Final Drainage Report
for
Johnson Trust 13-I Facility

Prepared For:

Extraction Oil & Gas

370 17th St. Suite #5300

Denver, CO 80202

Prepared By:

Petroleum Field Services

7535 Hilltop Circle

Denver, CO 80221

October 28, 2015

October 28, 2015

Mr. Adam Smith
Engineering & Utilities
Town of Frederick
401 Locust Street
Frederick, Colorado 80530

Re: Johnson Trust 13-I Facility

Dear Mr. Smith,

Petroleum Field Services (PFS) has completed a final drainage report for the Johnson Trust 13-I Facility located 85 feet east of Weld County Road 11 and 1,750 feet north of Weld County Road 20.

This report is prepared in accordance to the *Urban Storm Drainage Criteria Manuals* (USDCM), as well as the South Weld I-25 Corridor Master Drainage Plan. The proposed site collects 10 and 100-year developed flows and releases at the historic 10 and 100-year rate. In addition, the outlet structure incorporates water quality measures in accordance with the USDCM. Therefore, the construction of the proposed Johnson Trust 13-I Facility development is in compliance with both the Town of Frederick and UDFCD stormwater criteria.

We look forward to your consideration and feedback of this Final Drainage Report. If you have any further questions or comments, please contact our office at 303-928-7128 or by email at mwelker@petro-fs.com.

Sincerely,

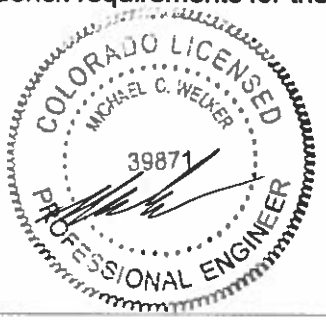
Petroleum Field Services, LLC.

Michael C. Welker, PE, CFM

Project Engineer

Certification of Engineering

I hereby certify that this report for the final drainage design of Johnson Trust 13-I Facility was prepared by me (or under my direct supervision) in accordance with the provisions of the Urban Drainage and Flood Control District Storm Drainage Criteria and supplemental Town of Frederick requirements for the owners thereof.



Michael C. Welker,

Registered Professional Engineer

State of Colorado No. 39871

Contents

FOLDER POCKET

1. General Location and Description

1.1. Location

The Johnson Trust 13-I Facility is located in the Northwest ¼ of the Southwest ¼ of Section 13, Township 2 North, Range 68 West of the 6th Principal Meridian, Town of Frederick, County of Weld, State of Colorado. It is physically located 85 feet east of Weld County Road 11 and 1,750 feet north of Weld County Road 20 (see Vicinity Map in Appendix A for exact location). A drainage ditch is located just east of the site, and a roadside ditch is just west. The site is surrounded by dry crop land.

1.2. Description of the Property

The proposed site is approximately 6.0 acres in area and consists of a well pad that will be partially reclaimed. The remaining pad with an area of 3.8 acres will be repurposed to operate and maintain oil production facilities. The facilities will consist of three water tanks, 18 oil tanks, nine separators, four vapor recovery units, two vapor recovery towers, and eight emission combustion devices. There will be a topsoil stockpile located along the south edge of the pad, a portion of this will be used for reclamation, and the footprint will remain unchanged following reclamation.

Drainage facilities, including a detention pond, an emergency spillway, and outlet structures are proposed to the southwest of the proposed production facility pad. Swales are also proposed along the east, north and south edges of the pad which, along with the proposed landscaping berm, will redirect offsite stormwater around the site. An additional swale will be located along the western edge of the pad to convey onsite stormwater to the proposed detention pond.

As determined by the USDA Web Soil Survey, the historical soils on within the proposed basin are Nelson fine sandy loam and Olney fine sandy loam. The hydrologic soil property is a 100% hydrologic type B. Offsite basin 1 contains Vona Sandy Loam (hydrological type A) in addition to the previously mentioned soil types (see Hydrologic Soils Map in Appendix A). The historical site generally slopes from the east to the west with slopes ranging from 0 to 9%. The percent imperviousness for the historical site is 2%. Upon completion of development, the proposed site will be a combination of native planted areas and compacted gravel. The composite percent imperviousness will be 36.00% (please see calculations in Appendix B for details).

2. Drainage Basins and Sub-Basins

2.1. Major Basin Description

The project is located inside the Godding Hollow Basin defined in the South Weld I-25 Corridor (see Basin Map in Appendix A), thus the proposed drainage plan is designed in accordance to the South Weld I-25 Corridor Master Drainage Plan. The Weld County Road 11 ditch lies just west of the proposed site. Onsite stormwater will be detained within the pond and released at a

historical 10 and 100 year rate into the roadside ditch. As indicated by the Weld County FEMA Map Index, the proposed site is within Panel Number 080244-1890E, panel 1890 of 2250, which accompanies preliminary flood insurance study number 08123CV000A, issued May 31, 2013 (please see FEMA Firmette in Appendix A). The Johnson Trust 13-I site is shown to not be located within Zone A floodplain, and therefore FEMA considers it as an area of minimal flooding.

2.2. Sub-Basin Description

Stormwater historically drains from the east to the west of the site.

Offsite stormwater, which flows from the east, is redirected around the site via a combination of berms and swales. Onsite runoff drains to the proposed detention pond and then outlets to the existing Weld County Road 11 ditch.

The proposed swales at the east and west form the boundary of a single drainage basin of the proposed site. Onsite stormwater follows the recommendation from the Town of Frederick and flows to the proposed detention pond via proposed swales and drains to the southwest corner by an outlet pipe.

2.3. Summary Table

Refer to Appendix B for the summary tables.

3. Drainage Design Criteria

3.1. Development Criteria Reference and Constraints

The South Weld I-25 Corridor Master Drainage Plan was used to analyze the existing drainage pattern due to the proposed site being located within the Godding Hollow drainage basin.

In its existing condition, stormwater from the site flows undetained to the existing Weld County Road 11 drainage ditch. After construction of the proposed site, developed stormwater will be routed through the detention pond and travel via an outlet pipe west to the Weld County Road 11 ditch at the historical rate.

3.2. Hydrological Criteria

This proposed drainage plan follows the *Town of Frederick Design Standards and Specifications and Urban Storm Drainage Criteria Manuals (USDCM)(Volumes 1-3).* The minor and major design storm frequency for the design of the detention pond is 10 years and 100 years. As indicated in the NOAA Atlas in Appendix A, the associated one hour point rainfalls are 1.39 inches and 2.72 inches respectively.

As the on-site basin is less than 160 acres (6.0 acres), the rational method was used to compute the runoff. The weighted percent imperviousness and runoff coefficient were calculated for Basin 1 for the proposed development using USDCM RO-3 and RO-4, and Equations RO-6

and RO-7. The time of concentration was calculated using USDCM Table RO-2 and Equation RO-2, RO-3, RO-4, and RO-5.

The detention pond is sized by the difference between 100-year fully developed runoff rate and the allowable 100-year release rate per UDFCD table SO-1. The storage volume of the detention pond was computed by the Modified FAA Method using UDFCD UD-Detention_v2.34 Spreadsheet.

Please see Hydrological Computations in Appendix B for details.

3.3. Hydraulic Criteria

The hydraulic structure proposed on-site includes one detention pond, outlet structures, an emergency spillway, and swales.

The outlet structures of the detention pond were computed using the UDFCD UD-Detention_v2.34 Spreadsheet. These hydraulic calculations include Stage Storage Sizing for Detention Basins, Stage-Discharge Sizing of the Water Quality Capture Volume (WQCV) Outlet, Restrictor Plate Sizing for Circular Vertical Orifices, Stage-Discharge Sizing of the Weirs and Orifices, Stage-Discharge Sizing of the Outlet Culvert, and Stage-Discharge Sizing of the Spillway. Water quality capture volume was determined with a 40-hour drain time. The Water Quality trash screen size and trash rack over the outlet were calculated per USDCM V3 Chapter 4 Outlet Structure**.** Please see Hydraulic Computations in Appendix C for details.

4. Drainage Facility Design

4.1. General Concept

As mentioned in section 3.1 Development Criteria Reference and Constraints, the existing condition has runoff from the site flowing to the southwest and undetained across the field to the existing Weld County Road 11 Ditch.

Runoff will to be collected into a detention pond, released at a 10 and 100-year historical rate to the southwest corner of the site, then conveyed via existing ditch and follow the existing flow line to the historical low point 15 feet south of the outlet pipe, at the intersection of Weld County Road 11 and an existing culvert, which flows via existing ditch to the Godding Hollow drainage channel.

An outlet structure and emergency spillway will be constructed at the west end of the detention pond to convey flows offsite.

Water quality will be incorporated in the outlet structure and a micropool is proposed to control sedimentation.

4.2. Specific Details

The depth of the proposed detention pond is 3.4 ft. (including 1.0 ft of freeboard) with the 100 year water surface elevation at 4914.0 ft and the invert of the outlet pipe at 4911.35 ft. The proposed detention pond has a calculated storage volume of 0.384 acre-ft. The proposed detention pond is graded with a 4:1 interior side slope and provides 1 foot of freeboard above the developed 100-year water surface elevation. The associated outlet structure includes a water quality plate, a restrictor plate, and one 15-inch outlet pipe. The diameter of the holes in the water quality plate is 0.625 inches.

An emergency spillway, which is designed to provide failure protection for the embankment in the event the outlet is clogged, is designed with 4:1 side slopes and a length of 40 feet at the 100 year water surface elevation of 4914.0 ft.

The owner is responsible for maintaining the operation and access of the drainage facilities. The proposed detention pond can be accessed from WCR 11, and on-site access roads. The disturbed area of the detention pond will be re-seeded. Any vegetation should be trimmed. Any debris or trash from the trash grates attached to the outlet structure should be cleaned. Any sediment from the micropool box should be cleaned out regularly. Any blockage in the culverts, ditches, or outlet pipes should be removed to keep the drainage facilities at full capacity.

In its existing condition, stormwater from the site flows undetained to the existing WCR 11 ditch. The water flows across the pad in a southwestern direction towards this ditch. As mentioned in section 1.2 of the Drainage Report, the proposed site is developed in two construction phases. Phase 1 includes the construction of the well pad and the installation of a modular large volume tank (MLVT). Failure of the MLVT tank would result in a flow with a hydraulic depth of 0.63 ft. Therefore, the location of the 10 ft. tall topsoil stockpile to the south of the pad, the 3:1 cut slope on the east and southeast edge of the pad, and the east to west slope of the site will be sufficient in protecting the residential development, and flow at an acceptable volume southwest into the Godding Hollow drainage basin. The flow of the tank in the event of a failure was calculated to be 392 cfs. For reference, the South Weld I-25 Corridor Master Drainage Plan, section 4.13, table 4.4, lists the 100-yr peak discharge for the Godding Hollow Basin in the area in the vicinity of our site (i.e. between WCR 22 and WCR 20) as 4,583 cfs. Phase 2 construction includes the partially reclaimed well pad and repurposing the remaining pad to an oil production facility. After construction of the proposed site, developed stormwater will be routed through the detention pond and travel via swale west to the borrow ditch of Weld County Road 11.

The existing Weld County Road 11 borrow ditch has been rerouted to accommodate an 18 inch equivalent reinforced concrete culvert (see detail sheet DP1) in order to keep the permanent access road at a maximum 10% grade for emergency vehicles. The reroute of the ditch has been proposed to maintain the existing average cross section and hydraulic grade line, with a maximum slope of 2%.

4.3. Summary Tables

Refer to Appendix B and C for the summary tables.

5. Conclusion

The hydrologic and hydraulic calculations associated with the proposed drainage plan follow the *Urban Storm Drainage Criteria Manuals* (USDCM). These calculations show that the detention pond will detain the difference of developed 100-year flow and the 10 and 100-year historic release rate. The outlet structure will be able to control water quality, detain the 10 and 100-year stormwater, and release stormwater runoff at the 10 and 100-year historic rate. The emergency spillway will be able to release storm runoff at the 100-year developed flow rate. Thus, the Town of Frederick's stormwater requirements have been met and stormwater impacts due to proposed development have been mitigated.

6. References

1. Town of Frederick Design Standards and Construction Specifications; Town of Frederick, Weld County; Colorado

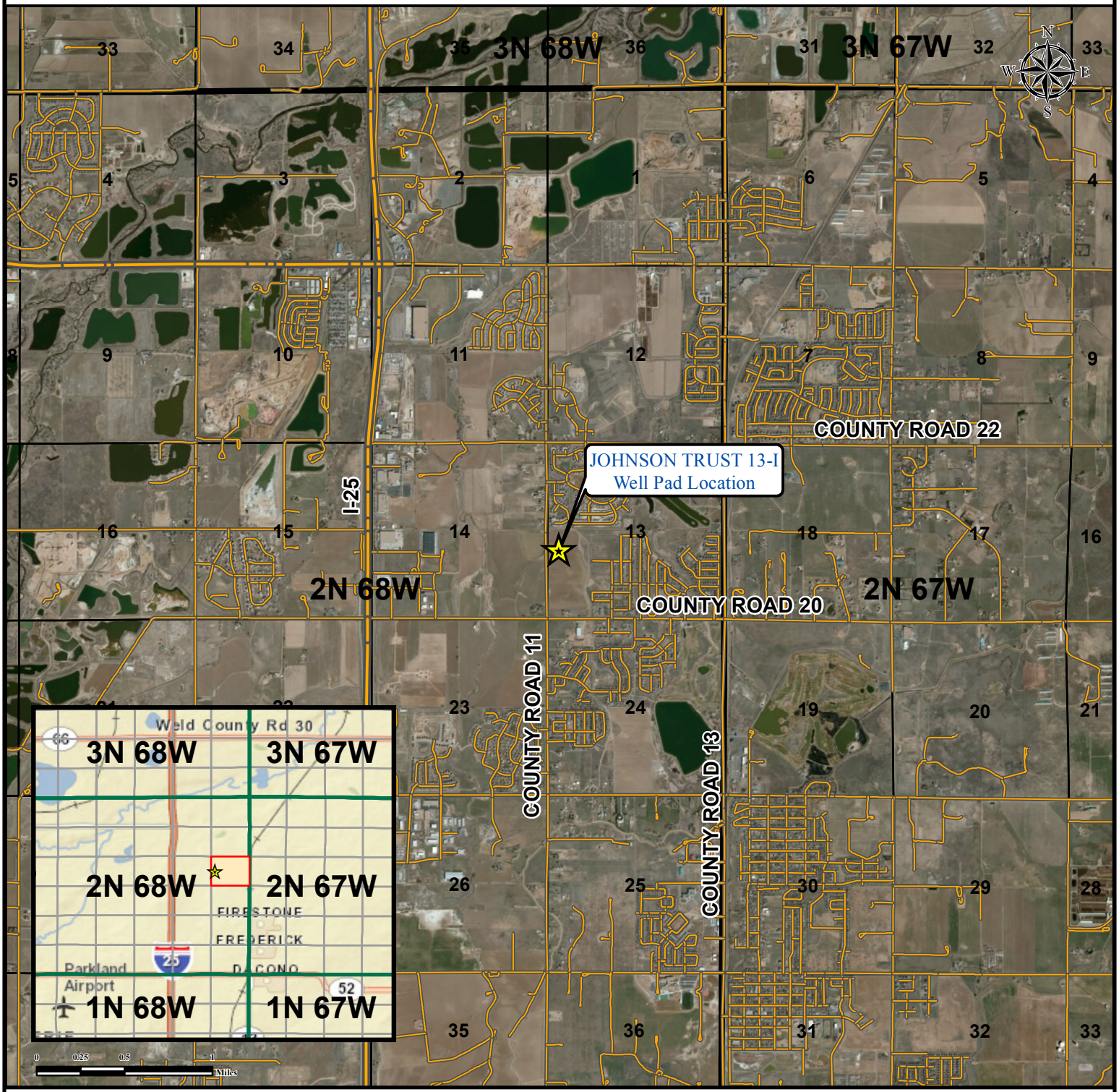
2. Urban Storm Drainage Criteria Manual Vol. 1, 2 and 3; Urban Drainage and Flood Control District; Latest Revision

3. Hydrologic Group Rating for Town of Frederick, Weld County, Colorado, Northern Part ; USDA-Natural Resources Conservation Services; National Cooperative Soil Survey

4. FEMA FIRM Flood Insurance Rate Map, Map Number 080266-0864C; Federal Emergency Management Agency: September 28, 1982

5. South Weld I-25 Corridor Master Drainage Plan; Anderson Consulting Engineers, Inc.: February 17, 2000

JOHNSON TRUST 13-I PAD
VICINITY MAP



Legend

- JOHNSON TRUST 13-I Well Pad Location
- Roads

PFS Petroleum Field Services	FIELD DATE: 07-12-14	SITE NAME: JOHNSON TRUST 13-I PAD
	DRAWING DATE: 03-23-15	SURFACE LOCATION: NW1/4 SW1/4, SEC. 13, T2N, R68W, 6TH P.M. WELD COUNTY, COLORADO
	BY: CSG / CHECKED BY: FMB	PREPARED FOR: EXTRACTION Oil & Gas

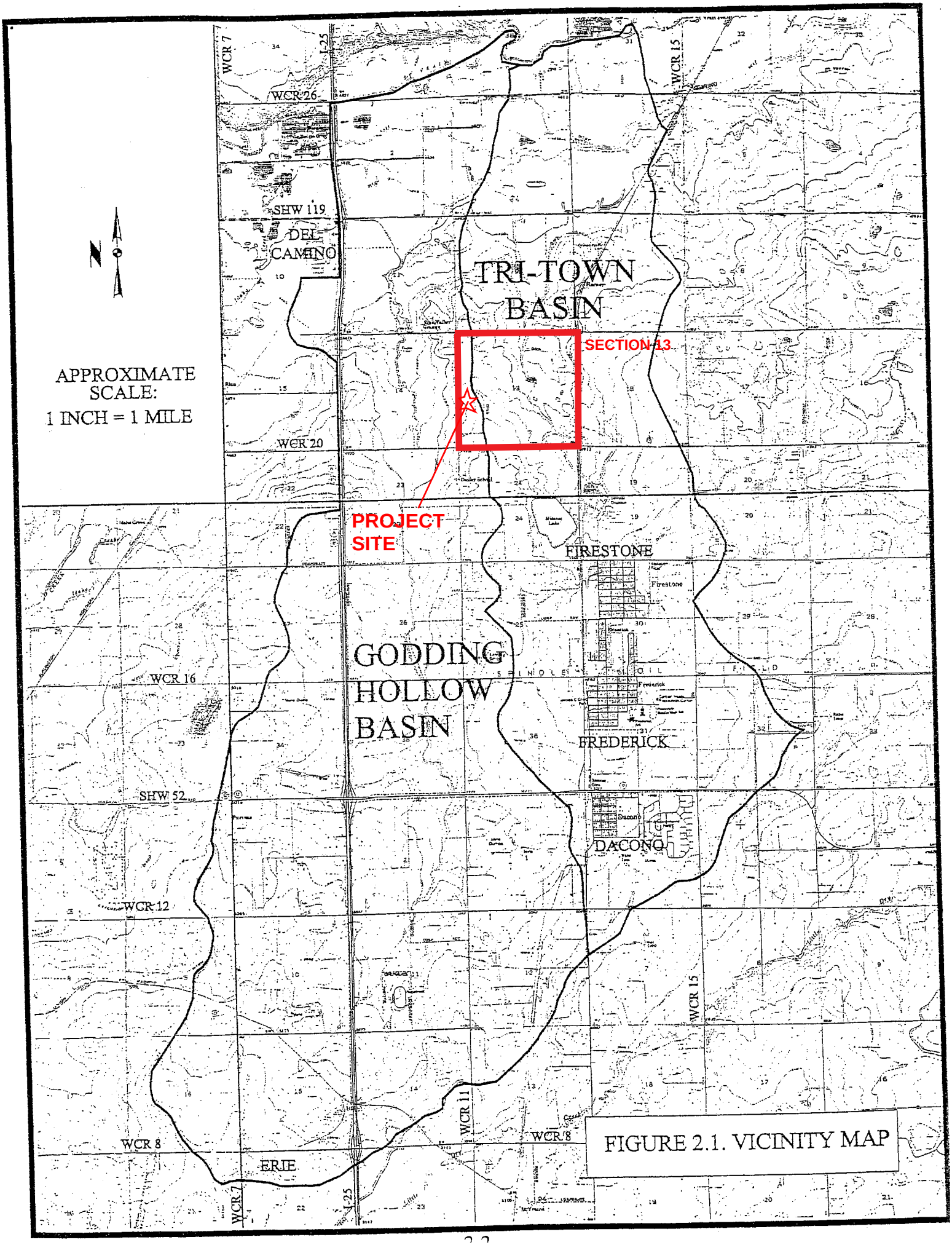


FIGURE 2.1. VICINITY MAP

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was derived from NAIP Orthophotography produced with a one meter ground resolution from photography dated 2011.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables for multiple streams in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

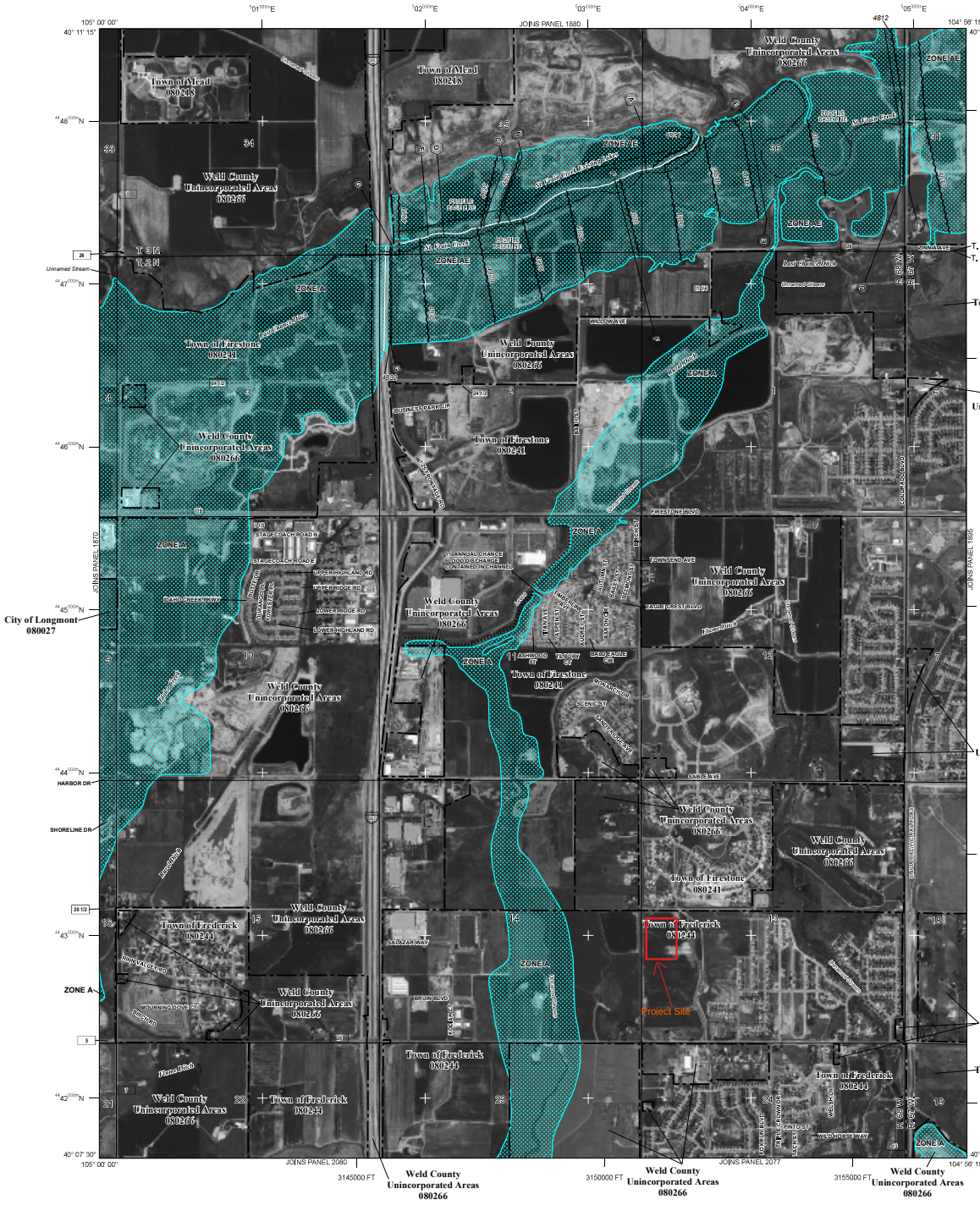
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

NOTICE TO MAP USERS

FEMA maintains information about map features, such as street locations and names, in or near designated flood hazard areas. Requests to revise information in or near designated flood hazard areas may be provided to FEMA during the community review period, at the final Consultation Coordination Officer's meeting, or during the statutory 90-day appeal period. Approved requests for changes will be shown on the final printed FIRM.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% Annual Chance Floodplain Boundary

0.2% Annual Chance Floodplain Boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.

513 (EL 987) — Base Flood Elevation line and value; elevation in feet*

Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A — Cross section line

23 — 23 — Transect line

45° 02' 08", 93° 02' 12" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere

3100000 FT — 5000-foot ticks: Colorado State Plane North Zone (FIPS Zone 0501), Lambert Conformal Conic projection

4489000mN — 1000-meter Universal Transverse Mercator grid values, zone 13

DX5510 × — Bench mark (see explanation in Notes to Users section of this FIRM panel)

M1.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in 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 1-800-638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

300 0 300 600 METERS

NFIP

PANEL 1890E

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

WELD COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 1890 OF 2250

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
FIRESTONE, TOWN OF	080241	1890	E
FREDERICK, TOWN OF	080244	1890	E
MEAD, TOWN OF	080218	1890	E
WELD COUNTY	080266	1890	E

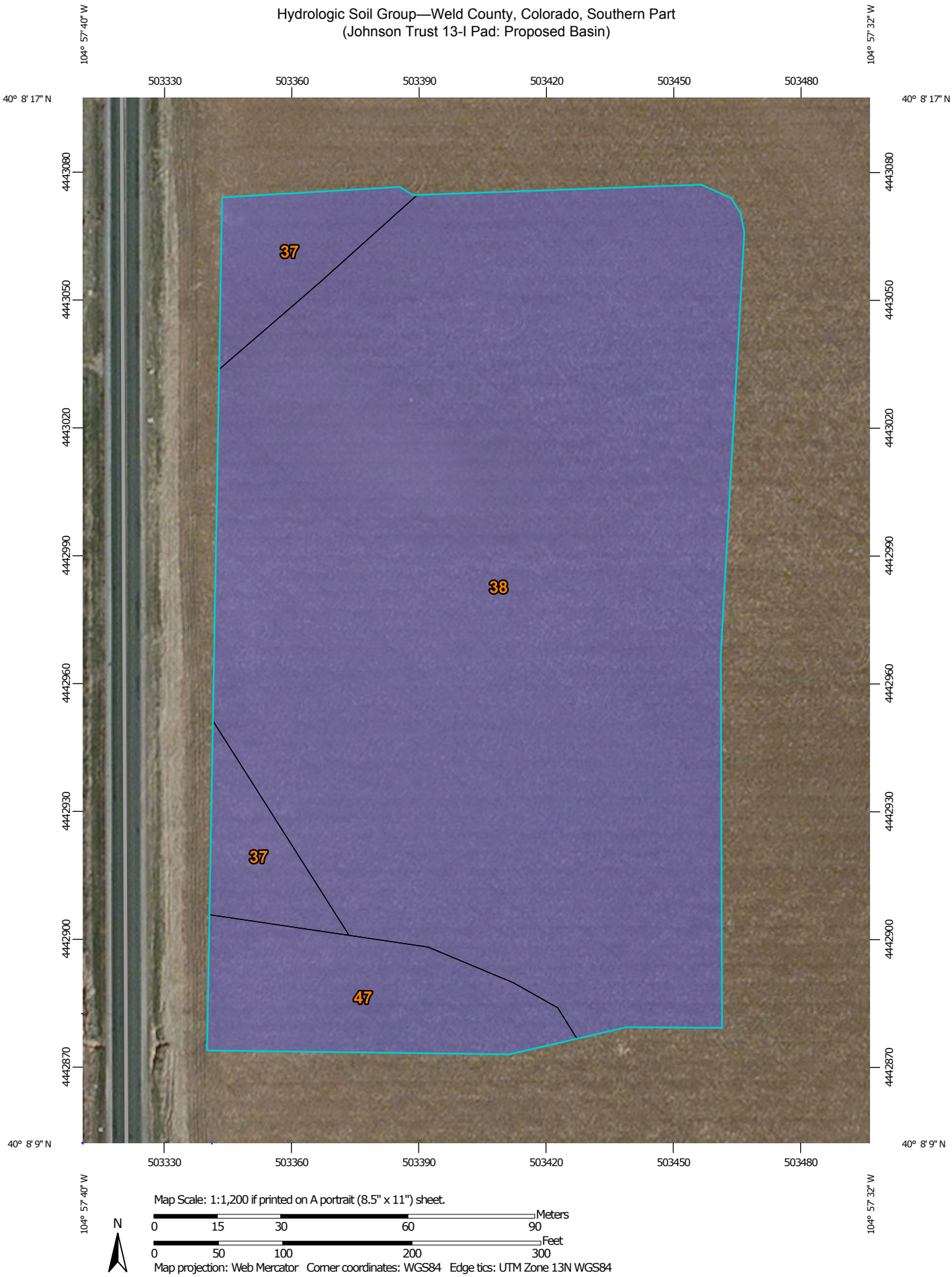
PRELIMINARY

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08123C1890E
EFFECTIVE DATE

Federal Emergency Management Agency

Hydrologic Soil Group—Weld County, Colorado, Southern Part
(Johnson Trust 13-I Pad: Proposed Basin)



Map Scale: 1:1,200 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 15 30 60 90

Feet
0 50 100 200 300

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

MAP LEGEND

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

Soils

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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 14, Sep 22, 2015

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

Date(s) aerial images were photographed: Mar 16, 2012—Apr 13, 2012

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

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Weld County, Colorado, Southern Part (CO618)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
37	Nelson fine sandy loam, 0 to 3 percent slopes	B	0.4	7.1%
38	Nelson fine sandy loam, 3 to 9 percent slopes	B	5.1	84.4%
47	Olney fine sandy loam, 1 to 3 percent slopes	B	0.5	8.4%
Totals for Area of Interest			**6.0**	**100.0%**

Description

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

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

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

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

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

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

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

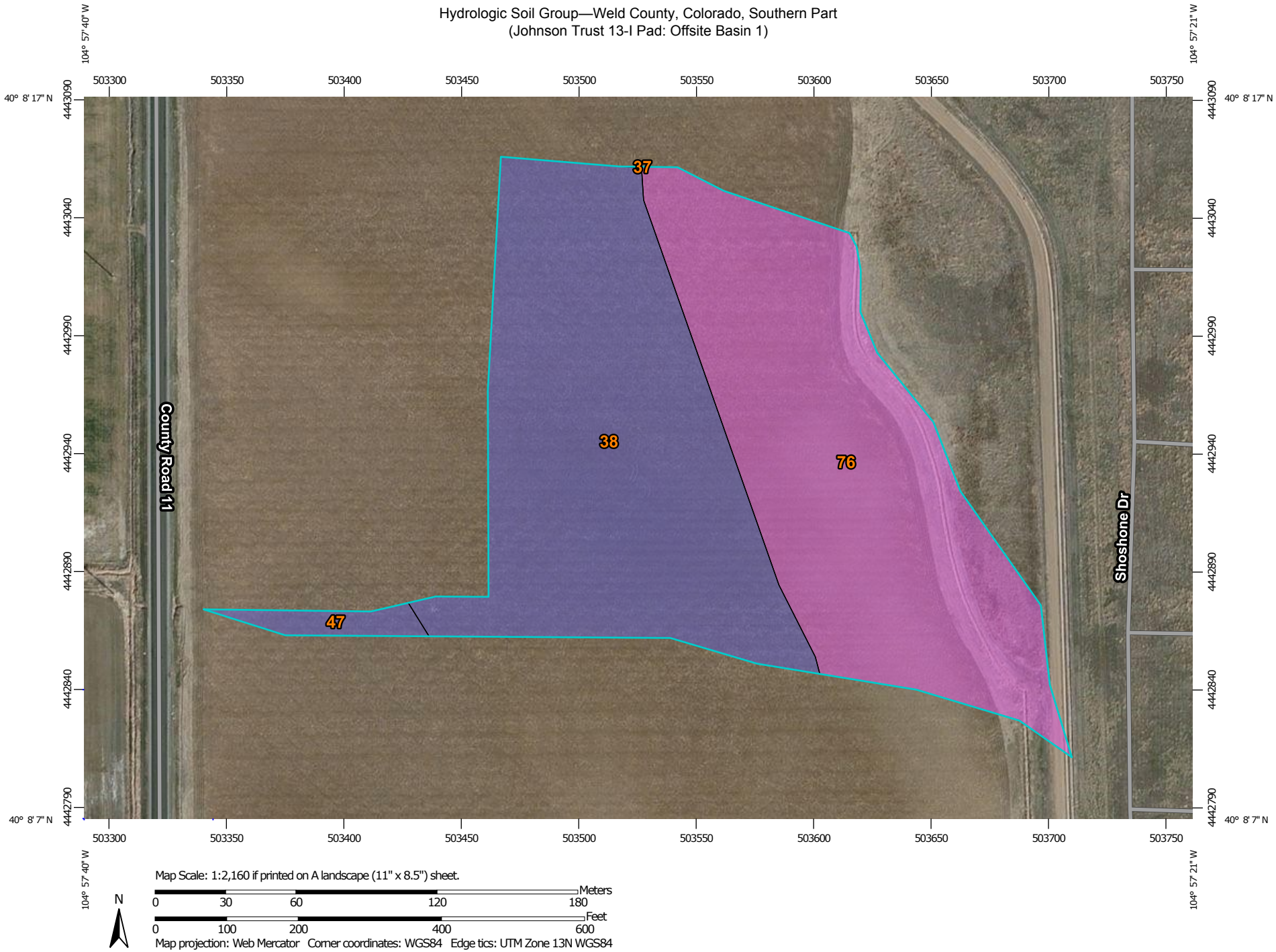
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Hydrologic Soil Group—Weld County, Colorado, Southern Part
(Johnson Trust 13-I Pad: Offsite Basin 1)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

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

Soil Rating Lines

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

Soil Rating Points

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

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

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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 14, Sep 22, 2015

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

Date(s) aerial images were photographed: Mar 16, 2012—Apr 13, 2012

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

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Weld County, Colorado, Southern Part (CO618)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
37	Nelson fine sandy loam, 0 to 3 percent slopes	B	0.0	0.0%
38	Nelson fine sandy loam, 3 to 9 percent slopes	B	5.0	50.0%
47	Olney fine sandy loam, 1 to 3 percent slopes	B	0.2	2.0%
76	Vona sandy loam, 1 to 3 percent slopes	A	4.8	47.9%
Totals for Area of Interest			**10.0**	**100.0%**

Description

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

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

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

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

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

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

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

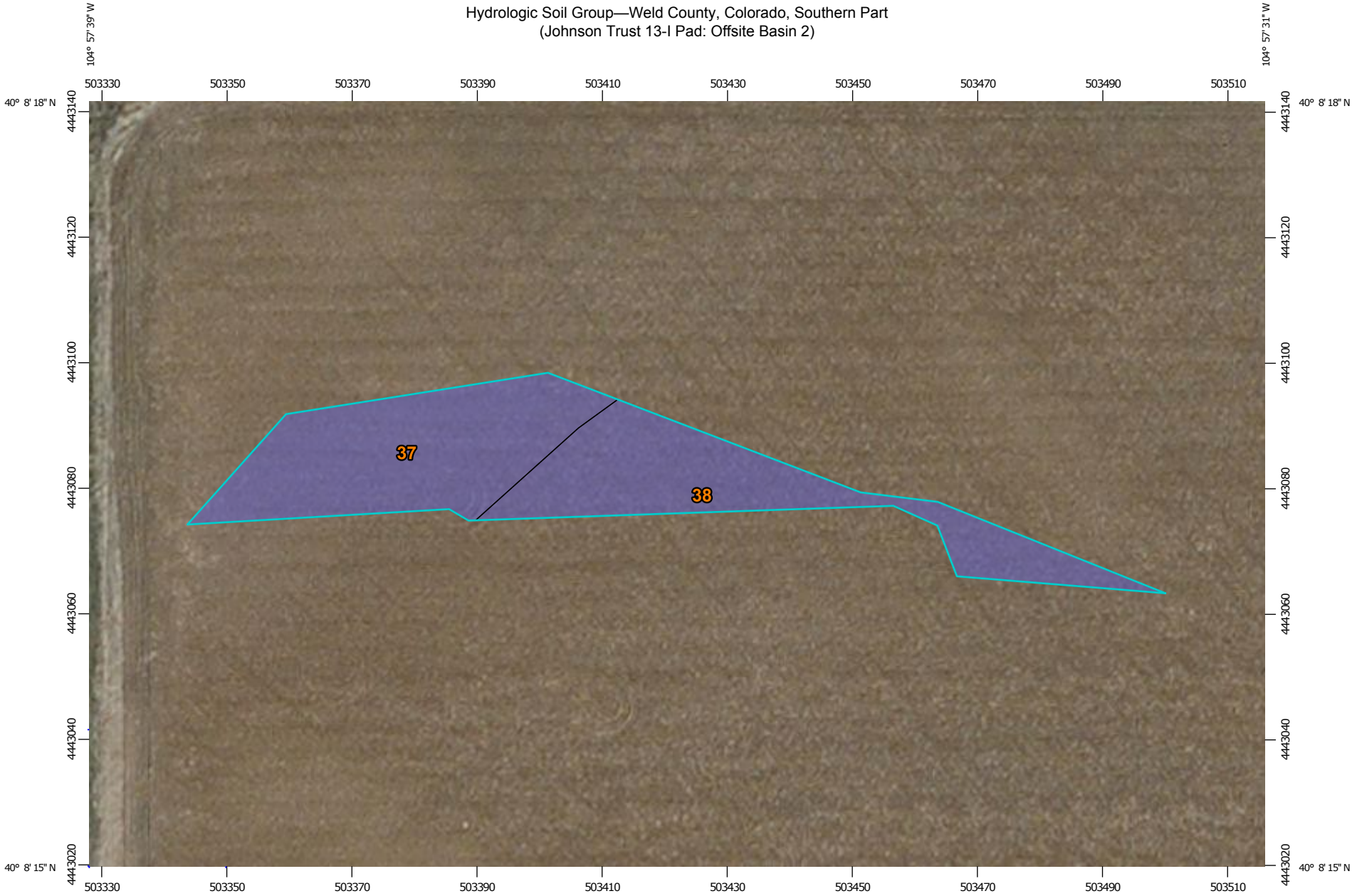
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Weld County, Colorado, Southern Part
(Johnson Trust 13-I Pad: Offsite Basin 2)



Map Scale: 1:860 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 10 20 40 60

Feet
0 40 80 160 240

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

MAP LEGEND

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

Soils

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

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

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

Water Features
- Streams and Canals

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- Interstate Highways
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- Aerial Photography

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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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 14, Sep 22, 2015

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

Date(s) aerial images were photographed: Mar 16, 2012—Apr 13, 2012

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.

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Hydrologic Soil Group— Summary by Map Unit — Weld County, Colorado, Southern Part (CO618)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
37	Nelson fine sandy loam, 0 to 3 percent slopes	B	0.2	53.0%
38	Nelson fine sandy loam, 3 to 9 percent slopes	B	0.2	47.0%
Totals for Area of Interest			**0.4**	**100.0%**

Description

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

NOAA Atlas 14, Volume 8, Version 2
Location name: Longmont, Colorado, US*
Latitude: 40.1376°, Longitude: -104.9596°
Elevation: 4926 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.228** (0.176-0.297)	**0.277** (0.213-0.360)	**0.374** (0.287-0.487)	**0.470** (0.358-0.615)	**0.625** (0.473-0.881)	**0.763** (0.559-1.08)	**0.917** (0.650-1.33)	**1.09** (0.742-1.63)	**1.34** (0.880-2.06)	**1.56** (0.985-2.39)
10-min	**0.334** (0.258-0.434)	**0.406** (0.312-0.528)	**0.547** (0.420-0.714)	**0.688** (0.525-0.901)	**0.915** (0.692-1.29)	**1.12** (0.819-1.58)	**1.34** (0.952-1.95)	**1.60** (1.09-2.39)	**1.97** (1.29-3.02)	**2.28** (1.44-3.50)
15-min	**0.408** (0.314-0.530)	**0.495** (0.381-0.644)	**0.667** (0.512-0.870)	**0.838** (0.640-1.10)	**1.12** (0.844-1.57)	**1.36** (0.999-1.93)	**1.64** (1.16-2.38)	**1.95** (1.32-2.91)	**2.40** (1.57-3.69)	**2.78** (1.76-4.27)
30-min	**0.553** (0.426-0.718)	**0.669** (0.515-0.870)	**0.900** (0.690-1.17)	**1.13** (0.861-1.48)	**1.50** (1.14-2.12)	**1.83** (1.34-2.60)	**2.20** (1.56-3.21)	**2.62** (1.78-3.92)	**3.23** (2.12-4.96)	**3.74** (2.37-5.76)
60-min	**0.676** (0.521-0.878)	**0.819** (0.630-1.06)	**1.10** (0.845-1.44)	**1.39** (1.06-1.82)	**1.85** (1.40-2.61)	**2.26** (1.66-3.21)	**2.72** (1.93-3.96)	**3.24** (2.21-4.85)	**4.00** (2.62-6.15)	**4.64** (2.94-7.14)
2-hr	**0.800** (0.623-1.02)	**0.968** (0.753-1.24)	**1.30** (1.01-1.68)	**1.64** (1.27-2.13)	**2.19** (1.68-3.06)	**2.69** (1.99-3.77)	**3.24** (2.32-4.65)	**3.86** (2.66-5.70)	**4.78** (3.16-7.24)	**5.54** (3.54-8.40)
3-hr	**0.868** (0.681-1.10)	**1.05** (0.822-1.34)	**1.41** (1.10-1.80)	**1.78** (1.38-2.28)	**2.37** (1.83-3.28)	**2.90** (2.17-4.03)	**3.50** (2.52-4.98)	**4.17** (2.89-6.09)	**5.15** (3.43-7.74)	**5.97** (3.85-8.98)
6-hr	**1.03** (0.817-1.29)	**1.23** (0.978-1.55)	**1.64** (1.29-2.06)	**2.04** (1.60-2.58)	**2.69** (2.09-3.66)	**3.27** (2.47-4.47)	**3.92** (2.85-5.49)	**4.64** (3.25-6.68)	**5.71** (3.84-8.44)	**6.60** (4.29-9.77)
12-hr	**1.26** (1.01-1.57)	**1.50** (1.20-1.86)	**1.94** (1.55-2.42)	**2.38** (1.89-2.97)	**3.07** (2.40-4.09)	**3.67** (2.79-4.93)	**4.34** (3.19-5.97)	**5.08** (3.59-7.19)	**6.17** (4.19-8.96)	**7.06** (4.64-10.3)
24-hr	**1.51** (1.23-1.84)	**1.80** (1.46-2.21)	**2.33** (1.88-2.86)	**2.82** (2.26-3.47)	**3.55** (2.80-4.62)	**4.18** (3.20-5.49)	**4.85** (3.59-6.53)	**5.57** (3.97-7.72)	**6.61** (4.53-9.42)	**7.45** (4.95-10.7)
2-day	**1.73** (1.42-2.08)	**2.10** (1.72-2.54)	**2.74** (2.24-3.32)	**3.29** (2.68-4.01)	**4.09** (3.23-5.19)	**4.74** (3.65-6.08)	**5.41** (4.03-7.13)	**6.11** (4.38-8.28)	**7.08** (4.88-9.88)	**7.84** (5.27-11.1)
3-day	**1.88** (1.56-2.25)	**2.26** (1.87-2.71)	**2.92** (2.40-3.50)	**3.48** (2.85-4.20)	**4.29** (3.41-5.39)	**4.94** (3.84-6.29)	**5.62** (4.22-7.33)	**6.33** (4.57-8.50)	**7.31** (5.07-10.1)	**8.07** (5.46-11.3)
4-day	**2.01** (1.67-2.39)	**2.39** (1.99-2.85)	**3.04** (2.52-3.63)	**3.60** (2.96-4.32)	**4.42** (3.53-5.51)	**5.07** (3.96-6.42)	**5.76** (4.35-7.47)	**6.47** (4.69-8.64)	**7.46** (5.21-10.2)	**8.24** (5.60-11.5)
7-day	**2.31** (1.94-2.71)	**2.70** (2.27-3.18)	**3.38** (2.82-3.99)	**3.96** (3.29-4.70)	**4.79** (3.87-5.90)	**5.46** (4.30-6.81)	**6.15** (4.68-7.87)	**6.87** (5.03-9.04)	**7.86** (5.53-10.6)	**8.63** (5.92-11.8)
10-day	**2.56** (2.16-2.99)	**2.98** (2.51-3.48)	**3.69** (3.10-4.32)	**4.29** (3.59-5.05)	**5.14** (4.17-6.27)	**5.82** (4.61-7.19)	**6.51** (4.99-8.26)	**7.23** (5.32-9.43)	**8.21** (5.81-11.0)	**8.97** (6.18-12.2)
20-day	**3.27** (2.80-3.77)	**3.76** (3.21-4.33)	**4.55** (3.88-5.26)	**5.22** (4.42-6.05)	**6.14** (5.03-7.35)	**6.86** (5.49-8.33)	**7.58** (5.87-9.44)	**8.32** (6.18-10.6)	**9.31** (6.66-12.3)	**10.1** (7.01-13.5)
30-day	**3.85** (3.31-4.39)	**4.40** (3.78-5.02)	**5.29** (4.54-6.06)	**6.03** (5.14-6.94)	**7.04** (5.80-8.33)	**7.82** (6.30-9.39)	**8.59** (6.69-10.6)	**9.37** (7.00-11.9)	**10.4** (7.47-13.5)	**11.2** (7.83-14.8)
45-day	**4.53** (3.93-5.13)	**5.19** (4.50-5.88)	**6.25** (5.40-7.10)	**7.12** (6.11-8.11)	**8.28** (6.85-9.68)	**9.15** (7.41-10.9)	**10.0** (7.84-12.2)	**10.8** (8.15-13.6)	**11.9** (8.64-15.4)	**12.7** (9.00-16.7)
60-day	**5.09** (4.44-5.73)	**5.87** (5.11-6.60)	**7.09** (6.16-8.00)	**8.08** (6.98-9.16)	**9.39** (7.81-10.9)	**10.4** (8.43-12.2)	**11.3** (8.89-13.6)	**12.2** (9.23-15.2)	**13.4** (9.72-17.1)	**14.2** (10.1-18.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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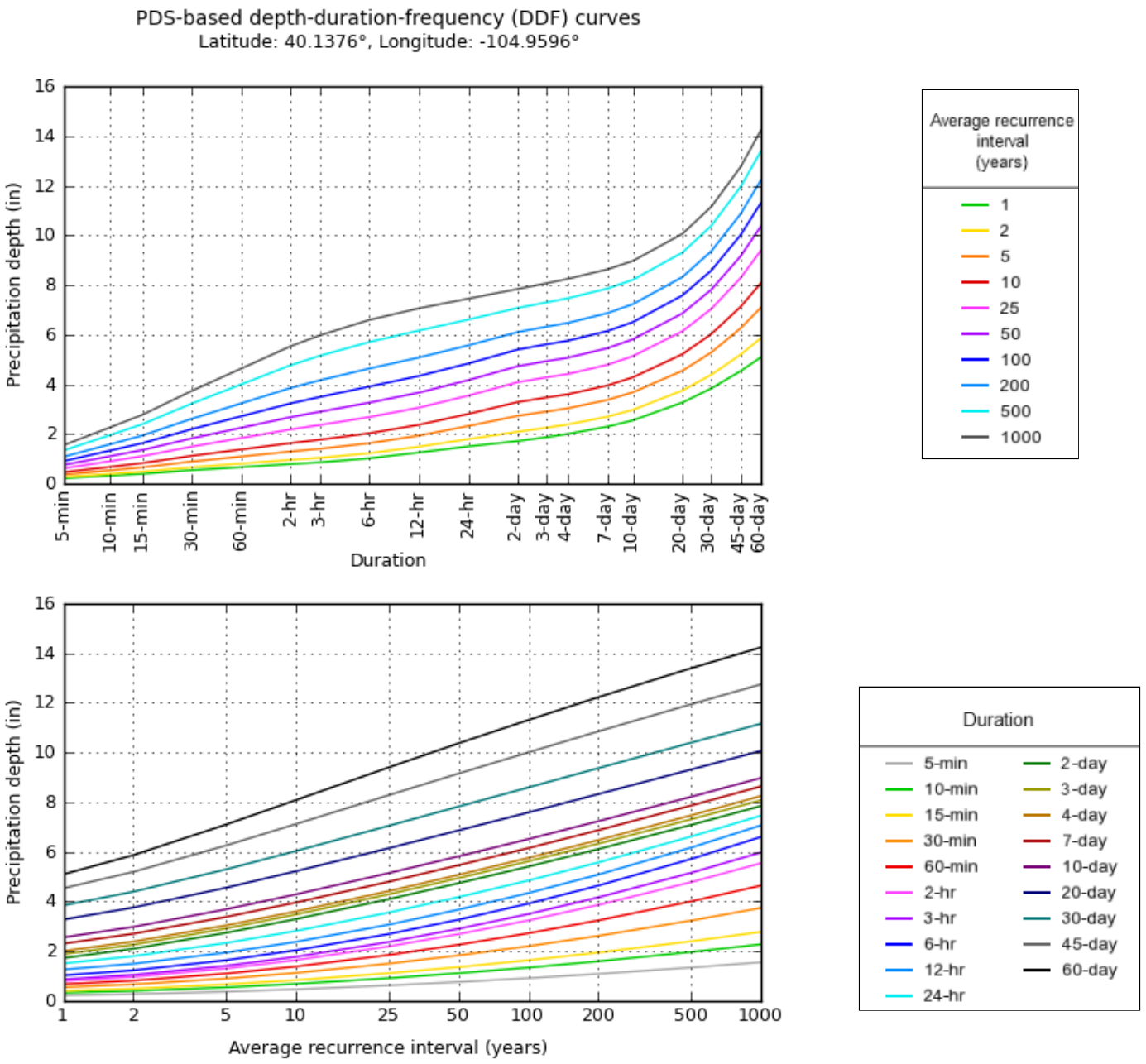
PF graphical



NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Mon Apr 20 15:47:41 2015

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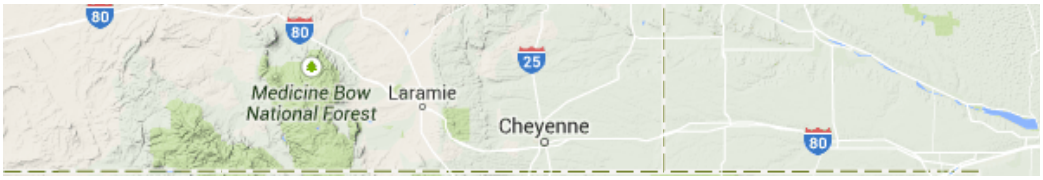
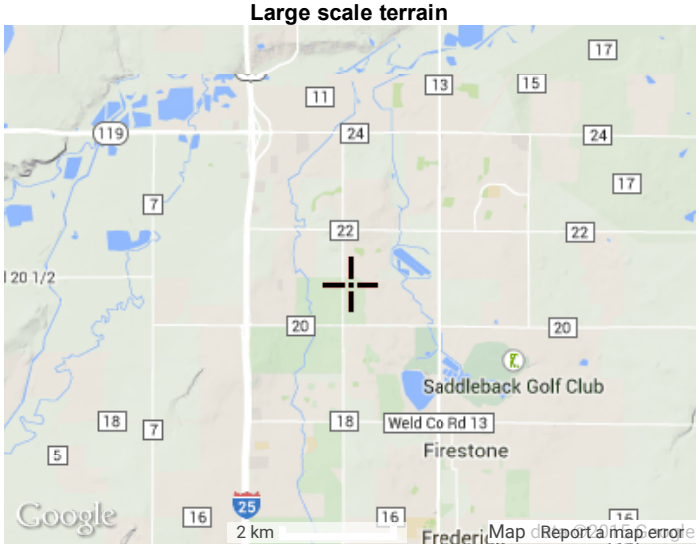
Maps & aerials

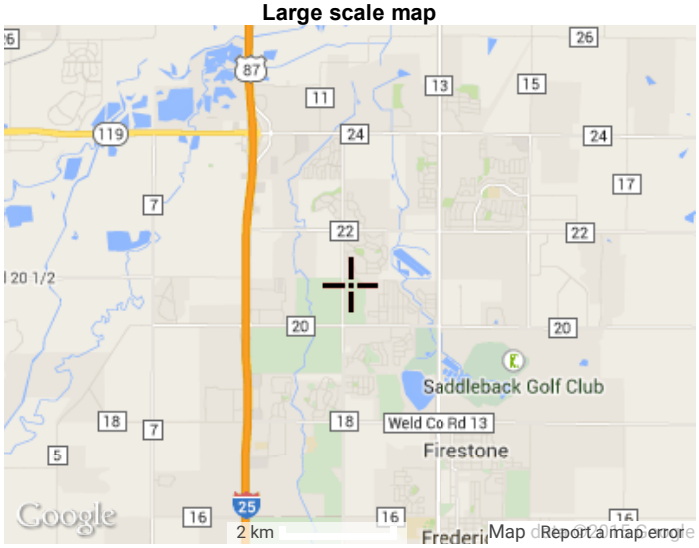
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

COMPOSITE BASIN -WEIGHTED "% IMPERVIOUS" CALCULATIONS

-REFERENCE : UDFCD V.1 Chapter 5 Runoff Table RO-3 Recommended Percentage Imperviousness Values

	Undeveloped areas			Street									
	Historic flow analysis	**Greenbelts, Agricultural**	**Off-site flow analysis (when land use not defined)**	**Paved**	**Gravel**	**Recycled asphalts**	**Dives and walks**	**Roofs**					
% Imperv.	2.00%	2.00%	45.00%	100.00%	40.00%	75.00%	90.00%	90.00%					
												Total	**Percent**
BASIN	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Imperv.**
Proposed Basin		1.80			3.38		0.84					6.02	36.00%
												0.00	0.00%
												0.00	0.00%
												0.00	0.00%
												0.00	0.00%
												0.00	0.00%
												0.00	0.00%
												6.02	**36.00%**
Offsite Basin 1	10.02											10.02	2.00%
												0.00	0.00%
												0.00	0.00%
												10.02	**2.00%**
Offsite Basin 2	0.45											0.45	2.00%
												0.00	0.00%
												0.00	0.00%
												0.45	**2.00%**
												0.00	0.00%
												0.00	0.00%
												0.00	**#DIV/0!**

COMPOSITE BASIN -WEIGHTED "C" CALCULATIONS

REFERENCE UDFCD V.1 Chapter 5 Runoff

$C_A = K_A + (1.31i^3 - 1.44i^2 + 1.135i - 0.12)$ for C_A > or + 0, otherwise $C_A = 0$ (RO-6)

$C_B = (C_A + C_{CD})/2$

$C_{CD} = K_{CD} + (0.858i^3 - 0.786i^2 + 0.774i + 0.04)$ (RO-7)

i = % imperviousness/100 expressed as a decimal

K_A = Correction factor for Type A soils

K_{CD} = Correction factor for Type C and Type D soils

Correction Factors, K_A & K_{CD}

Soil Type	Storm Return Period		
	5-Year	**10-Year**	**100-Year**
A	$-0.08i + 0.09$	$-0.14i + 0.17$	$-0.25i + 0.32$
C or D	$-0.10i + 0.11$	$-0.18i + 0.21$	$-0.39i + 0.46$

Basin ID	**% Imperv.**	***i***	**Soil Type**	**Correction Factors, K_A & K_{CD}**			**Runoff Coefficients, C**			**Basin Area**	**Total Area**	**Weighted Runoff Coefficients, C**		
				5-Year	**10-Year**	**100-Year**	**5-Year**	**10-Year**	**100-Year**			**5-Year**	**10-Year**	**100-Year**
Proposed Basin	36.00%	0.36	A	0.06	0.12	0.23	0.22	0.28	0.39	0.00	6.02	0.28	0.34	0.48
			B	-	-	-	0.28	0.34	0.48	6.02				
			C or D	0.07	0.15	0.32	0.33	0.40	0.58	0.00				
0	0.00%	0.00	A	0.09	0.17	0.32	0.00	0.05	0.20	0.00	0.0	-	-	-
			B	-	-	-	0.08	0.15	0.35	0.00				
			C or D	0.11	0.21	0.46	0.15	0.25	0.50	0.00				
0	0.00%	0.00	A	0.09	0.17	0.32	0.00	0.05	0.20	0.00	0.0	-	-	-
			B	-	-	-	0.08	0.15	0.35					
			C or D	0.11	0.21	0.46	0.15	0.25	0.50					
0	0.00%	0.00	A	0.09	0.17	0.32	0.00	0.05	0.20	0.00	0.0	-	-	-
			B	-	-	-	0.08	0.15	0.35					
			C or D	0.11	0.21	0.46	0.15	0.25	0.50					
0	0.00%	0.00	A	0.09	0.17	0.32	0.00	0.05	0.20	0.00	0.0	-	-	-
			B	-	-	-	0.08	0.15	0.35					
			C or D	0.11	0.21	0.46	0.15	0.25	0.50					
0	0.00%	0.00	A	0.09	0.17	0.32	0.00	0.05	0.20	0.00	0.0	-	-	-
			B	-	-	-	0.08	0.15	0.35					
			C or D	0.11	0.21	0.46	0.15	0.25	0.50					
Offsite Basin 1	2.00%	0.02	A	0.09	0.17	0.32	0.00	0.07	0.22	4.81	10.0	0.04	0.12	0.29
			B	-	-	-	0.08	0.17	0.36	5.21				
			C or D	0.11	0.21	0.45	0.16	0.26	0.507					
0	0.00%	0.00	A	0.09	0.17	0.32	0.00	0.05	0.20	0.00	0.0	-	-	-
			B	-	-	-	0.08	0.15	0.35					
			C or D	0.11	0.21	0.46	0.15	0.25	0.500					
0	0.00%	0.00	A	0.09	0.17	0.32	0.00	0.05	0.20	0.00	0.0	-	-	-
			B	-	-	-	0.08	0.15	0.35					
			C or D	0.11	0.21	0.46	0.15	0.25	0.50					
Offsite Basin 2	2.00%	0.02	A	0.09	0.17	0.32	0.00	0.07	0.22	0.45	0.5	0.08	0.17	0.36
			B	-	-	-	0.08	0.17	0.36					
			C or D	0.11	0.21	0.45	0.16	0.26	0.51					

Time of Concentration

REFERENCE UDFCD V.1 Chapter 5 Runoff Table RO-2 Conveyance Coefficient, C_v

Heavy Meadow	2.50	Short Grass Pasture & Lawns	7.00		Grassed Waterway	15.00
Tillage/field	5.00	Nearly Bare Ground	10.00		Paved Area & Shallow Gutter	20.00

	SUB-BASIN DATA			INITIAL / OVERLAND TIME			TRAVEL TIME T(t)					T(c) CHECK (URBANIZED BASINS)			FINAL T(c)
DESIGN POINT	DRAIN BASIN	AREA ac.	C(5)	Length ft.	Slope %	T(i) min	Length ft.	Slope %	Coeff.	Velocity fps	T(t) min.	COMP. T(c)	TOTAL LENGTH	L/180+10	min.
1	Proposed Basin	6.02	0.28	300	2.2	19.7	614	1.4	10.00	1.2	8.5	28.2	914	15.1	15.1
2	Offsite Basin 1	10.02	0.04	500	0.5	53.6	1836	1.3	10.00	1.1	27.8	81.4			81.4
3	Offsite Basin 2	0.45	0.08	500	1.7	34.4	63	2.7	10.00	1.6	0.7	35.1			35.1

Rational Method Procedure

10-yr Rainfall Depth-Duration-Frequency (1-hr) = 1.39

REFERENCE USDCM V.1 RUNOFF

Design Storm ***10 Year***

BASIN INFORMATON				DIRECT RUNOFF				TOTAL RUNOFF				
DESIGN POINT	DRAIN BASIN	AREA ac.	RUNOFF COEFF	T(c) min	C x A	I in/hr	Q cfs	T(c) min	SUM C x A	I in/hr	Q cfs	REMARKS
1	Proposed Basin	6.02	0.34	15.1	2.06	3.15	6.5	15.1	2.06	3.15	6.5	
2	Offsite Basin 1	10.02	0.12	81.4	1.20	1.14	1.4	81.4	1.20	1.14	1.4	
3	Offsite Basin 2	0.45	0.17	35.1	0.07	1.98	0.1	35.1	0.07	1.98	0.1	

Rational Method Procedure

100-yr Rainfall Depth-Duration-Frequency (1-hr) = 2.72

REFERENCE USDCM V.1 RUNOFF

Design Storm ***100 Year***

BASIN INFORMATON				DIRECT RUNOFF				TOTAL RUNOFF				
DESIGN POINT	DRAIN BASIN	AREA ac.	RUNOFF COEFF	T(c) min	C x A	I in/hr	Q cfs	T(c) min	SUM C x A	I in/hr	Q cfs	REMARKS
1	Proposed Basin	6.02	0.48	15.1	2.92	6.16	18.0	15.1	2.92	6.16	18.0	
2	Offsite Basin 1	10.02	0.29	81.4	2.93	2.23	6.5	81.4	2.93	2.23	6.5	
3	Offsite Basin 2	0.45	0.36	35.1	0.16	3.88	0.6	35.1	0.16	3.88	0.6	

DETENTION VOLUME BY THE MODIFIED FAA METHOD

Project: Johnson Trust 13-I

Basin ID: Proposed Basin 1

(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 MINOR Detention Volume Using Modified FAA Method

Design Information (Input):

Catchment Drainage Imperviousness	I_a =	36.00	percent
Catchment Drainage Area	A =	6.020	acres
Predevelopment NRCS Soil Group	Type =	B	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	Tc =	15	minutes
Allowable Unit Release Rate	q =	0.23	cfs/acre
One-hour Precipitation	P_1 =	1.39	inches
Design Rainfall IDF Formula	$i = C_1 * P_1/(C_2+T_c)^{\wedge}C_3$		
Coefficient One	C_1 =	28.50	
Coefficient Two	C_2 =	10	
Coefficient Three	C_3 =	0.789	

Determination of Average Outflow from the Basin (Calculated):

Runoff Coefficient	C =	0.34	
Inflow Peak Runoff	Qp-in =	6.38	cfs
Allowable Peak Outflow Rate	Qp-out =	**1.38**	cfs
Mod. FAA Minor Storage Volume =		7,226	**cubic feet**
Mod. FAA Minor Storage Volume =		**0.166**	**acre-ft**

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)
5	4.68	0.066	1.00	1.38	0.010	0.056
10	3.73	0.105	1.00	1.38	0.019	0.086
15	3.13	0.132	1.00	1.38	0.029	0.104
20	2.71	0.153	0.88	1.21	0.033	0.119
25	2.40	0.169	0.80	1.11	0.038	0.131
30	2.16	0.182	0.75	1.04	0.043	0.139
35	1.97	0.194	0.72	0.99	0.048	0.146
40	1.81	0.204	0.69	0.95	0.053	0.151
45	1.68	0.213	0.67	0.92	0.057	0.156
50	1.57	0.221	0.65	0.90	0.062	0.159
55	1.47	0.228	0.64	0.88	0.067	0.161
60	1.39	0.235	0.63	0.87	0.072	0.163
65	1.31	0.241	0.62	0.85	0.076	0.164
70	1.25	0.246	0.61	0.84	0.081	0.165
75	1.19	0.252	0.60	0.83	0.086	0.166
80	1.14	0.257	0.59	0.82	0.091	0.166
85	1.09	0.261	0.59	0.82	0.095	0.166
90	1.05	0.266	0.58	0.81	0.100	0.165
95	1.01	0.270	0.58	0.80	0.105	0.165
100	0.97	0.274	0.58	0.80	0.110	0.164
105	0.94	0.278	0.57	0.79	0.115	0.163
110	0.91	0.281	0.57	0.79	0.119	0.162
115	0.88	0.285	0.57	0.78	0.124	0.161
120	0.85	0.288	0.56	0.78	0.129	0.159
125	0.83	0.291	0.56	0.78	0.134	0.158
130	0.80	0.294	0.56	0.77	0.138	0.156
135	0.78	0.297	0.56	0.77	0.143	0.154
140	0.76	0.300	0.55	0.77	0.148	0.152
145	0.74	0.303	0.55	0.76	0.153	0.150
150	0.72	0.306	0.55	0.76	0.157	0.148
155	0.71	0.308	0.55	0.76	0.162	0.146
160	0.69	0.311	0.55	0.76	0.167	0.144
165	0.67	0.313	0.55	0.76	0.172	0.141
170	0.66	0.316	0.54	0.75	0.177	0.139
175	0.64	0.318	0.54	0.75	0.181	0.137
180	0.63	0.320	0.54	0.75	0.186	0.134
185	0.62	0.322	0.54	0.75	0.191	0.132
190	0.61	0.325	0.54	0.75	0.196	0.129
195	0.59	0.327	0.54	0.75	0.200	0.126
200	0.58	0.329	0.54	0.74	0.205	0.124
205	0.57	0.331	0.54	0.74	0.210	0.121
210	0.56	0.333	0.54	0.74	0.215	0.118
215	0.55	0.335	0.54	0.74	0.219	0.115
220	0.54	0.337	0.53	0.74	0.224	0.112
225	0.53	0.338	0.53	0.74	0.229	0.109
230	0.52	0.340	0.53	0.74	0.234	0.106
235	0.52	0.342	0.53	0.74	0.238	0.103
240	0.51	0.344	0.53	0.74	0.243	0.100
245	0.50	0.345	0.53	0.73	0.248	0.097
250	0.49	0.347	0.53	0.73	0.253	0.094
255	0.49	0.349	0.53	0.73	0.258	0.091
260	0.48	0.350	0.53	0.73	0.262	0.088
265	0.47	0.352	0.53	0.73	0.267	0.085
270	0.46	0.354	0.53	0.73	0.272	0.082
275	0.46	0.355	0.53	0.73	0.277	0.079
280	0.45	0.357	0.53	0.73	0.281	0.075
285	0.45	0.358	0.53	0.73	0.286	0.072
290	0.44	0.360	0.53	0.73	0.291	0.069
295	0.43	0.361	0.53	0.73	0.296	0.065
300	0.43	0.363	0.53	0.73	0.300	0.062
305	0.42	0.364	0.52	0.73	0.305	0.059

Mod. FAA Minor Storage Volume (cubic ft.) = 7,226
Mod. FAA Minor Storage Volume (acre-ft.) = 0.1659

Determination of MAJOR Detention Volume Using Modified FAA Method

Design Information (Input):

Catchment Drainage Imperviousness	I_a =	36.00	percent
Catchment Drainage Area	A =	6.020	acres
Predevelopment NRCS Soil Group	Type =	B	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	Tc =	15	minutes
Allowable Unit Release Rate	q =	0.85	cfs/acre
One-hour Precipitation	P_1 =	2.72	inches
Design Rainfall IDF Formula	$i = C_1 * P_1/(C_2+T_c)^{\wedge}C_3$		
Coefficient One	C_1 =	28.50	
Coefficient Two	C_2 =	10	
Coefficient Three	C_3 =	0.789	

Determination of Average Outflow from the Basin (Calculated):

Runoff Coefficient	C =	0.48	
Inflow Peak Runoff	Qp-in =	17.62	cfs
Allowable Peak Outflow Rate	Qp-out =	**5.12**	cfs
Mod. FAA Major Storage Volume =		16,705	**cubic feet**
Mod. FAA Major Storage Volume =		**0.384**	**acre-ft**

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	9.15	0.182	1.00	5.12	0.035	0.147
10	7.29	0.290	1.00	5.12	0.070	0.220
15	6.12	0.365	1.00	5.12	0.106	0.259
20	5.30	0.422	0.88	4.49	0.124	0.298
25	4.69	0.467	0.80	4.10	0.141	0.325
30	4.22	0.504	0.75	3.85	0.159	0.345
35	3.85	0.536	0.72	3.66	0.177	0.359
40	3.54	0.563	0.69	3.52	0.194	0.369
45	3.28	0.588	0.67	3.42	0.212	0.376
50	3.07	0.610	0.65	3.33	0.229	0.381
55	2.88	0.630	0.64	3.26	0.247	0.383
60	2.71	0.648	0.63	3.20	0.265	0.384
65	2.57	0.665	0.62	3.15	0.282	0.383
70	2.44	0.681	0.61	3.11	0.300	0.381
75	2.33	0.695	0.60	3.07	0.318	0.378
80	2.23	0.709	0.59	3.04	0.335	0.374
85	2.13	0.722	0.59	3.01	0.353	0.369
90	2.05	0.734	0.58	2.99	0.370	0.363
95	1.97	0.745	0.58	2.97	0.388	0.357
100	1.90	0.756	0.58	2.94	0.406	0.351
105	1.83	0.767	0.57	2.93	0.423	0.343
110	1.77	0.777	0.57	2.91	0.441	0.336
115	1.72	0.786	0.57	2.89	0.458	0.328
120	1.67	0.795	0.56	2.88	0.476	0.319
125	1.62	0.804	0.56	2.87	0.494	0.311
130	1.57	0.813	0.56	2.86	0.511	0.301
135	1.53	0.821	0.56	2.84	0.529	0.292
140	1.49	0.829	0.55	2.83	0.547	0.282
145	1.45	0.837	0.55	2.82	0.564	0.272
150	1.41	0.844	0.55	2.82	0.582	0.262
155	1.38	0.851	0.55	2.81	0.599	0.252
160	1.35	0.858	0.55	2.80	0.617	0.241
165	1.32	0.865	0.55	2.79	0.635	0.230
170	1.29	0.872	0.54	2.79	0.652	0.219
175	1.26	0.878	0.54	2.78	0.670	0.208
180	1.23	0.884	0.54	2.77	0.688	0.197
185	1.21	0.891	0.54	2.77	0.705	0.185
190	1.19	0.897	0.54	2.76	0.723	0.174
195	1.16	0.902	0.54	2.76	0.740	0.162
200	1.14	0.908	0.54	2.75	0.758	0.150
205	1.12	0.914	0.54	2.75	0.776	0.138
210	1.10	0.919	0.54	2.74	0.793	0.126
215	1.08	0.924	0.54	2.74	0.811	0.114
220	1.06	0.930	0.53	2.73	0.829	0.101
225	1.04	0.935	0.53	2.73	0.846	0.089
230	1.03	0.940	0.53	2.73	0.864	0.076
235	1.01	0.945	0.53	2.72	0.881	0.063
240	0.99	0.950	0.53	2.72	0.899	0.051
245	0.98	0.954	0.53	2.72	0.917	0.038
250	0.96	0.959	0.53	2.71	0.934	0.025
255	0.95	0.964	0.53	2.71	0.952	0.012
260	0.94	0.968	0.53	2.71	0.969	-0.001
265	0.92	0.973	0.53	2.70	0.987	-0.015
270	0.91	0.977	0.53	2.70	1.005	-0.028
275	0.90	0.981	0.53	2.70	1.022	-0.041
280	0.88	0.985	0.53	2.70	1.040	-0.054
285	0.87	0.990	0.53	2.69	1.058	-0.068
290	0.86	0.994	0.53	2.69	1.075	-0.081
295	0.85	0.998	0.53	2.69	1.093	-0.095
300	0.84	1.002	0.53	2.69	1.110	-0.109
305	0.83	1.006	0.52	2.69	1.128	-0.122

Mod. FAA Major Storage Volume (cubic ft.) = 16,705
Mod. FAA Major Storage Volume (acre-ft.) = 0.3835

UDFCD DETENTION BASIN VOLUME ESTIMATING WORKBOOK Version 2.34, Released November 2013

COMPOSITE BASIN -WEIGHTED "% IMPERVIOUS" CALCULATIONS REF:

Weld County Engineering and Construction Criteria Table 5-3 Recommended Percentage Imperviousness Values

Table 5-3 Recommended Percentage Imperviousness Values

Land Use or Surface Characteristics	Percentage Impervious
Business:	
Commercial areas	95
Neighborhood area	85
Residential:	
Single-family	See UDFCD Manual
Multi-family (detached)	60
Multi-family (attached)	75
Half-acre lot or larger	See UDFCD Manual
Apartments	80
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	5
Playgrounds	10
Schools	50
Railroad yard areas	15
Undeveloped areas*:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel	40
Recycled asphalt	75
Drives and walks	90
Roofs	90

Obtained from the runoff chapter of the UDFCD Manual (Volume 1), Table RO-3

COMPOSITE BASIN -WEIGHTED WEIGHTED "C" CALCULATIONS REF:

USDCM V.1 Runoff Table RO-3 Recommended Percentage Imperviousness Values

$$C_A = K_A + \left(1.31i^3 - 1.44i^2 + 1.135i - 0.12\right) \text{ for } C_A \geq 0, \text{ otherwise } C_A = 0 \qquad \text{(RO-6)}$$

$$C_{CD} = K_{CD} + \left(0.858i^3 - 0.786i^2 + 0.774i + 0.04\right) \qquad \text{(RO-7)}$$

$$C_B = \left(C_A + C_{CD}\right)/2$$

in which:

i = % imperviousness/100 expressed as a decimal (see Table RO-3)

C_A = Runoff coefficient for Natural Resources Conservation Service (NRCS) Type A soils

C_B = Runoff coefficient for NRCS Type B soils

C_{CD} = Runoff coefficient for NRCS Type C and D soils

K_A = Correction factor for Type A soils defined in Table RO-4

K_{CD} = Correction factor for Type C and D soils defined in Table RO-4

Table RO-4—Correction Factors K_A and K_{CD} for Use with Equations RO-6 and RO-7

NRCS Soil Type	Storm Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
C and D	0	-0.10i + 0.11	-0.18i + 0.21	-0.28i + 0.33	-0.33i + 0.40	-0.39i + 0.46
A	0	-0.08i + 0.09	-0.14i + 0.17	-0.19i + 0.24	-0.22i + 0.28	-0.25i + 0.32

COMPOSITE DEVELOPED BASIN -Rational Method Procedure

REFERENCE USDCM VOL.1 RUNOFF

$$t_c = t_i + t_t \quad \text{(RO-2)}$$

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \quad \text{(RO-3)}$$

$$V = C_v S_w^{0.5} \quad \text{(RO-4)}$$

in which:

V = velocity (ft/sec)

C_v = conveyance coefficient (from Table RO-2)

S_w = watercourse slope (ft/ft)

$$t_c = \frac{L}{180} + 10 \quad \text{(RO-5)}$$

in which:

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

Table RO-2—Conveyance Coefficient, C_v

Type of Land Surface	Conveyance Coefficient, C_v
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

RELEASE RATE

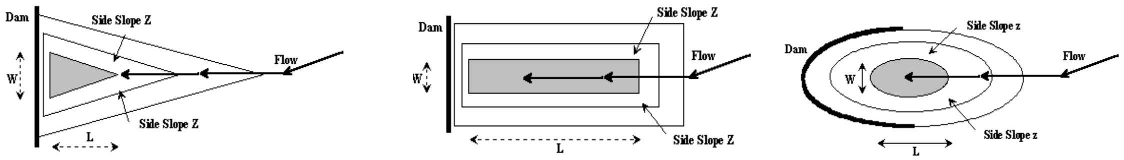
REFERENCE USDCM VOL.2 STORAGE

Table SO-1—Maximum Unit Flow Release Rates (cfs/acre) from On-Site Detention Facilities

Design Return Period (Years)	NRCS Hydrologic Soil Group		
	A	B	C & D
2	0.02	0.03	0.04
5	0.07	0.13	0.17
10	0.13	0.23	0.30
25	0.24	0.41	0.52
50	0.33	0.56	0.68
100	0.50	0.85	1.00

STAGE-STORAGE SIZING FOR DETENTION BASINS

Project: Johnson Trust 13-I Facilities
Basin ID: Proposed Basin 1



Design Information (Input):

Width of Basin Bottom, W =		ft
Length of Basin Bottom, L =		ft
Dam Side-slope (H:V), Z_d =	4.00	ft/ft

Check Basin Shape

Right Triangle		OR…
Isosceles Triangle		OR…
Rectangle		OR…
Circle / Ellipse		OR…
Irregular	X	(Use Overide values in cells G32:G52)

Stage-Storage Relationship:

	MINOR	MAJOR	
Storage Requirement from Sheet 'Modified FAA':	0.17	0.38	acre-ft.
Storage Requirement from Sheet 'Hydrograph':			acre-ft.
Storage Requirement from Sheet 'Full-Spectrum':			acre-ft.

Labels for WQCV, Minor, & Major Storage Stages (input)	Water Surface Elevation ft (input)	Side Slope (H:V) ft/ft Below El.	Basin Width at Stage ft (output)	Basin Length at Stage ft (output)	Surface Area at Stage ft^2 (output)	Surface Area at Stage ft^2 User Overide	Volume Below Stage ft^3 (output)	Surface Area at Stage acres (output)	Volume Below Stage acre-ft (output)	Target Volumes for WQCV, Minor, & Major Storage Volumes (for goal seek)
	4911.60	(input)				50		0.001	0.000	
	4912.00	4.00	0.00	0.00		3,450	700	0.079	0.016	
	4912.50	4.00	0.00	0.00		7,738	3,497	0.178	0.080	
	4912.70	4.00	0.00	0.00		8,026	5,073	0.184	0.116	WQCV
	4913.00	4.00	0.00	0.00		8,467	7,547	0.194	0.173	10 YR
	4913.50	4.00	0.00	0.00		9,220	11,969	0.212	0.275	
	4914.00	4.00	0.00	0.00		9,999	16,774	0.230	0.385	100 YR
	4914.30	4.00	0.00	0.00		10,478	19,845	0.241	0.456	
	4915.00	4.00	0.00	0.00		11,632	27,584	0.267	0.633	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
		4.00					#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	

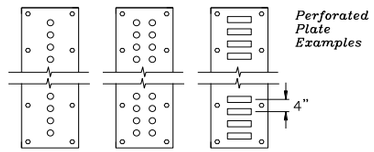
STAGE-DISCHARGE SIZING OF THE WATER QUALITY CAPTURE VOLUME (WQCV) OUTLET

Project: Johnson Trust 13-I Facilities
Basin ID: Proposed Basin 1

WQCV Design Volume (Input):

Catchment Imperviousness, I_a = 36.0 percent
Catchment Area, A = 6.02 acres
Depth at WQCV outlet above lowest perforation, H = 1.30 feet
Vertical distance between rows, h = 4.00 inches
Number of rows, NL = 4.00
Orifice discharge coefficient, C_o = 0.65
Slope of Basin Trickle Channel, S = 0.005 ft / ft
Time to Drain the Pond = 40 hours

Diameter of holes, D = 0.625 inches
Number of holes per row, N = 1
OR
Height of slot, H = inches
Width of slot, W = inches



Watershed Design Information (Input):

Percent Soil Type A = %
Percent Soil Type B = 100 %
Percent Soil Type C/D = %

Outlet Design Information (Output):

Water Quality Capture Volume, WQCV = 0.170 watershed inches
Water Quality Capture Volume (WQCV) = 0.085 acre-feet
Design Volume (WQCV / 12 * Area * 1.2) Vol = 0.102 acre-feet
Outlet area per row, Ao = 0.31 square inches
Total opening area at each row based on user-input above, Ao = 0.31 square inches
Total opening area at each row based on user-input above, Ao = 0.002 square feet

3

Central Elevations of Rows of Holes in feet

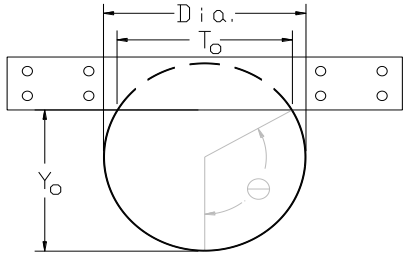
	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	Row 9	Row 10	Row 11	Row 12	Row 13	Row 14	Row 15	Row 16	Row 17	Row 18	Row 19	Row 20	Row 21	Row 22	Row 23	Row 23	**Σ Flow**
	4911.85	4912.18	4912.52	4912.85																					
	Collection Capacity for Each Row of Holes in cfs																								
4911.60	0.0000	0.0000	0.0000	0.0000																					**0.00**
4911.70	0.0000	0.0000	0.0000	0.0000																					**0.00**
4911.80	0.0000	0.0000	0.0000	0.0000																					**0.00**
4911.90	0.0025	0.0000	0.0000	0.0000																					**0.00**
4912.00	0.0043	0.0000	0.0000	0.0000																					**0.00**
4912.10	0.0056	0.0000	0.0000	0.0000																					**0.01**
4912.20	0.0066	0.0016	0.0000	0.0000																					**0.01**
4912.30	0.0075	0.0038	0.0000	0.0000																					**0.01**
4912.40	0.0082	0.0052	0.0000	0.0000																					**0.01**
4912.50	0.0090	0.0063	0.0000	0.0000																					**0.02**
4912.60	0.0096	0.0072	0.0031	0.0000																					**0.02**
4912.70	0.0102	0.0080	0.0047	0.0000																					**0.02**
4912.80	0.0108	0.0088	0.0059	0.0000																					**0.03**
4912.90	0.0114	0.0094	0.0069	0.0025																					**0.03**
4913.00	0.0119	0.0101	0.0077	0.0043																					**0.03**
4913.10	0.0124	0.0107	0.0085	0.0056																					**0.04**
4913.20	0.0129	0.0112	0.0092	0.0066																					**0.04**
4913.30	0.0134	0.0118	0.0098	0.0075																					**0.04**
4913.40	0.0138	0.0123	0.0104	0.0082																					**0.04**
4913.50	0.0143	0.0128	0.0110	0.0090																					**0.05**
4913.60	0.0147	0.0132	0.0115	0.0096																					**0.05**
4913.70	0.0151	0.0137	0.0121	0.0102																					**0.05**
4913.80	0.0155	0.0141	0.0126	0.0108																					**0.05**
4913.90	0.0159	0.0146	0.0131	0.0114																					**0.05**
4914.00	0.0163	0.0150	0.0135	0.0119																					**0.06**
4914.10	0.0167	0.0154	0.0140	0.0124																					**0.06**
4914.20	0.0170	0.0158	0.0144	0.0129																					**0.06**
4914.30	0.0174	0.0162	0.0148	0.0134																					**0.06**
4914.40	0.0177	0.0166	0.0152	0.0138																					**0.06**
4914.50	0.0181	0.0169	0.0156	0.0143																					**0.06**
4914.60	0.0184	0.0173	0.0160	0.0147																					**0.07**
4914.70	0.0188	0.0176	0.0164	0.0151																					**0.07**
4914.80	0.0191	0.0180	0.0168	0.0155																					**0.07**
4914.90	0.0194	0.0183	0.0171	0.0159																					**0.07**
4915.00	0.0197	0.0187	0.0175	0.0163																					**0.07**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	#N/A	#N/A	#N/A	#N/A																					**#N/A**
	Override Area Row 1	Override Area Row 2	Override Area Row 3	Override Area Row 4	Override Area Row 5	Override Area Row 6	Override Area Row 7	Override Area Row 8	Override Area Row 9	Override Area Row 10	Override Area Row 11	Override Area Row 12	Override Area Row 13	Override Area Row 14	Override Area Row 15	Override Area Row 16	Override Area Row 17	Override Area Row 18	Override Area Row 19	Override Area Row 20	Override Area Row 21	Override Area Row 22	Override Area Row 23	Override Area Row 24	

RESTRICTOR PLATE SIZING FOR CIRCULAR VERTICAL ORIFICES

Project: **Johnson Trust 13-I Facilities**

Basin ID: **Proposed Basin 1**

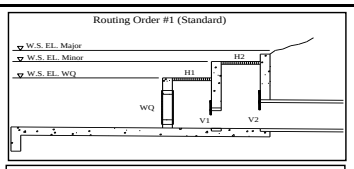
X

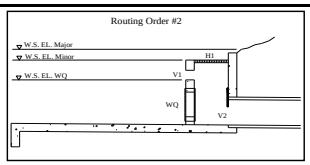


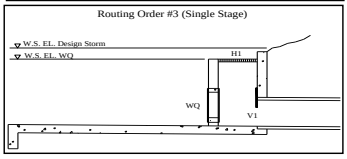
		#1 Vertical Orifice	#2 Vertical Orifice	
Sizing the Restrictor Plate for Circular Vertical Orifices or Pipes (Input)				
Water Surface Elevation at Design Depth	Elev: WS =	4,914.00		feet
Pipe/Vertical Orifice Entrance Invert Elevation	Elev: Invert =	4,911.35		feet
Required Peak Flow through Orifice at Design Depth	Q =	5.12		cfs
Pipe/Vertical Orifice Diameter (inches)	Dia =	15.0		inches
Orifice Coefficient	C_o =	0.65		
Full-flow Capacity (Calculated)				
Full-flow area	Af =	1.23		sq ft
Half Central Angle in Radians	Theta =	3.14		rad
Full-flow capacity	Qf =	9.1		cfs
	Percent of Design Flow =	178%		
Calculation of Orifice Flow Condition				
Half Central Angle (0<Theta<3.1416)	Theta =	1.61		rad
Flow area	A_o =	0.64		sq ft
Top width of Orifice (inches)	T_o =	14.99		inches
Height from Invert of Orifice to Bottom of Plate (feet)	Y_o =	0.65		feet
Elevation of Bottom of Plate	Elev Plate Bottom Edge =	4,912.00		feet
Resultant Peak Flow Through Orifice at Design Depth	Q_o =	5.1		cfs
Width of Equivalent Rectangular Vertical Orifice	**Equivalent Width =**	**0.98**		**feet**
Centroid Elevation of Equivalent Rectangular Vertical Orifice	**Equiv. Centroid El. =**	**4,911.68**		**feet**

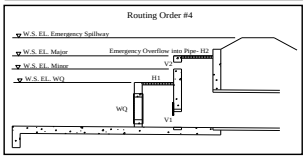
STAGE-DISCHARGE SIZING OF THE WEIRS AND ORIFICES (INLET CONTROL)

Project: **Johnson Trust 13-I Facilities**
Basin ID: **Proposed Basin 1**









Current Routing Order is #3

Design Information (Input):

			#1 Horiz.	#2 Horiz.	#1 Vert.	#2 Vert.	
Circular Opening:	Diameter in Inches	Dia. =					inches
OR							
Rectangular Opening:	Width in Feet	W =	2.92		0.98		ft.
	Length (Height for Vertical)	L or H =	5.67		0.65		ft.
	Percentage of Open Area After Trash Rack Reduction	% open =	50		100		%
	Orifice Coefficient	C_o =	0.61		0.65		
	Weir Coefficient	C_w =	3.00				
	Orifice Elevation (Bottom for Vertical)	E_o =	4912.90		4,911.35		ft.

Calculation of Collection Capacity:

Net Opening Area (after Trash Rack Reduction)	A_o =	8.28		0.64		sq. ft.
OPTIONAL: User-Overide Net Opening Area	A_o =					sq. ft.
Perimeter as Weir Length	L_w =	14.26	ft.			
OPTIONAL: User-Overide Weir Length	L_w =		ft.			

Top Elevation of Vertical Orifice Opening, Top = 4912.00 ft.
Center Elevation of Vertical Orifice Opening, Cen = 4911.68 ft.

Routing 3: Single Stage - Water flows through WQCV plate and #1 horizontal opening into #1 vertical opening. This flow will be applied to culvert sheet (#2 vertical & horizontal openings is not used).

			Horizontal Orifices				**Vertical Orifices**			
Labels for WQCV, Minor, & Major Storage W.S. Elevations (input)	Water Surface Elevation ft (linked)	WQCV Plate/Riser Flow cfs (User-linked)	#1 Horiz. Weir Flow cfs (output)	#1 Horiz. Orifice Flow cfs (output)	#2 Horiz. Weir Flow cfs (output)	#2 Horiz. Orifice Flow cfs (output)	#1 Vert. Collection Capacity cfs (output)	#2 Vert. Collection Capacity cfs (output)	**Total Collection Capacity cfs (output)**	Target Volumes for WQCV, Minor, & Major Storage Volumes (link for goal seek)
	4911.60	0.00	0.00	0.00	0.00	0.00	0.45	0.00	**0.00**	
	4912.00	0.00	0.00	0.00	0.00	0.00	1.90	0.00	**0.00**	
	4912.50	0.00	0.00	0.00	0.00	0.00	3.03	0.00	**0.00**	
WQCV	4912.70	0.00	0.00	0.00	0.00	0.00	3.38	0.00	**0.00**	
10 yr	4913.00	0.00	1.35	12.81	0.00	0.00	3.84	0.00	**1.36**	
	4913.50	0.01	19.88	31.39	0.00	0.00	4.51	0.00	**4.51**	
100 yr	4914.00	0.01	49.35	42.50	0.00	0.00	5.09	0.00	**5.09**	
	4914.30	0.01	70.87	47.95	0.00	0.00	5.41	0.00	**5.41**	
	4915.00	0.01	130.19	58.72	0.00	0.00	6.09	0.00	**6.09**	
		0.02	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.02	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.02	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.03	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.03	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.03	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.04	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.04	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.04	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.04	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.05	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.05	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.05	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.05	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.05	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.06	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.06	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.06	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.06	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.06	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.06	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.07	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
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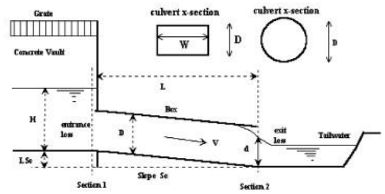
		0.07	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.07	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		0.07	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	
		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.00	**#N/A**	

STAGE-DISCHARGE SIZING OF THE OUTLET CULVERT (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: **Johnson Trust 13-I Facilities**
Basin ID: **Proposed Basin 1**

Status: Culvert Data is valid!



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches	D =	15	in.
Circular Culvert: Inlet Edge Type (choose from pull-down list)		Square End with Headwall	
OR:			
Box Culvert: Barrel Height (Rise) in Feet	Height (Rise) =		ft.
Box Culvert: Barrel Width (Span) in Feet	Width (Span) =		ft.
Box Culvert: Inlet Edge Type (choose from pull-down list)		Square Edge w/ 90-15 deg. Flared Wingwall	
Number of Barrels	No =	1	
Inlet Elevation at Culvert Invert	I_{elev} =	4911.35	ft. elev.
Outlet Elevation at Culvert Invert	O_{elev} =	4910.95	ft. elev.
Culvert Length in Feet	L =	64.0	ft.
Manning's Roughness	n =	0.0130	
Bend Loss Coefficient	K_b =	0.00	
Exit Loss Coefficient	K_x =	1.00	

Design Information (calculated):

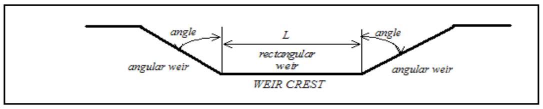
Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	1.48
Sum of All Loss Coefficients	K_s =	2.98
Orifice Inlet Condition Coefficient	C_d =	0.86
Minimum Energy Condition Coefficient	KE_{low} =	-0.09

Calculations of Culvert Capacity (output):

Water Surface Elevation From Sheet "Basin" (ft., linked)	Tailwater Surface Elevation ft (input if known)	Culvert Inlet-Control Flowrate cfs (output)	Culvert Outlet-Control Flowrate cfs (output)	Flowrate Into Culvert From Sheet "Outlet" (cfs, linked)	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used (output)
4911.60	0.00	0.20	2.32	**0.00**	**0.00**	Min. Energy. Eqn.
4912.00	0.00	1.50	2.58	**0.00**	**0.00**	Regression Eqn.
4912.50	0.00	3.50	3.17	**0.00**	**0.00**	Regression Eqn.
4912.70	0.00	4.40	3.63	**0.00**	**0.00**	Regression Eqn.
4913.00	0.00	5.60	4.47	**1.36**	**1.36**	Regression Eqn.
4913.50	0.00	7.10	5.64	**4.51**	**4.51**	Regression Eqn.
4914.00	0.00	8.40	6.64	**5.09**	**5.09**	Regression Eqn.
4914.30	0.00	10.40	8.27	**5.41**	**5.41**	Regression Eqn.
4915.00	0.00	0.00	0.00	**6.09**	**0.00**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)
0.00	0.00	0.00	0.00	**#N/A**	**#N/A**	No Flow (WS < inlet)

STAGE-DISCHARGE SIZING OF THE SPILLWAY

Project: **Johnson Trust 13-I Facilities**
Basin ID: **Basin 1**



Design Information (input):

Bottom Length of Weir	L =	40.00	feet
Angle of Side Slope Weir	Angle =	75.96	degrees
Elev. for Weir Crest	EL. Crest =	4,914.00	feet
Coef. for Rectangular Weir	C_w =	3.00	
Coef. for Trapezoidal Weir	C_t =	2.51	

Calculation of Spillway Capacity (output):

	Water Surface Elevation ft. (linked)	Rect. Weir Flowrate cfs (output)	Triangle Weir Flowrate cfs (output)	Total Spillway Release cfs (output)	Total Pond Release cfs (output)
	4911.60	0.00	0.00	0.00	0.00
	4912.00	0.00	0.00	0.00	0.00
	4912.50	0.00	0.00	0.00	0.00
	4912.70	0.00	0.00	0.00	0.00
	4913.00	0.00	0.00	0.00	1.36
	4913.50	0.00	0.00	0.00	4.51
100 YR	4914.00	0.00	0.00	0.00	5.09
100 YR+0.3 FT	4914.30	19.72	0.49	20.21	25.62
	4915.00	120.00	10.04	130.04	130.04
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A	#N/A	#N/A

Water Quality Trash Screen Sizing

Ref: UDFCD V3 Chapter 4 T-12 Outlet Structures Table OS-2a and OS-2b
The Diameter from WQCV Outlet Spreadsheet = 0.625" < 1.25 "

Table OS-2a. Trash Rack Sizing for Small Circular Orifices (up to 1-1/4" diameter)[1,3]

Number of Columns	Diameter of Circular Orifice (in)	Width of Trash Rack Opening ($W_{opening}$) as a Function of Water Depth H Above Lowest Perforation				
		H=2.0'	H=3.0'	H=4.0'	H=5.0'	H=6.0'
1	≤ 1-1/4	12"[2]	12"[2]	12"[2]	12"	13"

For D < 1.25" and WQCV Depth H <2', the Min recommended width is 12"

[1] For use with Johnson VEE WireTM Stainless Steel Screen1 (or equivalent screen with 60% open area). Assumes inundation of well screen into the permanent pool 2'4".

[2] Represents the minimum recommended width of 12 inches, otherwise width is calculated based on Figure OS-1.

[3] This table provides the minimum opening in the concrete, not the minimum width of the well screen. Ensure the well screen is wide enough to properly attach to the structure.

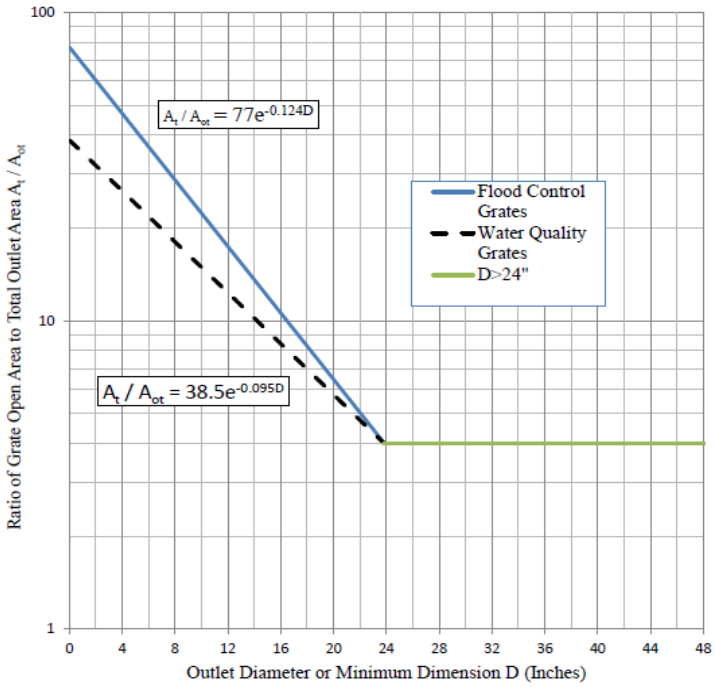
Concrete opening = 2 ft > minimum 1 ft ==> OK

Table OS-2b. Trash Rack Specifications for Circular Orifice Plates

Max. Width of Opening (in)	Screen #93 VEE Wire Slot Opening (in)	Support Rod Type	Support Rod, On Center, Spacing	Total Screen Thickness	Carbon Steel Frame Type
≤18	0.139	TE 0.074"x0.50"	1"	0.655"	¾" x 1.0 angle
≤24	0.139	TE 0.074"x0.75"	1"	1.03"	1.0" x 1½" angle
≤27	0.139	TE 0.074"x0.75"	1"	1.03"	1.0" x 1½" angle
≤30	0.139	TE 0.074"x1.0"	1"	1.155"	1 ¼"x 1½" angle
≤36	0.139	TE 0.074"x1.0"	1"	1.155"	1 ¼"x 1½" angle
≤42	0.139	TE 0.105"x1.0"	1"	1.155"	1 ¼"x 1½" angle

[1] Johnson Screens, St. Paul, Minnesota, USA (1-800-833-9473)

Trash Rack Sizing



UD-Dentention_v2.34 Restrictor Plate Sizing for Circular Vertical Orifices

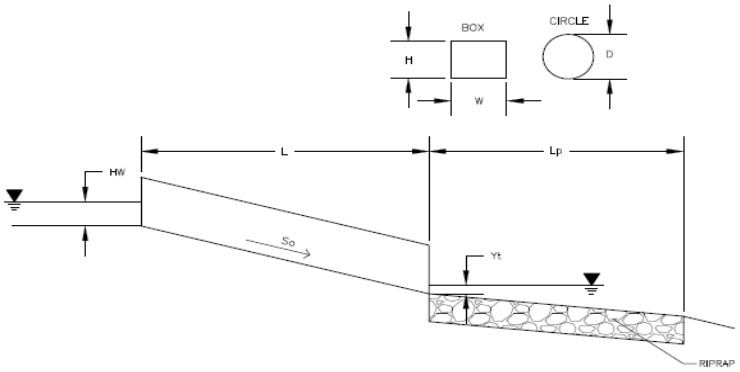
Minimum Open Area of Trash Rack		
Number of Pipes, n		1
Diameter of Pipes	in	15
Total Outlet Area, A_{ot}	ft^2	0.64
Equivalent Diameter, D	ft	0.90
Equivalent Diameter, D	in	10.83
Ratio of trash rack open area to total outlet area, $A_t/A_{ot,}$ ($A_t/A_{ot} = 77e^{-0.124*D}$, use 4 if D$\geq$ 24")		20.10
Minimum Trash Rack open Area, $A_t = (A_t/A_{ot})*A_{ot}$	ft^2	12.86

Actual Open Area of Trash Rack		
Number of Trash Racks, n_T		2
Effective Total Width, W_T	ft	2.875
Effective Total Width, W_T	in	34.5
Effective Total Length, L_T	ft	3.1875
Effective Total Length, L_T	in	38.25
Number of Rods, n_R		11
Thickness of Rods, T_R	in	0.375
Total Thickness of Rods, $T_{TR} = n_R*T_R$	in	4.125
Number of Bars, n_B		18
Thickness of Bars, T_B	in	0.375
Total Thickness of Bars, $T_{TB} = n_B*T_B$	in	6.75
Total Open Area of Trash Rack, A_{ot} $A_{ot} = n*(W_T-T_{TR})*(L_T-T_{TB})$	in^2	1913.63
Total Open Area of Trash Rack, A_{ot}	ft^2	13.29

Max Clear Spacing of Trash Rack = min(50%*D, 6 in)	in	5.4
Actual Spacing of Rods	in	3.0

Determination of Culvert Headwater and Outlet Protection

Project: Bybee 14-L Facility
Basin ID: Outlet Pipe Rip Rap Sizing



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Design Information (Input):

	Design Discharge	Q =	5.12	cfs
Circular Culvert:				
	Barrel Diameter in Inches	D =	15	inches
	Inlet Edge Type (Choose from pull-down list)		Square End with Headwall	
Box Culvert:			**OR**	
	Barrel Height (Rise) in Feet	Height (Rise) =		ft
	Barrel Width (Span) in Feet	Width (Span) =		ft
	Inlet Edge Type (Choose from pull-down list)			
	Number of Barrels	No =	1	
	Inlet Elevation	Elev IN =	4911.35	ft
	Outlet Elevation **OR** Slope	Elev OUT =	4910.95	ft
	Culvert Length	L =	64	ft
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	k_b =	0	
	Exit Loss Coefficient	k_x =	1	
	Tailwater Surface Elevation	Elev Y_t =		ft
	Max Allowable Channel Velocity	V =	5.5	ft/s

Required Protection (Output):

Tailwater Surface Height	Y_t =	0.50	ft
Flow Area at Max Channel Velocity	A_t =	0.93	ft^2
Culvert Cross Sectional Area Available	A =	1.23	ft^2
Entrance Loss Coefficient	k_e =	0.50	
Friction Loss Coefficient	k_f =	1.48	
Sum of All Losses Coefficients	k_s =	2.98	ft
Culvert Normal Depth	Y_n =	1.02	ft
Culvert Critical Depth	Y_c =	0.92	ft
Tailwater Depth for Design	d =	1.08	ft
Adjusted Diameter **OR** Adjusted Rise	D_a =	-	ft
Expansion Factor	1/(2*tan(Θ)) =	4.51	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/D^2.5 =	2.93	$ft^{0.5}/s$
Froude Number	Fr =	0.79	
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/D =	0.40	
Inlet Control Headwater	HW_I =	1.53	ft
Outlet Control Headwater	HW_O =	1.49	
Design Headwater Elevation	**HW =**	**4,912.88**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**1.22**	
Minimum Theoretical Riprap Size	d_{50} =	3	in
Nominal Riprap Size	d_{50} =	6	in
UDFCD Riprap Type	**Type =**	**VL**	**Use Type M**
Length of Protection	**L_p =**	**4**	**ft**
Width of Protection	**T =**	**3**	**ft**

DETENTION POND EMERGENCY SPILLWAY REF:

REFERENCE UDFCD VOL.2 STORAGE

Broad-Crested Weir: The equation typically used for a broad-crested weir is:

$$Q = C_{BCW} L H^{1.5} \qquad \text{(SO-18)}$$

in which:

Q = discharge (cfs)

C_{BCW} = broad-crested weir coefficient (This ranges from 2.38 to 3.32 as per Brater and King (1976). A value of 3.0 is often used in practice.)

L = broad-crested weir length (ft)

H = head above weir crest (ft)

V-Notch Weir: The discharge through a V-notch or triangular weir is shown in Figure SO-5 and can be calculated from the following equation:

$$Q = C_t \tan\left(\frac{\theta}{2}\right) H^{2.5} \qquad \text{(SO-20)}$$

in which:

C_t = Coefficient for Triangular Weir taken from the table below

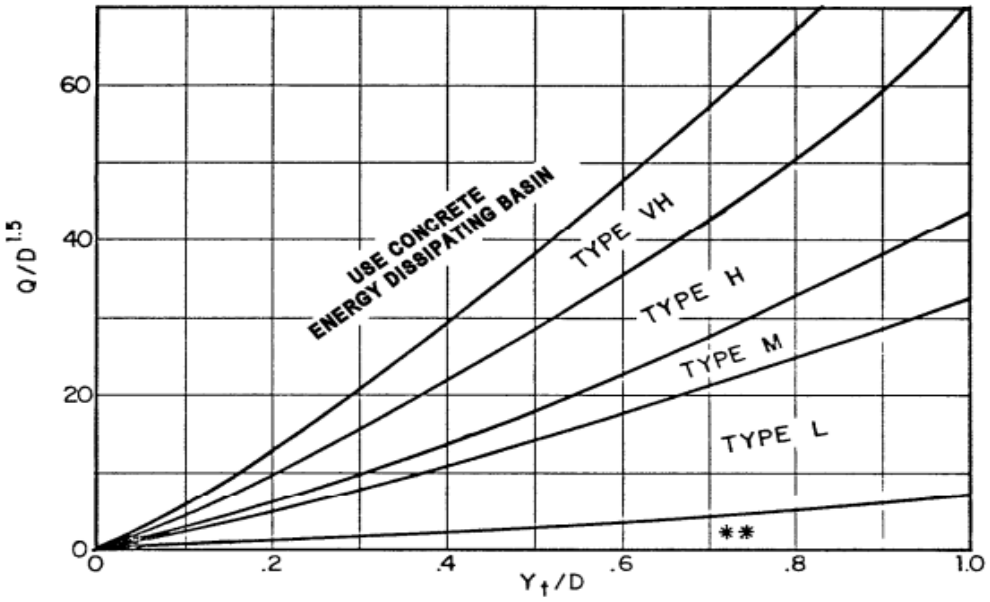
Q = discharge (cfs)

θ = angle of V-notch in degrees

H = head above the apex of V-notch (ft)

Riprap Sizing

Ref: UDFCD V1. Major Drainage Section 4.4.2.3 and Section 7.0-7.4



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

Figure MD-21—Riprap Erosion Protection at Circular Conduit Outlet Valid for $Q/D^{2.5} \leq 6.0$

Table MD-10—Riprap Requirements for Channel Linings*

$\frac{VS^{0.17}}{(G_s-1)^{0.66}}$ **	Rock Type
< 3.3	VL** (d_{50} = 6 inches)
≥ 3.3 to < 4.0	L** (d_{50} = 9 inches)
≥ 4.0 to < 4.6	M (d_{50} = 12 inches)
≥ 4.6 to < 5.6	H (d_{50} = 18 inches)
≥ 5.6 to 6.4	VH (d_{50} = 24 inches)

* Applicable only for a Froude number of < 0.8 and side slopes no steeper than 2H:1V.

** Use G_s = 2.5 unless the source of rock and its density are known at time of design.

Riprap Sizing

Ref: UDFCD V1. Major Drainage Section 4.4.2.3 and Section 7.0-7.4

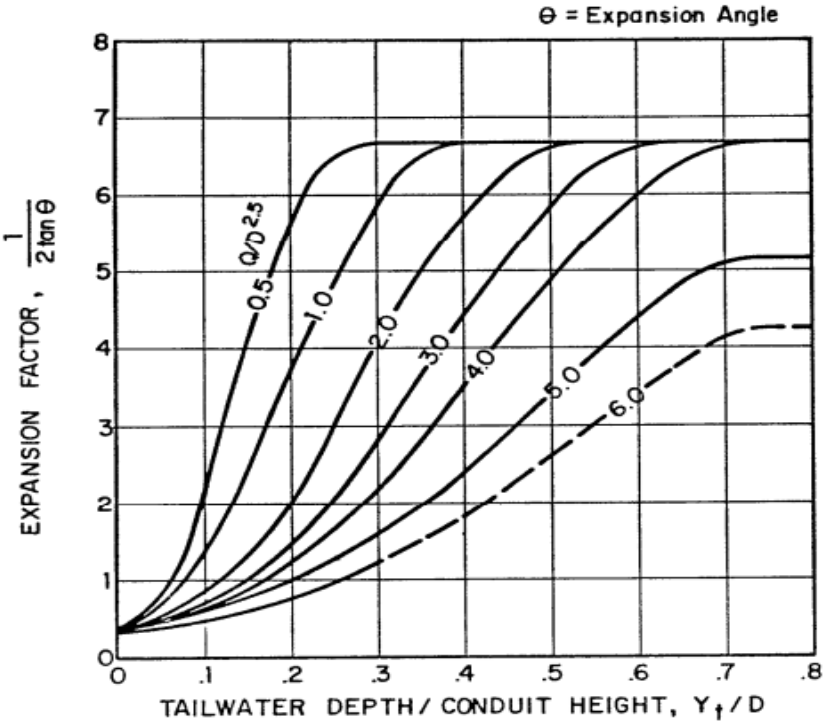


Figure MD-23—Expansion Factor for Circular Conduits

$$A_t = \frac{Q}{V} \qquad \text{(MD-23)}$$

where:

Q = design discharge (cfs)

V = the allowable non-eroding velocity in the downstream channel (ft/sec)

A_t = required area of flow at allowable velocity (ft²)

$$L_p = \left(\frac{1}{2\tan\theta}\right)\left(\frac{A_t}{Y_t} - W\right) \qquad \text{(MD-22)}$$

where:

L_p = length of protection (ft)

W = width of the conduit in (ft) (use diameter for circular conduits)

Y_t = tailwater depth (ft)

θ = the expansion angle of the culvert flow

Offsite Swale Analysis

The following analysis involves evaluation of the water depth for the perimeter swales

Given the following calculated values for the Off site basin 100-YR historic flow rate

Calculated Values: (See Appendix B-5)

Off-site Basin 1 100-YR historic flow rate: 6.5 cfs

Off-site Basin 2 100-YR historic flow rate: 0.6 cfs

To evaluate the capacity of perimeter swales, Off-site basin 1 100-YR historical flow rate is selected. The characteristics of the proposed swales are designed as shown below:

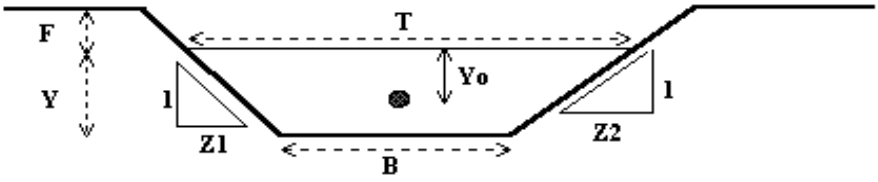
Characteristics:

Slope of the swales	0.008 ft/ft
Bottom Width: B =	2 ft
Swale Side Slope	3ft/ft
Manning's Coefficient: n =	0.03

The above parameters were entered into the UD-Channels Spreadsheets to determine the water depth at 100-YR historic flow rate (7.1 cfs). Please refer to Appendix C-14 the Normal Flow Analysis Trapezoidal Channel for details. Based on this analysis, a swale of 1 ft in height is 0.31 ft taller than the calculated water depth. Thus, the perimeter swale with 1 ft height, 8 ft wide and 3:1 slope is sufficient to convey offsite flow.

Normal Flow Analysis - Trapezoidal Channel

Project: Johnson Trust 13-I Facilities
Channel ID: Offsite Swales



Design Information (Input)			
Channel Invert Slope	So =	0.0080	ft/ft
Manning's n	n =	0.030	
Bottom Width	B =	2.00	ft
Left Side Slope	Z1 =	3.00	ft/ft
Right Side Slope	Z2 =	3.00	ft/ft
Freeboard Height	F =	0.31	ft
Design Water Depth	Y =	**0.69**	ft

Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**7.23**	cfs
Froude Number	**Fr =**	**0.67**	
Flow Velocity	**V =**	**2.57**	fps
Flow Area	A =	2.81	sq ft
Top Width	T =	6.14	ft
Wetted Perimeter	P =	6.36	ft
Hydraulic Radius	R =	0.44	ft
Hydraulic Depth	D =	0.46	ft
Specific Energy	Es =	0.79	ft
Centroid of Flow Area	Yo =	0.29	ft
Specific Force	Fs =	0.09	kip

Berm Analysis for MLVT

The following analysis involves evaluation of the water depth and velocity of the discharge in the event of The MLVT failure.

Given the following characteristics of the MLVT and assumptions of a MLVT failure:

Given:

Diameter: D= 157 ft
Capacity: Vol = 42,000 Barrels = 1,764,000 Gallons
= 235,813 cubic feet

In the event of MLVT failure, the assumption is shown as follows:

Assumption:

Slope of the sheet flow 0.03 ft/ft
sheet flow width: B = 100 ft
MLVT Drain Time: T= 10 min = 600 Sec
Manning's Coefficient: n = 0.03

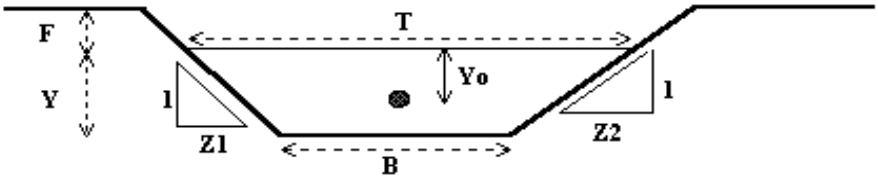
the discharge is calculated as follows:

Discharge: Q = Vol / T
= 235,813 ft^3 / 600 Sec
= 393.02 cfs

The above parameters were entered into the UD-Channels Spreadsheets to determine the discharge velocity. Please refer to Appendix C-16 the Normal Flow Analysis Trapezoidal Channel for details. Based on this analysis, the resulting water depth given the above parameters would be 0.63 feet. In addition, the calculations indicate the flow velocity (6.25 fps) is smaller than the allowable velocity (7 fps) per UDFCD Table MD-14 Guidelines of Use of Various Types of Channels.
This analysis indicates that the cut slopes on the east and north edges of the pad (with minimum heights of 6.3 feet and 4.8 feet respectively) and the 10' tall topsoil stockpile along the south edge of the site would be sufficient to direct water away from the surrounding development in these directions. In the event of a failure, the water would be directed towards the low point along Weld County Road 11, where it will then be carried west towards the Godding Hollow major drainage channel.

Normal Flow Analysis - Trapezoidal Channel

Project: Johnson Trust 13-I Facilities
Channel ID: Berm



Design Information (Input)			
Channel Invert Slope	So =	0.0300	ft/ft
Manning's n	n =	0.030	
Bottom Width	B =	100.00	ft
Left Side Slope	Z1 =	0.00	ft/ft
Right Side Slope	Z2 =	0.00	ft/ft
Freeboard Height	F =	1.00	ft
Design Water Depth	Y =	**0.63**	ft

Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**391.86**	cfs
Froude Number	**Fr =**	**1.39**	
Flow Velocity	**V =**	**6.25**	fps
Flow Area	A =	62.70	sq ft
Top Width	T =	100.00	ft
Wetted Perimeter	P =	101.25	ft
Hydraulic Radius	R =	0.62	ft
Hydraulic Depth	D =	0.63	ft
Specific Energy	Es =	1.23	ft
Centroid of Flow Area	Yo =	0.31	ft
Specific Force	Fs =	5.98	kip

Analysis of Culverts

The following is an analysis of the sizing of the proposed culverts for the Johnson Trust 13-I Facility

Analysis of Proposed Roadside Ditch

Given the following analysis of the cross section for the proposed reroute of the Weld County 11 roadside ditch:

Calculated Values: (See Appendix C-20)

Proposed Reroute Channel Slope	2.00%	
Bottom Width	1.10 ft	
Left Side Slope	9:1	
Right Side Slope	6:1	
Design Water Depth (depth of channel):	0.44 ft	
Maximum Flow Capacity (channel full)	5.51cfs	see appendix C-18

Analysis of Drainage Channel Culverts

The proposed horizontal elliptical culvert (see detail pg. DP6) was designed to convey the flow of the existing roadside ditch when the ditch is at it's maximum capacity. The culvert, 14" rise x 23" span, will convey a flow of 6.10 cfs when it is at maximum capacity, or 4916.68 ft when compared to the maximum capacity of the 18" equivalent circular pipe (appendix C-19). the required outlet protection was then designed from these calculations.

The western swale is designed to convey a flow produced by approximately 1 acre of the proposed basin. Therefore, since flow rate is directly proportional to area, the design capacity of the swale is [(1.0 acre / 6.02 acre)*18.0 cfs] = 3.0 cfs. This capacity can be achieved by a 18" equivalent horizontal elliptical culvert underneath the access road.

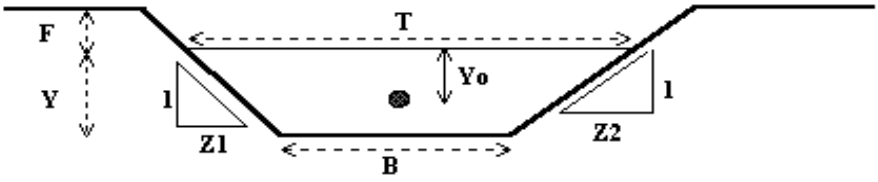
Characteristics:	**Roadside Drainage Channel Culvert**	**Western Swale Drainage Culvert**
Required Capacity =	5.51 cfs	3.0 cfs
Proposed Culverts:	1 - 14" x 23" Elliptical RCP	1 - 14" x 23" Elliptical RCP
Equivalent Diameter =	18"	18"
Inlet Edge Type =	Square End Projects	Square End Projects
Number of Barrels =	1	1
Inlet Elevation =	4915.21'	4917.23'
Outlet Elevation =	4914.8'	4916.9'
Length =	36	16
Manning's Roughness =	0.013	0.013
Design HW Elevation =	4916.4'	4918.23'
Calculated Flow Capacity at Design HW Elevation =	6.10 cfs	3.4 cfs
Rip Rap Sizing =	Type M, 3' x 5'	Type M, 3' x 5'

Conclusion

The western swale drainage culvert has the ability to convey a flow of 3.4 cfs, exceeding the required flow based on the 100 year developed flow of 1.0 acre of the proposed basin. The proposed roadside drainage channel will run at a -2.00% grade and hit a maximum capacity of 5.51 cfs at a maximum depth of 0.44 ft (appendix C-19). Rip-rap, of type M for saftey considerations, is sized for both culvert outlets to be 3' by 5' (appendix C-20, 22).

Normal Flow Analysis - Trapezoidal Channel

Project: Johnson Trust 13-I Facilities
Channel ID: Weld County Road 11 Borrow Ditch Reroute

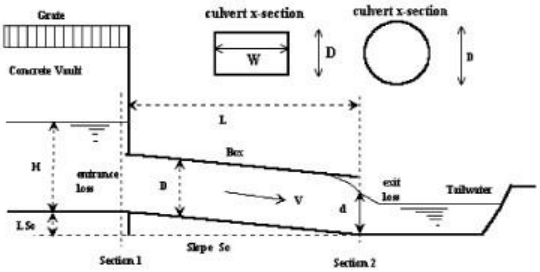


Design Information (Input)			
Channel Invert Slope	So =	0.0200	ft/ft
Manning's n	n =	0.030	
Bottom Width	B =	1.10	ft
Left Side Slope	Z1 =	6.00	ft/ft
Right Side Slope	Z2 =	9.00	ft/ft
Freeboard Height	F =	0.00	ft
Design Water Depth	Y =	**0.44**	ft

Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**5.39**	cfs
Froude Number	**Fr =**	**0.98**	
Flow Velocity	**V =**	**2.78**	fps
Flow Area	A =	1.94	sq ft
Top Width	T =	7.70	ft
Wetted Perimeter	P =	7.76	ft
Hydraulic Radius	R =	0.25	ft
Hydraulic Depth	D =	0.25	ft
Specific Energy	Es =	0.56	ft
Centroid of Flow Area	Yo =	0.16	ft
Specific Force	Fs =	0.05	kip

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Johnson Trust 13-I
Basin ID: Weld County Road 11 Ditch Culvert
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches — D = 18 inches
Inlet Edge Type (choose from pull-down list) — Square End Projection

OR:

Box Culvert: Barrel Height (Rise) in Feet — Height (Rise) = ft.
Barrel Width (Span) in Feet — Width (Span) = ft.
Inlet Edge Type (choose from pull-down list) — Square Edge w/ 30-78 deg. Flared Wingwall

Number of Barrels	No =	1	
Inlet Elevation at Culvert Invert	Inlet Elev =	4915.21	ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	4914.8	ft. elev.
Culvert Length in Feet	L =	36	ft.
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	K_b =	0	
Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

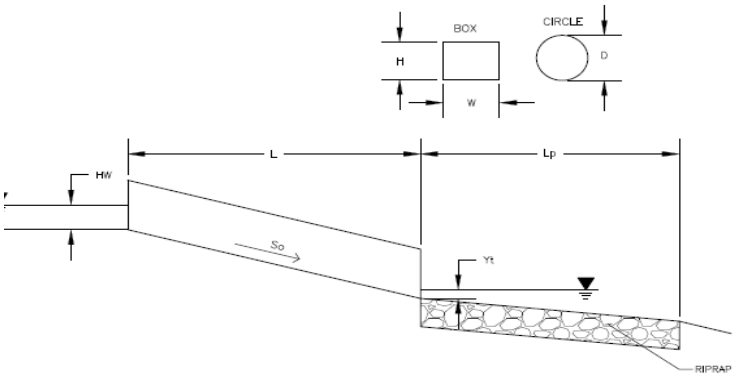
Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	0.65
Sum of All Loss Coefficients	K_s =	2.15
Orifice Inlet Condition Coefficient	C_d =	0.85
Minimum Energy Condition Coefficient	KE_{low} =	0.0070

Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
4915.48		0.30	3.87	**0.30**	Min. Energy. Eqn.	INLET
4915.58		0.60	3.92	**0.60**	Min. Energy. Eqn.	INLET
4915.68		0.90	3.98	**0.90**	Min. Energy. Eqn.	INLET
4915.78		1.30	4.04	**1.30**	Min. Energy. Eqn.	INLET
4915.88		1.80	4.15	**1.80**	Min. Energy. Eqn.	INLET
4915.98		2.20	4.32	**2.20**	Regression Eqn.	INLET
4916.08		2.70	4.54	**2.70**	Regression Eqn.	INLET
4916.18		3.20	4.76	**3.20**	Regression Eqn.	INLET
4916.28		3.70	4.99	**3.70**	Regression Eqn.	INLET
4916.38		4.30	4.99	**4.30**	Regression Eqn.	INLET
4916.48		4.90	5.27	**4.90**	Regression Eqn.	INLET
4916.58		5.50	5.72	**5.50**	Regression Eqn.	INLET
4916.68		6.10	6.11	**6.10**	Regression Eqn.	INLET
4916.78		6.60	6.73	**6.60**	Regression Eqn.	INLET
4916.88		7.20	7.40	**7.20**	Regression Eqn.	INLET
4916.98		7.70	8.02	**7.70**	Regression Eqn.	INLET
4917.08		8.20	8.58	**8.20**	Regression Eqn.	INLET
4917.18		8.70	9.08	**8.70**	Regression Eqn.	INLET
4917.28		9.10	9.58	**9.10**	Regression Eqn.	INLET
4917.38		9.50	10.09	**9.50**	Regression Eqn.	INLET
4917.48		9.90	10.54	**9.90**	Regression Eqn.	INLET
4917.58		10.30	10.99	**10.30**	Regression Eqn.	INLET
4917.68		10.70	11.38	**10.70**	Regression Eqn.	INLET
4917.78		11.10	11.77	**11.10**	Regression Eqn.	INLET
4917.88		11.40	12.16	**11.40**	Regression Eqn.	INLET
4917.98		11.80	12.56	**11.80**	Regression Eqn.	INLET
4918.08		12.10	12.95	**12.10**	Regression Eqn.	INLET
4918.18		12.40	13.28	**12.40**	Regression Eqn.	INLET
4918.28		12.70	13.62	**12.70**	Regression Eqn.	INLET
4918.38		13.00	13.96	**13.00**	Regression Eqn.	INLET

Determination of Culvert Headwater and Outlet Protection

Project: Johnson Trust 13-I
Basin ID: Weld County Road 11 Ditch Culvert



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Supercritical Flow! Using Da to calculate protection type.

Design Information (Input):

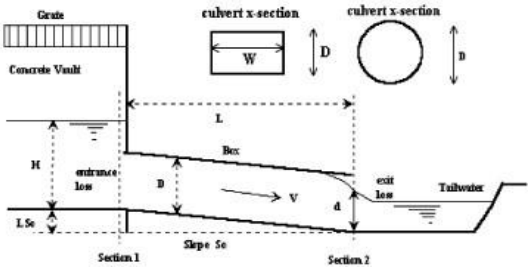
	Design Discharge	Q =	6.1	cfs
Circular Culvert:				
	Barrel Diameter in Inches	D =	18	inches
	Inlet Edge Type (Choose from pull-down list)		Square End Projection	
Box Culvert:			**OR**	
	Barrel Height (Rise) in Feet	Height (Rise) =		ft
	Barrel Width (Span) in Feet	Width (Span) =		ft
	Inlet Edge Type (Choose from pull-down list)			
	Number of Barrels	No =	1	
	Inlet Elevation	Elev IN =	4915.21	ft
	Outlet Elevation **OR** Slope	Elev OUT =	4914.8	ft
	Culvert Length	L =	36	ft
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	k_b =	0	
	Exit Loss Coefficient	k_x =	1	
	Tailwater Surface Elevation	Elev Y_t =		ft
	Max Allowable Channel Velocity	V =	5	ft/s

Required Protection (Output):

Tailwater Surface Height	Y_t =	0.60	ft
Flow Area at Max Channel Velocity	A_t =	1.22	ft^2
Culvert Cross Sectional Area Available	A =	1.77	ft^2
Entrance Loss Coefficient	k_e =	0.50	
Friction Loss Coefficient	k_f =	0.65	
Sum of All Losses Coefficients	k_s =	2.15	ft
Culvert Normal Depth	Y_n =	0.79	ft
Culvert Critical Depth	Y_c =	0.95	ft
Tailwater Depth for Design	d =	1.23	ft
Adjusted Diameter **OR** Adjusted Rise	D_a =	1.14	ft
Expansion Factor	1/(2*tan(Θ)) =	6.57	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/D^2.5 =	2.21	$ft^{0.5}/s$
Froude Number	Fr =	1.44	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/D =	0.52	
Inlet Control Headwater	HW_I =	1.48	ft
Outlet Control Headwater	HW_O =	1.22	
Design Headwater Elevation	**HW =**	**4,916.69**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**0.99**	
Minimum Theoretical Riprap Size	d_{50} =	3	in
Nominal Riprap Size	d_{50} =	6	in
UDFCD Riprap Type	**Type =**	**VL**	**Use Type M**
Length of Protection	**L_p =**	**5**	**ft**
Width of Protection	**T =**	**3**	**ft**

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Johnson Trust 13-I Facilities
Basin ID: Western Basin 1 Culvert Sizing at Access Road
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches — D = 18 inches
Inlet Edge Type (choose from pull-down list) — Square End Projection

OR:

Box Culvert: Barrel Height (Rise) in Feet — Height (Rise) = ft.
Barrel Width (Span) in Feet — Width (Span) = ft.
Inlet Edge Type (choose from pull-down list) — Square Edge w/ 30-78 deg. Flared Wingwall

Number of Barrels	No =	1	
Inlet Elevation at Culvert Invert	Inlet Elev =	4917.23	ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	4916.9	ft. elev.
Culvert Length in Feet	L =	16	ft.
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	K_b =	0	
Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	0.29
Sum of All Loss Coefficients	K_s =	1.79
Orifice Inlet Condition Coefficient	C_d =	0.85
Minimum Energy Condition Coefficient	KE_{low} =	0.0070

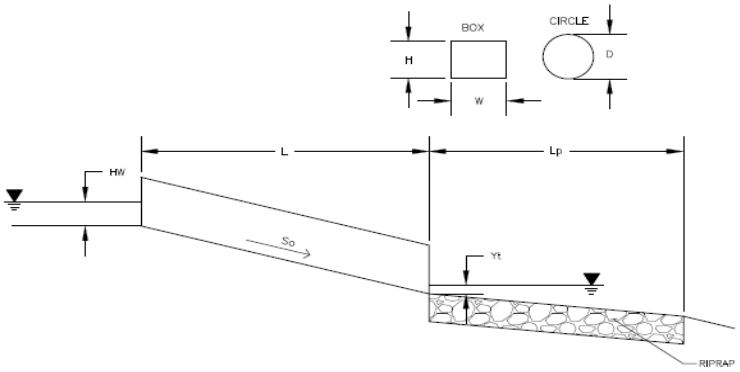
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
4917.23		0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
4917.33		0.10	2.79	**0.10**	Min. Energy. Eqn.	INLET
4917.43		0.20	3.24	**0.20**	Min. Energy. Eqn.	INLET
4917.53		0.30	3.62	**0.30**	Min. Energy. Eqn.	INLET
4917.63		0.70	3.92	**0.70**	Min. Energy. Eqn.	INLET
4917.73		1.00	3.92	**1.00**	Min. Energy. Eqn.	INLET
4917.83		1.40	4.00	**1.40**	Min. Energy. Eqn.	INLET
4917.93		1.90	4.07	**1.90**	Min. Energy. Eqn.	INLET
4918.03		2.30	4.22	**2.30**	Regression Eqn.	INLET
4918.13		2.90	4.37	**2.90**	Regression Eqn.	INLET
4918.23		3.40	4.60	**3.40**	Regression Eqn.	INLET
4918.33		4.00	4.90	**4.00**	Regression Eqn.	INLET
4918.43		4.50	4.98	**4.50**	Regression Eqn.	INLET
4918.53		5.10	5.13	**5.10**	Regression Eqn.	INLET
4918.63		5.70	5.66	**5.66**	Regression Eqn.	OUTLET
4918.73		6.30	6.11	**6.11**	Regression Eqn.	OUTLET
4918.83		6.80	7.01	**6.80**	Regression Eqn.	INLET
4918.93		7.40	7.77	**7.40**	Regression Eqn.	INLET
4919.03		7.90	8.45	**7.90**	Regression Eqn.	INLET
4919.13		8.40	9.13	**8.40**	Regression Eqn.	INLET
4919.23		8.80	9.73	**8.80**	Regression Eqn.	INLET
4919.33		9.30	10.26	**9.30**	Regression Eqn.	INLET
4919.43		9.70	10.79	**9.70**	Regression Eqn.	INLET
4919.53		10.10	11.31	**10.10**	Regression Eqn.	INLET
4919.63		10.50	11.77	**10.50**	Regression Eqn.	INLET
4919.73		10.90	12.29	**10.90**	Regression Eqn.	INLET
4919.83		11.20	12.75	**11.20**	Regression Eqn.	INLET
4919.93		11.60	13.12	**11.60**	Regression Eqn.	INLET
4920.03		11.90	13.58	**11.90**	Regression Eqn.	INLET
4920.13		12.20	13.95	**12.20**	Regression Eqn.	INLET

Processing Time: 72.27 ms

Determination of Culvert Headwater and Outlet Protection

Project: Johnson Trust 13-I
Basin ID: Basin 1 Culvert Sizing at Access Road



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Supercritical Flow! Using Da to calculate protection type.

Design Information (Input):

	Design Discharge	Q =	3.4	cfs
Circular Culvert:				
	Barrel Diameter in Inches	D =	18	inches
	Inlet Edge Type (Choose from pull-down list)		Square End Projection	
Box Culvert:			**OR**	
	Barrel Height (Rise) in Feet	Height (Rise) =		ft
	Barrel Width (Span) in Feet	Width (Span) =		ft
	Inlet Edge Type (Choose from pull-down list)			
	Number of Barrels	No =	1	
	Inlet Elevation	Elev IN =	4917.23	ft
	Outlet Elevation **OR** Slope	Elev OUT =	4916.9	ft
	Culvert Length	L =	16	ft
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	k_b =	0	
	Exit Loss Coefficient	k_x =	1	
	Tailwater Surface Elevation	Elev Y_t =		ft
	Max Allowable Channel Velocity	V =	5	ft/s

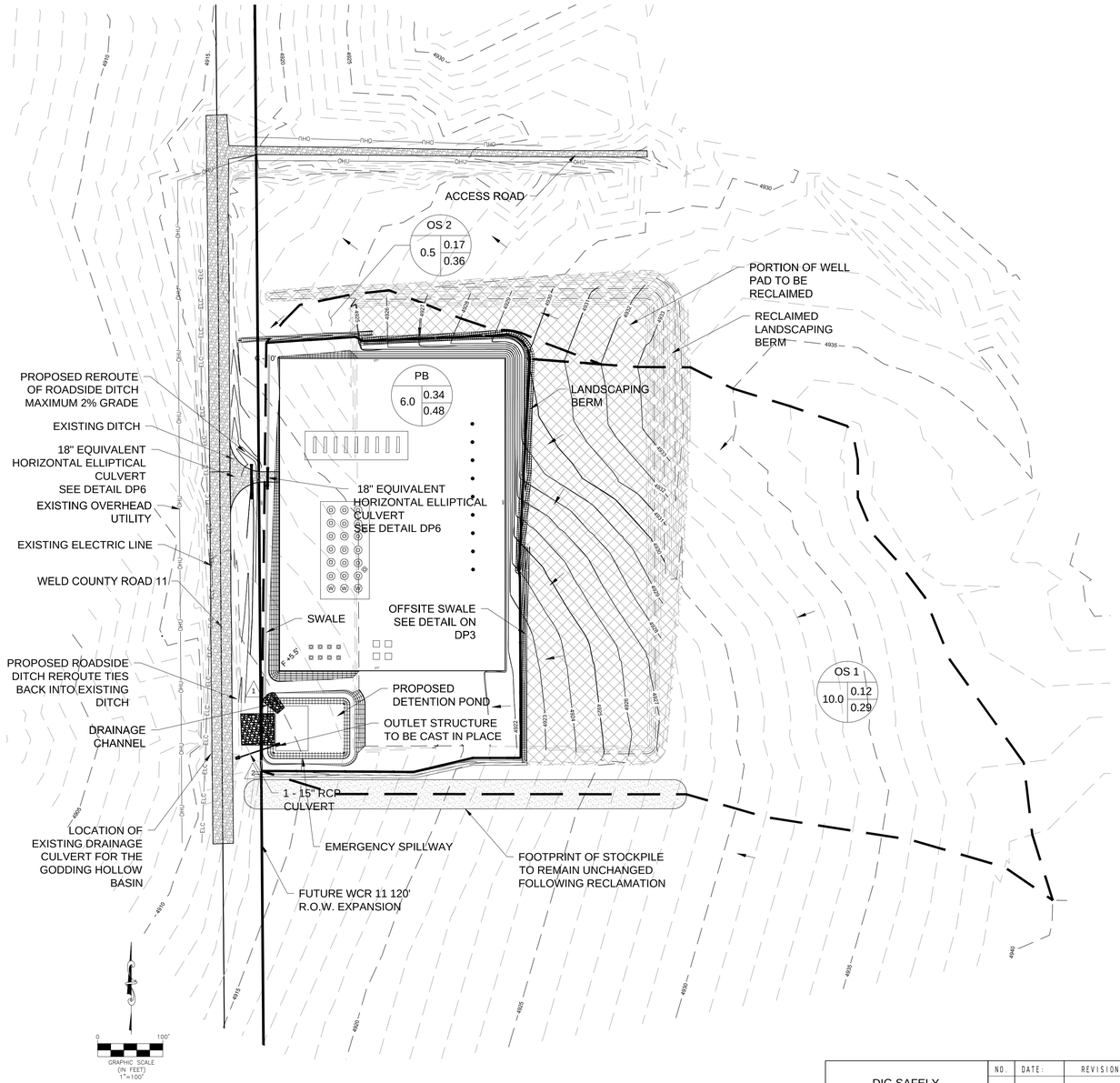
Required Protection (Output):

Tailwater Surface Height	Y_t =	0.60	ft
Flow Area at Max Channel Velocity	A_t =	0.68	ft^2
Culvert Cross Sectional Area Available	A =	1.77	ft^2
Entrance Loss Coefficient	k_e =	0.50	
Friction Loss Coefficient	k_f =	0.29	
Sum of All Losses Coefficients	k_s =	1.79	ft
Culvert Normal Depth	Y_n =	0.48	ft
Culvert Critical Depth	Y_c =	0.70	ft
Tailwater Depth for Design	d =	1.10	ft
Adjusted Diameter **OR** Adjusted Rise	D_a =	0.99	ft
Expansion Factor	1/(2*tan(Θ)) =	6.70	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/D^2.5 =	1.23	$ft^{0.5}/s$
Froude Number	Fr =	2.05	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/D =	0.61	
Inlet Control Headwater	HW_I =	1.01	ft
Outlet Control Headwater	HW_O =	0.87	
Design Headwater Elevation	**HW =**	**4,918.24**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**0.67**	
Minimum Theoretical Riprap Size	d_{50} =	2	in
Nominal Riprap Size	d_{50} =	6	in
UDFCD Riprap Type	**Type =**	**VL**	
Length of Protection	**L_p =**	**5**	**ft**
Width of Protection	**T =**	**3**	**ft**

SPECIAL USE REVIEW USRXX-XXXX
EXTRACTION OIL & GAS. JOHNSON TRUST 13-I FACILITY

SUMMARY RUNOFF TABLE

DESIGN POINT	CONTRIBUTING AREA (ACRES)	DIRECT RUNOFF 10-YR (CFS)	TOTAL RUNOFF 10-YR (CFS)	DIRECT RUNOFF 100-YR (CFS)	TOTAL RUNOFF 100-YR (CFS)	RELEASE RATE (CFS)
1	6.0	6.5	6.5	18.0	18.0	5.12
2	10.0	1.4	1.4	6.5	6.5	--
3	0.5	0.1	0.1	0.6	0.6	--



PROPOSED DRAINAGE PLAN

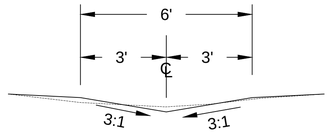
A
B C D

E

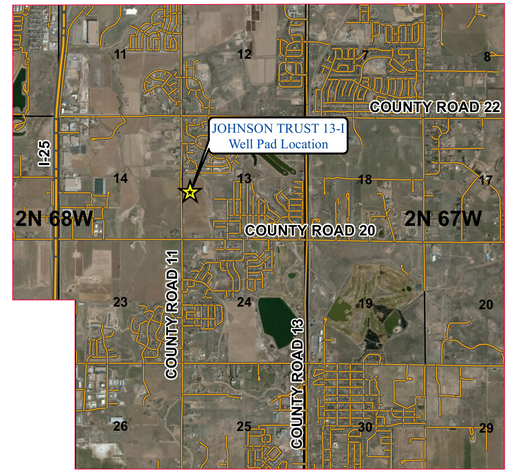
A = BASIN DESIGNATION
B = AREA IN ACRES
C = 10 - YR COMPOSITE RUNOFF COEFFICIENTS
D = 100 - YRCOMPOSITE RUNOFF COEFFICIENTS
E = DESIGN POINT DESIGNATION

LEGEND

- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONOUR
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- BASIN BOUNDARY
- PROPOSED WELL
- FLOW ARROW



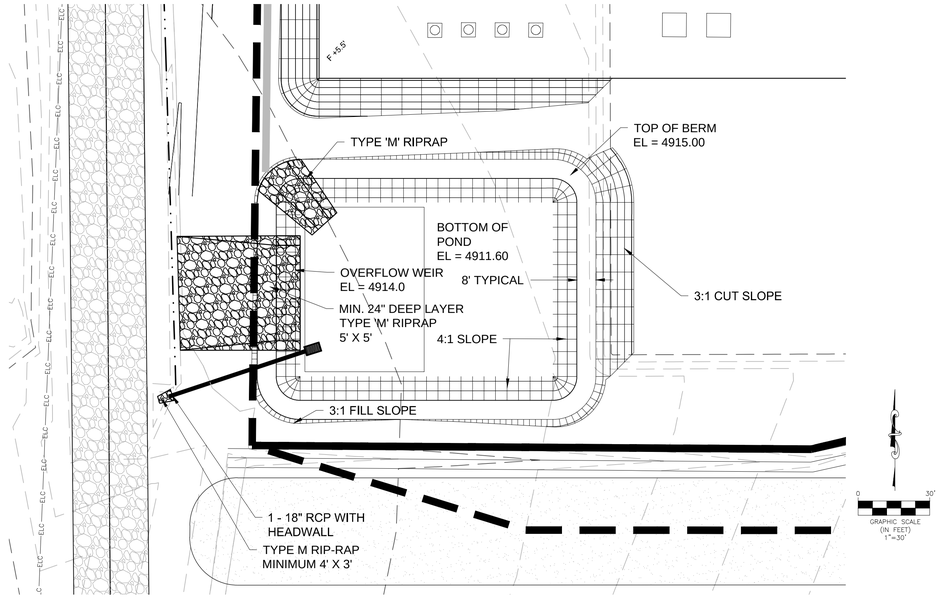
TYPICAL SWALE SECTION
N.T.S.



VICINITY MAP
NOT TO SCALE

SUMMARY DETENTION POND TABLE

WQCV VOLUME (ACRE-FEET)	WQCV ELEVATION (FEET)	10-YR VOLUME (ACRE-FEET)	10-YR ELEVATION (FEET)	100-YR VOLUME (ACRE-FEET)	100-YR ELEVATION (FEET)
0.102	4912.70	0.166	4913.00	0.384	4914.00



DETAILED DETENTION POND

NOTE: THE EXISTING TOPOGRAPHY INFORMATION WAS COLLECTED BY PETROLEUM FIELD SERVICES ON 03-18-2015.

DIG SAFELY BEFORE YOU DIG CALL:
1-800-922-1987
UTILITY NOTIFICATION CENTER OF COLORADO

NO.	DATE:	REVISION DESCRIPTION	NAME

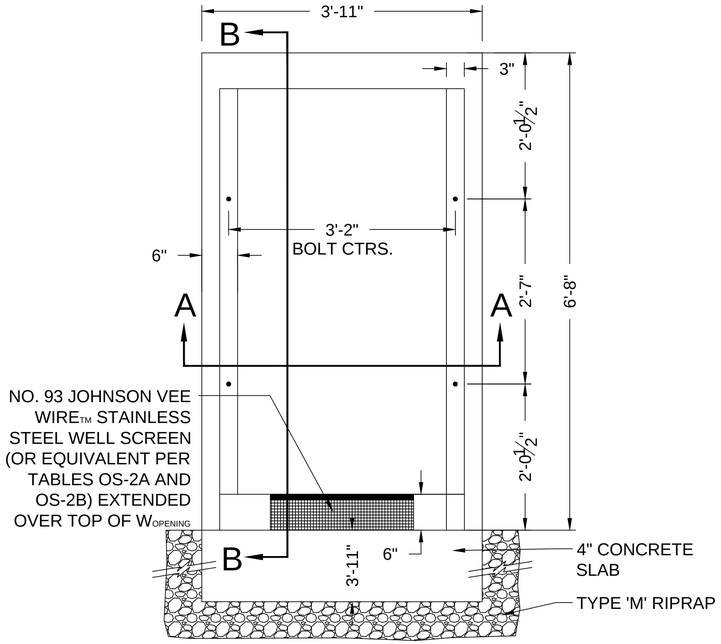
PREPARED FOR:
EXTRACTION Oil & Gas
EXTRACTION OIL & GAS

PREPARED BY:
PFS llc
Petroleum Field Services, LLC
7535 Hilltop Circle
Denver, CO 80221

EXTRACTION OIL & GAS

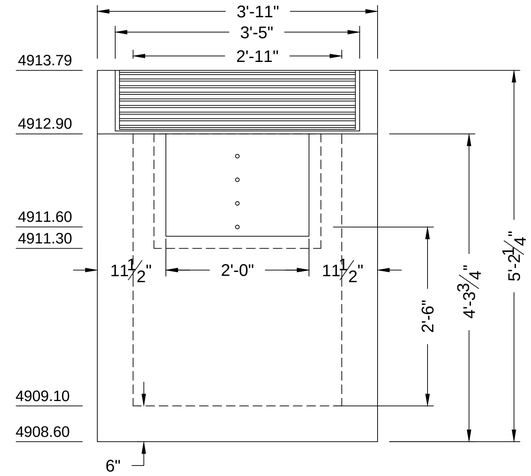
DRAWING DATE: 10/27/2015	DRAWING NAME: DRAINAGE PLAN
DRAWN BY: SWW	SURFACE LOCATION: SECTION 13, TOWNSHIP 2 NORTH RANGE 68 WEST, 6TH P.M. FREDERICK, COLORADO
CHECK BY: MCW	DP1

SPECIAL USE REVIEW USRXX-XXXX
EXTRACTION OIL & GAS. JOHNSON TRUST 13-I FACILITY

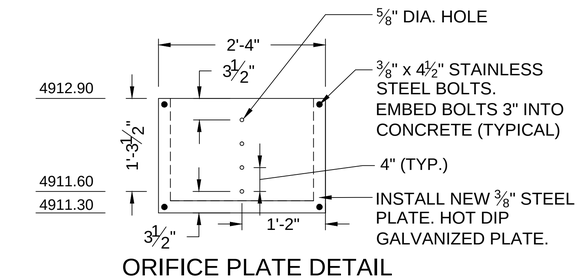


PLAN VIEW

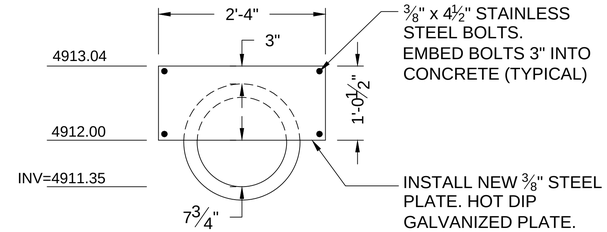
(SHOWING ANCHOR BOLT LAYOUT)



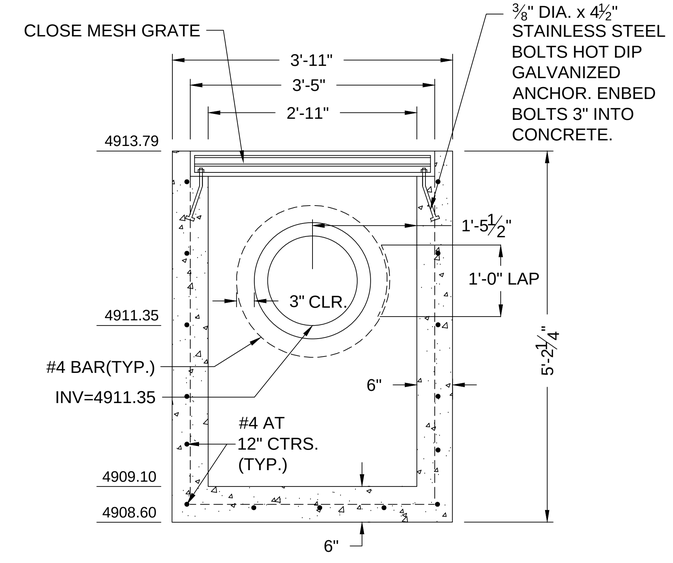
ELEVATION VIEW



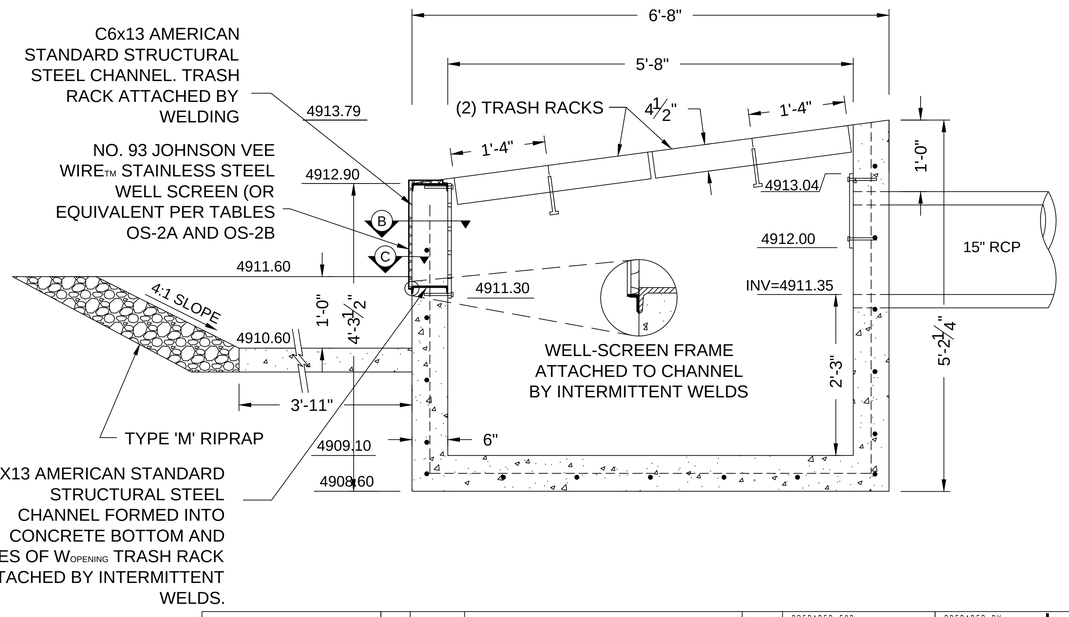
ORIFICE PLATE DETAIL



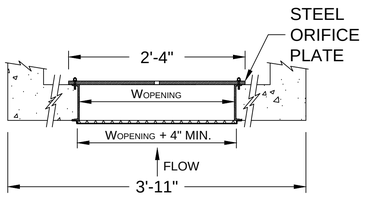
RESTRICTOR PLATE DETAIL



CROSS SECTION A-A

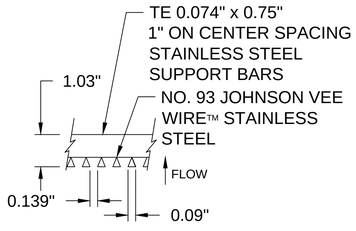


NOTE:
1. OUTLET STRUCTURE TO BE CAST-IN-PLACE
2. REFER TO CDOT TYPE D INLET(M-604-11) FOR REINFORCING BAR SIZE & SPACING.



SECTION B

NTS



SECTION C

NTS

0 1' 2'
GRAPHIC SCALE 1"=1'

DIG SAFELY BEFORE YOU DIG CALL:
1-800-922-1987
UTILITY NOTIFICATION CENTER OF COLORADO

NO.	DATE:	REVISION DESCRIPTION	NAME

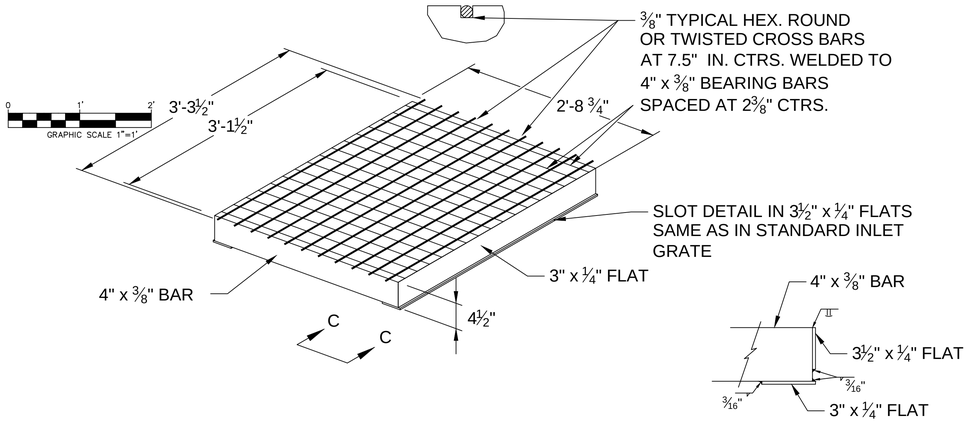
PREPARED FOR: EXTRACTION Oil & Gas
EXTRACTION OIL & GAS

PREPARED BY: PFS
Petroleum Field Services, LLC
7535 Hilltop Circle
Denver, CO 80221

EXTRACTION OIL & GAS

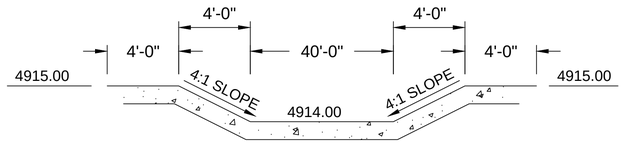
DRAWING DATE: 10-27-15	DRAWING NAME: DRAINAGE DETAILS SHEET 1
DRAWN BY: SWW	SURFACE LOCATION: SECTION 13, TOWNSHIP 2 NORTH RANGE 68 WEST, 6TH P.M. FREDERICK, COLORADO
CHECK BY: MCW	DP2

SPECIAL USE REVIEW USRXX-XXXX
EXTRACTION OIL & GAS. JOHNSON TRUST 13-I FACILITY

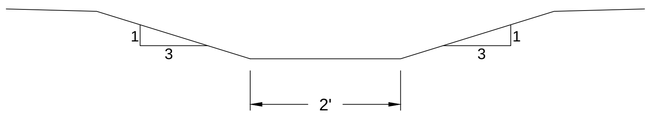


CLOSE MESH GRATE

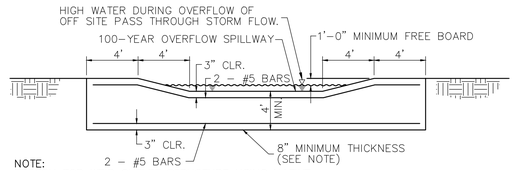
SECTION C-C



CONCRETE WEIR OVERFLOW STRUCTURE



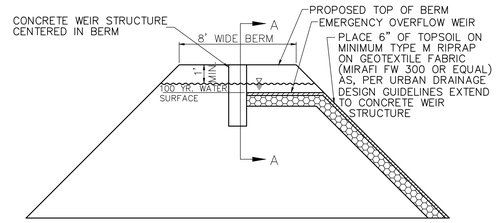
OFFSITE SWALE DETAIL
N.T.S



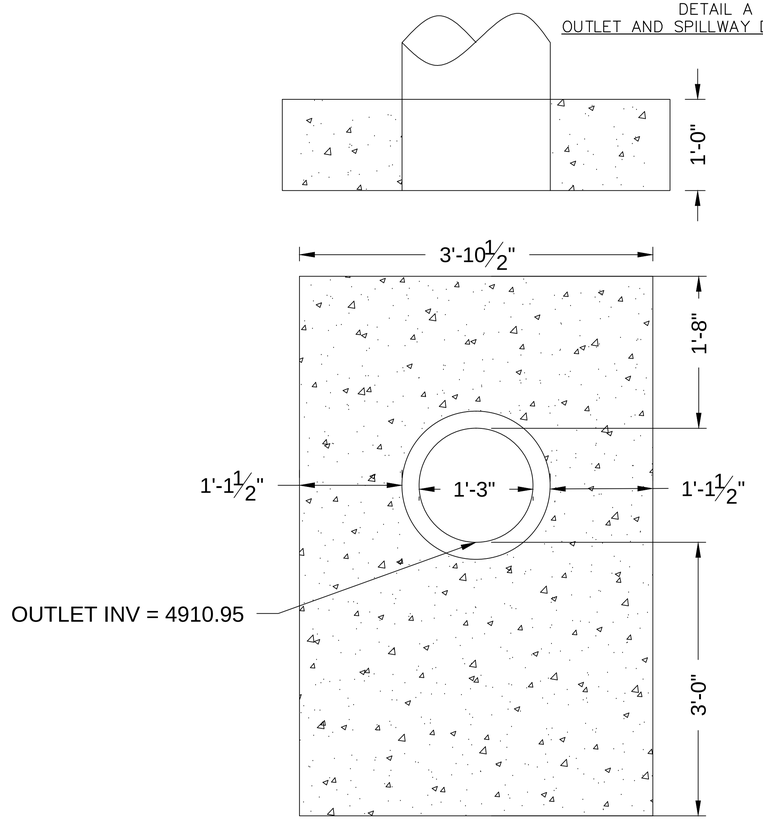
NOTE:
TRENCH FOR WEIR OUTLET STRUCTURE USING NATIVE GROUND AS FORM WORK. CONSTRUCT WEIR 8" MINIMUM THICKNESS. UPON COMPLETION OF TRENCHING, PLACE TEMPERATURE STEEL AND CONCRETE IMMEDIATELY, FORM TOP 4".

SECTION A – A

CONCRETE WEIR OVERFLOW STRUCTURE



DETAIL A
OUTLET AND SPILLWAY DETAILS



HEADWALL FOR PIPE

DIG SAFELY
BEFORE YOU DIG CALL:
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UTILITY NOTIFICATION
CENTER OF COLORADO

NO.	DATE:	REVISION DESCRIPTION	NAME

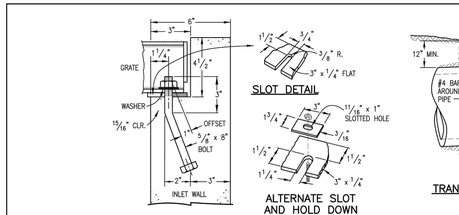
PREPARED FOR:
EXTRACTION Oil & Gas
EXTRACTION OIL & GAS

PREPARED BY:
PFS llc
Petroleum Field Services, LLC
7535 Hilltop Circle
Denver, CO 80221

EXTRACTION OIL & GAS

DRAWING DATE: 10-27-15	DRAWING NAME: DRAINAGE DETAILS SHEET 2
DRAWN BY: SWW	SURFACE LOCATION: SECTION 13, TOWNSHIP 2 NORTH RANGE 68 WEST, 6TH P.M. FREDERICK, COLORADO
CHECK BY: MCW	DP3

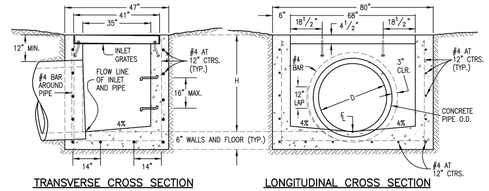
SPECIAL USE REVIEW USRXX-XXXX
EXTRACTION OIL & GAS. JOHNSON TRUST 13-I FACILITY



SLOT DETAIL

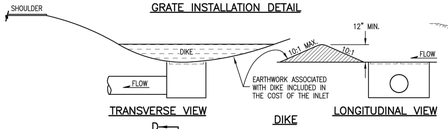
ALTERNATE SLOT AND HOLD DOWN PLATE DETAIL

GRATE INSTALLATION DETAIL



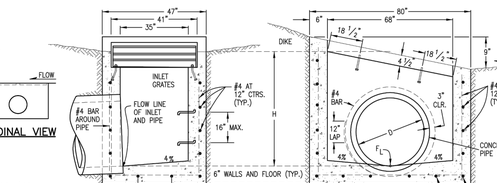
TRANSVERSE CROSS SECTION — LONGITUDINAL CROSS SECTION

LEVEL GRATE INSTALLATION



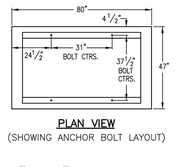
TRANSVERSE VIEW — LONGITUDINAL VIEW

DIKE

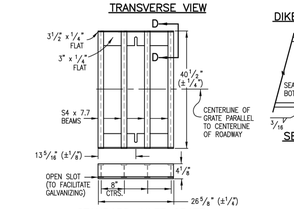


TRANSVERSE CROSS SECTION — LONGITUDINAL CROSS SECTION

SLOPING GRATE INSTALLATION



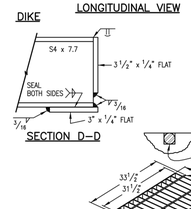
PLAN VIEW
(SHOWING ANCHOR BOLT LAYOUT)



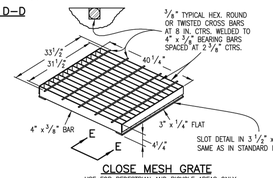
STANDARD INLET GRATE

TWO STEEL GRATE PER INLET QUANTITIES

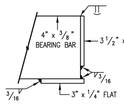
NO. PIECES	DESCRIPTION	LENGTH	LBS PER FT.	WEIGHT (LBS.)
8	S4 x 7.7 BEAM	40"	7.70	206
4	3 1/2" x 1/4" FLAT	26 5/8"	2.98	26
4	3" x 1/4" FLAT	26 5/8"	2.55	24
TOTAL LBS. = 256				



SECTION D–D



CLOSE MESH GRATE
USE FOR PEDESTRIAN AND BICYCLE AREAS ONLY.



SECTION E–E

OUTLET PIPE INSIDE DIA. FT. – "D"	MIN. "H" FT.
1.5	3.0
2.0	3.5
2.5	4.0
3.0	4.5
3.5	5.0

GENERAL NOTES

1. CONCRETE SHALL BE CLASS B. INLET MAY BE CAST-IN-PLACE OR PRECAST.
2. SEE PLANS FOR SIZE AND LOCATION OF PIPE.
3. STRUCTURAL STEEL FOR GRATES AND GRATE INSTALLATION HARDWARE SHALL BE GALVANIZED AND SHALL BE IN ACCORDANCE WITH SUBSECTION 712.06.
4. STANDARD INLET GRATES SHALL BE USED ON ALL TYPE D INLETS UNLESS CLOSE MESH GRATES ARE SPECIFIED ON THE PLANS.
5. STEPS SHALL BE PROVIDED WHEN INLET DIMENSION "H" IS EQUAL TO OR GREATER THAN 3 FT.–6 IN. AND SHALL CONFORM WITH AASHTO M 199.
6. REINFORCING BARS SHALL BE EPOXY COATED AND DEFORMED #4, AND SHALL HAVE A 2 IN. MINIMUM CLEARANCE. CUT OR BEND BARS AROUND PIPE AS REQUIRED.

"H" FT.	CONCRETE CU. YDS.	STEEL LBS.	CIRCULAR PIPE RANGE INSIDE DIA., IN. – "D"
3.0	1.5	127	18
3.5	1.7	149	18–24
4.0	1.9	157	18–30
4.5	2.0	179	18–36
5.0	2.2	187	18–42
5.5	2.4	208	18–42
6.0	2.6	215	18–42
6.5	2.8	236	18–42
7.0	2.9	243	18–42
7.5	3.1	264	18–42
8.0	3.3	271	18–42
8.5	3.5	292	18–42
9.0	3.6	299	18–42
9.5	3.8	320	18–42
10.0	4.0	327	18–42

▼ CONCRETE AND STEEL QUANTITIES ARE FOR ONE ENTIRE INLET BEFORE DEDUCTION FOR VOLUME OCCUPIED BY PIPE. WEIGHT OF STEEL INCLUDES A RING FOR THE MAXIMUM PIPE DIAMETER.

QUANTITIES FOR ONE INLET

Computer File Information	
Creation Date: 07/04/06	Initials: SJR
Last Modification Date: 07/04/06	Initials: LTA
Full Path: www.dot.state.co.us/DesignSupport/	
Drawing File Name: 6040110101.dwg	
CAD Ver.: MicroStation V8 Scale: Not to Scale	Units: English

Sheet Revisions	
Date:	Comments

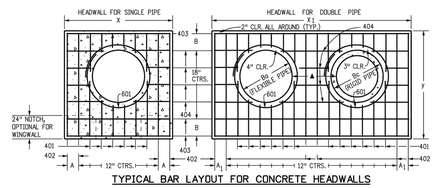
Colorado Department of Transportation
4201 East Arkansas Avenue
Denver, Colorado 80222
Phone: (303) 757-9083
Fax: (303) 757-9820
Project Development Branch SRJ/LTA

INLET, TYPE D

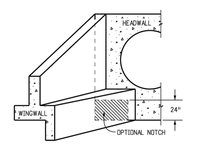
STANDARD PLAN NO. M-604-11

Issued By: Project Development Branch on July 04, 2006

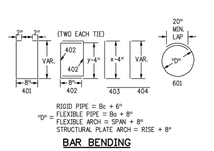
Sheet No. 1 of 1



TYPICAL BAR LAYOUT FOR CONCRETE HEADWALLS

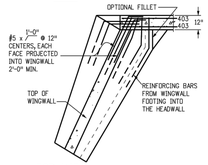


FRONT VIEW

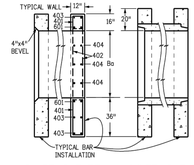


RIGID PIPE = Bo + 6"
"D" = FLEXIBLE PIPE = Bo + 8"
STRUCTURAL PLATE ARCH = RISE + 8"

BAR BENDING

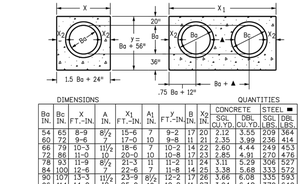


TOP VIEW
WINGWALL CONNECTION



INLET OUTLET ENDS OF FLEXIBLE PIPE

INLET OUTLET ENDS OF RIGID PIPE

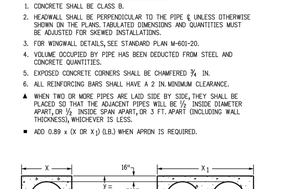


DIMENSIONS										QUANTITIES				
Bo IN.	Bc IN.	X FT.–IN.	A IN.	X1 FT.–IN.	A1 IN.	Y FT.–IN.	B IN.	X2 IN.	CONCRETE SGL CU. YD.	CONCRETE DBL CU. YD.	STEEL ■ SGL LBS.	STEEL ■ DBL LBS.
54	65	8–9	8½	15–6	7	9–2	17	20	2.12	3.55	209	364
60	72	9–6	7	17–0	10	9–8	11	21	2.35	3.99	236	414
66	79	10–3	11½	18–6	7	10–2	14	22	2.60	4.44	249	453
72	86	11–0	10	20–0	10	10–8	17	23	2.85	4.91	270	476
78	93	11–9	8½	21–3	11	11–2	11	24	3.11	5.29	306	527
84	100	12–6	7	22–6	7	11–8	14	25	3.38	5.68	333	572
90	107	13–3	11½	23–9	8½	12–2	17	26	3.68	6.08	335	593
96	114	14–0	10	25–0	10	12–8	11	27	3.94	6.48	379	649
102	121	14–9	8½	26–3	11½	13–2	14	28	4.24	6.89	400	664
108	128	15–6	7	27–6	7	13–8	17	29	4.54	7.30	424	707

HEADWALL FOR RIGID ROUND PIPE

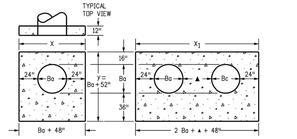
GENERAL NOTES

1. CONCRETE SHALL BE CLASS B.
2. HEADWALL SHALL BE PERPENDICULAR TO THE PIPE ℄ UNLESS OTHERWISE SHOWN ON THE PLANS. TABULATED DIMENSIONS AND QUANTITIES MUST BE ADJUSTED FOR SKEWED INSTALLATIONS.
3. FOR WINGWALL DETAILS, SEE STANDARD PLAN M-601-20.
4. VOLUME OCCUPIED BY PIPE HAS BEEN DEDUCTED FROM STEEL AND CONCRETE QUANTITIES.
5. EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED ¾ IN.
6. ALL REINFORCING BARS SHALL HAVE A 2 IN. MINIMUM CLEARANCE.
- ▲ WHEN TWO OR MORE PIPES ARE LAID SIDE BY SIDE, THEY SHALL BE PLACED SO THAT THE ADJACENT PIPES WILL BE ½" INSIDE DIAMETER APART, OR ½" INSIDE SPAN APART, OR 3 FT. APART (INCLUDING WALL THICKNESS), WHICHEVER IS LESS.
- ■ ADD 0.89 x (X OR X1) (LB.) WHEN APRON IS REQUIRED.



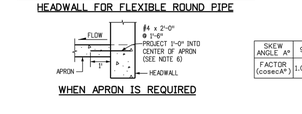
DIMENSIONS									QUANTITIES			
EQUIV. Bo IN.	SPAN IN.	RISE IN.	X FT.–IN.	A IN.	X1 FT.–IN.	A1 IN.	y FT.–IN.	B IN.	CONCRETE SGL CU. YD.	CONCRETE DBL CU. YD.	STEEL ■ SGL LBS.	STEEL ■ DBL LBS.
72	81	59	10–9	8½	20–6	7	9–3	17½	2.72	5.10	250	467
78	87	63	11–3	11½	21–6	7	9–7	17½	2.85	5.34	276	531
84	95	67	11–9	8½	22–10	9	9–11	12½	3.08	5.79	290	547
90	103	71	12–7	7½	24–2	11	10–3	15	3.30	6.21	321	591
96	112	75	13–4	12	25–8	8	10–7	16½	3.52	6.65	314	606
102	117	79	13–9	8½	26–6	7	10–11	9½	3.63	6.86	356	672
108	128	83	14–8	8	28–4	12	11–3	11½	3.96	7.51	376	699

HEADWALL FOR FLEXIBLE PIPE ARCH



DIMENSIONS								QUANTITIES			
Bo IN.	X FT.–IN.	A IN.	X1 FT.–IN.	A1 IN.	y FT.–IN.	B IN.	CONCRETE SGL CU. YD.	CONCRETE DBL CU. YD.	STEEL ■ SGL LBS.	STEEL ■ DBL LBS.
54	8–6	7	15–3	11½	8–10	15	2.19	3.81	211	358
60	9–0	10	16–6	7	9–4	18	2.38	4.25	217	396
66	9–6	7	17–9	8½	9–10	12	2.58	4.70	252	454
72	10–0	10	19–0	10	10–4	15	2.78	5.17	255	472
78	10–6	7	20–0	10	10–10	18	2.98	5.56	276	499
84	11–0	10	21–0	10	11–4	12	3.19	5.95	297	553
90	11–6	7	22–0	10	11–10	15	3.40	6.36	317	517
96	12–0	10	23–0	10	12–4	18	3.62	6.79	321	597
102	12–6	7	24–0	10	12–10	12	3.84	7.23	364	663
108	13–0	10	25–0	10	13–4	15	4.06	7.63	362	678

HEADWALL FOR FLEXIBLE ROUND PIPE



WHEN APRON IS REQUIRED

DIMENSIONS									QUANTITIES			
EQUIV. Bo IN.	SPAN FT.–IN.	RISE FT.–IN.	X FT.–IN.	A IN.	X1 FT.–IN.	A1 IN.	y FT.–IN.	B IN.	CONCRETE SGL CU. YD.	CONCRETE DBL CU. YD.	STEEL ■ SGL LBS.	STEEL ■ DBL LBS.
66	6–1	4–7	10–1	10½	19–2	11	8–11	15½	2.52	4.70	232	424
75	7–0	5–1	11–0	10	21–0	10	9–5	9½	2.80	5.25	282	509
84	7–11	5–7	11–11	9½	22–10	9	9–11	12½	3.08	5.79	291	540
93	8–10	6–1	12–10	9	24–8	8	10–5	15½	3.36	6.33	309	622
102	9–9	6–7	13–9	8½	26–6	7	10–11	9½	3.63	6.86	379	673
111	10–11	7–1	14–11	9½	28–10	9	11–5	12½	4.05	7.67	377	711
120	11–10	7–7	15–10	9	30–8	8	11–11	15½	4.36	8.28	365	731
132	12–10	8–4	16–10	9	32–8	8	12–8	11	4.75	9.03	441	839
141	14–1	8–9	18–1	10½	35–2	11	13–1	13½	5.17	9.86	448	931
150	15–4	9–3	19–4	12	37–8	8	13–7	16½	5.69	10.88	490	953
159	15–10	9–10	19–10	9	38–8	8	14–2	11	5.89	11.25	534	1019

HEADWALL FOR STRUCTURAL PLATE ARCH

SKEW ANGLE A°	90	85	80	75	70	65	60	55	50	45	40	35	30
FACTOR (cosecA°)	1.000	1.004	1.015	1.035	1.064	1.103	1.155	1.221	1.305	1.414	1.556	1.743	2.000

SKEW FACTOR TABLE

Computer File Information	
Creation Date: 07/04/12	Initials: DD
Last Modification Date: 07/04/12	Initials: LTA
Full Path: www.coloradodot.info/business/designsupport	
Drawing File Name: 601000101.dgn	
CAD Ver.: MicroStation V8 Scale: Not to Scale	Units: English

Sheet Revisions	
Date:	Comments

Colorado Department of Transportation
4201 East Arkansas Avenue
Denver, Colorado 80222
Phone: (303) 757-9083
Fax: (303) 757-9820
Project Development Branch DD/LTA

HEADWALL FOR PIPES

STANDARD PLAN NO. M-601-10

Issued By: Project Development Branch July 4, 2012

Sheet No. 1 of 1

DIG SAFELY
BEFORE YOU DIG CALL:
1-800-922-1987
UTILITY NOTIFICATION
CENTER OF COLORADO

NO.	DATE:	REVISION DESCRIPTION	NAME

PREPARED FOR:
EXTRACTION OIL & GAS

PREPARED BY:
Petroleum Field Services, LLC
7535 Hilltop Circle
Denver, CO 80221

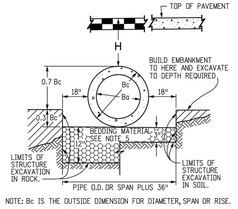
EXTRACTION OIL & GAS

DRAWING DATE: 07-24-2015
DRAWN BY: JWJ
CHECK BY: MCW

DRAWING NAME: DRAINAGE DETAILS SHEET 3
SURFACE LOCATION: SECTION 13, TOWNSHIP 2 NORTH RANGE 68 WEST, 6TH P.M. FREDERICK, COLORADO

DP4

SPECIAL USE REVIEW USRXX-XXXX
EXTRACTION OIL & GAS. JOHNSON TRUST 13-I FACILITY



NOTE: Bc IS THE OUTSIDE DIMENSION FOR DIAMETER, SPAN OR RISE.

PIPE INSTALLATION
(WITH 0.7 PROJECTION RATIO)

CIRCULAR (CIR)			VERTICAL ELLIPTICAL (VE)				HORIZONTAL ELLIPTICAL (HE)			
△ PIPE SIZE- Ba (INSIDE DIA)	WALL THICKNESS	0.3 Bc OUTSIDE DIA)	SPAN	RISE	WALL THICKNESS	0.3 OUTSIDE RISE	SPAN	RISE	WALL THICKNESS	0.3 OUTSIDE RISE
IN.		FT.	IN.			FT.	IN.			FT.
12	2	0.40								
15	2-1/4	0.49								
18	2-1/2	0.58					23	14	2-3/4	0.49
21	2-3/4	0.66								
24	3	0.75					30	19	3-1/4	0.66
27	3-1/4	0.84					34	22	3-1/2	0.73
30	3-1/2	0.92					38	24	3-3/4	0.79
33	3-3/4	1.01								
36	4	1.10	29	45	4-1/2	1.35	45	29	4-1/2	0.95
42	4-1/2	1.28	34	53	5	1.58	53	34	5	1.10
48	5	1.45	38	60	5-1/2	1.78	60	38	5-1/2	1.23
54	5-1/2	1.62	43	68	6	2.00	68	43	6	1.38
60	6	1.80	48	76	6-1/2	2.23	76	48	6-1/2	1.53
66	6-1/2	1.97	53	83	7	2.43	83	53	7	1.68
72	7	2.15	58	91	7-1/2	2.65	91	58	7-1/2	1.83
78	7-1/2	2.32	63	98	8	2.85	98	63	8	1.98
84	8	2.50	68	106	8-1/2	3.08	106	68	8-1/2	2.13
90	8-1/2	2.68	72	113	9	3.28	113	72	9	2.25
96	9	2.85	77	121	9-1/2	3.50	121	77	9-1/2	2.40
102	9-1/2	3.02	82	128	9-3/4	3.69	128	82	9-3/4	2.54
108	10	3.20	87	136	10	3.90	136	87	10	2.68

△ ALSO EQUIVALENT ROUND DIMENSION FOR ELLIPTICAL PIPE.

DIMENSIONS FOR REINFORCED CONCRETE PIPE
(FOR INFORMATION ONLY)

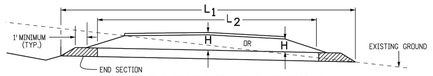
GENERAL NOTES

REINFORCED CONCRETE PIPE

1. FILL HEIGHTS GREATER THAN MAXIMUM ALLOWED IN THE HEIGHTS OF FILL TABLE ON THIS SHEET REQUIRE SPECIAL DESIGN OF STRUCTURE.
2. PIPE DESIGN IS BASED ON SAFETY FACTOR OF 1.33 ON ULTIMATE STRENGTH.
3. THE HEIGHTS OF FILL OVER TOP OF PIPE ARE BASED ON UNIT WEIGHT OF SOIL AT 135 LBS. PER CUBIC FT.
4. PIPE CLASS IS DETERMINED FROM 0.01 IN. CRACK D-LOAD.
5. BEDDING IS CLASS B (MODIFIED) (FROM CONCRETE PIPE DESIGN MANUAL-AMERICAN CONCRETE PIPE ASSOCIATION) WITH SETTLEMENT RATIO $R = 0.0_{SE}$ (YIELDING BED). BEDDING MATERIAL FOR RIGID PIPE IN SOIL SHALL BE 3 IN. LOOSE THICKNESS STRUCTURE BACKFILL CLASS 2, BEDDING MATERIAL FOR RIGID PIPE IN ROCK SHALL BE 12 IN. LOOSE THICKNESS STRUCTURE BACKFILL CLASS 1.
6. CHANGES IN DESIGN FACTORS REQUIRE COMPENSATING IN PIPE DESIGN.
7. MINIMUM WALL THICKNESS DIMENSIONS ARE BASED ON AASHTO M 170 (WALL B) FOR CIRCULAR PIPE, AND AASHTO M 207 FOR ELLIPTICAL PIPE.
8. SPACING FOR MULTIPLE PIPE INSTALLATIONS SHALL CONFORM TO THE DETAILS SHOWN ON STANDARD PLAN M-206-1.
9. WHEN A PIPE IS TO BE EXTENDED, THE SAME PIPE MATERIAL AND SIZE AS IN THE ORIGINAL PIPE INSTALLATION SHALL BE USED.

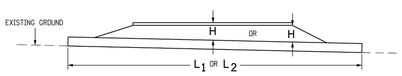
NONREINFORCED CONCRETE PIPE

1. AT THE OPTION OF THE CONTRACTOR, NONREINFORCED CONCRETE PIPE CONFORMING TO AASHTO M 86 MAY BE USED IN LIEU OF REINFORCED CONCRETE PIPE FOR ALL SIZES 36 INCHES IN DIAMETER AND SMALLER. THE NONREINFORCED CONCRETE PIPE SHALL MEET THE SAME D-LOAD TO PRODUCE THE ULTIMATE LOAD UNDER THE THREE-EDGE BEARING METHOD AS SPECIFIED FOR REINFORCED CONCRETE PIPE IN CONFORMANCE WITH AASHTO M 170. THE CONTRACTOR SHALL PROVIDE WRITTEN CERTIFICATION OF CONFORMANCE. THE WALL THICKNESS OF THE NONREINFORCED PIPE MAY BE INCREASED AS REQUIRED TO MEET D-LOAD REQUIREMENT.
2. ALL REQUIREMENTS FOR REINFORCED CONCRETE PIPE, EXCEPT THOSE REFERRING TO REINFORCEMENT, SHALL APPLY TO NONREINFORCED CONCRETE PIPE.

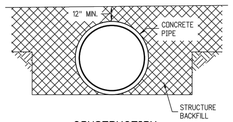


CONCRETE PIPE WITH END SECTIONS
NOTE: USE THE H THAT IS GREATER FOR MAXIMUM ALLOWABLE FILL HEIGHT.

H = HEIGHT OF FILL OVER TOP OF PIPE, INCLUDING PAVEMENT THICKNESS.
L_1 = LENGTH OF PIPE TO BE MEASURED WHEN PLACED IN ACCORDANCE WITH SECTION 624.
L_2 = LENGTH OF PIPE TO BE MEASURED WHEN PLACED IN ACCORDANCE WITH SECTION 603.



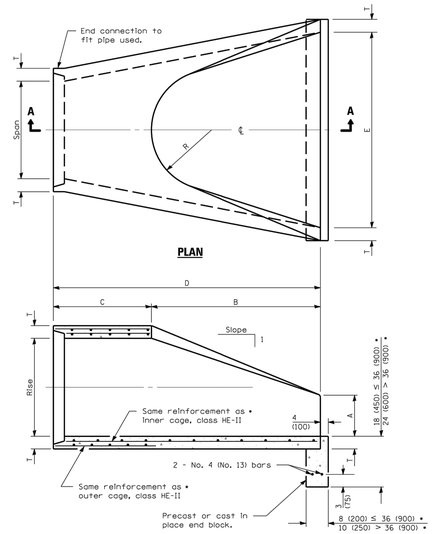
CONCRETE PIPE WITHOUT END SECTIONS
NOTE: USE THE H THAT IS GREATER FOR MAXIMUM ALLOWABLE FILL HEIGHT.



CONSTRUCTION MINIMUM COVER FOR RIGID PIPE

TYPE OF PIPE	HEIGHT OF FILL OVER TOP OF PIPE, H (FEET)			
	CLASS OF PIPE		(0.01 IN. CRACK D-LOAD)	
	CLASS CIR II CLASS VE II CLASS HE II 1000 D	CLASS CIR III CLASS VE III CLASS HE III 1350 D	CLASS CIR IV CLASS VE IV CLASS HE IV 2000 D	CLASS CIR V CLASS VE V 3000 D	CLASS VE VI 4000 D
CIRCULAR (CIR)	1 TO 18	1 TO 25	± 25 TO 37	± 37 TO 45	
VERTICAL ELLIPTICAL (VE)	1 TO 18	1 TO 25	± 25 TO 37	± 37 TO 45	± 45 TO 62
HORIZONTAL ELLIPTICAL (HE)	1 TO 18	1 TO 25	± 25 TO 37		

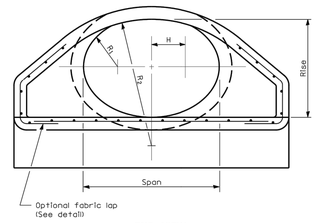
ALLOWABLE RANGE OF HEIGHTS FOR FILL OVER REINFORCED CONCRETE PIPE
(ALL SIZES)



• Refers to the equivalent pipe diameter.

SECTION A–A

SPAN	RISE	EQUIV. DIA.	WALL T	A	B	C	D	E	H	R	R_1	R_2	APPROX. SLOPE
23 (584)	14 (356)	18 (450)	2-3/4 (70)	8 (203)	27 (686)	3'-9'' (1,143 m)	6'-0'' (1,829 m)	36 (914)	5-5/8 (137)	6 (152)	6 (152)	20 (508)	1:3.1
30 (762)	19 (483)	24 (600)	3-1/4 (83)	8-1/2 (216)	39 (991)	5'-3'' (1,600 m)	6'-0'' (1,829 m)	4'-0'' (1,219 m)	6-7/8 (175)	7 (178)	8-1/4 (210)	26-1/4 (667)	1:2.8
34 (864)	22 (559)	27 (675)	3-1/2 (89)	9 (229)	43 (1,092)	6'-0'' (1,829 m)	6'-0'' (1,829 m)	4'-6'' (1,372 m)	7-3/4 (197)	8 (203)	9-1/4 (235)	29-1/4 (743)	1:2.9
38 (965)	24 (610)	30 (750)	3-1/2 (95)	9-1/2 (241)	47 (1,194)	6'-6'' (1,372 m)	6'-0'' (1,829 m)	5'-0'' (1,524 m)	8-5/8 (219)	9 (229)	10-1/4 (260)	32-3/4 (832)	1:2.9
45 (1143)	29 (737)	36 (900)	4-1/2 (114)	11-1/4 (286)	55 (1,397)	5'-0'' (1,524 m)	8'-0'' (2,438 m)	6'-0'' (1,829 m)	10-1/2 (267)	12 (305)	12-1/4 (311)	39-1/4 (997)	1:2.7
53 (1346)	34 (864)	42 (1050)	5 (127)	15-3/4 (400)	63 (1,600)	5'-0'' (1,524 m)	8'-0'' (2,438 m)	6'-6'' (1,981 m)	12-1/8 (308)	13 (330)	14-1/2 (368)	3'-10'' (1,168 m)	1:2.6
60 (1524)	38 (965)	48 (1200)	5-1/2 (140)	21 (533)	71 (1,803)	5'-0'' (1,524 m)	8'-0'' (2,438 m)	7'-0'' (2,134 m)	13-1/2 (343)	14 (356)	16-1/2 (419)	4'-3-1/2'' (1,308 m)	1:2.7
68 (1727)	43 (1092)	54 (1350)	6 (152)	26 (660)	79 (2,007)	5'-0'' (1,524 m)	8'-0'' (2,438 m)	7'-6'' (2,286 m)	15-1/4 (387)	16 (406)	18-3/4 (476)	4'-10-1/2'' (1,486 m)	1:2.6
76 (1930)	48 (1219)	60 (1500)	6-1/2 (165)	31 (787)	87 (2,210)	5'-0'' (1,524 m)	8'-0'' (2,438 m)	8'-0'' (2,439 m)	17 (432)	18 (457)	20-3/4 (527)	5'-5'' (1,651 m)	1:2.6



END VIEW

OPTIONAL FABRIC LAP

GENERAL NOTES

All slope ratios are expressed as units of vertical displacement to units of horizontal displacement (V:H).

All dimensions are in inches (millimeters) unless otherwise shown.

PRECAST REINFORCED CONCRETE ELLIPTICAL FLARED END SECTION

Computer File Information		Sheet Revisions	
Creation Date: 07/04/12 Initials: DLM		Date:	Comments
Last Modification Date: 10/02/14 Initials: LTA	(R-X)	3/25/14	Note 16: Cover for Rigid Pipe detail like others. Deleted Gen Note 11 & renumbered.
Full Path: www.coloradodot.info/business/designsupport	(R-X)	4/11/14	Changed "Min." to 1 in Heights table.
Drawing File Name: 603020101.dgn	(R-X)		
CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English	(R-X)		

Colorado Department of Transportation
4201 East Arkansas Avenue
CDOT HQ, 4th Floor
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Division of Project Support DLM/LTA

REINFORCED CONCRETE PIPE

Issued By: Project Development Branch on July 4, 2012

STANDARD PLAN NO.
M-603-2
Sheet No. 1 of 1

DIG SAFELY
BEFORE YOU DIG CALL:
1-800-922-1987
UTILITY NOTIFICATION
CENTER OF COLORADO

NO.	DATE:	REVISION DESCRIPTION	NAME

PREPARED FOR:
EXTRACTION OIL & GAS

PREPARED BY:
Petroleum Field Services, LLC
7535 Hilltop Circle
Denver, CO 80221

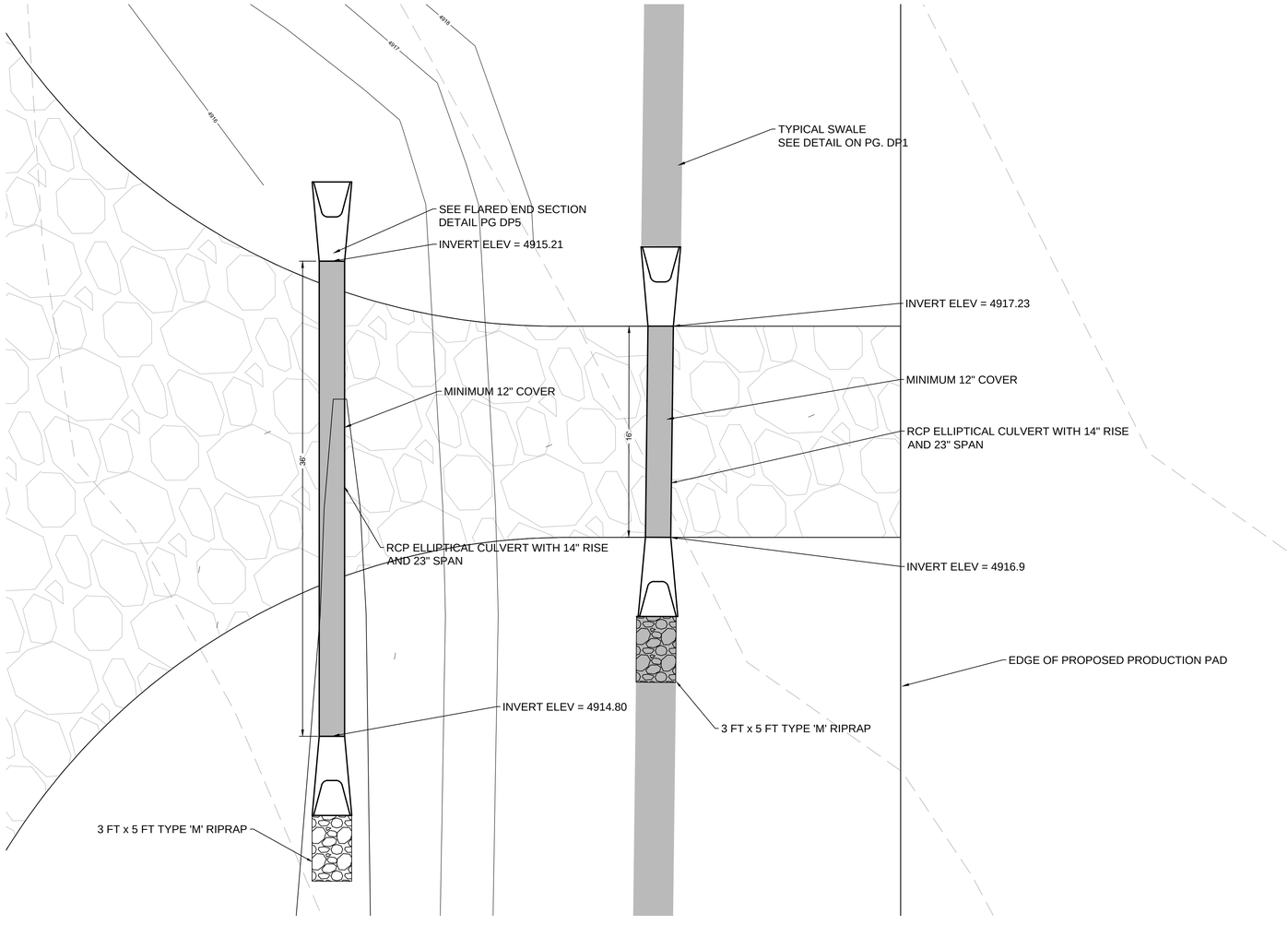
EXTRACTION OIL & GAS

DRAWING DATE: 09-29-2015
DRAWN BY: JWJ
CHECK BY: MCW

DRAWING NAME: DRAINAGE DETAILS SHEET 4
SURFACE LOCATION: SECTION 13, TOWNSHIP 2 NORTH RANGE 68 WEST, 6TH P.M. FREDERICK, COLORADO

DP5

SPECIAL USE REVIEW USRXX-XXXX
EXTRACTION OIL & GAS. JOHNSON TRUST 13-I FACILITY



0 5'
GRAPHIC SCALE
(IN FEET)
1"=5'

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UTILITY NOTIFICATION
CENTER OF COLORADO

NO.	DATE:	REVISION DESCRIPTION	NAME

PREPARED FOR:
EXTRACTION
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EXTRACTION OIL & GAS

PREPARED BY:
PFS
Petroleum Field Services, LLC
7535 Hilltop Circle
Denver, CO 80221

EXTRACTION OIL & GAS

DRAWING DATE: 10-07-2015
DRAWN BY: JWJ
CHECK BY: MCW

DRAWING NAME: DRAINAGE DETAILS SHEET 5
SURFACE LOCATION: SECTION 13, TOWNSHIP 2 NORTH
RANGE 68 WEST, 6TH P.M.
FREDERICK, COLORADO

DP6