



November 6th, 2025

Attn: Travis Hertneky, PE; THEngineering, LLC

Project Name: Kiowa Creek Recycling Facility  
Case Number: USR25-001  
Parcel No.: 2067-00-0-00-372  
Variance Letter: #1

The Arapahoe County Technical Review Committee (TRC) and Southeast Metro Stormwater Authority (SEMSWA) met on October 29<sup>th</sup>, 2025, for a regularly scheduled meeting to discuss the Kiowa Creek Facility Use By Special Review application and associated variance request letter. The request and justification are described in detail in the attached Variance Request Memo provided by THEngineering, LLC., and are summarized here:

**1. Vegetated Treatment Area –**

- a. Section 3.4.1 of the Stormwater Management Manual (SMM) states that all developments must construct the Local Drainage System as necessary to collect, detail, and provide water quality treatment of the minor and major storm runoff for the development. The applicant requests to outfall the proposed detention pond across a vegetated treatment area.
- b. Section 9.2 of the SMM requires that all storm sewer located in County easements be constructed with reinforced concrete pipe (RCP) of a minimum 18” in size. The applicant proposes 8” or 10” gated PVC pipe to distribute the detention pond outfall across the VTA..

**2. Alternative Outlet Structure –**

- a. Section 13.3.12 of the SMM requires that detention basin outlet structures shall be provided with oversized safety/debris grates and easy to maintain. Section 13.4.4 requires that the outlet configuration be designed in accordance with the criteria shown in Volume 3 of the Urban Storm Drainage Criteria Manual (USDCM). The applicant proposes a “Hickenbottom inlet” which consists of an 8” slotted PVC pipe in riser pipe configuration.

TRC Response and Comment:

Request #1 for a **Vegetated Treatment Area:**

- a. TRC does not consider this the use of a VTA be a variance, as there is no existing drainage system in which to connect an outfall, and the SMM notes that a Local Drainage System may include “curb, gutter, inlets and storm sewers, culverts, bridges, swales, ditches, channels, detention facilities, and water quality best management practices.” The VTA would be considered a vegetated buffer.



- b. The use of gated PVC pipe is not approved. In the opinion of TRC, the proposed alternative to 18" RCP would not meet the same standards in terms of resiliency and maintenance and the applicant should explore options such as a level spreader to distribute flow across the VTA.

**Request #2 for an Alternative Outlet Structure:**

- a. This request is denied by the TRC. The proposed outlet structure appears to require significantly more maintenance than a standard concrete outlet structure and would be more likely to clog with smaller debris. It is the opinion of TRC that it has not been sufficiently demonstrated that there is a need for a variance from the standard outlet structure design criteria and requirements.

Decisions of the TRC may be appealed to the Director of Public Works & Development. If you wish to appeal the decision of the TRC, please submit a request in writing to my attention. Within 6 working days, you will be notified of a date and time for the appeal meeting with the Director of Public Works & Development. This process is further outlined in Arapahoe County's Infrastructure & Design Construction Standards (2019), Section 3.2.

If you have any questions, please feel free to contact me at 720-874-6500.

Sincerely,

Emily Gonzalez, PE  
Engineering Services Division on Behalf of TRC

Attachments: Kiowa Creek Facility USR Variance Request Letter  
USR25-001 Drainage Report

cc: Technical Review Committee  
Arapahoe County Case File USR25-001



October 8, 2025

Arapahoe County Public Works and Development  
Technical Review Committee  
6924 S Lima St  
Centennial, CO 80112

RE: USR25-001 Kiowa Creek Facility, E 1/2 of the E 1/2 of the NW 1/4 Section 12, Township 5S, Range 67W, of the 6th P>M>, Arapahoe County, Colorado, Parcel no: 2067-00-0-00372

To Whom It May Concern,

As requested on the redline review of the drainage design for the above referenced facility dated 9/18/2025, this letter is to request a variance to allow for an alternative outlet.

The proposed site consists of a green waste recycling/composting facility. Truckloads of green waste including grass clipping, tree trimming and similar will be trucked in from the companies receiving facility located in Aurora. These feedstuffs will be mixed, and ground as necessary then windrowed to be periodically turned to introduce air and aerobically create compost. Compost windrows will be collected and screened as necessary to be loaded into trucks for transport offsite.

This site will be a solid waste site, to be permitted as a Class I composting facility by the Colorado Department of Public Health and Environment (CDPHE). Composting facilities typically require retention of the 25yr-24hr design storm; however, this facility, as currently planned must meet the requirements of 6 CCR 1007-2 14.2.3(A)(2) specifically section (b) allowing for a Vegetative Treatment Area (VTA). This allowance of a VTA is a newer addition to the regulations and it is my professional opinion that the classification of this facility could change in the future due to regulatory revisions, or that the option for a VTA will be removed from regulations. For this reason, it is important for the facility design to be able to be easily adapted and renovated to match the evolving regulations. It is anticipated that if retention is required, that the stormwater system would need further review by regulating bodies such as Arapahoe County, and the conversion to a retention pond would require amongst other things, the addition of a liner system.

The VTA requires a distribution system to evenly distribute the runoff equally across the entire treatment area. A gated pipe distribution system is proposed as components are readily available, relatively inexpensive, and commonly used resulting in faster adoption and less learning curve than developing a new untested system. Gated pipe utilized many orifices along the length of the pipe to evenly distribute the water. Filtering of effluent is paramount to ensure gated pipe orifices do not regularly plug. For this reason an outlet structure that will filter the pond outfall was chosen. A "typical" detention pond outfall which has an orifice plate for the lower storage volume and a weir box for the higher elevation discharge was evaluated but eventually ruled out due to the potential for high debris runoff to pass through the outlet and plug the gated pipe. A Hickenbottom outlet was chosen due to its inherent design to screen debris. These outlets are also readily available as opposed to fabricating a site specific perforated outlet.

Hydraulic modeling of the outlet indicated that using orifice equations for all the riser orifices resulted in a flow which exceeded the capacity of the outlet pipe. For this reason the outlet structure was modeled by calculating the flow through the orifices on the end of the pipe using standard orifice equations. The

higher flows through the Hickenbottom inlet were modeled by assuming a large weir box with an 8" outlet with a restrictor plate fully open.

Gated pipe outlet restricts outfall to less than the historic 5yr rate but still drains 99% of the 100yr inflow from the basin in 58hrs. Basin is oversized to allow for option of future conversion to retention in the event of regulation change and thus the basin can hold the total projected runoff of the 100yr-1hr storm event of 3.128ac-ft or the 25yr-24hr storm event of 4.35ac-ft before overflowing the emergency spillway at 5.4ac-ft.

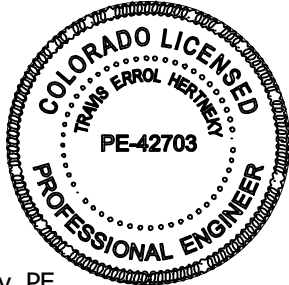
Design methodology for composting operations is outlined in the Natural Resources Conservation Service (NRCS) Part 651 Ag Waste Management Field Handbook, specifically Chapter 10 and Appendix 10D addressing liner design. The VTA design is designed in accordance with NRCS Colorado Practice standard 635, NRCS Engineering technical note 26, and NRCS design guide PA-14.

In summary, the proposed design yields a collection volume that is in excess of what would be required by Arapahoe County utilizing the Urban Drainage criteria and a release rate that is lower than that required by Urban Drainage criteria. This design also allows for relatively easy modifications in the future if CDPHE solid waste regulations change. The outlet structure provides screening of debris which is highly likely from the composting operations and reduces the risks of plugging the gated pipe.

We ask for you to grant us a variance to allow us to use the proposed outlet structure as designed

Please feel free to reach out with any questions.

This Variance Request from the Arapahoe County Infrastructure Design and Construction Standards, and Stormwater management manual hydrology runoff prediction methods listed in chapter 10, and 13.4.4 of the Stormwater management manual dated 7/1/2019 was prepared for the Kiowa Creek Facility by me and is based on sound engineering judgement and practices.



Travis Hertneky, PE  
THEngineering, LLC

Enclosure: Phase III Drainage report dated October 6, 2025  
Drainage plan dated October 6, 2025  
List of references

# Phase III Drainage Report

## USR25-001

# KIOWA CREEK FACILITY

E 1/2 OF THE E 1/2 OF THE NW 1/4 SECTION 12, TOWNSHIP 5S,  
RANGE 67W, OF THE 6TH P.M., ARAPAHOE COUNTY, COLORADO

Parcel No: 2067-00-0-00372

Kurtis Katte, Owner

Prepared By



PO Box 337748  
Greeley, CO 80633

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October 6, 2025

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## 1.0 Approval and Certification, and Applicability

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### 1.1 Professional Certification

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I hereby affirm that this report and plan for the Phase III drainage design of the Kiowa Creek Facility prepared by me, or under my direct supervision, for the owners thereof, in accordance with the provisions of Arapahoe County Stormwater Management Manual and the Urban Drainage and Flood Control District Criteria Manual, and approved variances and exceptions thereto. I understand that Arapahoe County does not and will not assume liability for drainage facilities designed by others.



Travis Hertneky P.E.

### 1.2 Owner Certification

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"I Kurt Katte hereby certifies that the drainage facilities for Kiowa Creek Facility shall be constructed according to the design presented in this report. I understand that Arapahoe County does not and will not assume liability for drainage facilities designed and/or certified by my engineer and that Arapahoe County reviews drainage plans pursuant to Colorado Revised Statutes Title 30, Article 28; but cannot, on behalf of Kiowa Creek Facility guarantee that final drainage design review will absolve Kurt Katte of Aesthetic Alternative Recycling, LLC and/or their successors and/or assigns of future liability for improper design. I further understand that approval of the Final Plats, Final Development Plans, and/or Subdivision Development Plans does not imply approval of my engineer's drainage design."

\_\_\_\_\_  
Name of Owner

\_\_\_\_\_  
Authorized Signature

## **Phase III Drainage Report Checklist**

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## 2.0 General Location and Description

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### 2.A Site Location

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1. Vicinity map: See Appendix

2-3. Legal description:

E 1/2 OF THE E 1/2 OF THE NW 1/4 SECTION 12, TOWNSHIP 5S, RANGE 67W, OF THE 6TH P.M. ARAPAHOE COUNTY, COLORADO.

4. Existing streets:

Quincy Ave is adjacent to the site and runs along the northern edge of the property. No other roads are impacted by this facility.

### 2.B Description of Property

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1. Area:

This parcel is an approximate 40 acre parcel located in rural Arapahoe County. Approximately 21.3 acres will be disturbed and used for this project.

2. Current and proposed zoning:

This parcel is currently zoned A-E and a use by special review permit is being requested for “processing, packaging and selling of an agricultural commodity with manufacturing”.

3. Existing site conditions:

This site is located in unincorporated Arapahoe County. This site appears to have been historically dryland farmed along with the adjacent parcels. The site is currently weedy rangeland. The majority of the site naturally drained to the northeast corner of the site with an approximate 2.5% slope to the road ditch for Quincy Ave. A small portion of the southern edge of the site drained to the south east. This southern edge of the property is not proposed to be developed in order to minimize the drainage basins.

Adjacent parcels share similar historic and current uses as current site. All of the immediate area was historically small grain farming and either is still dryland farmed or has been returned to grass. Directly east of the site the parcels have been divided off into 40acre parcels with each having a single family residence and agricultural outbuildings. The remaining portions of the properties are currently grass rangeland.

4. Existing irrigation:

No evidence of historic irrigation is present on this site or the vicinity.

5. Significant geologic features:

This site is mapped as an Eolian Deposit by the geologic maps of Colorado. This poses no risk to the proposed uses.

#### 6. NRCS soil Classification:

NRCS soil survey has this site mapped as a Nunn-Bresser-Ascalon Complex, see Appendix 12.A.3 for soils map. This soil complex is a lean clay intermixed with coarser sands. The Nunn clay is high water holding capability soils with greater than 65% passing the #200 sieve and PI's in the range of 10-40. These soils tend to provide low permeability and compliment the proposed use by providing a low permeability pad and on-site soils for compacted clay liner.

#### 7. Proposed land use:

The proposed site consists of a green waste recycling/composting facility. Truckloads of green waste including grass clipping, tree trimming and similar will be trucked in from the companies receiving facility located in Aurora. These feedstuffs will be mixed, and ground as necessary then windrowed to be periodically turned to introduce air and aerobically create compost. Compost windrows will be collected and screened as necessary to be loaded into trucks for transport offsite.

Normal site operations will include the unloading of trucks either onto mixing pads that are graded and compacted, or directly into windrows. Windrows will be pushed up and shaped using a front end loader or compost windrow turner. The windrows will then be periodically turned every few weeks utilizing a compost turner or front end loader to introduce oxygen. Once complete the compost will be left in the windrows until shipped offsite. When shipping offsite, trucks will either be loaded directly on the composting pad or the compost will be transferred to a screening area to be screened and immediately hauled offsite.

This process dictates that we need a good all weather operating surface for the access road and accessing the mixing/screening pads. The general composting pad sees very minimal traffic and this traffic can be scheduled when the weather and site conditions are adequate to ensure minimal rutting and disturbance.

#### 8. Estimated proposed impervious area:

The site currently has no significant impervious areas and the site development will create relatively minimal impervious areas. The proposed site is approximately 40 acres and we are proposing developing approximately 21 acres. The majority of this 21 acres will be undisturbed native soils with a few other areas moderately disturbed for earthwork and leveling. A few impervious areas will be constructed including the shop roof, office roof, scale, and concrete apron on the shop. These areas total approximately 0.2 acres or 0.7% of developed area.

Although pervious, the remainder of the area will be disturbed and groundcover removed thus increasing the potential runoff. The majority of this runoff will be "contaminated" runoff from the composting operations and must be caught or treated before flowing off property as per 6 CCR 1007-2 14.2. A runoff collection pond is proposed in the northeast corner of the proposed site which will catch

the peak runoff from a 25yr-24hr storm event and release it via a controlled outlet to a vegetative treatment strip as per 6 CCR 1007-2 14.2.3(A)(2)(b). County design criteria requires full spectrum detention and release at less than the 5year historic rate but less than 72hrs.

SCS methodology has been utilized to determine the projected runoff from the developed site and utilizes a Curve Number reflective of developed conditions as discussed later in this report for compliance with the requirement of 6 CCR 1007-2 14. Secondary runoff projections are developed utilizing the rational method to determine systems compliance with county requirements and provided later in this report.

9. Total disturbed area:

Total disturbed area is 21.3acres.

## 2.C Groundwater Investigation

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1. Groundwater investigation and results:

Site investigations were performed by borings. A truck mounted soil exploration rig was utilized to advance a slotted 2” tube to a depth of 22ft in the location of the proposed pond with a planned excavation depth of 8ft in that location. Investigations are detailed in trip report and soil logs and summarized by the lack of groundwater or indicators of seasonal groundwater.

2. Identify potential groundwater issues:

None

3. Discuss improvements to mitigate groundwater impacts:

None

## 3.0 Floodplain

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### 3.A Major Drainageway – Designated Floodplain

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1-2. Identify site floodplain zone and map:

Site is mapped as a “Zone X, area of minimal flood hazard” as per panel 08005C0270K effective 12/17/2010. See FIRMette in Appendix.

3-4. Floodplain modifications required:

None

5. Floodplain development permit:

None

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### 3.B Major Drainageway – Undesignated Floodplain

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1,2,3. Discuss floodplain issues and strategy:

N/A

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## 4.0 Drainage Basins

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### 4.A Major Drainage Basins

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1. Major drainage basin:

This area is dominated with rural undeveloped ground which was either dryland farmed or rangeland grazed. Most of the area drains to natural drainageways with few exceptions of playa potholes. These natural drainageways typically flow north towards the South Platte River and ultimately are part of the Missouri River watershed. Runoff once exiting the site to the Quincy road ditch flows to the east where it eventually crosses and flows to an unnamed drainage paralleling Quincy approximately 1/8 mile north. This unnamed drainage flows to the east for approximately ¼ mile before entering Wolf Creek which flows north before eventually merging with Comanche Creek and Kiowa Creek before terminating into the South Platte River.

2. Existing and proposed land uses and impervious values within the basins:

This site and adjacent land uses appeared to be dryland small grain farming. Much of this land has been returned to grass. Historic flow patterns were generally to the northeast with only a small portion on the southern edge that drained to the south. Runoff from this and the adjacent site to the west created significant channel erosion along the eastern edge of the property. This created a channel that varies in depth and width with its maximum dimensions of approximately 15ft wide and 3ft deep. An adjacent historic channel exists directly to the east of this channel of similar dimensions which appears to have had the water diverted from it at some time in the past. This channel flattens out as it approaches Quincy and is almost unnoticeable. This erosion channel is typical of historic tilled summer fallow dryland small grain production in the area.

The site currently has no significant impervious areas and the site development will create relatively minimal impervious areas. The proposed site is approximately 40 acres and we are proposing developing approximately 21 acres. The majority of this 21 acres will be undisturbed native soils with a few other areas moderately disturbed for earthwork and leveling. A few impervious areas will be constructed including the shop roof, office roof, scale, and concrete apron on the shop. These areas total approximately 0.2 acres or 0.7% of developed area.

Although pervious, the remainder of the area will be disturbed and groundcover removed and thus increasing the potential runoff. This majority of this runoff will be “contaminated” runoff from the composting operations and must be caught before flowing off property as per 6 CCR 1007-2 14.2.3. A runoff storage pond is proposed in the northeast corner of the proposed site. A runoff collection pond

is proposed in the northeast corner of the proposed site which will catch the peak runoff from a 25yr-24hr storm event and release it via a controlled outlet to a vegetative treatment strip as per 6 CCR 1007-2 14.2.3(A)(2)(b). County design criteria requires capture and release of the 100yr-1hr storm event and release a less than the 5yr-1hr historic rate.

SCS methodology has been utilized to determine the projected runoff from the developed site and utilizes a Curve Number reflective of developed conditions as discussed later in this report for compliance with the requirement of 6 CCR 1007-2 14. Secondary runoff projections are developed utilizing the rational method to determine systems compliance with county requirements and provided later in this report.

The previously mentioned erosion channel will have almost all of the runoff cut off from it. Channel will be backfilled and seeded.

3. Discussion of all drainageway master planning or studies that affect:

N/A

4. Discuss site restrictions imposed by Master Plans:

N/A

5. Condition of the drainage channel within or adjacent to the development:

The historic terminal location of this site is the Quincy road ditch. Most of the undeveloped portions of the site will still drain this way naturally and the outfall from the storage pond via the vegetative treatment strip will flow this direction.

6. Impacts of proposed development to basin flow patterns and paths:

Portions of the parcel adjacent to the west historically drained through the site. This run-on water is problematic as it leads to additional contaminated water that would need to be collected and thus must be diverted around the site. The site has an access road along the western edge of the facility that will intercept this run-on water and safely divert it to the north to the Quincy road ditch. This diversion of the run-on water does not change the volume or characteristic of the historic runoff water from offsite.

Runoff did historically congregate at the northeast corner of this site at the Quincy road ditch. This run-on water is now diverted along the access road and outlets to the Quincy road ditch in a location approximately 660ft west of historic outlet location.

7. Cherry Creek Basin:

N/A

## 4.B Minor Drainage Basins

### 1. On-site/offsite minor drainage basin:

The existing site was historically dryland farmground along with the adjacent parcels. These fields predominantly drained to the northeast to the road ditch for Quincy Ave. A small portion at the south side of the site historically drained to the southeast. Slopes are generally consistent at about 2.4% to the northeast. Runoff was predominantly overland flow and small channelized flow which led to moderate erosion.

Historic runoff values were evaluated utilizing the rational method with a 5% impervious area on a "B" hydrologic soil type "Historic flow Analysis" from table 6-3 of the USDCM.

Rational methodology was utilized to estimate the projected runoff from the historic site to be 8.65cfs for a 5yr-1hr storm at a location approximately the same as the proposed pond emergency spillway.

### 2. Existing and proposed land uses within the basins:

See section 4.A.2. above

### 3. Discussion of all drainage studies or master development plans:

N/A

### 4. Discuss drainage studies of adjacent properties:

N/A

### 5. Discuss impacts of the minor basin characteristics, flow patterns and paths, under both historic and developed conditions:

Historic runoff flowed via overland flow to the northeastern corner of the site where it entered the road ditch for Quincy Ave. Undeveloped portions of this site and diverted run-on will follow this same flow pattern. Flows from the developed site will be intercepted in the pond and decrease the overall outfall from the site.

### 6. Summary of sub-Basin characteristics, size in acres, C2, C5 and C100 values and Q2, Q5 and Q100 values:

#### Runoff areas

Area	Area (acres)	Cover	Soil	CN	Slope	
South composting area	18.8	"Newly graded areas"	B	86	2.4%	

Equipment parking area	1.2	"farmstead"	B	74	2.4%	1. Use CN 86 for simplicity for entire area
Shop/office area	1.1	"farmstead"	B	74	1.3%	1. Use CN 86 for simplicity for entire area
Shop and office roof	0.2	Impervious	N/A	100		
Total	21.3					
Run-on area	26.1	Small grain SR+residue	B	72	2.83%	

**Runoff areas**

Area	2yr, 1hr	5yr, 1hr	100yr, 1hr	25yr, 24hr	
	Q2 (cfs)	Q5 (cfs)	Q100 (cfs)	Q25 (cfs)	Total (ac-ft)
South composting area	13.0	22.0	81.1	42.3	3.45
Equipment parking area	3.0	4.4	13.1	4.0	0.28
Shop/office area					
Shop and office roof					
Pond Surface					0.41
Total					4.35
<b>Historic</b>		<b>8.0</b>			
<b>Developed pond outfall</b>			<b>3.6</b>		
Run-on area	2.4	8.2	68.8	17	2.61

7. Discuss impacts of the off-site flow patterns and paths, under fully developed conditions:

Portions of the parcel adjacent to the west historically drained through the site. This run-on water is problematic as it leads to additional contaminated water that must be diverted around the site. The site has an access road along the western edge of the facility that will intercept this run-on water and safely divert it to the north to the Quincy road ditch. This diversion of the run-on water does not change the volume or characteristic of the historic runoff water from offsite only the location.

Complete discussion of off-site flows and proposed ditch capacity is included in section 7.B.6 of this report.

## 5.0 Existing Stormwater Conveyance or Storage Facilities

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### 5.A Existing Stormwater Storage Facilities

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1-5. No existing stormwater storage facilities are present on or adjacent to this site. In addition, no flood detention structures are present along Wolf Creek, Comanche Creek, or Kiowa Creek.

### 5.B Existing Stormwater Conveyance Facilities

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1-4. Existing conveyance facilities include the Quincy road ditch and Wolf Creek. This site development will not impact any of these facilities as it is a zero discharge site.

## 6.0 Drainage Design Criteria

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### 6.A Regulations

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1-3. County Criteria, UDFCD Criteria, Cherry Creek Basin criteria:

Site is a Class I composting facility and subject to Regulation 6 CCR 1007-2, specifically Section 14.2.3 which supersedes County jurisdiction and is a more stringent requirement. Site is designed to detain runoff to facilitate sediment settling and release via a controlled outlet across a vegetative treatment area.

### 6.B Compliance with Phase II Assumptions

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1-2. Changes from Phase II plan:

No phase II report was prepared or referenced.

### 6.C Hydrologic Design Criteria

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1. Methods used to determine runoff calculations:

SCS Curve Number methodology specifically Engineering Field Handbook Chapter 2, and Tech Release 55 were utilized to determine peak runoff flows and volume to determine compliance with state department of health requirements. Rational methodology was utilized to determine compliance with county requirements.

2. Design storm:

Various design storms were evaluated in this design including the 5yr-1hr storm for the historic site discharge. The 25yr-24hr storm, the 100yr-24hr storm, and 100yr-1hr storm event were evaluated for the design developed site. 6 CCR 1007-2 14.2.3. dictates that the facility prevent run-on from the 25yr-24hr storm event as well as control and treat the runoff from the same 25yr-24hr storm event. The emergency spillway was designed to safely convey the 100yr-1hr storm event without any detention or routing taken into account for a conservative design.

NOAA Atlas 14, Volume 8, Version 2 was utilized to determine the point precipitation frequency estimates and is included in the Appendix.

3. Design rainfall:

5yr-24hr,	2.45in	5yr 1hr,	1.16in
25yr-24hr,	3.62in	25yr-1hr,	1.84in
100yr-24hr,	4.81in	100yr-1hr,	2.57in

4-5. Detention storage calculation method:

Detention was determined based on vegetative treatment area design criteria and structural limitations of the 8" gated pipe utilized as the distribution device across the vegetative treatment area dictate the release rate which is significantly lower than the historic 5 year runoff from the same area. Detention is far higher with this minimal release rate and leads to a pond volume of nearly 100% of the 100year storm volume.

### 6.D Hydraulic Design Criteria

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1. Methods used to determine conveyance facility capacities:

Simple open diversions will be utilized on this facility and each diversion has been calculated utilizing Mannings equation. Diversions are oversized for constructability, maintenance and allow for sediment accumulation and still provide an adequate diversion. Due these reasons, the diversions are equally sized from start to end. Runoff from the watershed will increase as the diversion progresses towards the pond or the end of the access road for run-on. The required capacity utilized is the total runoff from the contributing watershed which would only be experienced at the end of the diversion providing the most conservative design.

2-3. Hydraulic grade line calculation method and loss coefficients:

Carrying capacity of the diversion down the length with a progressively increasing flow was not calculated. Single point capacity and thus hydraulic grade line and water surface profiled along channel was not calculated.

Channel was assumed to be a straight earthen channel with some grass and a Mannings coefficient (n) of 0.026 (natural channel, earth, straight, some grass) was utilized.

4. Detention pond routing:

Detention pond routing was calculated by using the Mile High Flood Districts Detention sizing spreadsheet Version 4.06 dated July 2022.

### 6.E Water Quality Control Measure Design Criteria

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1-2. Water quality CM requirements:

Colorado regulation 6 CCR 1007-2 specifically section 14.2.3(A)(2)(b) supersedes county requirements and provides a superior water quality control methodology.

## 7.0 Proposed Stormwater Conveyance or Storage Facilities

### 7.A Proposed Stormwater Storage Facilities

Current best management practices advise composting operations intercept any stormwater runoff that comes in contact with feedstocks or compost. As per 6 CCR 1007-2 14.2.3(A)(2)(b) a runoff detention pond is utilized to capture runoff and facilitate solids settling before outletting to a vegetative treatment area. A runoff pond is proposed in the northeast corner of the site which will catch the 25yr-24hr storm event and release via a distribution system to the vegetative treatment area at a rate that can safely be infiltrated by the vegetative treatment area

This stormwater treatment system is designed to treat the 25yr-24hr event as determined from the NOAA Atlas 14, Volume 8, Version 2. System is designed to capture and manage the volume from the 100yr-24hr storm event.

Proposed stormwater facilities have also been evaluated for compliance with Arapahoe County requirements and determined to exceed the capacity necessary to capture the 100yr-1hr storm event and release it at a rate less than the historic 5yr-1hr rate for the undeveloped site. The detention pond outlet is sized to release the detained water in less than 72hrs.

All stormwater from the composting area will be contained in the proposed containment pond. All precipitation that does not fall directly on these areas will be diverted away from the containment area and will flow into the natural drainages.

#### 7.A.1 Runoff storage pond:

The design storm for county compliance is determined to be the 100yr-1hr storm event based on the NOAA Precipitation frequency data server for the center of the facility location and corresponds to a depth of 2.57in. Peak runoff was determined to be 81.14cfs from the south composting area based on a composting lot area of 18.8 acres and a percent impervious of 40%. 40% impervious is an ultra-conservative number as this area will remain native soils however will be hardpacked and typically free of any vegetation. Although none of this area will be truly impervious the 40% value was utilized based on best fit of categories as recommended in chapter 6 of the USDCM, and matching back to runoff predictions from the Runoff curve method. Note that this represents a worst case scenario with the site empty of compost which absorbs nearly all rainfall on the windrows and the site completely void of vegetation. Runoff from the shop/office and equipment storage area were projected utilizing an area of 2.3 acres and a percent impervious of 80% and 40% respectively.

Finally, for department of health compliance, the precipitation falling directly on the pond surface of 1.46ac yields another 0.44ac-ft.

The runoff pond is rectangular in shape and utilized much of the excavated material for site fill to achieve positive drainage. Pond will be constructed with a planned capacity at the 2ft freeboard mark of 5.4ac-ft. The embankments include 2' of freeboard with an emergency spillway located in the northeast corner of the pond.

## 2. Pond outfall location and design:

Outfall design is relatively simple including a perforated riser to facilitate sediment settling without restricting outlet pipe capacity. A stock 8" Hickenbottom inlet with 1" holes and 1"x4" slots is utilized as outlet riser with a rated max flow capacity of 5.93cfs for the 42in riser height. In the event this pond does overflow, an emergency spillway will be installed in the northeast corner to safely convey the overtopping and not compromise the integrity of the embankment. Emergency spillway is located in an area where the spillway crest is approximately the same as adjacent grade. A concrete cut-off wall will be installed to ensure any minimal erosion does not cut back into the pond and provides a permanent crest. Flow will be exiting spillway at essentially grade and thus no energy dissipation or additional erosion control is necessary.

This outlet design was chosen as opposed to the typical detention outlet featuring an orifice plate secondary stage outlet due to the primary design concern of sediment filtering. The typical urban detention outlet would work decent for zone 1 restricting flow through orifices however the secondary zones would be problematic in that there would be little to no filtering of debris. When utilizing the MHFD detention pond spreadsheet the outlet was modeled by looking at all the cumulative orifices and determined to exceed the 8" outlet pipe capacity. The outlet was then modeled as a 2 stage outlet with which utilized the low elevation orifices as zone 1 then modeled the zone 2 outlet as an 8" outlet pipe with a restrictor plate placed at the top of the pipe and thus providing full pipe flow. This modeling reflects that the first 1.83ft of water will flow through the orifices and directly into the 8" outlet pipe, Any water above the 1.83ft elevation will flow through the Hickenbottom outlet as a debris filter and the 8" pipe capacity and subsequent downstream gated pipe will control the flow.

Maximum outfall capacity has been determined to be 3.64cfs at emergency spillway crest of 6ft depth.

## 3. How is runoff conveyed from outfall to nearest major drainageway:

Outfall is conveyed via 80ft of PVC pipe through the embankment until it just about daylights at grade. Surface gated pipe is then connected with approximately 60ft of non gated leader pipe till the gated section starts and extends for approximately 620ft to the northwest along the top of the vegetative treatment area. The vegetative treatment area will be minimally graded to ensure consistent flow while minimally disturbing topsoil. The main grading will be the filling of small gully erosion in the VTA area. The VTA will drain to the northeast as it naturally did to the Quincy road ditch.

In the event of an overtopping of the pond via the emergency spillway, the flows will flow via overland flow in the historic drainage pattern to the northeast corner of the site to the Quincy Ave road ditch.

4. Discuss maintenance aspects:

The stormwater drainage system will be relatively maintenance free. The main areas of concern will be the eastern run-off diversion channel which will need to be inspected to ensure it does not have significant erosion and cleaned periodically of sediment accumulation. Sediment generation is expected to be minimal however the pond will need to be monitored and sediment removed when the sediment begins to accumulate at approximately 6".

The vegetative treatment area will require the most attention to ensure that the flow distribution device is properly adjusted and functioning. The VTA itself will need to be maintained to ensure that there is no erosion within the VTA field. Vegetation will need to be annually removed from the VTA likely as a harvested grass hay crop.

5. Discuss impacts caused by constraints:

N/A

6. Vegetative treatment area

Soil water holding capacity along with infiltration rate was utilized to determine the effectiveness of the VTA area. Based on NRCS soil survey the soils have a water holding capacity of 0.17cm/cm for the top 60" root zone of the soils. This equates to a total available water holding capacity in the root zone of 4.0ac-ft. Projected total runoff from the 25yr-24hr storm event is 4.35c-ft.

The saturated hydraulic conductivity as reported from the NRCS Soil Survey is rated at 9 micrometers/sec or 0.0000295 ft/sec. Applying this to the 4.7acres this gives us a total infiltration rate of 6 cfs which is less than our outlet capacity of 4.2cfs.

Detention should be limited to less than 72hrs and utilizing the 8" outlet modeled vs pond head it is determined that the drawdown to 8" which is pipe height will be completed within 30hrs and drawdown to 2" in 48hrs.

8" gated pipe will be utilized as a distribution device across the VTA. To evenly distribute our peak outflow from the 100yr storm event of 3.64cfs we can use 620ft of standard 8" gated pipe with 30" gates, and each 3<sup>rd</sup> gate opened 1/4. Each gate at 1/4 open is rated at 23.4gpm or 0.052cfs/gate and thus yields a total 4.26cfs of capacity.

VTA will need to be permanently seeded to a perennial grass which can withstand the additional water addition, prevent erosion, and utilize the nutrients. This will be a seed blend consisting of both warm and cool season grasses. A recommended seeding mix is the Arkansas Valley Seed Dryland Pasture mix. Dryland Pasture Mix contains:

20% Tetraploid Perennial Rye (*Lolium perenne*)

Bunchgrass with germination in 5-10 days. One of the most widely used grasses and is adaptable to a wide variety of soils and climate conditions. It is leafy and fine stemmed.

20% Smooth Brome, Lincoln (*Bromus inermis*)

Sod Forming grass with germination in 10-14 days Smooth brome is resistant to drought and extremes in temperature. Lincoln smooth brome is the most widely used of the cultivated brome grasses.

15% Paiute Orchardgrass (*Dactylis glomerata*)

Bunchgrass with germination in 14-21 days. One of the earliest species to exhibit growth in the spring, making tremendous forage potential during cool conditions. Performs well on different textured soils. Is a great forage and hay producer.

15% Hycrest Crested Wheatgrass (*Agropyron cristatum*)

Bunchgrass with germination in 14-21 days. A hybrid cross between Standard and Desert wheatgrass, resulting in a plant with excellent seedling vigor that establishes quickly. It is taller and has higher forage yield potential than its parents.

15% Pubescent Wheatgrass (*Agropyron trichophorum*)

Cool season, sod-forming with germination in 21-28 days. Stays green into the summer months when soil moisture is adequate.

15% Dahurian Wildrye (*Elymus dahuricus*)

Bunchgrass with germination in 7 – 21 days. Deep rooted allowing good drought tolerance. Regrows aggressively after cutting and grazing, providing excellent palatable forage.

## 7.B Proposed Stormwater Conveyance Facilities

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### 1. General onsite conveyance concepts:

All diversions are sized to handle the 100yr-1hr storm event of 2.57in. The site generally flows naturally to the northeast where the retention pond is located. A distinct diversion is created along the eastern edge of the site that catches and conveys the runoff to the pond's south inlet. This south inlet catches the majority of the site; however, there is a small area of approximately two acres located around the shop and office that drains to its own western pond inlet.

Projected flow down this south conveyance is 81.14cfs for the 100yr-1hr storm event which corresponds to a flow depth of 0.92ft in the 3ft deep channel.

The runoff from shop and office area is relatively minimal at 7.94cfs for the 100yr-1hr. This area funnels directly to the inlet by grading without any distinct diversions.

In the event storms overwhelm the pond capacity an emergency spillway will be installed to ensure structural integrity of the embankment. This emergency spillway is not expected to see flows in less than a 100yr-1hr storm event.

2. Storm sewer design:

All flows are overland and open channel.

3. Discuss storm sewer outfall locations:

All flows are overland and open channel. Open channels enter the pond via concrete spill channel to safely convey the flows down to the bottom without erosion of the banks.

4. Discuss open channel and swale design, including dimension...:

The south runoff diversion consists of a 14ft flat bottom, a 3ft high 14ft wide berm. This channel slopes toward the pond at 1.32% and yields a carrying capacity of 1,910cfs. This far exceeds the design storm runoff of 81.14cfs for the 100yr-1hr storm.

5. Discuss allowable street capacities:

N/A

6. Discuss general offsite conveyance concepts:

As discussed a portion of the adjacent parcel to the west historically drained to the northeast across the site. This run-on water will be diverted by the access road and its associated borrow ditch. The western ditch is a V ditch with 6:1 sideslopes up to a road 2ft higher. This ditch slopes to the north at 2.7% and yields a carrying capacity of 233cfs. Again this is significantly larger than the projected design storm runoff of 68.63cfs for the 100yr-1hr storm event. This run-on diversion discharges to the south road ditch of Quincy Ave. These flows are run-on flows from areas unaltered from this project and this project does not increase the flow or volume of this water.

7. Discussion of the facilities needed offsite for the conveyance of minor and major flows:

All facilities for the conveyance of runoff from the site and diversion of run-on will be constructed on the property and no offsite easements or flow paths are necessary.

8. Discuss maintenance of conveyances:

All conveyances are open channels and will require regular maintenance. Open channels will be seeded and once established these channels will need to be maintained including mowing and erosion repair. The southern runoff diversion will collect runoff from the composting area and thus may be subject to high sediment loading. These diversions were designed oversized to accommodate this

loading; however, the diversion will need to be periodically cleaned of sediment. This sediment can be re-used in the composting process.

## **8.0 Water Quality Control Measure**

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Water quality is the main concern on this site. The retention system negates the typical water quality concerns associated with a discharging detention system. Runoff is regulated by Colorado Department of Public Health and Environment under their Solid Waste Program and is regulated by 6 CCR 1007-2 Section 14.

## **9.0 Additional Permitting Requirements**

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### **9.A Compliance with Section 404 of the Clean Water Act**

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This site is a solid waste site regulated by Colorado Department of Public Health and Environment under their Solid Waste program and is regulated by 6 CCR 1007-2 section 14. Site is designed as zero discharge as a result of a 25yr-24hr storm event.

### **9.B Compliance with the Endangered Species Act**

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No known endangered species are known on this property that would be affected by this operation.

### **9.C Other local, State, or Federal requirements**

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This site is a solid waste site regulated by Colorado Department of Public Health and Environment under their Solid Waste program and is regulated by 5 CCR 1002-2 section 14.

## **10.0 Conclusions**

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### **10.A Compliance with Standards**

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Drainage design is dictated by 6 CCR 1007-2 14.2.3. which dictates a zero discharge for the 25yr-24hr storm. This environmental regulation supersedes County standards and is a stricter standard. By default, zero discharge means the site design exceeds the standards set forth by Arapahoe County and the UDFCD. The site is designed to retain the 25yr-24hr storm event along with enough storage capacity to handle normal runoff during the storage period and smaller rainfall events.

### **10.B Variances**

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No variances necessary.

### **10.C Drainage Concept**

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The drainage concept is very simple: zero discharge from a 25yr-24hr storm and divert any unnecessary water. The pond is designed in the natural low point on the site where all water naturally

drained. Site is designed from the natural high spot to the north in order to not have to divert natural runoff flowing to the south around to the north or require excessive grading to elevate the southern portion. Run-on is simply diverted along the western edge utilizing the road ditch and discharges to the historic drainage of Quincy Ave. Un-developed portions of the site remain as-is and will flow as they have historically. Overall water flow from the site is less due to zero discharge.

## 11.0 Design Assumptions

### 11.A Summarize Design Assumptions

#### Runoff areas

Area	Area (acres)	Cover	Soil	CN	Slope	
South composting area	18.8	"Newly graded areas"	B	86	2.4%	
Equipment parking area	1.2	"farmstead"	B	74	2.4%	1. Use CN 86 for simplicity for entire area
Shop/office area	1.1	"farmstead"	B	74	1.3%	1. Use CN 86 for simplicity for entire area
Shop and office roof	0.2	Impervious	N/A	100		
Total	21.3					
Run-on area	26.1	Small grain SR+residue	B	72	2.83%	

Design storm		
25yr 24hr storm	3.65	in
2yr 24hr storm	0.87	in
5yr 1hr storm	1.16	in
100yr 1hr storm	2.57	in

South pond inlet			
Peak flow 2yr-1hr	13.0	cfs	1. Rational
Peak flow 5yr-1hr	22.0	cfs	1. Rational
Peak flow 100yr-1hr	81.1	cfs	1. Rational
Peak flow 25yr-24hr	42.3	cfs	2. RCN
Channel capacity	1,910	cfs	
Total depth	3.00	ft	
Depth at 5yr-1hr	0.55	ft	
Depth at 100yr-1hr	0.92	ft	

West pond inlet			
Peak flow 2yr-1hr	3.0	cfs	1. Rational
Peak flow 5yr-1hr	4.4	cfs	1. Rational
Peak flow 100yr-1hr	13.1	cfs	1. Rational
Peak flow 25yr-24hr	42.3	cfs	2. RCN
Channel capacity	N/A		
Total depth	N/A		
Depth at 25	N/A		
Depth at 100	N/A		

Total site			
Peak flow 2yr-1hr	16.0	cfs	1. Rational
Peak flow 5yr-1hr	26.4	cfs	1. Rational
Peak flow 100yr-1hr	94.3	cfs	1. Rational
Outlet capacity	3.64	cfs	
Spillway capacity	164	cfs	
Spillway depth	2.0	ft	

Historic 5yr from site	8.04	cfs
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Run on		
Peak flow 2yr-1hr	2.36	cfs
Peak flow 5yr-1hr	8.24	cfs
Peak flow 100yr-1hr	68.76	cfs
Peak flow 25yr-24hr	17.00	cfs
Channel capacity	223.00	cfs
Total depth	2.00	ft
Depth at 100yr-1hr	1.29	ft
Depth at 25yr-24hr	0.97	ft

- 1. Rational
- 1. Rational
- 1. Rational
- 2. RCN

**Runoff areas**

Area	2yr, 1hr	5yr, 1hr	100yr, 1hr	25yr, 24hr	
	Q2 (cfs)	Q5 (cfs)	Q100 (cfs)	Q25 (cfs)	Total (ac-ft)
South composting area	13.0	22.0	81.1	42.3	3.45
Equipment parking area	3.0	4.4	13.1	4.0	0.28
Shop/office area					
Shop and office roof					
Pond Surface					0.41
Total					4.35
<b>Historic</b>		<b>8.0</b>			
<b>Developed pond outfall</b>			<b>3.6</b>		
Run-on area	2.4	8.2	68.8	17	2.61

## **11.0B      References**

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This facility was designed in accordance with various universities' research and extension publications, the Natural Resources Conservation Service (NRCS) recommendations and generally accepted best management practices. Publications directly referenced are from Colorado State University, Kansas State University, Texas A&M University, American Society of Agricultural Engineers (ASAE). The facility was also designed in accordance with the current Colorado Department of Public Health and Environment (CDPHE) regulation 6 CCR 1007-2, Urban Drainage and Flood Control District criteria, and Arapahoe County Stormwater Management Manual.

## 12.0 Appendices

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### 12.A Reference Materials

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12.A.1.b	Aerial map 1:2000
12.A.1.c	Topo map 1:2000
12.A.2	Flood plain map
12.A.3	Soils map
12.A.8.a	Subsurface exploration trip report
12.A.8.b	Subsurface soil logs
12.A.9	NRCS Practice standard 635, Vegetative treatment area
12.A.10.a	Soil Survey Available Water capacity
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12.B.4	Runoff flows
12.B.6	Runoff diversion capacity, South
12.B.6	Run-on area
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12.C.2	Stage Storage curve
12.C.4	Hickenbottom outlet capacity
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12.C.6	Access road culvert capacity
12.C.13	Open channel and swale capacities
12.C.21	Historic drainage basins
12.C.22	Developed drainage basins

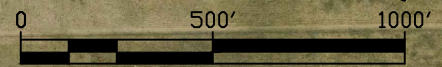
### 12.D Drainage Plan

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QUINCY AVE

UNNAMED DRAINAGE

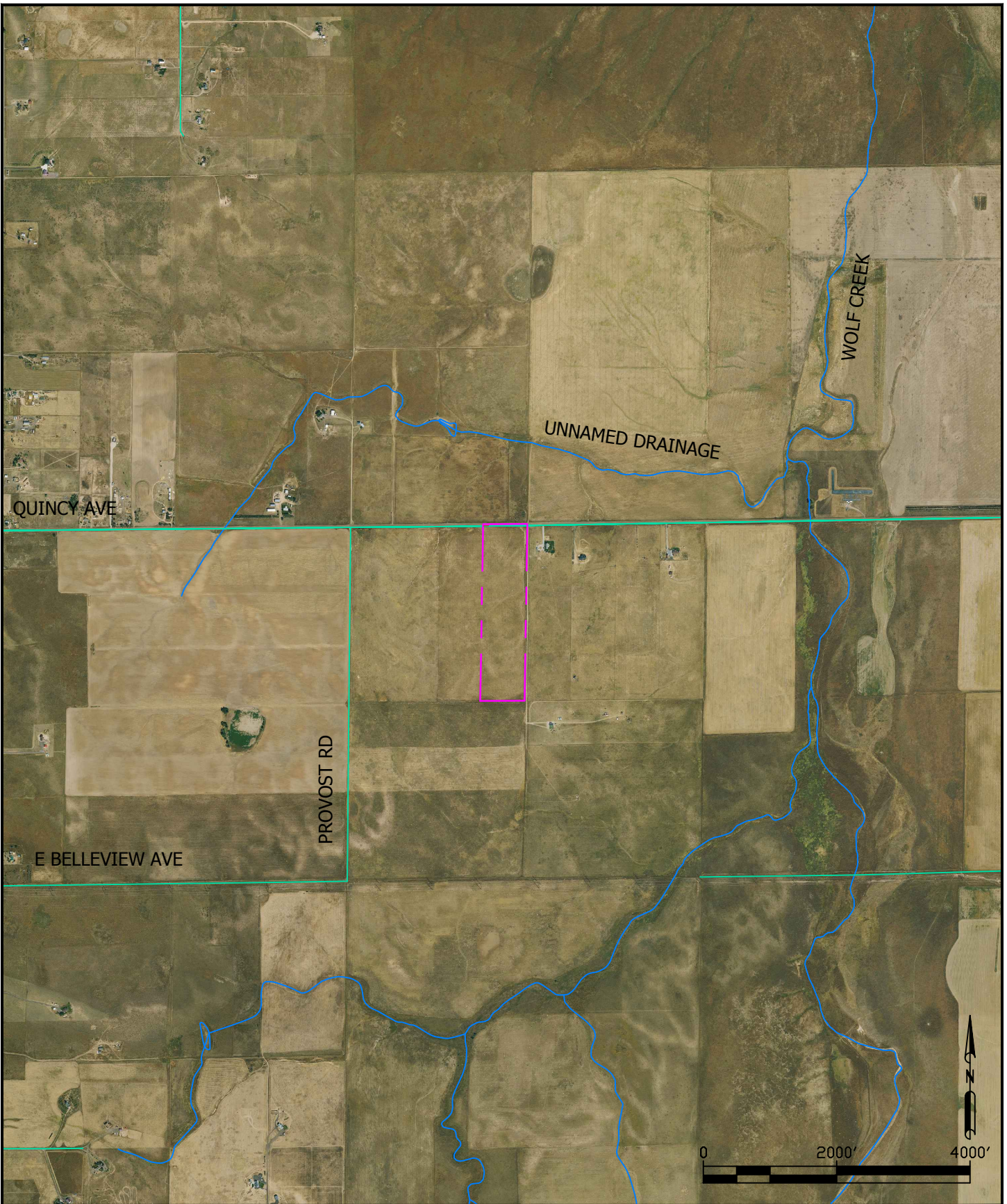


**THE** ENGINEERING, LLC  
Greeley, CO 719-661-6209

# KIOWA CREEK FACILITY AERIAL MAP

E 1/2 OF THE E 1/2 OF THE NW 1/4 SECTION 12, T 5S, R 67W,  
OF THE 6TH P.M., ARAPAHOE COUNTY, COLORADO

Date:  
1/14/2025  
Sheet No.  
1 OF 1

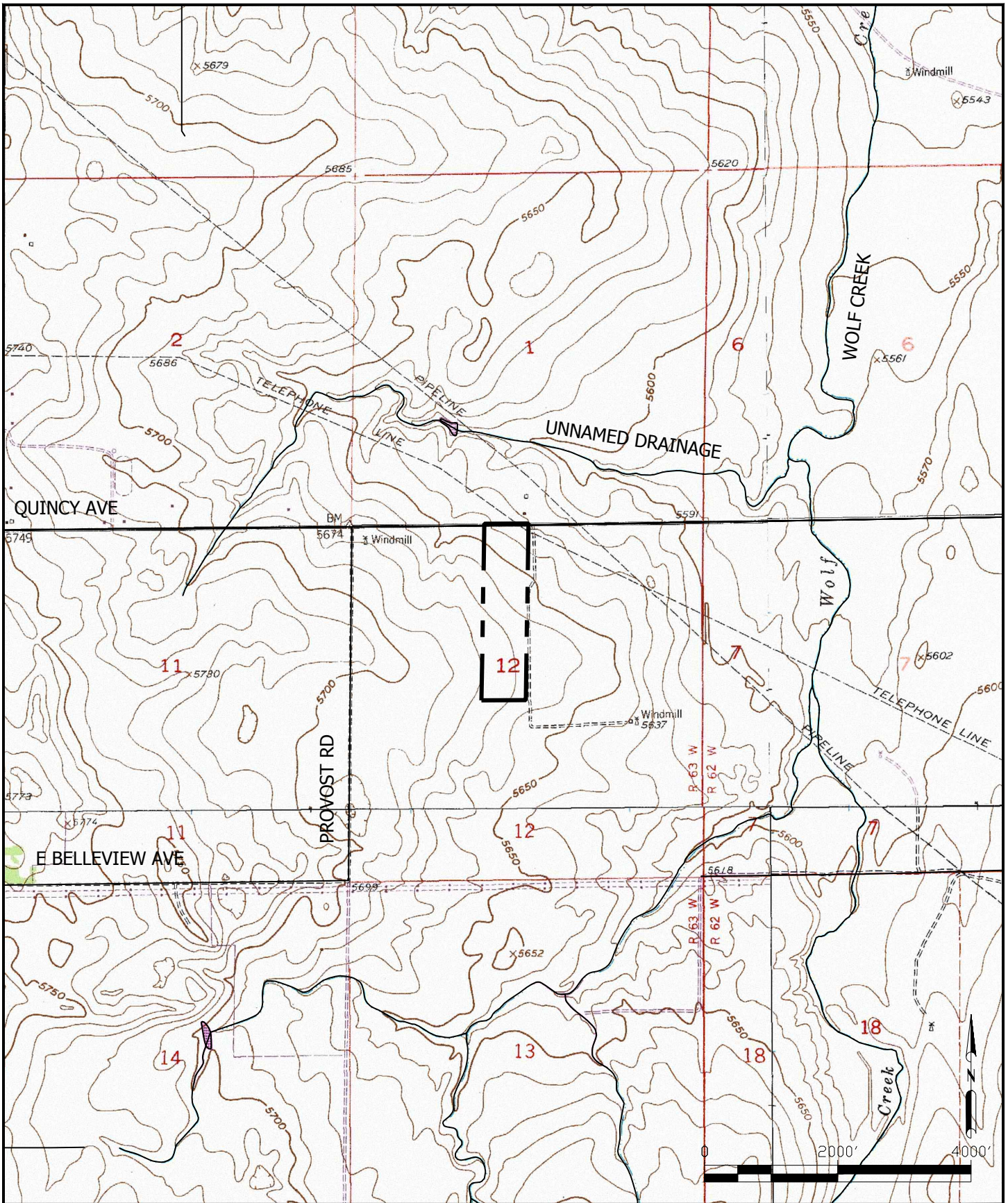


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**KIOWA CREEK FACILITY  
 TOPO MAP**

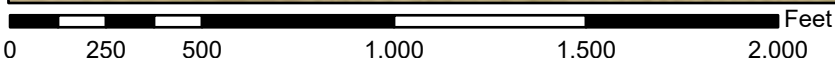
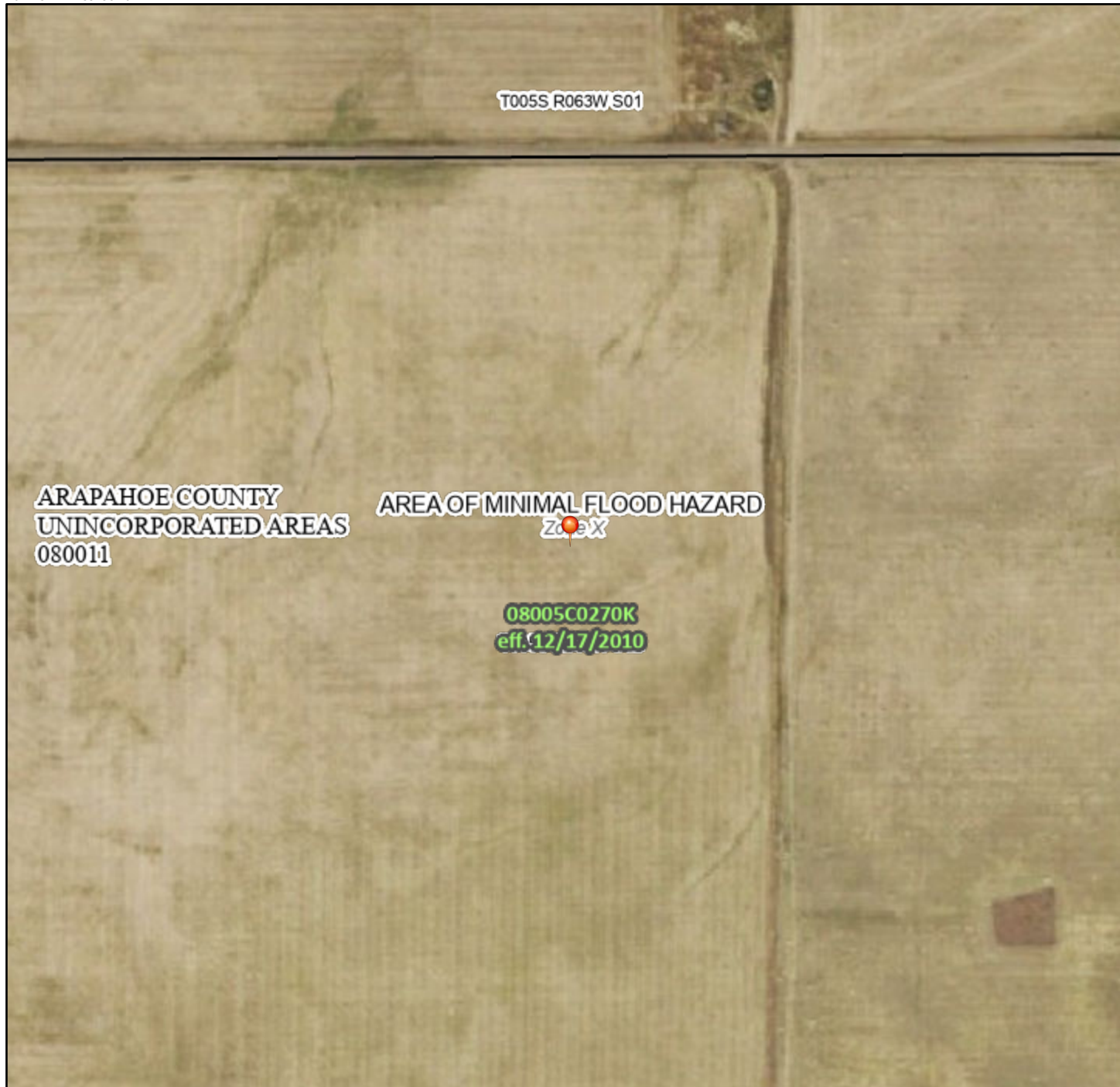
E 1/2 OF THE E 1/2 OF THE NW 1/4 SECTION 12, T 5S, R 67W,  
 OF THE 6TH P.M., ARAPAHOE COUNTY, COLORADO

Date:  
 1/14/2025  
 Sheet No.  
 1 OF 1

# National Flood Hazard Layer FIRMette



104°23'44"W 39°38'16"N



1:6,000

104°23'6"W 39°37'48"N

Basemap Imagery Source: USGS National Map 2023

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) <i>Zone A, V, A99</i>
		With BFE or Depth <i>Zone AE, AO, AH, VE, AR</i>
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile <i>Zone X</i>
		Future Conditions 1% Annual Chance Flood Hazard <i>Zone X</i>
		Area with Reduced Flood Risk due to Levee. See Notes. <i>Zone X</i>
		Area with Flood Risk due to Levee <i>Zone D</i>
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard <i>Zone X</i>
		Effective LOMRs
GENERAL STRUCTURES		Area of Undetermined Flood Hazard <i>Zone D</i>
		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5 Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
MAP PANELS		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Digital Data Available
		No Digital Data Available
		Unmapped

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **1/12/2025 at 10:08 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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# Custom Soil Resource Report for Arapahoe County, Colorado

## Aesthetic Alternative Recycling



# Preface

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

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

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

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

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

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

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# Soil Map

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

# Custom Soil Resource Report Soil Map




Map Scale: 1:4,790 if printed on A portrait (8.5" x 11") sheet.




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

### MAP LEGEND

**Area of Interest (AOI)**

 Area of Interest (AOI)


**Soils**


 Soil Map Unit Polygons


 Soil Map Unit Lines


 Soil Map Unit Points

**Special Point Features**

 Blowout

 Borrow Pit


 Clay Spot


 Closed Depression

 Gravel Pit

 Gravelly Spot


 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water


 Perennial Water

 Rock Outcrop

 Saline Spot

 Sandy Spot

 Severely Eroded Spot


 Sinkhole

 Slide or Slip


 Sodic Spot


 Spoil Area

 Stony Spot


 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

**Water Features**

 Streams and Canals


**Transportation**

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

**Background**

 Aerial Photography

### MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

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

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

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

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

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

Soil Survey Area: Arapahoe County, Colorado  
 Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	45.8	100.0%
<b>Totals for Area of Interest</b>		<b>45.8</b>	<b>100.0%</b>

## Map Unit Descriptions

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

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

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

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

## Custom Soil Resource Report

onsite investigation is needed to define and locate the soils and miscellaneous areas.

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

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

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

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

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

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

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

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

## Arapahoe County, Colorado

### NrB—Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes

#### Map Unit Setting

*National map unit symbol:* 34yw  
*Elevation:* 4,500 to 6,800 feet  
*Mean annual precipitation:* 12 to 18 inches  
*Mean annual air temperature:* 46 to 57 degrees F  
*Frost-free period:* 115 to 180 days  
*Farmland classification:* Prime farmland if irrigated

#### Map Unit Composition

*Nunn and similar soils:* 40 percent  
*Bresser and similar soils:* 25 percent  
*Ascalon and similar soils:* 20 percent  
*Minor components:* 15 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

#### Description of Nunn

##### Setting

*Landform:* Stream terraces, streams, playas  
*Landform position (three-dimensional):* Tread  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Eolian deposits

##### Typical profile

*H1 - 0 to 8 inches:* loam  
*H2 - 8 to 28 inches:* clay  
*H3 - 28 to 60 inches:* sandy clay loam

##### Properties and qualities

*Slope:* 0 to 3 percent  
*Depth to restrictive feature:* More than 80 inches  
*Drainage class:* Well drained  
*Runoff class:* Low  
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to moderately high (0.06 to 0.20 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Calcium carbonate, maximum content:* 15 percent  
*Maximum salinity:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)  
*Available water supply, 0 to 60 inches:* Moderate (about 8.8 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 3c  
*Hydrologic Soil Group:* C  
*Ecological site:* R049XB202CO - Loamy Foothill  
*Hydric soil rating:* No

## Description of Bresser

### Setting

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Noncalcareous sandy alluvium and/or noncalcareous sandy eolian deposits

### Typical profile

*H1 - 0 to 6 inches:* sandy loam

*H2 - 6 to 26 inches:* sandy clay loam

*H3 - 26 to 60 inches:* gravelly loamy coarse sand

### Properties and qualities

*Slope:* 0 to 3 percent

*Depth to restrictive feature:* More than 80 inches

*Drainage class:* Well drained

*Runoff class:* Low

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

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum content:* 10 percent

*Available water supply, 0 to 60 inches:* Moderate (about 6.4 inches)

### Interpretive groups

*Land capability classification (irrigated):* 2e

*Land capability classification (nonirrigated):* 4c

*Hydrologic Soil Group:* B

*Ecological site:* R049XB202CO - Loamy Foothill

*Hydric soil rating:* No

## Description of Ascalon

### Setting

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Parent material:* Reworked by wind outwash

### Typical profile

*H1 - 0 to 6 inches:* sandy loam

*H2 - 6 to 17 inches:* sandy clay loam

*H3 - 17 to 60 inches:* fine sandy loam

### Properties and qualities

*Slope:* 0 to 3 percent

*Depth to restrictive feature:* More than 80 inches

*Drainage class:* Well drained

*Runoff class:* Low

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

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Calcium carbonate, maximum content:* 10 percent

*Maximum salinity:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

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*Available water supply, 0 to 60 inches: Moderate (about 6.7 inches)*

### **Interpretive groups**

*Land capability classification (irrigated): 2e*

*Land capability classification (nonirrigated): 3e*

*Hydrologic Soil Group: B*

*Ecological site: R049XB202CO - Loamy Foothill*

*Hydric soil rating: No*

### **Minor Components**

#### **Olney**

*Percent of map unit: 10 percent*

*Hydric soil rating: No*

#### **Aquic ustochrepts**

*Percent of map unit: 5 percent*

*Landform: Swales*

*Hydric soil rating: Yes*

# **Soil Information for All Uses**

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## **Suitabilities and Limitations for Use**

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

## **Building Site Development**

Building site development interpretations are designed to be used as tools for evaluating soil suitability and identifying soil limitations for various construction purposes. As part of the interpretation process, the rating applies to each soil in its described condition and does not consider present land use. Example interpretations can include corrosion of concrete and steel, shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping.

## **Small Commercial Buildings**

ENG - Engineering

Small commercial buildings are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (which is inferred from the Unified classification of the soil). The properties that affect the ease and amount of excavation include flooding, depth to a water table, ponding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use.

## Custom Soil Resource Report

"Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

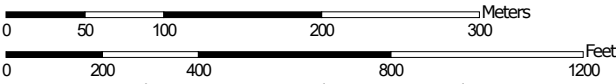
# Custom Soil Resource Report Map—Small Commercial Buildings



Soil Map may not be valid at this scale.























Map Scale: 1:4,790 if printed on A portrait (8.5" x 11") sheet.



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

### MAP LEGEND

- Area of Interest (AOI)**
  -  Area of Interest (AOI)
- Background**
  -  Aerial Photography
- Soils**
  - Soil Rating Polygons**
    -  Very limited
    -  Somewhat limited
    -  Not limited
    -  Not rated or not available
  - Soil Rating Lines**
    -  Very limited
    -  Somewhat limited
    -  Not limited
    -  Not rated or not available
  - Soil Rating Points**
    -  Very limited
    -  Somewhat limited
    -  Not limited
    -  Not rated or not available
- Water Features**
  -  Streams and Canals
- Transportation**
  -  Rails
  -  Interstate Highways
  -  US Routes
  -  Major Roads
  -  Local Roads

### MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

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

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

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

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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: Arapahoe County, Colorado  
 Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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.

**Tables—Small Commercial Buildings**

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	Somewhat limited	Nunn (40%)	Shrink-swell (0.85)	45.8	100.0%
			Bresser (25%)	Shrink-swell (0.00)		
<b>Totals for Area of Interest</b>					<b>45.8</b>	<b>100.0%</b>

Rating	Acres in AOI	Percent of AOI
Somewhat limited	45.8	100.0%
<b>Totals for Area of Interest</b>	<b>45.8</b>	<b>100.0%</b>

**Rating Options—Small Commercial Buildings**

*Aggregation Method:* Dominant Condition  
*Component Percent Cutoff:* None Specified  
*Tie-break Rule:* Higher

**Shallow Excavations**

ENG - Engineering

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot

## Custom Soil Resource Report

be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

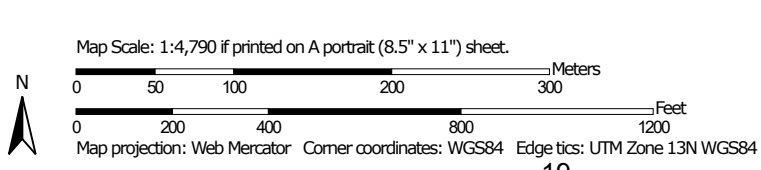
The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.





















# Custom Soil Resource Report Map—Shallow Excavations



Soil Map may not be valid at this scale.



### MAP LEGEND

- Area of Interest (AOI)**
  -  Area of Interest (AOI)
- Background**
  -  Aerial Photography
- Soils**
  - Soil Rating Polygons**
    -  Very limited
    -  Somewhat limited
    -  Not limited
    -  Not rated or not available
  - Soil Rating Lines**
    -  Very limited
    -  Somewhat limited
    -  Not limited
    -  Not rated or not available
  - Soil Rating Points**
    -  Very limited
    -  Somewhat limited
    -  Not limited
    -  Not rated or not available
- Water Features**
  -  Streams and Canals
- Transportation**
  -  Rails
  -  Interstate Highways
  -  US Routes
  -  Major Roads
  -  Local Roads

### MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

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

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

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

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Soil Survey Area: Arapahoe County, Colorado  
 Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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.

**Tables—Shallow Excavations**

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	Somewhat limited	Nunn (40%)	Dusty (0.36)	45.8	100.0%
				Too clayey (0.03)		
				Unstable excavation walls (0.01)		
			Bresser (25%)	Dusty (0.10)		
				Unstable excavation walls (0.01)		
			Ascalon (20%)	Dusty (0.09)		
Unstable excavation walls (0.01)						
<b>Totals for Area of Interest</b>					<b>45.8</b>	<b>100.0%</b>

Rating	Acres in AOI	Percent of AOI
Somewhat limited	45.8	100.0%
<b>Totals for Area of Interest</b>	<b>45.8</b>	<b>100.0%</b>

**Rating Options—Shallow Excavations**

*Aggregation Method: Dominant Condition*  
*Component Percent Cutoff: None Specified*  
*Tie-break Rule: Higher*

## Soil Properties and Qualities

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

## Soil Qualities and Features

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

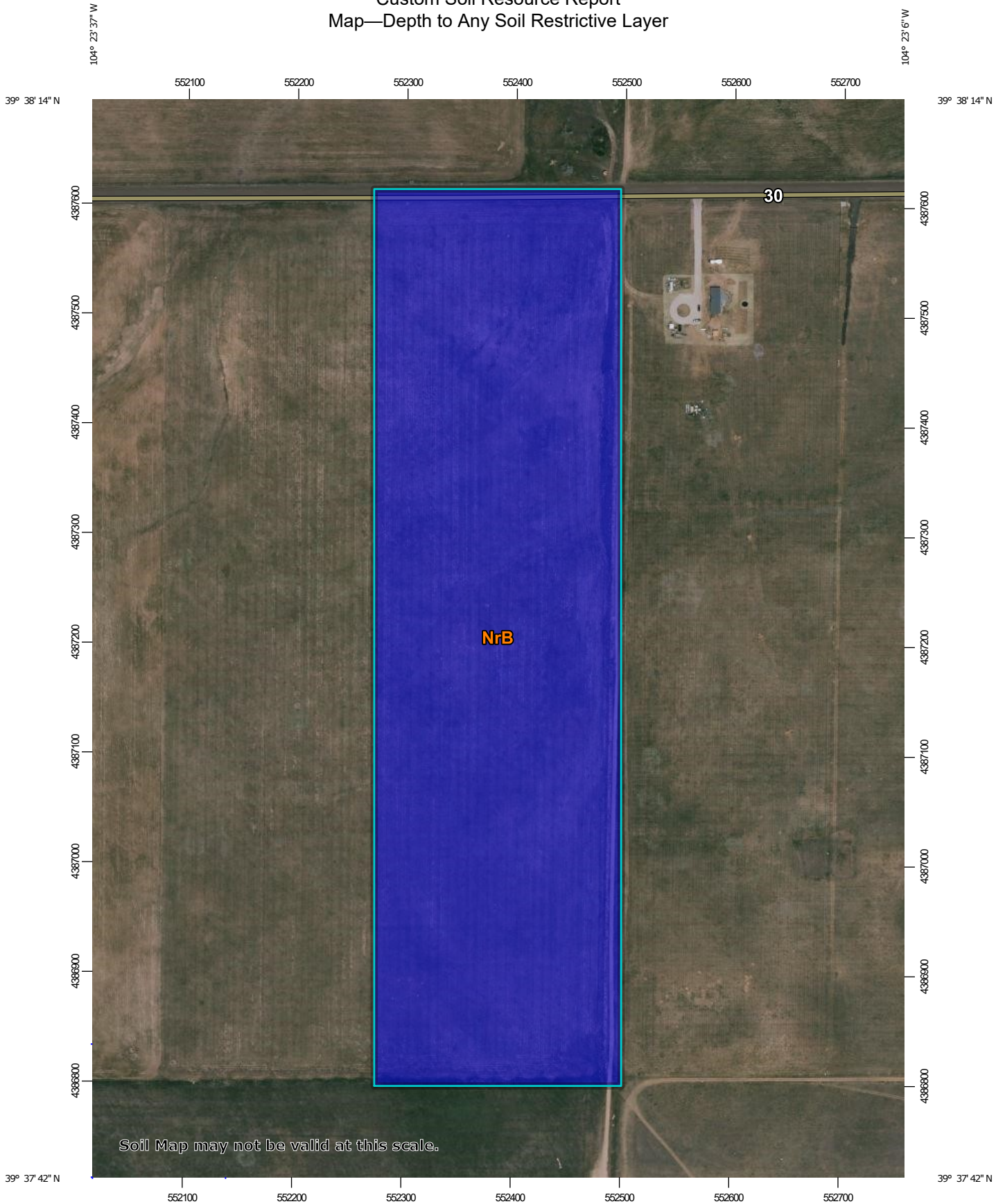
## Depth to Any Soil Restrictive Layer

A "restrictive layer" is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers.

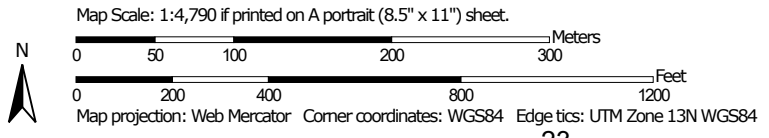
This theme presents the depth to any type of restrictive layer that is described for each map unit. If more than one type of restrictive layer is described for an individual soil type, the depth to the shallowest one is presented. If no restrictive layer is described in a map unit, it is represented by the "greater than 200" depth class.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.


Custom Soil Resource Report  
Map—Depth to Any Soil Restrictive Layer



Soil Map may not be valid at this scale.










### MAP LEGEND








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

**Soils**







**Soil Rating Polygons**


-  0 - 25
-  25 - 50
-  50 - 100
-  100 - 150
-  150 - 200
-  > 200
-  Not rated or not available

**Soil Rating Lines**






-  0 - 25
-  25 - 50
-  50 - 100
-  100 - 150
-  150 - 200
-  > 200
-  Not rated or not available


**Soil Rating Points**


-  0 - 25
-  25 - 50
-  50 - 100
-  100 - 150
-  150 - 200
-  > 200

**Water Features**  
 Streams and Canals

**Transportation**

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

**Background**  
 Aerial Photography

 Not rated or not available

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**Table—Depth to Any Soil Restrictive Layer**

Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	>200	45.8	100.0%
<b>Totals for Area of Interest</b>			<b>45.8</b>	<b>100.0%</b>

**Rating Options—Depth to Any Soil Restrictive Layer**

*Units of Measure:* centimeters

*Aggregation Method:* Dominant Component

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Lower

*Interpret Nulls as Zero:* No

**Unified Soil Classification (Surface)**

The Unified soil classification system classifies mineral and organic mineral soils for engineering purposes on the basis of particle-size characteristics, liquid limit, and plasticity index. It identifies three major soil divisions: (i) coarse-grained soils having less than 50 percent, by weight, particles smaller than 0.074 mm in diameter; (ii) fine-grained soils having 50 percent or more, by weight, particles smaller than 0.074 mm in diameter; and (iii) highly organic soils that demonstrate certain organic characteristics. These divisions are further subdivided into a total of 15 basic soil groups. The major soil divisions and basic soil groups are determined on the basis of estimated or measured values for grain-size distribution and Atterberg limits. ASTM D 2487 shows the criteria chart used for classifying soil in the Unified system and the 15 basic soil groups of the system and the plasticity chart for the Unified system.

The various groupings of this classification correlate in a general way with the engineering behavior of soils. This correlation provides a useful first step in any field or laboratory investigation for engineering purposes. It can serve to make some general interpretations relating to probable performance of the soil for engineering uses.

For each soil horizon in the database one or more Unified soil classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil.

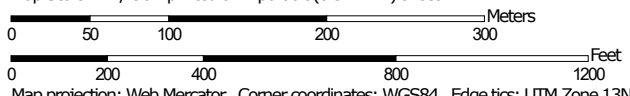
Custom Soil Resource Report  
Map—Unified Soil Classification (Surface)



Soil Map may not be valid at this scale.



Map Scale: 1:4,790 if printed on A portrait (8.5" x 11") sheet.




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

# Custom Soil Resource Report




## MAP LEGEND

### Area of Interest (AOI)

 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons

-  CH
-  CL
-  CL-A (proposed)
-  CL-K (proposed)
-  CL-ML
-  CL-O (proposed)
-  CL-T (proposed)
-  GC
-  GC-GM
-  GM
-  GP
-  GP-GC
-  GP-GM
-  GW
-  GW-GC
-  GW-GM
-  MH
-  MH-A (proposed)
-  MH-K (proposed)
-  MH-O (proposed)
-  MH-T (proposed)
-  ML









































-  ML-A (proposed)
-  ML-K (proposed)
-  ML-O (proposed)
-  ML-T (proposed)
-  OH
-  OH-T (proposed)
-  OL
-  PT
-  SC
-  SC-SM
-  SM
-  SP
-  SP-SC
-  SP-SM
-  SW
-  SW-SC
-  SW-SM
-  Not rated or not available

#### Soil Rating Lines


-  CH
-  CL
-  CL-A (proposed)
-  CL-K (proposed)
-  CL-ML
-  CL-O (proposed)
-  CL-T (proposed)
-  GC
-  GC-GM
-  GM
-  GP
-  GP-GC
-  GP-GM
-  GW
-  GW-GC
-  GW-GM
-  MH
-  MH-A (proposed)
-  MH-K (proposed)
-  MH-O (proposed)
-  MH-T (proposed)
-  ML
-  ML-A (proposed)
-  ML-K (proposed)
-  ML-O (proposed)
-  ML-T (proposed)
-  OH
-  OH-T (proposed)
-  OL
-  PT
-  SC
-  SC-SM
-  SM

-  SP
-  SP-SC
-  SP-SM
-  SW
-  SW-SC
-  SW-SM
-  Not rated or not available

#### Soil Rating Points

-  CH
-  CL
-  CL-A (proposed)
-  CL-K (proposed)
-  CL-ML
-  CL-O (proposed)
-  CL-T (proposed)
-  GC
-  GC-GM
-  GM
-  GP
-  GP-GC
-  GP-GM
-  GW
-  GW-GC
-  GW-GM
-  MH
-  MH-A (proposed)
-  MH-K (proposed)
-  MH-O (proposed)
-  MH-T (proposed)
-  ML
-  ML-A (proposed)
-  ML-K (proposed)
-  ML-O (proposed)
-  ML-T (proposed)
-  OH
-  OH-T (proposed)
-  OL
-  PT
-  SC
-  SC-SM
-  SM
-  SP
-  SP-SC
-  SP-SM
-  SW
-  SW-SC
-  SW-SM
-  Not rated or not available






#### Water Features

 Streams and Canals

#### Transportation

 Rails

## MAP INFORMATION

-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads
- Background**
-  Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

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

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

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

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

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

Soil Survey Area: Arapahoe County, Colorado  
Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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

**Table—Unified Soil Classification (Surface)**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	CL	45.8	100.0%
<b>Totals for Area of Interest</b>			<b>45.8</b>	<b>100.0%</b>

**Rating Options—Unified Soil Classification (Surface)**

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Lower

*Layer Options (Horizon Aggregation Method):* Surface Layer (Not applicable)

**Hydrologic Soil Group**

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.

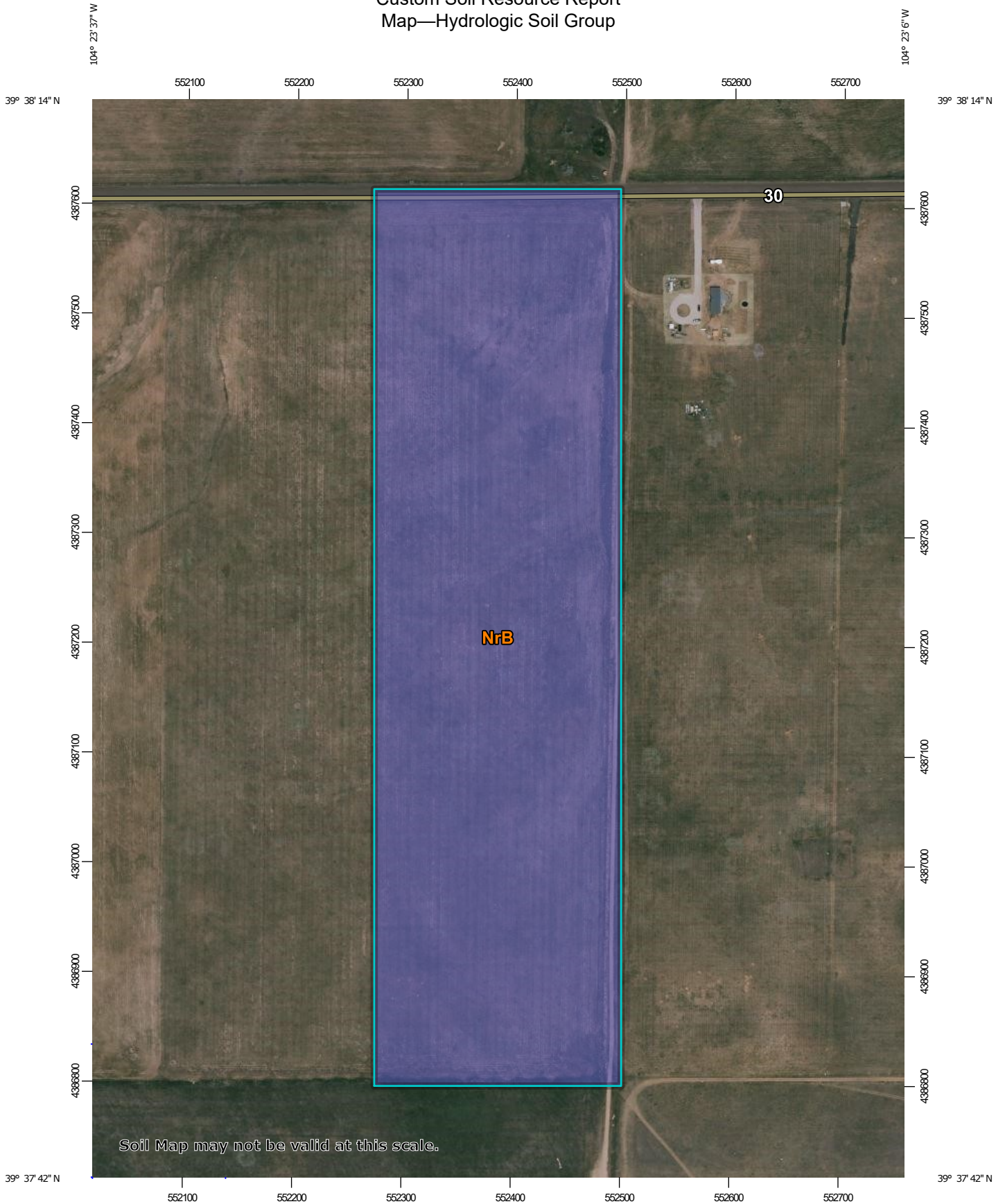
Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

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.

## Custom Soil Resource Report

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

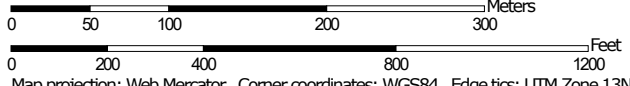
# Custom Soil Resource Report Map—Hydrologic Soil Group



Soil Map may not be valid at this scale.



































Map Scale: 1:4,790 if printed on A portrait (8.5" x 11") sheet.



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

### MAP LEGEND

- Area of Interest (AOI)**
  -  Area of Interest (AOI)
- Soils**
  - Soil Rating Polygons**
    -  A
    -  A/D
    -  B
    -  B/D
    -  C
    -  C/D
    -  D
    -  Not rated or not available
  - Soil Rating Lines**
    -  A
    -  A/D
    -  B
    -  B/D
    -  C
    -  C/D
    -  D
    -  Not rated or not available
  - Soil Rating Points**
    -  A
    -  A/D
    -  B
    -  B/D
- Soils**
  -  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 1:20,000.

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

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

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

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

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

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

Soil Survey Area: Arapahoe County, Colorado  
 Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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

**Table—Hydrologic Soil Group**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	B	45.8	100.0%
<b>Totals for Area of Interest</b>			<b>45.8</b>	<b>100.0%</b>

**Rating Options—Hydrologic Soil Group**

*Aggregation Method: Dominant Condition*

*Component Percent Cutoff: None Specified*

*Tie-break Rule: Higher*

## Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

## Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

## Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

*Hydrologic soil group* is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

*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.

## Custom Soil Resource Report

*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.

*Depth* to the upper and lower boundaries of each layer is indicated.

*Texture* is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

*Classification* of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

*Percentage of rock fragments* larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

*Percentage (of soil particles) passing designated sieves* is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves,

## Custom Soil Resource Report

numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

*Liquid limit* and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

### References:

- American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.
- American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

## Custom Soil Resource Report

Absence of an entry indicates that the data were not estimated. The asterisk '\*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Custom Soil Resource Report

Engineering Properties—Arapahoe County, Colorado														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>	<i>L-R-H</i>
NrB—Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes														
Nunn	40	C	0-8	Loam	CL, CL-ML	A-4	0-0-0	0-0-0	100-100-100	100-100-100	85-90-95	60-68-75	25-28-30	5-8-10
			8-28	Clay, clay loam	CL, CH	A-7	0-0-0	0-3-5	95-98-100	90-95-100	85-90-95	65-70-75	40-50-60	25-33-40
			28-60	Sandy clay loam, fine sandy loam, sandy loam	SC-SM, SC, SM	A-2, A-4	0-0-0	0-3-5	80-90-100	75-88-100	50-65-80	25-38-50	15-20-25	NP-5-10
Bresser	25	B	0-6	Sandy loam	SC-SM, SM	A-2, A-4	0-0-0	0-0-0	100-100-100	100-100-100	50-60-70	20-30-40	20-23-25	NP-3-5
			6-26	Sandy clay loam, clay loam	SC	A-2, A-6, A-7	0-0-0	0-0-0	95-98-100	75-88-100	50-60-70	30-40-50	30-43-55	15-23-30
			26-60	Very gravelly loamy sand, loamy coarse sand, gravelly loamy sand, gravelly loamy coarse sand	SM	A-1	0-0-0	0-3-5	80-90-100	35-60-85	20-35-50	10-18-25	—	NP
Ascalon	20	B	0-6	Sandy loam	SM	A-2, A-4	0-0-0	0-0-0	95-98-100	90-95-100	70-83-95	25-38-50	15-20-25	NP-3-5
			6-17	Sandy clay loam, sandy loam	CL, SC	A-6	0-0-0	0-0-0	95-98-100	90-95-100	80-90-100	40-48-55	25-33-40	10-15-20
			17-60	Fine sandy loam, loamy fine sand, sandy loam	SM	A-2	0-0-0	0-0-0	95-98-100	95-98-100	70-83-95	20-28-35	—	NP

# References

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- American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.
- American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.
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- Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. [http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2\\_053577](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577)
- Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. [http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2\\_053580](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580)
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- United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.
- United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. [http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2\\_053374](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374)
- United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084>

## Custom Soil Resource Report

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

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. [http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2\\_053624](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624)

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

<b>SUBJECT:</b>	Trip Report Kiowa Creek Facility Bennett, CO	<b>LOCATION:</b>	39.634444, -104.388611
<b>TO:</b>	Whom it may concern	<b>PROJECT:</b>	Retention pond

**PARTICIPANTS:** Travis Hertneky (THEngineering)

**PURPOSE:** Perform soil boring to determine soil type and groundwater presence.

**OBSERVATIONS:** One bore was completed in a pre-determined location using a pickup mounted Giddings drill rig. A slotted tube was advanced to 22ft and soils logged at 3" increments.

The surface soils were a lean clay with a field estimated PI of approximately 15. Field observations indicate that this material is likely suitable for use to construct a low permeability compacted clay liner in the runoff pond. Subsoils were significantly sandier with moderate amounts of clay present in certain layers as indicated on the bore logs. Soils logs are attached

**PENDING ACTIONS:** None.

Sincerely,

Travis Hertneky  
THEngineering

**Kiowa Creek Facility**

Hole #1	Northwest corner proposed pond		Sample		
	Depth (in)	Description of Material	USCS*	Number	Depth (in)
5655.3	0-18	Lean Clay, approx PI =15	CL		
	18-36	Poorly graded sand w/Clay	SP-w/C		
	36-162	Poorly graded fine sand	SP		
	162-204	Poorly graded sand w/Clay	SP-w/C		
	204-240	Sandy clay	SC		
5633.3	240-264	Poorly graded sand	SP		

\* USCS classification is from in field classification by TEH, subject to change with lab analysis.



**Natural Resources Conservation Service**  
**CONSERVATION PRACTICE STANDARD**  
**VEGETATED TREATMENT AREA**

**CODE 635**

**(ac)**

**DEFINITION**

An area of permanent vegetation used for agricultural wastewater treatment.

**PURPOSE**

This practice is used to accomplish the following purpose:

- Improve water quality by using vegetation to reduce the loading of nutrients, organics, pathogens, and other contaminants associated with livestock, poultry, and other agricultural operations

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where:

- A vegetated treatment area (VTA) can be constructed, operated and maintained to treat contaminated runoff from such areas as feedlots, feed storage, compost areas, solid manure storage areas, barnyards, and other livestock holding areas; or to treat process wastewater from agricultural operations.
- A VTA is a component of a planned agricultural waste management system.

**CRITERIA**

**General Criteria Applicable to All Purposes**

Size the total treatment area for the VTA on both the contributing site water runoff and vegetation nutrient balances.

- Water balance is the soil's capacity to infiltrate and retain runoff within the root zone. Base the runoff determination on the most restrictive soil layer within the root zone regardless of its thickness. Use the soil's water holding capacity in the root zone, infiltration rate, permeability, and hydraulic conductivity to determine its ability to absorb and retain runoff.
- Nutrient balance utilizes the nutrients from the waste runoff to meet the nutrient removal requirements in the harvested vegetation. Base the nutrient balance on the most limiting nutrient (i.e. nitrogen or phosphorus).

Divert uncontaminated water from the treatment area to the fullest extent possible unless additional moisture is needed to manage vegetation growth in the treatment area.

Establish permanent vegetation in the treatment area. Use a single species or a mixture of grasses, legumes, and other forbs adapted to the soil and climate. Select species to meet the current site conditions and intended use. Selected species will have the capacity to achieve adequate density, vigor, and yield within an appropriate time frame to treat contaminated runoff. Complete site preparation and seeding at a time and in a manner that best ensures survival and growth of the selected species.

NRCS reviews and periodically updates conservation practice standards. To obtain the current version of this standard, contact your Natural Resources Conservation Service State office or visit the Field Office Technical Guide online by going to the NRCS website at <https://www.nrcs.usda.gov/> and type FOTG in the search field.

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NRCS, CO  
January 2017

Select vegetation that will withstand anticipated wetting or submerged conditions. Harvest vegetation as appropriate to encourage dense growth, maintain an upright growth habit, and remove nutrients and other contaminants that are contained in the plant tissue.

Design the VTA based on the need to treat the runoff volume from the 25-year, 24-hour storm event from the agricultural animal management facility. Infiltrate a portion or the entire volume of the design storm, based on management objectives. Unless discharge is permitted by applicable regulations, store the noninfiltrated portion of the design volume for utilization or treatment.

Exclude all livestock, including grazing, from the VTA.

Apply discharge into and through vegetated treatment area as sheet flow. To encourage sheet flow across the treatment area, provide a means to disperse concentrated flow, such as a ditch, curb, gated pipe, level spreader, or a sprinkler system. Complete land grading and install structural components necessary to maintain sheet flow throughout the treatment area.

Limit the natural or constructed slope of the VTA from 0.3 to 6 percent. The minimum entrance slope to the VTA is 1 percent.

Use NRCS Conservation Practice Standard (CPS) Code 632, Waste Separation Facility, to pretreat influent with waste separation (i.e., settling basin) to reduce organic loading and nutrients to levels that are tolerated by the VTA and to prevent excessive accumulation of solids in the treatment area.

Utilize inlet control structures to control the rate and timing of inflow during normal operations and to control inflow as necessary for operation and maintenance.

Locate VTAs outside of floodplains. However, if site restrictions require location within a floodplain, provide protection from inundation or damage from a 25-year flood event, or larger, if required by regulation.

Install VTAs where the water table is either naturally deep or artificially lowered so that the infiltrated runoff does not mingle with the groundwater at the bottom of the root zone. Subsurface drainage within the VTA is not allowed. Subsurface drainage may be used to lower the seasonal high water table to an acceptable level provided the subsurface drain lines are at least 10 feet away from the VTA boundary.

Unless soil moisture can be maintained to prevent drying and cracking, do not plan infiltration areas where soil features such as cracking will result in preferential flow paths that transport untreated runoff from the surface to below the root zone.

Ensure that appropriate erosion control measures and sheet flow control measures (i.e., gravel spreaders) are adequately addressed over the entire length of the VTA.

#### **Additional Criteria for Pressure Dosing Systems**

Distribute the effluent over the VTA through sprinkler irrigation or other pressure dosing system. Match the application rate of sprinkler nozzles to the most restrictive soil infiltration rate or other factors to prevent effluent from discharging from the VTA.

#### **CONSIDERATIONS**

Additional nutrient and infiltration design guidance in *Vegetated Treatment Systems for Open Lot Runoff*, (Koelsch, et. al., 2006).

Provide more than one vegetated treatment area to allow for resting, harvesting vegetation, and maintenance, and to minimize the potential for overloading.

Provide additional storage in the basin collection area to minimize or eliminate discharge into the VTA during rainfall events. Delay application until rainfall has ended to improve infiltration and nutrient uptake.

To maximize nutrient uptake, use warm and cool season species in separate areas to ensure that plants are actively growing during different times of the year.

Supplement water as necessary to maintain plants in a condition suitable for the treatment purpose.

Direct contaminated effluent to a waste storage facility during excessively wet or cold climatic conditions.

Consider suspension of application to treatment area when weather conditions are not favorable for aerobic activity or when soil temperatures are lower than 39° F. When soil temperatures are between 39° F and 50° F, consider reducing application rate and increasing application period while maintaining a constant hydraulic loading rate.

Manage the VTA to maintain vegetative treatment effectiveness throughout the growing season. Time the harvest of the VTA plants so vegetation can regrow to a sufficient height to effectively filter effluent late in the growing season.

Install a berm around the lower end of the VTA to contain excess runoff that may occur.

Effluent from the VTA may be stored for land application, recycled through the wastewater management system, or otherwise used in the agricultural operation.

Install fences or other measures to exclude or minimize access of the VTA to humans or animals.

Install a pumping system at the bottom of the VTA to either recirculate the effluent to the top of the VTA or transfer to a waste storage facility.

## **PLANS AND SPECIFICATIONS**

Prepare plans and specifications that describe the requirements for applying the practice to achieve its intended use.

As a minimum include:

- Critical construction perimeters, necessary construction sequence, vegetation establishment requirements, level spreader mechanism requirements, associated practices and agronomic nutrient removal
- Plan view showing the location of the VTA
- Details of the length, width, and slope of the treatment area to accomplish the planned purpose (length refers to flow length down the slope of the treatment area)
- Herbaceous species, seed selection, and seeding rates to accomplish the planned purpose
- Planting dates, care, and handling of the seed to ensure that planted materials have an acceptable rate of survival
- Site preparation sufficient to establish and grow selected species

## **OPERATION AND MAINTENANCE**

Develop an operation and maintenance plan consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design.

Include the following items as appropriate:

- Control undesired weed species, especially state-listed noxious weeds, and other pests that could inhibit proper functioning of the VTA
- Inspect and repair treatment areas after storm events to address gullies, reseed disturbed areas, and prevent concentrated flow
- Apply supplemental nutrients and soil amendments as needed to maintain the desired species

composition and stand density of herbaceous vegetation

- Maintain or restore the treatment area as necessary by periodically grading or removing excess material when deposition jeopardizes its function. Reestablish herbaceous vegetation
- Routinely dethatch or aerate a treatment area used for treating runoff from livestock holding areas in order to promote infiltration
- Conduct maintenance activities only when the surface layer of the VTA is dry enough to prohibit compaction

Monitor treatment areas in arid or semiarid regions that potentially could be affected by high salinity or sodium content for excessive salt and sodium buildup. Take corrective action if excessive salt or sodium is found.

Monitor all treatment areas to maintain optimal crop growth and environmental protection. Ensure that neither phosphorus is accumulating in the soil profile, nor nitrogen is leaching below the root zone.

## **REFERENCES**

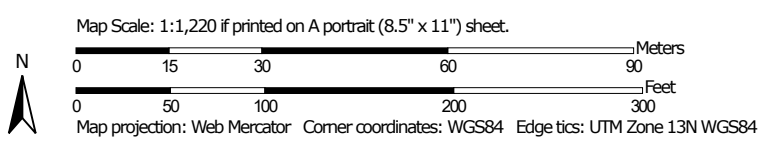
USDA/NRCS, National Engineering Handbook, Part 651, Agricultural Waste Management Field Handbook.

Koelsch, R., B. Kintzer, and D. Meyer. (ed.) 2006. Vegetated Treatment Systems for Open Lot Runoff - A Collaborative Report. USDA, NRCS.

Available Water Capacity—Arapahoe County, Colorado  
(AAR VTA)




Soil Map may not be valid at this scale.



## MAP LEGEND


### Area of Interest (AOI)

 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons

 = 0.17


 Not rated or not available


#### Soil Rating Lines

 = 0.17


 Not rated or not available

#### Soil Rating Points

 = 0.17

 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 1:20,000.

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

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

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

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Arapahoe County, Colorado

Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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.

## Available Water Capacity

Map unit symbol	Map unit name	Rating (centimeters per centimeter)	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	0.17	4.7	100.0%
<b>Totals for Area of Interest</b>			<b>4.7</b>	<b>100.0%</b>

### Description

Available water capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in centimeters of water per centimeter of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure, with corrections for salinity and rock fragments. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. It is not an estimate of the quantity of water actually available to plants at any given time.

Available water supply (AWS) is computed as AWC times the thickness of the soil. For example, if AWC is 0.15 cm/cm, the available water supply for 25 centimeters of soil would be 0.15 x 25, or 3.75 centimeters of water.

For each soil layer, AWC is recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

### Rating Options

*Units of Measure:* centimeters per centimeter

*Aggregation Method:* Dominant Component

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Higher

*Interpret Nulls as Zero:* No

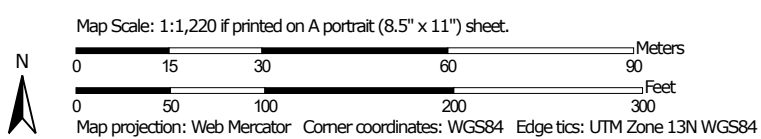
*Layer Options (Horizon Aggregation Method):* Depth Range (Weighted Average)

*Top Depth:* 0

*Bottom Depth:* 48


*Units of Measure:* Centimeters

Saturated Hydraulic Conductivity (Ksat)—Arapahoe County, Colorado  
(AAR VTA)





## MAP LEGEND

### Area of Interest (AOI)



 Area of Interest (AOI)

### Soils



#### Soil Rating Polygons

 = 9.0000  
 Not rated or not available

#### Soil Rating Lines

 = 9.0000  
 Not rated or not available






#### Soil Rating Points

 = 9.0000  
 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 1:20,000.

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

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

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

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

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

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

Soil Survey Area: Arapahoe County, Colorado  
Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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.

## Saturated Hydraulic Conductivity (Ksat)

Map unit symbol	Map unit name	Rating (micrometers per second)	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	9.0000	4.7	100.0%
<b>Totals for Area of Interest</b>			<b>4.7</b>	<b>100.0%</b>

### Description

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity is considered in the design of soil drainage systems and septic tank absorption fields.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

The numeric Ksat values have been grouped according to standard Ksat class limits.

### Rating Options

*Units of Measure:* micrometers per second

*Aggregation Method:* Dominant Component

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Fastest

*Interpret Nulls as Zero:* No

*Layer Options (Horizon Aggregation Method):* Surface Layer (Not applicable)



**NOAA Atlas 14, Volume 8, Version 2**  
**Location name: Strasburg, Colorado, USA\***  
**Latitude: 39.6327°, Longitude: -104.3894°**  
**Elevation: 5666 ft\*\***

\* source: ESRI Maps  
\*\* source: USGS



### **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 & aerals](#)

## PF tabular

<b>PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup></b>										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
<b>5-min</b>	<b>0.238</b> (0.196-0.291)	<b>0.295</b> (0.243-0.361)	<b>0.397</b> (0.325-0.486)	<b>0.488</b> (0.397-0.601)	<b>0.626</b> (0.494-0.807)	<b>0.740</b> (0.566-0.963)	<b>0.862</b> (0.634-1.15)	<b>0.994</b> (0.696-1.35)	<b>1.18</b> (0.791-1.65)	<b>1.33</b> (0.862-1.87)
<b>10-min</b>	<b>0.349</b> (0.287-0.426)	<b>0.432</b> (0.355-0.529)	<b>0.581</b> (0.476-0.712)	<b>0.715</b> (0.582-0.880)	<b>0.916</b> (0.723-1.18)	<b>1.08</b> (0.829-1.41)	<b>1.26</b> (0.928-1.68)	<b>1.46</b> (1.02-1.98)	<b>1.73</b> (1.16-2.41)	<b>1.95</b> (1.26-2.74)
<b>15-min</b>	<b>0.425</b> (0.350-0.520)	<b>0.527</b> (0.434-0.645)	<b>0.709</b> (0.580-0.869)	<b>0.872</b> (0.709-1.07)	<b>1.12</b> (0.881-1.44)	<b>1.32</b> (1.01-1.72)	<b>1.54</b> (1.13-2.05)	<b>1.77</b> (1.24-2.42)	<b>2.11</b> (1.41-2.94)	<b>2.37</b> (1.54-3.34)
<b>30-min</b>	<b>0.573</b> (0.471-0.700)	<b>0.707</b> (0.581-0.865)	<b>0.948</b> (0.776-1.16)	<b>1.17</b> (0.949-1.44)	<b>1.50</b> (1.18-1.93)	<b>1.77</b> (1.36-2.31)	<b>2.07</b> (1.52-2.76)	<b>2.39</b> (1.68-3.26)	<b>2.85</b> (1.91-3.98)	<b>3.21</b> (2.08-4.52)
<b>60-min</b>	<b>0.713</b> (0.587-0.871)	<b>0.872</b> (0.717-1.07)	<b>1.16</b> (0.951-1.42)	<b>1.43</b> (1.16-1.76)	<b>1.84</b> (1.46-2.39)	<b>2.19</b> (1.68-2.86)	<b>2.57</b> (1.89-3.43)	<b>2.98</b> (2.09-4.07)	<b>3.57</b> (2.40-5.00)	<b>4.05</b> (2.63-5.70)
<b>2-hr</b>	<b>0.853</b> (0.706-1.04)	<b>1.04</b> (0.857-1.26)	<b>1.38</b> (1.13-1.68)	<b>1.69</b> (1.38-2.07)	<b>2.19</b> (1.74-2.82)	<b>2.61</b> (2.02-3.39)	<b>3.07</b> (2.28-4.07)	<b>3.57</b> (2.53-4.85)	<b>4.30</b> (2.91-5.98)	<b>4.89</b> (3.20-6.83)
<b>3-hr</b>	<b>0.940</b> (0.780-1.14)	<b>1.13</b> (0.940-1.37)	<b>1.50</b> (1.24-1.82)	<b>1.84</b> (1.51-2.24)	<b>2.37</b> (1.90-3.05)	<b>2.83</b> (2.20-3.67)	<b>3.34</b> (2.49-4.42)	<b>3.89</b> (2.77-5.27)	<b>4.70</b> (3.20-6.51)	<b>5.35</b> (3.52-7.44)
<b>6-hr</b>	<b>1.12</b> (0.932-1.34)	<b>1.34</b> (1.12-1.61)	<b>1.75</b> (1.45-2.11)	<b>2.14</b> (1.76-2.58)	<b>2.74</b> (2.20-3.49)	<b>3.25</b> (2.54-4.18)	<b>3.82</b> (2.86-5.01)	<b>4.43</b> (3.18-5.96)	<b>5.33</b> (3.65-7.33)	<b>6.06</b> (4.01-8.36)
<b>12-hr</b>	<b>1.35</b> (1.13-1.61)	<b>1.61</b> (1.35-1.92)	<b>2.08</b> (1.74-2.49)	<b>2.52</b> (2.09-3.02)	<b>3.17</b> (2.56-4.00)	<b>3.73</b> (2.92-4.73)	<b>4.32</b> (3.26-5.61)	<b>4.96</b> (3.58-6.60)	<b>5.88</b> (4.06-8.02)	<b>6.62</b> (4.43-9.08)
<b>24-hr</b>	<b>1.62</b> (1.36-1.91)	<b>1.92</b> (1.62-2.28)	<b>2.45</b> (2.06-2.91)	<b>2.93</b> (2.44-3.49)	<b>3.62</b> (2.93-4.51)	<b>4.20</b> (3.30-5.27)	<b>4.81</b> (3.64-6.17)	<b>5.46</b> (3.96-7.18)	<b>6.36</b> (4.43-8.59)	<b>7.09</b> (4.78-9.66)
<b>2-day</b>	<b>1.90</b> (1.61-2.24)	<b>2.24</b> (1.89-2.63)	<b>2.81</b> (2.37-3.31)	<b>3.31</b> (2.77-3.92)	<b>4.04</b> (3.28-4.96)	<b>4.63</b> (3.66-5.76)	<b>5.24</b> (4.00-6.67)	<b>5.90</b> (4.31-7.69)	<b>6.80</b> (4.77-9.10)	<b>7.52</b> (5.12-10.2)
<b>3-day</b>	<b>2.08</b> (1.76-2.43)	<b>2.42</b> (2.06-2.84)	<b>3.02</b> (2.55-3.55)	<b>3.54</b> (2.97-4.18)	<b>4.29</b> (3.49-5.24)	<b>4.89</b> (3.88-6.05)	<b>5.52</b> (4.22-6.98)	<b>6.18</b> (4.53-8.02)	<b>7.09</b> (4.99-9.44)	<b>7.81</b> (5.34-10.5)
<b>4-day</b>	<b>2.20</b> (1.88-2.57)	<b>2.57</b> (2.18-3.00)	<b>3.18</b> (2.70-3.73)	<b>3.72</b> (3.13-4.38)	<b>4.49</b> (3.66-5.46)	<b>5.10</b> (4.06-6.29)	<b>5.74</b> (4.40-7.23)	<b>6.40</b> (4.71-8.28)	<b>7.32</b> (5.17-9.71)	<b>8.04</b> (5.52-10.8)
<b>7-day</b>	<b>2.51</b> (2.14-2.91)	<b>2.91</b> (2.49-3.38)	<b>3.59</b> (3.05-4.18)	<b>4.16</b> (3.52-4.87)	<b>4.98</b> (4.08-6.01)	<b>5.62</b> (4.49-6.88)	<b>6.28</b> (4.85-7.86)	<b>6.97</b> (5.15-8.94)	<b>7.90</b> (5.61-10.4)	<b>8.63</b> (5.96-11.5)
<b>10-day</b>	<b>2.78</b> (2.38-3.22)	<b>3.22</b> (2.76-3.72)	<b>3.94</b> (3.36-4.57)	<b>4.55</b> (3.86-5.30)	<b>5.41</b> (4.44-6.50)	<b>6.08</b> (4.88-7.40)	<b>6.77</b> (5.24-8.43)	<b>7.48</b> (5.55-9.55)	<b>8.43</b> (6.01-11.0)	<b>9.17</b> (6.36-12.2)
<b>20-day</b>	<b>3.60</b> (3.11-4.14)	<b>4.13</b> (3.56-4.75)	<b>4.99</b> (4.28-5.75)	<b>5.71</b> (4.87-6.60)	<b>6.70</b> (5.52-7.96)	<b>7.46</b> (6.01-8.99)	<b>8.22</b> (6.40-10.1)	<b>9.00</b> (6.73-11.4)	<b>10.0</b> (7.21-13.0)	<b>10.8</b> (7.58-14.3)
<b>30-day</b>	<b>4.31</b> (3.72-4.93)	<b>4.92</b> (4.25-5.64)	<b>5.92</b> (5.09-6.79)	<b>6.73</b> (5.76-7.76)	<b>7.84</b> (6.48-9.26)	<b>8.68</b> (7.02-10.4)	<b>9.51</b> (7.44-11.7)	<b>10.3</b> (7.76-13.0)	<b>11.4</b> (8.25-14.8)	<b>12.2</b> (8.62-16.1)
<b>45-day</b>	<b>5.21</b> (4.52-5.93)	<b>5.95</b> (5.16-6.79)	<b>7.14</b> (6.17-8.16)	<b>8.10</b> (6.96-9.30)	<b>9.37</b> (7.76-11.0)	<b>10.3</b> (8.36-12.3)	<b>11.2</b> (8.80-13.7)	<b>12.1</b> (9.12-15.1)	<b>13.3</b> (9.60-17.0)	<b>14.1</b> (9.97-18.4)
<b>60-day</b>	<b>5.98</b> (5.19-6.79)	<b>6.85</b> (5.95-7.79)	<b>8.23</b> (7.12-9.38)	<b>9.32</b> (8.02-10.7)	<b>10.7</b> (8.89-12.5)	<b>11.8</b> (9.55-13.9)	<b>12.8</b> (10.0-15.4)	<b>13.7</b> (10.3-17.0)	<b>14.8</b> (10.8-19.0)	<b>15.7</b> (11.1-20.4)

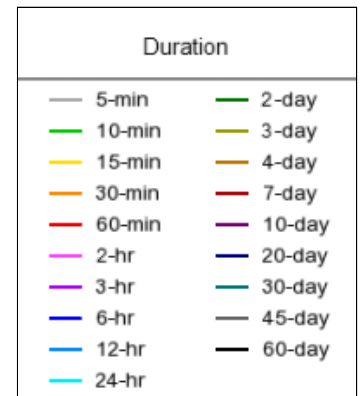
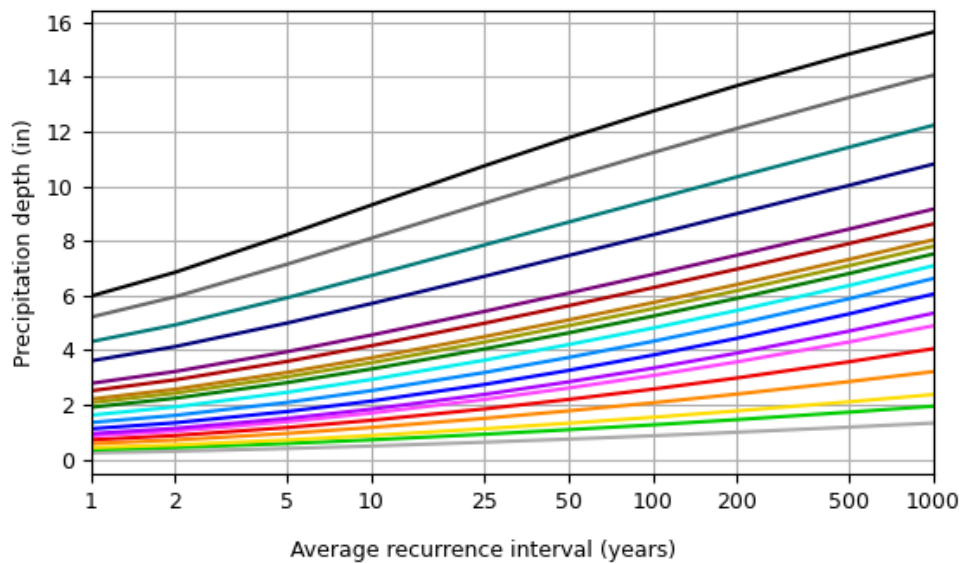
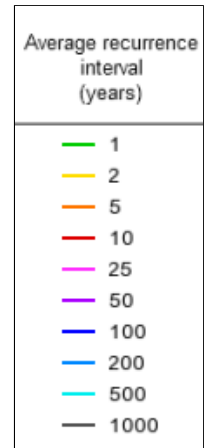
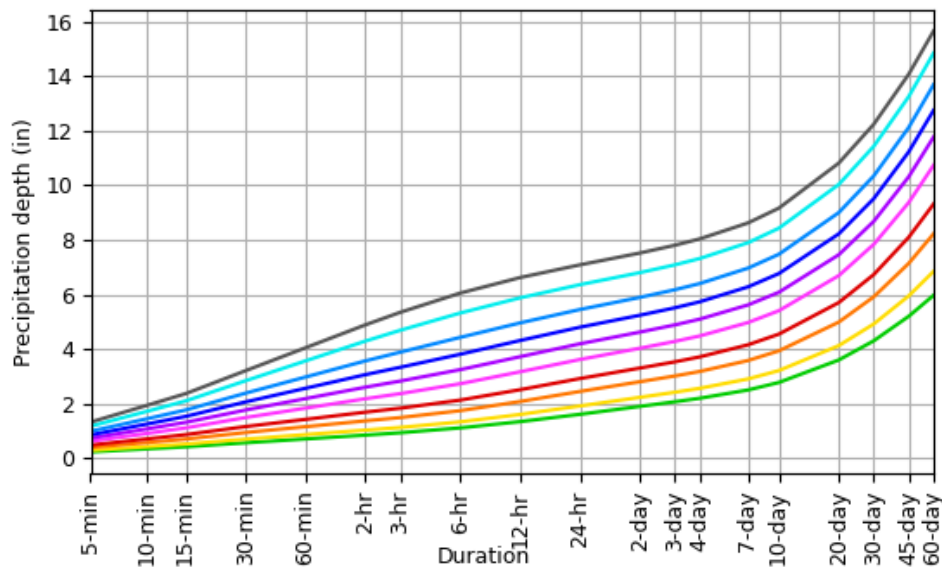
<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration 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

PDS-based depth-duration-frequency (DDF) curves

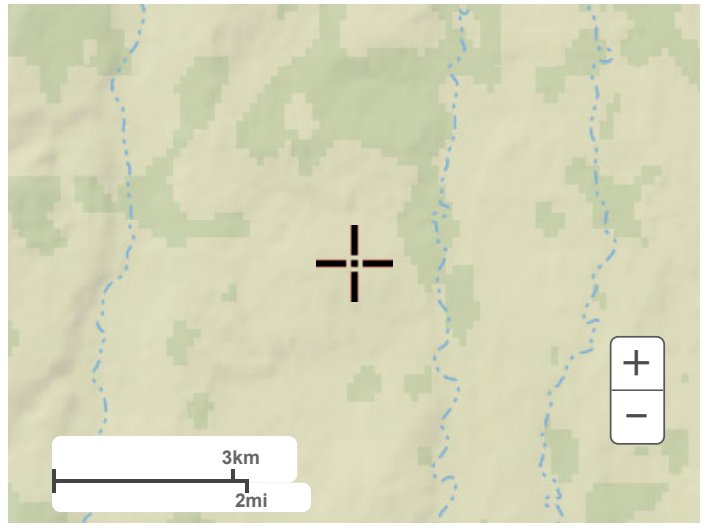
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**Maps & aeriels**

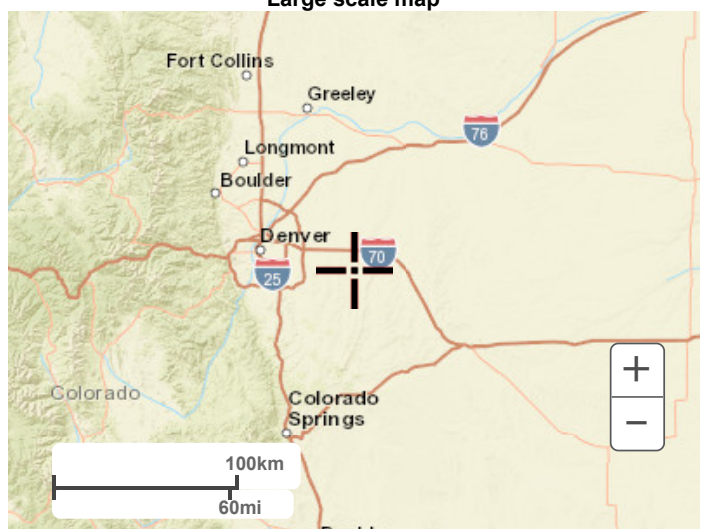
**Small scale terrain**



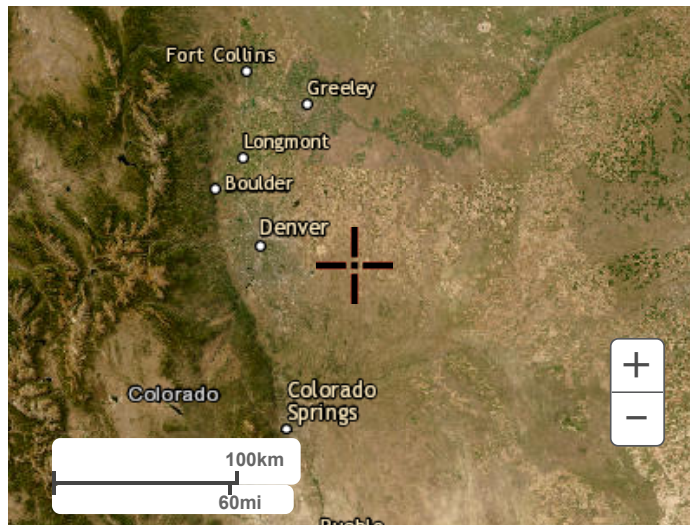
Large scale terrain



Large scale map



Large scale aerial



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[US Department of Commerce](#)  
[National Oceanic and Atmospheric Administration](#)  
[National Weather Service](#)  
[National Water Center](#)  
1325 East West Highway  
Silver Spring, MD 20910  
Questions?: [HDSC.Questions@noaa.gov](mailto:HDSC.Questions@noaa.gov)

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**Runoff areas**

Area	Area (acres)	Cover	Soil	CN	Slope	
South composting area	18.8	"Newly graded areas"	B	86	2.4%	
Equipment parking area	1.2	"farmstead"	B	74	2.4%	1. Use CN 86 for simplicity for entire area
Shop/office area	1.1	"farmstead"	B	74	1.3%	1. Use CN 86 for simplicity for entire area
Shop and office roof	0.2	Impervious	N/A	100		
Total	21.3					
Run-on area	26.1	Small grain SR+residue	B	72	2.83%	

Design storm		
25yr 24hr storm	3.65	in
2yr 24hr storm	0.87	in
5yr 1hr storm	1.16	in
100yr 1hr storm	2.57	in

**Runoff flows**

South pond inlet		
Peak flow 2yr-1hr	13.0	cfs
Peak flow 5yr-1hr	22.0	cfs
Peak flow 100yr-1hr	81.1	cfs
Peak flow 25yr-24hr	42.3	cfs
Channel capacity	1,910	cfs
Total depth	3.00	ft
Depth at 5yr-1hr	0.55	ft
Depth at 100yr-1hr	0.92	ft

- 1. Rational
- 1. Rational
- 1. Rational
- 2. RCN

West pond inlet		
Peak flow 2yr-1hr	3.0	cfs
Peak flow 5yr-1hr	4.4	cfs
Peak flow 100yr-1hr	13.1	cfs
Peak flow 25yr-24hr	42.3	cfs
Channel capacity	N/A	
Total depth	N/A	
Depth at 25	N/A	
Depth at 100	N/A	

- 1. Rational
- 1. Rational
- 1. Rational
- 2. RCN

Total site		
Peak flow 2yr-1hr	16.0	cfs
Peak flow 5yr-1hr	26.4	cfs
Peak flow 100yr-1hr	94.3	cfs
Outlet capacity	3.64	cfs
Spillway capacity	164	cfs
Spillway depth	2.0	ft
Historic 5yr from site	8.04	cfs

- 1. Rational
- 1. Rational
- 1. Rational

Run on		
Peak flow 2yr-1hr	2.36	cfs
Peak flow 5yr-1hr	8.24	cfs
Peak flow 100yr-1hr	68.76	cfs
Peak flow 25yr-24hr	17.00	cfs
Channel capacity	223.00	cfs
Total depth	2.00	ft
Depth at 100yr-1hr	1.29	ft
Depth at 25yr-24hr	0.97	ft

- 1. Rational
- 1. Rational
- 1. Rational
- 2. RCN

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Historic

### I. Catchment Hydrologic Data

Catchment ID = 1  
 Area = 24.10 Acres  
 Percent Imperviousness = 5.00 %  
 NRCS Soil Type = B A, B, C, or D

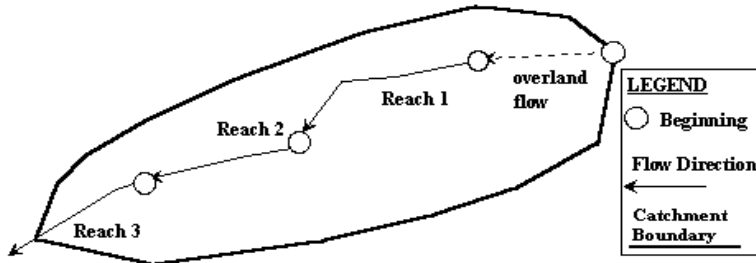
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 5 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 1.16 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.10  
 Override Runoff Coefficient,  $C$  =  (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.10  
 Override 5-yr. Runoff Coefficient,  $C$  =  (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft input	ft input	C-5 output		fps output	minutes output
Overland	2.8300	100	0.10	N/A	0.60	2.80
1	2.8300	1,475		2.50	4.21	5.85
2						
3						
4						
5						
Sum		1,575				
Computed Tc =						8.65
Regional Tc =						18.75
User-Entered Tc =						8.65

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 3.32 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 2.36 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 3.32 inch/hr

Peak Flowrate,  $Q_p$  = 8.04 cfs  
 Peak Flowrate,  $Q_p$  = 5.72 cfs  
 Peak Flowrate,  $Q_p$  = 8.04 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Kiowa Creek Facility  
 Catchment ID: South composting area

### I. Catchment Hydrologic Data

Catchment ID = 2  
 Area = 18.80 Acres  
 Percent Imperviousness = 40.00 %  
 NRCS Soil Type = B A, B, C, or D

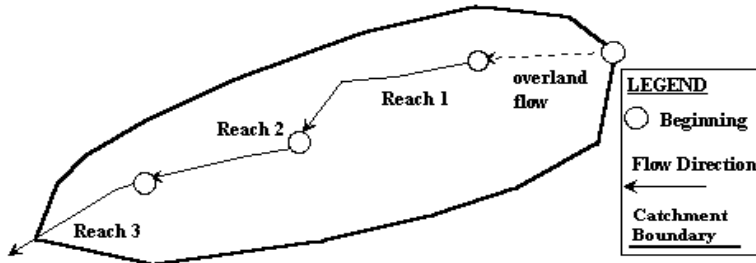
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 2 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 0.87 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.23  
 Override Runoff Coefficient,  $C$  = \_\_\_\_\_ (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.30  
 Override 5-yr. Runoff Coefficient,  $C$  = \_\_\_\_\_ (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
input	input	input	output	output	output	
Overland	2.4000	100	0.30	N/A	0.70	2.38
1	2.4000	980		10.00	15.49	1.05
2	1.2600	460		10.00	11.22	0.68
3						
4						
5						
Sum		1,540				
Computed Tc =						4.11
Regional Tc =						18.56
User-Entered Tc =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 3.10 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 1.78 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 2.96 inch/hr

Peak Flowrate,  $Q_p$  = 13.60 cfs  
 Peak Flowrate,  $Q_p$  = 7.81 cfs  
 Peak Flowrate,  $Q_p$  = 12.96 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Kiowa Creek Facility  
 Catchment ID: South composting area

### I. Catchment Hydrologic Data

Catchment ID = 2  
 Area = 18.80 Acres  
 Percent Imperviousness = 40.00 %  
 NRCS Soil Type = B A, B, C, or D

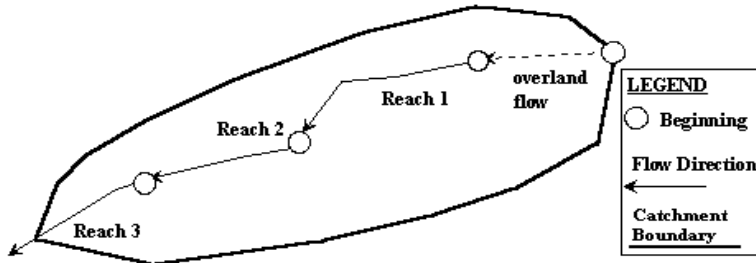
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 5 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 1.16 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.30  
 Override Runoff Coefficient,  $C$  = (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.30  
 Override 5-yr. Runoff Coefficient,  $C$  = (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			fps	minutes
input	input	input	output	output	output	
Overland	2.4000	100	0.30	N/A	0.70	2.38
1	2.4000	980		10.00	15.49	1.05
2	1.2600	460		10.00	11.22	0.68
3						
4						
5						
Sum		1,540				
Computed Tc =						4.11
Regional Tc =						18.56
User-Entered Tc =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 4.13 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 2.37 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 3.93 inch/hr

Peak Flowrate,  $Q_p$  = 23.06 cfs  
 Peak Flowrate,  $Q_p$  = 13.25 cfs  
 Peak Flowrate,  $Q_p$  = 21.98 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Kiowa Creek Facility  
 Catchment ID: South composting area

### I. Catchment Hydrologic Data

Catchment ID = 2  
 Area = 18.80 Acres  
 Percent Imperviousness = 40.00 %  
 NRCS Soil Type = B A, B, C, or D

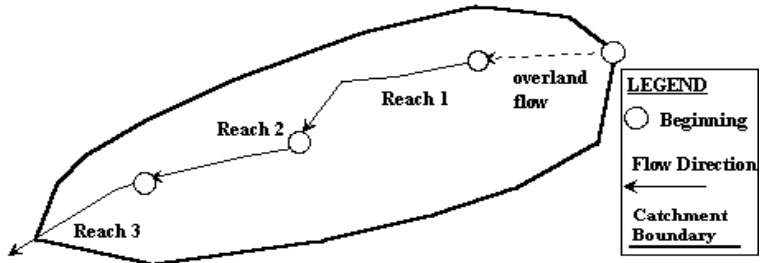
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 100 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.50  
 Override Runoff Coefficient,  $C$  = (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.30  
 Override 5-yr. Runoff Coefficient,  $C$  = (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft input	ft input	C-5 output		fps output	minutes output
Overland	2.4000	100	0.30	N/A	0.70	2.38
1	2.4000	980		10.00	15.49	1.05
2	1.2600	460		10.00	11.22	0.68
3						
4						
5						
Sum		1,540				
Computed Tc =						4.11
Regional Tc =						18.56
User-Entered Tc =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 9.15 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 5.25 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 8.72 inch/hr

Peak Flowrate,  $Q_p$  = 85.13 cfs  
 Peak Flowrate,  $Q_p$  = 48.91 cfs  
 Peak Flowrate,  $Q_p$  = 81.14 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Equipment parking area

### I. Catchment Hydrologic Data

Catchment ID = 3  
 Area = 1.20 Acres  
 Percent Imperviousness = 40.00 %  
 NRCS Soil Type = B A, B, C, or D

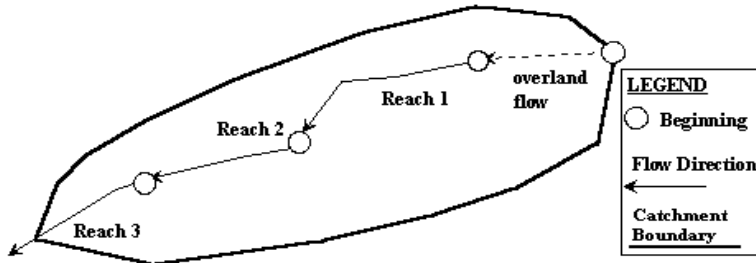
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 2 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 0.87 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.23  
 Override Runoff Coefficient,  $C$  = \_\_\_\_\_ (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.30  
 Override 5-yr. Runoff Coefficient,  $C$  = \_\_\_\_\_ (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft	ft	C-5		fps	minutes
Overland	2.4000	50	0.30	N/A	0.50	1.68
1	2.4000	235		10.00	15.49	0.25
2						
3						
4						
5						
Sum		285				
Computed Tc =						1.93
Regional Tc =						11.58
User-Entered Tc =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 3.53 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 2.22 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 2.95 inch/hr

Peak Flowrate,  $Q_p$  = 0.99 cfs  
 Peak Flowrate,  $Q_p$  = 0.62 cfs  
 Peak Flowrate,  $Q_p$  = 0.83 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Equipment parking area

### I. Catchment Hydrologic Data

Catchment ID = 3  
 Area = 1.20 Acres  
 Percent Imperviousness = 40.00 %  
 NRCS Soil Type = B A, B, C, or D

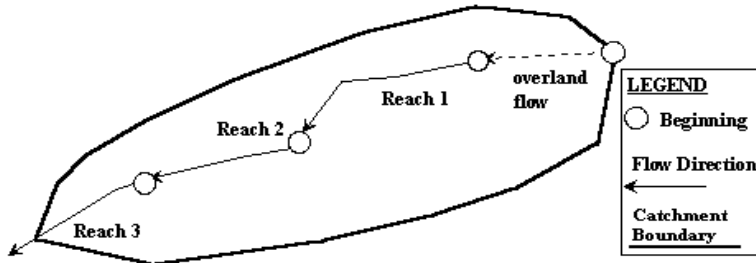
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 5 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 1.16 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.30  
 Override Runoff Coefficient,  $C$  = (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.30  
 Override 5-yr. Runoff Coefficient,  $C$  = (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft input	ft input	C-5 output	input	fps output	minutes output
Overland	2.4000	50	0.30	N/A	0.50	1.68
1	2.4000	235		10.00	15.49	0.25
2						
3						
4						
5						
Sum		285				
Computed Tc =						1.93
Regional Tc =						11.58
User-Entered Tc =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 4.71 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 2.96 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 3.93 inch/hr

Peak Flowrate,  $Q_p$  = 1.68 cfs  
 Peak Flowrate,  $Q_p$  = 1.05 cfs  
 Peak Flowrate,  $Q_p$  = 1.40 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Kiowa Creek Facility  
 Catchment ID: Equipment parking area

### I. Catchment Hydrologic Data

Catchment ID = 3  
 Area = 1.20 Acres  
 Percent Imperviousness = 40.00 %  
 NRCS Soil Type = B A, B, C, or D

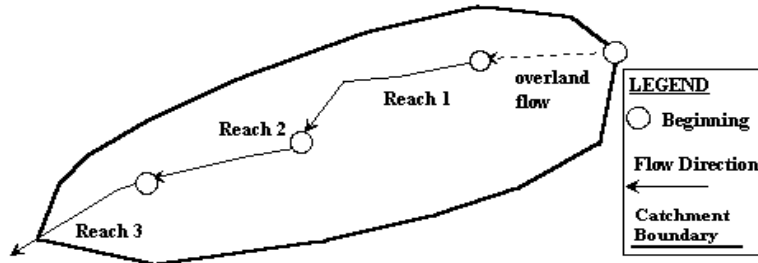
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 100 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.50  
 Override Runoff Coefficient,  $C$  = (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.30  
 Override 5-yr. Runoff Coefficient,  $C$  = (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time T <sub>f</sub>
	ft/ft input	ft input	C-5 output	input	fps output	minutes output
Overland	2.4000	50	0.30	N/A	0.50	1.68
1	2.4000	235		10.00	15.49	0.25
2						
3						
4						
5						
Sum		285				
Computed T <sub>c</sub> =						1.93
Regional T <sub>c</sub> =						11.58
User-Entered T <sub>c</sub> =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed T<sub>c</sub>,  $I$  = 10.44 inch/hr  
 Rainfall Intensity at Regional T<sub>c</sub>,  $I$  = 6.55 inch/hr  
 Rainfall Intensity at User-Defined T<sub>c</sub>,  $I$  = 8.72 inch/hr

Peak Flowrate,  $Q_p$  = 6.20 cfs  
 Peak Flowrate,  $Q_p$  = 3.89 cfs  
 Peak Flowrate,  $Q_p$  = 5.18 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Shop Office area

### I. Catchment Hydrologic Data

Catchment ID = 3  
 Area = 1.30 Acres  
 Percent Imperviousness = 80.00 %  
 NRCS Soil Type = B A, B, C, or D

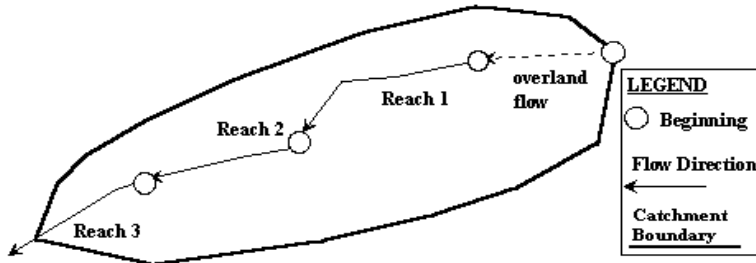
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 2 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 0.87 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.57  
 Override Runoff Coefficient,  $C$  =  (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.59  
 Override 5-yr. Runoff Coefficient,  $C$  =  (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft input	ft input	C-5 output		fps output	minutes output
Overland	1.3000	50	0.59	N/A	0.64	1.30
1	1.3000	280		10.00	11.40	0.41
2						
3						
4						
5						
Sum		330				
Computed Tc =						1.70
Regional Tc =						11.83
User-Entered Tc =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 3.59 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 2.20 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 2.95 inch/hr

Peak Flowrate,  $Q_p$  = 2.64 cfs  
 Peak Flowrate,  $Q_p$  = 1.62 cfs  
 Peak Flowrate,  $Q_p$  = 2.17 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Shop Office area

### I. Catchment Hydrologic Data

Catchment ID = 3  
 Area = 1.30 Acres  
 Percent Imperviousness = 80.00 %  
 NRCS Soil Type = B A, B, C, or D

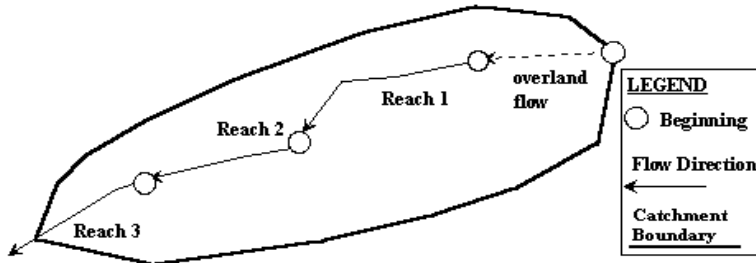
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 5 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 1.16 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.59  
 Override Runoff Coefficient,  $C$  =  (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.59  
 Override 5-yr. Runoff Coefficient,  $C$  =  (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Conveyance	Flow Velocity V	Flow Time Tf
	ft/ft	ft			input	output
Overland	1.3000	50	0.59	N/A	0.64	1.30
1	1.3000	280		10.00	11.40	0.41
2						
3						
4						
5						
Sum		330				
Computed Tc =						1.70
Regional Tc =						11.83
User-Entered Tc =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc,  $I$  = 4.78 inch/hr  
 Rainfall Intensity at Regional Tc,  $I$  = 2.93 inch/hr  
 Rainfall Intensity at User-Defined Tc,  $I$  = 3.93 inch/hr

Peak Flowrate,  $Q_p$  = 3.70 cfs  
 Peak Flowrate,  $Q_p$  = 2.26 cfs  
 Peak Flowrate,  $Q_p$  = 3.04 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Shop Office area

### I. Catchment Hydrologic Data

Catchment ID = 3  
 Area = 1.30 Acres  
 Percent Imperviousness = 80.00 %  
 NRCS Soil Type = B A, B, C, or D

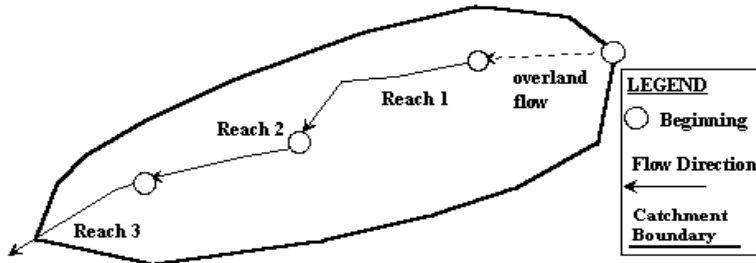
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 100 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.70  
 Override Runoff Coefficient,  $C$  =  (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.59  
 Override 5-yr. Runoff Coefficient,  $C$  =  (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

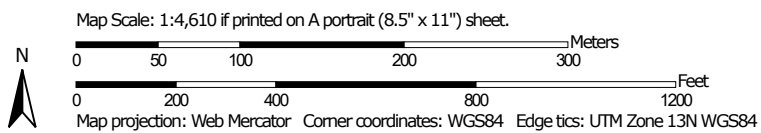
Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time T <sub>f</sub>
	ft/ft input	ft input	C-5 output		fps output	minutes output
Overland	1.3000	50	0.59	N/A	0.64	1.30
1	1.3000	280		10.00	11.40	0.41
2						
3						
4						
5						
Sum		330				
Computed T <sub>c</sub> =						1.70
Regional T <sub>c</sub> =						11.83
User-Entered T <sub>c</sub> =						5.00

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed T<sub>c</sub>,  $I$  = 10.60 inch/hr  
 Rainfall Intensity at Regional T<sub>c</sub>,  $I$  = 6.49 inch/hr  
 Rainfall Intensity at User-Defined T<sub>c</sub>,  $I$  = 8.72 inch/hr


Peak Flowrate,  $Q_p$  = 9.65 cfs  
 Peak Flowrate,  $Q_p$  = 5.91 cfs  
 Peak Flowrate,  $Q_p$  = 7.94 cfs

Hydrologic Soil Group—Arapahoe County, Colorado  
(AAR\_Run-on)




## 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 1:20,000.

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

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

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

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

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

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

Soil Survey Area: Arapahoe County, Colorado  
 Survey Area Data: Version 20, Aug 29, 2024

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

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

## Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
NrB	Nunn-Bresser-Ascalon complex, 0 to 3 percent slopes	B	26.1	100.0%
<b>Totals for Area of Interest</b>			<b>26.1</b>	<b>100.0%</b>

### 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*

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Run-on

### I. Catchment Hydrologic Data

Catchment ID = 1  
 Area = 26.10 Acres  
 Percent Imperviousness = 5.00 %  
 NRCS Soil Type = B A, B, C, or D

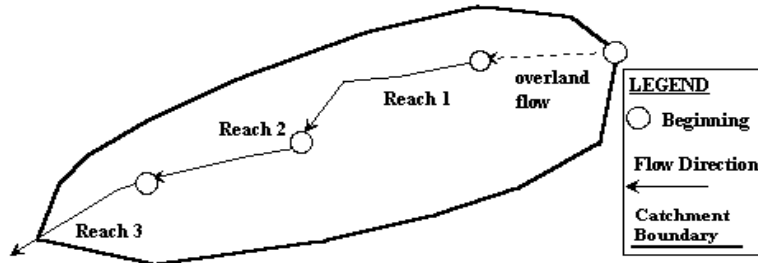
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 2 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 0.87 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.04  
 Override Runoff Coefficient,  $C$  =  (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.10  
 Override 5-yr. Runoff Coefficient,  $C$  =  (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff C-5	NRCS Conveyance	Flow Velocity V	Flow Time T <sub>f</sub>
	ft/ft	ft			fps	minutes
Overland	2.8300	100	0.10	N/A	0.60	2.80
1	2.8300	1,575		2.50	4.21	6.24
2	2.5000	917		10.00	15.81	0.97
3						
4						
5						
Sum		2,592				
Computed T <sub>c</sub> =						10.01
Regional T <sub>c</sub> =						24.40
User-Entered T <sub>c</sub> =						10.01

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed T<sub>c</sub>,  $I$  = 2.36 inch/hr  
 Rainfall Intensity at Regional T<sub>c</sub>,  $I$  = 1.54 inch/hr  
 Rainfall Intensity at User-Defined T<sub>c</sub>,  $I$  = 2.36 inch/hr

Peak Flowrate,  $Q_p$  = 2.36 cfs  
 Peak Flowrate,  $Q_p$  = 1.54 cfs  
 Peak Flowrate,  $Q_p$  = 2.36 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Run-on

### I. Catchment Hydrologic Data

Catchment ID = 1  
 Area = 26.10 Acres  
 Percent Imperviousness = 5.00 %  
 NRCS Soil Type = B A, B, C, or D

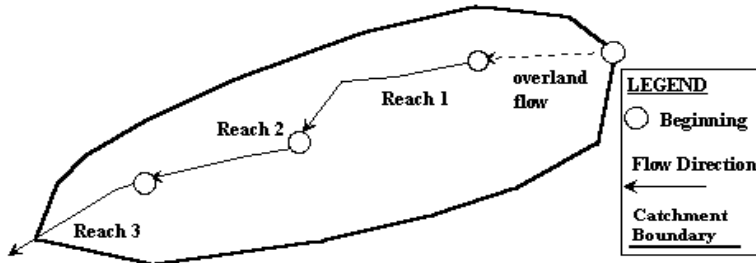
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 5 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 1.16 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.10  
 Override Runoff Coefficient,  $C$  =  (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.10  
 Override 5-yr. Runoff Coefficient,  $C$  =  (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time T <sub>f</sub>
	ft/ft	ft	C-5		fps	minutes
input	input	input	output	input	output	output
Overland	2.8300	100	0.10	N/A	0.60	2.80
1	2.8300	1,575		2.50	4.21	6.24
2	2.5000	917		10.00	15.81	0.97
3						
4						
5						
Sum		2,592				
Computed T <sub>c</sub> =						10.01
Regional T <sub>c</sub> =						24.40
User-Entered T <sub>c</sub> =						10.01

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed T<sub>c</sub>,  $I$  = 3.14 inch/hr  
 Rainfall Intensity at Regional T<sub>c</sub>,  $I$  = 2.05 inch/hr  
 Rainfall Intensity at User-Defined T<sub>c</sub>,  $I$  = 3.14 inch/hr

Peak Flowrate,  $Q_p$  = 8.24 cfs  
 Peak Flowrate,  $Q_p$  = 5.38 cfs  
 Peak Flowrate,  $Q_p$  = 8.24 cfs

## CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

**Project Title:** Kiowa Creek Facility  
**Catchment ID:** Run-on

### I. Catchment Hydrologic Data

Catchment ID = 1  
 Area = 26.10 Acres  
 Percent Imperviousness = 5.00 %  
 NRCS Soil Type = B A, B, C, or D

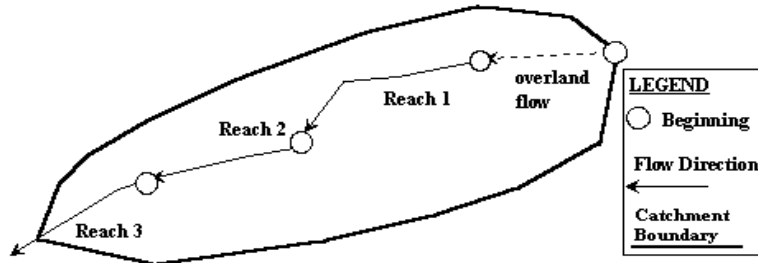
### II. Rainfall Information $I \text{ (inch/hr)} = C1 * P1 / (C2 + Td)^{C3}$

Design Storm Return Period,  $T_r$  = 100 years (input return period for design storm)  
 $C1$  = 28.50 (input the value of C1)  
 $C2$  = 10.00 (input the value of C2)  
 $C3$  = 0.786 (input the value of C3)  
 $P1$  = 2.57 inches (input one-hr precipitation--see Sheet "Design Info")

### III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient,  $C$  = 0.38  
 Override Runoff Coefficient,  $C$  =  (enter an override C value if desired, or leave blank to accept calculated C.)  
 5-yr. Runoff Coefficient,  $C-5$  = 0.10  
 Override 5-yr. Runoff Coefficient,  $C$  =  (enter an override C-5 value if desired, or leave blank to accept calculated C-5.)

#### Illustration



NRCS Land Type	Heavy Meadow	Tillage/Field	Short Pasture/Lawns	Nearly Bare Ground	Grassed Swales/Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

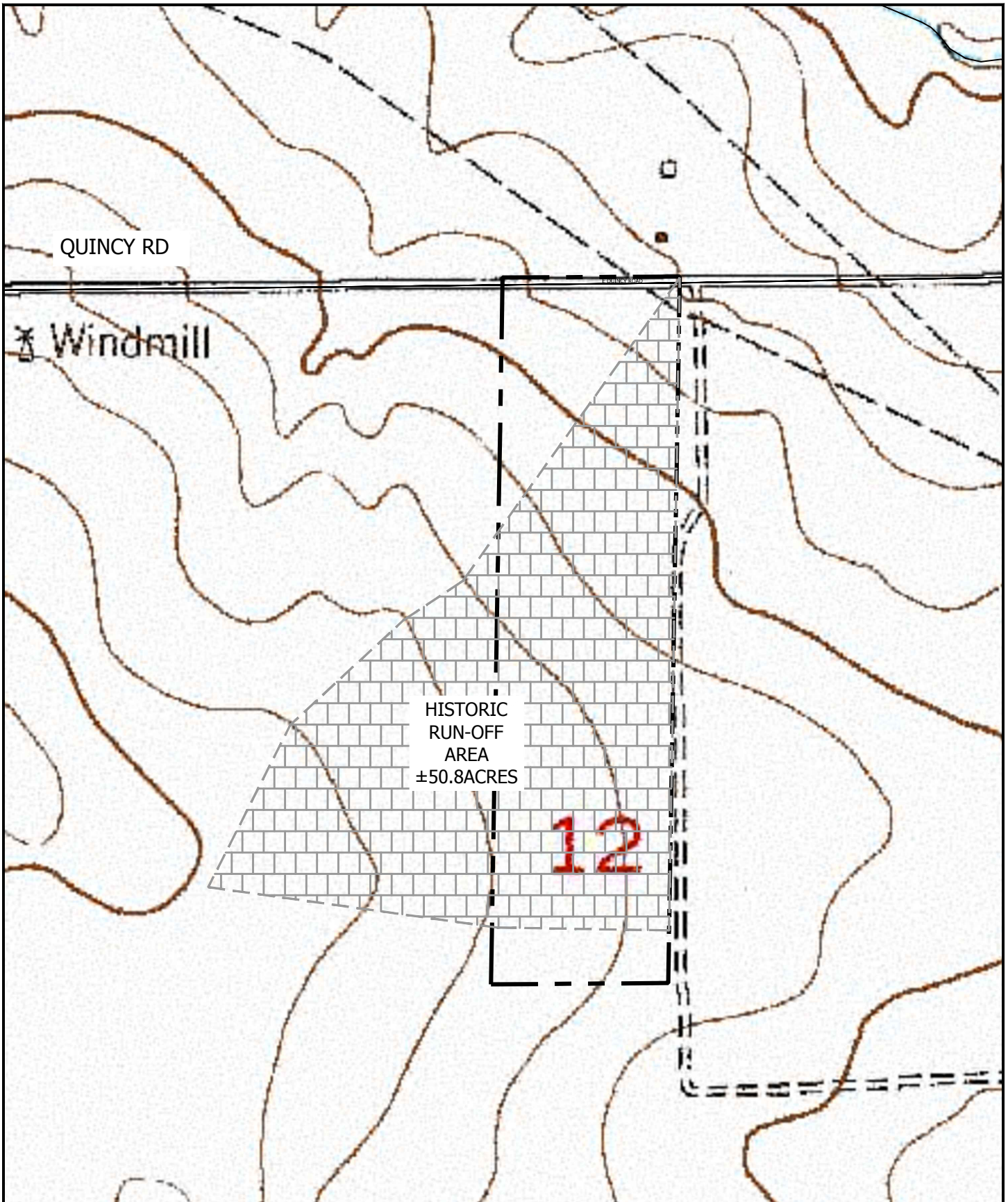
Calculations:

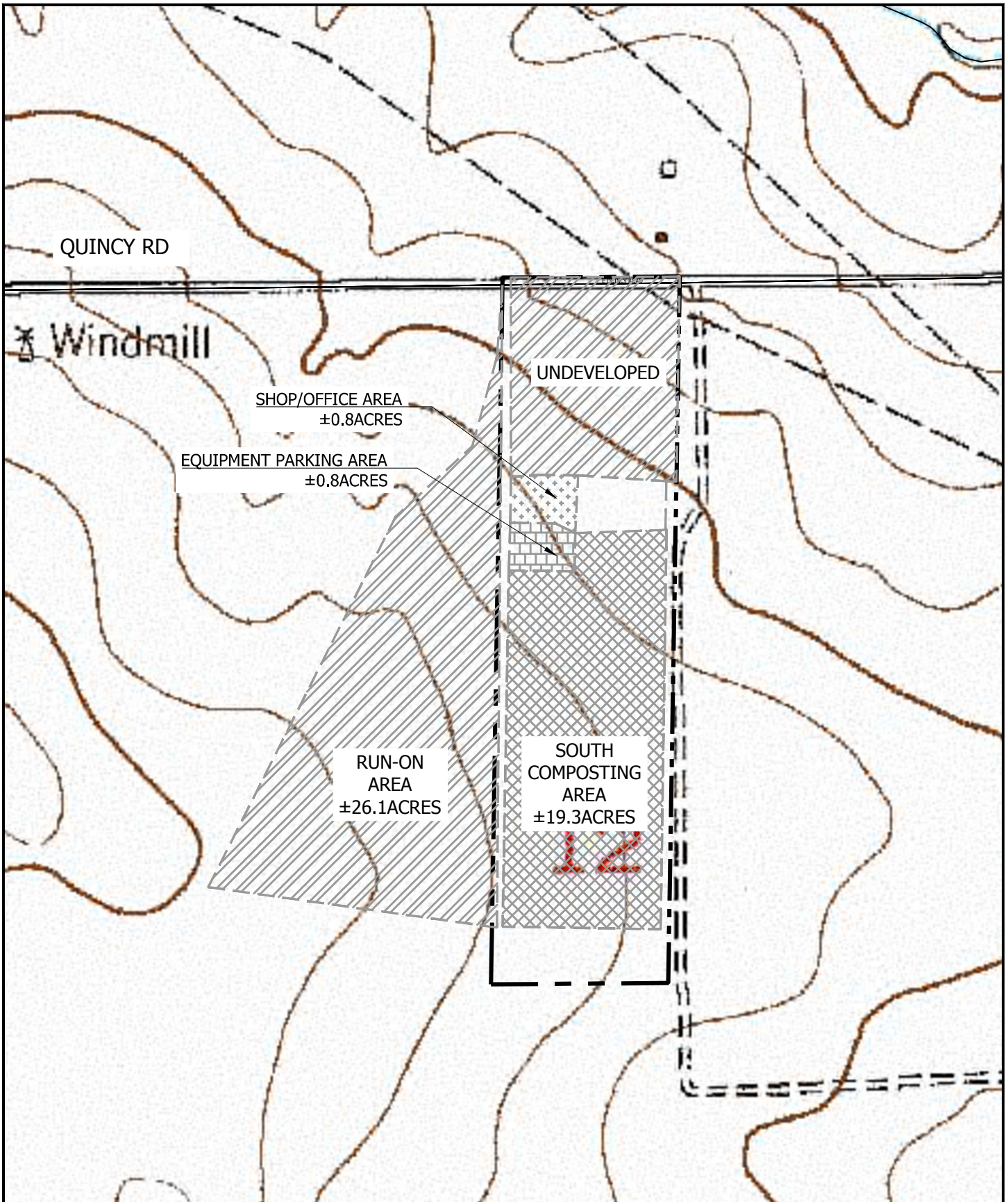
Reach ID	Slope S	Length L	5-yr Runoff Coeff	NRCS Conveyance	Flow Velocity V	Flow Time T <sub>f</sub>
	ft/ft input	ft input	C-5 output	input	fps output	minutes output
Overland	2.8300	100	0.10	N/A	0.60	2.80
1	2.8300	1,575		2.50	4.21	6.24
2	2.5000	917		10.00	15.81	0.97
3						
4						
5						
Sum		2,592				
Computed T <sub>c</sub> =						10.01
Regional T <sub>c</sub> =						24.40
User-Entered T <sub>c</sub> =						10.01

### IV. Peak Runoff Prediction

Rainfall Intensity at Computed T<sub>c</sub>,  $I$  = 6.95 inch/hr  
 Rainfall Intensity at Regional T<sub>c</sub>,  $I$  = 4.54 inch/hr  
 Rainfall Intensity at User-Defined T<sub>c</sub>,  $I$  = 6.95 inch/hr

Peak Flowrate,  $Q_p$  = 68.76 cfs  
 Peak Flowrate,  $Q_p$  = 44.92 cfs  
 Peak Flowrate,  $Q_p$  = 68.76 cfs

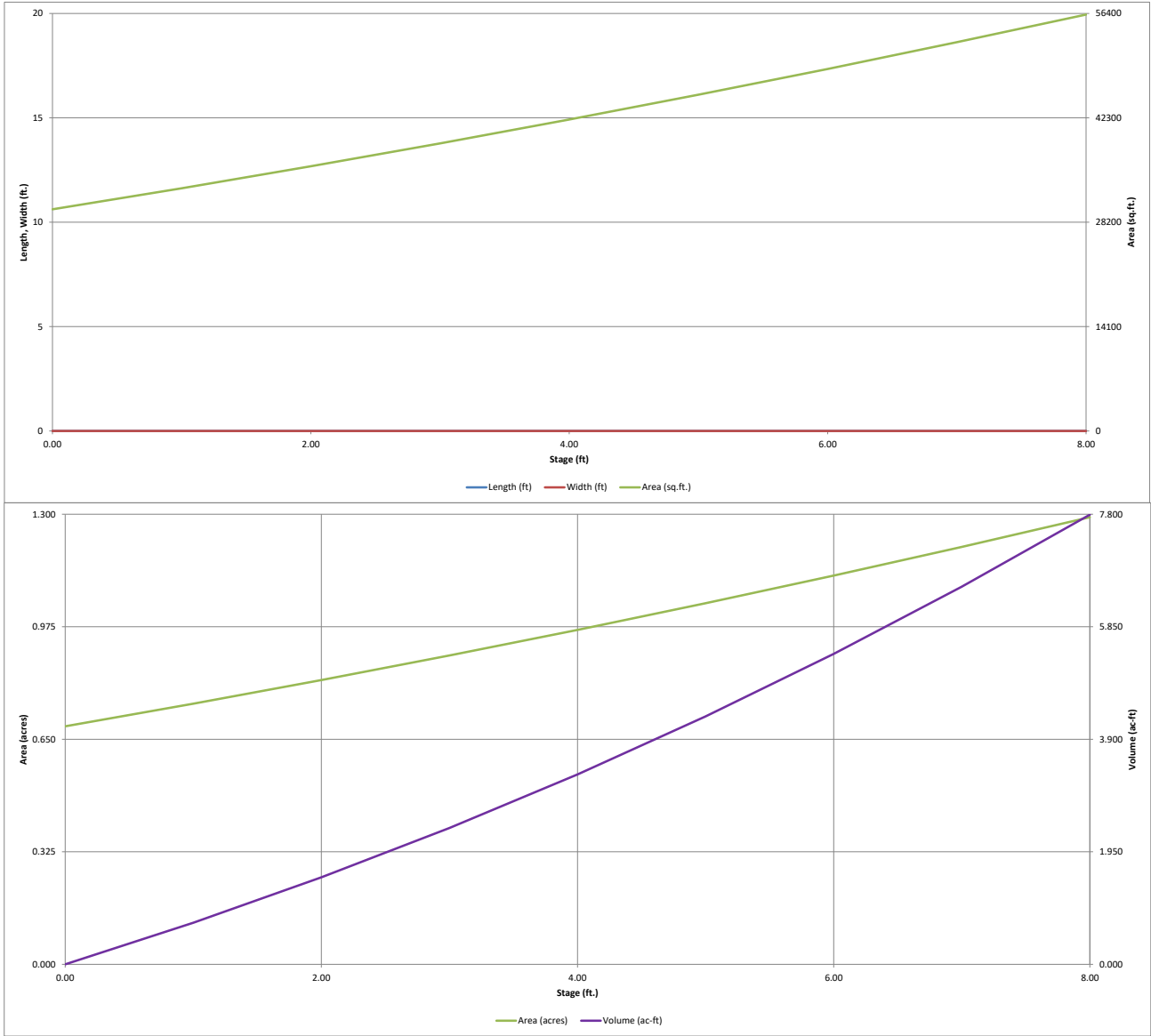






# DETENTION BASIN STAGE-STORAGE TABLE BUILDER

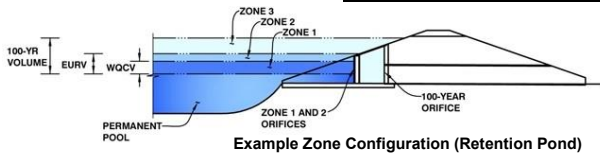
*MHFD-Detention, Version 4.06 (July 2022)*



# DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

**Project:** Kiowa Creek Facility  
**Basin ID:** Composting area



	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.47	0.329	Orifice Plate
Zone 2 (100-year)	2.23	1.363	Weir&Pipe (Restrict)
Zone 3			Not Utilized
<b>Total (all zones)</b>		<b>1.692</b>	

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

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

**Calculated Parameters for Underdrain**  
 Underdrain Orifice Area =  ft<sup>2</sup>  
 Underdrain Orifice Centroid =  feet

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

Centroid of Lowest Orifice =  ft (relative to basin bottom at Stage = 0 ft)  
 Depth at top of Zone using Orifice Plate =  ft (relative to basin bottom at Stage = 0 ft)  
 Orifice Plate: Orifice Vertical Spacing =  inches  
 Orifice Plate: Orifice Area per Row =  sq. inches

**Calculated Parameters for Plate**  
 WQ Orifice Area per Row =  ft<sup>2</sup>  
 Elliptical Half-Width =  feet  
 Elliptical Slot Centroid =  feet  
 Elliptical Slot Area =  ft<sup>2</sup>

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.33	0.58					
Orifice Area (sq. inches)	6.28	18.84	6.28					
	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

**User Input:** Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	<input type="text" value="N/A"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	<input type="text" value="N/A"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	<input type="text" value="N/A"/>	<input type="text" value="N/A"/>	inches

**Calculated Parameters for Vertical Orifice**  
 Vertical Orifice Area =  ft<sup>2</sup>  
 Vertical Orifice Centroid =  feet

**User Input:** Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

	Zone 2 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	<input type="text" value="1.58"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	<input type="text" value="5.00"/>	<input type="text" value="N/A"/>	feet
Overflow Weir Grate Slope =	<input type="text" value="0.00"/>	<input type="text" value="N/A"/>	H:V
Horiz. Length of Weir Sides =	<input type="text" value="5.00"/>	<input type="text" value="N/A"/>	feet
Overflow Grate Type =	<input type="text" value="No Grate"/>	<input type="text" value="N/A"/>	
Debris Clogging % =	<input type="text" value="0%"/>	<input type="text" value="N/A"/>	%

**Calculated Parameters for Overflow Weir**  
 Height of Grate Upper Edge, H<sub>u</sub> =  feet  
 Overflow Weir Slope Length =  feet  
 Grate Open Area / 100-yr Orifice Area =    
 Overflow Grate Open Area w/o Debris =  ft<sup>2</sup>  
 Overflow Grate Open Area w/ Debris =  ft<sup>2</sup>

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

	Zone 2 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	<input type="text" value="0.00"/>	<input type="text" value="N/A"/>	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	<input type="text" value="7.63"/>	<input type="text" value="N/A"/>	inches
Restrictor Plate Height Above Pipe Invert =	<input type="text" value="7.63"/>	<input type="text" value="N/A"/>	inches

**Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate**  
 Outlet Orifice Area =  ft<sup>2</sup>  
 Outlet Orifice Centroid =  feet  
 Half-Central Angle of Restrictor Plate on Pipe =  radians

**User Input:** Emergency Spillway (Rectangular or Trapezoidal)

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

**Calculated Parameters for Spillway**  
 Spillway Design Flow Depth =  feet  
 Stage at Top of Freeboard =  feet  
 Basin Area at Top of Freeboard =  acres  
 Basin Volume at Top of Freeboard =  acre-ft

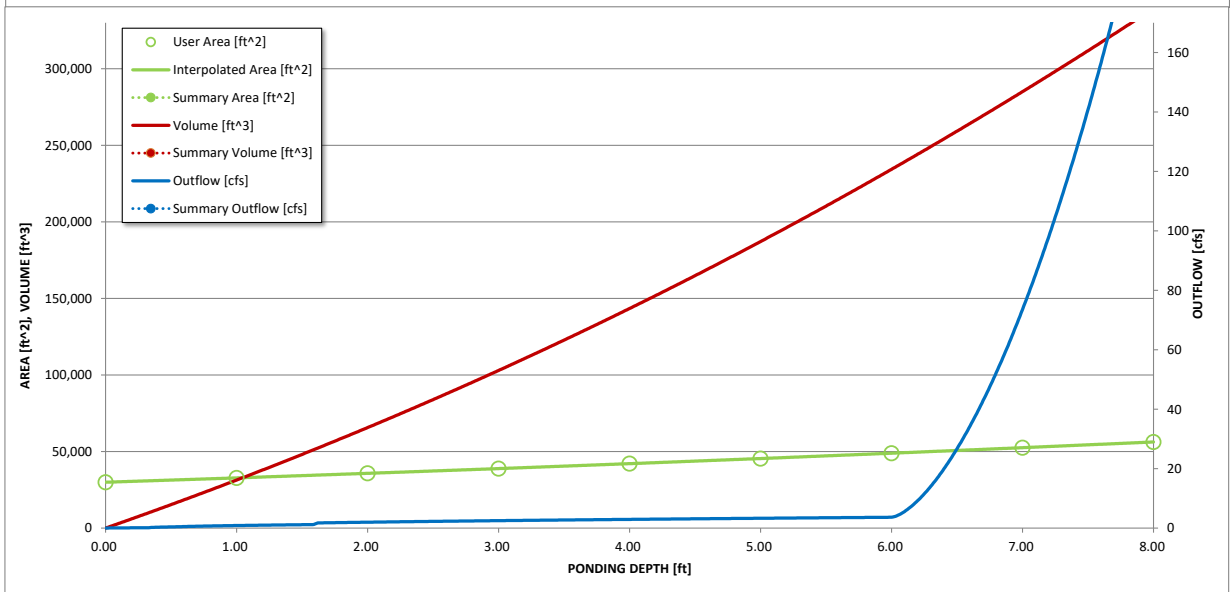
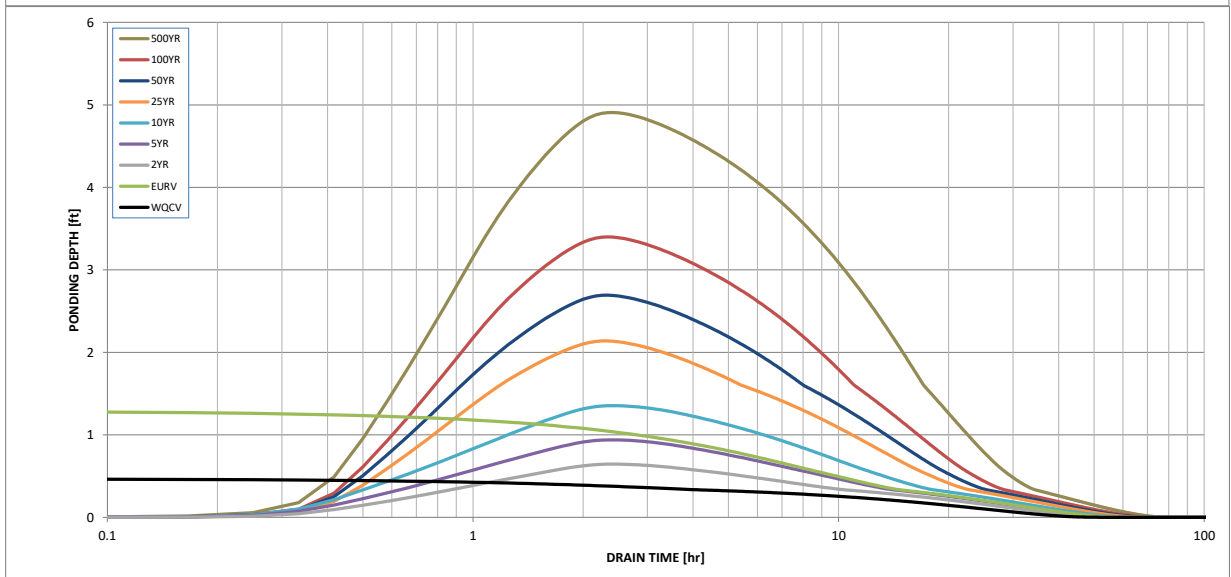
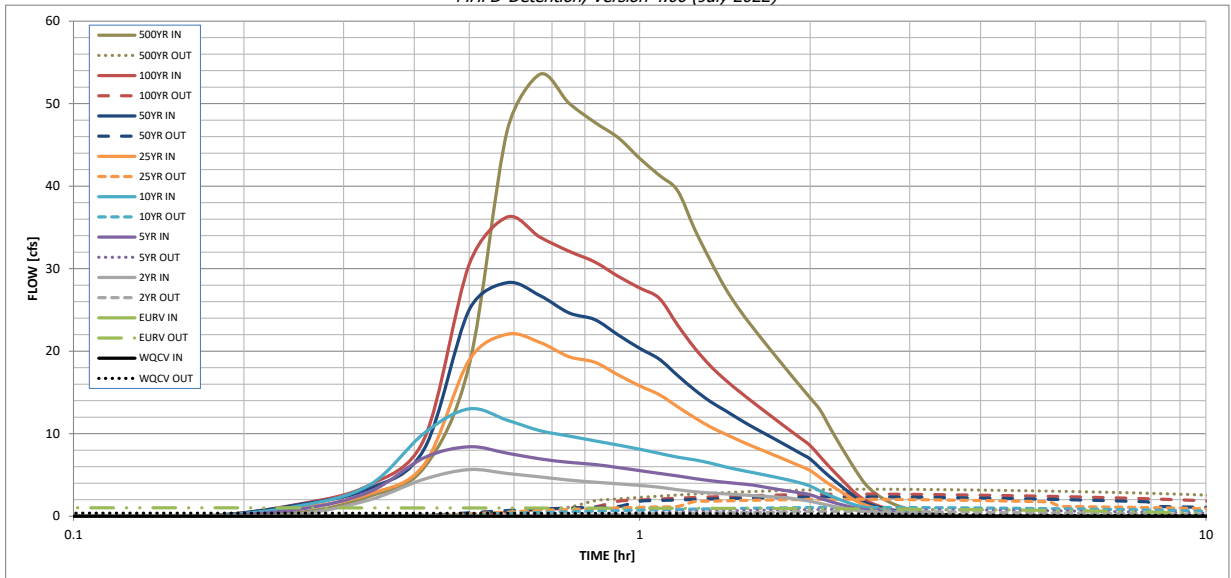
## Routed Hydrograph Results

The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =	N/A	N/A	0.84	1.13	1.39	1.77	2.08	2.42	3.30
One-Hour Rainfall Depth (in) =	0.329	0.943	0.540	0.801	1.164	1.909	2.440	3.128	4.726
CUHP Runoff Volume (acre-ft) =	N/A	N/A	0.540	0.801	1.164	1.909	2.440	3.128	4.726
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.2	0.5	3.5	10.7	15.2	20.7	32.9
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A							
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.02	0.17	0.50	0.71	0.97	1.54
Peak Inflow Q (cfs) =	N/A	N/A	5.7	8.4	13.0	22.1	28.3	36.3	53.6
Peak Outflow Q (cfs) =	0.4	1.0	0.6	0.8	1.1	2.1	2.4	2.7	3.3
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.7	0.3	0.2	0.2	0.1	0.1
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.0	0.0	0.0	0.0
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	41	45	45	46	47	46	46	45	45
Time to Drain 99% of Inflow Volume (hours) =	46	52	50	52	54	56	57	58	60
Maximum Ponding Depth (ft) =	0.47	1.30	0.65	0.94	1.35	2.14	2.69	3.40	4.91
Area at Maximum Ponding Depth (acres) =	0.72	0.77	0.73	0.75	0.78	0.83	0.87	0.92	1.04
Maximum Volume Stored (acre-ft) =	0.330	0.949	0.453	0.668	0.988	1.614	2.090	2.717	4.192

# DETENTION BASIN OUTLET STRUCTURE DESIGN

*MHFD-Detention, Version 4.06 (July 2022)*



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

# DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: *FALSE*

## Inflow Hydrographs

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

Time Interval	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
	0:15:00	0.00	0.00	0.28	0.83	1.24	0.99	1.40	1.47	2.42
	0:20:00	0.00	0.00	1.98	2.96	3.78	2.69	3.36	3.79	5.93
	0:25:00	0.00	0.00	4.51	7.10	10.09	6.30	8.19	9.42	18.33
	0:30:00	0.00	0.00	5.65	8.42	13.01	18.94	25.02	30.53	46.69
	0:35:00	0.00	0.00	5.18	7.64	11.64	22.05	28.30	36.25	53.56
	0:40:00	0.00	0.00	4.77	6.95	10.37	21.06	26.74	33.82	50.07
	0:45:00	0.00	0.00	4.38	6.53	9.72	19.34	24.65	32.12	47.73
	0:50:00	0.00	0.00	4.13	6.27	9.14	18.66	23.83	30.81	45.87
	0:55:00	0.00	0.00	3.93	5.90	8.62	17.12	21.96	29.07	43.37
	1:00:00	0.00	0.00	3.73	5.53	8.12	15.80	20.35	27.66	41.32
	1:05:00	0.00	0.00	3.52	5.19	7.62	14.73	19.03	26.41	39.45
	1:10:00	0.00	0.00	3.21	4.88	7.16	13.27	17.06	23.17	34.82
	1:15:00	0.00	0.00	2.97	4.57	6.84	11.95	15.32	20.41	30.97
	1:20:00	0.00	0.00	2.82	4.31	6.44	10.82	13.89	18.21	27.64
	1:25:00	0.00	0.00	2.71	4.11	5.98	9.96	12.81	16.52	25.05
	1:30:00	0.00	0.00	2.61	3.94	5.62	9.18	11.75	15.11	22.90
	1:35:00	0.00	0.00	2.51	3.78	5.30	8.48	10.82	13.85	20.96
	1:40:00	0.00	0.00	2.41	3.52	4.99	7.85	9.98	12.67	19.17
	1:45:00	0.00	0.00	2.31	3.27	4.69	7.25	9.19	11.57	17.47
	1:50:00	0.00	0.00	2.22	3.05	4.39	6.67	8.42	10.52	15.86
	1:55:00	0.00	0.00	2.01	2.84	4.06	6.11	7.68	9.54	14.36
	2:00:00	0.00	0.00	1.82	2.61	3.66	5.55	6.95	8.57	12.87
	2:05:00	0.00	0.00	1.55	2.18	3.06	4.67	5.83	7.22	10.79
	2:10:00	0.00	0.00	1.30	1.81	2.52	3.85	4.79	5.94	8.84
	2:15:00	0.00	0.00	1.08	1.48	2.06	3.12	3.87	4.77	7.06
	2:20:00	0.00	0.00	0.88	1.20	1.65	2.44	3.00	3.67	5.39
	2:25:00	0.00	0.00	0.70	0.96	1.32	1.82	2.21	2.66	3.95
	2:30:00	0.00	0.00	0.57	0.80	1.08	1.37	1.68	1.98	2.99
	2:35:00	0.00	0.00	0.48	0.67	0.91	1.07	1.31	1.51	2.30
	2:40:00	0.00	0.00	0.41	0.56	0.76	0.85	1.03	1.16	1.78
	2:45:00	0.00	0.00	0.35	0.47	0.64	0.68	0.82	0.89	1.37
	2:50:00	0.00	0.00	0.30	0.40	0.54	0.56	0.67	0.69	1.06
	2:55:00	0.00	0.00	0.25	0.33	0.45	0.45	0.54	0.53	0.81
	3:00:00	0.00	0.00	0.21	0.28	0.37	0.37	0.43	0.41	0.63
	3:05:00	0.00	0.00	0.17	0.23	0.30	0.30	0.35	0.33	0.50
	3:10:00	0.00	0.00	0.14	0.18	0.24	0.24	0.28	0.26	0.40
	3:15:00	0.00	0.00	0.11	0.14	0.19	0.19	0.22	0.21	0.32
	3:20:00	0.00	0.00	0.09	0.11	0.15	0.15	0.17	0.17	0.25
	3:25:00	0.00	0.00	0.07	0.08	0.11	0.11	0.13	0.12	0.19
	3:30:00	0.00	0.00	0.05	0.06	0.08	0.08	0.09	0.09	0.13
	3:35:00	0.00	0.00	0.03	0.04	0.05	0.06	0.06	0.06	0.09
	3:40:00	0.00	0.00	0.02	0.03	0.03	0.03	0.04	0.04	0.05
	3:45:00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03
	3:50:00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	





# Aesthetic Alternative Recycling, LLC

## Storm pond

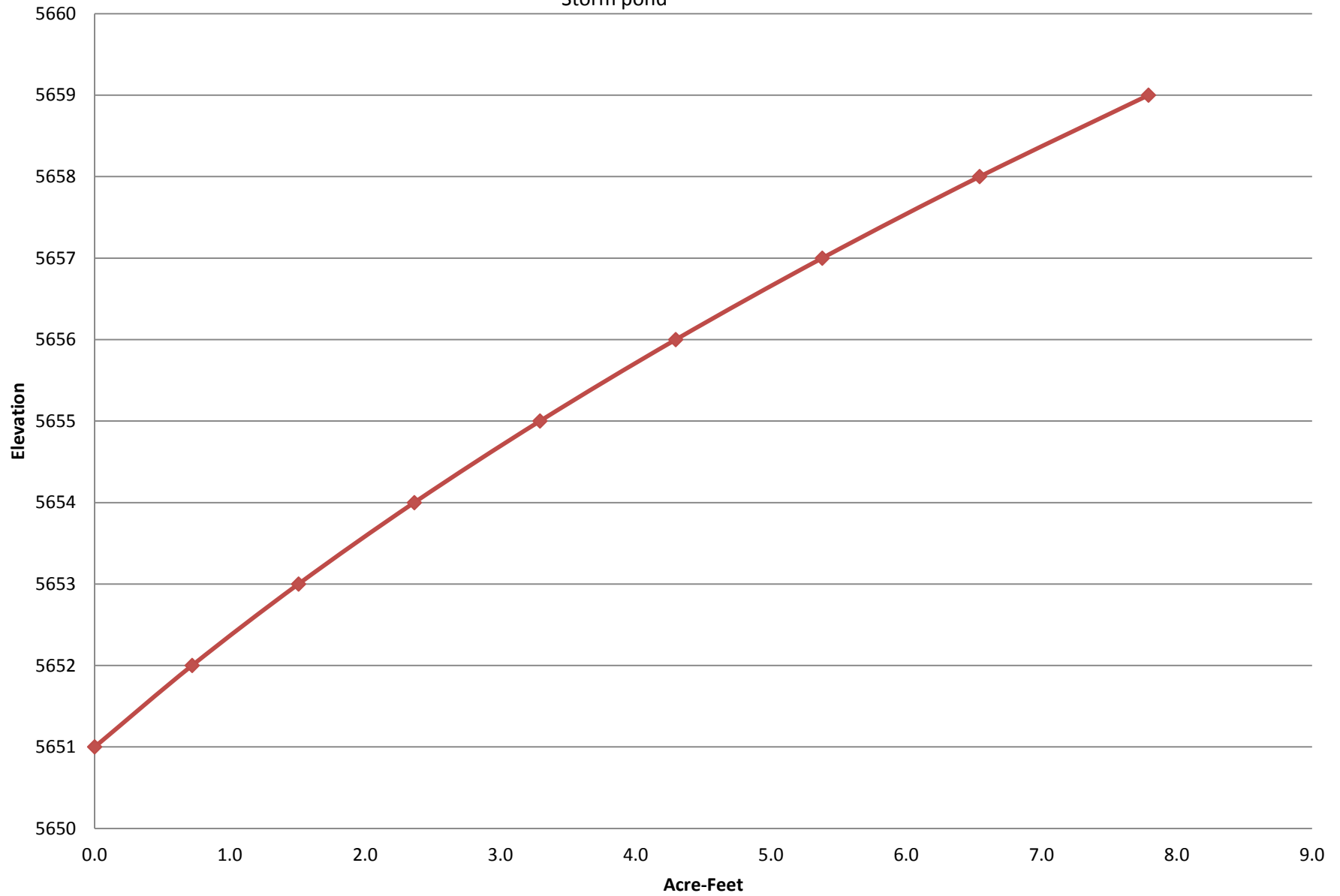
<u>Elev</u> <u>(ft)</u>	<u>Gauge</u> <u>Reading</u> <u>(ft)</u>	<u>Contour</u> <u>Area</u> <u>(ft^2)</u>	<u>Slice Volume</u> <u>(ft^3)</u>	<u>Cumulative</u> <u>Volume</u> <u>(ft^3)</u>	<u>Cumulative</u> <u>Volume</u> <u>(ac-ft)</u>
5651	0.0	29,946	0	0	0.0
5652	1.0	32,786	31,366	31,366	0.7
5653	2.0	35,754	34,270	65,636	1.5
5654	3.0	38,850	37,302	102,938	2.4
5655	4.0	42,074	40,462	143,400	3.3
5656	5.0	45,426	43,750	187,150	4.3
5657	6.0	48,906	47,166	234,316	5.4
5658	7.0	52,514	50,710	285,026	6.5
5659	8.0	56,250	54,382	339,408	7.8

Emergency Spill Crest

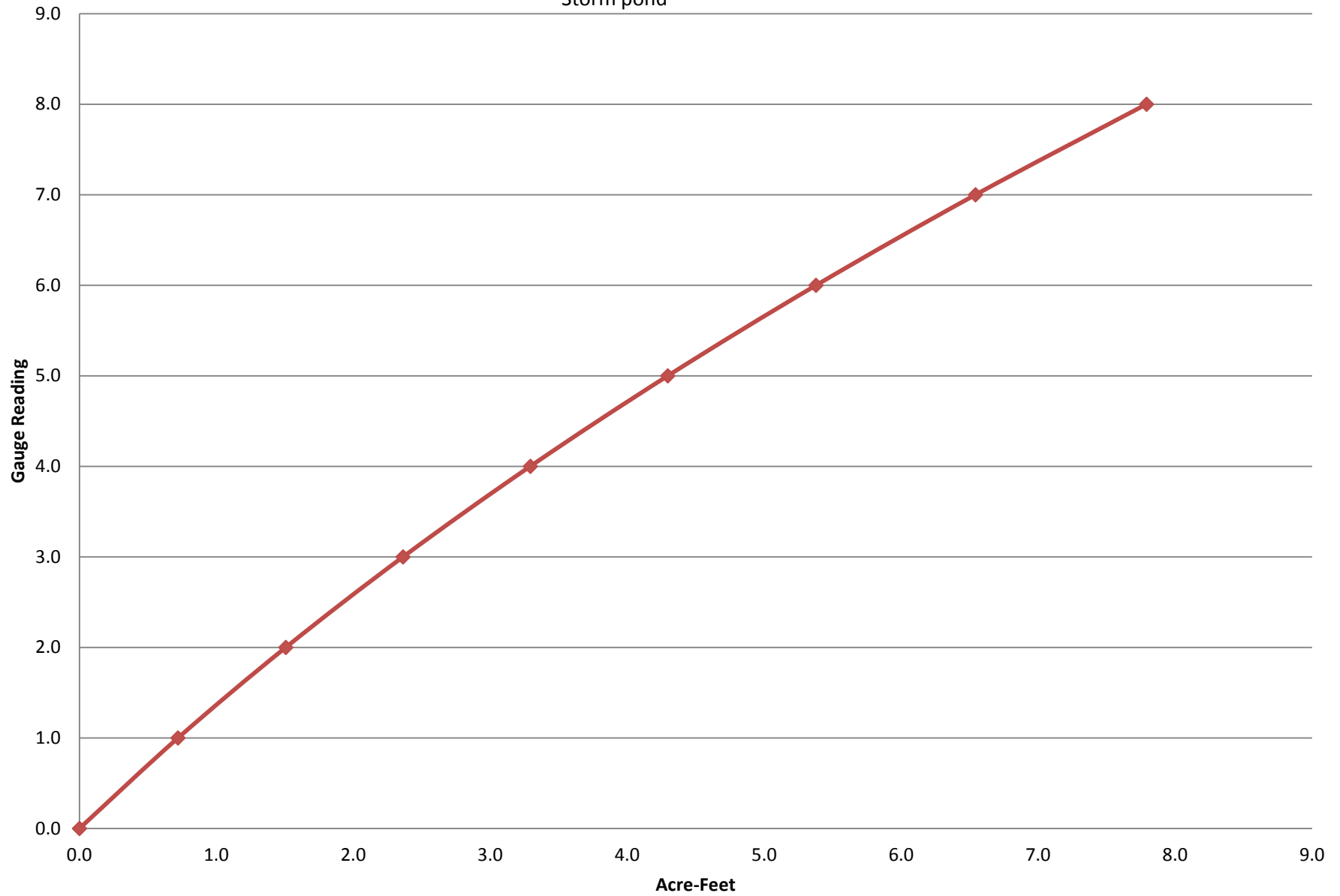
Top of berm

Based on planned contours

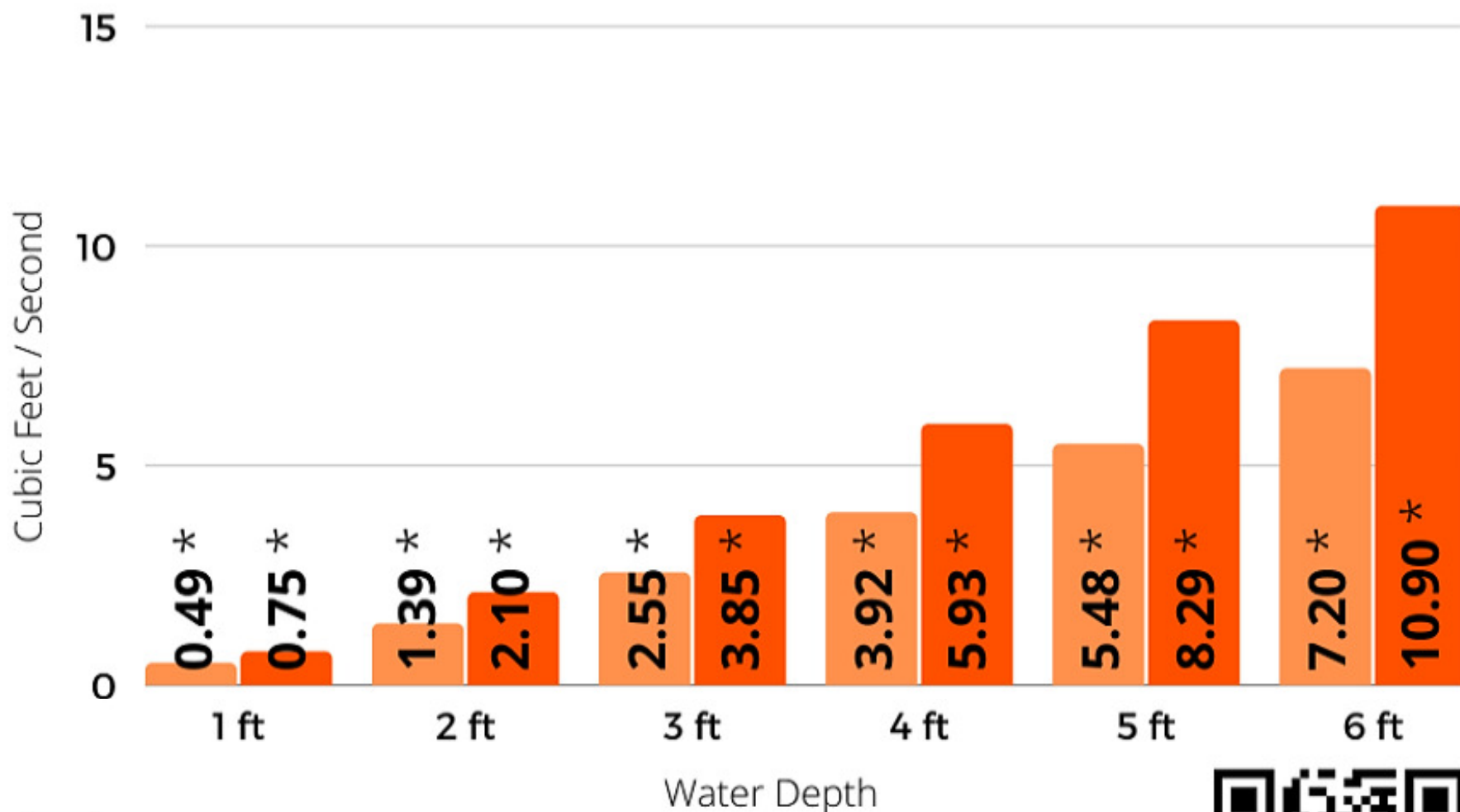
Storm pond



Storm pond



## Hickenbottom® 8-Inch Inlet Flow Rates



Stock 8" Inlet with 1" Holes (HBI-8810)

Stock 8" Inlet with 1" Holes & 1" x 4" Slots (HBI-88SL)



\* These values are contingent on certain factors. Visit [hickenbottominlets.com/flow](https://www.hickenbottominlets.com/flow) for details.

# Weir Report

## AAR\_Emergency spillway

### Trapezoidal Weir

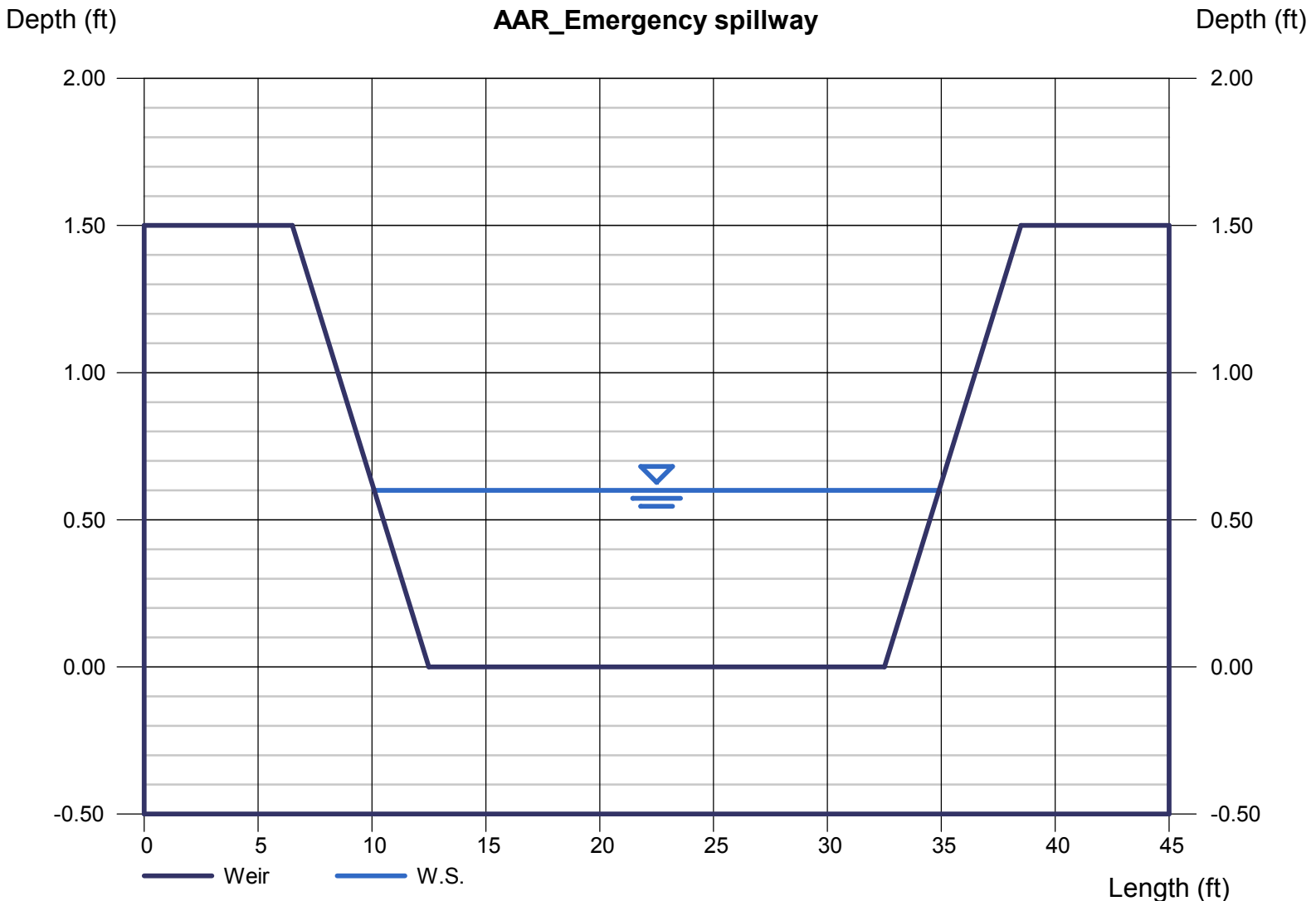
Crest = Sharp  
Bottom Length (ft) = 20.00  
Total Depth (ft) = 1.50  
Side Slope (z:1) = 4.00

### Highlighted

Depth (ft) = 0.60  
Q (cfs) = 36.88  
Area (sqft) = 13.44  
Velocity (ft/s) = 2.74  
Top Width (ft) = 24.80

### Calculations

Weir Coeff. Cw = 3.62  
Compute by: Q vs Depth  
No. Increments = 10



Depth	Q	Area
(ft)	(cfs)	(sqft)
0.15	4.307	3.09
0.30	12.47	6.36
0.45	23.43	9.81
0.60	36.88	13.44
0.75	52.67	17.25
0.90	70.72	21.24
1.05	90.98	25.41
1.20	113.45	29.76
1.35	138.09	34.29
1.50	164.93	39.00

Veloc	TopWidth	Energy
(ft/s)	(ft)	(ft)
1.39	21.20	0.18
1.96	22.40	0.36
2.39	23.60	0.54
2.74	24.80	0.72
3.05	26.00	0.89
3.33	27.20	1.07
3.58	28.40	1.25
3.81	29.60	1.43
4.03	30.80	1.60
4.23	32.00	1.78

# Culvert Report

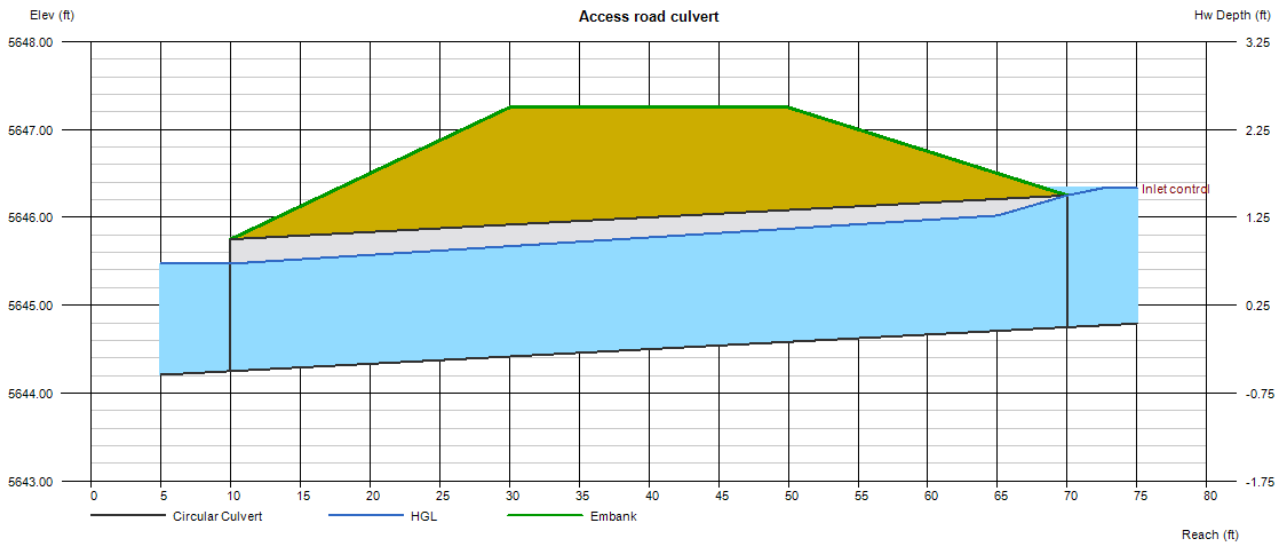
## Access road culvert

Invert Elev Dn (ft)	= 5644.25
Pipe Length (ft)	= 60.00
Slope (%)	= 0.83
Invert Elev Up (ft)	= 5644.75
Rise (in)	= 18.0
Shape	= Circular
Span (in)	= 18.0
No. Barrels	= 1
n-Value	= 0.023
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Projecting
Coeff. K,M,c,Y,k	= 0.034, 1.5, 0.0553, 0.54, 0.9

<b>Embankment</b>	
Top Elevation (ft)	= 5647.25
Top Width (ft)	= 20.00
Crest Width (ft)	= 10.00

<b>Calculations</b>	
Qmin (cfs)	= 0.00
Qmax (cfs)	= 32.00
Tailwater Elev (ft)	= (dc+D)/2

<b>Highlighted</b>	
Qtotal (cfs)	= 6.00
Qpipe (cfs)	= 6.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 3.89
Veloc Up (ft/s)	= 3.64
HGL Dn (ft)	= 5645.47
HGL Up (ft)	= 5646.07
Hw Elev (ft)	= 5646.33
Hw/D (ft)	= 1.05
Flow Regime	= Inlet Control



Q			Veloc		Depth	
Total	Pipe	Over	Dn	Up	Dn	Up
(cfs)	(cfs)	(cfs)	(ft/s)	(ft/s)	(in)	(in)
1.00	1.00	0.00	0.86	2.92	11.24	4.47
2.00	2.00	0.00	1.57	3.56	12.20	6.39
3.00	3.00	0.00	2.20	4.02	12.95	7.90
4.00	4.00	0.00	2.79	4.42	13.59	9.18
5.00	5.00	0.00	3.35	4.77	14.16	10.31
6.00	6.00	0.00	3.89	3.64	14.67	15.84
7.00	7.00	0.00	4.41	3.96	15.14	18.00
8.00	8.00	0.00	4.92	4.53	15.57	18.00
9.00	8.19	0.81	5.02	4.64	15.65	18.00
10.00	8.30	1.70	5.08	4.70	15.69	18.00
11.00	8.40	2.60	5.13	4.75	15.73	18.00
12.00	8.50	3.50	5.18	4.81	15.77	18.00
13.00	8.58	4.42	5.22	4.86	15.80	18.00
14.00	8.68	5.32	5.27	4.91	15.84	18.00
15.00	8.77	6.23	5.32	4.96	15.87	18.00
16.00	8.85	7.15	5.36	5.01	15.90	18.00
17.00	8.90	8.10	5.38	5.04	15.92	18.00
18.00	8.97	9.03	5.42	5.07	15.94	18.00
19.00	9.02	9.98	5.44	5.10	15.97	18.00
20.00	9.08	10.92	5.47	5.14	15.98	18.00
21.00	9.13	11.87	5.50	5.17	16.01	18.00
22.00	9.20	12.80	5.54	5.21	16.03	18.00
23.00	9.24	13.76	5.56	5.23	16.05	18.00
24.00	9.30	14.70	5.59	5.26	16.07	18.00
25.00	9.37	15.63	5.62	5.30	16.10	18.00
26.00	9.41	16.59	5.64	5.32	16.11	18.00

Q			Veloc		Depth	
Total	Pipe	Over	Dn	Up	Dn	Up
(cfs)	(cfs)	(cfs)	(ft/s)	(ft/s)	(in)	(in)
27.00	9.46	17.54	5.67	5.35	16.13	18.00
28.00	9.52	18.48	5.69	5.38	16.14	18.00
29.00	9.55	19.45	5.71	5.41	16.15	18.00
30.00	9.62	20.38	5.75	5.44	16.18	18.00
31.00	9.66	21.34	5.77	5.47	16.20	18.00
32.00	9.70	22.30	5.79	5.49	16.21	18.00

HGL			
Dn	Up	Hw	Hw/D
(ft)	(ft)	(ft)	
5645.19	5645.12	5645.27	0.34
5645.27	5645.28	5645.52	0.51
5645.33	5645.41	5645.74	0.66
5645.38	5645.52	5645.94	0.79
5645.43	5645.61	5646.14	0.92
5645.47	5646.07	5646.33	1.05
5645.51	5646.39	5646.85	1.40
5645.55	5646.65	5647.26	1.67
5645.55	5646.71	5647.34	1.73
5645.56	5646.74	5647.39	1.76
5645.56	5646.77	5647.43	1.79
5645.56	5646.79	5647.48	1.82
5645.57	5646.82	5647.51	1.84
5645.57	5646.85	5647.56	1.87
5645.57	5646.87	5647.60	1.90
5645.58	5646.90	5647.64	1.92
5645.58	5646.91	5647.66	1.94
5645.58	5646.93	5647.69	1.96
5645.58	5646.95	5647.72	1.98
5645.58	5646.96	5647.74	2.00
5645.58	5646.98	5647.77	2.01
5645.59	5647.00	5647.80	2.04
5645.59	5647.02	5647.83	2.05
5645.59	5647.03	5647.85	2.07
5645.59	5647.06	5647.89	2.09
5645.59	5647.07	5647.90	2.10

HGL			
Dn	Up	Hw	Hw/D
(ft)	(ft)	(ft)	
5645.59	5647.08	5647.93	2.12
5645.60	5647.10	5647.96	2.14
5645.60	5647.11	5647.98	2.15
5645.60	5647.13	5648.01	2.17
5645.60	5647.15	5648.03	2.19
5645.60	5647.16	5648.05	2.20

# Channel Report

## AAR\_Run-off diversion

### User-defined

Invert Elev (ft) = 100.00  
Slope (%) = 1.32  
N-Value = 0.026

### Calculations

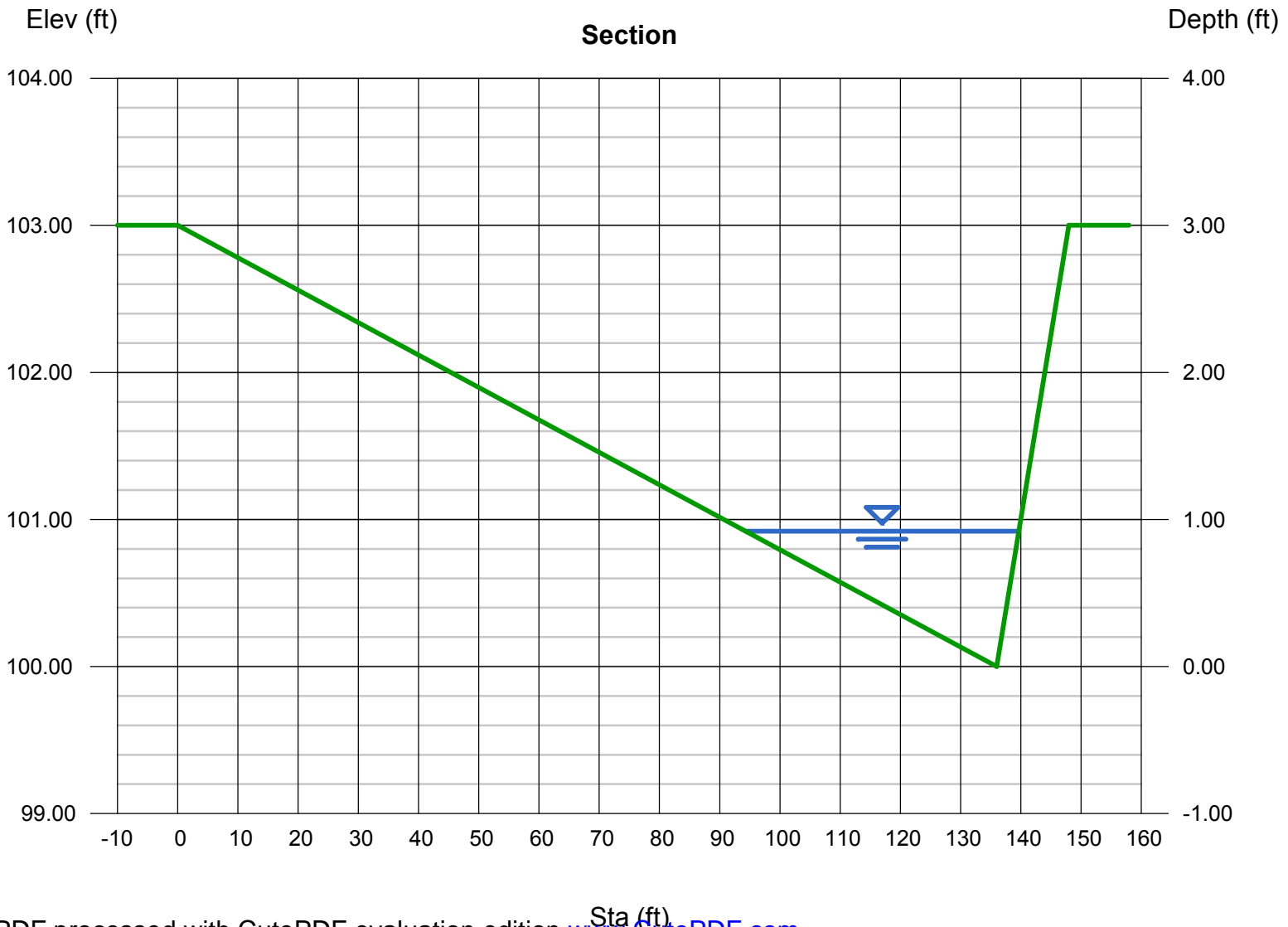
Compute by: Known Q  
Known Q (cfs) = 81.00

### Highlighted

Depth (ft) = 0.92  
Q (cfs) = 81.00  
Area (sqft) = 20.88  
Velocity (ft/s) = 3.88  
Wetted Perim (ft) = 45.51  
Crit Depth, Yc (ft) = 0.93  
Top Width (ft) = 45.39  
EGL (ft) = 1.15

### (Sta, El, n)-(Sta, El, n)...

(0.00, 103.00)-(136.00, 100.00, 0.026)-(148.00, 103.00, 0.026)



Depth	Q	Area	Veloc	Wp
(ft)	(cfs)	(sqft)	(ft/s)	(ft)
0.10	0.220	0.247	0.89	4.95
0.20	1.395	0.987	1.41	9.89
0.30	4.113	2.220	1.85	14.84
0.40	8.859	3.947	2.24	19.79
0.50	16.06	6.167	2.60	24.73
0.60	26.12	8.880	2.94	29.68
0.70	39.40	12.09	3.26	34.63
0.80	56.26	15.79	3.56	39.57
0.90	77.02	19.98	3.86	44.52
1.00	102.0	24.67	4.14	49.47
1.10	131.5	29.85	4.41	54.41
1.20	165.9	35.52	4.67	59.36
1.30	205.4	41.69	4.93	64.31
1.40	250.3	48.35	5.18	69.25
1.50	300.8	55.50	5.42	74.20
1.60	357.3	63.15	5.66	79.15
1.70	420.0	71.29	5.89	84.09
1.80	489.2	79.92	6.12	89.04
1.90	565.1	89.05	6.35	93.99
2.00	647.9	98.67	6.57	98.93
2.10	737.9	108.8	6.78	103.88
2.20	835.4	119.4	7.00	108.83
2.30	940.6	130.5	7.21	113.78
2.40	1,054	142.1	7.42	118.72
2.50	1,175	154.2	7.62	123.67
2.60	1,304	166.7	7.82	128.62
2.70	1,442	179.8	8.02	133.56

Depth	Q	Area	Veloc	Wp
(ft)	(cfs)	(sqft)	(ft/s)	(ft)
2.80	1,589	193.4	8.22	138.51
2.90	1,745	207.4	8.41	143.46
3.00	1,910	222.0	8.61	148.40

Yc	TopWidth	Energy
(ft)	(ft)	(ft)
0.09	4.93	0.11
0.19	9.87	0.23
0.29	14.80	0.35
0.39	19.73	0.48
0.49	24.67	0.61
0.59	29.60	0.73
0.70	34.53	0.87
0.80	39.47	1.00
0.91	44.40	1.13
1.02	49.33	1.27
1.13	54.27	1.40
1.23	59.20	1.54
1.34	64.13	1.68
1.45	69.07	1.82
1.57	74.00	1.96
1.68	78.93	2.10
1.79	83.87	2.24
1.90	88.80	2.38
2.01	93.73	2.53
2.13	98.67	2.67
2.24	103.60	2.82
2.35	108.53	2.96
2.47	113.47	3.11
2.58	118.40	3.25
2.70	123.33	3.40
2.81	128.27	3.55
2.93	133.20	3.70

Yc	TopWidth	Energy
(ft)	(ft)	(ft)
3.00	138.13	3.85
3.00	143.07	4.00
3.00	148.00	4.15

# Channel Report

## AAR\_Run-on diversion

### Triangular

Side Slopes (z:1) = 6.00, 6.00

Total Depth (ft) = 2.00

Invert Elev (ft) = 100.00

Slope (%) = 2.70

N-Value = 0.026

### Calculations

Compute by: Known Q

Known Q (cfs) = 68.76

### Highlighted

Depth (ft) = 1.29

Q (cfs) = 68.76

Area (sqft) = 9.98

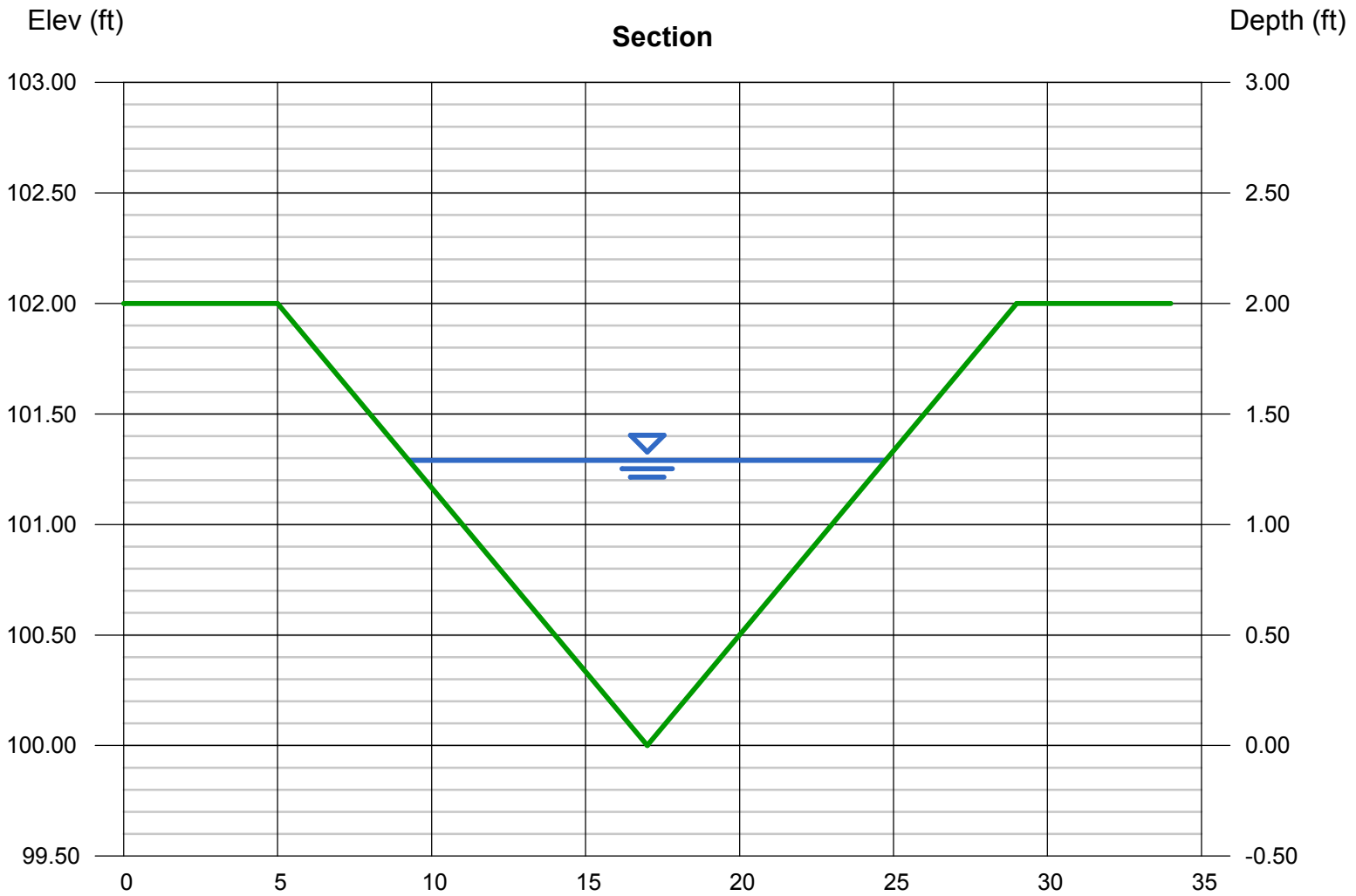
Velocity (ft/s) = 6.89

Wetted Perim (ft) = 15.69

Crit Depth, Yc (ft) = 1.53

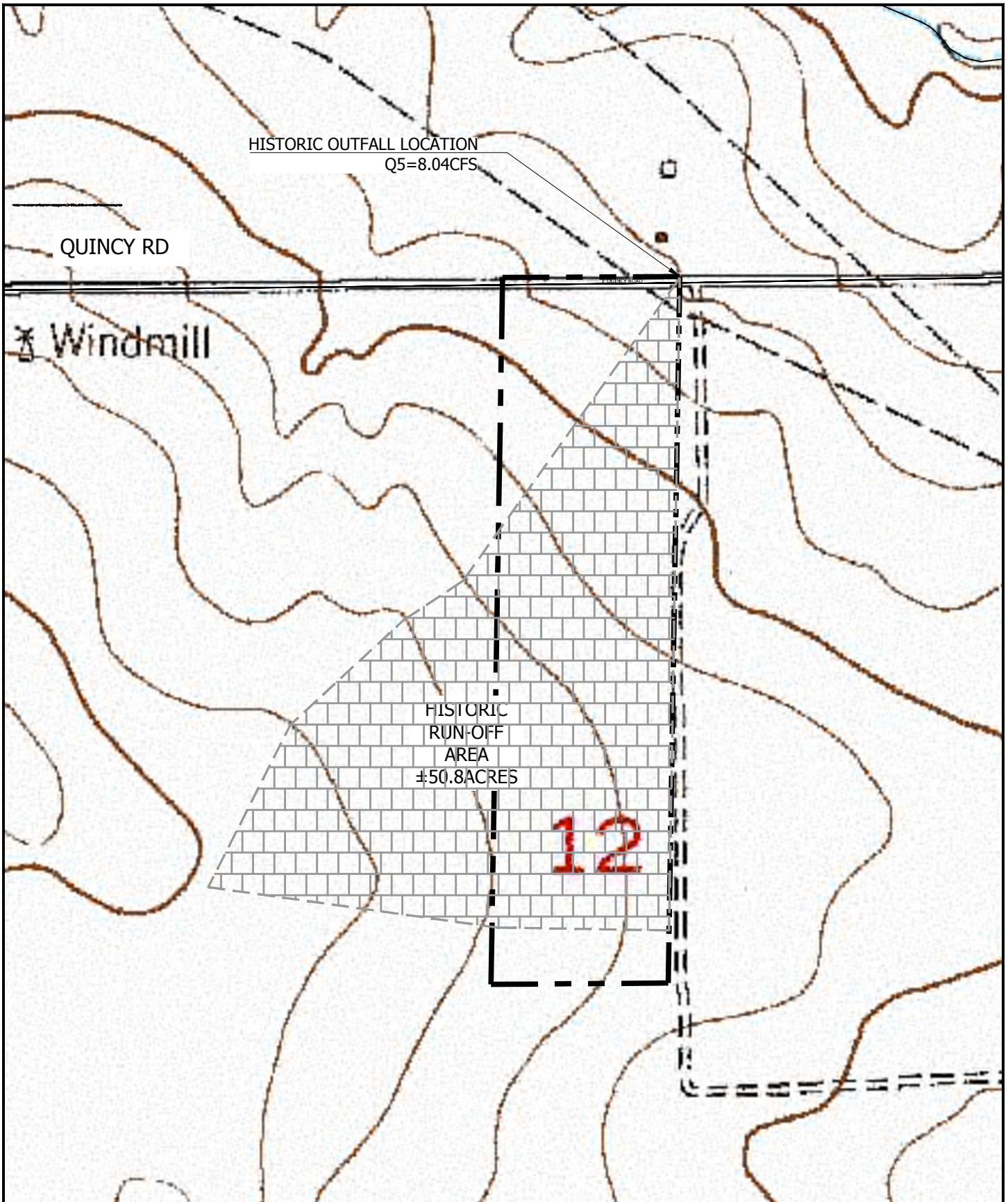
Top Width (ft) = 15.48

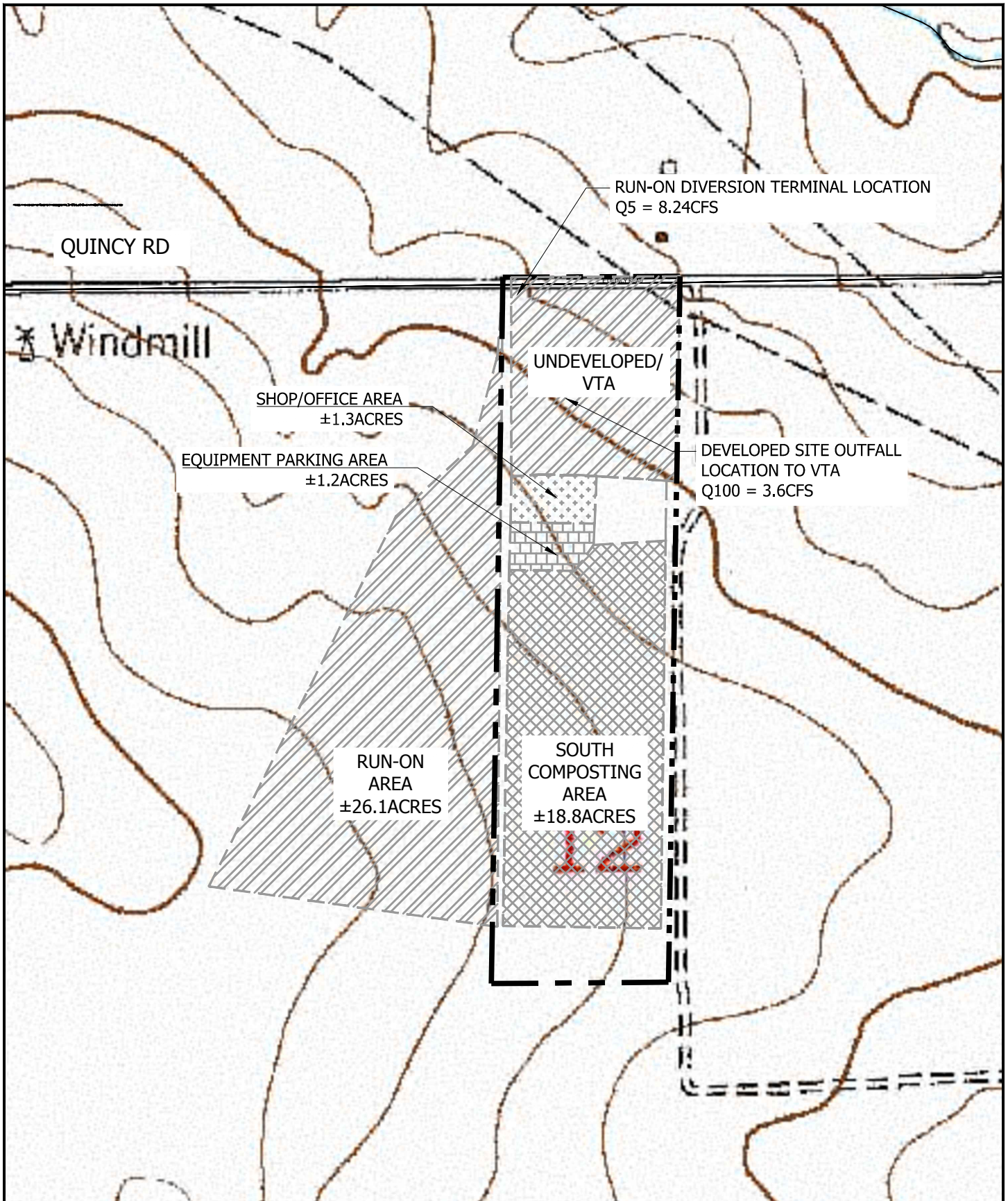
EGL (ft) = 2.03



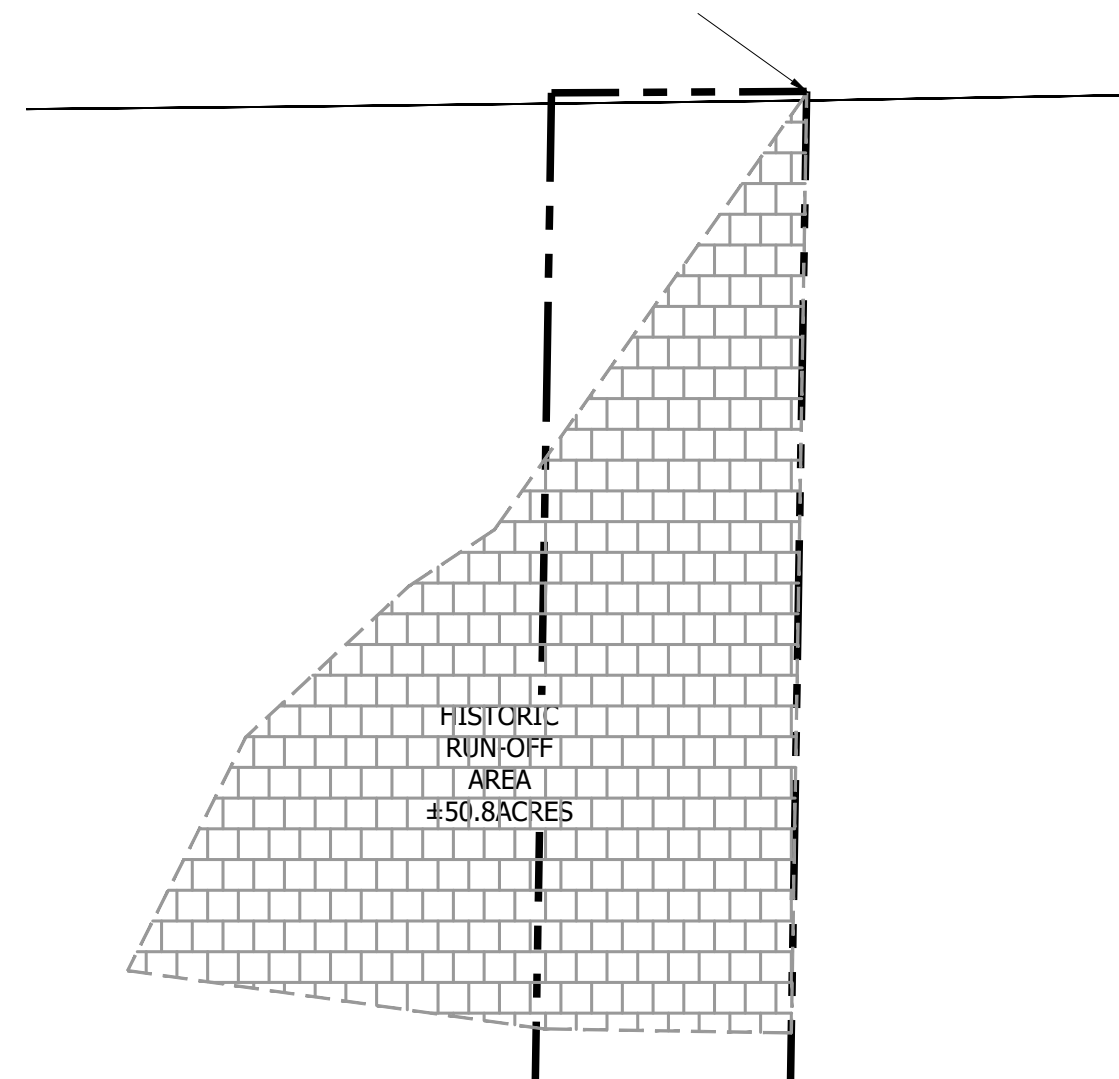
Depth	Q	Area	Veloc	Wp
(ft)	(cfs)	(sqft)	(ft/s)	(ft)
0.10	0.076	0.060	1.26	1.22
0.20	0.481	0.240	2.00	2.43
0.30	1.418	0.540	2.63	3.65
0.40	3.054	0.960	3.18	4.87
0.50	5.537	1.500	3.69	6.08
0.60	9.004	2.160	4.17	7.30
0.70	13.58	2.940	4.62	8.52
0.80	19.39	3.840	5.05	9.73
0.90	26.55	4.860	5.46	10.95
1.00	35.17	6.000	5.86	12.17
1.10	45.34	7.260	6.25	13.38
1.20	57.19	8.640	6.62	14.60
1.30	70.80	10.14	6.98	15.82
1.40	86.27	11.76	7.34	17.03
1.50	103.7	13.50	7.68	18.25
1.60	123.2	15.36	8.02	19.46
1.70	144.8	17.34	8.35	20.68
1.80	168.6	19.44	8.67	21.90
1.90	194.8	21.66	8.99	23.11
2.00	223.3	24.00	9.31	24.33

Yc	TopWidth	Energy
(ft)	(ft)	(ft)
0.10	1.20	0.12
0.21	2.40	0.26
0.33	3.60	0.41
0.44	4.80	0.56
0.56	6.00	0.71
0.68	7.20	0.87
0.80	8.40	1.03
0.92	9.60	1.20
1.05	10.80	1.36
1.17	12.00	1.53
1.29	13.20	1.71
1.42	14.40	1.88
1.54	15.60	2.06
1.67	16.80	2.24
1.80	18.00	2.42
1.93	19.20	2.60
2.00	20.40	2.78
2.00	21.60	2.97
2.00	22.80	3.16
2.00	24.00	3.35

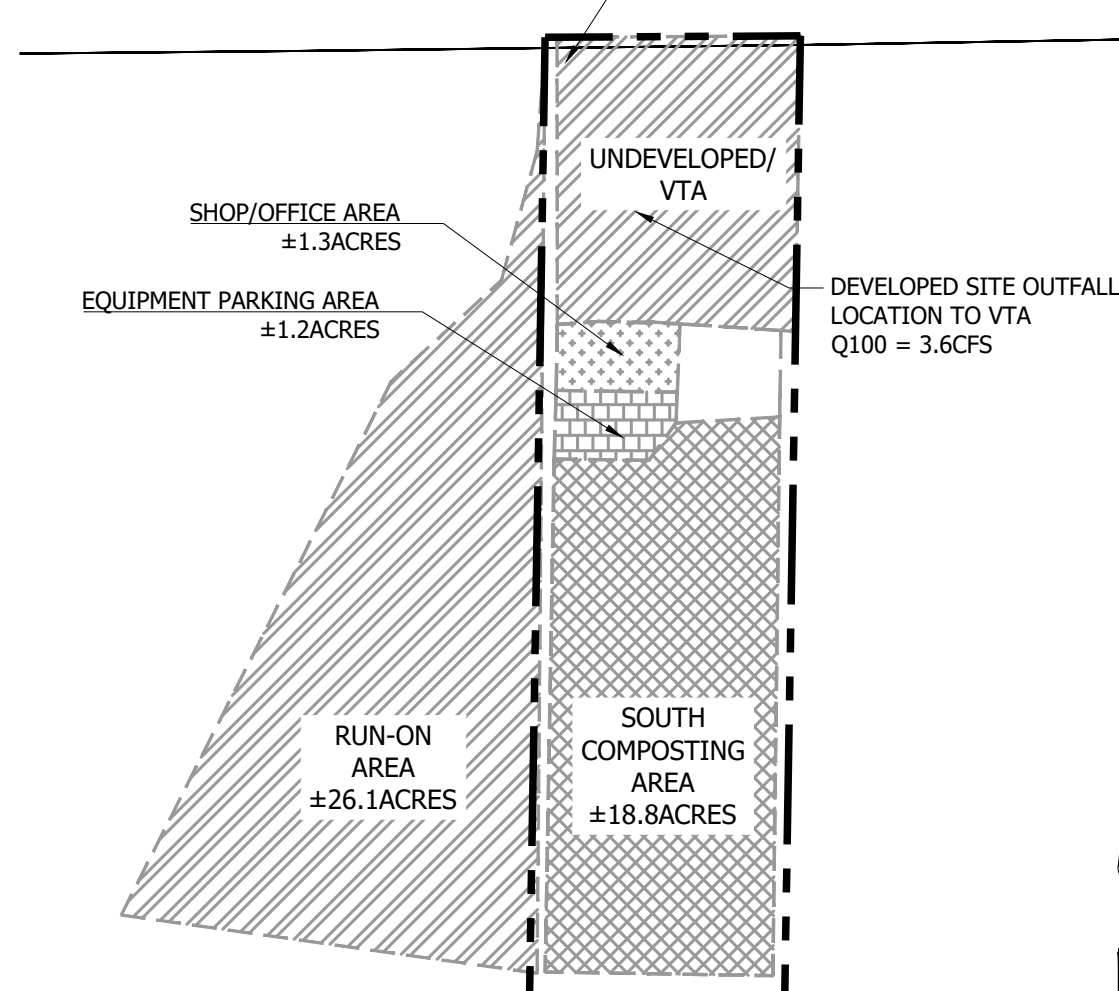








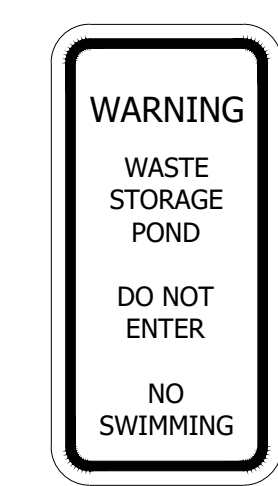
4 EXISTING DRAINAGE



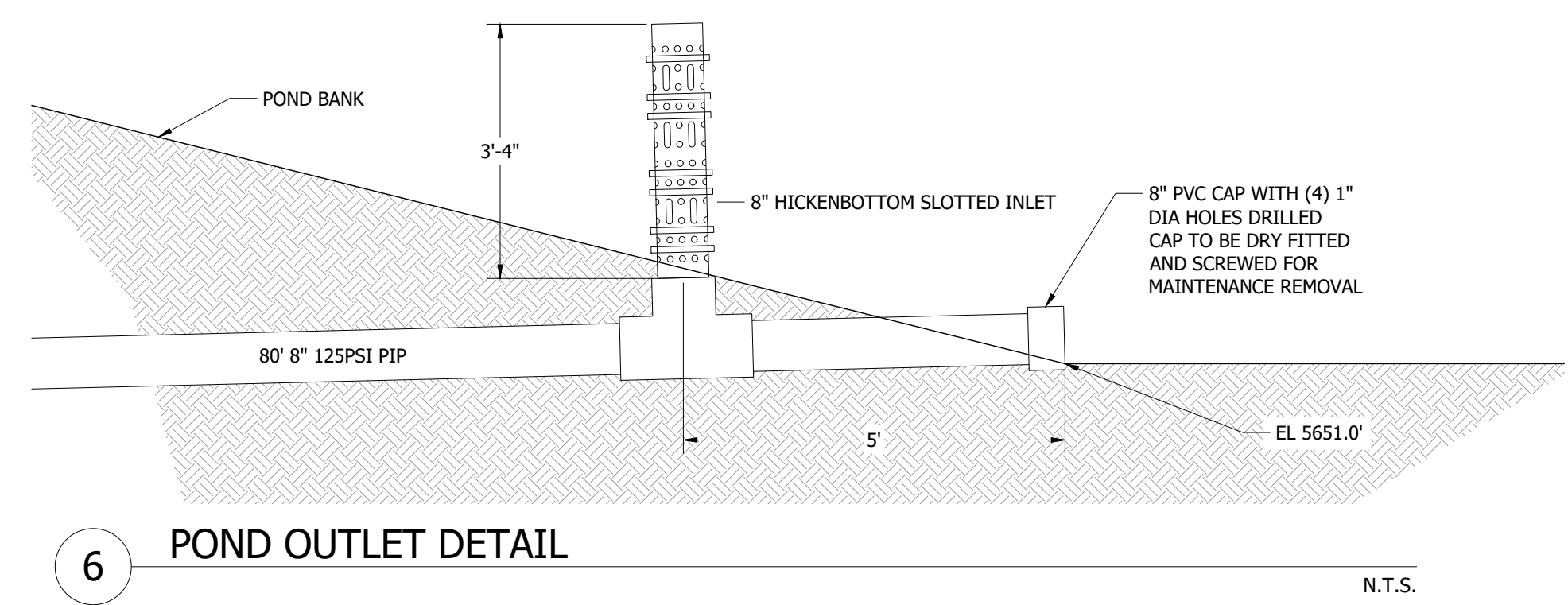
5 PROPOSED DRAINAGE

NOTES:  
1. NO MAPPED 100YR FLOODPLAIN AFFECTS THIS PROJECT

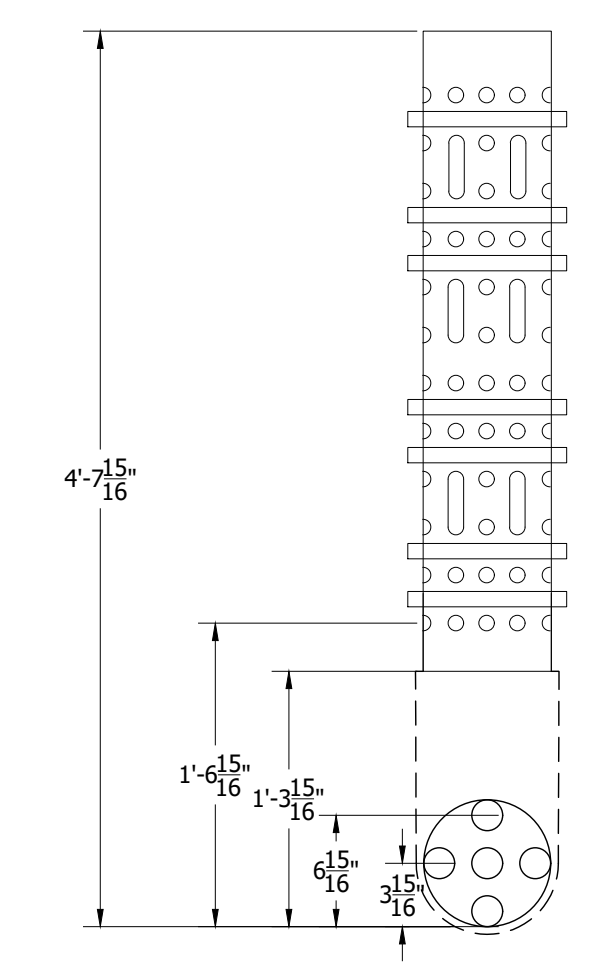
Runoff areas						
Area	2yr, 1hr Q2 (cfs)	5yr, 1hr Q5 (cfs)	100yr, 1hr Q100 (cfs)	5yr, 24hr Q25 (cfs)	Total (ac-ft)	
South composting area	13.0	22.0	81.1	42.3	3.45	
Equipment parking area	3.0	4.4	13.1	4.0	0.28	
Shop/office area		1.0	3.0	2.0	0.20	
Shop and office roof						
Pond Surface					0.41	
Total					4.35	
<b>Historic</b>		<b>8.0</b>				
<b>Developed pond outfall</b>			<b>3.6</b>			
Run-on area	2.4	8.2	68.8	17	2.61	



4 WARNING SIGN



6 POND OUTLET DETAIL N.T.S.



7 POND OUTLET DETAIL N.T.S.

Date	Designed	Drawn	Revised	Revised
1/14/2025	TRAVIS HERTNEKY	TRAVIS HERTNEKY	TRAVIS HERTNEKY	TRAVIS HERTNEKY
1/14/2025				
8/7/2025				
10/6/2025				

**KIOWA CREEK FACILITY**  
**DRAINAGE PLAN**  
 E 1/2 OF THE E 1/4 OF THE NW 1/4 SECTION 12, TOWNSHIP 5S, RANGE 63W, OF THE 6TH P.M., ARAPAHOE COUNTY, COLORADO

**TTE** ENGINEERING, LLC  
 Greeley, CO 719-661-6209

Sheet: **DP-2**

File Name: KATTE\_P-2.DWG

Sheet 2 of 2

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