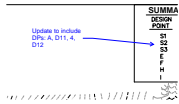
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2.44



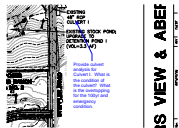
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**Color:** ■

3.02



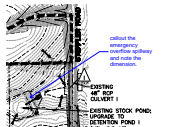
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**Author:** dsdlaforce  
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Update to include DPs: A, D11, 4, D12



**Subject:** Callout  
**Page Label:** 115  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 1:24:28 PM  
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Provide culvert analysis for Culvert I. What is the condition of the culvert? What is the overtopping for the 100yr and emergency condition.



**Subject:** Callout  
**Page Label:** 115  
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**Author:** dsdlaforce  
**Date:** 8/28/2017 12:55:39 PM  
**Color:** ■

callout the emergency overflow spillway and note the dimension.