Periodic Run-On and Run-Off Control System Plan Fly Ash Landfill Area 2, Phase 1

Evergy Kansas Central, Inc.

Jeffrey Energy Center
Project No. 117742

Revision 0
10/1/2021

Periodic Run-On and Run-Off Control System Plan Fly Ash Landfill Area 2, Phase 1

prepared for

Evergy Kansas Central, Inc.
Jeffrey Energy Center
St Marys, Kansas

Project No. 117742

Revision 0
10/1/2021

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Evergy Kansas Central, Inc.
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Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Kansas, that the information in this document was assembled under my direct personal charge and that this periodic run-on and run-off control system plan meets the applicable requirements of 40 CFR 257.81. This report is not intended or represented to be suitable for reuse by the Evergy Kansas Central, Inc. or others without specific verification or adaptation by the Engineer.

Matthew D. Bleything – KS PE # PE17686

Date: 10/1/2021

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TABLE OF CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
cfs	Cubic Foot per second
CHDPE	corrugated high-density polyethylene
EPA	Environmental Protection Agency
HDPE	High-Density Polyethylene
HSG	Hydrologic Soil Group
JEC	Jeffrey Energy Center
K. A. R.	Kansas Administrative Regulations
KDHE	Kansas Department of Health and Environment
Landfill	Fly Ash Landfill Area 2, Phase 1
NRCS	Natural Resources Conservation Service
RCRA	Resource Conservation and Recovery Act
U.S.C.	United States Code

1.0 BACKGROUND

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual (CCR) Rule to regulate the disposal of CCR materials generated at coal-fired units. The rule is administered as part of the Resource Conservation and Recovery Act [RCRA, 42 United States Code (U.S.C.) §6901 et seq.], using the Subtitle D approach.

Evergy Kansas Central, Inc (Evergy) is subject to the CCR Rule and as such must develop a Run-On and Run-Off Control System Plan per 40 Code of Federal Regulations (CFR) §257.81. This report demonstrates and discusses the design for the Run-Ona and Run-Off Control system Plan for the Jeffrey Energy Center (JEC) Fly Ash Landfill Area 2, Phase 1 (Landfill), Located in St. Marys, Kansas.

Run-on controls for the JEC Landfill, as well as the current and post-closure run-off controls, were designed as part of permit applications to the Kansas Department of Health and Environment (KDHE). The Run-On and Post-Closure Run-Off Control System Plan provided herein are based on analysis of the permitted facility conditions. This run-on and run-off control system plan is in addition to, not in place of, any other applicable site permits, environmental standards, or work safety practices.

1.1 Facility Information

Name of Facility:	Jeffrey Energy Center
Name of CCR Unit:	Fly Ash Landfill Area 2
Name of Operator:	Evergy Kansas Central, Inc.
Facility Mailing Address:	25905 Jeffrey Rd, St Marys, KS 66536
Location:	Approximately six miles north of St Marys, Kansas in Pottawatomie County
Facility Description:	The JEC Landfill is located in the central-western portion of the JEC site in Pottawatomie County, Kansas, approximately 4.5 miles north of Belvue, Kansas, and approximately 4.3 miles west of highway 63.

1.2 Regulatory Requirements

Per 40 CFR §257.81, the Run-on and Run-off control system plan must contain documentation (including supporting engineering calculations) that the control system has been designed and constructed to meet the applicable requirements of 40 CFR 257.81. The owner or operator of a CCR unit must prepare a written plan that includes the information specified in 40 CFR 257.81 (a) and (b) which is as follows:

(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate and maintain:

(1) A Run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and

(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

(b) Run-off from the active portion of CCR unit must be handled in accordance with the surface water requirements under §257.3-3.

These items are addressed in Sections 2.0 and 3.0 of this document. Per 40 CFR §257.81(c)(5), Evergy must obtain certification from a qualified professional engineer that the run-on and run-off control system plan, and subsequent updates to the plan, meet the requirements of 40 CFR §257.81. This sealed document serves as that certification.

2.0 LANDFILL RUN-ON AND RUN-OFF CONTROLS

The Run-On and Run-Off control features were designed to convey the run-off from the 25-year, 24-hour storm event. The methods of determination of the peak flow rates and run-off volumes are based on the Soil Conservation Service's (SCS) [now known as the Natural Resources Conservation Service (NRCS)] run-off curve number method (NRCS, 1986) to calculate losses. Additional methods of determination are the Rational Method, Manning's equation to calculate channel depths, and HydroCAD Stormwater Modeling 10 (40 node s/n 08510). Phase 1 of the landfill encompasses an area of approximately 22 acres (with approximately 14.5 acres of lined landfill area) constructed as one cell. The balance of the constructed area is reserved for contact stormwater channels. The Landfill was designed to collect and contain the stormwater coming into contact with landfilled CCR material. Additionally, the design limits the chance of stormwater entering the landfill site from surrounding areas.

2.1 Run-On Controls

Run-on channels or ditches intercept off-site drainage and prevent it from running onto the working surface. The Landfill access road prevents run-on to the Landfill and also serves as an access road for the Landfill and leachate pond.

On the North side of the active face of the Landfill, a 4-foot-wide swale prevents run-on from entering the site. This is drained to the southeast where it discharges to an existing channel. The existing channel runs along the east side and is a minimum of 8-feet wide and a minimum of 5-feet deep. This stormwater then discharges in the JEC site's process water channel and ultimately to Tower Hill Lake.

The West side of the active face of the landfill is protected from run-on by an 8-foot-wide swale. This swale runs the length of landfill on the west side and discharges into the leachate pond.

Table 2-1 presents the excess capacities of the exterior ditch for the 25-year, 24-hour design storm event. For the purposes of this calculation, the ditch was evaluated at several different points which are intended to represent "typical" geometry and flow conditions.

Table 2-1: Run-On Control Performance

Storm Water System Component		Calculated Excess Capacity	Units
Channels	Exterior Ditch North (4H:1V side slopes)	161.8	cubic feet per second
	Exterior Ditch East (3H:1V side slopes)	686.49	cubic feet per second

Supporting calculations are presented in Appendix A. As indicated in Table 2-1 and Appendix A, the landfill has significant excess capacity beyond the design 25-year, 24-hour storm event, therefore the run-on protection system exceeds the requirement to provide protection from run-on from the 24-hour, 25-year storm event.

2.2 Run-Off Controls

The site stormwater run-off predominantly drains east toward an existing ravine, which is the low point of Phase 1. The run-off will be collected in 8-foot-wide flat bottom ditches with variable side slopes (Typically 4H:1V) that parallel the perimeter of Phase 1. These ditches will be lined with 80 to 150-pound riprap and are located north, west and east side of the landfill. From the perimeter ditch, run-off is directed south where flow enters the Leachate Pond through four 24-in diameter high-density polyethylene (HDPE) culverts on the east side of the pond and two 24-in diameter high-density polyethylene (HDPE) culverts on the west side of the pond. The Leachate Pond and HDPE culverts were designed to collect and accommodate the 25-year, 24-hour storm event. The stormwater detained in the pond drains through a riser pipe outlet or an emergency spillway and discharges from the Leachate Pond to then flow into the JEC site process water channel and ultimately to Tower Hill Lake, which discharges to the NPDES permitted outfall. The performance of Tower Hill Lake in accordance with 40 CFR 257.81 has been validated previously by others and will not be repeated here.

Table 2-2 presents the excess capacities of the storm water run-off system components for the current landfill area for the 25-year, 24-hour design storm event. For the purposes of these calculations, it is assumed the active portion of the landfill has received interim cover with all stormwater runoff directed to the channels. The supporting calculations are presented in Appendix A.

Table 2-2: Run-Off Control Performance

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Stormwater Ponds	Stormwater Pond	1,188.00 Water EL.	1,184.31 Water EL.	3.86	ft of freeboard
Culverts	2x24” HHPE at West ditch to stormwater pond	72.04	64.29	7.75	cfs
	4x24” CHPE at East ditch to stormwater pond	83.16	77.94	5.22	cfs
Channels	Perimeter Ditch – West	558.68	64.29	494.39	cfs
	Perimeter Ditch - Southeast	395.05	77.94	317.11	cfs

As indicated in Table 2-2 and Appendix A, the landfill has significant excess capacity beyond the design 25-year, 24-hour storm event, therefore the run-off protection system exceeds the requirement to provide protection from run-off from the 24-hour, 25-year storm event.

3.0 RUN-OFF CONTROL FOR §257.3-3

Per the CCR Rule, under Section 257.81(b), stormwater best management practices (BMPs) shall be employed at the site to comply with CFR 257.3-3, which stipulates that a facility shall not cause a discharge of pollutants, dredged material, or fill material to waters of the United States or cause non-point source pollution of waters of the United States. The landfill discharges to the JEC site process water channel and ultimately to Tower Hill Lake which discharges to the NPDES permitted outfall. Per the current NPDES permit, discharged water is tested for pollutants and the discharge meets the minimum regulatory requirements of the permit. Therefore, the facility does not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the NPDES under Section 402 of the Clean Water Act, and therefore meets the requirements of 40 CFR 257.81(b).

4.0 AMENDMENT OF RUN-ON AND RUN-OFF CONTROL PLAN

The owner or operator may amend the written run-off and run-on control system plan at any time provided the revised plan is placed in the facility's operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and runoff control system plan whenever there is a change in conditions that would substantially affect the written plan in effect. Additionally, the owner or operator of the CCR unit must prepare periodic run-on and runoff control system plans every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan.

The owner or operator may complete any required plan prior to the required deadline provided the completed plan is placed into the facility's operating record within a reasonable amount of time.

A written certification from a qualified professional engineer that the initial and any amendment of the written run-on and run-off control system plan meets the requirements of §257.81 must be obtained. Plan changes will be documented using the Revision History which follows this Plan. Changes to this Plan will be certified by a Qualified Professional Engineer.

5.0 REFERENCES

1. U.S. Environmental Protection Agency, Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments, 40 CFR §257, Federal Register 80, Subpart D, April 17, 2015.

2. EPA Code of Federal Regulations. 40 CFR 257.70 Design criteria for new CCR landfills and any lateral expansion of a CCR landfill. 05 August 2016.

3. Western Air Maps, Inc, Topographic Survey, 2007.

4. United States Department of Agriculture, Natural Resources Conservation Service. Urban Hydrology for Small Watersheds, Technical Release 55. June 1986. (210-VI-TR-55, Second Ed., June 1986)
5. CB&I (a/k/a AECOM). Run-on and Run-off Control System Plan, Jeffrey Energy Center, Fly Ash Landfill, October 2016 and subsequent updates.

6.0 RECORD OF REVISIONS

Revision Number	Date	Revisions Made	By Whom
0	10/1/2021	Initial Issue	Burns & McDonnell

APPENDIX A – SUPPORTING CALCULATIONS

ATTACHMENT 1 – CALCULATION SUMMARY SHEET AND REFERENCE DOCUMENTS

September 20, 2021

Evergy Kansas Central, Inc.

Supporting Calculations for the Jeffrey Energy Center CCR Landfill Periodic Run-on and Run-off Control System Plan

Burns & McDonnell (BMcD) was retained by Evergy Kansas Central, Inc. (Evergy) to provide engineering support for the periodic update to the Run-on and Run-off Control System Plan for the Jeffrey Energy Center CCR Landfill which is required as part of the Federal Coal Combustion Residuals Rule (CCR Rule). Calculations were prepared to evaluate the capacity of the landfill run-on and run-off controls which include the leachate pond, perimeter ditches, and culverts which convey flow from the ditches to the ponds. Additionally, calculations were prepared to evaluate the capacity of the exterior ditch which is used for run-on control. HydroCAD 10.00-24 (HydroCAD) was used to model the drainage areas for each of these features in order to determine peak flows and/or peak water surface elevations.

Ground cover types and flow paths were input into HydroCAD to compute the time of concentration, weighted curve numbers, and post-closure peak flows using the SCS Unit Hydrograph method. Cover type curve numbers were selected within the HydroCAD model based on the hydrologic soil group. According to National Resource Conservation Service (NRCS) Web Soil Survey, the entire site soil belongs to hydrologic soil group (HSG) D. Cover types in the drainage areas include riprap, gravel, geomembrane and bottom ash. The time of concentration (T_c) was input based on the flow path for the hydraulically most distant point within each watershed. A minimum T_c of 6-minutes was used for all drainage areas. The 25-year, 24-hour design storm depth of 5.90 inches was obtained from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server.

FlowMaster was used to determine the full flow capacity of the culvert and channel features. Channel and culvert geometry were determined using existing survey data and design drawings. Channel features were evaluated at typical cross section locations.

The calculations are broken into three groupings: pond, culverts, and channels. A list of the calculations attached to this memorandum is as follows:

- Attachment 1 – Calculation Summary Sheet and Reference Documents
- Attachment 2 – Pond Calculations:
    - SK-001 – Pond Drainage Areas
    - HydroCAD Report for 25-year, 24-hour storm event
- Attachment 3 – Culvert Calculations:
    - SK-002 – Culvert Drainage Areas
    - HydroCAD Report for 25-year, 24-hour storm event
    - FlowMaster Worksheet for 4x24” HDPE at southeast ditch to stormwater pond

9400 Ward Parkway \ Kansas City, MO 64114
O 816-333-9400 \ F 816-333-3690 \ burnsmcd.com

    - FlowMaster Worksheet for 2x24" HDPE at west ditch to stormwater pond
- Attachment 4 – Channel Calculations
    - SK-003 – Channel Drainage Areas
    - HydroCAD Report for 25-year, 24-hour storm event
    - FlowMaster Worksheet for North Riprapped Exterior Ditch
    - FlowMaster Worksheet for East Grassed Exterior Ditch
    - FlowMaster Worksheet for West Riprapped Perimeter Ditch
    - FlowMaster Worksheet for Southeast Riprapped Perimeter Ditch

Results

The calculated peak values were compared with the full capacity values in order to determine excess capacity for each of the stormwater run-off and run-on control features. A summary of the calculated excess capacities is included in Table 1 and Table 2 for the run-on controls and run-off controls respectively.

Table 1: Stormwater Run-on Controls – Calculated Excess Capacity

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Channels	Exterior Ditch – North (4H:1V side slopes)	176.67	14.83	161.84	cfs
	Exterior Ditch – East (3H:1V side slopes)	754.74	68.25	686.49	cfs

Table 2: Stormwater Run-off Controls – Calculated Excess Capacity

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Stormwater Ponds	Leachate Stormwater Pond	1,188.00 Water EL	1,184.14 Water EL	3.86	ft of freeboard
Culverts	2x24" HDPE at West ditch to stormwater pond	72.04	64.29	7.75	cfs
	4x24" HDPE at Southeast ditch to stormwater pond	83.16	77.94	5.22	cfs

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Channels	Perimeter Ditch – West (4H:1V side slopes)	558.68	64.29	494.39	cfs
	Perimeter Ditch – Southeast (4H:1V side slopes)	395.05	77.94	317.11	cfs

Based on the results of the calculations, the run-off and run-on controls at the Jeffrey Energy Center CCR Landfill are adequate for conveying and controlling flows from the 25-year, 24-hour storm event.

Reference 2

BURNS McDONNELL

WORKSHEET TITLE:	Evergy - Jeffrey Energy Center Landfill Run-On and Run-Off Controls	**CALCULATION NO.:**	C - 001
CREATED:	9/20/2021	**REVISION:**	A
PERFORMED BY:	C. Dominguez	**REVIEWED BY:**	Matt Bleything
OBJECTIVE:	Check Jeffrey Energy Center CCR Landfill run-off controls for 25-year, 24-hour storm		

REFERENCES:

1 Natural Resources Conservation Service (June 1986). TR-55: Urban Hydrology for Small Watersheds.
Retrieved from : www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf

2 US Department of Agriculture. (June 2021). Custom soil map for Pottawatomie County, Kansas
Retrieved from : http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

3 National Oceanic and Atmospheric Administration. (June 2021). NOAA Atlas 14, Volume 8, Version 2. [Point precipitation frequency estimates for Saint Marys, Kansas, USA].
Retrieved from : https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mo

SOFTWARE:

1 HydroCAD 10.00-24 (40 node s/n 08510)

2 Bentley FlowMaster Connect Edition

ASSUMPTIONS:

1 Hydrologic Soil Group D Reference 2

2 Depth for 25-year, 24-hour storm is 5.90" Reference 3

CALCULATIONS:

Refer to the following documents:

-SK-001, SK-002 and SK-003 for drainage area delineations for the pond, culverts and channels respectively

-see HydroCAD reports for Peak Flow calculations

-see FlowMaster reports for Capacity calculations

RUN-ON CONTROLS

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Channels	Exterior Ditch - North (4H:1V side Slopes)	176.7	14.8	161.8	cfs
	Exterior Ditch - East (3H:1V side Slopes)	754.7	68.3	686.5	cfs

RUN-OFF CONTROLS

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Stormwater Ponds	Leachates Stormwater Pond	1188 Water EL	1184.14 Water EL	3.86	ft of freeboard
Culverts	2x24" HDPE at West ditch to stormwater pond	72.0*	64.3	7.8	cfs
	4x24" HDPE at Southwest ditch to stormwater pond	83.2**	77.9	5.2	cfs
Channels	Perimenter Ditch - West (4H:1V side slopes)	558.7	64.3	494.4	cfs
	Perimenter Ditch - Southeast (4H:1V side slopes)	395.1	77.9	317.1	cfs

* 72.0 = 2 culverts x36.0 cfs capacity per culvert

**83.2 = 4 culverts x 20.8 cfs capacity per culvert

Map Scale: 1:8,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 100 200 400 600

Feet
0 400 800 1600 2400

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

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

Soil Rating Lines

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

Soil Rating Points

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Pottawatomie County, Kansas
Survey Area Data: Version 21, Jun 10, 2020

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

Date(s) aerial images were photographed: Data not available.

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
4590	Clime-Sogn complex, 3 to 20 percent slopes	D	244.0	100.0%
9983	Gravel pits and quarries		0.1	0.0%
Totals for Area of Interest			**244.1**	**100.0%**

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Reference 3

NOAA Atlas 14, Volume 8, Version 2
Location name: Saint Marys, Kansas, USA*
Latitude: 39.2834°, Longitude: -96.1146°
Elevation: 1299.64 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_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.402** (0.321-0.510)	**0.475** (0.379-0.602)	**0.598** (0.475-0.759)	**0.704** (0.557-0.895)	**0.855** (0.658-1.11)	**0.976** (0.735-1.27)	**1.10** (0.804-1.45)	**1.23** (0.866-1.65)	**1.41** (0.957-1.91)	**1.55** (1.03-2.11)
10-min	**0.589** (0.470-0.746)	**0.695** (0.555-0.882)	**0.875** (0.696-1.11)	**1.03** (0.815-1.31)	**1.25** (0.964-1.63)	**1.43** (1.08-1.87)	**1.61** (1.18-2.13)	**1.81** (1.27-2.41)	**2.07** (1.40-2.80)	**2.28** (1.50-3.09)
15-min	**0.718** (0.574-0.910)	**0.848** (0.677-1.08)	**1.07** (0.849-1.36)	**1.26** (0.994-1.60)	**1.53** (1.18-1.98)	**1.74** (1.31-2.28)	**1.97** (1.44-2.60)	**2.20** (1.55-2.94)	**2.52** (1.71-3.42)	**2.77** (1.83-3.77)
30-min	**1.01** (0.809-1.28)	**1.20** (0.958-1.52)	**1.52** (1.21-1.93)	**1.79** (1.42-2.28)	**2.18** (1.68-2.83)	**2.49** (1.87-3.24)	**2.81** (2.05-3.70)	**3.14** (2.20-4.19)	**3.59** (2.43-4.86)	**3.94** (2.60-5.36)
60-min	**1.32** (1.06-1.67)	**1.57** (1.26-2.00)	**2.00** (1.59-2.54)	**2.36** (1.87-3.01)	**2.88** (2.22-3.74)	**3.29** (2.48-4.29)	**3.72** (2.71-4.90)	**4.16** (2.92-5.55)	**4.75** (3.22-6.43)	**5.22** (3.45-7.10)
2-hr	**1.63** (1.31-2.04)	**1.95** (1.57-2.44)	**2.48** (1.99-3.12)	**2.94** (2.35-3.70)	**3.58** (2.78-4.60)	**4.10** (3.11-5.29)	**4.63** (3.41-6.04)	**5.17** (3.67-6.85)	**5.92** (4.05-7.94)	**6.50** (4.34-8.77)
3-hr	**1.82** (1.48-2.27)	**2.18** (1.77-2.72)	**2.78** (2.25-3.47)	**3.30** (2.65-4.12)	**4.03** (3.15-5.15)	**4.61** (3.52-5.92)	**5.21** (3.86-6.76)	**5.82** (4.16-7.67)	**6.67** (4.59-8.90)	**7.32** (4.92-9.83)
6-hr	**2.15** (1.76-2.65)	**2.57** (2.11-3.17)	**3.28** (2.68-4.05)	**3.89** (3.16-4.82)	**4.76** (3.76-6.02)	**5.45** (4.21-6.92)	**6.16** (4.61-7.92)	**6.89** (4.97-9.00)	**7.90** (5.50-10.5)	**8.68** (5.90-11.6)
12-hr	**2.48** (2.05-3.02)	**2.95** (2.44-3.59)	**3.74** (3.09-4.57)	**4.42** (3.63-5.41)	**5.40** (4.32-6.76)	**6.18** (4.83-7.79)	**6.99** (5.30-8.92)	**7.84** (5.72-10.1)	**8.99** (6.33-11.8)	**9.90** (6.80-13.1)
24-hr	**2.86** (2.40-3.45)	**3.34** (2.79-4.02)	**4.15** (3.46-5.01)	**4.86** (4.04-5.88)	**5.90** (4.78-7.33)	**6.74** (5.34-8.42)	**7.63** (5.85-9.65)	**8.57** (6.33-11.0)	**9.86** (7.03-12.9)	**10.9** (7.57-14.3)
2-day	**3.32** (2.82-3.96)	**3.78** (3.20-4.51)	**4.59** (3.87-5.47)	**5.30** (4.45-6.35)	**6.37** (5.22-7.84)	**7.25** (5.81-8.97)	**8.18** (6.35-10.3)	**9.18** (6.87-11.7)	**10.6** (7.64-13.7)	**11.7** (8.22-15.2)
3-day	**3.61** (3.08-4.27)	**4.12** (3.51-4.88)	**5.00** (4.24-5.92)	**5.76** (4.87-6.85)	**6.88** (5.67-8.40)	**7.80** (6.28-9.57)	**8.75** (6.83-10.9)	**9.76** (7.34-12.3)	**11.2** (8.10-14.3)	**12.3** (8.68-15.9)
4-day	**3.87** (3.31-4.55)	**4.42** (3.78-5.21)	**5.36** (4.57-6.32)	**6.17** (5.24-7.30)	**7.34** (6.06-8.89)	**8.28** (6.69-10.1)	**9.25** (7.25-11.5)	**10.3** (7.75-12.9)	**11.7** (8.51-14.9)	**12.8** (9.07-16.4)
7-day	**4.60** (3.98-5.37)	**5.22** (4.50-6.09)	**6.25** (5.38-7.31)	**7.14** (6.11-8.37)	**8.40** (7.00-10.1)	**9.41** (7.68-11.4)	**10.4** (8.26-12.8)	**11.5** (8.79-14.4)	**13.0** (9.57-16.5)	**14.2** (10.2-18.1)
10-day	**5.26** (4.57-6.10)	**5.94** (5.16-6.89)	**7.08** (6.13-8.23)	**8.06** (6.94-9.39)	**9.45** (7.91-11.3)	**10.5** (8.65-12.7)	**11.7** (9.29-14.2)	**12.9** (9.85-15.9)	**14.4** (10.7-18.2)	**15.7** (11.3-20.0)
20-day	**7.04** (6.19-8.07)	**8.02** (7.04-9.20)	**9.62** (8.42-11.0)	**10.9** (9.54-12.6)	**12.8** (10.8-15.0)	**14.2** (11.8-16.8)	**15.6** (12.5-18.8)	**17.1** (13.2-20.9)	**19.0** (14.2-23.7)	**20.4** (14.9-25.8)
30-day	**8.56** (7.58-9.75)	**9.77** (8.64-11.1)	**11.7** (10.3-13.4)	**13.3** (11.7-15.2)	**15.4** (13.1-17.9)	**17.0** (14.2-20.0)	**18.6** (15.0-22.2)	**20.2** (15.7-24.5)	**22.2** (16.7-27.5)	**23.7** (17.5-29.8)
45-day	**10.6** (9.42-12.0)	**12.0** (10.7-13.6)	**14.3** (12.7-16.2)	**16.1** (14.2-18.3)	**18.4** (15.7-21.2)	**20.2** (16.9-23.5)	**21.9** (17.7-25.9)	**23.5** (18.4-28.3)	**25.5** (19.2-31.3)	**26.9** (19.9-33.6)
60-day	**12.4** (11.1-13.9)	**13.9** (12.5-15.7)	**16.4** (14.6-18.5)	**18.3** (16.2-20.7)	**20.8** (17.8-23.7)	**22.5** (18.9-26.1)	**24.2** (19.7-28.4)	**25.7** (20.2-30.8)	**27.6** (20.9-33.7)	**28.8** (21.4-35.9)

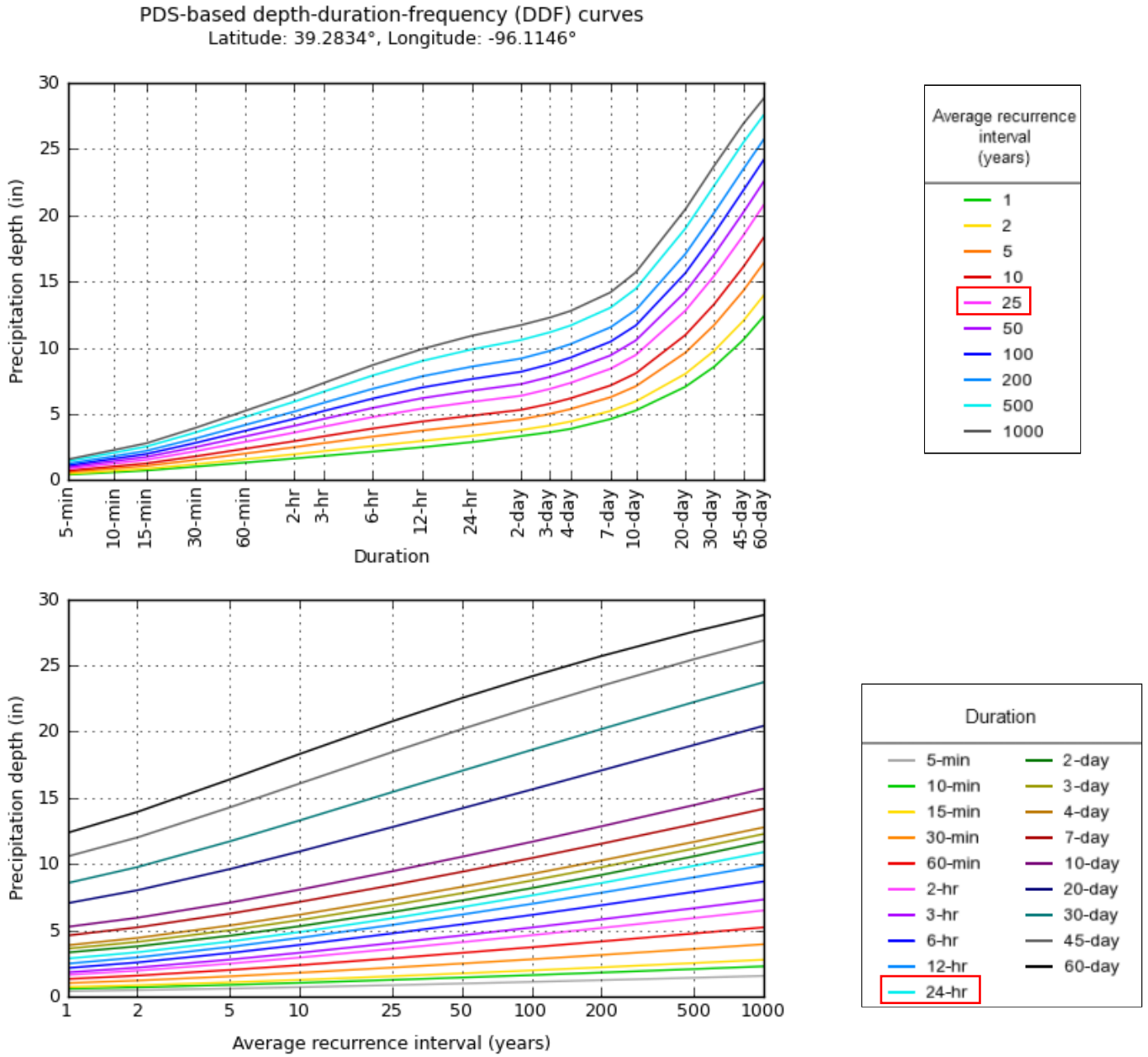
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

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

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



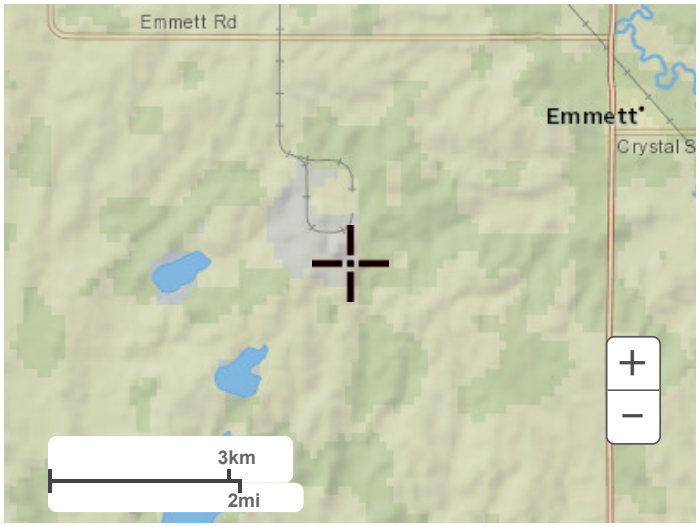
NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Thu Jul 8 14:17:03 2021

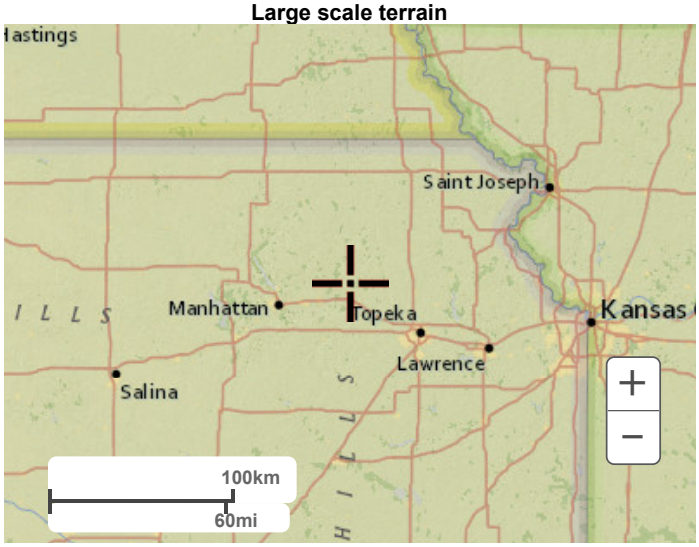
Back to Top

Maps & aerials

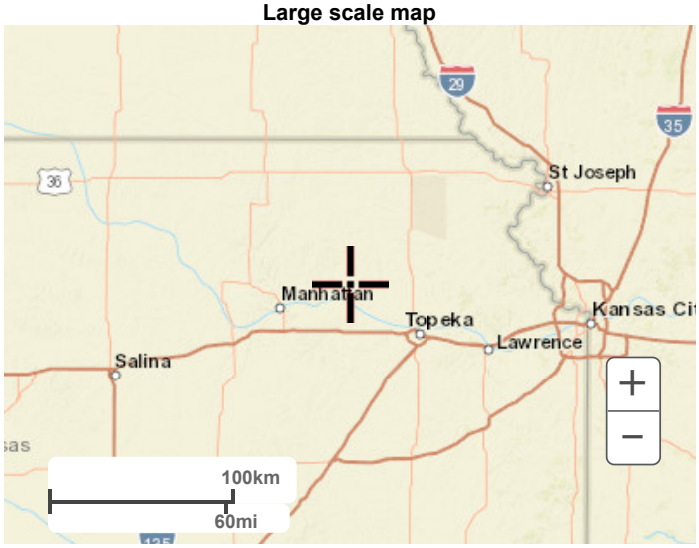
Small scale terrain



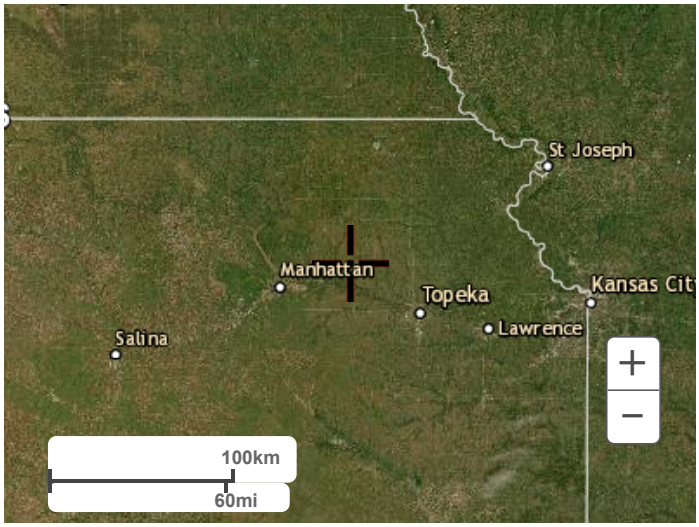
Large scale terrain



Large scale map



Large scale aerial



Back to Top

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Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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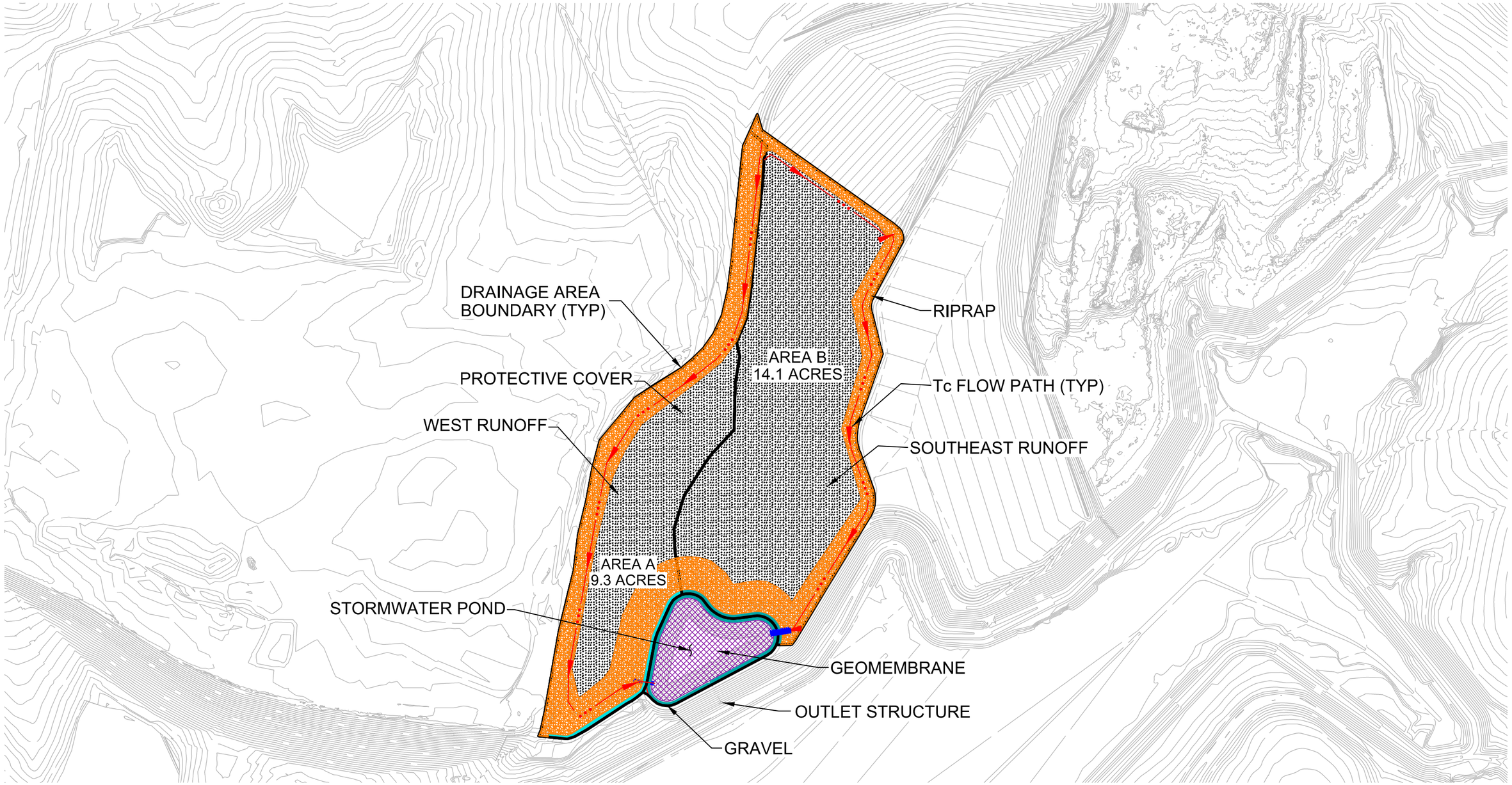
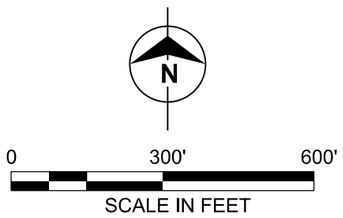
ATTACHMENT 2 – POND CALCULATIONS





GRAVEL

GEOMEMBRANE

RIPRAP

PROTECTIVE COVER

BURNS McDONNELL

date 09/20/2021

designed C.DOMINGUEZ

EVERGY

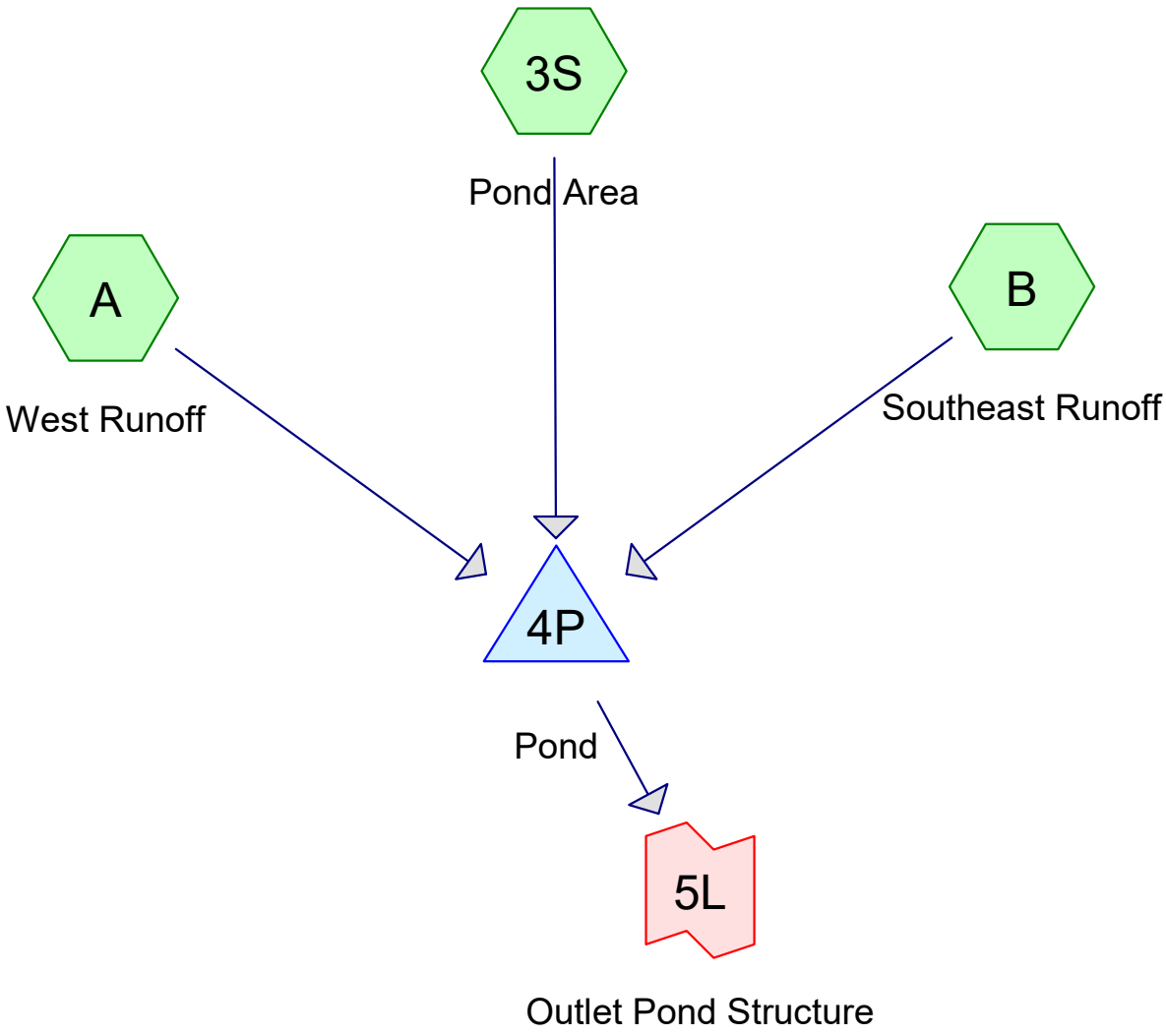
JEFFREY ENERGY CENTER
RUN-ON RUN-OFF CONTROL SYSTEM
POND DRAINAGE AREAS
FLY ASH LANDFILL AREA I

project 117742

contract -

SK - 001

9/24/2021 \\bmcd\dfs\Clients\ENR\WestarEnr\108337_JECFlyAshLF\Design\Civil\Dsgn\Landfill\RORO Control System\Sketches\SK-001.dgn



Subcat Reach Pond Link

Routing Diagram for Jeffrey Fly Ash Landfill HydroCAD Design-Pond
Prepared by Burns and McDonnell, Printed 9/15/2021

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
15.648	94	Fallow, bare soil, HSG D (A, B)
0.241	91	Gravel roads, HSG D (A, B)
0.300	96	Gravel surface, HSG D (3S)
4.490	98	Paved roads w/curbs & sewers, HSG D (3S, B)
4.670	98	Water Surface, HSG D (A)

Time span=1.00-46.00 hrs, dt=0.05 hrs, 901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 3S: Pond Area Runoff Area=1.940 ac 84.54% Impervious Runoff Depth>5.66"
Flow Length=133' Tc=6.0 min CN=98 Runoff=15.87 cfs 0.915 af

Subcatchment A: West Runoff Runoff Area=9.289 ac 50.27% Impervious Runoff Depth=5.43"
Flow Length=2,214' Tc=11.3 min CN=96 Runoff=64.29 cfs 4.202 af

Subcatchment B: Southeast Runoff Runoff Area=14.120 ac 20.18% Impervious Runoff Depth=5.31"
Flow Length=1,873' Tc=13.4 min CN=95 Runoff=91.54 cfs 6.251 af

Pond 4P: Pond Peak Elev=1,184.14' Storage=459,913 cf Inflow=166.37 cfs 11.368 af
Outflow=1.94 cfs 0.993 af

Link 5L: Outlet Pond Structure Inflow=1.94 cfs 0.993 af
Primary=1.94 cfs 0.993 af

Summary for Subcatchment 3S: Pond Area

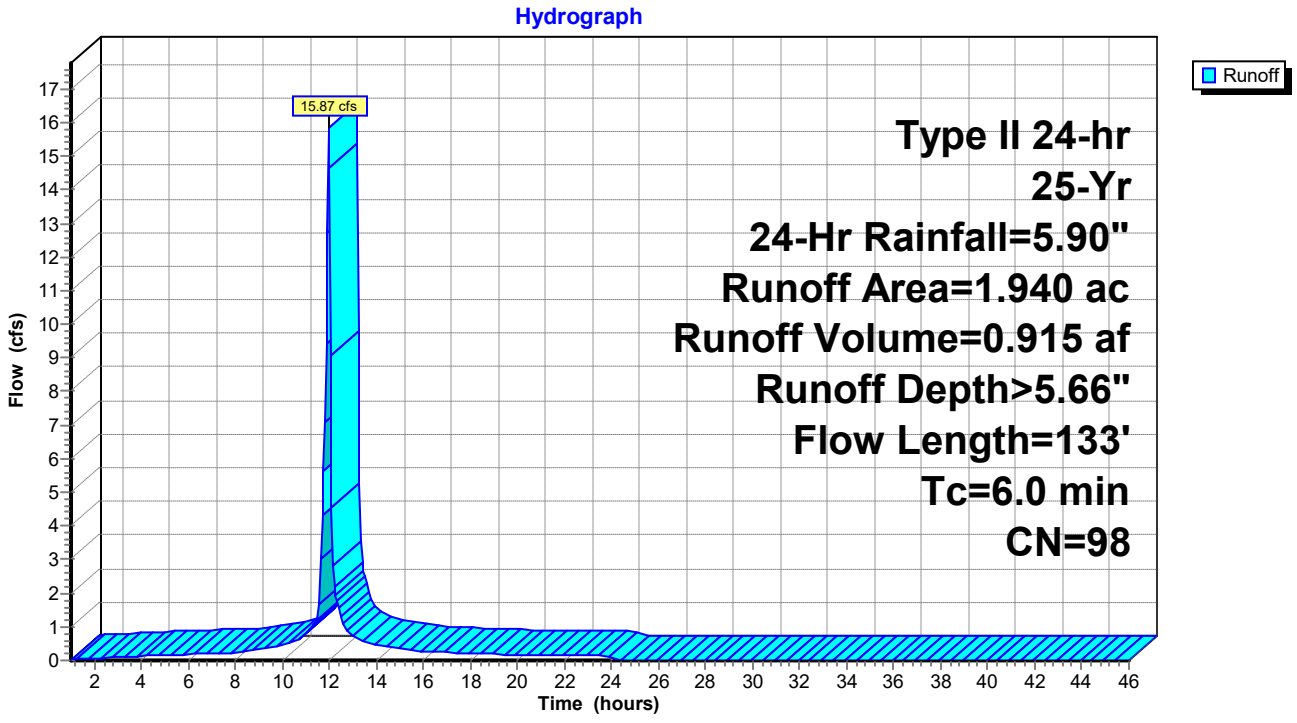
Runoff = 15.87 cfs @ 11.96 hrs, Volume= 0.915 af, Depth> 5.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Yr, 24-Hr Rainfall=5.90"

Area (ac)	CN	Description
1.640	98	Paved roads w/curbs & sewers, HSG D
0.300	96	Gravel surface, HSG D
1.940	98	Weighted Average
0.300		15.46% Pervious Area
1.640		84.54% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	68	0.2520	1.07		**Sheet Flow, down flow to pond** Fallow n= 0.050 P2= 3.34"
0.2	65	0.0050	5.52	17.33	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Corrugated PP, smooth interior
1.3	133	Total, Increased to minimum Tc = 6.0 min			

Subcatchment 3S: Pond Area



Summary for Subcatchment A: West Runoff

[47] Hint: Peak is 361% of capacity of segment #1
[47] Hint: Peak is 442% of capacity of segment #2
[47] Hint: Peak is 361% of capacity of segment #3
[47] Hint: Peak is 625% of capacity of segment #4
[47] Hint: Peak is 240% of capacity of segment #5
[47] Hint: Peak is 510% of capacity of segment #6
[47] Hint: Peak is 371% of capacity of segment #7

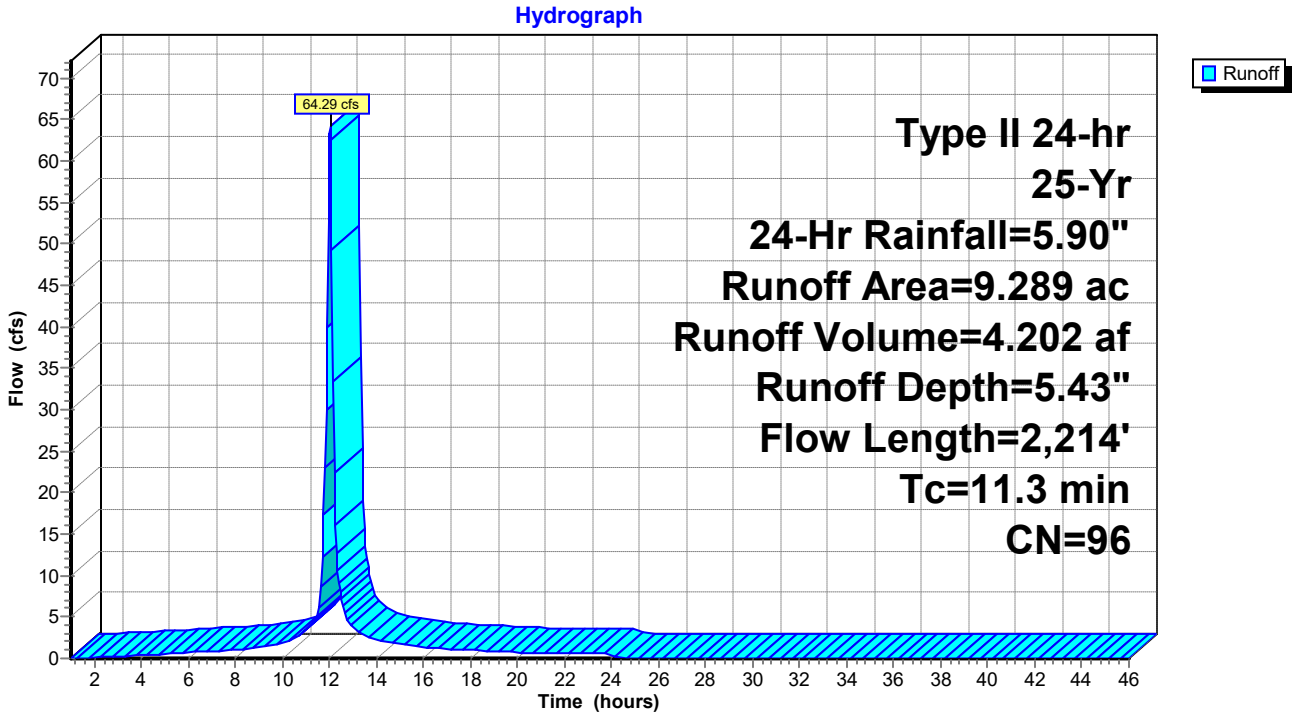
Runoff = 64.29 cfs @ 12.02 hrs, Volume= 4.202 af, Depth= 5.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Yr, 24-Hr Rainfall=5.90"

Area (ac)	CN	Description
0.150	91	Gravel roads, HSG D
4.469	94	Fallow, bare soil, HSG D
4.670	98	Water Surface, HSG D
9.289	96	Weighted Average
4.619		49.73% Pervious Area
4.670		50.27% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	883	0.0300	3.57	17.83	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
3.0	520	0.0200	2.91	14.56	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
1.3	284	0.0300	3.57	17.83	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
1.0	125	0.0100	2.06	10.29	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
0.6	178	0.0675	5.35	26.74	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
1.1	160	0.0150	2.52	12.61	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
0.2	64	0.0050	5.52	17.33	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012
11.3	2,214	Total			

Subcatchment A: West Runoff



Summary for Subcatchment B: Southeast Runoff

[47] Hint: Peak is 1240% of capacity of segment #2
[47] Hint: Peak is 391% of capacity of segment #3
[47] Hint: Peak is 407% of capacity of segment #4
[47] Hint: Peak is 1258% of capacity of segment #5
[47] Hint: Peak is 1577% of capacity of segment #6
[47] Hint: Peak is 528% of capacity of segment #7

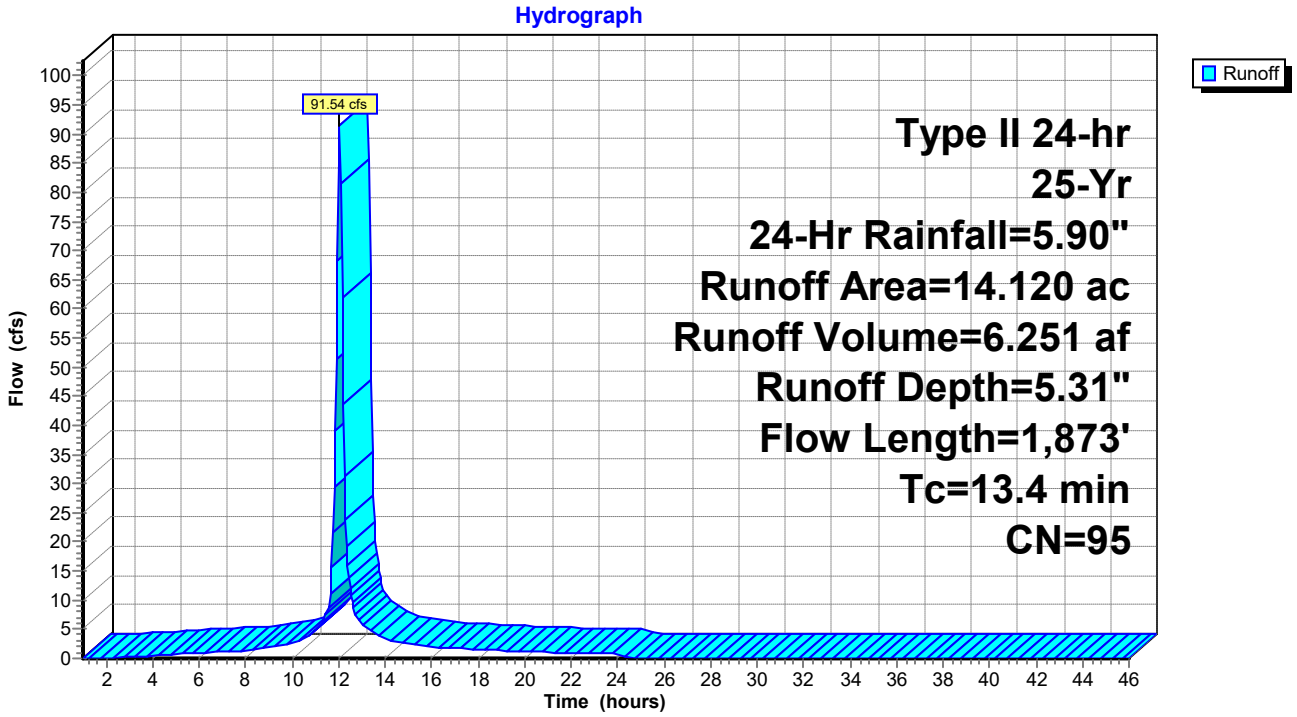
Runoff = 91.54 cfs @ 12.04 hrs, Volume= 6.251 af, Depth= 5.31"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Yr, 24-Hr Rainfall=5.90"

Area (ac)	CN	Description
0.091	91	Gravel roads, HSG D
11.179	94	Fallow, bare soil, HSG D
2.850	98	Paved roads w/curbs & sewers, HSG D
14.120	95	Weighted Average
11.270		79.82% Pervious Area
2.850		20.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	470	0.8000	18.41	92.05	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
2.9	254	0.0050	1.44	7.38	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 & 3.0 '/' Top.W=12.50' n= 0.040 Riprap, 12-inch
0.6	144	0.0460	4.26	23.41	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 '/' Top.W=14.00' n= 0.040 Riprap, 12-inch
1.2	302	0.0450	4.28	22.49	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 5.0 '/' Top.W=13.00' n= 0.040 Riprap, 12-inch
4.8	418	0.0050	1.46	7.28	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040 Riprap, 12-inch
3.3	220	0.0030	1.11	5.81	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 & 4.0 '/' Top.W=13.00' n= 0.040 Riprap, 12-inch
0.2	65	0.0050	5.52	17.33	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Corrugated PP, smooth interior
13.4	1,873	Total			

Subcatchment B: Southeast Runoff



Summary for Pond 4P: Pond

Inflow Area = 25.349 ac, 36.14% Impervious, Inflow Depth > 5.38" for 25-Yr, 24-Hr event
Inflow = 166.37 cfs @ 12.03 hrs, Volume= 11.368 af
Outflow = 1.94 cfs @ 20.33 hrs, Volume= 0.993 af, Atten= 99%, Lag= 498.2 min
Primary = 1.94 cfs @ 20.33 hrs, Volume= 0.993 af

Routing by Dyn-Stor-Ind method, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Peak Elev= 1,184.14' @ 20.33 hrs Surf.Area= 57,524 sf Storage= 459,913 cf

Plug-Flow detention time= 939.8 min calculated for 0.993 af (9% of inflow)
Center-of-Mass det. time= 573.4 min (1,335.7 - 762.3)

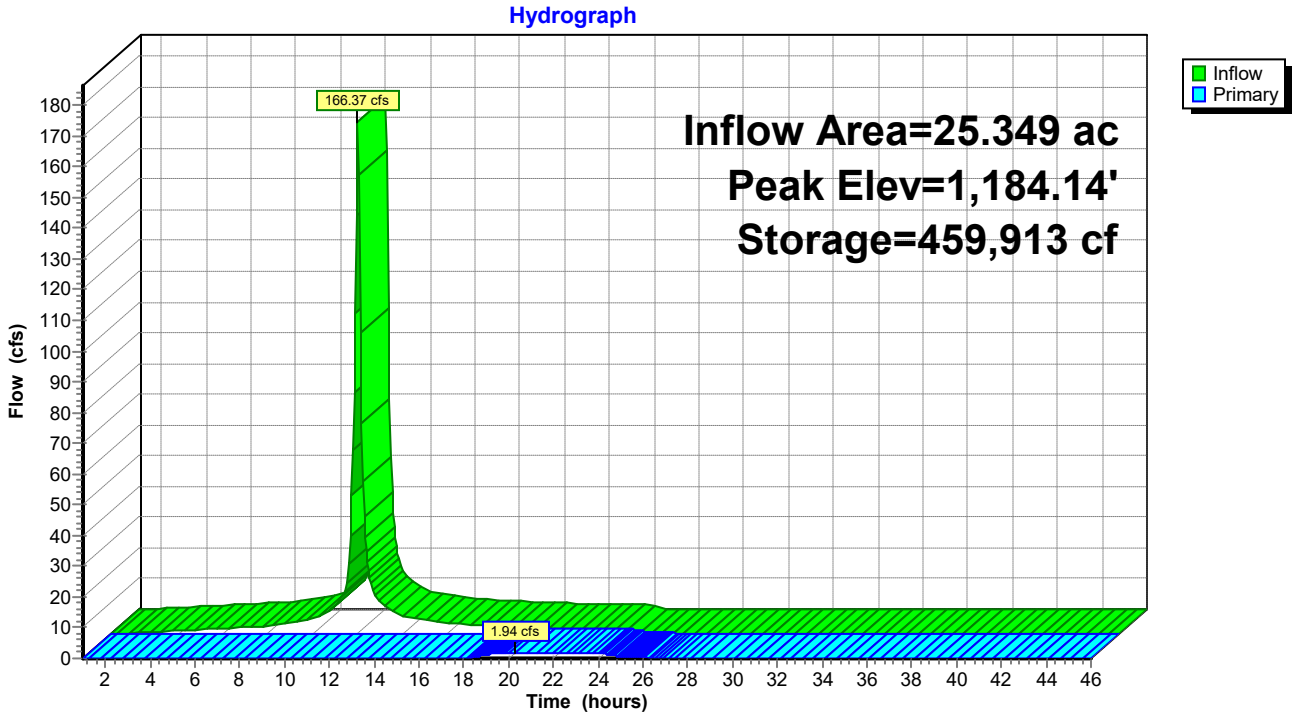
Volume	Invert	Avail.Storage	Storage Description
#1	1,173.00'	704,202 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,173.00	26,500	0	0
1,174.00	28,884	27,692	27,692
1,176.00	34,070	62,954	90,646
1,178.00	39,483	73,553	164,199
1,180.00	44,550	84,033	248,232
1,182.00	50,986	95,536	343,768
1,184.00	57,078	108,064	451,832
1,186.00	63,396	120,474	572,306
1,188.00	68,500	131,896	704,202

Device	Routing	Invert	Outlet Devices
#1	Primary	1,184.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 1.00 Width (feet) 10.00 31.00

Primary OutFlow Max=1.94 cfs @ 20.33 hrs HW=1,184.14' TW=0.00' (Dynamic Tailwater)
1=Custom Weir/Orifice (Weir Controls 1.94 cfs @ 1.20 fps)

Pond 4P: Pond

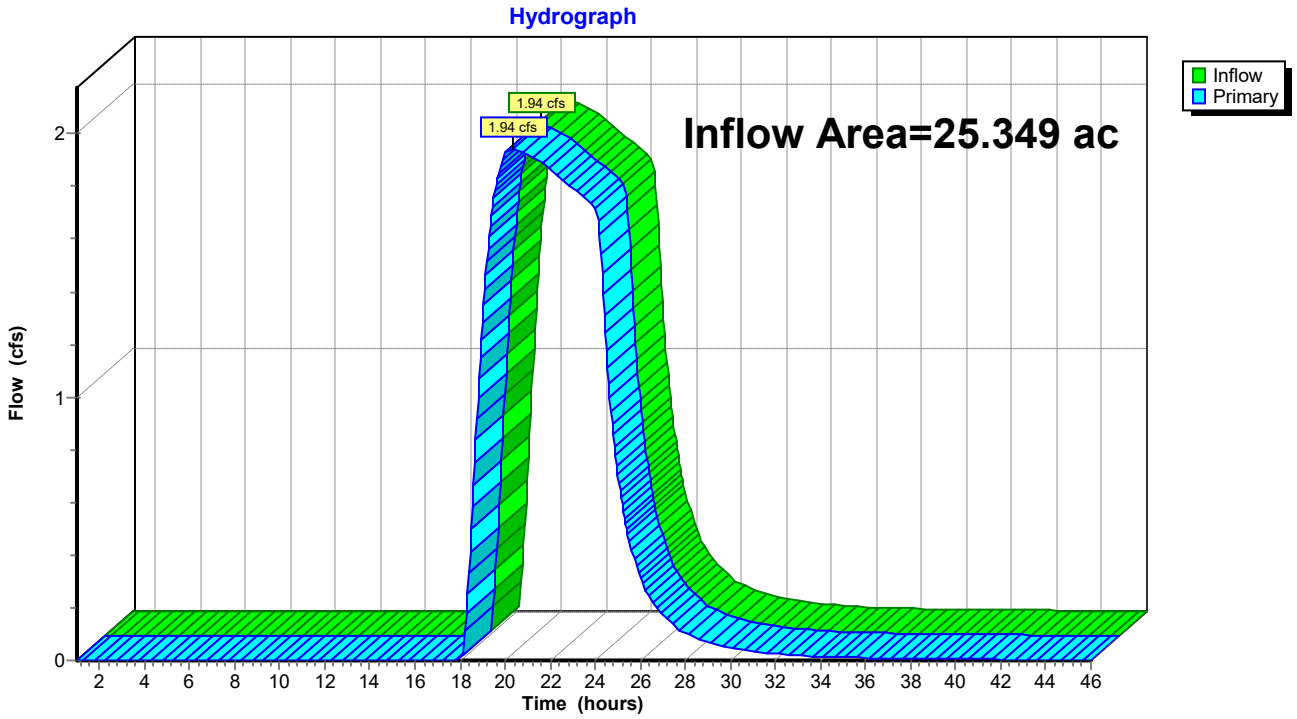

Hydrograph
Inflow
Primary
166.37 cfs
1.94 cfs
Inflow Area=25.349 ac
Peak Elev=1,184.14'
Storage=459,913 cf
Flow (cfs)
Time (hours)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46

Summary for Link 5L: Outlet Pond Structure

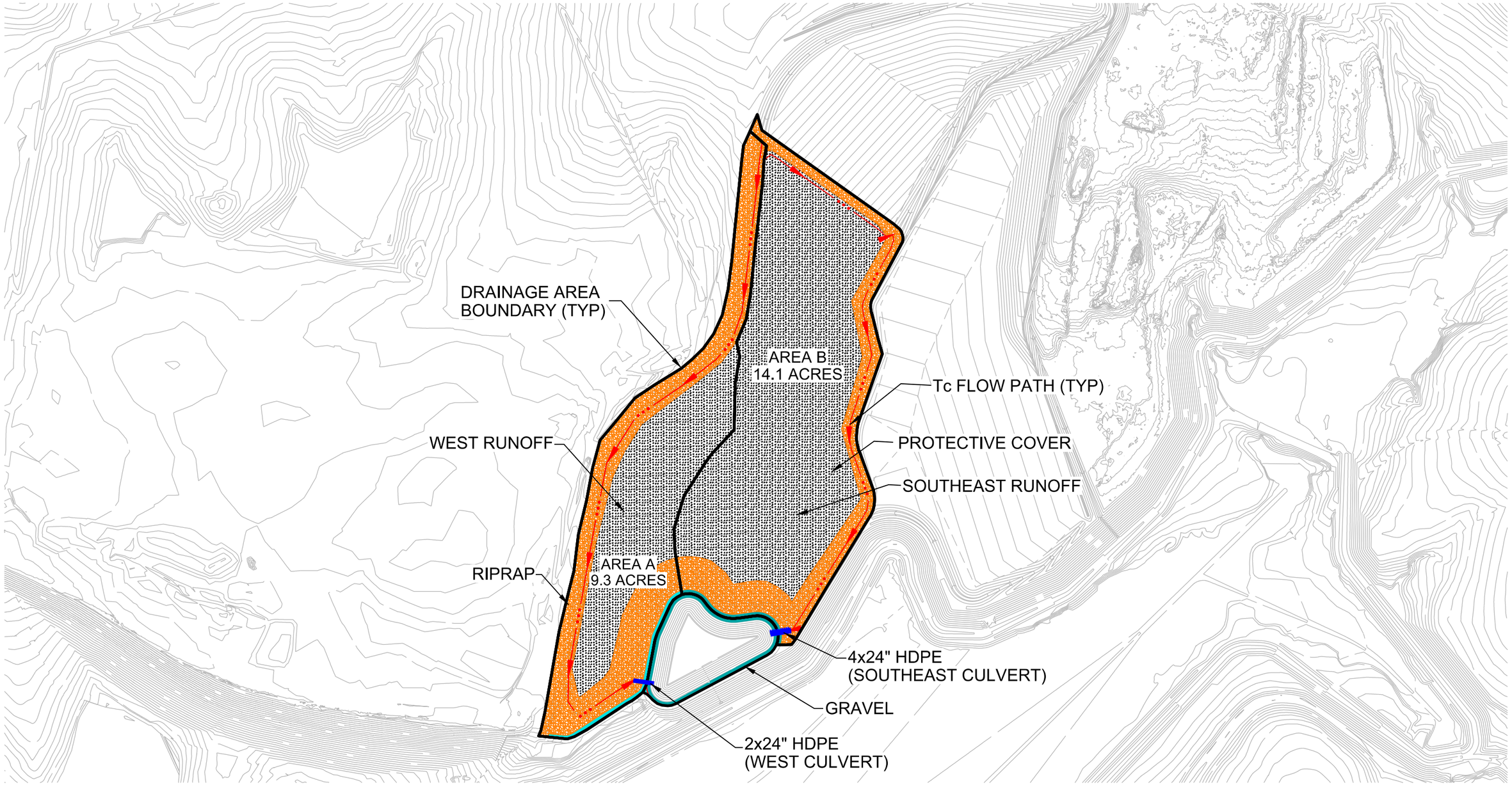
Inflow Area = 25.349 ac, 36.14% Impervious, Inflow Depth > 0.47" for 25-Yr, 24-Hr event
Inflow = 1.94 cfs @ 20.33 hrs, Volume= 0.993 af
Primary = 1.94 cfs @ 20.33 hrs, Volume= 0.993 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs

Link 5L: Outlet Pond Structure



ATTACHMENT 3 – CULVERT AND DITCH CALCULATIONS



N

0 300' 600'

SCALE IN FEET

PROTECTIVE COVER

GRAVEL

RIPRAP

BURNS McDONNELL

date 09/20/2021

designed C.DOMINGUEZ

EVERGY

JEFFREY ENERGY CENTER
RUN-ON RUN-OFF CONTROL SYSTEM
CULVERT DRAINAGE AREAS
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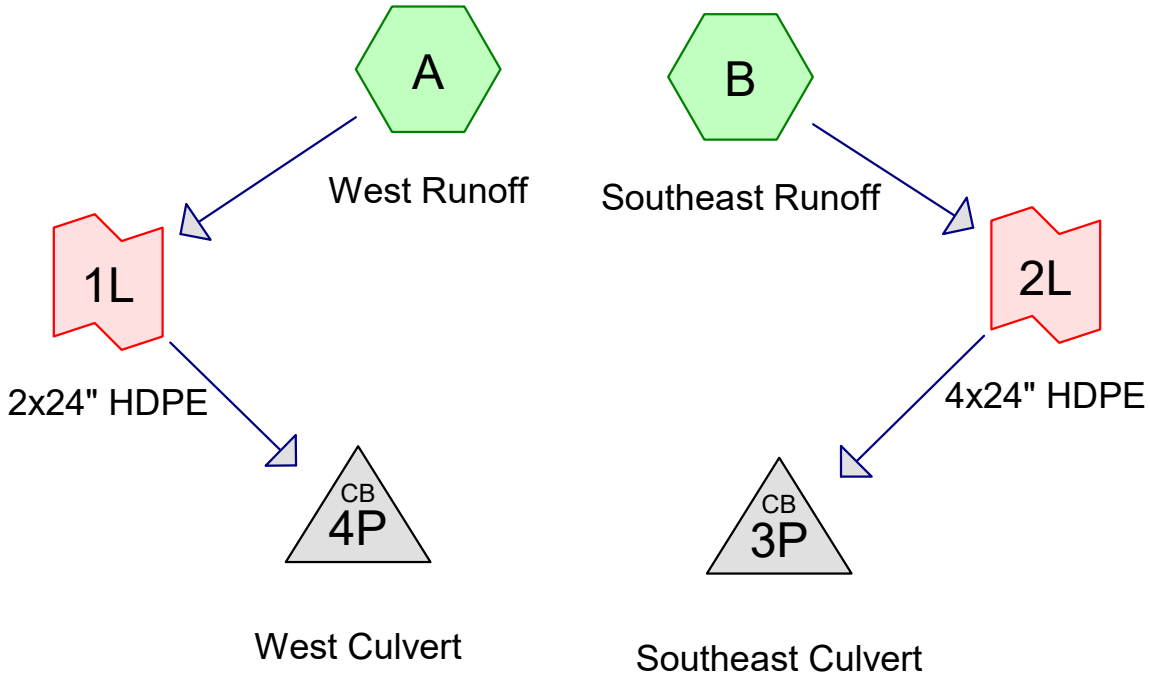
SK - 002

9/24/2021 \\bmcd\dfs\Clients\ENR\WestarEnr\108337_JECFlyAshLF\Design\Civil\Dsgn\Landfill\RORO Control System\Sketches\SK-002.dgn



Subcat Reach Pond Link

Routing Diagram for Jeffrey Fly Ash Landfill HydroCAD Design- Culvert
Prepared by Burns and McDonnell, Printed 9/6/2021

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
15.648	94	Fallow, bare soil, HSG D (A, B)
0.241	91	Gravel roads, HSG D (A, B)
7.520	98	Paved roads w/curbs & sewers, HSG D (A, B)
23.409	**95**	**TOTAL AREA**

Time span=1.00-46.00 hrs, dt=0.05 hrs, 901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment A: West Runoff Runoff Area=9.289 ac 50.27% Impervious Runoff Depth=5.43"
Flow Length=2,214' Tc=11.3 min CN=96 Runoff=64.29 cfs 4.202 af

Subcatchment B: Southeast Runoff Runoff Area=14.120 ac 20.18% Impervious Runoff Depth=5.31"
Flow Length=1,873' Tc=19.1 min CN=95 Runoff=77.94 cfs 6.251 af

Pond 3P: Southeast Culvert Peak Elev=1,228.65' Inflow=77.94 cfs 6.251 af
24.0" Round Culvert n=0.012 L=65.0' S=0.0051 '/' Outflow=77.94 cfs 6.251 af

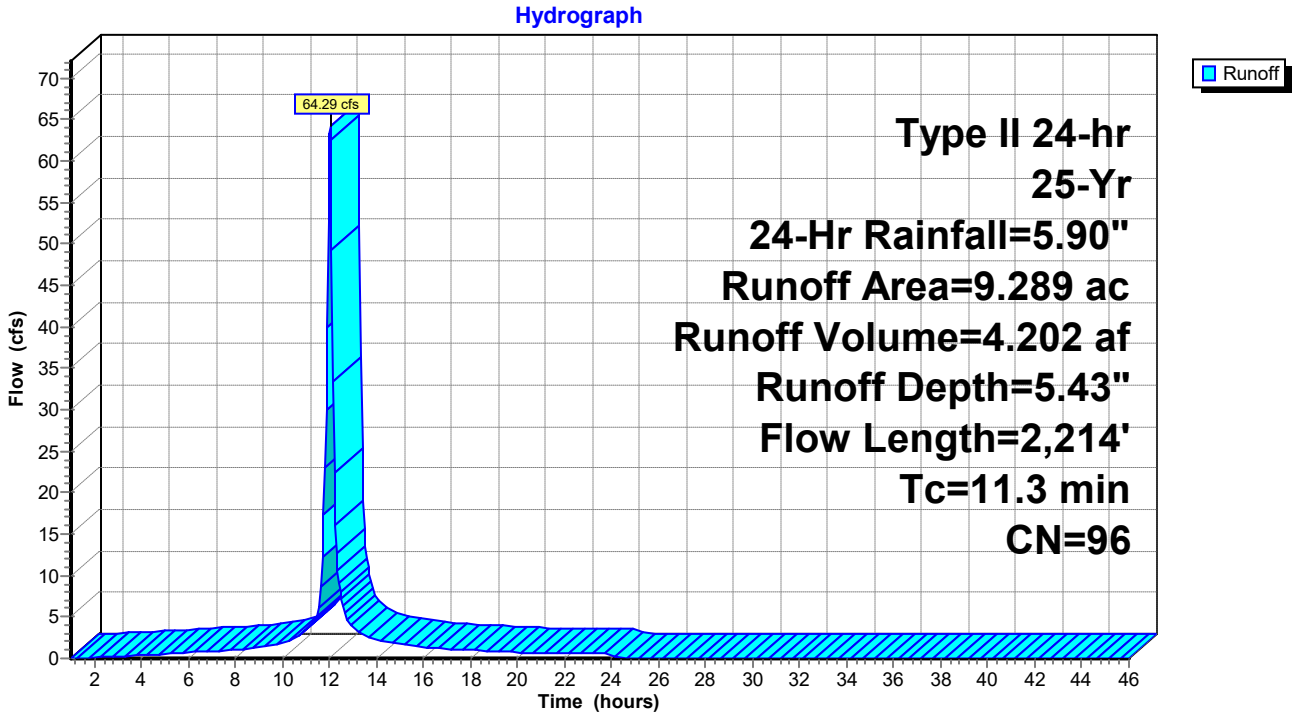
Pond 4P: West Culvert Peak Elev=1,215.09' Inflow=64.29 cfs 4.202 af
24.0" Round Culvert n=0.012 L=64.0' S=0.0050 '/' Outflow=64.29 cfs 4.202 af

Link 1L: 2x24" HDPE Inflow=64.29 cfs 4.202 af
Primary=64.29 cfs 4.202 af

Link 2L: 4x24" HDPE Inflow=77.94 cfs 6.251 af
Primary=77.94 cfs 6.251 af

Total Runoff Area = 23.409 ac Runoff Volume = 10.452 af Average Runoff Depth = 5.36"
67.88% Pervious = 15.889 ac 32.12% Impervious = 7.520 ac

Subcatchment A: West Runoff



Summary for Subcatchment B: Southeast Runoff

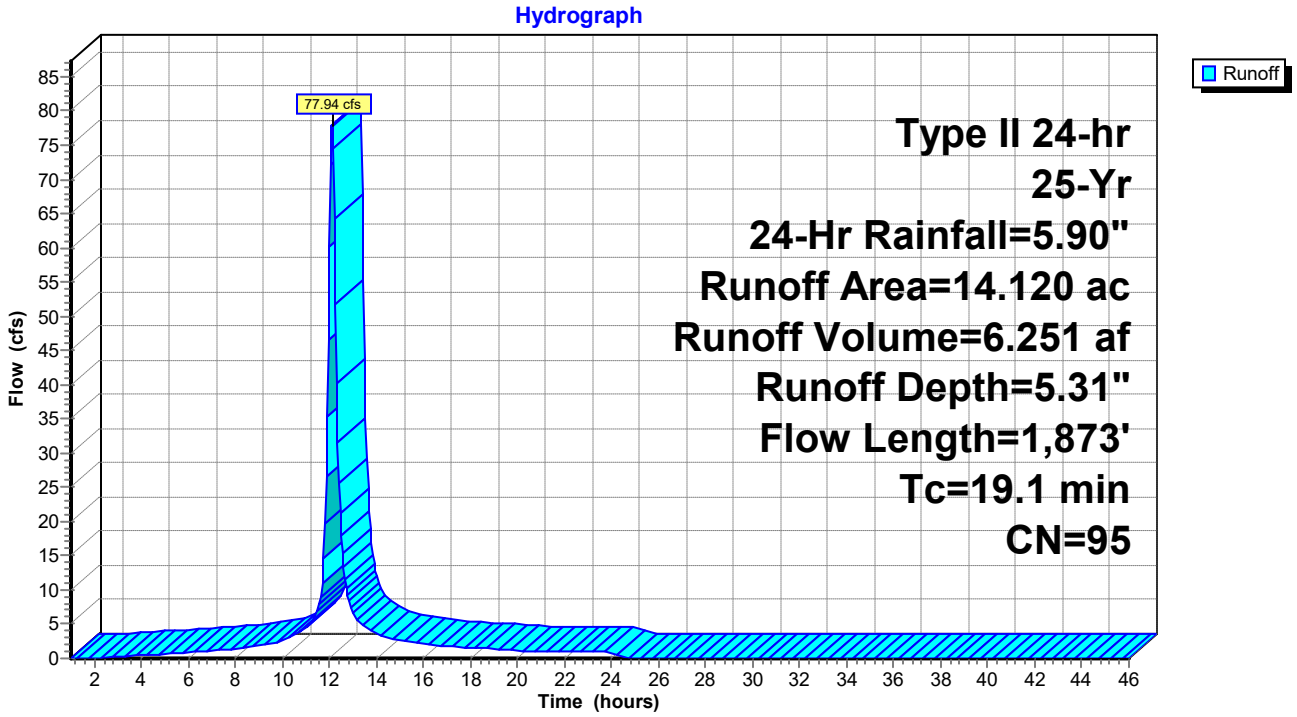
Runoff = 77.94 cfs @ 12.11 hrs, Volume= 6.251 af, Depth= 5.31"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Yr, 24-Hr Rainfall=5.90"

Area (ac)	CN	Description
0.091	91	Gravel roads, HSG D
11.179	94	Fallow, bare soil, HSG D
2.850	98	Paved roads w/curbs & sewers, HSG D
14.120	95	Weighted Average
11.270		79.82% Pervious Area
2.850		20.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	254	0.0050	1.44	7.38	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 & 3.0 '/' Top.W=12.50' n= 0.040 Riprap, 12-inch
0.6	144	0.0460	4.26	23.41	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 '/' Top.W=14.00' n= 0.040 Riprap, 12-inch
1.2	302	0.0450	4.28	22.49	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 5.0 '/' Top.W=13.00' n= 0.040 Riprap, 12-inch
4.8	418	0.0050	1.46	7.28	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040 Riprap, 12-inch
3.3	220	0.0030	1.11	5.81	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 & 4.0 '/' Top.W=13.00' n= 0.040 Riprap, 12-inch
0.2	65	0.0050	5.52	17.33	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Corrugated PP, smooth interior
6.1	470	0.8000	1.29	1.29	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=0.50' Z= 4.0 '/' Top.W=4.00' n= 0.400
19.1	1,873	Total			

Subcatchment B: Southeast Runoff



Summary for Pond 3P: Southeast Culvert

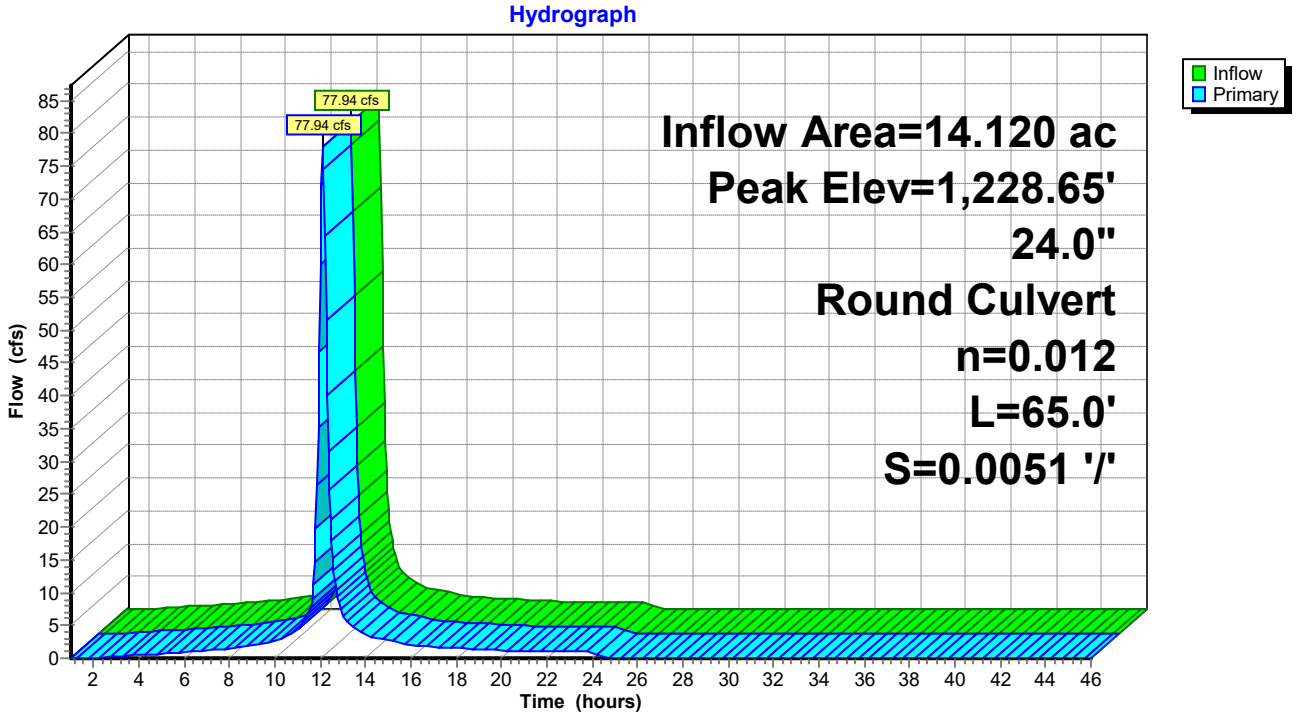
Inflow Area = 14.120 ac, 20.18% Impervious, Inflow Depth = 5.31" for 25-Yr, 24-Hr event
Inflow = 77.94 cfs @ 12.11 hrs, Volume= 6.251 af
Outflow = 77.94 cfs @ 12.11 hrs, Volume= 6.251 af, Atten= 0%, Lag= 0.0 min
Primary = 77.94 cfs @ 12.11 hrs, Volume= 6.251 af

Routing by Dyn-Stor-Ind method, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Peak Elev= 1,228.65' @ 12.11 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	1,185.06'	**24.0" Round Culvert** L= 65.0' Ke= 0.900 Inlet / Outlet Invert= 1,185.06' / 1,184.73' S= 0.0051 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=77.46 cfs @ 12.11 hrs HW=1,228.14' (Free Discharge)
1=Culvert (Inlet Controls 77.46 cfs @ 24.66 fps)

Pond 3P: Southeast Culvert



Summary for Pond 4P: West Culvert

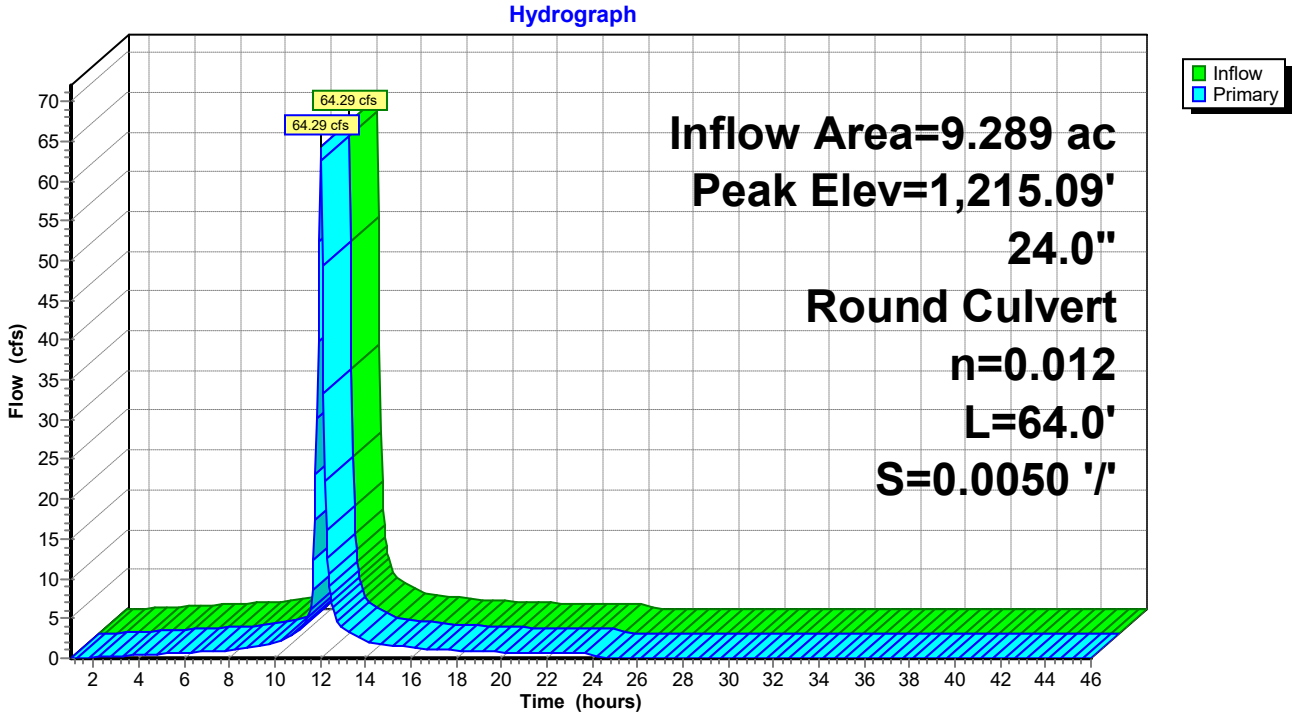
Inflow Area = 9.289 ac, 50.27% Impervious, Inflow Depth = 5.43" for 25-Yr, 24-Hr event
Inflow = 64.29 cfs @ 12.02 hrs, Volume= 4.202 af
Outflow = 64.29 cfs @ 12.02 hrs, Volume= 4.202 af, Atten= 0%, Lag= 0.0 min
Primary = 64.29 cfs @ 12.02 hrs, Volume= 4.202 af

Routing by Dyn-Stor-Ind method, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Peak Elev= 1,215.09' @ 12.02 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	1,185.21'	**24.0" Round Culvert** L= 64.0' Ke= 0.900 Inlet / Outlet Invert= 1,185.21' / 1,184.89' S= 0.0050 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=62.89 cfs @ 12.02 hrs HW=1,213.94' (Free Discharge)
1=Culvert (Inlet Controls 62.89 cfs @ 20.02 fps)

Pond 4P: West Culvert



Worksheet For Single 24" HDPE (Southeast)

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data	
Roughness Coefficient	0.010
Channel Slope	0.005 ft/ft
Normal Depth	24.0 in
Diameter	24.0 in
Discharge	20.79 cfs

Results	
Discharge	20.79 cfs
Normal Depth	24.0 in
Flow Area	3.1 ft²
Wetted Perimeter	6.3 ft
Hydraulic Radius	6.0 in
Top Width	0.00 ft
Critical Depth	19.6 in
Percent Full	100.0 %
Critical Slope	0.005 ft/ft
Velocity	6.62 ft/s
Velocity Head	0.68 ft
Specific Energy	2.68 ft
Froude Number	(N/A)
Maximum Discharge	22.37 cfs
Discharge Full	20.79 cfs
Slope Full	0.005 ft/ft
Flow Type	Undefined

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	0.0 %
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	24.0 in
Critical Depth	19.6 in
Channel Slope	0.005 ft/ft
Critical Slope	0.005 ft/ft

Worksheet For Single 24" HDPE (West)

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data	
Roughness Coefficient	0.010
Channel Slope	0.015 ft/ft
Normal Depth	24.0 in
Diameter	24.0 in
Discharge	36.02 cfs

Results	
Discharge	36.02 cfs
Normal Depth	24.0 in
Flow Area	3.1 ft²
Wetted Perimeter	6.3 ft
Hydraulic Radius	6.0 in
Top Width	0.00 ft
Critical Depth	23.1 in
Percent Full	100.0 %
Critical Slope	0.013 ft/ft
Velocity	11.46 ft/s
Velocity Head	2.04 ft
Specific Energy	4.04 ft
Froude Number	(N/A)
Maximum Discharge	38.74 cfs
Discharge Full	36.02 cfs
Slope Full	0.015 ft/ft
Flow Type	Undefined

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	100.0 %
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	24.0 in
Critical Depth	23.1 in
Channel Slope	0.015 ft/ft
Critical Slope	0.013 ft/ft

EXTERIOR DITCH (NORTH)

AREA D
22.5 ACRES

AREA C
3.8 ACRES

EXTERIOR DITCH (EAST)

PROTECTIVE COVER

GRASS

DRAINAGE AREA BOUNDARY (TYP)

AREA B
14.1 ACRES

INTERIOR DITCH (WEST)

Tc FLOW PATH (TYP)

AREA A
9.3 ACRES

RIPRAP

SOUTHEAST PERIMETER DITCH

CULVERTS

GRAVEL

N

0 300' 600'

SCALE IN FEET

GRAVEL

GRASS

RIPRAP

PROTECTIVE COVER

BURNS McDONNELL

date 09/20/2021

designed C.DOMINGUEZ

EVERGY

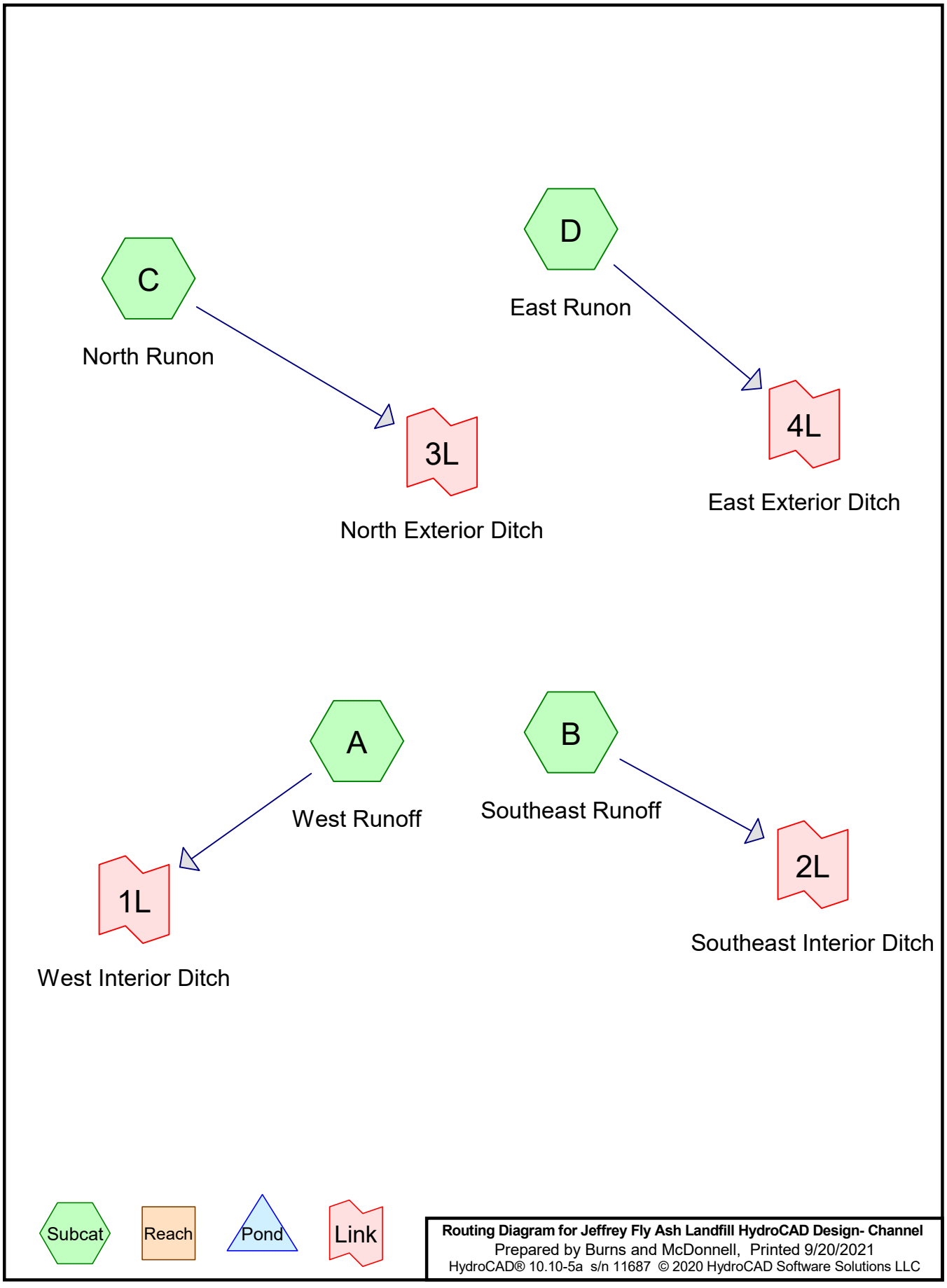
JEFFREY ENERGY CENTER
RUN-ON RUN-OFF CONTROL SYSTEM
CHANNEL DRAINAGE AREAS
FLY ASH LANDFILL AREA I

project 117742

contract -

SK - 003

9/24/2021 \\bmcd\dfs\Clients\ENR\WestarEnr\108337_JECFlyAshLF\Design\Civil\Dsgn\Landfill\RORO Control System\Sketches\SK-003.dgn



Routing Diagram for Jeffrey Fly Ash Landfill HydroCAD Design- Channel
Prepared by Burns and McDonnell, Printed 9/20/2021

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
23.580	80	>75% Grass cover, Good, HSG D (C, D)
15.648	94	Fallow, bare soil, HSG D (A, B)
0.241	91	Gravel roads, HSG D (A, B)
7.520	98	Paved roads w/curbs & sewers, HSG D (A, B)
2.720	93	Paved roads w/open ditches, 50% imp, HSG D (C, D)
49.709	**88**	**TOTAL AREA**

Time span=1.00-46.00 hrs, dt=0.05 hrs, 901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment A: West Runoff Runoff Area=9.289 ac 50.27% Impervious Runoff Depth=5.43"
Flow Length=2,214' Tc=11.3 min CN=96 Runoff=64.29 cfs 4.202 af

Subcatchment B: Southeast Runoff Runoff Area=14.120 ac 20.18% Impervious Runoff Depth=5.31"
Flow Length=1,873' Tc=13.4 min CN=95 Runoff=91.54 cfs 6.251 af

Subcatchment C: North Runon Runoff Area=3.770 ac 23.61% Impervious Runoff Depth=4.31"
Flow Length=1,609' Tc=27.1 min CN=86 Runoff=14.83 cfs 1.355 af

Subcatchment D: East Runon Runoff Area=22.530 ac 2.09% Impervious Runoff Depth=3.79"
Flow Length=6,936' Tc=33.9 min CN=81 Runoff=68.25 cfs 7.121 af

Link 1L: West Interior Ditch Inflow=64.29 cfs 4.202 af
Primary=64.29 cfs 4.202 af

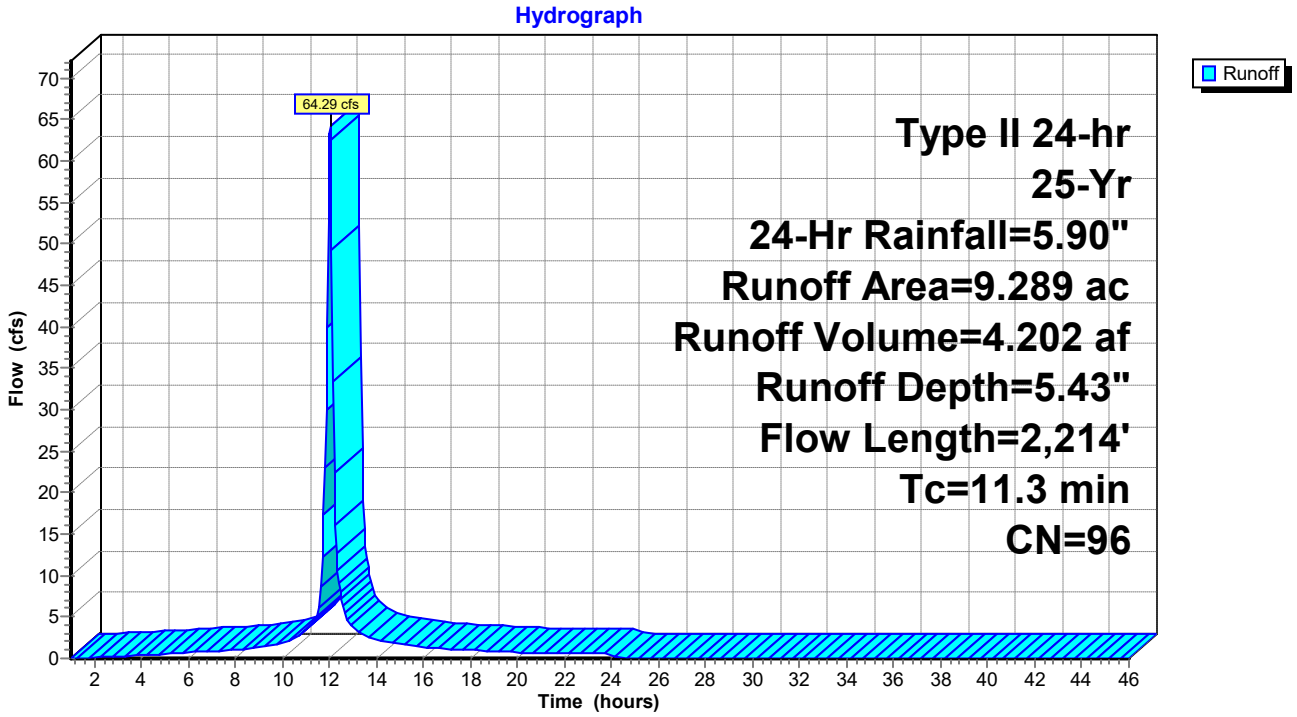
Link 2L: Southeast Interior Ditch Inflow=91.54 cfs 6.251 af
Primary=91.54 cfs 6.251 af

Link 3L: North Exterior Ditch Inflow=14.83 cfs 1.355 af
Primary=14.83 cfs 1.355 af

Link 4L: East Exterior Ditch Inflow=68.25 cfs 7.121 af
Primary=68.25 cfs 7.121 af

Total Runoff Area = 49.709 ac Runoff Volume = 18.929 af Average Runoff Depth = 4.57"
82.14% Pervious = 40.829 ac 17.86% Impervious = 8.880 ac

Subcatchment A: West Runoff



Summary for Subcatchment B: Southeast Runoff

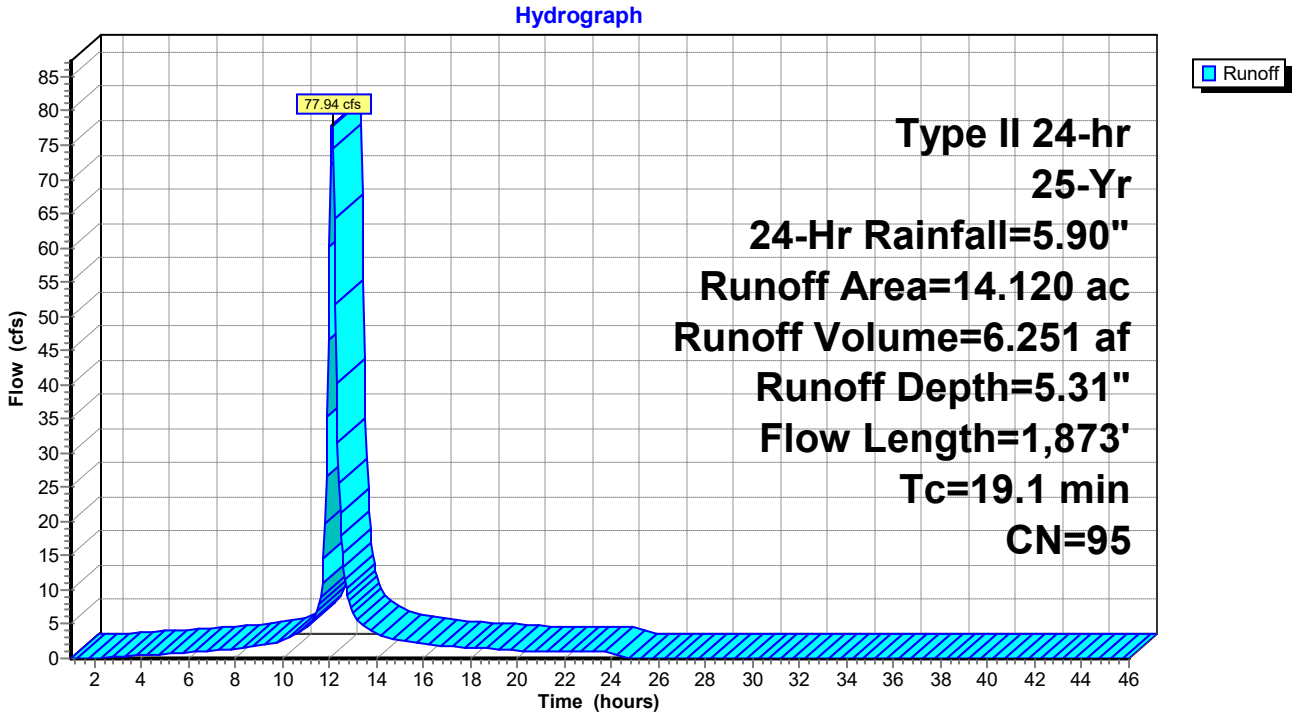
Runoff = 77.94 cfs @ 12.11 hrs, Volume= 6.251 af, Depth= 5.31"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Yr, 24-Hr Rainfall=5.90"

Area (ac)	CN	Description
0.091	91	Gravel roads, HSG D
11.179	94	Fallow, bare soil, HSG D
2.850	98	Paved roads w/curbs & sewers, HSG D
14.120	95	Weighted Average
11.270		79.82% Pervious Area
2.850		20.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	254	0.0050	1.44	7.38	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 & 3.0 '/' Top.W=12.50' n= 0.040 Riprap, 12-inch
0.6	144	0.0460	4.26	23.41	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 '/' Top.W=14.00' n= 0.040 Riprap, 12-inch
1.2	302	0.0450	4.28	22.49	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 5.0 '/' Top.W=13.00' n= 0.040 Riprap, 12-inch
4.8	418	0.0050	1.46	7.28	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040 Riprap, 12-inch
3.3	220	0.0030	1.11	5.81	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 6.0 & 4.0 '/' Top.W=13.00' n= 0.040 Riprap, 12-inch
0.2	65	0.0050	5.52	17.33	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012 Corrugated PP, smooth interior
6.1	470	0.8000	1.29	1.29	**Trap/Vee/Rect Channel Flow,** Bot.W=0.00' D=0.50' Z= 4.0 '/' Top.W=4.00' n= 0.400
19.1	1,873	Total			

Subcatchment B: Southeast Runoff



Summary for Subcatchment C: North Runon

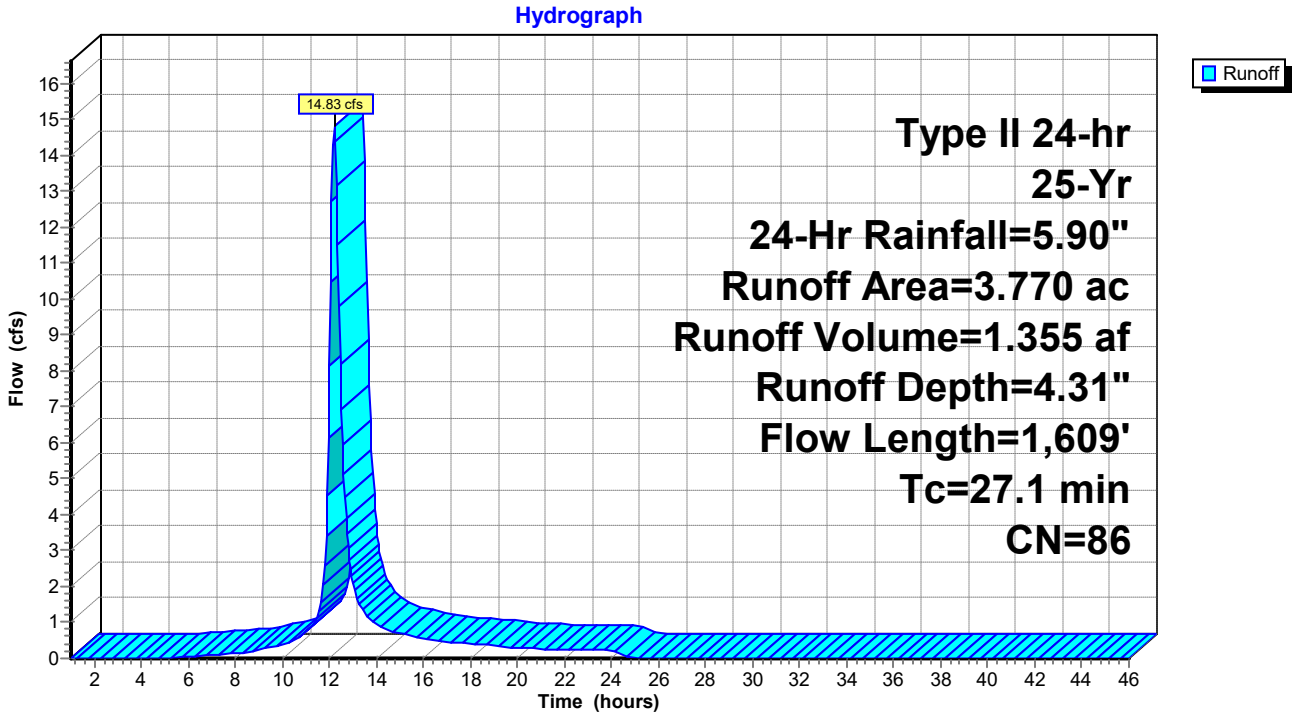
Runoff = 14.83 cfs @ 12.20 hrs, Volume= 1.355 af, Depth= 4.31"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Yr, 24-Hr Rainfall=5.90"

Area (ac)	CN	Description
1.780	93	Paved roads w/open ditches, 50% imp, HSG D
1.990	80	>75% Grass cover, Good, HSG D
3.770	86	Weighted Average
2.880		76.39% Pervious Area
0.890		23.61% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.9	331	0.0150	0.25	1.26	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.400
1.6	374	0.0350	3.85	19.25	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
2.5	536	0.0300	3.57	17.83	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
1.1	368	0.0800	5.82	29.11	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.040
27.1	1,609	Total			

Subcatchment C: North Runon



Summary for Subcatchment D: East Runon

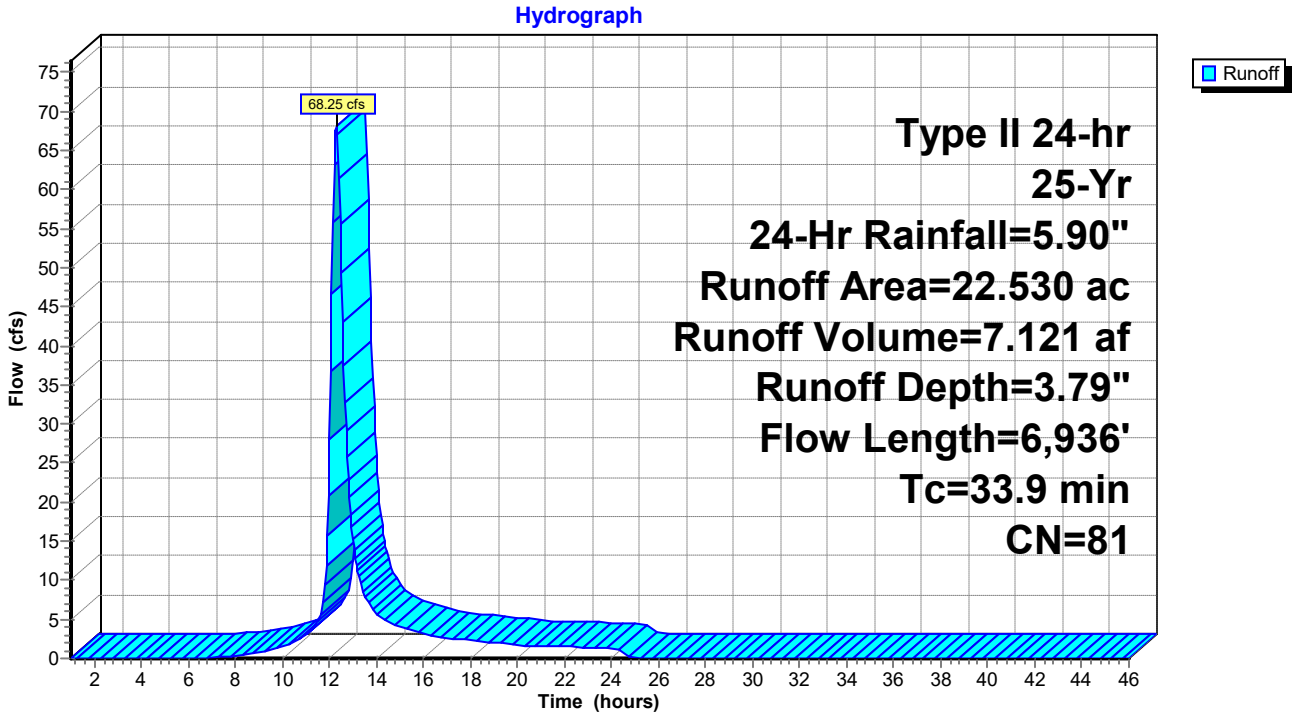
Runoff = 68.25 cfs @ 12.29 hrs, Volume= 7.121 af, Depth= 3.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-46.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Yr, 24-Hr Rainfall=5.90"

Area (ac)	CN	Description
0.940	93	Paved roads w/open ditches, 50% imp, HSG D
21.590	80	>75% Grass cover, Good, HSG D
22.530	81	Weighted Average
22.060		97.91% Pervious Area
0.470		2.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.1	1,047	0.0030	1.72	4.73	**Trap/Vee/Rect Channel Flow,** Bot.W=4.00' D=0.50' Z= 3.0 '/' Top.W=7.00' n= 0.025 Earth, grassed & winding
16.6	4,433	0.0200	4.44	12.21	**Trap/Vee/Rect Channel Flow,** Bot.W=4.00' D=0.50' Z= 3.0 '/' Top.W=7.00' n= 0.025 Earth, grassed & winding
1.1	146	0.0050	2.22	6.11	**Trap/Vee/Rect Channel Flow,** Bot.W=4.00' D=0.50' Z= 3.0 '/' Top.W=7.00' n= 0.025 Earth, grassed & winding
1.1	435	0.0375	6.38	31.89	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.025 Earth, grassed & winding
0.3	167	0.0700	8.71	43.57	**Trap/Vee/Rect Channel Flow,** Bot.W=8.00' D=0.50' Z= 4.0 '/' Top.W=12.00' n= 0.025 Earth, grassed & winding
1.4	232	0.0340	2.77		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.3	476	0.0250	2.37		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
33.9	6,936	Total			

Subcatchment D: East Runon



Exterior Ditch-North

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.078
Channel Slope	0.003 ft/ft
Normal Depth	48.0 in
Left Side Slope	4.000 H:V
Right Side Slope	4.000 H:V
Bottom Width	8.00 ft

Results	
Discharge	176.67 cfs
Flow Area	96.0 ft²
Wetted Perimeter	41.0 ft
Hydraulic Radius	28.1 in
Top Width	40.00 ft
Critical Depth	21.9 in
Critical Slope	0.085 ft/ft
Velocity	1.84 ft/s
Velocity Head	0.05 ft
Specific Energy	4.05 ft
Froude Number	0.209
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	48.0 in
Critical Depth	21.9 in
Channel Slope	0.003 ft/ft
Critical Slope	0.085 ft/ft

Exterior Ditch-East

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.030
Channel Slope	0.020 ft/ft
Normal Depth	48.0 in
Left Side Slope	3.000 H:V
Right Side Slope	3.000 H:V
Bottom Width	4.00 ft

Results	
Discharge	754.74 cfs
Flow Area	64.0 ft²
Wetted Perimeter	29.3 ft
Hydraulic Radius	26.2 in
Top Width	28.00 ft
Critical Depth	55.4 in
Critical Slope	0.010 ft/ft
Velocity	11.79 ft/s
Velocity Head	2.16 ft
Specific Energy	6.16 ft
Froude Number	1.375
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	48.0 in
Critical Depth	55.4 in
Channel Slope	0.020 ft/ft
Critical Slope	0.010 ft/ft

Perimeter Ditch-West

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.078
Channel Slope	0.030 ft/ft
Normal Depth	48.0 in
Left Side Slope	4.000 H:V
Right Side Slope	4.000 H:V
Bottom Width	8.00 ft

Results	
Discharge	558.68 cfs
Flow Area	96.0 ft²
Wetted Perimeter	41.0 ft
Hydraulic Radius	28.1 in
Top Width	40.00 ft
Critical Depth	39.4 in
Critical Slope	0.072 ft/ft
Velocity	5.82 ft/s
Velocity Head	0.53 ft
Specific Energy	4.53 ft
Froude Number	0.662
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	(N/A) ft/s
Upstream Velocity	(N/A) ft/s
Normal Depth	48.0 in
Critical Depth	39.4 in
Channel Slope	0.030 ft/ft
Critical Slope	0.072 ft/ft

Perimeter Ditch-Southeast

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.078
Channel Slope	0.015 ft/ft
Normal Depth	48.0 in
Left Side Slope	4.000 H:V
Right Side Slope	4.000 H:V
Bottom Width	8.00 ft

Results	
Discharge	395.05 cfs
Flow Area	96.0 ft²
Wetted Perimeter	41.0 ft
Hydraulic Radius	28.1 in
Top Width	40.00 ft
Critical Depth	33.2 in
Critical Slope	0.076 ft/ft
Velocity	4.12 ft/s
Velocity Head	0.26 ft
Specific Energy	4.26 ft
Froude Number	0.468
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	(N/A) ft/s
Upstream Velocity	(N/A) ft/s
Normal Depth	48.0 in
Critical Depth	33.2 in
Channel Slope	0.015 ft/ft
Critical Slope	0.076 ft/ft

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