

# FINAL DRAINAGE REPORT

## **BADGER CENTRAL GATHERING FACILITY**

LOCATED IN NE ¼ OF SECTION 30, T 1 N, R 67 W  
OF THE 6TH PM WELD COUNTY,  
STATE OF COLORADO

Prepared By:

### **Baseline Engineering Corporation**

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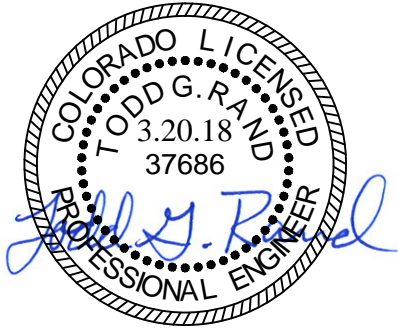
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**March 20, 2018**



Engineering · Planning · Surveying

I hereby certify that this report for the drainage design of the Central Gathering Facility was prepared by me (or under my direct supervision) in accordance with the provisions of the Weld County storm drainage criteria for the owners thereof.”



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Todd G Rand, P.E.

State of Colorado No. 37686

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## I. General Location and Descriptions

### A. Location

1. Township, Range, Section, ¼ Section: The subject property is located in the northeast 1/4 of Section 30, Township 1 North, Range 67 West of the 6th P.M., Weld County, Colorado. Site Plans are included for reference in Appendix G.
2. Local streets within and adjacent to the development: The parcel is bounded by Weld County Road (WCR) 6 to the north and Weld County Road 15 to the east.
3. Major open channels, lakes, streams, irrigation and other water resource facilities within and adjacent to proposed project site: There is an ephemeral channel running from northwest to southeast in the lower half of the site. There are no known irrigation ditches, or streams adjacent to the site.
4. Names of surrounding developments including jurisdiction (municipalities): There are no known developments surrounding the site. WCR 4 abuts the section to the south, and WCR 13 to the west, both governed by Weld County. The Town of Dacono lies approximately 4 miles to the north, I25 is approximately 2.5 miles to the west.

### B. Description of Property

1. Area in Acres: Property Area = 157.52 Acres. Approximate Total Project Area Drainage Analysis Limits = 53.97 Acres.  
Disturbance Limits = 66.50 Acres.
2. Ground cover and soil types: According to the Natural Resources Conservation Service (NRCS) Soils Survey in Appendix A, the northern project area, above the channel, is comprised primarily of soils in Hydrologic Soil Group C, soils having a slow infiltration rate when thoroughly wet. The southern project area, below the channel, is comprised primarily of soils in Hydrologic Soil Group B, soils having a moderate infiltration rate when thoroughly wet. Calculations for composite "C" factors are included in Appendix C. Hydrologic soil Type C was used based on over 54.3% site coverage and that it is the dominate soil group on the project site, Type B on 37.5% site coverage and Type D on 8.1% site coverage in the channel.
3. Major Open Channels and Property Ownership: There are no major open channels adjacent to the site and no defined roadside ditches.
4. General Project Description: The existing zoning for the property is currently Agricultural and it is surrounded by Agricultural zoned properties. No changes to zoning are proposed. The site is proposed to be developed into a central gathering facility. The site will also include a compressor station and substation located on the southern side of the site. There are several existing oil and gas well facilities on the site. There is an abandoned Train Track ROW for the Union Pacific Rail Road running northwest to southeast in the upper half of the property area, the tracks have been removed. An eighty-five foot (85') perpetual easement for an existing electric line runs east-west in

the approximate center of the property area. There is an existing residence at the southwest corner of the intersection of WCR 6 and WCR 15 that is not a part of this project site.

5. Irrigation facilities and facility ownership information within 200 ft. of property: There are no irrigation facilities within the site or within 200 feet of the site.
6. Groundwater characteristics (where applicable): The NRCS survey stated there is potential groundwater in the channel, in the Type D hydrologic soil area. No excavation activities are proposed to mitigate groundwater impacts.

## II. Drainage Basins and Sub-basins

### A. Major Basin Description

1. Reference to Weld County Master Drainage Plan(s) where applicable: There are no known Weld County Master Drainage Plans for the project site.
2. Major basin drainage characteristics: There are no known details of the drainage basin characteristics of the project site defined by a Master Drainage Plan on record.
3. Identification of all FEMA-defined 100-year floodplains and floodways affecting the property: A Letter of Map Revision (LOMR) Determination Document is included in the appendix. The site lies outside the 100-yr floodplain of Big Dry Creek based on the FEMA FIRM panel 08123C2100E with an effective date of January 20, 2016. The site is in an area of Minimal Flood Hazard, Zone X. A map on page 12 of the LOMR shows the site located in the NW  $\frac{1}{4}$  of Section 30. The LOMR with FEMA map is provided for reference in Appendix B.
4. On-site & offsite contours at minimum 2-ft vertical intervals are to be included on the Drainage Report Drawings: Topography at the project site has been provided from a recent engineering survey. Contours are labeled accordingly on the Site Plans provided in Appendix G.

### B. Sub-Basin Description

1. Historic Drainage patterns on the subject property and adjacent properties: Historically, the project area has drained from northwest to southeast at a 2% slope across an undeveloped, cultivated field. The site is split by a natural drainage channel with all site flows converging at the southeast corner of the site. The area to the north of the channel is 104.70 acres in area. The area to the south of the channel is 52.82 acres in area. This site includes a residential lot in the northeast corner and County Road right-of-way.

The drainage area for the CGF developed portion of the property is divided into TEN (10) separate drainage basins. The basins 10-year discharge and 100-year discharge is summarized in Table 1, Part III, Drainage Design Criteria.

**Basin P1** is 2.65 acres and 6% impervious, located in the northwest corner of the site. Runoff flows southwest to a culvert. The basin area is mostly undeveloped with a portion of gravel road along the west boundary and a portion of the paved WCR 6 on the north.

**Basin P2** is 1.67 acres and 4% impervious, located along the western portion of the site. Runoff flows southwest to a shallow swale on the south basin boundary. The basin area is mostly undeveloped with a portion of gravel road along the west boundary.

**Basin P3** is 2.50 acres and 34% impervious, located along the western portion of the site. This basin is the west half of the gravel road running most of the length of the western boundary. A natural drainage channel is approximately in the midpoint of the basin, therefore, flows run south from the north end and north from the south end of the basin to a culvert at the low point. The culvert discharges to the natural drainage channel on the site. The basin includes the gravel road, borrow ditch and western access to the site.

**Basin P4** is 8.01 acres and 5% impervious, located along the northern central portion of the site. Runoff flows south into a swallow swale along the southern basin boundary.

**Basin P5** is 13.28 acres and 40% impervious, located in the western central portion of the site. Runoff flows southeast into a swallow swale along the southern basin boundary. The basin area includes gravel and processing equipment. This basin also includes one (1) tank battery with containment berms surrounding the battery. The containment area and tanks were included in the runoff calculations.

**Basin P6** is 12.90 acres and 39% impervious, located in the eastern central portion of the site. Runoff flows from the northwest to the southeast into a swale surrounding the outer boundary of the basin. The basin area includes gravel and processing equipment. This basin also includes one (1) tank battery with containment berms surrounding the battery. The containment area and tanks were included in the runoff calculations.

**Basin P7** is 9.73 acres and 3% impervious, located along the southern portion of the developed site. This basin consists of screening berms and drainage swales. Runoff flows into a swallow swales along the northern and southern basin boundary. Flows in these swales ultimately discharge into the detention pond.

**Basin P8** is 3.23 acres and 2% impervious, located south of the center of the site and north of the natural drainage channel. This undeveloped basin includes the proposed detention pond.

**Basin P9** is 103.26 acres and 2% impervious, located along the eastern and southern portions of the site. This undeveloped basin straddles, and includes the natural drainage swale, and is comprised of the undisturbed area of the property. Runoff flows, from the northern and western edge of the site boundary to the natural channel. Flows originating west of the site are routed directly to the channel through the site. A 21 acre clear water pond is proposed in this basin between the channel and the southern

boundary.

**Basin P10** is 0.29 acres and 23% impervious, located along the western portion of the site. This basin is the southern end of the gravel road contained in Basin P3. Runoff flows south in the roadside ditch to the end of the road improvements. Flows then travel east in historic patterns.

2. Off-site drainage flow patterns and impacts on the subject property (minimum 200 ft outside property boundary or until no further off-site contributing flow area is encountered): There is historic evidence of off-site drainage flow entering the property. The field to the west drains in a southeasterly direction to the existing swale bisecting the subject property, a new culvert will be installed under the road which will capture any offsite flows. There is no drainage onto the site from the north.

### III. Drainage Design Criteria

#### A. Development Criteria Reference and Constraints

1. Discussion of previous drainage studies (i.e. project master plans) for the subject property that influence or are influenced by the proposed drainage design for the site: There are no known Drainage Reports that affect this property.
2. Discussion of site constraints such as slopes, streets, utilities, existing structures, irrigation ditches, and the site plan impacts on the proposed drainage plan: There are no significant constraints to the project site. The proposed stormwater detention pond contains adequate storage capacity to mitigate stormwater runoff as necessary. The topography is gentle with slopes generally to the southeast at 2.0%. There are no known significant geologic features within the project area.

#### B. Hydrological Criteria

1. Identify design rainfall amounts and source of design storm depth information, NOAA Atlas, UD&FCD maps, etc.: Design rainfall depths were taken from the UDFCD Urban Storm Drainage Criteria Manual, Volume 1. The Drainage calculations can be viewed in Appendices C, D, and E of this report. The UDFCD rainfall depth-duration-frequency charts can be found in Appendix H.
2. Identify design storm recurrence intervals. Reference the appropriate information in the Appendix: Design storm recurrence intervals of 10 year and 100 year storms were analyzed in this study. The 1-hour 10-yr and 100-yr storm was used since the site is NON-URBANIZED. Relevant calculations can be viewed in Appendices C, D, and E of this report.
  - A. Identify runoff calculation method(s) and any computer models. Include summaries of the routing and accumulation of flows at all identified design points for minor and major storm runoff. Reference the results in the Appendix: The Rational Method was used to determine developed flow volumes in each basin. The Rational Formula is  $Q = CIA$ , where Q, the maximum rate of runoff is

equal to the runoff coefficient (C), times the rainfall intensity (I), times the area (A). Relevant calculations can be viewed in Appendices C, D, and E of this report. The results for each basin are as follows in Table 1.

Basin Number	10 Year Runoff (CFS)	100 Year Runoff (CFS)
Basin P1	1.66	5.99
Basin P2	1.12	4.31
Basin P3	2.25	5.50
Basin P4	3.73	14.05
Basin P5	17.22	39.88
Basin P6	12.40	28.97
Basin P7	7.05	27.59
Basin P8	1.50	6.00
Basin P9	30.34	120.81
Basin P10	0.48	1.33

Table 1. Basin Runoff Volumes for 10- and 100-Year Storms

3. Identify detention discharge and storage calculation methods and computer models. Reference the results in the Appendix: Stormwater Detention storage was calculated in accordance with the Weld County Criteria. The required detention volume is the 1-hour 100-year storm volume. The required volume was calculated to be 280,472 CF. The required volume is provided within the proposed detention pond southeast of the CFG with a volume of 325,162 CF at the spillway elevation and a total volume of 460,673 CF at the top of bank elevation. The additional volume provided in the pond allows for the required one foot of freeboard over the 1-hour, 100-year storm depth. The 100-year storm event depth for the pond is 4.17 feet. The percolation rate of the soils within the detention pond has not been analyzed.
4. Discuss how off-site flows will be routed around the proposed site or over the spillway for the 100-yr developed condition: There is no significant off-site drainage flow entering the property. The field to the west drains in a southeasterly direction towards a drainage channel through the site, then flows under WCR 15, and will continue to do so after this site is developed.

### C. Hydraulic Criteria

1. The hydraulic criteria and drainage design features of this project were designed in accordance with the Denver, Colorado, Urban Drainage and Flood Control District's (UDFC) "Urban Storm Drainage Criteria Manual," Volumes 1-3 and Weld County Storm Drainage Criteria identified in Chapter 8 Public Works, Article 11 Storm Drainage Criteria General Provisions and amendments to the UDFCD.
2. Identify detention outlet type. Include a summary of the 100-year water surface

elevation, spillway/overflow facility. Reference the appendix for the calculations. Include summaries of the detention storage sizing and provide a stage-storage table/curve identifying water quality storage, 100-year detention pond storage, and 1 ft of freeboard. Reference the calculations in the Appendix: An outlet structure with a culvert and an overflow spillway has been designed for the detention pond. The detention pond area is shown on Plan Sheets C2 and C10. The CFG Pond has a capacity of 7.46 ac-ft at an elevation of 5083.5 ft as shown in the calculations provided in Appendix F. The 100-year storm creates 6.44 ac-ft of water at an elevation of 5083.17 ft. A 47' wide spillway at elevation 5083.20 ft accounts for overflow capacity.

3. Identify the water quality outlet configuration. Reference the calculations in the Appendix: One outlet structure is proposed for this project designed to release the water quality volume at a 40-hour rate. Calculations are provided in Appendix F.
4. Identify culverts including diameter, type, and slope. Reference the calculations in the Appendix: There is 1 pond outlet culvert proposed for this project. The culvert for the pond is an 18" reinforced concrete pipe (RCP) with a 2% slope. Six (6) additional culverts are proposed to convey runoff to swales and the detention pond. A new culvert is proposed on the western boundary to convey offsite flows under the new gravel road on the west boundary; this culvert is sized to convey the 10-year storm runoff. Calculations for the culvert sizes can be found in Appendix F.
5. Identify storm sewer inlets, manholes, etc. Reference the calculations in the Appendix: A Type C inlet will be constructed at the detention pond outlet. A Type C inlet will also be constructed at Design Point 3 and Design Point 6. See calculations in Appendix F.
6. Discussion of permanent erosion control features: There will be riprap pads for each culvert with minimum dimensions of 3 x pipe diameter in width, by 10 x pipe diameters in length. The detention emergency overflow channel will also receive permanent riprap protection to the dimensions shown on the erosion control plan.
7. Discussion and justification of criteria or calculation methods (for water quality, check dams, drop structures, rundowns, etc.) used that are not presented in Weld County Code: No additional calculation methods were utilized in addition to the Urban Drainage and Flood Control District's (UDFCD) "Urban Storm Drainage Criteria Manual," Volumes 1-3 and Weld County Storm Drainage Criteria identified in Chapter 8 Public Works, Article 11 Storm Drainage Criteria General Provisions and amendments to the UDFCD.

## **IV. Drainage Facility Design**

### **A. General Concept**

1. Discussion of concept and typical on-site drainage patterns: The site consists of gravel and paved areas, oil storage equipment, and existing ground cover as described in the NRCS Soil Survey. Drainage will be directed into an on-site detention pond.
2. Discussion of compliance with off-site runoff considerations and constraints:

Drainage off-site improvements shall be controlled by the detention pond outlets to maintain the historic 10-year runoff rates.

3. Discussion of the content of all tables, charts, figures or drawings in the report: Each of the Appendices provided in this report are discussed throughout the narrative of this document as they pertain to each topic. The list of Appendices to this report include the following:

Appendix A: NRCS Soils Map – Includes map and report discussing the soil conditions in accordance with soil classifications which include properties and features and hydrologic soil group for drainage calculations.

Appendix B: FEMA Map – Attached FEMA FIRM panel 08123C1975E with an effective date of January 20, 2016. The project location is identified on the map for reference.

Appendix C: Composite “C” Factors – Standard Form 1 from the UDFCD and Weld County Code which identify the various coefficients present on-site which are combined to create a composite “C” value used in the formula to calculate site runoff. ( $Q = CiA$ ).

Appendix D: Time of Concentration – Standard Form 2 from the UDFCD and Weld County Code utilize variables including but not limited to the drainage basin area, slope, length, etc. as defined by the rational method of computation for peak flow values.

Appendix E: Storm Drainage System Design – Standard Form 3 from UDFCD and Weld County Code including rational method computations for 10-year and 100-year peak runoff values in cfs.

Appendix F: Hydraulic and Detention Pond Design Calculations – includes Hydrograph Report and data utilized to determine required culvert diameters and detention pond volume, as well as outlet structure and inlet design information. This section also included analysis of the swales which convey runoff to the detention pond. The swale analysis determined the capacities of the swales are adequate for the design flows conveyed and that velocities of flow will not cause excess erosion.

Appendix G: Proposed Drainage Plan – Includes Plan Sheets C9 (Historic Drainage Plan), and C10 (Developed Drainage Plan) which show the necessary information as requested by the Weld County Site Plan Review and the Drainage Report Outline checklist.

Appendix H: Rainfall Depth-Duration-Frequency Estimates for the 5-year, 10-year and 100-year storm events from UDFCD Volume 1 Chapter 5.

## B. Specific Details

1. Discussion of maintenance access and aspects of the design. Include a maintenance plan: The site is designed to have minimal maintenance. The site shall be maintained by the owner in accordance with Weld County Code. The drainage features associated with this project are designed to tie into existing grades. The site is covered with natural vegetation and the drainage mitigation plan includes the detention pond areas which

contain adequate capacity for stormwater overflows. Debris and other accumulations that might reduce the storage capacity of the pond shall be monitored and removed as necessary.

2. Provide copies of CDPHE, CAFO, DRMS, or State Engineer’s permit applications where applicable: No additional permit applications are included with this project.

## V. Conclusions

### A. Compliance with Standards

1. Statement of whether or not the design will meet Weld County Code: To the best of my knowledge, the drainage design set forth in the plans and specifications complies with the Weld County Standards.

### B. Drainage Concept

1. Effectiveness of drainage design to control damage from storm runoff: The existing detention ponds will serve to prevent developed runoff rates from exceeding historic conditions.
2. Influence of proposed development on any applicable Weld County Master Drainage Plan recommendations: The project site is located in an area that is not defined by a Master Drainage Plan on record. There is no proposed development associated with this project that would greatly influence the drainage conditions of the site. Current drainage patterns will be retained and there will be no damage from storm runoff from this site.
3. Identification of and intent to obtain written approval of affected irrigation company or other property owner(s). Weld County may require that the applicant provide evidence that offsite impacted jurisdictions have been notified or the proposed plans: There are no impacts of this project to irrigation companies or other property owners. The site is currently used for agriculture and the property owner maintains the site. A small number of Oil and Gas well exist on the site. The property use is compatible with the Zoning standards for Weld County Agriculture, and the site shall be developed in compliance with Weld County Code.
4. Reference all criteria and technical resources utilized:

Weld County Storm Drainage Criteria – Article XI, Weld County Code Ordinance 2006-07.

Urban Storm Drainage Criteria Manual, Vol. 1, 2 and 3, Urban Drainage and Flood Control District, Denver, Colorado, current Version.

Civil Engineering Reference Manual, Ninth Edition, Michael R. Lindeburg, P.E., 2003.



**VI. APPENDIX**

## **A. NRCS Soils Map**



United States  
Department of  
Agriculture

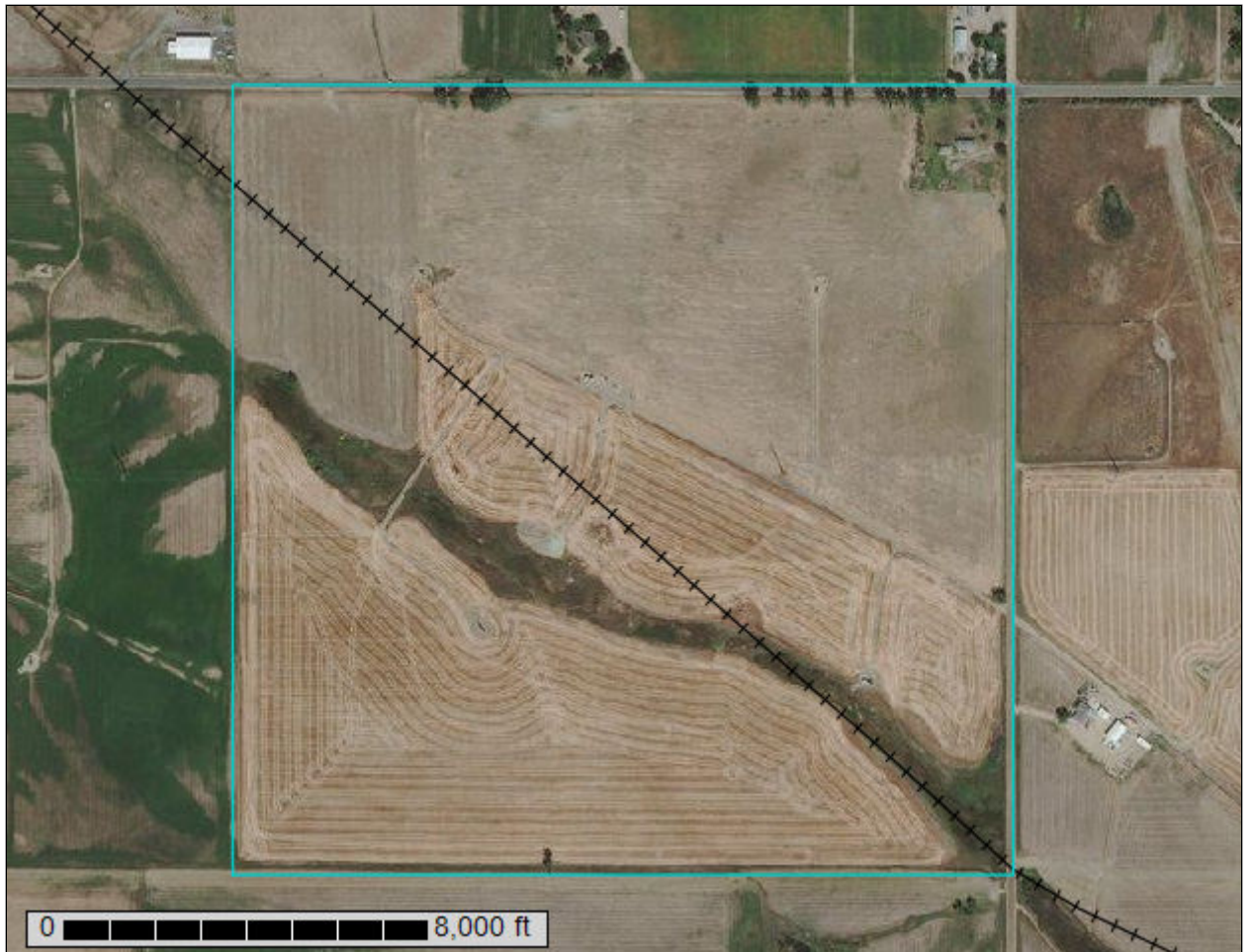
**NRCS**

Natural  
Resources  
Conservation  
Service

A product of the National  
Cooperative Soil Survey,  
a joint effort of the United  
States Department of  
Agriculture and other  
Federal agencies, State  
agencies including the  
Agricultural Experiment  
Stations, and local  
participants

# Custom Soil Resource Report for Weld County, Colorado, Southern Part

## CODY Central Gathering Facility



# 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.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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# 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.

# Custom Soil Resource Report Soil Map



Map Scale: 1:6,260 if printed on A portrait (8.5" x 11") sheet.


0 50 100 200 300 Meters

0 300 600 1200 1800 Feet


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


### MAP LEGEND

**Area of Interest (AOI)**

 Area of Interest (AOI)


**Soils**


 Soil Map Unit Polygons


 Soil Map Unit Lines


 Soil Map Unit Points

**Special Point Features**

 Blowout

 Borrow Pit


 Clay Spot


 Closed Depression

 Gravel Pit

 Gravelly Spot


 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water


 Perennial Water

 Rock Outcrop


 Saline Spot

 Sandy Spot

 Severely Eroded Spot


 Sinkhole

 Slide or Slip


 Sodic Spot


 Spoil Area

 Stony Spot


 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

**Water Features**

 Streams and Canals


**Transportation**

 Rails


 Interstate Highways

 US Routes

 Major Roads

 Local Roads

**Background**

 Aerial Photography

### MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Weld County, Colorado, Southern Part  
 Survey Area Data: Version 16, Oct 10, 2017

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

Date(s) aerial images were photographed: Sep 20, 2015—Oct 15, 2016

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

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
4	Aquolls and Aquepts, flooded	13.9	8.5%
42	Nunn clay loam, 1 to 3 percent slopes	85.5	52.4%
67	Ulm clay loam, 3 to 5 percent slopes	0.6	0.4%
79	Weld loam, 1 to 3 percent slopes	3.2	2.0%
82	Wiley-Colby complex, 1 to 3 percent slopes	42.1	25.8%
83	Wiley-Colby complex, 3 to 5 percent slopes	17.8	10.9%
<b>Totals for Area of Interest</b>		<b>163.2</b>	<b>100.0%</b>

## 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

## Custom Soil Resource Report

was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

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

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

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

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

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

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

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

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

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

## Weld County, Colorado, Southern Part

### 4—Aquolls and Aquepts, flooded

#### Map Unit Setting

*National map unit symbol:* 3621

*Elevation:* 3,600 to 4,700 feet

*Mean annual precipitation:* 12 to 16 inches

*Mean annual air temperature:* 50 to 55 degrees F

*Frost-free period:* 100 to 165 days

*Farmland classification:* Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

#### Map Unit Composition

*Aquolls and similar soils:* 55 percent

*Aquepts, flooded, and similar soils:* 25 percent

*Minor components:* 20 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Aquolls

##### Setting

*Landform:* Depressions, drainageways, plains

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Recent alluvium

##### Typical profile

*H1 - 0 to 8 inches:* variable

*H2 - 8 to 60 inches:* stratified sandy loam to clay

##### Properties and qualities

*Slope:* 0 to 3 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Poorly drained

*Runoff class:* Very low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high  
(0.06 to 6.00 in/hr)

*Depth to water table:* About 6 to 36 inches

*Frequency of flooding:* Frequent

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 10 percent

*Salinity, maximum in profile:* Moderately saline to strongly saline (8.0 to 16.0  
mmhos/cm)

*Sodium adsorption ratio, maximum in profile:* 5.0

*Available water storage in profile:* Low (about 4.7 inches)

##### Interpretive groups

*Land capability classification (irrigated):* 6w

*Land capability classification (nonirrigated):* 6w

*Hydrologic Soil Group:* D

*Ecological site:* Salt Meadow (R067BY035CO)

*Hydric soil rating:* Yes

## Description of Aquepts, Flooded

### Setting

*Landform:* Stream terraces  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Recent alluvium

### Typical profile

*H1 - 0 to 8 inches:* variable  
*H2 - 8 to 60 inches:* stratified sandy loam to clay

### Properties and qualities

*Slope:* 0 to 3 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Poorly drained  
*Runoff class:* Very low  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to high  
(0.06 to 6.00 in/hr)  
*Depth to water table:* About 6 to 36 inches  
*Frequency of flooding:* Frequent  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 10 percent  
*Salinity, maximum in profile:* Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 5.0  
*Available water storage in profile:* Low (about 4.7 inches)

### Interpretive groups

*Land capability classification (irrigated):* 6w  
*Land capability classification (nonirrigated):* 6w  
*Hydrologic Soil Group:* D  
*Ecological site:* Wet Meadow (R067BY038CO)  
*Hydric soil rating:* Yes

## Minor Components

### Thedalund

*Percent of map unit:* 10 percent  
*Hydric soil rating:* No

### Haverson

*Percent of map unit:* 10 percent  
*Hydric soil rating:* No

## 42—Nunn clay loam, 1 to 3 percent slopes

### Map Unit Setting

*National map unit symbol:* 2tlpl  
*Elevation:* 3,900 to 5,840 feet

## Custom Soil Resource Report

*Mean annual precipitation:* 13 to 17 inches  
*Mean annual air temperature:* 50 to 54 degrees F  
*Frost-free period:* 135 to 160 days  
*Farmland classification:* Prime farmland if irrigated

### Map Unit Composition

*Nunn and similar soils:* 85 percent  
*Minor components:* 15 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Nunn

#### Setting

*Landform:* Terraces  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Pleistocene aged alluvium and/or eolian deposits

#### Typical profile

*Ap - 0 to 9 inches:* clay loam  
*Bt - 9 to 13 inches:* clay loam  
*Btk - 13 to 25 inches:* clay loam  
*Bk1 - 25 to 38 inches:* clay loam  
*Bk2 - 38 to 80 inches:* clay loam

#### Properties and qualities

*Slope:* 1 to 3 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 low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 7 percent  
*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)  
*Sodium adsorption ratio, maximum in profile:* 0.5  
*Available water storage in profile:* High (about 9.9 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 2e  
*Land capability classification (nonirrigated):* 3e  
*Hydrologic Soil Group:* C  
*Ecological site:* Clayey Plains (R067BY042CO)  
*Hydric soil rating:* No

### Minor Components

#### Heldt

*Percent of map unit:* 10 percent  
*Landform:* Terraces  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear

## Custom Soil Resource Report

*Ecological site:* Clayey Plains (R067BY042CO)  
*Hydric soil rating:* No

### **Satanta**

*Percent of map unit:* 5 percent  
*Landform:* Terraces  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Ecological site:* Loamy Plains (R067BY002CO)  
*Hydric soil rating:* No

## **67—Ulm clay loam, 3 to 5 percent slopes**

### **Map Unit Setting**

*National map unit symbol:* 363k  
*Elevation:* 5,070 to 5,200 feet  
*Mean annual precipitation:* 13 to 15 inches  
*Mean annual air temperature:* 46 to 48 degrees F  
*Frost-free period:* 105 to 120 days  
*Farmland classification:* Farmland of statewide importance

### **Map Unit Composition**

*Ulm and similar soils:* 85 percent  
*Minor components:* 15 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### **Description of Ulm**

#### **Setting**

*Landform:* Plains  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Alluvium and/or eolian deposits derived from shale

#### **Typical profile**

*H1 - 0 to 5 inches:* clay loam  
*H2 - 5 to 17 inches:* clay  
*H3 - 17 to 60 inches:* clay loam

#### **Properties and qualities**

*Slope:* 3 to 5 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Well drained  
*Runoff class:* Low  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent

## Custom Soil Resource Report

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

*Available water storage in profile:* High (about 10.5 inches)

### Interpretive groups

*Land capability classification (irrigated):* 4e

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* C

*Ecological site:* Clayey Plains (R067BY042CO)

*Hydric soil rating:* No

### Minor Components

#### Renohill

*Percent of map unit:* 11 percent

*Hydric soil rating:* No

#### Heldt

*Percent of map unit:* 4 percent

*Hydric soil rating:* No

## 79—Weld loam, 1 to 3 percent slopes

### Map Unit Setting

*National map unit symbol:* 2x0hw

*Elevation:* 3,600 to 5,750 feet

*Mean annual precipitation:* 12 to 17 inches

*Mean annual air temperature:* 46 to 54 degrees F

*Frost-free period:* 115 to 155 days

*Farmland classification:* Prime farmland if irrigated

### Map Unit Composition

*Weld and similar soils:* 80 percent

*Minor components:* 20 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Weld

#### Setting

*Landform:* Interfluves

*Landform position (two-dimensional):* Summit

*Landform position (three-dimensional):* Interfluve

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Calcareous loess

#### Typical profile

*Ap - 0 to 8 inches:* loam

*Bt1 - 8 to 12 inches:* clay

*Bt2 - 12 to 15 inches:* clay loam

*Btk - 15 to 28 inches:* loam

## Custom Soil Resource Report

*Bk - 28 to 60 inches: silt loam*

*C - 60 to 80 inches: silt loam*

### Properties and qualities

*Slope: 1 to 3 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 low to moderately high (0.06 to 0.20 in/hr)*

*Depth to water table: More than 80 inches*

*Frequency of flooding: None*

*Frequency of ponding: None*

*Calcium carbonate, maximum in profile: 14 percent*

*Salinity, maximum in profile: Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)*

*Sodium adsorption ratio, maximum in profile: 5.0*

*Available water storage in profile: High (about 11.3 inches)*

### Interpretive groups

*Land capability classification (irrigated): 2e*

*Land capability classification (nonirrigated): 3c*

*Hydrologic Soil Group: C*

*Ecological site: Loamy Plains (R067BY002CO)*

*Hydric soil rating: No*

### Minor Components

#### Adena

*Percent of map unit: 8 percent*

*Landform: Interfluves*

*Landform position (two-dimensional): Shoulder*

*Landform position (three-dimensional): Interfluve*

*Down-slope shape: Convex*

*Across-slope shape: Convex*

*Ecological site: Loamy Plains (R067BY002CO)*

*Hydric soil rating: No*

#### Colby

*Percent of map unit: 7 percent*

*Landform: Hillslopes*

*Landform position (two-dimensional): Backslope*

*Landform position (three-dimensional): Side slope*

*Down-slope shape: Convex*

*Across-slope shape: Convex*

*Ecological site: Loamy Plains (R067BY002CO)*

*Hydric soil rating: No*

#### Keith

*Percent of map unit: 3 percent*

*Landform: Interfluves*

*Landform position (two-dimensional): Summit*

*Landform position (three-dimensional): Interfluve*

*Down-slope shape: Linear*

*Across-slope shape: Linear*

*Ecological site: Loamy Plains (R067BY002CO)*

*Hydric soil rating: No*

**Baca**

*Percent of map unit:* 2 percent  
*Landform:* Interfluves  
*Landform position (two-dimensional):* Shoulder, summit  
*Landform position (three-dimensional):* Interfluve  
*Down-slope shape:* Linear, convex  
*Across-slope shape:* Linear, convex  
*Ecological site:* Loamy Plains (R067BY002CO)  
*Hydric soil rating:* No

**82—Wiley-Colby complex, 1 to 3 percent slopes**

**Map Unit Setting**

*National map unit symbol:* 3643  
*Elevation:* 4,850 to 5,000 feet  
*Mean annual precipitation:* 12 to 16 inches  
*Mean annual air temperature:* 48 to 54 degrees F  
*Frost-free period:* 135 to 170 days  
*Farmland classification:* Prime farmland if irrigated

**Map Unit Composition**

*Wiley and similar soils:* 60 percent  
*Colby and similar soils:* 30 percent  
*Minor components:* 10 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Wiley**

**Setting**

*Landform:* Plains  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Calcareous eolian deposits

**Typical profile**

*H1 - 0 to 11 inches:* silt loam  
*H2 - 11 to 60 inches:* silty clay loam  
*H3 - 60 to 64 inches:* silty clay loam

**Properties and qualities**

*Slope:* 1 to 3 percent  
*Depth to restrictive feature:* More than 80 inches  
*Natural drainage class:* Well drained  
*Runoff class:* Low  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum in profile:* 15 percent

## Custom Soil Resource Report

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

*Available water storage in profile:* High (about 11.7 inches)

### Interpretive groups

*Land capability classification (irrigated):* 2e

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* B

*Ecological site:* Loamy Plains (R067BY002CO)

*Hydric soil rating:* No

### Description of Colby

#### Setting

*Landform:* Plains

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Calcareous eolian deposits

#### Typical profile

*H1 - 0 to 7 inches:* loam

*H2 - 7 to 60 inches:* silt loam

#### Properties and qualities

*Slope:* 1 to 3 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.57 to 2.00 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 15 percent

*Available water storage in profile:* High (about 10.6 inches)

### Interpretive groups

*Land capability classification (irrigated):* 3e

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* B

*Ecological site:* Loamy Plains (R067BY002CO)

*Hydric soil rating:* No

### Minor Components

#### Heldt

*Percent of map unit:* 4 percent

*Hydric soil rating:* No

#### Weld

*Percent of map unit:* 4 percent

*Hydric soil rating:* No

#### Keith

*Percent of map unit:* 2 percent

*Hydric soil rating:* No

## 83—Wiley-Colby complex, 3 to 5 percent slopes

### Map Unit Setting

*National map unit symbol:* 3644

*Elevation:* 4,850 to 5,000 feet

*Mean annual precipitation:* 12 to 16 inches

*Mean annual air temperature:* 48 to 54 degrees F

*Frost-free period:* 135 to 170 days

*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Wiley and similar soils:* 55 percent

*Colby and similar soils:* 30 percent

*Minor components:* 15 percent

*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Wiley

#### Setting

*Landform:* Plains

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Calcareous eolian deposits

#### Typical profile

*H1 - 0 to 11 inches:* silt loam

*H2 - 11 to 60 inches:* silty clay loam

*H3 - 60 to 64 inches:* silty clay loam

#### Properties and qualities

*Slope:* 3 to 5 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 15 percent

*Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

*Available water storage in profile:* High (about 11.7 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3e

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* B

*Ecological site:* Loamy Plains (R067BY002CO)

## Custom Soil Resource Report

*Hydric soil rating:* No

### Description of Colby

#### Setting

*Landform:* Plains

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Calcareous eolian deposits

#### Typical profile

*H1 - 0 to 7 inches:* loam

*H2 - 7 to 60 inches:* silt loam

#### Properties and qualities

*Slope:* 3 to 5 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.57 to 2.00 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum in profile:* 15 percent

*Available water storage in profile:* High (about 10.6 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3e

*Land capability classification (nonirrigated):* 4e

*Hydrologic Soil Group:* B

*Ecological site:* Loamy Plains (R067BY002CO)

*Hydric soil rating:* No

### Minor Components

#### Heldt

*Percent of map unit:* 9 percent

*Hydric soil rating:* No

#### Weld

*Percent of map unit:* 6 percent

*Hydric soil rating:* No

# **Soil Information for All Uses**

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## **Soil Properties and Qualities**

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

## **Soil Qualities and Features**

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

## **Hydrologic Soil Group (Cody CGF)**

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.

## Custom Soil Resource Report

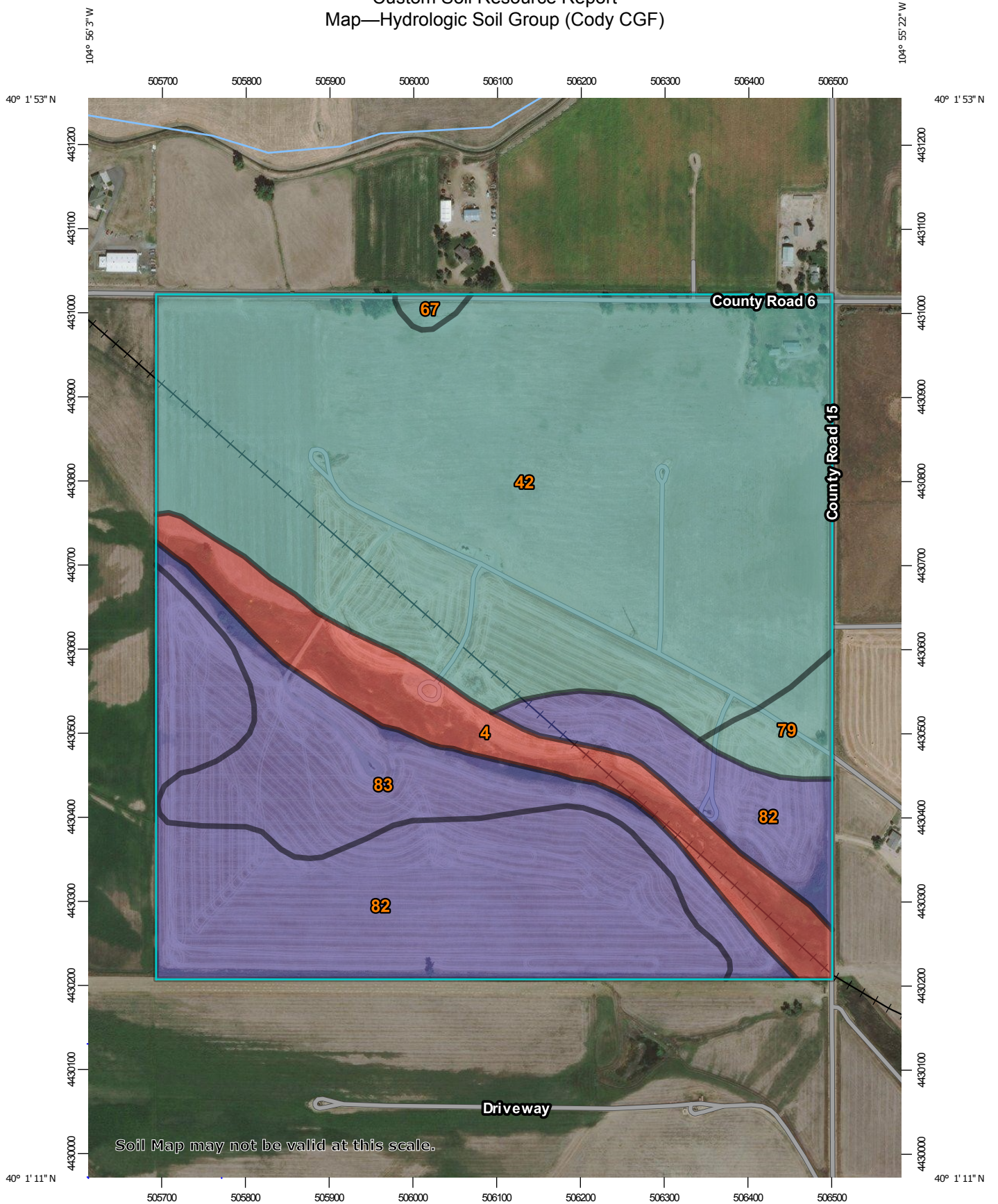
Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

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.

# Custom Soil Resource Report

## Map—Hydrologic Soil Group (Cody CGF)




Map Scale: 1:6,260 if printed on A portrait (8.5" x 11") sheet.

0 50 100 200 300 Meters

0 300 600 1200 1800 Feet









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

### MAP LEGEND









**Area of Interest (AOI)**  
 Area of Interest (AOI)

**Soils**





**Soil Rating Polygons**

-  A
-  A/D
-  B
-  B/D
-  C
-  C/D
-  D
-  Not rated or not available


**Soil Rating Lines**

-  A
-  A/D
-  B
-  B/D
-  C
-  C/D
-  D
-  Not rated or not available






**Soil Rating Points**

-  A
-  A/D
-  B
-  B/D


**Water Features**

-  Streams and Canals





**Transportation**

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

**Background**

-  Aerial Photography

**Soils**

-  C
-  C/D
-  D
-  Not rated or not available

### 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: Weld County, Colorado, Southern Part  
 Survey Area Data: Version 16, Oct 10, 2017

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

Date(s) aerial images were photographed: Sep 20, 2015—Oct 15, 2016

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.

**Table—Hydrologic Soil Group (Cody CGF)**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
4	Aquolls and Aquepts, flooded	D	13.9	8.5%
42	Nunn clay loam, 1 to 3 percent slopes	C	85.5	52.4%
67	Ulm clay loam, 3 to 5 percent slopes	C	0.6	0.4%
79	Weld loam, 1 to 3 percent slopes	C	3.2	2.0%
82	Wiley-Colby complex, 1 to 3 percent slopes	B	42.1	25.8%
83	Wiley-Colby complex, 3 to 5 percent slopes	B	17.8	10.9%
<b>Totals for Area of Interest</b>			<b>163.2</b>	<b>100.0%</b>

**Rating Options—Hydrologic Soil Group (Cody CGF)**

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Higher

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- United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084>

## Custom Soil Resource Report

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. [http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2\\_054242](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242)

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

**B. FEMA Firm Map**



# Federal Emergency Management Agency

Washington, D.C. 20472

## LETTER OF MAP REVISION DETERMINATION DOCUMENT

COMMUNITY AND REVISION INFORMATION		PROJECT DESCRIPTION	BASIS OF REQUEST
COMMUNITY	Weld County Colorado (Unincorporated Areas)	NO PROJECT	UPDATE
	COMMUNITY NO.: 080266		
IDENTIFIER	Weld County FHAD	APPROXIMATE LATITUDE AND LONGITUDE: 40.004, -104.932 SOURCE: USGS QUADRANGLE DATUM: NAD 1983	
ANNOTATED MAPPING ENCLOSURES		ANNOTATED STUDY ENCLOSURES	
TYPE: FIRM	NO.: 08123C2100E      DATE: January 20, 2016	DATE OF EFFECTIVE FLOOD INSURANCE STUDY: January 20, 2016 PROFILE(S): 145P-147P FLOODWAY DATA TABLE: 5 SUMMARY OF DISCHARGE TABLE: 2	

Enclosures reflect changes to flooding sources affected by this revision.

\* FIRM - Flood Insurance Rate Map; \*\* FBFM - Flood Boundary and Floodway Map; \*\*\* FHBM - Flood Hazard Boundary Map

### FLOODING SOURCES AND REVISED REACHES

Big Dry Creek – from approximately 9,830 feet to approximately 9,870 feet upstream of Weld County Road 4  
Union Pacific Split Flow – from approximately 2,770 feet downstream to approximately 350 feet upstream of Colorado Boulevard

### SUMMARY OF REVISIONS

Flooding Source	Effective Flooding	Revised Flooding	Increases	Decreases
Big Dry Creek	No Floodway	Floodway	YES	NONE
	No BFE	BFE	YES	NONE
	Zone A	Zone AE	YES	YES
Union Pacific Split Flow	No Floodway	Floodway	YES	NONE
	No BFE	BFE	YES	NONE
	Zone X (shaded)	Zone AE	YES	NONE

\* BFEs - Base Flood Elevations

### DETERMINATION

This document provides the determination from the Department of Homeland Security's Federal Emergency Management Agency (FEMA) regarding a request for a Letter of Map Revision (LOMR) for the area described above. Using the information submitted, we have determined that a revision to the flood hazards depicted in the Flood Insurance Study (FIS) report and/or National Flood Insurance Program (NFIP) map is warranted. This document revises the effective NFIP map, as indicated in the attached documentation. Please use the enclosed annotated map panels revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals in your community.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 847 South Pickett Street, Alexandria, VA 22304. Additional Information about the NFIP is available on our Web site at <http://www.fema.gov/nfip>.

Luis Rodriguez, P.E., Chief  
Engineering Management Branch  
Federal Insurance and Mitigation Administration

15-08-1446P

102-I-A-C



# Federal Emergency Management Agency

Washington, D.C. 20472

## LETTER OF MAP REVISION DETERMINATION DOCUMENT (CONTINUED)

### COMMUNITY INFORMATION

#### APPLICABLE NFIP REGULATIONS/COMMUNITY OBLIGATION

We have made this determination pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (P.L. 93-234) and in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, P.L. 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65. Pursuant to Section 1361 of the National Flood Insurance Act of 1968, as amended, communities participating in the NFIP are required to adopt and enforce floodplain management regulations that meet or exceed NFIP criteria. These criteria, including adoption of the FIS report and FIRM, and the modifications made by this LOMR, are the minimum requirements for continued NFIP participation and do not supersede more stringent State/Commonwealth or local requirements to which the regulations apply.

#### COMMUNITY REMINDERS

We based this determination on the 1-percent-annual-chance flood discharges computed in the FIS for your community without considering subsequent changes in watershed characteristics that could increase flood discharges. Future development of projects upstream could cause increased flood discharges, which could cause increased flood hazards. A comprehensive restudy of your community's flood hazards would consider the cumulative effects of development on flood discharges subsequent to the publication of the FIS report for your community and could, therefore, establish greater flood hazards in this area.

Your community must regulate all proposed floodplain development and ensure that any permits required by Federal or State/Commonwealth law have been obtained. State/Commonwealth or community officials, based on knowledge of local conditions and in the interest of safety, may set higher standards for construction or may limit development in floodplain areas. If your State/Commonwealth or community has adopted more restrictive or comprehensive floodplain management criteria, those criteria take precedence over the minimum NFIP requirements.

We will not print and distribute this LOMR to primary users, such as local insurance agents or mortgage lenders; instead, the community will serve as a repository for the new data. We encourage you to disseminate the information in this LOMR by preparing a news release for publication in your community's newspaper that describes the revision and explains how your community will provide the data and help interpret the NFIP maps. In that way, interested persons, such as property owners, insurance agents, and mortgage lenders, can benefit from the information.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 847 South Pickett Street, Alexandria, VA 22304. Additional Information about the NFIP is available on our Web site at <http://www.fema.gov/nfip>.

A handwritten signature in black ink, appearing to read "Luis Rodriguez".

Luis Rodriguez, P.E., Chief  
Engineering Management Branch  
Federal Insurance and Mitigation Administration



Federal Emergency Management Agency  
Washington, D.C. 20472

**LETTER OF MAP REVISION  
DETERMINATION DOCUMENT (CONTINUED)**

We have designated a Consultation Coordination Officer (CCO) to assist your community. The CCO will be the primary liaison between your community and FEMA. For information regarding your CCO, please contact:

Ms. Jeanine D. Petterson  
Director, Mitigation Division  
Federal Emergency Management Agency, Region VIII  
Denver Federal Center, Building 710  
P.O. Box 25267  
Denver, CO 80225-0267  
(303) 235-4830

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 847 South Pickett Street, Alexandria, VA 22304. Additional Information about the NFIP is available on our Web site at <http://www.fema.gov/nfip>.

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Luis Rodriguez, P.E., Chief  
Engineering Management Branch  
Federal Insurance and Mitigation Administration



# Federal Emergency Management Agency

Washington, D.C. 20472

## LETTER OF MAP REVISION DETERMINATION DOCUMENT (CONTINUED)

### PUBLIC NOTIFICATION OF REVISION

A notice of changes will be published in the *Federal Register*. This information also will be published in your local newspaper on or about the dates listed below and through FEMA's Flood Hazard Mapping Web site at [https://www.floodmaps.fema.gov/fhm/Scripts/bfe\\_main.asp](https://www.floodmaps.fema.gov/fhm/Scripts/bfe_main.asp).

LOCAL NEWSPAPER      Name: *The Greeley Tribune*  
   Dates: December 25, 2015 and January 1, 2016

Within 90 days of the second publication in the local newspaper, a citizen may request that we reconsider this determination. Any request for reconsideration must be based on scientific or technical data. Therefore, this letter will be effective only after the 90-day appeal period has elapsed and we have resolved any appeals that we receive during this appeal period. Until this LOMR is effective, the revised flood hazard determination information presented in this LOMR may be changed.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 847 South Pickett Street, Alexandria, VA 22304. Additional Information about the NFIP is available on our Web site at <http://www.fema.gov/nfip>.

A handwritten signature in black ink, appearing to read "Luis Rodriguez".

Luis Rodriguez, P.E., Chief  
Engineering Management Branch  
Federal Insurance and Mitigation Administration

Table 2 – Summary of Discharges (Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area (Square Miles)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-Percent Annual Chance</u>	<u>2-Percent Annual Chance</u>	<u>1-Percent Annual Chance</u>	<u>0.2-Percent Annual Chance</u>
Spring Creek Tributary At Weld County Road 88	-- <sup>1</sup>	2,280	4,180	5,780	8,320
The Slough	-- <sup>1</sup>	275	1,350	2,150	4,800
The Slough – Below John Law Ditch Reservoir	37.47	-- <sup>1</sup>	-- <sup>1</sup>	4,443	-- <sup>1</sup>
Tri-Area Drainage					
At County Road 13	3.8	474	907	1,035	1,505
At McClure Avenue	3.1	416	674	767	1,106
At 1 <sup>st</sup> Street	2.7	318	358	365	380
At Miner's Park Pond Overflow	2.5	292	302	304	308
At Confluence of Tri-Area East Tributary	1.2	250	693	896	1,269
Union Pacific Split Flow					
At Confluence of Big Dry Creek	-- <sup>1</sup>	-- <sup>1</sup>	-- <sup>1</sup>	8,500	11,960
U.S. Highway 34 Bypass Split Flow Path					
At South Platte River Cross Section F	-- <sup>1</sup>	-- <sup>1</sup>	-- <sup>1</sup>	409	2,113

Revised  
Data

REVISED TO  
REFLECT LOMR  
EFFECTIVE: May 13, 2016

<sup>1</sup> Data Not Available

Table 2 – Summary of Discharges

Revised  
Data

<u>Flooding Source and Location</u>	<u>Drainage Area (Square Miles)</u>	<u>Peak Discharges (cfs)</u>		
		<u>10-Percent Annual Chance</u>	<u>2-Percent Annual Chance</u>	<u>1-Percent Annual Chance</u>
Ashcroft Draw At Mouth	6.33	285	710	960
Downstream of Arrowhead Reservoir	4.37	244	510	654
Upstream of Arrowhead Reservoir	4.37	458	1,130	1,546
At Upstream Limit of Study	1.86	256	640	860
Big Dry Creek At East 168 <sup>th</sup> Avenue	66.6	4,530	8,260	10,000
Big Thompson River				
Larimer-Weld County Line	595	3,600	7,600	10,000
Upstream from Little Thompson River	613	2,200	4,700	6,500
Downstream from Little Thompson River	813	3,200	7,300	9,900
Confluence with South Platte River	819	2,500	5,900	8,000
Cache La Poudre River				
At Mouth	1,890	3,100	7,550	10,600
At Eaton Draw	1,875	3,400	7,660	10,700
Downstream of Coalbank Creek	1,810	3,900	8,540	11,800
Upstream of Coalbank Creek	1,747	3,870	8,470	11,700
Downstream of Law Ditch	1,707	4,620	9,720	13,200
Upstream of Law Ditch	1,662	4,590	9,640	13,100
Downstream of Boxelder Creek	1,537	6,750	13,200	17,400
Coal Creek				
At Briggs Street	77.48	6,160	10,040	12,280
Near Tri-County Airport	68.61	5,970	9,670	11,850
Coalbank Creek				
At Confluence with Cache La Poudre River	46	772	1,531	1,817
Consolidated John Law Ditch				
At Confluence with John Law Ditch	-- <sup>1</sup>	-- <sup>1</sup>	-- <sup>1</sup>	-- <sup>1</sup>

REVISED TO

--<sup>1</sup> REFLECT LOMR 900  
EFFECTIVE: May 13, 2016

<sup>1</sup> Data Not Available

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE <sup>1</sup>	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
BIG DRY CREEK A	51,574	1,025	2,760	3.6	5,047.3	5,047.3	5,047.3	0.0

<sup>1</sup>Feet Above Confluence With South Platte River

FEDERAL EMERGENCY MANAGEMENT AGENCY

**WELD COUNTY, CO  
AND INCORPORATED AREAS**

REVISED TO

**FLOODWAY DATA**

REFLECT LOMR  
EFFECTIVE: May 13, 2016

**BIG DRY CREEK**

**TABLE 5**

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE <sup>1</sup>	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
UNION PACIFIC SPLIT FLOW								
A	1,609	1,688	1,387	6.1	5,049.3	5,049.3	5,049.7	0.4
B	3,102	952	1,704	5.0	5,061.1	5,061.1	5,061.4	0.3
C	4,311	691	1,407	6.0	5,073.8	5,073.8	5,074.0	0.2

<sup>1</sup>Feet Above Confluence with Big Dry Creek

FEDERAL EMERGENCY MANAGEMENT AGENCY

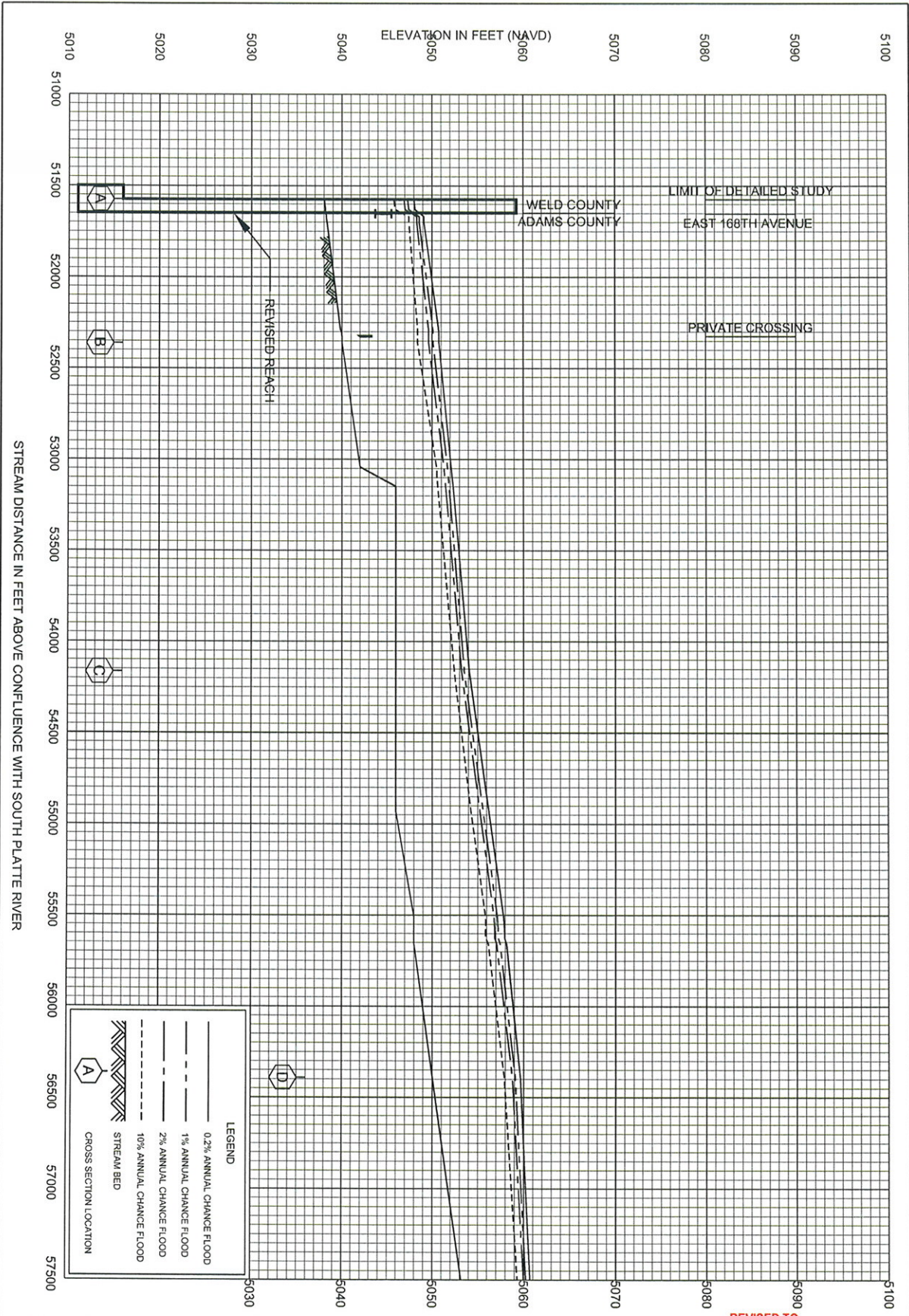
**WELD COUNTY, CO**  
AND INCORPORATED AREAS

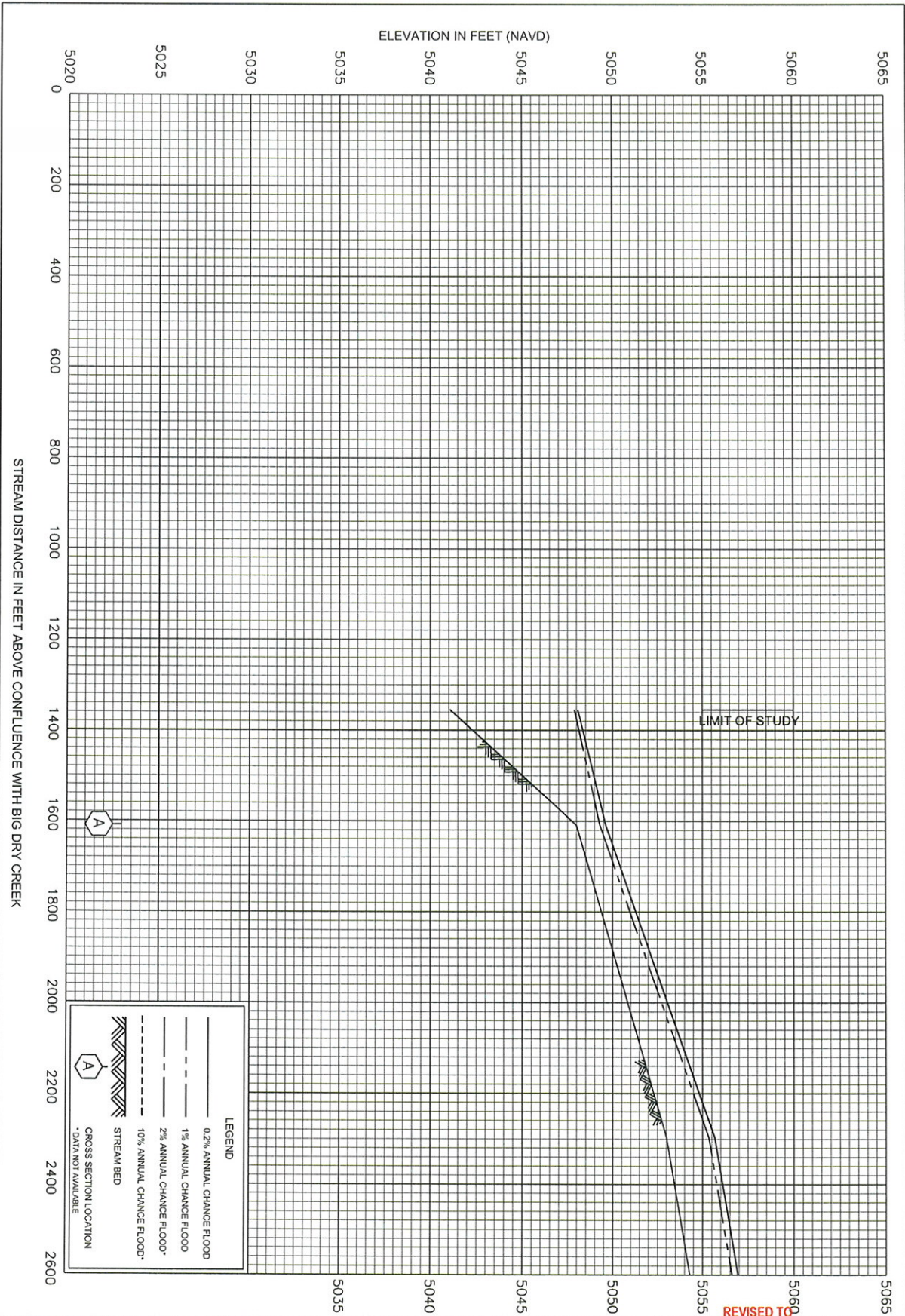
REVISED TO

**FLOODWAY DATA**  
REFLECT LOMR  
EFFECTIVE: May 13, 2016

**UNION PACIFIC SPLIT FLOW**

**TABLE 5**







THIS AREA SHOWN AT A SCALE OF 1" = 500' ON MAP NUMBER 08123C2077

THIS AREA SHOWN AT A SCALE OF 1" = 500' ON MAP NUMBER 08123C2081

THIS AREA SHOWN AT A SCALE OF 1" = 500' ON MAP NUMBER 08123C2082

THIS AREA SHOWN AT A SCALE OF 1" = 1000' ON MAP NUMBER 08123C2080

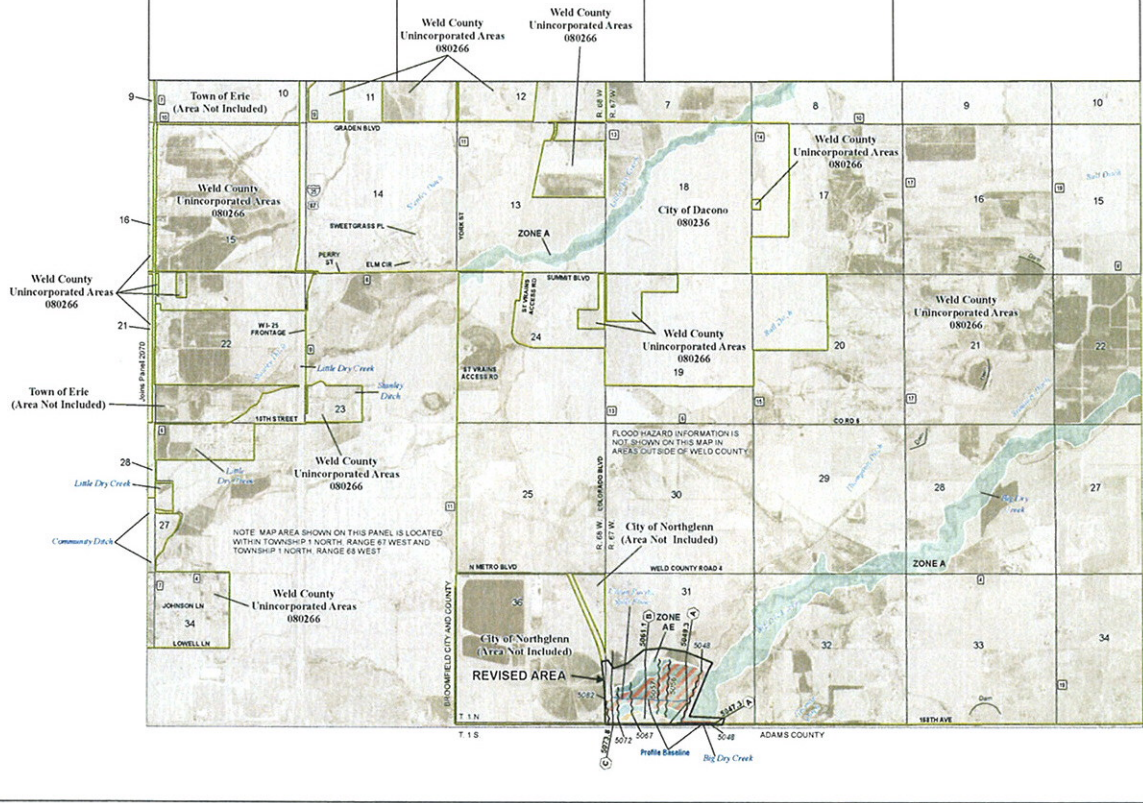
THIS AREA SHOWN AT A SCALE OF 1" = 500' ON MAP NUMBER 08123C2079

THIS AREA SHOWN AT A SCALE OF 1" = 500' ON MAP NUMBER 08123C2083

THIS AREA SHOWN AT A SCALE OF 1" = 500' ON MAP NUMBER 08123C2084

Join Panel 2080

Join Panel 1100



Join Panel 1100

Join Panel 2100

Join Panel 2100

Join Panel 2100

Join Panel 2100

Join Panel 2100

Join Panel 2100

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT. THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT: [HTTP://MSC.FEMA.GOV](http://MSC.FEMA.GOV)

- SPECIAL FLOOD HAZARD AREAS**
  - Without Base Flood Elevation (BFE) *Zone A, A:99*
  - With BFE or Depth *Zone A:AC, AD, AE, VE, VE:AR*
  - Regulatory Floodway
  - 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
  - Future Conditions 1% Annual Chance Flood Hazard *Zone X*
  - Area with Reduced Flood Risk due to Levee *See Notes, Zone X*
- OTHER AREAS OF FLOOD HAZARD**
  - NO SCREEN
  - Areas of Minimal Flood Hazard *Zone X*
  - Area of Undetermined Flood Hazard *Zone X*
- OTHER AREAS**
  - Channel, Culvert or Storm Sewer Accredited or Provisionally Accredited Levee, Dike, or Floodwall
  - Non-accredited Levee, Dike or Floodwall
  - Cross Sections with 1% Annual Chance
  - Water Surface Elevations (BFE)
  - Coastal Transect
  - Coastal Transect Baseline
  - Profile Baseline
  - Hydrographic Feature
  - Base Flood Elevation Line (BFE)
  - Limit of Study
  - Jurisdiction Boundary
- GENERAL STRUCTURES**
- OTHER FEATURES**

NOTES TO USERS

For information and questions about this map, available products associated with this FIRM including historic versions of the FIRM, how to order products or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 877-FEMA-9847 or visit the FEMA Map Service Center website at [msc.fema.gov](http://msc.fema.gov). Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or Digital Elevation Models. Many of these products can be ordered or obtained directly from the website. Users may determine the current map data for each FIRM panel by visiting the FEMA Map Service Center website or by contacting the FEMA Map Information eXchange.

Communities acquiring land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM data. These may be ordered directly from the Map Service Center at the number listed above.

For community and countywide map data refer to the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-426-6622.

ACCREDITED LEVEE NOTES TO USERS: Check with your local community to obtain more information, such as the estimated level of protection provided (which may exceed the 1-percent annual chance level) and Emergency Action Plan, on the levee system shown as providing protection for areas on this panel. To maintain accreditation, the levee owner or community is required to submit the data and documentation necessary to comply with Section 85.12 of the NFIP regulations by March 31, 2015. If the community or owner does not provide the necessary data and documentation or if the data and documentation provided indicate the levee system does not comply with Section 85.12 requirements, FEMA will remove the flood hazard and risk information for this area to reflect de-accreditation of the levee system. To restore flood risk, or risk of loss, areas, property, contents, and residents are encouraged to consider flood insurance and participating in all protective measures. For more information on flood insurance, interested parties should visit the FEMA Website at <http://www.fema.gov/business/flood-insure>.

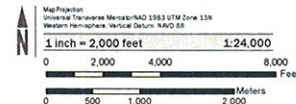
PROVISIONALLY ACCREDITED LEVEE NOTES TO USERS: Check with your local community to obtain more information, such as the estimated level of protection provided (which may exceed the 1-percent annual chance level) and Emergency Action Plan, on the levee system shown as providing protection for areas on this panel. To maintain accreditation, the levee owner or community is required to submit the data and documentation necessary to comply with Section 85.12 of the NFIP regulations by March 31, 2015. If the community or owner does not provide the necessary data and documentation or if the data and documentation provided indicate the levee system does not comply with Section 85.12 requirements, FEMA will remove the flood hazard and risk information for this area to reflect de-accreditation of the levee system. To restore flood risk, or risk of loss, areas, property, contents, and residents are encouraged to consider flood insurance and participating in all protective measures. For more information on flood insurance, interested parties should visit the FEMA Website at <http://www.fema.gov/business/flood-insure>.

The AE Zone category has been divided by a Limit of Moderate Wave Action (LIMWA). The LIMWA represents the approximate seaward limit of the 1.5-foot breaking wave. The effects of wave hazards between the VE Zone and the LIMWA or between the shoreline and the LIMWA for areas where VE Zones are not identified will be similar to, but less severe than those in the VE Zone.

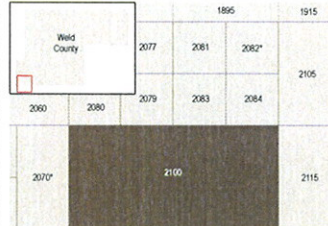
COASTAL BARRIER RESOURCES (CBRS) NOTE: This map includes approximate boundaries of the CBRS for informational purposes only. Flood insurance is not available within CBRS areas for structures that are newly built or substantially improved on or after the date(s) indicated on the map. For more information see <http://www.fema.gov/publications/national-coastal-barrier.html>, the FIS report, or call the U.S. Fish and Wildlife Service Customer Service Center at 800-344-6850.

- CBRS Area
- Otherwise Protected Area

SCALE



PANEL LOCATOR



**FEMA**

**National Flood Insurance Program**

**NATIONAL FLOOD INSURANCE PROGRAM FLOOD INSURANCE RATE MAP**

**WELD COUNTY, COLORADO**

At Jurisdiction

Panel 2100 of 2250

Panel Contains:

COMMUNITY	NUMBER	PANEL	SUFFIX
DACONO CITY OF	080236	2100	E
WELD COUNTY	080266	2100	E

REVISSED TO REFLECT CORN EFFECTIVE: May 13, 2016

VERSION NUMBER 1.1.1.0

MAP NUMBER 08123C2100E

EFFECTIVE DATE January 20, 2016

\*PANEL NOT PRINTED

**C. Standard Form 1  
(C-Factor Calculations)**



Engineering · Planning · Surveying

## SF-1 RUNOFF COEFFICIENTS

PROJECT NAME: Badger CGF  
 PROJECT NUMBER: EXT1N67W30-01  
 CALCULATED BY: TGR  
 CHECKED BY: NJN

DATE: 3/20/2018

LAND USE:	GRAVEL AREA	HISTORIC ANALYSIS	PAVED AREA	INDUSTRIAL: LIGHT	
% IMPERVIOUS	40%	2%	100%	80%	0%
5-YEAR COEFF.	0.40	0.07	0.92	0.75	0.00
10-YEAR COEFF.	0.50	0.21	0.94	0.79	0.00
100-YEAR COEFF.	0.69	0.52	0.96	0.87	0.00

HYDROLOGIC SOIL TYPE = **C**

DESIGN BASIN	DESIGN POINT	GRAVEL AREA	HISTORIC ANALYSIS	PAVED AREA	INDUSTRIAL: LIGHT		TOTAL AREA	RUNOFF COEFFICIENTS			PERCENT IMPERVIOUS
								(AC)	(AC)	(AC)	
H1	1	0.64	156.07	0.81			<b>157.52</b>	0.08	0.22	0.52	3%
H2	2		98.42	3.69			<b>102.11</b>	0.10	0.24	0.53	6%
<b>HISTORIC BASIN SUBTOTAL</b>		<b>0.64</b>	<b>254.49</b>	<b>4.50</b>	<b>0.00</b>	<b>0.00</b>	<b>259.63</b>	<b>0.08</b>	<b>0.23</b>	<b>0.53</b>	<b>4%</b>
		0.2%	98.0%	1.7%	0.0%	0.0%	100%				
P1	1	0.08	2.48	0.09			<b>2.65</b>	0.11	0.25	0.54	6%
P2	2	0.07	1.60				<b>1.67</b>	0.08	0.23	0.52	4%
P3	3	1.61	0.66	0.01	0.220		<b>2.50</b>	0.35	0.45	0.66	34%
P4	4		7.80	0.21			<b>8.01</b>	0.09	0.23	0.53	5%
P5	5	10.340	1.570		1.370		<b>13.28</b>	0.40	0.49	0.69	40%
P6	6	10.08	1.67		1.15		<b>12.90</b>	0.39	0.49	0.68	39%
P7	7	0.18	9.53	0.02			<b>9.73</b>	0.08	0.22	0.52	3%
P8	8		3.23				<b>3.23</b>	0.07	0.21	0.52	2%
P9	9	0.49	102.70	0.07			<b>103.26</b>	0.07	0.22	0.52	2%
P10	10	0.16	0.13				<b>0.29</b>	0.25	0.37	0.61	23%
<b>DEVELOPED BASIN SUBTOTAL</b>		<b>22.36</b>	<b>28.54</b>	<b>0.33</b>	<b>2.74</b>	<b>0.00</b>	<b>53.97</b>	<b>0.25</b>	<b>0.37</b>	<b>0.61</b>	<b>22.30%</b>
		41.4%	52.9%	0.6%	5.1%	0.0%	100%				
<b>TOTAL STUDY</b>		<b>23.01</b>	<b>131.37</b>	<b>0.40</b>	<b>2.74</b>	<b>0.00</b>	<b>157.52</b>	<b>0.13</b>	<b>0.27</b>	<b>0.55</b>	<b>9%</b>
		14.6%	83.4%	0.3%	1.7%	0.0%	100.0%				

NOTE: BASINS P2 THROUGH P7, ARE USED FOR DEVELOPED BASIN SUBTOTAL

**D. Standard Form 2  
(Time of Concentration Calculations)**



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## STANDARD FORM SF-2 TIME OF CONCENTRATION

PROJECT NAME: Badger CGF  
 PROJECT NUMBER: EXT1N67W30-01  
 CALCULATED BY: TGR  
 CHECKED BY: NJN

DATE: 3/20/2018

SUB-BASIN DATA			INITIAL TIME (T <sub>i</sub> )			TRAVEL TIME (T <sub>t</sub> )							FIRST DESIGN POINT T <sub>c</sub> CHECK (URBANIZED BASINS)			FINAL T <sub>c</sub>	RUNOFF COEFF.		
DESIGN BASIN (1)	AREA Ac (2)	C <sub>s</sub> (3)	LENGTH Ft (4)	SLOPE % (5)	T <sub>i</sub> Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	Land Surface (9)	C <sub>v</sub> (10)	VEL fps (11)	T <sub>t</sub> Min. (12)	COMP. T <sub>c</sub> (13)	URBAN BASIN? (14)	i (15)	TOTAL LENGTH (16)	T <sub>c</sub> = Eq 6-5 Min. (17)	Min. (18)	C <sub>10</sub> (19)	C <sub>100</sub> (20)
H1	157.52	0.08	300	2.0%	25.8	3,887	1.4%	Tillage/Field	5.0	0.6	111.1	136.9	No	0.03			136.9	0.22	0.52
H2	102.11	0.10	300	2.3%	23.9	2,459	2.0%	Tillage/Field	5.0	0.7	58.1	82.1	No	0.06			82.1	0.24	0.53
P1	2.65	0.11	288	1.6%	26.5	223	0.5%	Grassed Waterway	15.0	1.1	3.5	30.0	No	0.06			30.0	0.25	0.54
P2	1.67	0.08	289	3.0%	22.0	96	2.3%	Grassed Waterway	15.0	2.3	0.7	22.7	No	0.04			22.7	0.23	0.52
P3	2.50	0.35	31	2.0%	6.1	2,020	0.8%	Nearly Bare Ground	10.0	0.9	37.6	43.8	No	0.34			43.8	0.45	0.66
P4	8.01	0.09	235	1.0%	28.7	1,172	0.7%	Grassed Waterway	15.0	1.3	15.3	44.1	No	0.05			44.1	0.23	0.53
P5	13.28	0.40	595	1.9%	25.2	298	1.4%	Grassed Waterway	15.0	1.8	2.8	28.0	No	0.40			28.0	0.49	0.69
P6	12.90	0.39	728	0.6%	42.5	401	4.7%	Grassed Waterway	15.0	3.3	2.1	44.6	No	0.39			44.6	0.49	0.68
P7	9.73	0.08	4	25.0%	1.3	1,624	1.1%	Grassed Waterway	15.0	1.5	17.5	18.8	No	0.03			18.8	0.22	0.52
P8	3.23	0.07	266	0.5%	38.8	1	1.0%	Short Pasture/Lawn	7.0	0.7	0.0	38.9	No	0.02			38.9	0.21	0.52
P9	103.26	0.07	300	1.3%	29.7	2,634	1.7%	Short Pasture/Lawn	7.0	0.9	48.5	78.2	No	0.02			78.2	0.22	0.52
P10	0.29	0.25	20	2.0%	5.5	580	3.1%	Grassed Waterway	15.0	2.6	3.7	9.2	No	0.23			9.2	0.37	0.61

$$T_i = \frac{0.395(1.1-C)L^{1/2}}{S^{1/3}} \quad T_t = \frac{L}{60V}$$



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### STANDARD FORM SF-2 TIME OF CONCENTRATION

PROJECT NAME: Badger CGF  
 PROJECT NUMBER: EXT1N67W30-01  
 CALCULATED BY: TGR  
 CHECKED BY: NJN

DATE: 3/20/2018

SUB-BASIN DATA			INITIAL TIME (T <sub>i</sub> )			TRAVEL TIME (T <sub>t</sub> )							FIRST DESIGN POINT T <sub>c</sub> CHECK (URBANIZED BASINS)				FINAL T <sub>c</sub>	RUNOFF COEFF.	
DESIGN BASIN (1)	AREA Ac (2)	C <sub>s</sub> (3)	LENGTH Ft (4)	SLOPE % (5)	T <sub>i</sub> Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	Land Surface (9)	C <sub>v</sub> (10)	VEL fps (11)	T <sub>t</sub> Min. (12)	COMP. T <sub>c</sub> (13)	URBAN BASIN? (14)	i (15)	TOTAL LENGTH (16)	T <sub>c</sub> = Eq 6-5 Min. (17)	Min. (18)	C <sub>10</sub> (19)	C <sub>100</sub> (20)
H1	157.52	0.08	300	2.0%	25.8	3,887	1.4%	Tillage/Field	5.0	0.6	111.1	136.9	No	0.03			136.9	0.22	0.52
H2	102.11	0.10	300	2.3%	23.9	2,459	2.0%	Tillage/Field	5.0	0.7	58.1	82.1	No	0.06			82.1	0.24	0.53
P1	2.65	0.11	288	1.6%	26.5	223	0.5%	Grassed Waterway	15.0	1.1	3.5	30.0	No	0.06			30.0	0.25	0.54
DP1 to DP2						257	1.5%	Grassed Waterway	15.0	1.9	2.3	2.3	No	#N/A			5.0	###	###
P2	1.67	0.08	289	3.0%	22.0	96	2.3%	Grassed Waterway	15.0	2.3	0.7	22.7	No	0.04			22.7	0.23	0.52
P3	2.50	0.35	31	2.0%	6.1	2,020	0.8%	Grassed Waterway	15.0	1.3	25.1	31.2	No	0.34			31.2	0.45	0.66
H2, P3 TO DP3						1	1.0%	Grassed Waterway	15.0	1.5	0.0	82.1	No	#N/A			82.1	###	###
P4	8.01	0.09	235	1.0%	28.7	1,172	0.7%	Grassed Waterway	15.0	1.3	15.3	44.1	No	0.05			44.1	0.23	0.53
DP4 to DP7						1,624	1.1%	Grassed Waterway	15.0	1.6	17.4	17.4	No	#N/A			17.4	###	###
P5	13.28	0.40	595	1.9%	25.2	298	1.4%	Grassed Waterway	15.0	1.8	2.8	28.0	No	0.40			28.0	0.49	0.69
DP5 to DP7						935	1.1%	Grassed Waterway	15.0	1.6	10.0	10.0	No	#N/A			10.0	###	###
P6	12.90	0.39	728	0.6%	42.5	401	4.7%	Grassed Waterway	15.0	3.3	2.1	44.6	No	0.39			44.6	0.49	0.68
DP6 to DP7						1,005	0.9%	Grassed Waterway	15.0	1.5	11.5	11.5	No	#N/A			11.5	###	###
P7	9.73	0.08	4	25.0%	1.3	1,624	1.1%	Grassed Waterway	15.0	1.5	17.5	18.8	No	0.03			18.8	0.22	0.52
P8	3.23	0.07	266	0.5%	38.8	1	1.0%	Short Pasture/Lawn	7.0	0.7	0.0	38.9	No	0.02			38.9	0.21	0.52
P9	103.26	0.07	300	1.3%	29.7	2,634	1.7%	Short Pasture/Lawn	7.0	0.9	48.5	78.2	No	0.02			78.2	0.22	0.52
P10	0.29	0.25	20	2.0%	5.5	580	3.1%	Grassed Waterway	15.0	2.6	3.7	9.2	No	0.23			9.2	0.37	0.61

$$T_i = \frac{0.395(1.1 - C)L^{1/2}}{S^{1/3}} \quad T_t = \frac{L}{60V}$$

**E. Standard Form 3  
(Storm Drainage System Design)**



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**STANDARD FORM SF-3  
STORM DRAINAGE DESIGN - RATIONAL METHOD 5-YEAR EVENT**

PROJECT NAME: Badger CGF  
 PROJECT NUMBER: EXT1N67W30-01  
 CALCULATED BY: TGR  
 CHECKED BY: NJN

$P_1$  (1-Hour Rainfall) = 1.34 in. (5-yr)

DATE: 3/20/2018

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE		TRAVEL TIME			REMARKS	
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF $C_5$	$t_c$ (min)	$C^*A$ (ac)	$I$ (in/hr)	$Q$ (cfs)	$t_c$ (min)	$\Sigma(C^*A)$ (ac)	$I$ (in/hr)	$Q$ (cfs)	SLOPE (%)	STREET FLOW(cfs)	DESIGN FLOW(cfs)	SLOPE (%)	PIPE SIZE (in)	LENGTH (ft)	VELOCITY (fps)		$t_t$ (min)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
	1	H1	157.52	0.08	136.9	11.83	0.76	8.95													
	2	H2	102.11	0.10	82.1	10.23	1.09	11.17													
	1	P1	2.65	0.11	30.0	0.29	2.10	0.60													
	2	P2	1.67	0.08	22.7	0.14	2.46	0.34													
	3	P3	2.50	0.35	43.8	0.86	1.67	1.44													
	4	P4	8.01	0.09	44.1	0.73	1.66	1.22													
	5	P5	13.28	0.40	28.0	5.27	2.19	11.53													
	6	P6	12.90	0.39	44.6	5.01	1.65	8.25													
	7	P7	9.73	0.08	18.8	0.75	2.72	2.05													
	8	P8	3.23	0.07	38.9	0.22	1.80	0.40													
	9	P9	103.26	0.07	78.2	7.39	1.13	8.34													
	10	P10	0.29	0.25	9.2	0.07	3.75	0.27													



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STANDARD FORM SF-3

STORM DRAINAGE DESIGN - RATIONAL METHOD 10-YEAR EVENT

PROJECT NAME: Badger CGF  
 PROJECT NUMBER: EXT1N67W30-01  
 CALCULATED BY: TGR  
 CHECKED BY: NJN

DATE: 3/20/2018

P<sub>1</sub> (1-Hour Rainfall) = 1.61 in. (10-yr)

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE		TRAVEL TIME			REMARKS	
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF C <sub>10</sub>	t <sub>c</sub> (min)	C*A(ac)	I (in/hr)	Q (cfs)	t <sub>c</sub> (min)	Σ(C*A) (ac)	I (in/hr)	Q (cfs)	SLOPE (%)	STREET FLOW(cfs)	DESIGN FLOW(cfs)	SLOPE (%)	PIPE SIZE (in)	LENGTH (ft)	VELOCITY (fps)		t <sub>t</sub> (min)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
	1	H1	157.52	0.22	136.9	34.60	0.91	31.44													
	2	H2	102.11	0.24	82.1	24.61	1.31	32.29													
	1	P1	2.65	0.25	30.0	0.66	2.53	1.66													
	2	P2	1.67	0.23	22.7	0.38	2.96	1.12													
	3	P3	2.50	0.45	43.8	1.12	2.00	2.25													
	4	P4	8.01	0.23	44.1	1.87	1.99	3.73													
	5	P5	13.28	0.49	28.0	6.55	2.63	17.22													
	6	P6	12.90	0.49	44.6	6.27	1.98	12.40													
	7	P7	9.73	0.22	18.8	2.16	3.27	7.05													
	8	P8	3.23	0.21	38.9	0.69	2.16	1.50													
	9	P9	103.26	0.22	78.2	22.37	1.36	30.34													
	10	P10	0.29	0.37	9.2	0.11	4.50	0.48													



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**STANDARD FORM SF-3  
STORM DRAINAGE DESIGN - RATIONAL METHOD 100-YEAR EVENT**

PROJECT NAME: Badger CGF  
 PROJECT NUMBER: EXT1N67W30-01  
 CALCULATED BY: TGR  
 CHECKED BY: NJN

P<sub>1</sub> (1-Hour Rainfall) = 2.68 in. (100-yr)

DATE: 3/20/2018

STORM LINE	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE		TRAVEL TIME			REMARKS	
		DESIGN BASIN	AREA (AC)	RUNOFF COEFF C <sub>100</sub>	t <sub>c</sub> (min)	C*A(ac)	I (in/hr)	Q (cfs)	t <sub>c</sub> (min)	Σ(C*A) (ac)	I (in/hr)	Q (cfs)	SLOPE (%)	STREET FLOW(cfs)	DESIGN FLOW(cfs)	SLOPE (%)	PIPE SIZE (in)	LENGTH (ft)	VELOCITY (fps)		t <sub>t</sub> (min)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
	1	H1	157.52	0.52	136.9	81.90	1.51	123.86													
	2	H2	102.11	0.53	82.1	54.42	2.18	118.85							118.85	2.46	36	111.0			OFFSITE
PIPE DP1	1	P1	2.65	0.54	30.0	1.42	4.21	5.99													
PIPE DP2	2	P2	1.67	0.52	22.7	0.88	4.93	4.31	35.0	2.30	3.83	8.81			5.99	2.00	18	58.0			DP 1
PIPE DP3	3	P3	2.50	0.66	43.8	1.65	3.33	5.50	82.1	56.07	2.18	122.45			8.81	1.65	18	294.0			DP 1 + DP 2
PIPE DP4	4	P4	8.01	0.53	44.1	4.23	3.32	14.05				14.05			122.4	2.47	36	110.0			H2 + DP 3
PIPE DP5	5	P5	13.28	0.69	28.0	9.11	4.38	39.88				39.88			14.0	2.00	18	61.0			DP4
PIPE DP6	6	P6	12.90	0.68	44.6	8.80	3.29	28.97				28.97			39.9	2.00	24	149.0			DP 5
PIPE DP7	7	P7	9.73	0.52	18.8	5.07	5.44	27.59	61.52	27.22	2.66	72.48			29.0	2.00	24	134.0			DP 6
PIPE DP8	8	P8	3.23	0.52	38.9	1.67	3.59	6.00							72.5	2.00	42	45.0			DP4 THRU DP 7
PIPE DP 9	9	P9	103.26	0.52	78.2	53.50	2.26	120.81							16.19	2.00	18	56.0			POND
	10	P10	0.29	0.61	9.2	0.18	7.49	1.33							12.00	2.00	42	45.0			SITE OUTLET

## **F. Detention Pond Design and Hydraulic Calculations**



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### STORM STORAGE CALCULATIONS DETENTION POND

PROJECT NAME: Badger CGF  
PROJECT NUMBER: EXT1N67W30-01  
CALCULATED BY: TGR  
CHECKED BY: NJN

DATE: 3/23/2018

<p>CALCULATED % IMPERVIOUSNESS =</p> <p><b>10-YR STORM CALCULATIONS</b></p> <p>EQUATION: <math>V_{10} = ((0.95 \cdot I - 1.9) / 900) \cdot A</math></p> <p>EQUATION: <math>Q_{10} = 0.30 \cdot A</math></p> <p><b>100-YR STORM CALCULATIONS</b></p> <p>EQUATION: <math>V_{100} = ((1.78 \cdot I - 0.002 \cdot I^2 - 3.56) / 900) \cdot A</math></p> <p>EQUATION: <math>Q_{100} = 1.0 \cdot A</math></p> <p><b>WATER QUALITY STORAGE VOL.</b></p> <p>EQUATION: <math>WQCV = 1.0 \cdot (0.91 \cdot I^3 - 1.19 \cdot I^2 + 0.78 \cdot I)</math></p>	<p>DESIGN DRAINAGE AREA      Onsite Area = <b>53.97 AC</b></p> <p><b>22.3%</b></p> <p><b>FAA OVERRIDE</b></p> <p><b>V10 = 50382 CF      56307</b></p> <p><b>RELEASE @ Q10 = 16.19 CFS</b></p> <p><b>FAA OVERRIDE</b></p> <p><b>V100 = 91802 CF      280472</b></p> <p><b>RELEASE @ Q 100= 53.97 CFS      15.79</b></p> <p><b>WQCV = 24462 CF</b></p> <p><b>TOTAL REQUIRED VOLUME = 280472 CF      (100-yr w/WQCV)</b></p>
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<p><b>OUTLET STRUCTURE</b></p> <p>MINIMUM POND VOLUME, V=</p> <p>Q10-Release = 0.30*Design Drainage Area</p> <p>Q100-Release = 1.0*Design Drainage Area</p> <p><b>SIZE 10-YR OUTLET CONTROL</b></p> <p>ORIFICE PLATE DIA. AREA, A10=</p> <p><b>SIZE 100-YR OUTLET CONTROL</b></p> <p>ORIFICE PLATE DIA. AREA, A100=</p> <p>OUTLET PIPE, D100= (12" minimum)</p> <p>SLOPE, S=</p> <p>HYDRAULIC RADIUS, FULL FLOW</p> <p>FLows FULL AT Q=</p> <p>SET BOX</p> <p>BOX CAPACITY, QOUTLET=</p> <p>SPILLWAY DEPTH</p> <p>LENGTH OF SPILLWAY</p> <p><b>OUTLET STRUCTURE SIZING SUMMARY</b></p> <p>PROVIDE A <b>21.0</b> INCH DIAMETER ORIFICE PLATE @ FL ELEVATION FOR 10-YR FLOWS</p> <p>PROVIDE A <b>17.4</b> INCH DIAMETER ORIFICE PLATE @ FL ELEVATION FOR 100-YR FLOWS</p>	<p>DEVELOPED BASIN A AREA</p> <p>56307 cf</p> <p>16.19 cfs      <b>h10= 2.0 ft</b></p> <p>16.19 cfs      <b>h100= 4.2 ft</b></p> <p>USE ORIFICE EQUATION:      <math>Q = Cd (0.6) \cdot A \cdot (2 g h)^{0.5}</math></p> <p><b>2.41 sf OR 21.0 inches in diameter</b></p> <p>USE ORIFICE EQUATION:      <math>Q = Cd (0.6) \cdot A \cdot (2 g h)^{0.5}</math></p> <p>1.65 sf OR <b>17.4 inches in diameter</b></p> <p>18 in. diameter</p> <p>2.00%</p> <p>0.38 ft</p> <p>13.8 cfs      USE MANNING EQUATION with n = 0.014</p> <p>2.0 feet high</p> <p>64.6 cfs      <math>Q = Cd(0.6) A (2 g h)^{0.5}</math></p> <p>0.6 ft</p> <p>65.0 ft      <math>Q_{100} = CW(2.6) L (h_{max} ht)^{3/2}</math></p>
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**DETENTION VOLUME BY THE MODIFIED FAA METHOD**

Project: **BADGER CGF**

Basin ID: **Developed Site**

(For catchments less than 160 acres only. For larger catchments, use hydrograph routing method)  
 (NOTE: for catchments larger than 90 acres, CUHP hydrograph and routing are recommended)

Determination of <b>MINOR</b> Detention Volume Using Modified FAA Method							Determination of <b>MAJOR</b> Detention Volume Using Modified FAA Method						
<b>Design Information (Input):</b> Catchment Drainage Imperviousness $I_p = 22.30$ percent Catchment Drainage Area $A = 53.970$ acres Predevelopment NRCS Soil Group $Type = C$ A, B, C, or D Return Period for Detention Control $T = 10$ years (2, 5, 10, 25, 50, or 100) Time of Concentration of Watershed $T_c = 62$ minutes Allowable Unit Release Rate $q = 0.30$ cfs/acre One-hour Precipitation $P_1 = 1.61$ inches <b>Design Rainfall IDF Formula</b> $i = C_1 \cdot P_1 / (C_2 + T_c)^{C_3}$ Coefficient One $C_1 = 28.50$ Coefficient Two $C_2 = 10$ Coefficient Three $C_3 = 0.789$							<b>Design Information (Input):</b> Catchment Drainage Imperviousness $I_p = 22.30$ percent Catchment Drainage Area $A = 53.970$ acres Predevelopment NRCS Soil Group $Type = C$ A, B, C, or D Return Period for Detention Control $T = 100$ years (2, 5, 10, 25, 50, or 100) Time of Concentration of Watershed $T_c = 62$ minutes Allowable Unit Release Rate $q = 0.30$ cfs/acre One-hour Precipitation $P_1 = 2.68$ inches <b>Design Rainfall IDF Formula</b> $i = C_1 \cdot P_1 / (C_2 + T_c)^{C_3}$ Coefficient One $C_1 = 28.50$ Coefficient Two $C_2 = 10$ Coefficient Three $C_3 = 0.789$						
<b>Determination of Average Outflow from the Basin (Calculated):</b> Runoff Coefficient $C = 0.35$ Inflow Peak Runoff $Qp-in = 29.68$ cfs Allowable Peak Outflow Rate $Qp-out = 16.19$ cfs Mod. FAA Minor Storage Volume = 56,307 cubic feet Mod. FAA Minor Storage Volume = 1.293 acre-ft							<b>Determination of Average Outflow from the Basin (Calculated):</b> Runoff Coefficient $C = 0.56$ Inflow Peak Runoff $Qp-in = 79.05$ cfs Allowable Peak Outflow Rate $Qp-out = 16.19$ cfs Mod. FAA Major Storage Volume = 280,472 cubic feet Mod. FAA Major Storage Volume = 6.439 acre-ft						
5							5						
< Enter Rainfall Duration Incremental Increase Value Here (e.g. 5 for 5-Minutes)													
Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)	Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)
5	5.42	0.705	1.00	16.19	0.112	0.593	5	9.02	1.877	1.00	16.19	0.112	1.765
10	4.32	1.123	1.00	16.19	0.223	0.900	10	7.19	2.991	1.00	16.19	0.223	2.768
15	3.62	1.413	1.00	16.19	0.335	1.078	15	6.03	3.763	1.00	16.19	0.335	3.428
20	3.13	1.631	1.00	16.19	0.446	1.185	20	5.22	4.345	1.00	16.19	0.446	3.899
25	2.78	1.806	1.00	16.19	0.558	1.248	25	4.62	4.809	1.00	16.19	0.558	4.251
30	2.50	1.950	1.00	16.19	0.669	1.281	30	4.16	5.194	1.00	16.19	0.669	4.525
35	2.28	2.073	1.00	16.19	0.781	1.293	35	3.79	5.522	1.00	16.19	0.781	4.741
40	2.09	2.180	1.00	16.19	0.892	1.288	40	3.49	5.807	1.00	16.19	0.892	4.915
45	1.94	2.275	1.00	16.19	1.004	1.272	45	3.23	6.060	1.00	16.19	1.004	5.056
50	1.81	2.360	1.00	16.19	1.115	1.245	50	3.02	6.286	1.00	16.19	1.115	5.171
55	1.70	2.437	1.00	16.19	1.227	1.211	55	2.84	6.492	1.00	16.19	1.227	5.265
60	1.61	2.508	1.00	16.19	1.338	1.170	60	2.67	6.680	1.00	16.19	1.338	5.342
65	1.52	2.573	0.98	15.82	1.416	1.157	65	2.53	6.853	0.98	15.82	1.416	5.437
70	1.45	2.633	0.94	15.27	1.472	1.161	70	2.41	7.014	0.94	15.27	1.472	5.542
75	1.38	2.690	0.91	14.79	1.528	1.162	75	2.29	7.164	0.91	14.79	1.528	5.636
80	1.32	2.743	0.89	14.37	1.583	1.159	80	2.19	7.304	0.89	14.37	1.583	5.721
85	1.26	2.792	0.86	14.00	1.639	1.153	85	2.10	7.437	0.86	14.00	1.639	5.797
90	1.21	2.839	0.84	13.67	1.695	1.144	90	2.02	7.562	0.84	13.67	1.695	5.867
95	1.17	2.884	0.83	13.38	1.751	1.133	95	1.94	7.680	0.83	13.38	1.751	5.930
100	1.12	2.926	0.81	13.11	1.806	1.120	100	1.87	7.793	0.81	13.11	1.806	5.987
105	1.09	2.967	0.80	12.88	1.862	1.104	105	1.81	7.901	0.80	12.88	1.862	6.039
110	1.05	3.005	0.78	12.66	1.918	1.087	110	1.75	8.004	0.78	12.66	1.918	6.086
115	1.02	3.042	0.77	12.46	1.974	1.069	115	1.69	8.103	0.77	12.46	1.974	6.129
120	0.99	3.078	0.76	12.28	2.029	1.048	120	1.64	8.197	0.76	12.28	2.029	6.168
125	0.96	3.112	0.75	12.11	2.085	1.027	125	1.59	8.288	0.75	12.11	2.085	6.203
130	0.93	3.145	0.74	11.96	2.141	1.004	130	1.55	8.376	0.74	11.96	2.141	6.235
135	0.90	3.177	0.73	11.81	2.197	0.980	135	1.51	8.461	0.73	11.81	2.197	6.264
140	0.88	3.207	0.72	11.68	2.252	0.955	140	1.47	8.542	0.72	11.68	2.252	6.290
145	0.86	3.237	0.71	11.56	2.308	0.929	145	1.43	8.621	0.71	11.56	2.308	6.313
150	0.84	3.266	0.71	11.44	2.364	0.902	150	1.39	8.698	0.71	11.44	2.364	6.334
155	0.82	3.294	0.70	11.33	2.420	0.874	155	1.36	8.772	0.70	11.33	2.420	6.353
160	0.80	3.321	0.69	11.23	2.475	0.845	160	1.33	8.845	0.69	11.23	2.475	6.369
165	0.78	3.347	0.69	11.14	2.531	0.816	165	1.30	8.915	0.69	11.14	2.531	6.384
170	0.76	3.373	0.68	11.05	2.587	0.786	170	1.27	8.983	0.68	11.05	2.587	6.396
175	0.75	3.398	0.68	10.96	2.643	0.755	175	1.24	9.049	0.68	10.96	2.643	6.407
180	0.73	3.422	0.67	10.88	2.699	0.724	180	1.22	9.114	0.67	10.88	2.699	6.416
185	0.72	3.446	0.67	10.81	2.754	0.692	185	1.19	9.177	0.67	10.81	2.754	6.423
190	0.70	3.469	0.66	10.74	2.810	0.659	190	1.17	9.239	0.66	10.74	2.810	6.429
195	0.69	3.492	0.66	10.67	2.866	0.626	195	1.15	9.299	0.66	10.67	2.866	6.433
200	0.68	3.514	0.66	10.61	2.922	0.592	200	1.12	9.358	0.66	10.61	2.922	6.436
205	0.66	3.535	0.65	10.54	2.977	0.558	205	1.10	9.416	0.65	10.54	2.977	6.438
210	0.65	3.556	0.65	10.49	3.033	0.523	210	1.08	9.472	0.65	10.49	3.033	6.439
215	0.64	3.577	0.64	10.43	3.089	0.488	215	1.06	9.527	0.64	10.43	3.089	6.438
220	0.63	3.597	0.64	10.38	3.145	0.453	220	1.05	9.581	0.64	10.38	3.145	6.436
225	0.62	3.617	0.64	10.33	3.200	0.417	225	1.03	9.634	0.64	10.33	3.200	6.433
230	0.61	3.637	0.63	10.28	3.256	0.381	230	1.01	9.686	0.63	10.28	3.256	6.430
235	0.60	3.656	0.63	10.23	3.312	0.344	235	1.00	9.736	0.63	10.23	3.312	6.425
240	0.59	3.674	0.63	10.19	3.368	0.307	240	0.98	9.786	0.63	10.19	3.368	6.419
245	0.58	3.693	0.63	10.14	3.423	0.270	245	0.96	9.835	0.63	10.14	3.423	6.412
250	0.57	3.711	0.62	10.10	3.479	0.232	250	0.95	9.883	0.62	10.10	3.479	6.404
255	0.56	3.729	0.62	10.06	3.535	0.194	255	0.94	9.931	0.62	10.06	3.535	6.396
260	0.55	3.746	0.62	10.03	3.591	0.156	260	0.92	9.977	0.62	10.03	3.591	6.387
265	0.55	3.763	0.62	9.99	3.646	0.117	265	0.91	10.023	0.62	9.99	3.646	6.377
270	0.54	3.780	0.61	9.95	3.702	0.078	270	0.90	10.068	0.61	9.95	3.702	6.366
275	0.53	3.797	0.61	9.92	3.758	0.039	275	0.88	10.112	0.61	9.92	3.758	6.354
280	0.52	3.813	0.61	9.89	3.814	0.000	280	0.87	10.156	0.61	9.89	3.814	6.342
285	0.52	3.829	0.61	9.86	3.869	-0.040	285	0.86	10.199	0.61	9.86	3.869	6.329
290	0.51	3.845	0.61	9.83	3.925	-0.080	290	0.85	10.241	0.61	9.83	3.925	6.316
295	0.50	3.861	0.61	9.80	3.981	-0.120	295	0.84	10.282	0.61	9.80	3.981	6.302
300	0.50	3.876	0.60	9.77	4.037	-0.161	300	0.83	10.323	0.60	9.77	4.037	6.287
305	0.49	3.891	0.60	9.74	4.092	-0.201	305	0.82	10.364	0.60	9.74	4.092	6.271

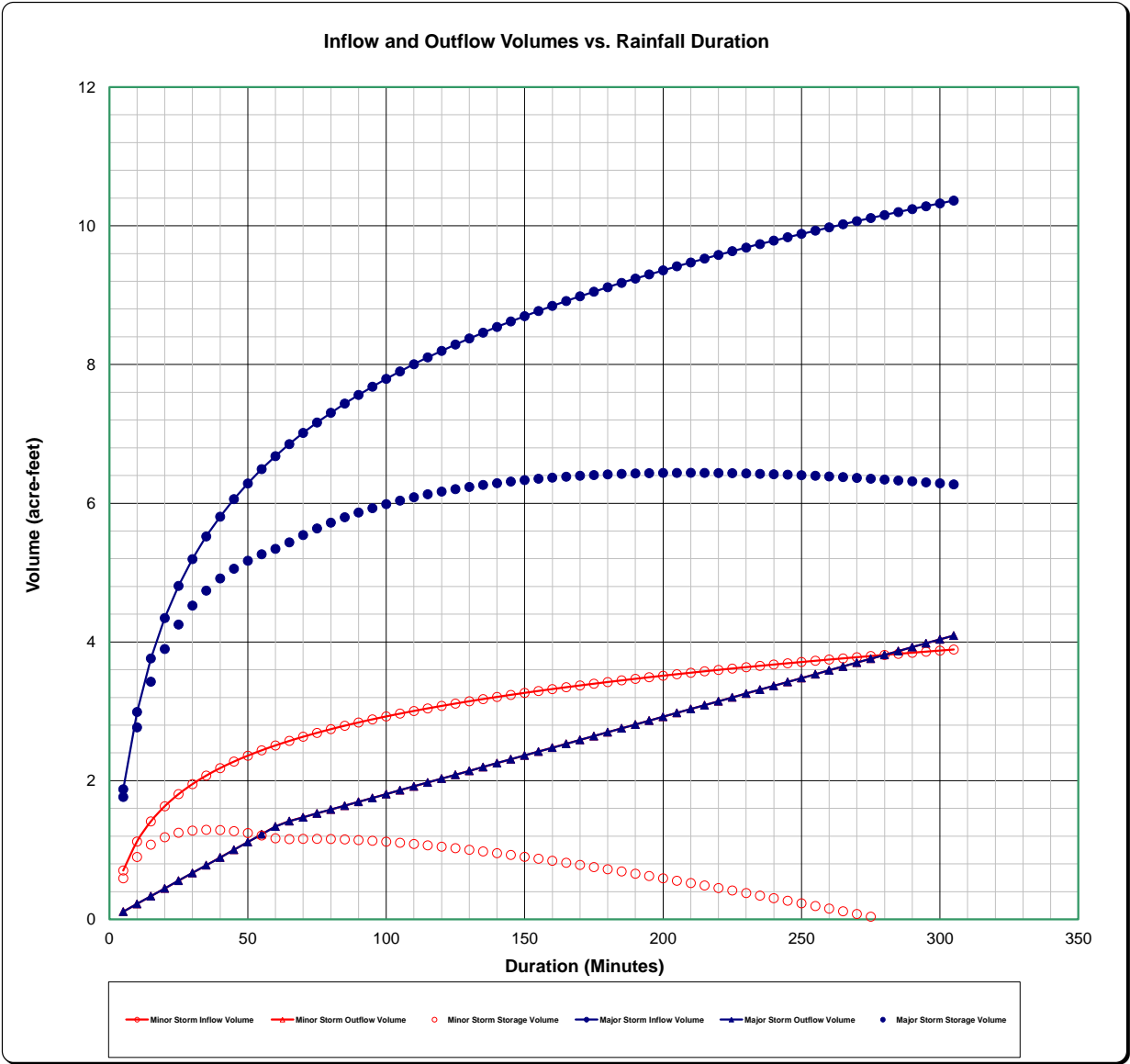
Mod. FAA Minor Storage Volume (cubic ft.) = 56,307  
 Mod. FAA Minor Storage Volume (acre-ft.) = 1.2926  
 Mod. FAA Major Storage Volume (cubic ft.) = 280,472  
 Mod. FAA Major Storage Volume (acre-ft.) = 6.4387

UDFCD DETENTION BASIN VOLUME ESTIMATING WORKBOOK Version 2.35, Released January 2015

**DETENTION VOLUME BY THE MODIFIED FAA METHOD**

Project: **BADGER CGF**

Basin ID: **Developed Site**



**VOLUME CALCULATIONS  
DETENTION POND**

PROJECT NAME: Badger CGF  
PROJECT NUMBER: EXT1N67W30-01  
CALCULATED BY: TGR  
CHECKED BY: NJN

DATE: 3/19/2018

DETENTION POND DESIGN

**DRAINAGE SUMMARY**

CALCULATED

WQCV REQUIRED =	<b>24462</b>	CF	0.56
10-YR STORAGE REQUIRED =	<b>56307</b>	CF	1.29
100-YR STORAGE REQUIRED =	<b>280472</b>	CF	6.44
TOTAL STORAGE REQUIRED=	<b>280472</b>	CF	<b>6.44</b>

**DETENTION POND DESIGN**

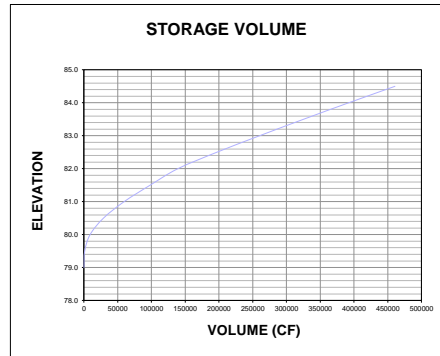
ASSUMPTIONS

USE CONIC METHOD FOR POND SIZING

Elev (ft)	Area (sf)	Area* (sf)	Volume (cf)	Sum Vol (cf)
79.0	0	0	0	0
79.5	6501	6501	1084	1084
80.0	27997	47989	7998	9082
80.5	52412	118715	19786	28868
81.0	70320	142688	30574	59441
81.5	88627	237892	39649	98006
82.0	107731	294071	49012	139020
82.5	123944	347228	57871	196891
83.0	128567	378745	63124	260016
83.5	132027	390880	65147	325162
84.0	135500	401279	66880	392042
84.5	139032	411787	68631	460673

AREA\* = AREA1+AREA2+(AREA1xAREA2)1/2  
VOLUME\* = 1/3 x depth x AREA\*

WQCV ELEV. =	<b>80.39</b>	ft	DWQV=	<b>1.39</b>	ft
10-YR ELEV. =	<b>80.95</b>	ft	D10-yr=	<b>1.95</b>	ft
100-YR ELEV. =	<b>83.17</b>	ft	D100-yr =	<b>4.17</b>	ft
SPILLWAY ELEV. =	<b>83.20</b>	ft	1-FT FREEBOARD=	<b>4.20</b>	ft



**OUTLET DETAIL CALCULATIONS**

WQCV = **0.56** ACRE-FT  
 $K40 = 0.2309 = 0.013D^2 + 0.22D - 0.10$        $D =$  **1.4** ft      (1ft. min. depth)  
 $a =$  **2.43** in<sup>2</sup>/row      = WQCV / K40  
 dia = **1 3/8** inch

# Weir Report

## Pond Emergency Overflow Weir

### Trapezoidal Weir

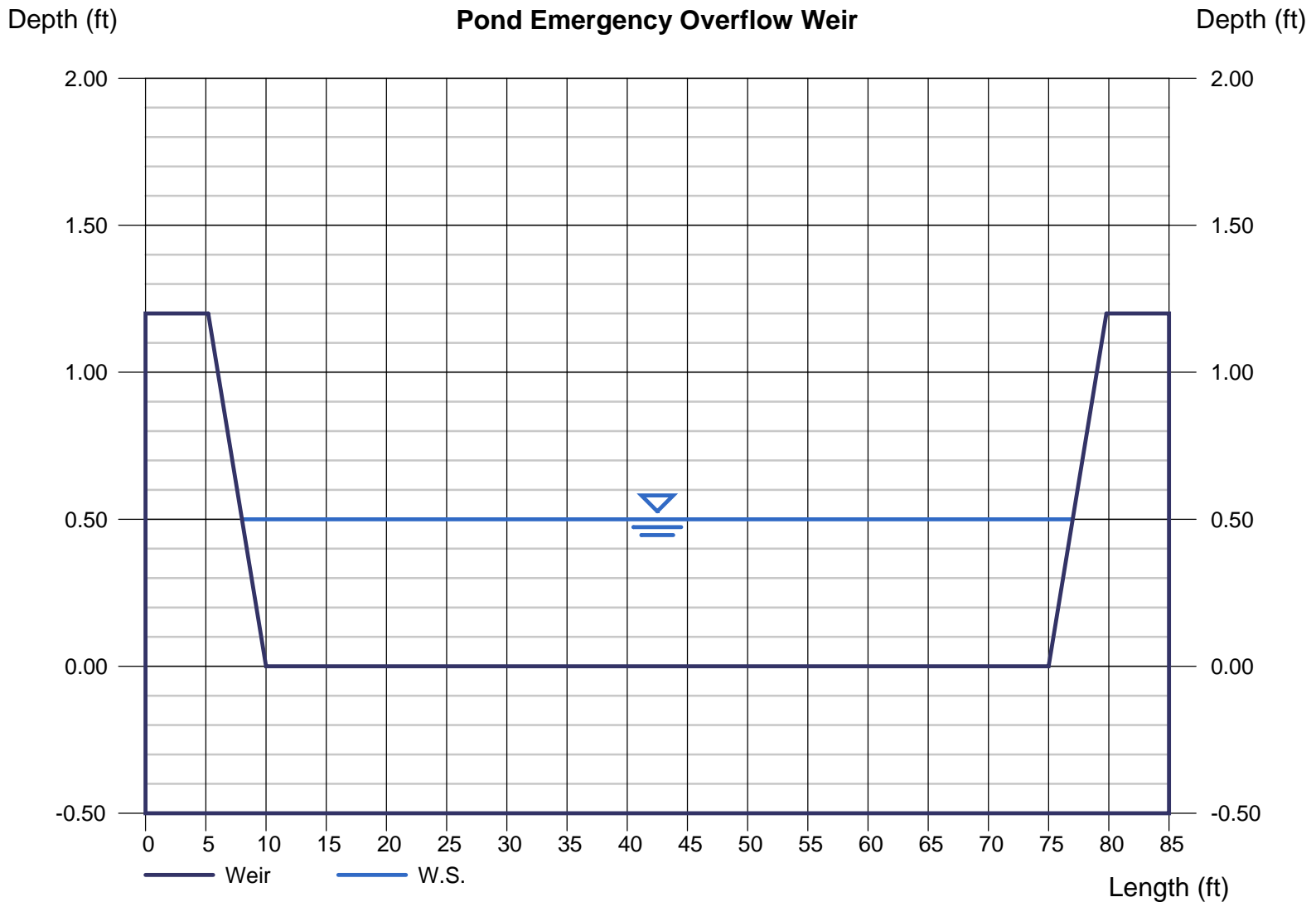
Crest = Sharp  
Bottom Length (ft) = 65.00  
Total Depth (ft) = 1.20  
Side Slope (z:1) = 4.00

### Highlighted

Depth (ft) = 0.50  
Q (cfs) = 72.50  
Area (sqft) = 33.50  
Velocity (ft/s) = 2.16  
Top Width (ft) = 69.00

### Calculations

Weir Coeff. Cw = 3.10  
Compute by: Known Q  
Known Q (cfs) = 72.50



# Channel Report

## Pond Overflow Channel

### Trapezoidal

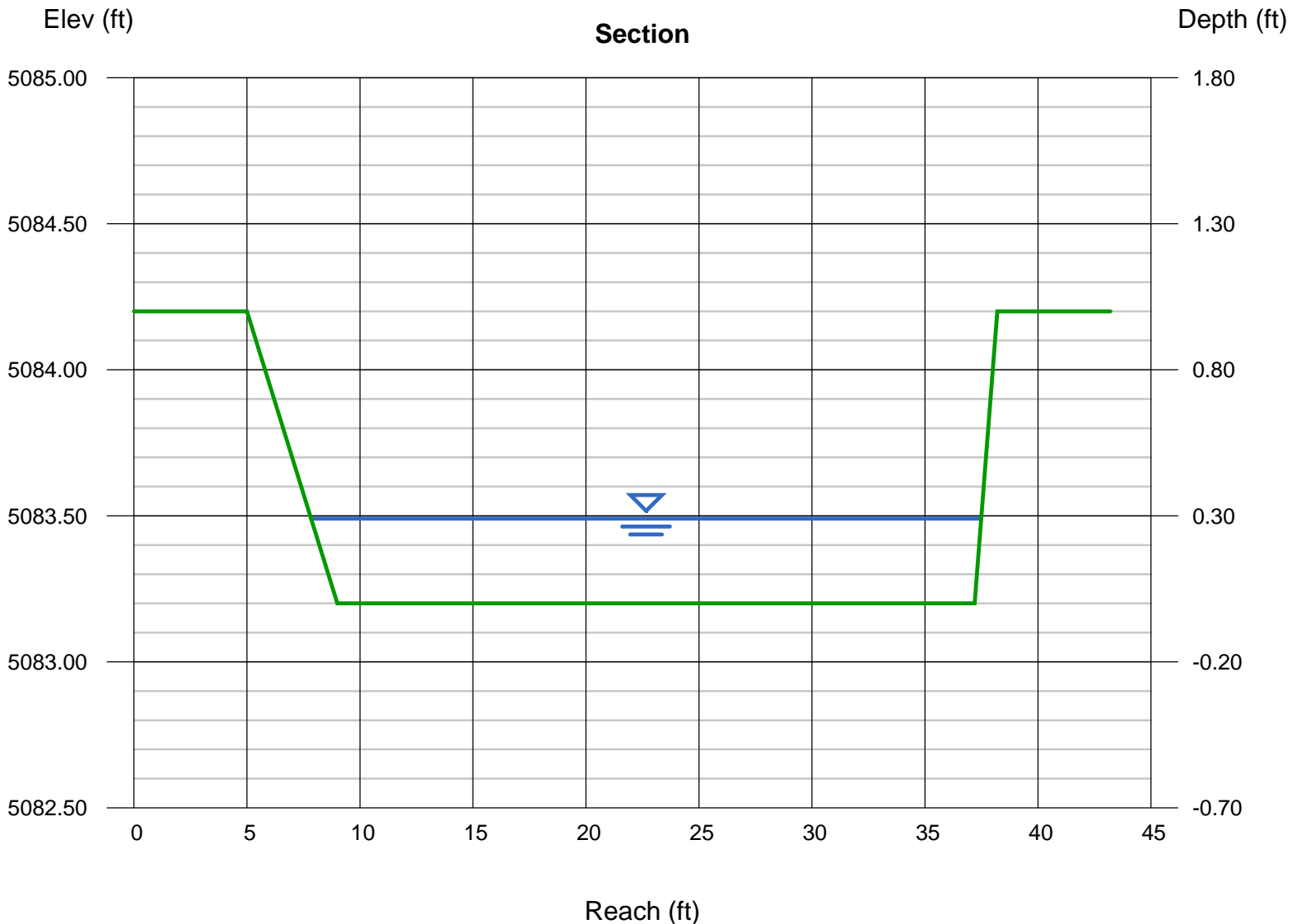
Bottom Width (ft) = 28.20  
Side Slopes (z:1) = 4.00, 1.00  
Total Depth (ft) = 1.00  
Invert Elev (ft) = 5083.20  
Slope (%) = 14.00  
N-Value = 0.027

### Highlighted

Depth (ft) = 0.29  
Q (cfs) = 72.50  
Area (sqft) = 8.39  
Velocity (ft/s) = 8.64  
Wetted Perim (ft) = 29.81  
Crit Depth, Yc (ft) = 0.58  
Top Width (ft) = 29.65  
EGL (ft) = 1.45

### Calculations

Compute by: Known Q  
Known Q (cfs) = 72.50





Engineering · Planning · Surveying

### DETENTION POND EMERGENCY OVERFLOW RIPRAP SIZING CALCULATION

PROJECT NAME: Badger CGF  
PROJECT NUMBER: EXT1N67W30-01  
CALCULATED BY: TGR  
CHECKED BY: NJN

DATE: 3/23/2018

#### RIPRAP SIZE

DESIGN FLOW VELOCITY, V =	8.75 ft/sec	From Flowmaster
DESIGN 100YR DISCHARGE, Q=	122.4 cfs	From spreadsheet SF3
SPECIFIC GRAVITY OF STONE, G <sub>s</sub> =	2.5	GIVEN
LONGITUDINAL CHANNEL SLOPE, S =	0.14 ft/ft	From Grading Plan
RIPRAP DESIGN PARAMETER, $(VS^{0.17})/((G_s-1)^{0.66}) =$	4.79	Equation MD-13 VOL 1 UDFCD
RIPRAP TYPE =	<b>H</b>	Table MD-10 VOL 1 UDFCD
MEDIAN SIZE OF RIPRAP, D <sub>50</sub> =	<b>18 inches</b>	Table MD-10 VOL 1 UDFCD

#### MINIMUM RIPRAP LENGTH & THICKNESS

MINIMUM LENGTH, L =	<b>35.0 ft</b>	Length of spillway plus 10 ft, see grading plan
MINIMUM WIDTH, W =	<b>65.0 ft</b>	Width of spillway, see grading plan
RIPRAP AVG. THICKNESS, T =	<b>27 inches</b>	T = 1.5*D <sub>50</sub>

# Culvert Report

## Pipe DP 1

Invert Elev Dn (ft)	= 5105.72
Pipe Length (ft)	= 58.00
Slope (%)	= 2.00
Invert Elev Up (ft)	= 5106.88
Rise (in)	= 18.0
Shape	= Circular
Span (in)	= 18.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

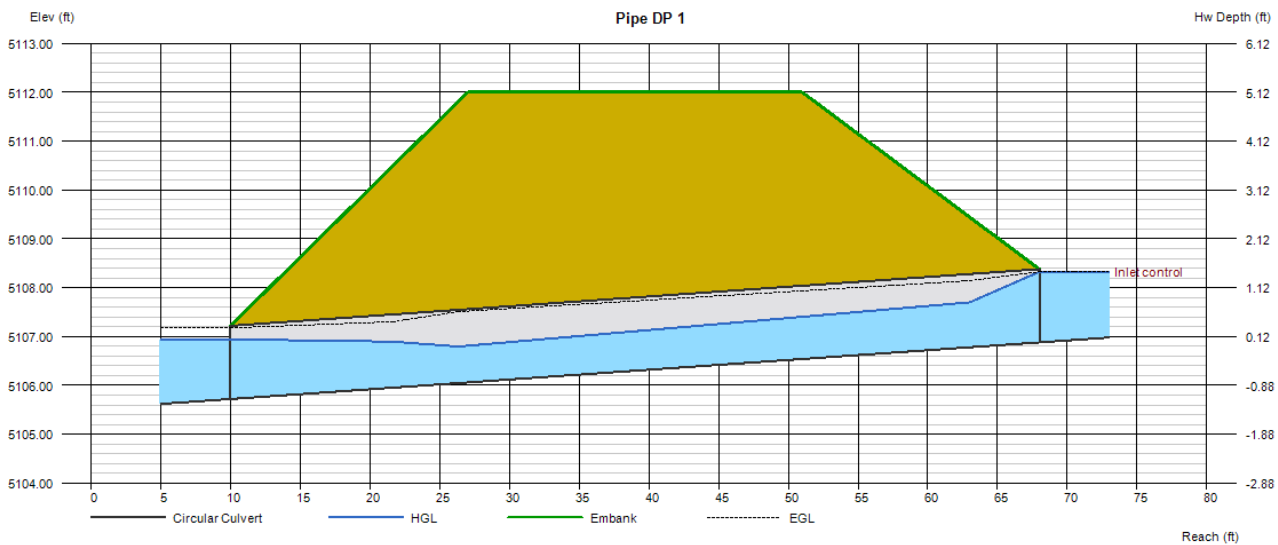
Top Elevation (ft)	= 5112.00
Top Width (ft)	= 24.00
Crest Width (ft)	= 150.00

### Calculations

Qmin (cfs)	= 1.66
Qmax (cfs)	= 5.99
Tailwater Elev (ft)	= (dc+D)/2

### Highlighted

Qtotal (cfs)	= 5.98
Qpipe (cfs)	= 5.98
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 3.88
Veloc Up (ft/s)	= 5.11
HGL Dn (ft)	= 5106.94
HGL Up (ft)	= 5107.82
Hw Elev (ft)	= 5108.33
Hw/D (ft)	= 0.96
Flow Regime	= Inlet Control



# Culvert Report

## Pipe DP 2

Invert Elev Dn (ft)	= 5098.46
Pipe Length (ft)	= 294.00
Slope (%)	= 1.14
Invert Elev Up (ft)	= 5101.80
Rise (in)	= 18.0
Shape	= Circular
Span (in)	= 18.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Groove end projecting (C)
Coeff. K,M,c,Y,k	= 0.0045, 2, 0.0317, 0.69, 0.2

### Calculations

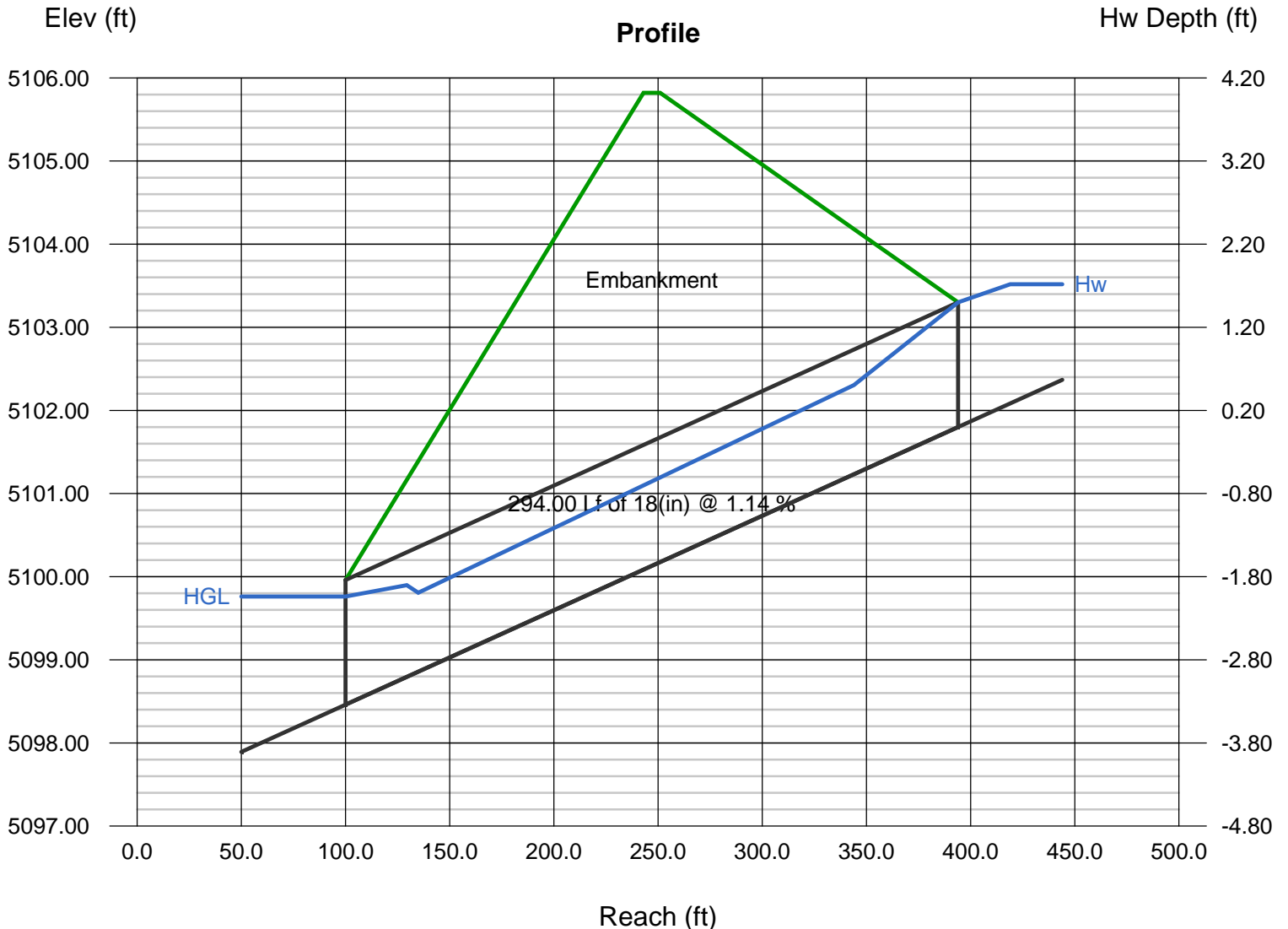
Qmin (cfs)	= 1.12
Qmax (cfs)	= 8.81
Tailwater Elev (ft)	= (dc+D)/2

### Highlighted

Qtotall (cfs)	= 8.12
Qpipe (cfs)	= 8.12
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 4.99
Veloc Up (ft/s)	= 5.83
HGL Dn (ft)	= 5099.76
HGL Up (ft)	= 5102.90
Hw Elev (ft)	= 5103.52
Hw/D (ft)	= 1.15
Flow Regime	= Inlet Control

### Embankment

Top Elevation (ft)	= 5105.82
Top Width (ft)	= 8.00
Crest Width (ft)	= 50.00



# Culvert Report

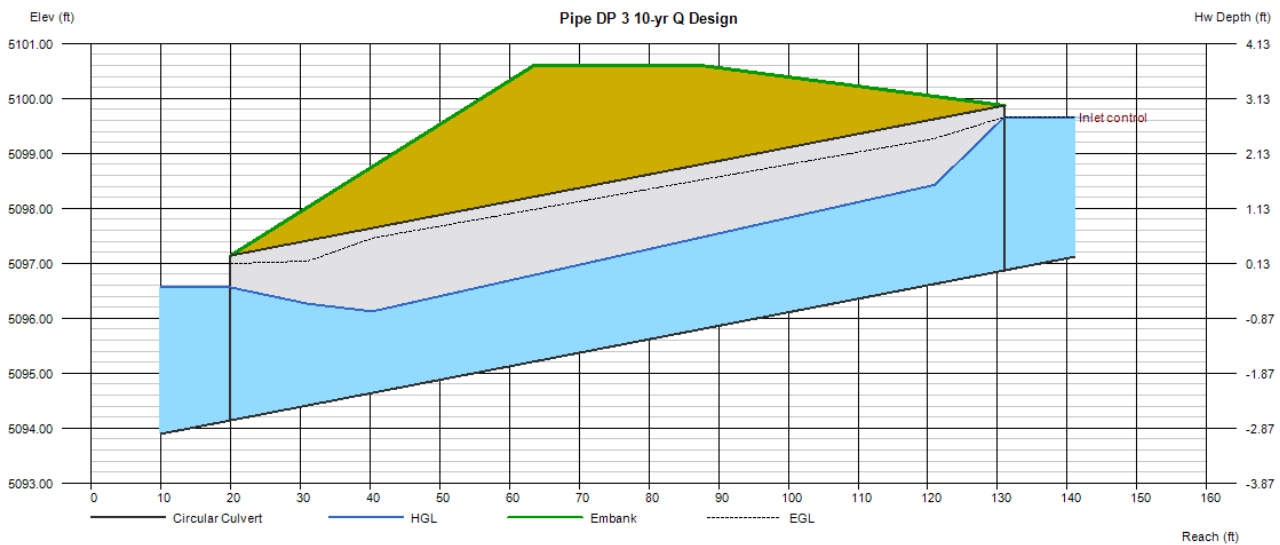
## Pipe DP 3 10-yr Q Design

Invert Elev Dn (ft)	= 5094.14
Pipe Length (ft)	= 111.00
Slope (%)	= 2.46
Invert Elev Up (ft)	= 5096.87
Rise (in)	= 36.0
Shape	= Circular
Span (in)	= 36.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

<b>Embankment</b>	
Top Elevation (ft)	= 5100.60
Top Width (ft)	= 24.00
Crest Width (ft)	= 200.00

<b>Calculations</b>	
Qmin (cfs)	= 32.29
Qmax (cfs)	= 122.40
Tailwater Elev (ft)	= (dc+D)/2

<b>Highlighted</b>	
Qtotal (cfs)	= 32.29
Qpipe (cfs)	= 32.29
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.28
Veloc Up (ft/s)	= 7.09
HGL Dn (ft)	= 5096.56
HGL Up (ft)	= 5098.71
Hw Elev (ft)	= 5099.66
Hw/D (ft)	= 0.93
Flow Regime	= Inlet Control



# Culvert Report

## Pipe DP 4

Invert Elev Dn (ft)	= 5098.62
Pipe Length (ft)	= 61.00
Slope (%)	= 2.00
Invert Elev Up (ft)	= 5099.84
Rise (in)	= 18.0
Shape	= Circular
Span (in)	= 18.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

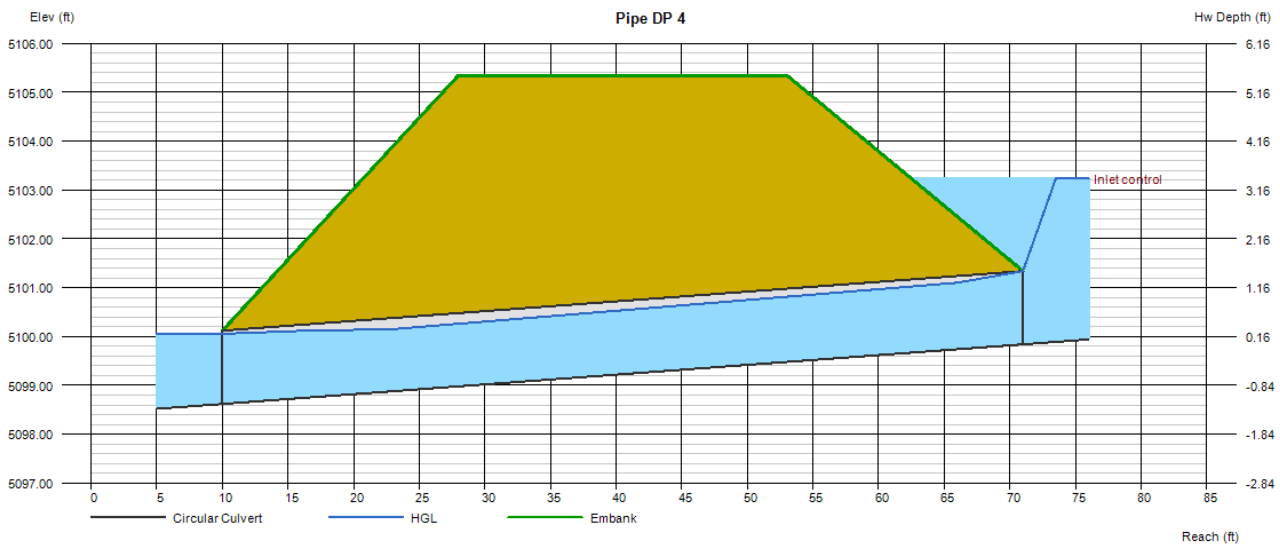
Top Elevation (ft)	= 5105.35
Top Width (ft)	= 25.00
Crest Width (ft)	= 25.00

### Calculations

Qmin (cfs)	= 3.73
Qmax (cfs)	= 14.00
Tailwater Elev (ft)	= (dc+D)/2

### Highlighted

Qtotal (cfs)	= 13.73
Qpipe (cfs)	= 13.73
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 7.88
Veloc Up (ft/s)	= 8.10
HGL Dn (ft)	= 5100.06
HGL Up (ft)	= 5101.21
Hw Elev (ft)	= 5103.23
Hw/D (ft)	= 2.26
Flow Regime	= Inlet Control



# Culvert Report

## Pipe DP 5

Invert Elev Dn (ft)	= 5093.46
Pipe Length (ft)	= 150.00
Slope (%)	= 1.99
Invert Elev Up (ft)	= 5096.45
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

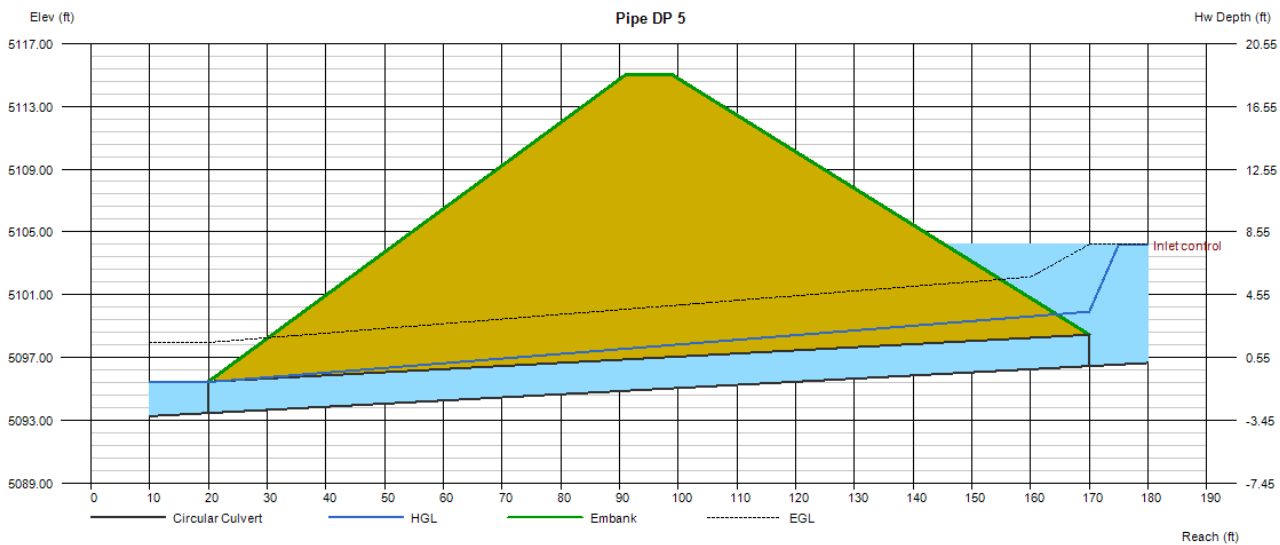
Top Elevation (ft)	= 5115.00
Top Width (ft)	= 8.00
Crest Width (ft)	= 150.00

### Calculations

Qmin (cfs)	= 17.90
Qmax (cfs)	= 39.90
Tailwater Elev (ft)	= (dc+D)/2

### Highlighted

Qtotal (cfs)	= 39.90
Qpipe (cfs)	= 39.90
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 12.73
Veloc Up (ft/s)	= 12.70
HGL Dn (ft)	= 5095.44
HGL Up (ft)	= 5099.92
Hw Elev (ft)	= 5104.19
Hw/D (ft)	= 3.87
Flow Regime	= Inlet Control



# Culvert Report

## Pipe DP 6

Invert Elev Dn (ft)	= 5090.69
Pipe Length (ft)	= 134.00
Slope (%)	= 2.00
Invert Elev Up (ft)	= 5093.37
Rise (in)	= 21.0
Shape	= Circular
Span (in)	= 21.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

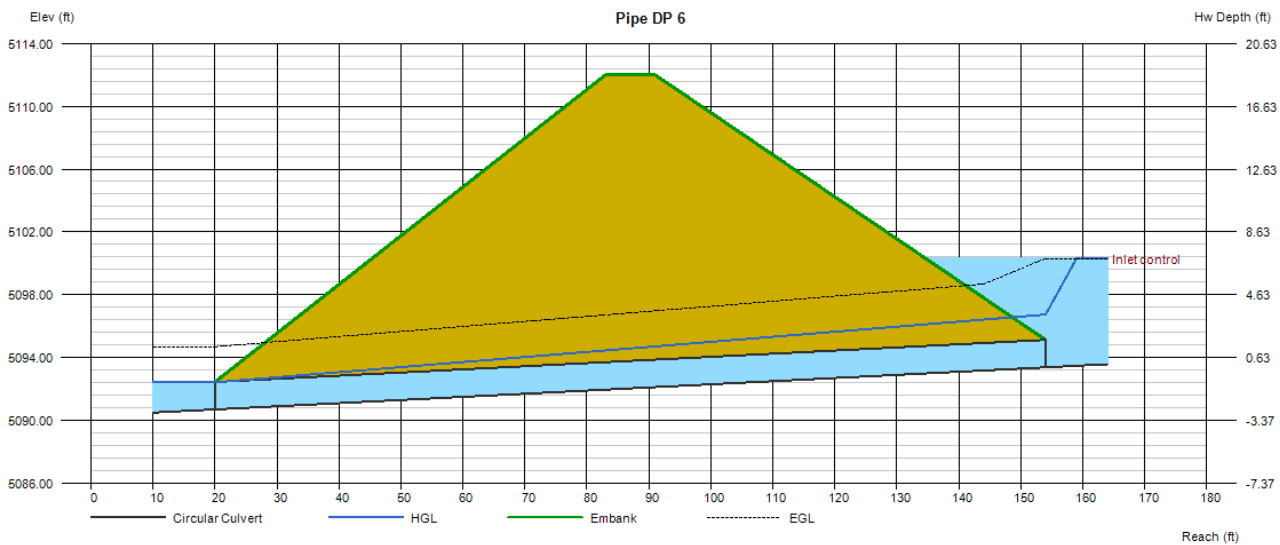
Top Elevation (ft)	= 5112.00
Top Width (ft)	= 8.00
Crest Width (ft)	= 150.00

### Calculations

Qmin (cfs)	= 13.00
Qmax (cfs)	= 29.00
Tailwater Elev (ft)	= (dc+D)/2

### Highlighted

Qtotal (cfs)	= 29.00
Qpipe (cfs)	= 29.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 12.08
Veloc Up (ft/s)	= 12.06
HGL Dn (ft)	= 5092.42
HGL Up (ft)	= 5096.73
Hw Elev (ft)	= 5100.31
Hw/D (ft)	= 3.97
Flow Regime	= Inlet Control



# Culvert Report

## Pipe DP 7

Invert Elev Dn (ft)	= 5080.37
Pipe Length (ft)	= 45.00
Slope (%)	= 2.00
Invert Elev Up (ft)	= 5081.27
Rise (in)	= 42.0
Shape	= Circular
Span (in)	= 42.0
No. Barrels	= 1
n-Value	= 0.013
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

### Embankment

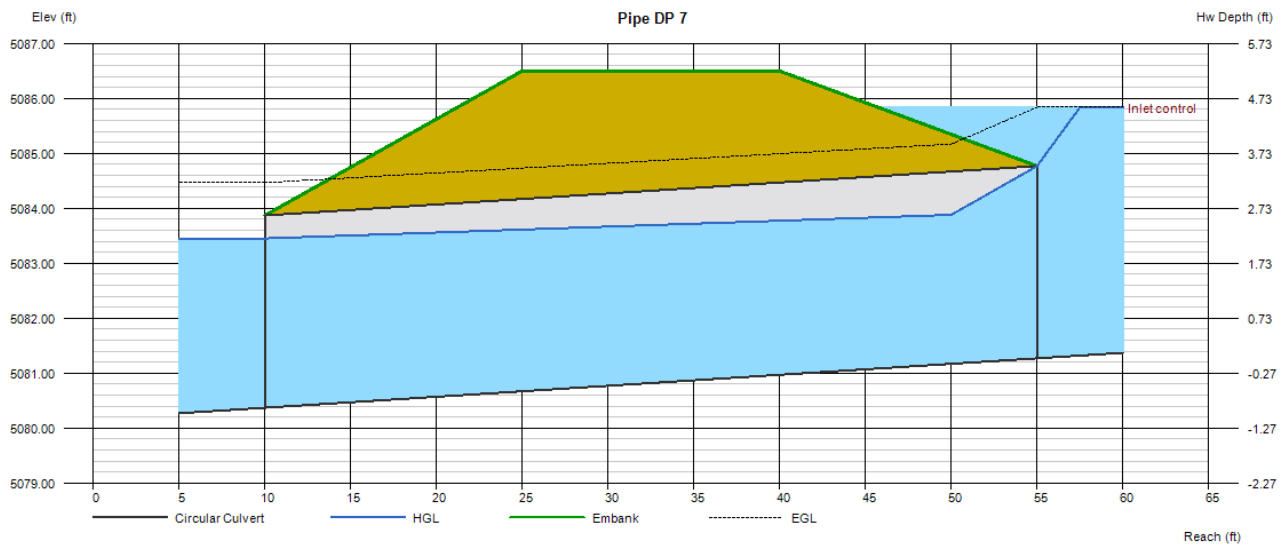
Top Elevation (ft)	= 5086.50
Top Width (ft)	= 15.00
Crest Width (ft)	= 50.00

### Calculations

Qmin (cfs)	= 7.50
Qmax (cfs)	= 72.50
Tailwater Elev (ft)	= (dc+D)/2

### Highlighted

Qtotal (cfs)	= 72.50
Qpipe (cfs)	= 72.50
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 8.08
Veloc Up (ft/s)	= 9.22
HGL Dn (ft)	= 5083.45
HGL Up (ft)	= 5083.94
Hw Elev (ft)	= 5085.84
Hw/D (ft)	= 1.31
Flow Regime	= Inlet Control



# Culvert Report

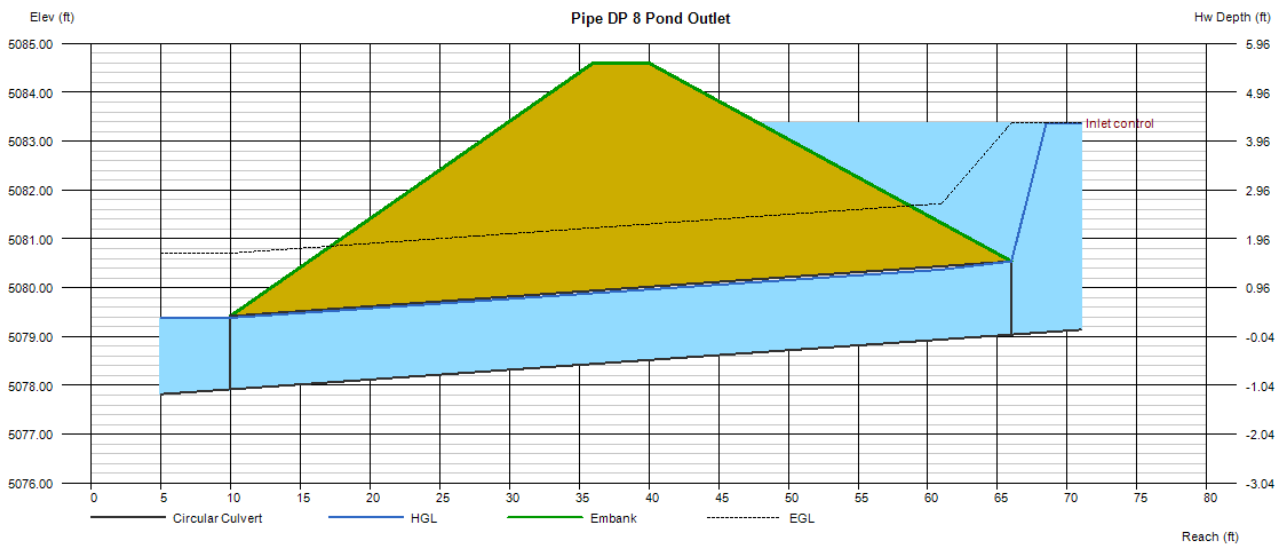
## Pipe DP 8 Pond Outlet

Invert Elev Dn (ft)	= 5077.92
Pipe Length (ft)	= 56.00
Slope (%)	= 2.00
Invert Elev Up (ft)	= 5079.04
Rise (in)	= 18.0
Shape	= Circular
Span (in)	= 18.0
No. Barrels	= 1
n-Value	= 0.012
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

<b>Embankment</b>	
Top Elevation (ft)	= 5084.60
Top Width (ft)	= 4.00
Crest Width (ft)	= 100.00

<b>Calculations</b>	
Qmin (cfs)	= 16.20
Qmax (cfs)	= 16.20
Tailwater Elev (ft)	= (dc+D)/2

<b>Highlighted</b>	
Qtotal (cfs)	= 16.20
Qpipe (cfs)	= 16.20
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 9.23
Veloc Up (ft/s)	= 9.33
HGL Dn (ft)	= 5079.38
HGL Up (ft)	= 5080.47
Hw Elev (ft)	= 5083.38
Hw/D (ft)	= 2.89
Flow Regime	= Inlet Control



# Culvert Report

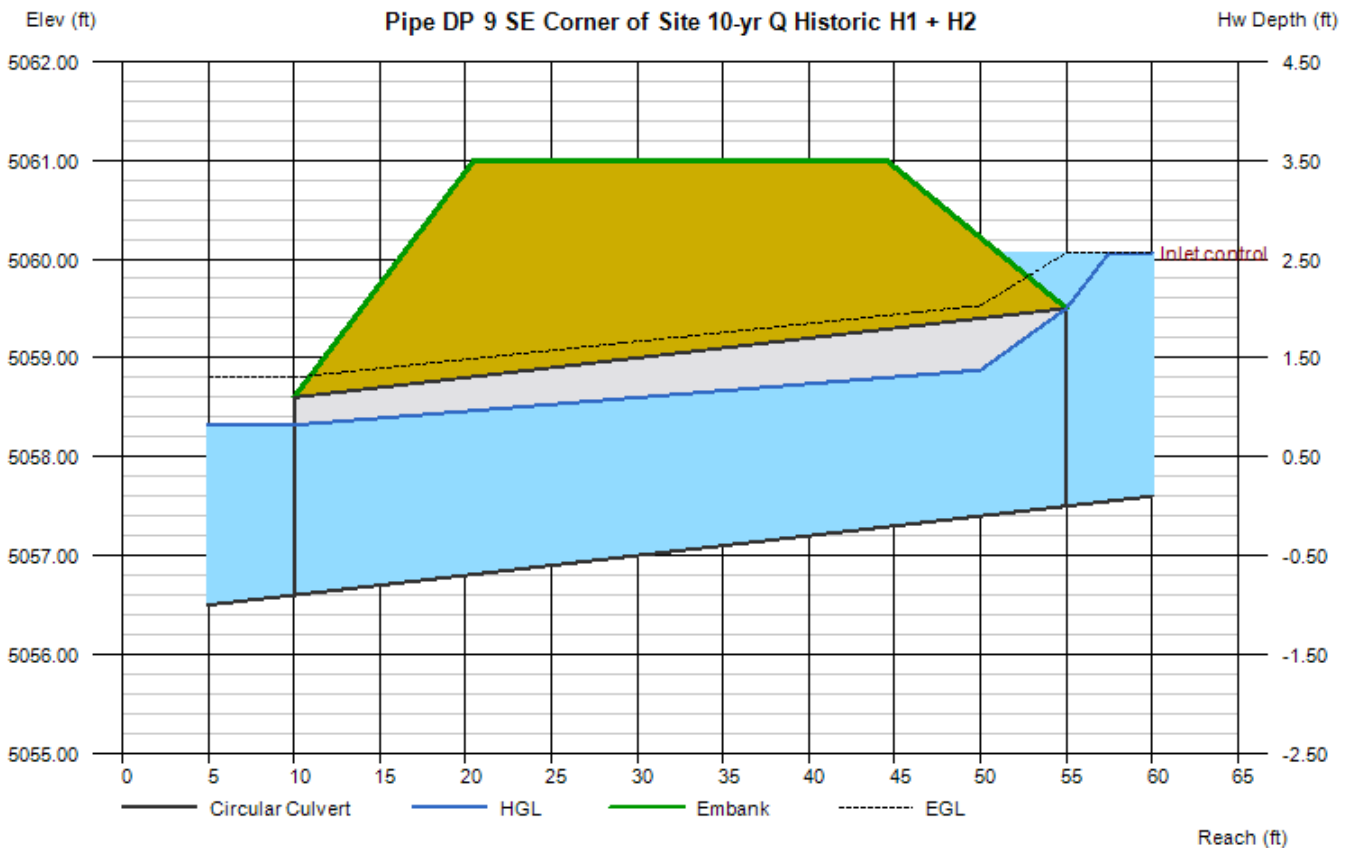
## Pipe DP 9 SE Corner of Site 10-yr Q Historic H1 + H2

Invert Elev Dn (ft)	= 5056.60
Pipe Length (ft)	= 45.00
Slope (%)	= 2.00
Invert Elev Up (ft)	= 5057.50
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 4
n-Value	= 0.024
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Projecting
Coeff. K,M,c,Y,k	= 0.034, 1.5, 0.0553, 0.54, 0.9

<b>Calculations</b>	
Qmin (cfs)	= 64.00
Qmax (cfs)	= 64.00
Tailwater Elev (ft)	= (dc+D)/2

<b>Highlighted</b>	
Qtotal (cfs)	= 64.00
Qpipe (cfs)	= 64.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.56
Veloc Up (ft/s)	= 6.58
HGL Dn (ft)	= 5058.32
HGL Up (ft)	= 5058.95
Hw Elev (ft)	= 5060.06
Hw/D (ft)	= 1.28
Flow Regime	= Inlet Control

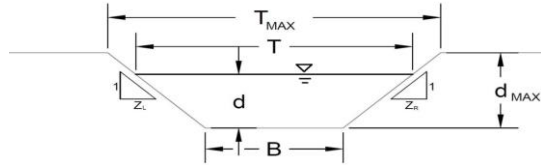
<b>Embankment</b>	
Top Elevation (ft)	= 5061.00
Top Width (ft)	= 24.00
Crest Width (ft)	= 100.00



**AREA INLET IN A SWALE**

Badger DP 3

Inlet 1



This worksheet uses the NRCS vegetative retardance method to determine Manning's n.  
For more information see Section 7.2.3 of the USDCM.

**Analysis of Trapezoidal Grass-Lined Channel Using SCS Method**

NRCS Vegetal Retardance (A, B, C, D, or E)  
Manning's n (Leave cell D16 blank to manually enter an n value)  
Channel Invert Slope  
Bottom Width  
Left Side Slope  
Right Side Slope

A, B, C, D or E: **A**  
n = see details below  
S<sub>0</sub> = 0.0130 ft/ft  
B = 0.00 ft  
Z1 = 4.00 ft/ft  
Z2 = 4.00 ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V <sub>MAX</sub> )	Max Froude No. (F <sub>MAX</sub> )
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:  
 Non-Cohesive  
 Cohesive  
 Paved

Max. Allowable Top Width of Channel for Minor & Major Storm  
Max. Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
T <sub>MAX</sub> =	8.00	16.00	feet
d <sub>MAX</sub> =	1.00	2.00	feet

**Allowable Channel Capacity Based On Channel Geometry**

MINOR STORM Allowable Capacity is based on Depth Criterion  
MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q <sub>allow</sub> =	1.4	7.2	cfs
d <sub>allow</sub> =	1.00	2.00	ft

**Water Depth in Channel Based On Design Peak Flow**

Design Peak Flow  
Water Depth

	Minor Storm	Major Storm	
Q <sub>c</sub> =	0.6	1.4	cfs
d =	0.69	1.01	feet

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'  
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

**AREA INLET IN A SWALE**

Badger DP 3

Inlet 1

**Inlet Design Information (Input)**

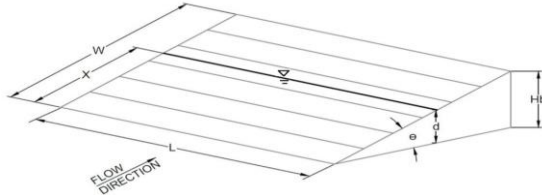
Type of Inlet

CDOT Type C

Inlet Type =

CDOT Type C

- Angle of Inclined Grate (must be <= 30 degrees)
- Width of Grate
- Length of Grate
- Open Area Ratio
- Height of Inclined Grate
- Clogging Factor
- Grate Discharge Coefficient
- Orifice Coefficient
- Weir Coefficient



$\theta$ =	30.00	degrees
W =	3.00	feet
L =	3.00	feet
A <sub>RATIO</sub> =	0.70	
H <sub>B</sub> =	1.50	feet
C <sub>d</sub> =	0.50	
C <sub>o</sub> =	0.86	
C <sub>w</sub> =	0.58	
	1.85	

Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)

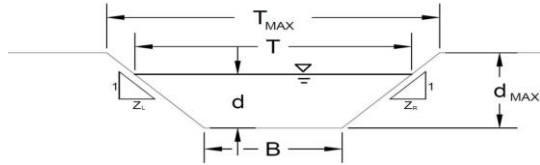
	MINOR	MAJOR	
d =	0.69	1.01	
Q <sub>a</sub> =	4.8	8.5	cfs
Bypassed Flow, Q <sub>b</sub> =	0.0	0.0	cfs
Capture Percentage = Q <sub>a</sub> /Q <sub>o</sub> = C%	100	100	%

**Total Inlet Interception Capacity (assumes clogged condition)**

AREA INLET IN A SWALE

Badger DP 6

Inlet 2



This worksheet uses the NRCS vegetative retardance method to determine Manning's n.  
For more information see Section 7.2.3 of the USDCM.

**Analysis of Trapezoidal Grass-Lined Channel Using SCS Method**

NRCS Vegetal Retardance (A, B, C, D, or E)  
Manning's n (Leave cell D16 blank to manually enter a n value)  
Channel Invert Slope  
Bottom Width  
Left Side Slope  
Right Side Slope

A, B, C, D or E	A
n =	see details below
S <sub>0</sub> =	0.0050 ft/ft
B =	0.00 ft
Z1 =	4.00 ft/ft
Z2 =	4.00 ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V <sub>MAX</sub> )	Max Froude No. (F <sub>MAX</sub> )
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:  
 Non-Cohesive  
 Cohesive  
 Paved

Max. Allowable Top Width of Channel for Minor & Major Storm  
Max. Allowable Water Depth in Channel for Minor & Major Storm

	Minor Storm	Major Storm	
T <sub>MAX</sub> =	25.00	40.00	feet
d <sub>MAX</sub> =	4.00	5.00	feet

**Maximum Channel Capacity Based On Allowable Top Width**

Max. Allowable Top Width  
Water Depth  
Flow Area  
Wetted Perimeter  
Hydraulic Radius  
Manning's n based on NRCS Vegetal Retardance  
Flow Velocity  
Velocity-Depth Product  
Hydraulic Depth  
Froude Number  
Max. Flow Based On Allowable Top Width

	Minor Storm	Major Storm	
T <sub>MAX</sub> =	25.00	40.00	ft
d =	3.13	5.00	ft
A =	39.06	100.00	sq ft
P =	25.77	41.23	ft
R =	1.52	2.43	ft
n =	0.356	0.094	
V =	0.39	2.03	fps
VR =	0.59	4.92	ft <sup>2</sup> /s
D =	1.56	2.50	ft
Fr =	0.06	0.23	
Q <sub>T</sub> =	15.3	202.7	cfs

**Maximum Channel Capacity Based On Allowable Water Depth**

Max. Allowable Water Depth  
Top Width  
Flow Area  
Wetted Perimeter  
Hydraulic Radius  
Manning's n based on NRCS Vegetal Retardance  
Flow Velocity  
Velocity-Depth Product  
Hydraulic Depth  
Froude Number  
Max. Flow Based On Allowable Water Depth

	Minor Storm	Major Storm	
d <sub>MAX</sub> =	4.00	5.00	feet
T =	32.00	40.00	feet
A =	64.00	100.00	square feet
P =	32.98	41.23	feet
R =	1.94	2.43	feet
n =	0.237	0.094	
V =	0.69	2.03	fps
VR =	1.34	4.92	ft <sup>2</sup> /s
D =	2.00	2.50	feet
Fr =	0.09	0.23	
Q <sub>d</sub> =	44.2	202.7	cfs

**Allowable Channel Capacity Based On Channel Geometry**

MINOR STORM Allowable Capacity is based on Top Width Criterion  
MAJOR STORM Allowable Capacity is based on Depth Criterion

	Minor Storm	Major Storm	
Q <sub>allow</sub> =	15.3	202.7	cfs
d <sub>allow</sub> =	3.13	5.00	ft

**Water Depth in Channel Based On Design Peak Flow**

Design Peak Flow  
Water Depth  
Top Width  
Flow Area  
Wetted Perimeter  
Hydraulic Radius  
Manning's n based on NRCS Vegetal Retardance  
Flow Velocity  
Velocity-Depth Product  
Hydraulic Depth  
Froude Number

	Minor Storm	Major Storm	
Q <sub>c</sub> =	12.4	29.0	cfs
d =	2.91	3.71	feet
T =	23.31	29.65	feet
A =	33.96	54.93	square feet
P =	24.03	30.56	feet
R =	1.41	1.80	feet
n =	0.363	0.295	
V =	0.37	0.53	fps
VR =	0.52	0.95	ft <sup>2</sup> /s
D =	1.46	1.85	feet
Fr =	0.05	0.07	

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'  
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

AREA INLET IN A SWALE

Badger DP 6

Inlet 2

**Inlet Design Information (Input)**

Type of Inlet:  Inlet Type =

Angle of Inclined Grate (must be <= 30 degrees):  $\theta =$   degrees

Width of Grate:  $W =$   feet

Length of Grate:  $L =$   feet

Open Area Ratio:  $A_{RATIO} =$

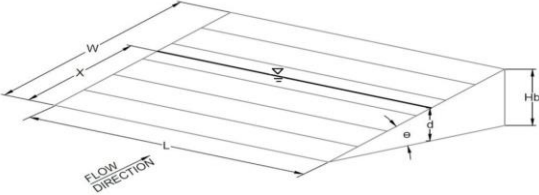
Height of Inclined Grate:  $H_B =$   feet

Clogging Factor:  $C_c =$

Grate Discharge Coefficient:  $C_d =$

Orifice Coefficient:  $C_o =$

Weir Coefficient:  $C_w =$



Water Depth at Inlet (for depressed inlets, 1 foot is added for depression):  $d =$

	MINOR	MAJOR
$d =$	<input type="text" value="2.91"/>	<input type="text" value="3.71"/>

**Grate Capacity as a Weir**

Submerged Side Weir Length:  $X =$   feet

Inclined Side Weir Flow:  $Q_{ws} =$   cfs

Base Weir Flow:  $Q_{wb} =$   cfs

Interception without Clogging:  $Q_{wi} =$   cfs

Interception with Clogging:  $Q_{wci} =$   cfs

**Grate Capacity as an Orifice**

Interception without Clogging:  $Q_{oi} =$   cfs

Interception with Clogging:  $Q_{oci} =$   cfs

**Total Inlet Interception Capacity (assumes clogged condition)**

$Q_a =$   cfs

Bypassed Flow,  $Q_b =$   cfs

Capture Percentage =  $Q_a/Q_o = C\%$   %

# Channel Report

## Channel to DP1

### Triangular

Side Slopes (z:1) = 3.00, 3.00

Total Depth (ft) = 4.00

Invert Elev (ft) = 5106.88

Slope (%) = 0.50

N-Value = 0.027

### Calculations

Compute by: Known Q

Known Q (cfs) = 5.99

### Highlighted

Depth (ft) = 0.94

Q (cfs) = 5.990

Area (sqft) = 2.65

Velocity (ft/s) = 2.26

Wetted Perim (ft) = 5.95 WP

Crit Depth, Yc (ft) = 0.76

Top Width (ft) = 5.64 TW

EGL (ft) = 1.02

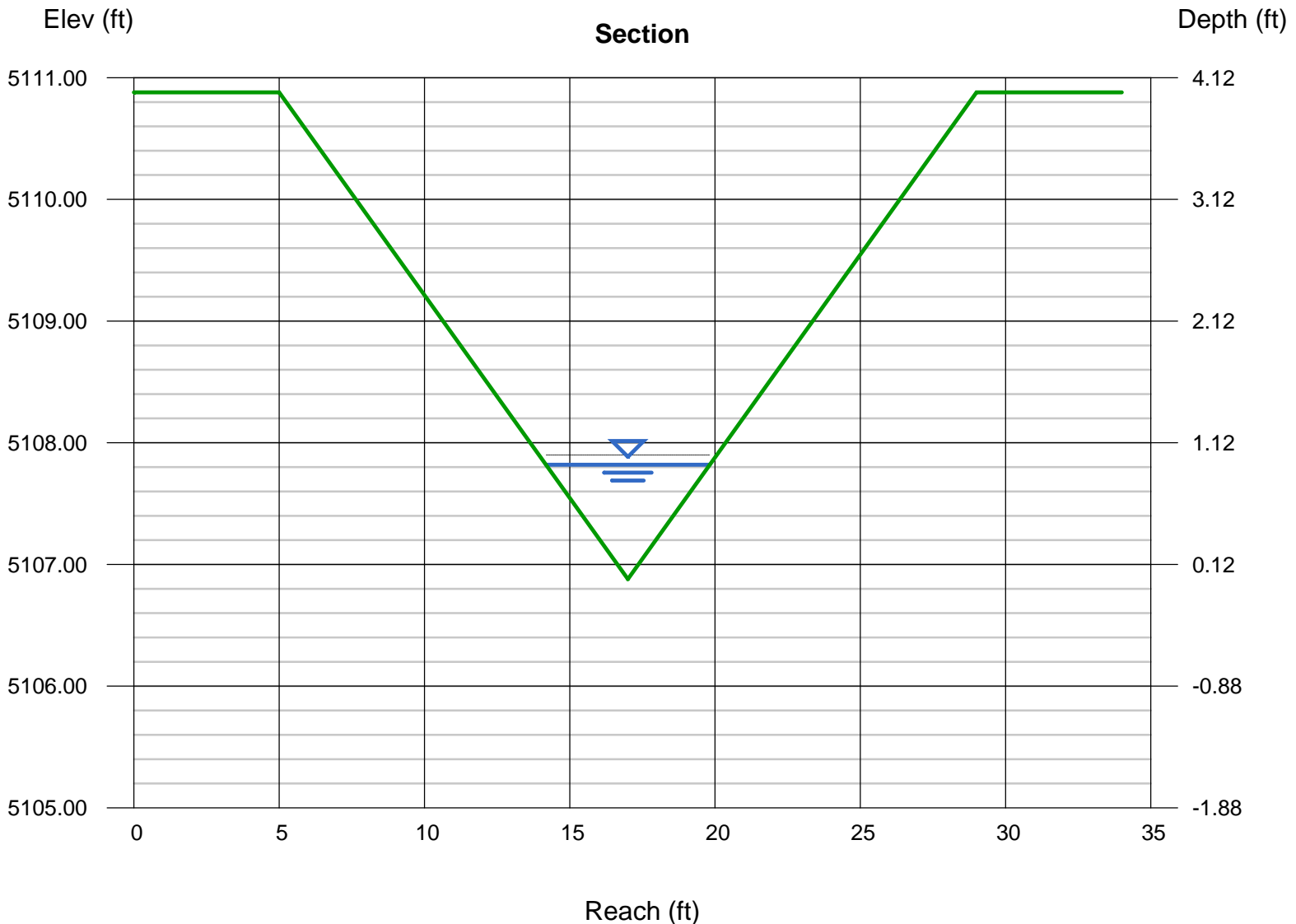
Fr =  $V/\sqrt{gD}$  = 0.39

D = WP/TW

Fr = 1, critical flow

Fr > 1, supercritical flow (fast rapid flow)

Fr < 1, subcritical flow (slow/tranquil flow)



# Channel Report

## Channel to DP 2

### Triangular

Side Slopes (z:1) = 3.00, 3.00  
Total Depth (ft) = 3.00

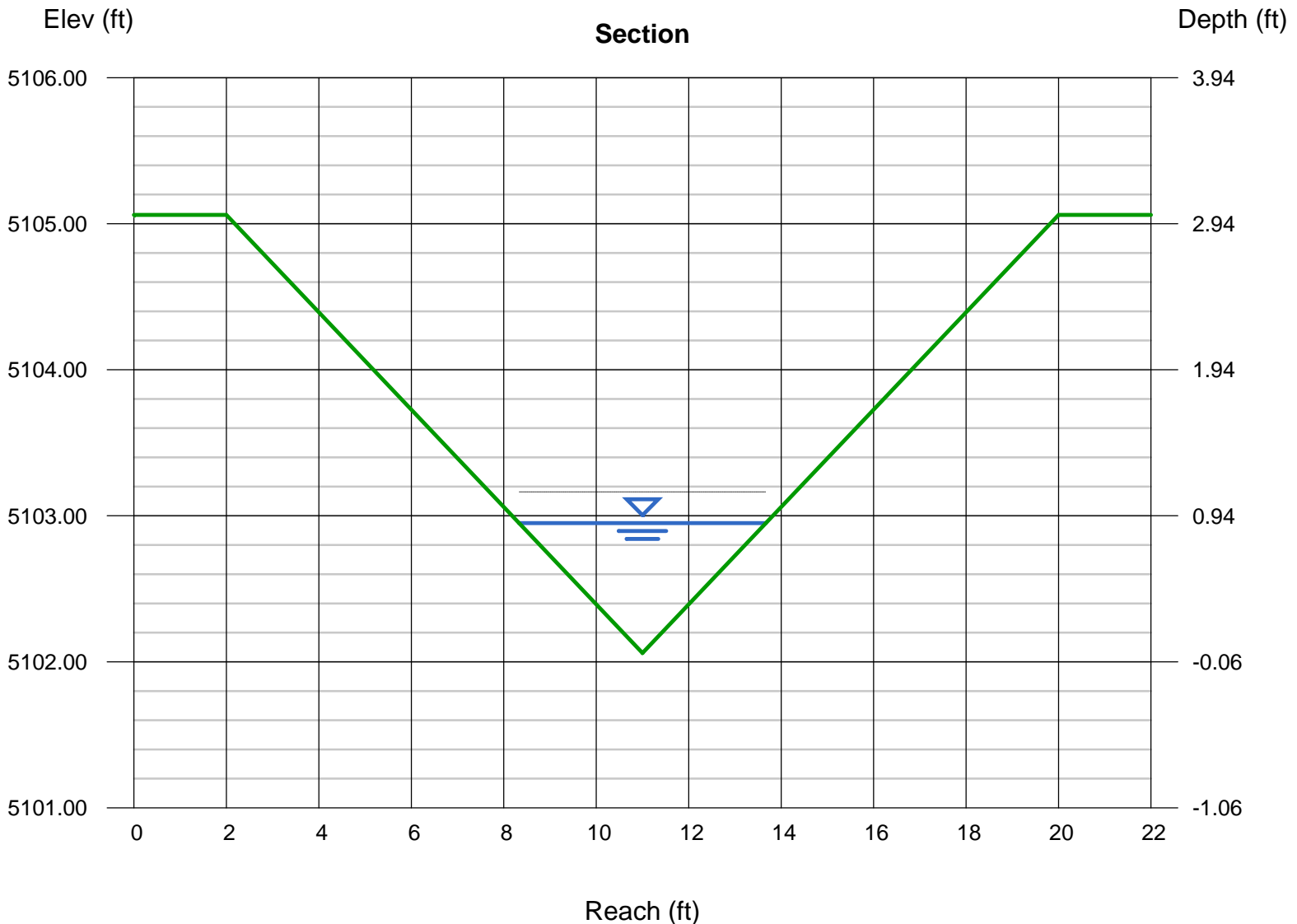
Invert Elev (ft) = 5102.06  
Slope (%) = 1.52  
N-Value = 0.027

### Calculations

Compute by: Known Q  
Known Q (cfs) = 8.81

### Highlighted

Depth (ft) = 0.89  
Q (cfs) = 8.810  
Area (sqft) = 2.38  
Velocity (ft/s) = 3.71  
Wetted Perim (ft) = 5.63  
Crit Depth, Yc (ft) = 0.89  
Top Width (ft) = 5.34  
EGL (ft) = 1.10  
Fr = 0.28



# Channel Report

## Channel to DP 3

### Triangular

Side Slopes (z:1) = 4.00, 4.00

Total Depth (ft) = 1.00

Invert Elev (ft) = 5099.42

Slope (%) = 1.30

N-Value = 0.027

### Calculations

Compute by: Known Q

Known Q (cfs) = 1.40

### Highlighted

Depth (ft) = 0.41

Q (cfs) = 1.400

Area (sqft) = 0.67

Velocity (ft/s) = 2.08

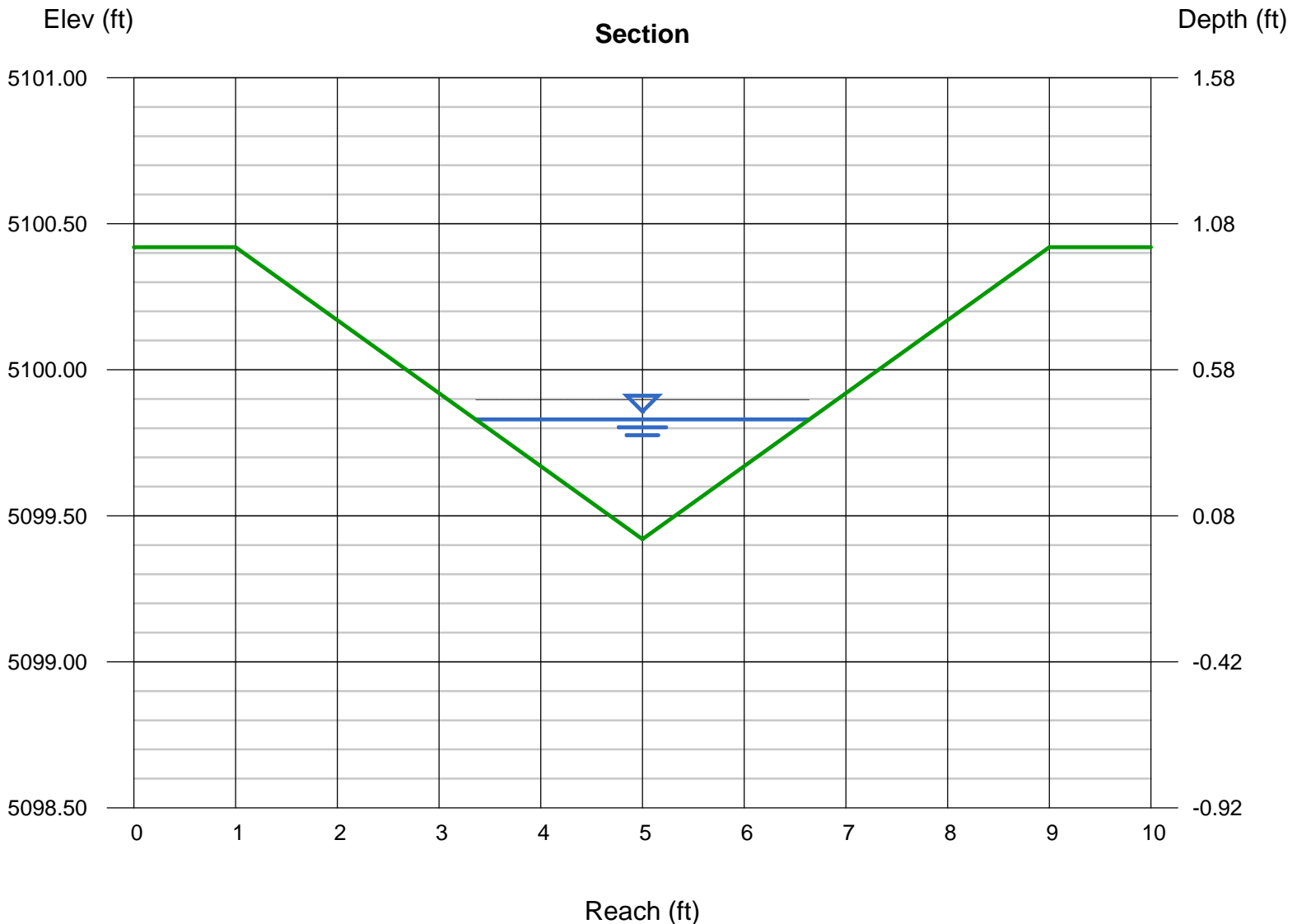
Wetted Perim (ft) = 3.38

Crit Depth, Yc (ft) = 0.38

Top Width (ft) = 3.28

EGL (ft) = 0.48

Fr = 0.36



# Channel Report

## Channel to DP 4

### Triangular

Side Slopes (z:1) = 3.00, 3.00  
Total Depth (ft) = 4.00

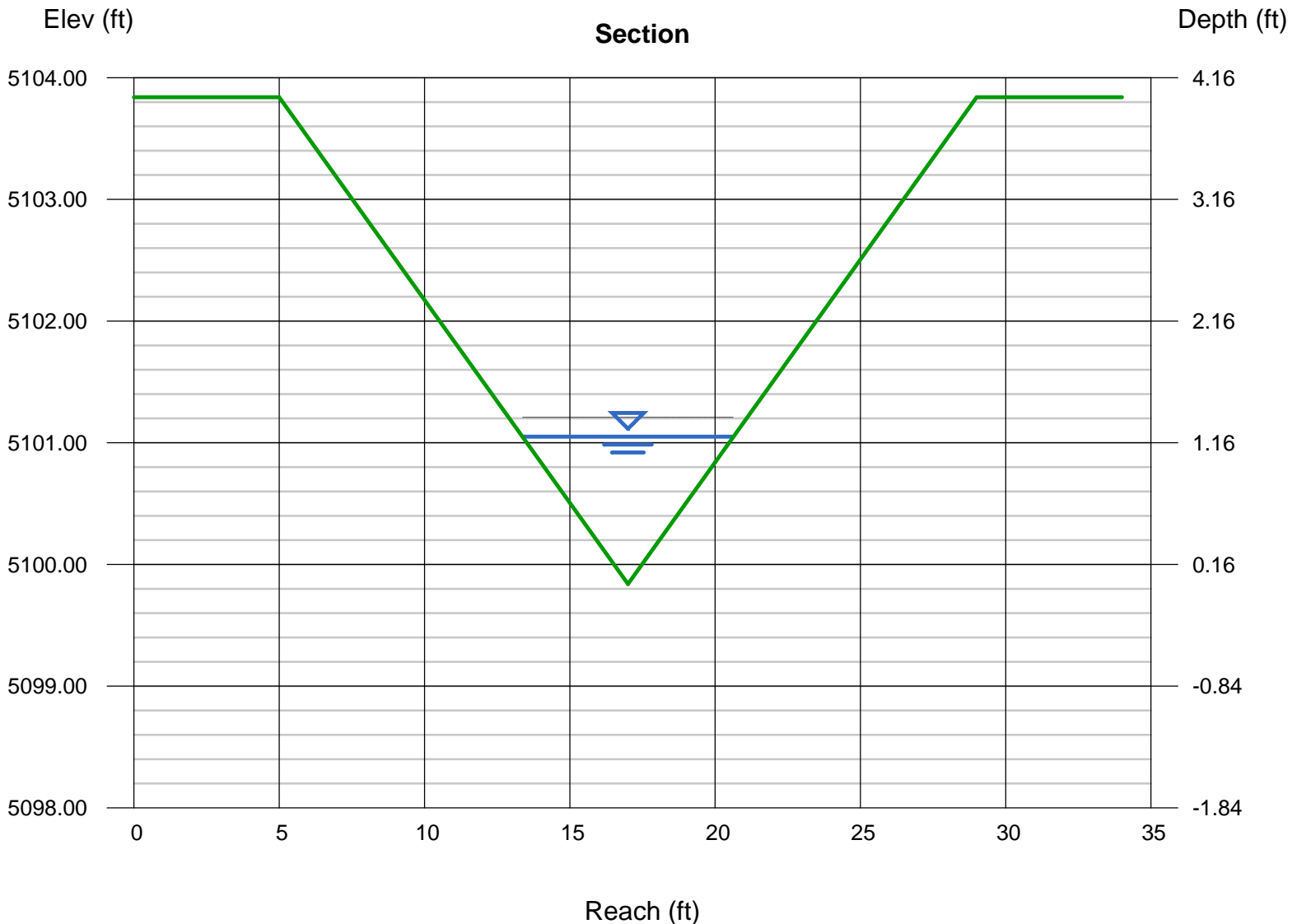
Invert Elev (ft) = 5099.84  
Slope (%) = 0.72  
N-Value = 0.027

### Calculations

Compute by: Known Q  
Known Q (cfs) = 14.05

### Highlighted

Depth (ft) = 1.21  
Q (cfs) = 14.05  
Area (sqft) = 4.39  
Velocity (ft/s) = 3.20  
Wetted Perim (ft) = 7.65  
Crit Depth, Yc (ft) = 1.07  
Top Width (ft) = 7.26  
EGL (ft) = 1.37  
Fr = 0.55



# Channel Report

## Channel to DP 5

### Triangular

Side Slopes (z:1) = 3.00, 3.00

Total Depth (ft) = 6.00

Invert Elev (ft) = 5097.97

Slope (%) = 0.50

N-Value = 0.027

### Calculations

Compute by: Known Q

Known Q (cfs) = 39.90

### Highlighted

Depth (ft) = 1.92

Q (cfs) = 39.90

Area (sqft) = 11.06

Velocity (ft/s) = 3.61

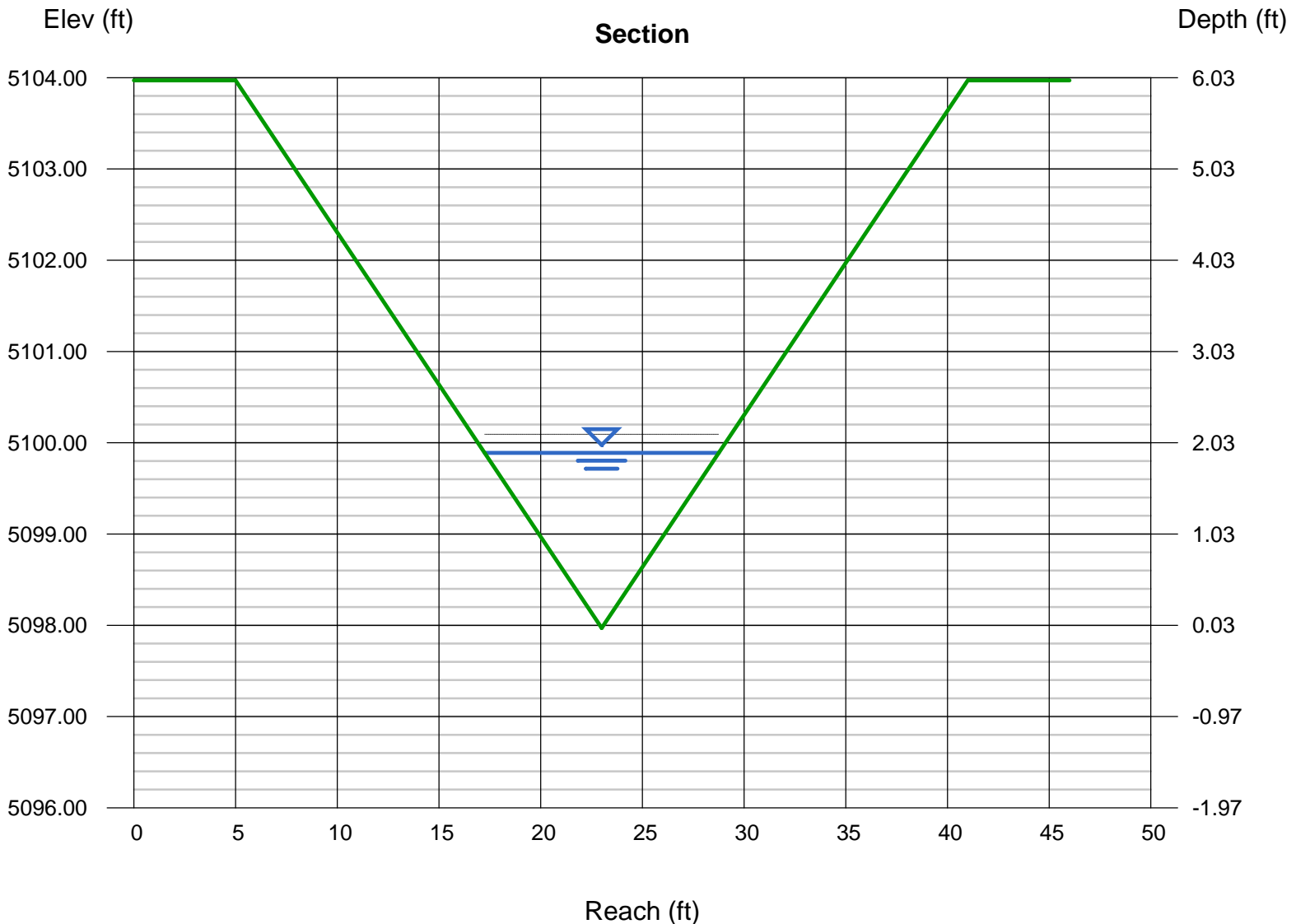
Wetted Perim (ft) = 12.14

Crit Depth, Yc (ft) = 1.62

Top Width (ft) = 11.52

EGL (ft) = 2.12

Fr = 0.62



# Channel Report

## Channel outlet from DP 5

### Triangular

Side Slopes (z:1) = 3.00, 3.00

Total Depth (ft) = 4.00

Invert Elev (ft) = 5097.97

Slope (%) = 1.62

N-Value = 0.027

### Calculations

Compute by: Known Q

Known Q (cfs) = 39.90

### Highlighted

Depth (ft) = 1.54

Q (cfs) = 39.90

Area (sqft) = 7.11

Velocity (ft/s) = 5.61

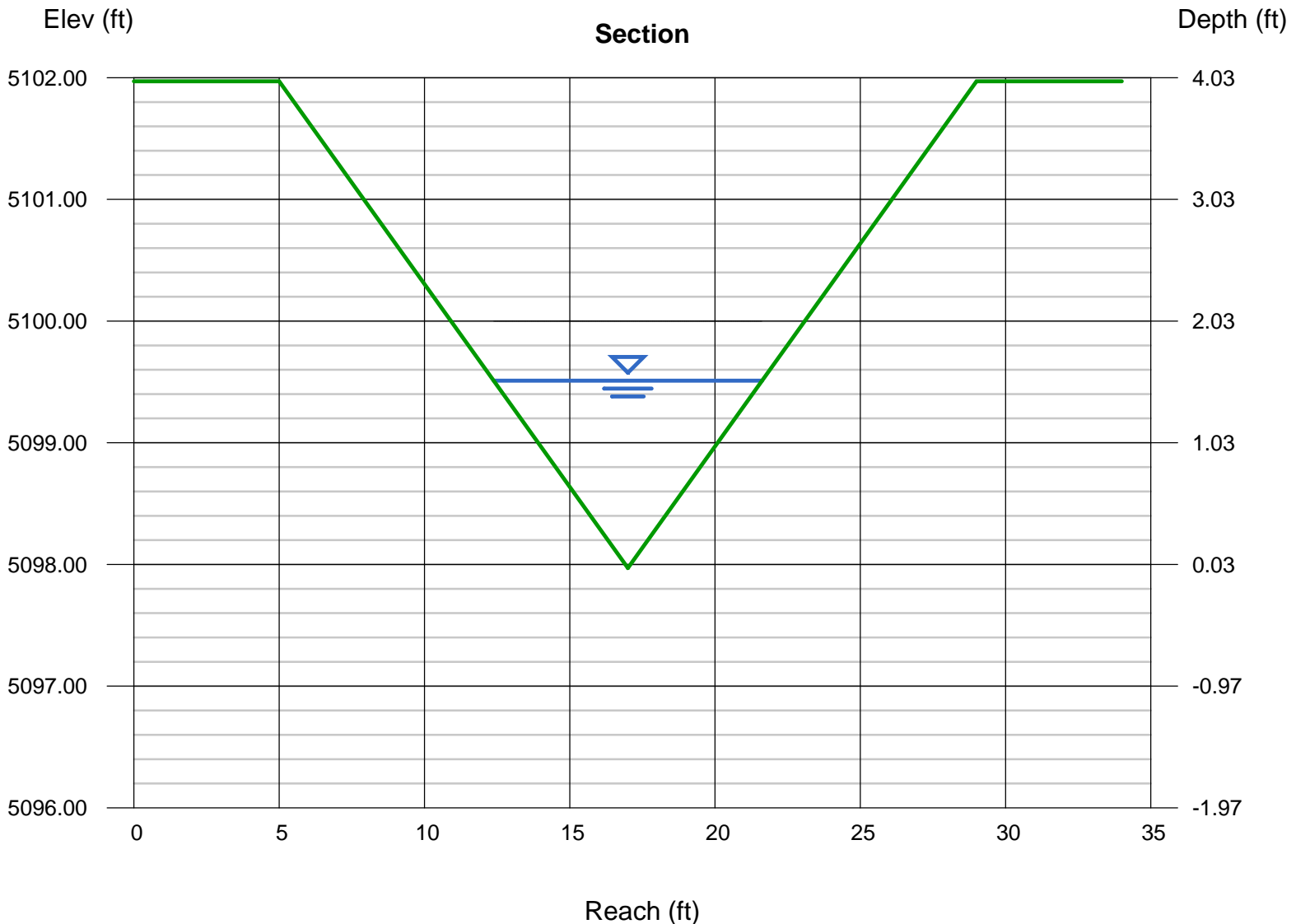
Wetted Perim (ft) = 9.74

Crit Depth, Yc (ft) = 1.62

Top Width (ft) = 9.24

EGL (ft) = 2.03

Fr = 0.96



# Channel Report

## Channel to DP 6

### Triangular

Side Slopes (z:1) = 3.00, 3.00  
Total Depth (ft) = 2.30

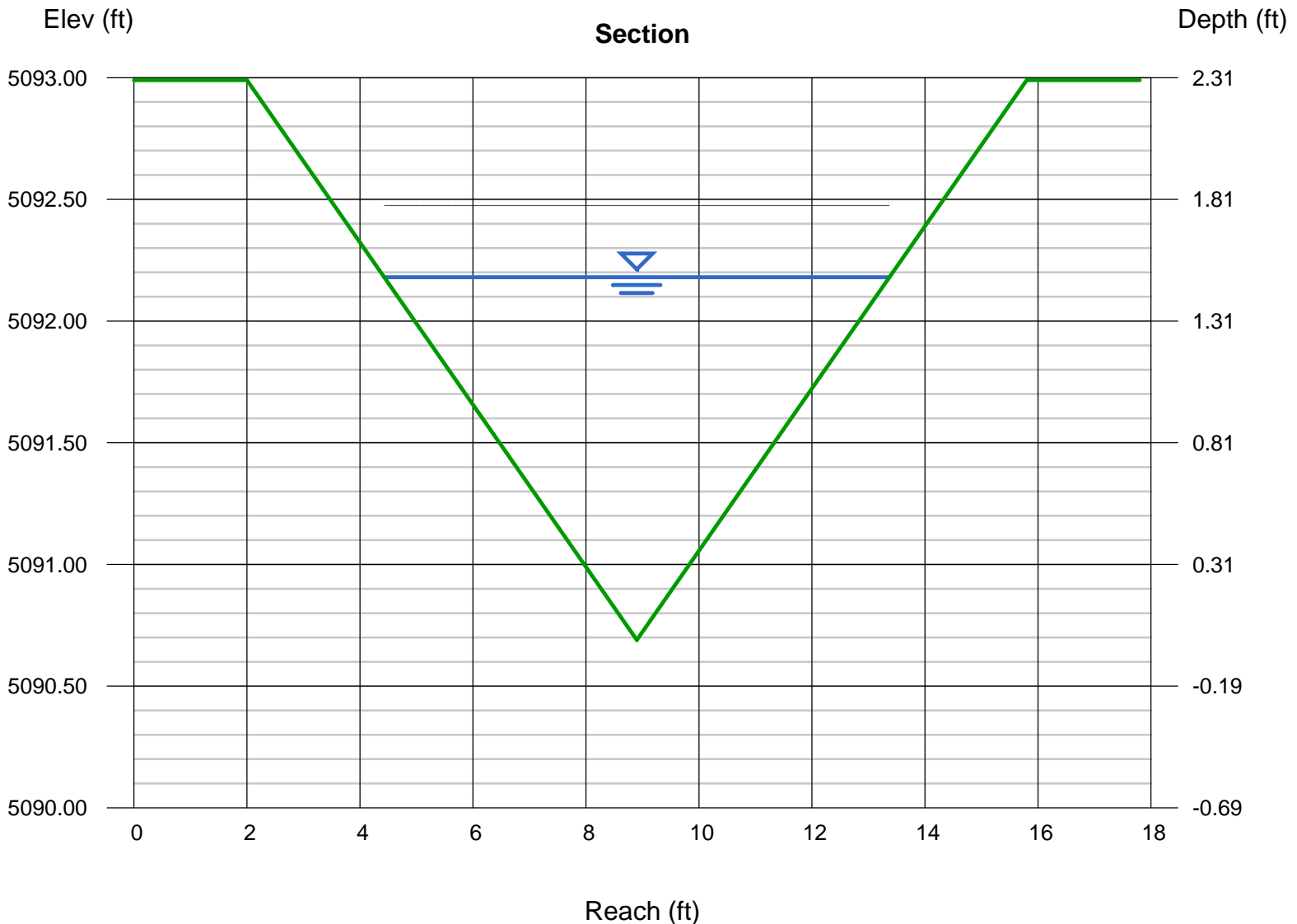
Invert Elev (ft) = 5090.69  
Slope (%) = 1.00  
N-Value = 0.027

### Calculations

Compute by: Known Q  
Known Q (cfs) = 29.00

### Highlighted

Depth (ft) = 1.49  
Q (cfs) = 29.00  
Area (sqft) = 6.66  
Velocity (ft/s) = 4.35  
Wetted Perim (ft) = 9.42  
Crit Depth, Yc (ft) = 1.43  
Top Width (ft) = 8.94  
EGL (ft) = 1.78  
Fr = 0.75



# Channel Report

## Channel outlet from DP 6

### Triangular

Side Slopes (z:1) = 3.00, 3.00

Total Depth (ft) = 2.30

Invert Elev (ft) = 5090.69

Slope (%) = 1.83

N-Value = 0.027

### Calculations

Compute by: Known Q

Known Q (cfs) = 29.00

### Highlighted

Depth (ft) = 1.33

Q (cfs) = 29.00

Area (sqft) = 5.31

Velocity (ft/s) = 5.46

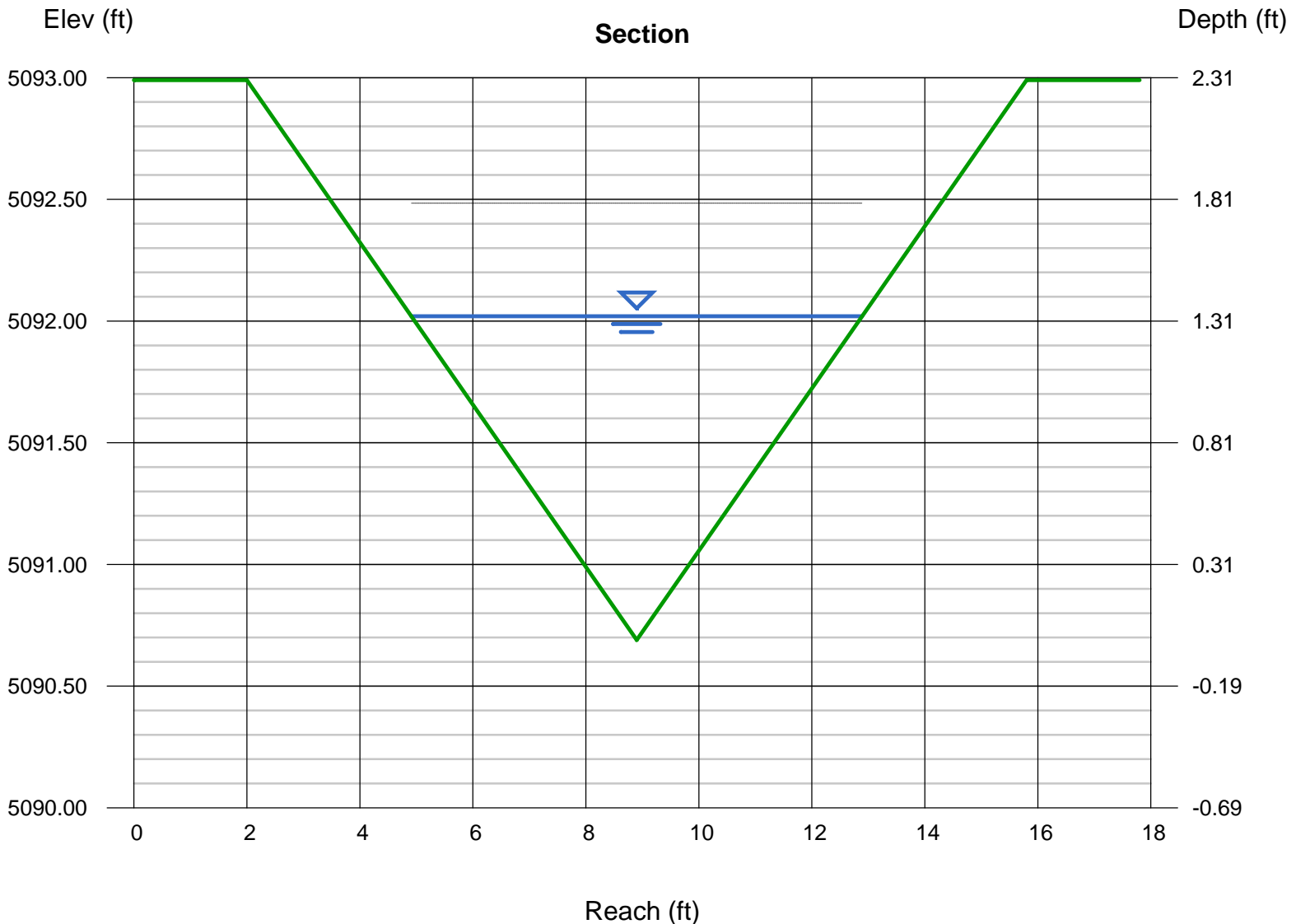
Wetted Perim (ft) = 8.41

Crit Depth,  $Y_c$  (ft) = 1.43

Top Width (ft) = 7.98

EGL (ft) = 1.79

Fr = 0.94



# Channel Report

## Channel to DP 7

### Triangular

Side Slopes (z:1) = 3.00, 3.00  
Total Depth (ft) = 4.00

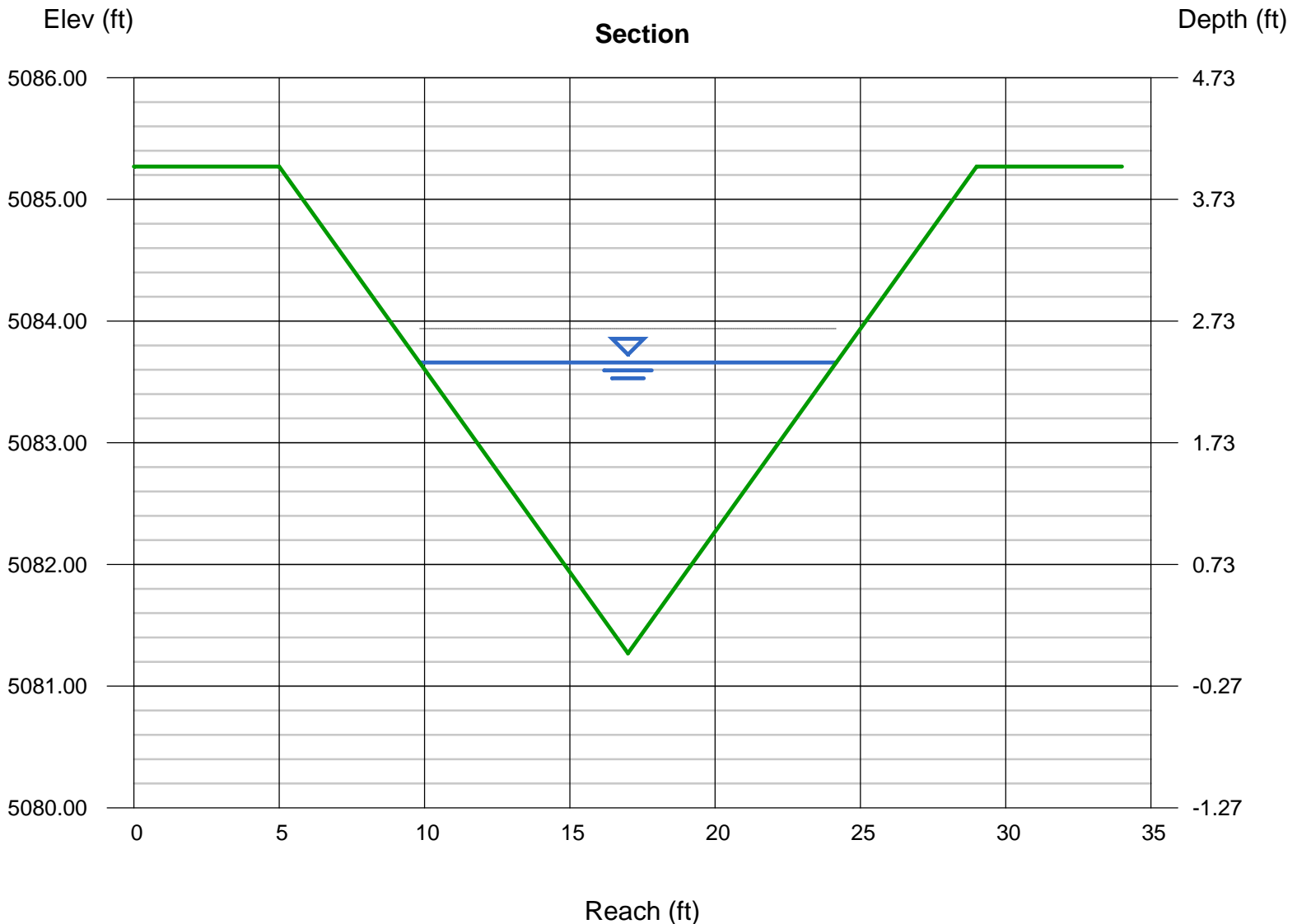
Invert Elev (ft) = 5081.27  
Slope (%) = 0.50  
N-Value = 0.027

### Calculations

Compute by: Known Q  
Known Q (cfs) = 72.50

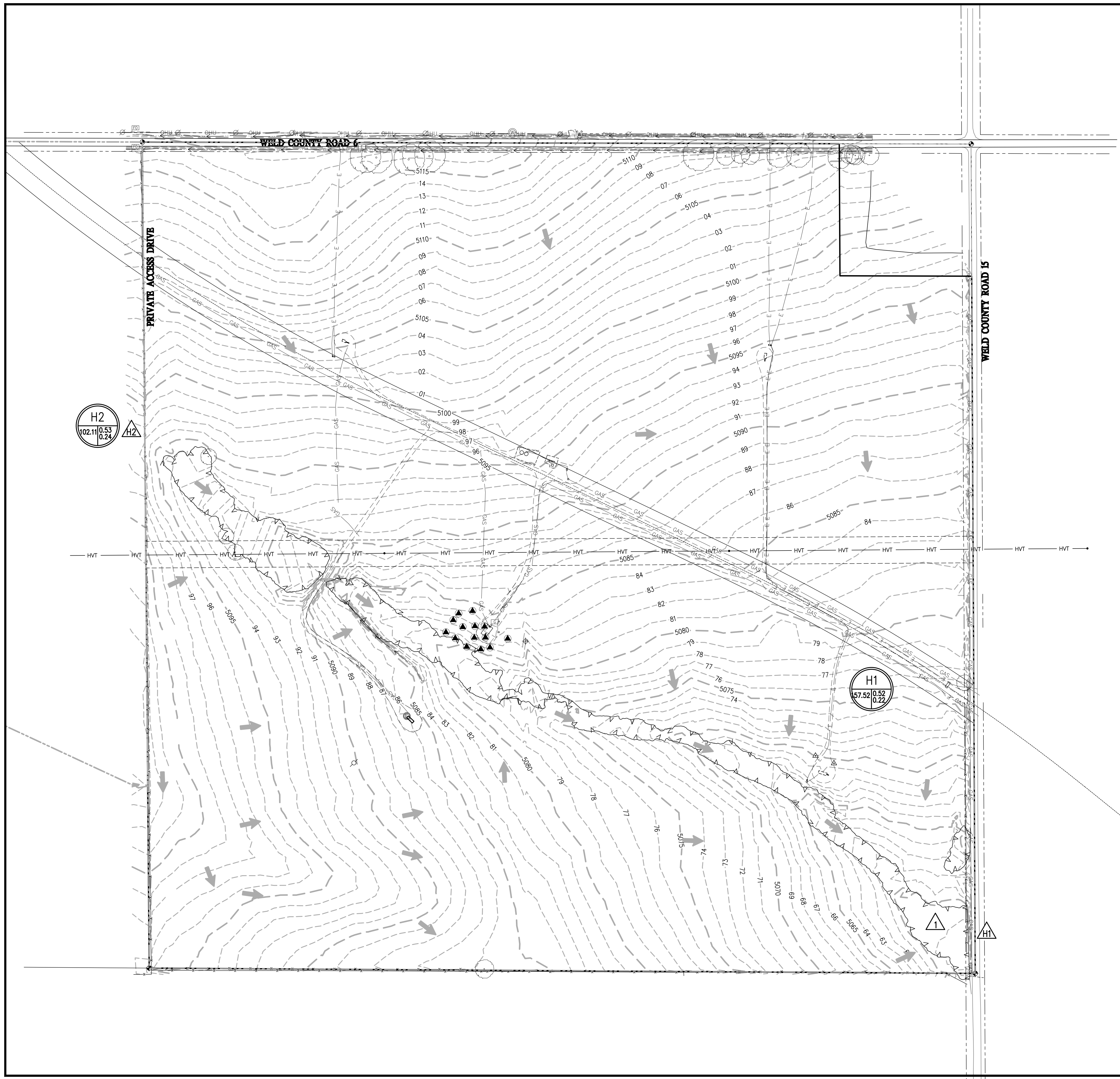
### Highlighted

Depth (ft) = 2.39  
Q (cfs) = 72.50  
Area (sqft) = 17.14  
Velocity (ft/s) = 4.23  
Wetted Perim (ft) = 15.12  
Crit Depth, Yc (ft) = 2.06  
Top Width (ft) = 14.34  
EGL (ft) = 2.67  
Fr = 0.73

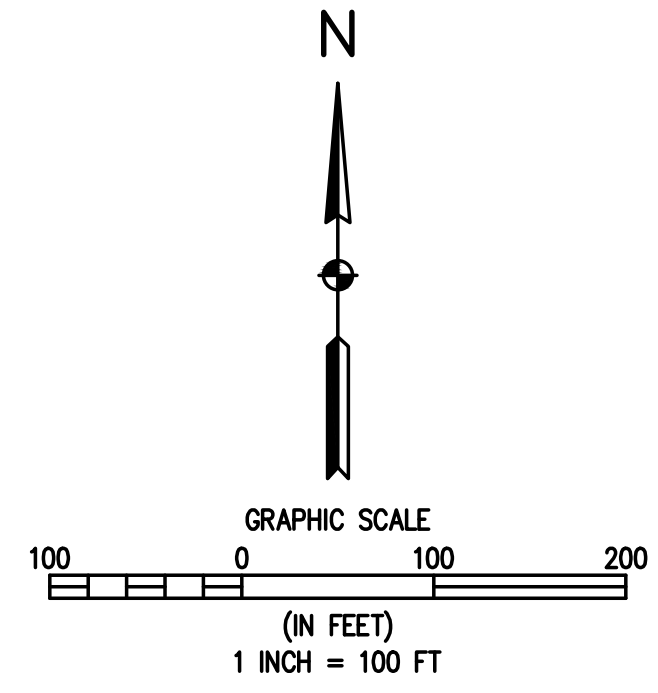


## **G. Proposed Drainage Plan**

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- DRAINAGE PLAN LEGEND**
- DEVELOPED DRAINAGE BASIN BOUNDARY
  - HISTORIC DRAINAGE BASIN BOUNDARY
  - 81 ----- EXISTING MINOR CONTOUR
  - 5280 ----- EXISTING MAJOR CONTOUR
  - 81 ----- PROPOSED MINOR CONTOUR
  - 5280 ----- PROPOSED MAJOR CONTOUR
  - FLOODPLAIN
  - 100-YR WATER SURFACE ELEVATION
  - FLOW DIRECTION, TYPICALLY ON PAVED SURFACES
  - FLOW DIRECTION, TYPICALLY IN GRASSED SWALE
  - FLOW DIRECTION, TYPICALLY IN FLOWLINE
  - ▲ HIGH OR LOW POINT IN PAVING
  - △ DESIGN POINT DESIGNATION
- A = BASIN DESIGNATION  
 B = BASIN AREA (ac)  
 C = 100-YR C-FACTOR  
 D = 10-YR C-FACTOR



**HISTORIC DRAINAGE SUMMARY**

BASIN ID	TOTAL AREA (ACRES)	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	% IMPERVIOUSNESS	T <sub>c</sub> (MINUTES)	Q <sub>1</sub> (CFS)	Q <sub>2</sub> (CFS)	Q <sub>3</sub> (CFS)
H1	157.52	0.08	0.22	0.52	3%	136.9	8.95	31.44	123.86
H2	102.11	0.10	0.24	0.53	6%	82.1	11.17	32.29	118.85

**BASELINE**  
 Engineering - Planning - Surveying  
 1950 FORD STREET • GOLDEN, COLORADO 80401  
 P. 303.940.9966 • F. 303.940.9969 • www.baselinecorp.com

DESIGNED BY: JDD  
 DRAWN BY: JDD  
 CHECKED BY: NJN

DATE: \_\_\_\_\_  
 PREPARED BY: \_\_\_\_\_

REVISION DESCRIPTION: \_\_\_\_\_

**ELEVATION MIDSTREAM, LLC.**  
 BADGER CENTRAL GATHERING FACILITY  
 NE QUARTER SEC. 30, T1N, R67W  
 HISTORIC DRAINAGE PLAN

WELD

PREPARED UNDER THE DIRECT SUPERVISION OF \_\_\_\_\_

**PRELIMINARY NOT FOR CONSTRUCTION**

FOR AND ON BEHALF OF BASELINE CORPORATION

INITIAL SUBMITTAL: XX/XX/XX  
 DRAWING SIZE: 24" X 36"  
 SURVEY FIRM: SURVEY FIRM  
 SURVEY DATE: XX/XX/XX  
 JOB NO.: C00000  
 DRAWING NAME: EXTING7W30-01 CGF GRADING.dwg  
 SHEET 10 OF 12

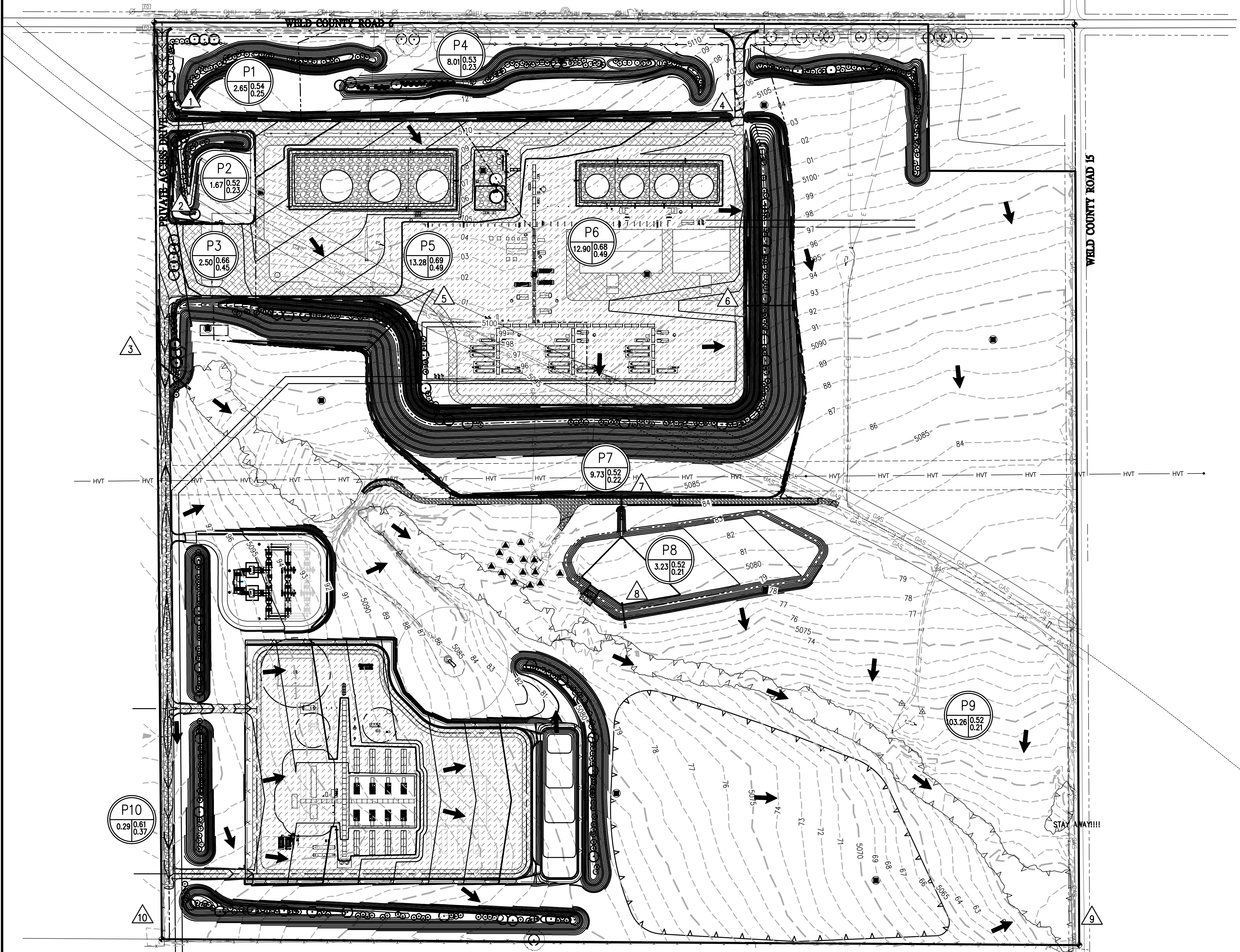
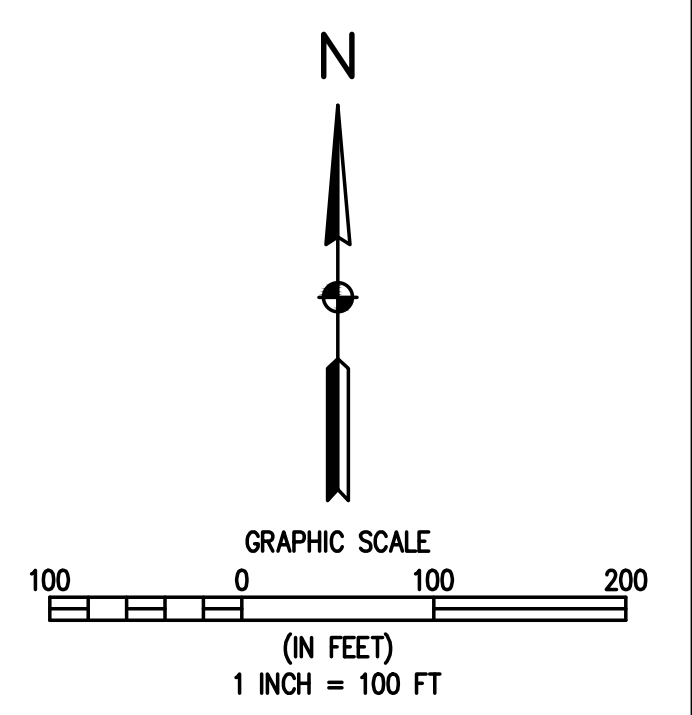
C10

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**DRAINAGE PLAN LEGEND**

- DEVELOPED DRAINAGE BASIN BOUNDARY
- - - HISTORIC DRAINAGE BASIN BOUNDARY
- 81 EXISTING MINOR CONTOUR
- 5280 EXISTING MAJOR CONTOUR
- 81 PROPOSED MINOR CONTOUR
- 5280 PROPOSED MAJOR CONTOUR
- FLOODPLAIN
- 100-YR WATER SURFACE ELEVATION
- FLOW DIRECTION, TYPICALLY ON PAVED SURFACES
- FLOW DIRECTION, TYPICALLY IN GRASSED SWALE
- FLOW DIRECTION, TYPICALLY IN FLOWLINE
- △ HIGH OR LOW POINT IN PAVING
- △ DESIGN POINT DESIGNATION

A = BASIN DESIGNATION  
 B = BASIN AREA (ac)  
 C = 100-YR C-FACTOR  
 D = 10-YR C-FACTOR



**DEVELOPED DRAINAGE SUMMARY**

BASIN ID	TOTAL AREA (ACRES)	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	% IMPERVIOUSNESS	T <sub>c</sub> (MINUTES)	Q <sub>1</sub> (CFS)	Q <sub>2</sub> (CFS)	Q <sub>3</sub> (CFS)
P1	2.65	0.11	0.25	0.54	6%	30.0	0.60	1.66	5.99
P2	1.67	0.08	0.23	0.52	4%	22.7	0.34	1.12	4.31
P3	2.50	0.35	0.45	0.66	34%	43.8	1.44	2.25	5.50
P4	8.01	0.09	0.23	0.53	5%	44.1	1.22	3.73	14.05
P5	13.28	0.40	0.49	0.69	40%	28.0	11.53	17.22	39.88
P6	12.90	0.39	0.49	0.68	39%	44.6	8.25	12.40	28.97
P7	9.73	0.08	0.22	0.52	3%	18.8	2.05	7.05	27.59
P8	3.23	0.07	0.21	0.52	2%	38.9	0.40	1.50	6.00
P9	103.26	0.07	0.22	0.52	2%	78.2	8.34	30.34	120.81
P10	0.29	0.25	0.37	0.61	23%	9.2	0.27	0.48	1.33

DESIGNED BY	DATE
JDD	

DRAWN BY	DATE
JDD	

CHECKED BY	DATE
NJN	

**ELEVATION MIDSTREAM, LLC.**  
 BADGER CENTRAL GATHERING FACILITY  
 NE QUARTER SEC. 30, T1N, R67W  
 DEVELOPED DRAINAGE PLAN

PREPARED UNDER THE DIRECT SUPERVISION OF  
**PRELIMINARY NOT FOR CONSTRUCTION**

FOR AND ON BEHALF OF	BASELINE CORPORATION
INITIAL SUBMITTAL	XX/XX/XX
DRAWING SIZE	24" X 36"
SURVEY FIRM	SURVEY DATE
SURVEY FIRM	XX/XX/XX
JOB NO.	COXXXX
DRAWING NAME	EXTING7\30-01 CGF GRADING.dwg
SHEET	11 OF 12

**H. UDFCD Depth Duration  
Frequency Charts**

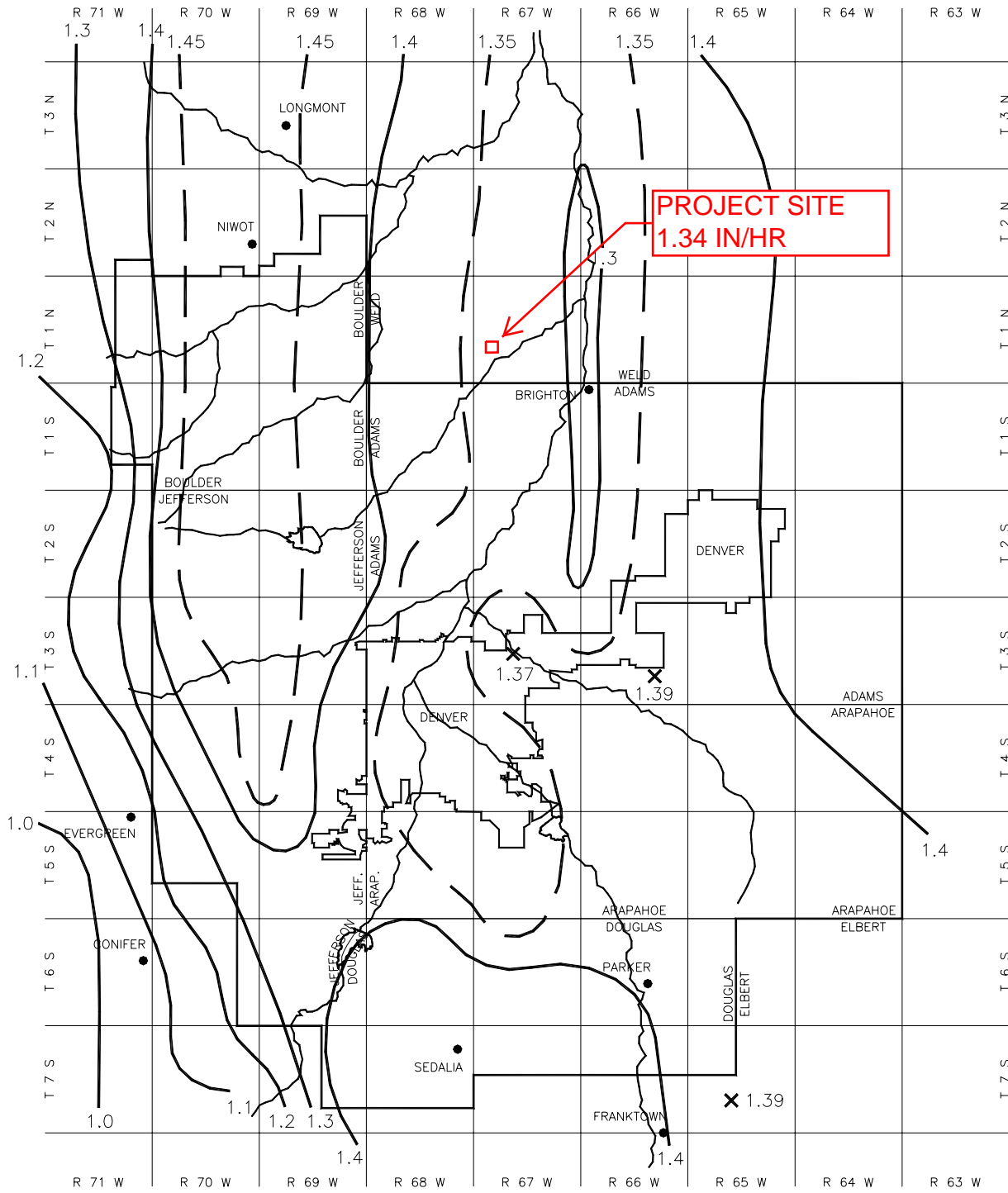


Figure RA-2—Rainfall Depth-Duration-Frequency: 5-Year, 1-Hour Rainfall

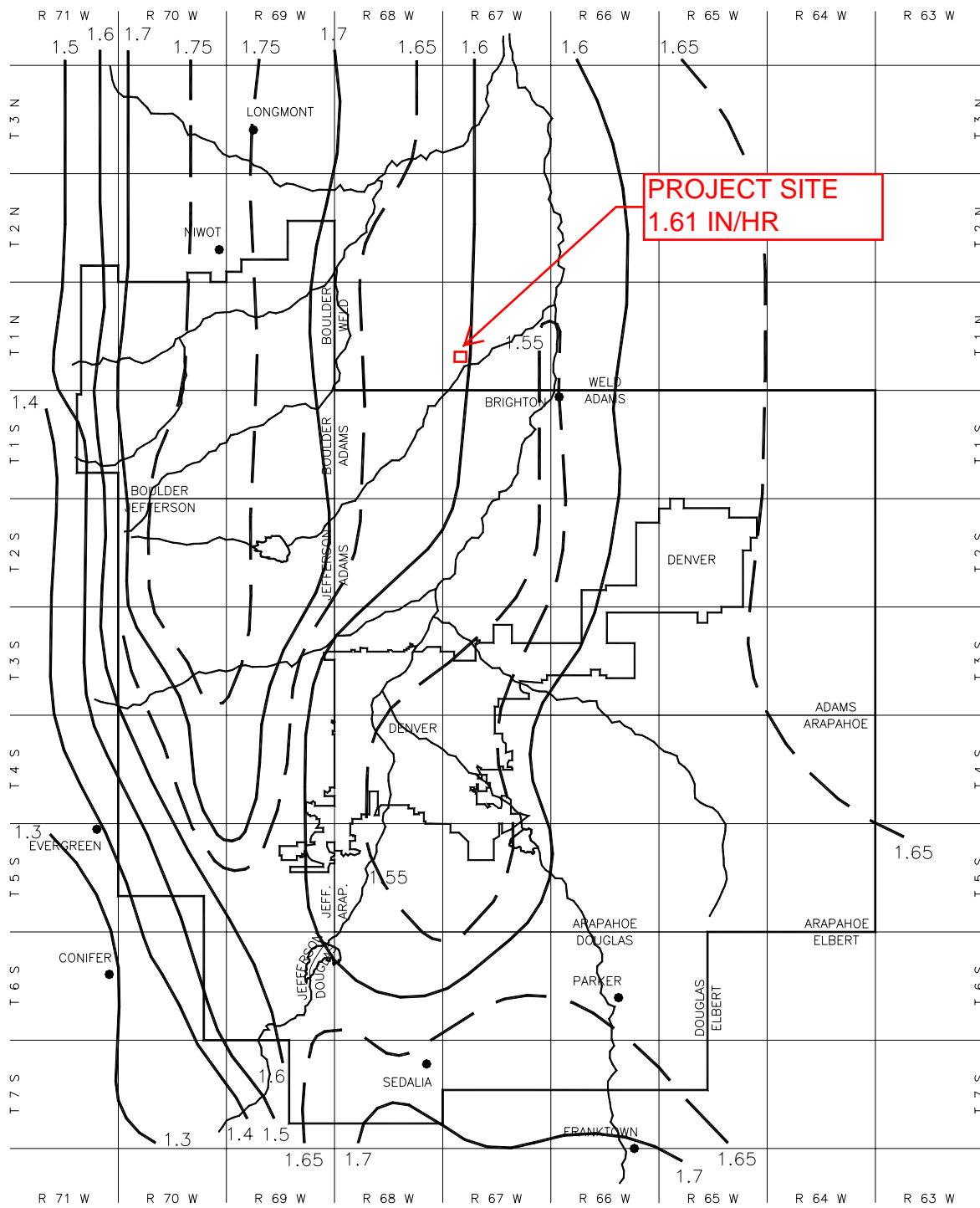


Figure RA-3—Rainfall Depth-Duration-Frequency: 10-Year, 1-Hour Rainfall

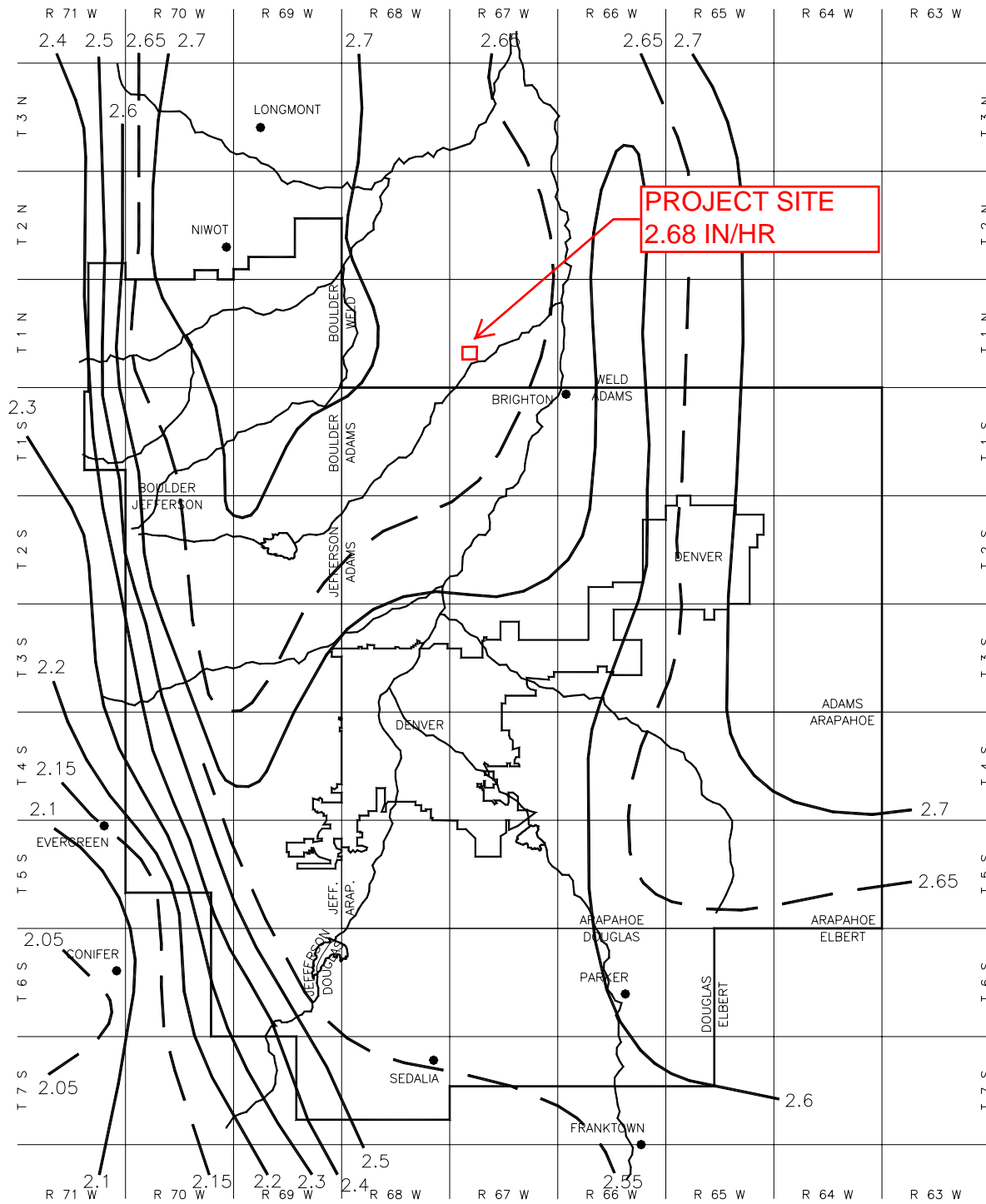


Figure RA-6—Rainfall Depth-Duration-Frequency: 100-Year, 1-Hour Rainfall