

Periodic Run-On and Run-Off Control System Plan CCR Landfill



Evergy Missouri West, Inc.

**Sibley Generating Station
Project No. 103871**

**Revision 1
10/1/2021**

Periodic Run-On and Run-Off Control System Plan CCR Landfill

prepared for

**Evergy Missouri West, Inc.
Sibley Generating Station
Jackson County, MO**

Project No. 103871

**Revision 1
10/1/2021**

prepared by

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

INDEX AND CERTIFICATION

**Evergy Missouri West, Inc.
Periodic Run-On and
Run-Off Control System Plan
CCR Landfill
Project No. 103871**

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Certification

I hereby certify, as a Professional Engineer in the state of Missouri, 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 Missouri West, Inc. or others without specific verification or adaptation by the Engineer.



Kira E. Wylam
Kira Wylam, P.E., Missouri PE-2011000966

Date: 10/1/2021

Sep 30 2021 3:42 PM

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LIST OF ABBREVIATIONS

<u>Abbreviation</u>	<u>Term/Phrase/Name</u>
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CHDPE	corrugated high-density polyethylene
CMP	corrugated metal pipe
EPA	Environmental Protection Agency
Evergy	Evergy Missouri West, Inc.
MDNR	Missouri Department of Natural Resources
Shaw	Shaw Environmental, Inc.
Sibley	Sibley Generating Station
RCRA	Resource Conservations and Recovery Act
U.S.C.	United States Code

1.0 BACKGROUND

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

Evergy Missouri West, Inc. (Evergy) is subject to the CCR Rule and as such must develop a run-on and run-off control system plan for the CCR Landfill at Sibley Generating Station (Sibley) per 40 Code of Federal Regulations (CFR) §257.81. This report serves as the periodic update to the run-on and run-off control system plan which was originally developed by Kansas City Power & Light (now Evergy) in 2016 with the support of calculations prepared by AECOM and Shaw Environmental, Inc. (Shaw) 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:	Sibley Generating Station
Name of CCR Unit:	CCR Landfill
Name of Operator:	Evergy Missouri West, Inc.
Facility Mailing Address:	33200 East Johnson Rd Sibley, MO 64088
Location:	East of and adjacent to Sibley, Missouri
Facility Description:	The Sibley Generating Station has three recently retired coal-fired units which produced fly ash, economizer ash, and bottom ash (slag). When the units were in operation, CCR was either shipped off-site for beneficial use or transported to the landfill for disposal from the Fly Ash Silo, the Fly Ash Impoundment, or the Slag Settling Impoundment. Related landfill facilities include a groundwater monitoring system, storm water and leachate management systems, and haul/access roads.

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 Sibley CCR Landfill is permitted with the Missouri Department of Natural Resources (MDNR). The landfill’s watershed area is approximately 28 acres, which includes the perimeter ditch and a portion of the perimeter road. The permitted run-on and run-off control system design was prepared by Shaw in March of 2009. The system consists of benches, letdown channels, ditches, and culverts which were designed to control the 25-year, 24-hour storm event in accordance with the MDNR rules for Utility Waste Landfills. The MDNR Solid Waste Management Program reviewed and approved the Shaw design in 2009.

2.1 Run-On Controls

The landfill is located in an elevated area with drainage to the north towards the Missouri River and drainage to the west and east towards existing unnamed creeks. A perimeter berm prevents run-on to the landfill on the south side and also serves as the access road for the landfill. There are ditches on the south exterior side of the perimeter berm which direct stormwater to either the west or east creeks. The exterior ditches typically have a 6-foot flat bottom with a 5% bottom slope and 3H:1V side slopes for the west ditch (Area 8) and 2H:1V side slopes for the east ditch (Area 9) (see SK-001 in Appendix A for area delineations). Drainage to the east creek must also pass through an 18-inch diameter corrugated metal pipe (CMP) under an existing access road to the south of the landfill. The ditch downstream of the culvert (in Area 10) has approximately an 8-foot flat bottom with a 10% bottom slope and 3H:1V side slopes.

A swale west of the exterior berm (Area 7), toward the north part of the landfill, has a bottom slope of approximately 4%. This swale drains to two, 36-inch diameter corrugated high-density polyethylene (CHDPE) culverts that run under the leachate pond access road and discharge to a ditch that follows along the landfill haul road and ties into an NPDES Outfall.

Table 2-1 presents the excess capacities of the exterior ditches and culvert for the 25-year, 24-hour design storm event. For the purposes of this calculation, the ditches were evaluated at four points which are intended to represent “typical” geometry and peak flow conditions.

Table 2-1: Run-On Control Performance

Storm Water System Component		Calculated Excess Capacity	Units
Area 7	Exterior Ditch	79.1	cubic feet per second
	2x36” CHDPE	275.9	cubic feet per second

Storm Water System Component		Calculated Excess Capacity	Units
Area 8	Exterior Ditch	76.8	cubic feet per second
Area 9	Exterior Ditch	261.9	cubic feet per second
Area 10	Exterior Ditch	4.4	cubic feet per second
	18" CMP	>300	cubic feet per second

Supporting calculations are presented in Appendix A. As indicated in Table 2-1 and Appendix A, the landfill has 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

Active portions of the landfill that have not received cover are contained by a temporary berm so contact stormwater will enter the leachate collection system. Final cover is placed on the established outside slopes of the landfill. The top portions of the landfill that have received interim or final cover are graded in a manner to gravity drain to letdown channels. As the landfill is filled, benches and letdown channels aid in directing non-contact stormwater runoff to the perimeter ditch within the landfill perimeter berm.

From the perimeter ditch, non-contact stormwater may be discharged to the surrounding area at six different points along the landfill perimeter. At the south side of the landfill the letdown channel acts as a break point for the perimeter ditch drainage areas. Drainage west of the letdown channel (Area 3) drains to the west toward a pair of 36-inch diameter CMP culverts, which discharge toward the west creek. From the south letdown channel (Area 4), stormwater drains from the bottom of the letdown into a 30-inch diameter CHDPE culvert, which drains to Area 9. The area east of the south letdown channel (Area 5) drains to the east to a pair of 24-inch diameter CHDPE culverts. The northeast quadrant of the landfill (Area 6) drains to the northeast to a concrete, low water crossing at the landfill perimeter berm. The crossing has a bottom width of approximately 10 feet with 10H:1V side slopes. Internal to Area 6 is a 6-foot flat bottom ditch which runs along the inside of the landfill access road and ties into a pair of 24-inch diameter CHDPE pipes which overflow to the letdown channel and the downstream low water crossing. The eastern portion of the north landfill area (Area 1) drains to two 30-inch diameter CHDPE culverts. The western portion of the north landfill (Area 2) drains to a pair of 30-inch diameter CHDPE culverts which discharge to Area 7.

The perimeter ditch geometry varies between the six different drainage areas. The ditch is grass surfaced apart from the portions in the northeast area which received ClosureTurf® topped with a concrete layer referred to as HydroBinder®.

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 letdown channels. The supporting calculations are presented in Appendix A.

Table 2-2: Run-Off Control Performance

Storm Water System Component		Calculated Excess Capacity	Units
Letdown Channel (Area 2A)		>300	cubic feet per second
Area 1	Perimeter Ditch (grassed) (Area 1A)	>300	cubic feet per second
	Perimeter Ditch (paved)	>300	cubic feet per second
	2x30" CHDPE	114.1	cubic feet per second
Area 2	Perimeter Ditch (paved)	273.8	cubic feet per second
	2x30" CHDPE	119.1	cubic feet per second
Area 3	Perimeter Ditch (grassed)	126.7	cubic feet per second
	2x36" CMP	20.3	cubic feet per second
Area 4	30" CHDPE	56.3	cubic feet per second
Area 5	Perimeter Ditch (grassed)	1.7	cubic feet per second
	2x24" CHDPE	125.7	cubic feet per second
Area 6	Access Road Ditch (Area 6A)	95.2	cubic feet per second
	2x24" CHDPE	52.6	cubic feet per second
	Perimeter Ditch	57.4	cubic feet per second

Storm Water System Component		Calculated Excess Capacity	Units
Area 6 (cont.)	Concrete Low Water Crossing	>300	cubic feet per second

As indicated in Table 2-2 and Appendix A, the landfill has 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

Contact stormwater run-off from the active portion of the Sibley CCR Landfill is retained within the active area and directed to the leachate collection system. The leachate collection system drains to the leachate pond which discharges to an 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. 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. Missouri Department of Natural Resources, Code of State Regulations, Rules of Department of Natural Resources, Division 80, Solid Waste Management, Chapter 11, Utility Waste Landfill, 1997.
3. Burns & McDonnell Engineering Company, Inc., Topographic Survey, November 2018.
4. McLaughlin-Mueller, Inc., Planimetric Feature Survey, December 2018.
5. Wilson & Company, Inc., Aerial Survey, May 2015.

APPENDIX A – SUPPORTING CALCULATIONS



June 30, 2021

Evergy Missouri West, Inc.

Supporting Calculations for the Sibley CCR Landfill Periodic Run-on and Run-off Control System Plan

Burns & McDonnell (BMcD) has been retained by Evergy Missouri West, Inc. (Evergy) to provide engineering support for the periodic update to the Run-on and Run-off Control System Plan for the Sibley 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 letdown channels, perimeter ditches, culverts, and low water crossing which convey flow from the ditches to the surrounding area. Additionally, calculations were prepared to evaluate the capacity of the exterior ditches which are 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 majority of the site is rated as soil group B or C; group C was used for areas within the landfill perimeter berm in consideration of the landfill cover material and group B was used for the exterior areas. Surface cover types in the drainage areas include grass, gravel, concrete, ClosureTurf™, dirt, woods, and riprap. 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 storm depth was obtained from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server. The design storm depth is 6.77 inches.

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 groupings by discharge location. A list of the calculations attached to this memorandum is as follows:

- Attachment 1 – Calculation Summary Sheet and Reference Documents
- Attachment 2 – SK-001 – Landfill Drainage Areas
- Attachment 2 – HydroCAD Report for 25-year, 24-hour storm event
- Attachment 3 – FlowMaster Worksheets:
 - Worksheet for Letdown Channel
 - Worksheet for A1 Perimeter Ditch – Paved

- Worksheet for A1 Perimeter Ditch – Grassed
- Worksheet for A1 30” CHDPE - 3%
- Worksheet for A2 Perimeter Ditch – Paved
- Worksheet for A2 30” CHDPE - 3%
- Worksheet for A3 Perimeter Ditch – Grassed
- Worksheet for A3 36” CMP – 0.63%
- Worksheet for A4 30” CHDPE – 1.8%
- Worksheet for A5 Perimeter Ditch – Grassed
- Worksheet for A5 24” CHDPE – 10%
- Worksheet for A6 Access Road Ditch – Grassed
- Worksheet for A6 24” CHDPE – 2.1%
- Worksheet for A6 Low Water Crossing
- Worksheet for A6 Perimeter Ditch – Grassed
- Worksheet for A7 Exterior Ditch – Grassed
- Worksheet for A7 36” CHDPE – 4.7%
- Worksheet for A8 Exterior Ditch – Grassed
- Worksheet for A9 Exterior Ditch – Grassed
- Worksheet for A9 18” CMP – 4.5%
- Worksheet for A10 Exterior Ditch - Grassed

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 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
Area 7	Exterior Ditch	88.8	9.8	79.1	cfs
	2x 36” CHDPE	313.6	37.7	275.9	cfs
Area 8	Exterior Ditch	80.8	4.0	76.8	cfs
Area 9	Exterior Ditch	269.0	7.1	261.9	cfs
	18” CMP	11.5	7.1	4.4	cfs

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Area 10	Exterior Ditch	505.6	9.0	496.5	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
Letdown Channel (use Area 2A as basis)		501.0	10.7	490.3	cfs
Area 1	Perimeter Ditch (grassed) (Area 1A)	363.2	13.3	349.8	cfs
	Perimeter Ditch (paved)	496.4	39.8	456.6	cfs
	2x30" CHDPE	153.9	39.8	114.1	cfs
Area 2	Perimeter Ditch (paved)	308.6	34.8	273.8	cfs
	2x30" CHDPE	153.9	34.8	119.1	cfs
Area 3	Perimeter Ditch (grassed)	161.5	34.8	126.7	cfs
	2x36" CMP	55.1	34.8	20.3	cfs
Area 4	30" CHDPE	59.3	3.0	56.3	cfs
Area 5	Perimeter Ditch (grassed) (Area 5A)	10.4	8.7	1.7	cfs
	2x24" CHDPE	155.0	29.3	125.7	cfs
Area 6	Access Road Ditch (Area 6A)	114.3	19.2	95.2	cfs
	2x24" CHDPE	71.7	19.2	52.6	cfs
	Perimeter Ditch (grassed) (Area 6B)	60.6	3.2	57.4	cfs
	Concrete Low Water Crossing	550.5	22.6	527.9	cfs

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

**ATTACHMENT 1 – CALCULATION SUMMARY SHEET AND REFERENCE
DOCUMENTS**



WORKSHEET TITLE: Evergy - Sibley Run-On and Run-Off Controls
CREATED: 6/18/2021
PERFORMED BY: A. Myers
OBJECTIVE: Check Sibley CCR Landfill run-on and run-off controls for 25-year, 24-hour storm

CALCULATION NO.: C - 001
REVISION: A
REVIEWED BY:

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 Jackson County, MO.
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 Sibley, Missouri, 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 Groups B & C, assume type C for landfill interior areas and B for exterior [Reference 2](#)
- 2 Depth for 25-year, 24-hour storm is 6.77" [Reference 3](#)

CALCULATIONS:

Refer to the following documents:
 -SK-001 for drainage area delineations
 -see HydroCAD report for Peak Flow calculations
 -see FlowMaster reports for Capacity calculations

RUN-OFF CONTROLS

Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Letdown Channel (use Area 2A as basis)		501.0	10.7	490.3	cfs
Area 1	Perimeter Ditch (grassed) (Area 1A)	363.2	13.3	349.8	cfs
	Perimeter Ditch (paved) 2x30" CHDPE	496.4	39.8	456.6	cfs
Area 2	Perimeter Ditch (paved) 2x30" CHDPE	308.6	34.8	273.8	cfs
	Perimeter Ditch (grassed)	161.5	34.8	126.7	cfs
Area 3	2x36" CMP	55.1	34.8	20.3	cfs
	Area 4	30" CHDPE	59.3	3.0	56.3
Area 5	Perimeter Ditch (grassed) (Area 5A)	10.4	8.7	1.7	cfs
	2x24" CHDPE	155.0	29.3	125.7	cfs
Area 6	Access Road Ditch (Area 6A)	114.3	19.2	95.2	cfs
	2x24" CHDPE	71.7	19.2	52.6	cfs
	Perimeter Ditch (grassed) (Area 6B)	60.6	3.2	57.4	cfs
	Concrete Low Water Crossing	550.5	22.6	527.9	cfs



WORKSHEET TITLE: Everygy - Sibley Run-On and Run-Off Controls
CREATED: 6/18/2021
PERFORMED BY: A. Myers
OBJECTIVE: Check Sibley CCR Landfill run-on and run-off controls for 25-year, 24-hour storm

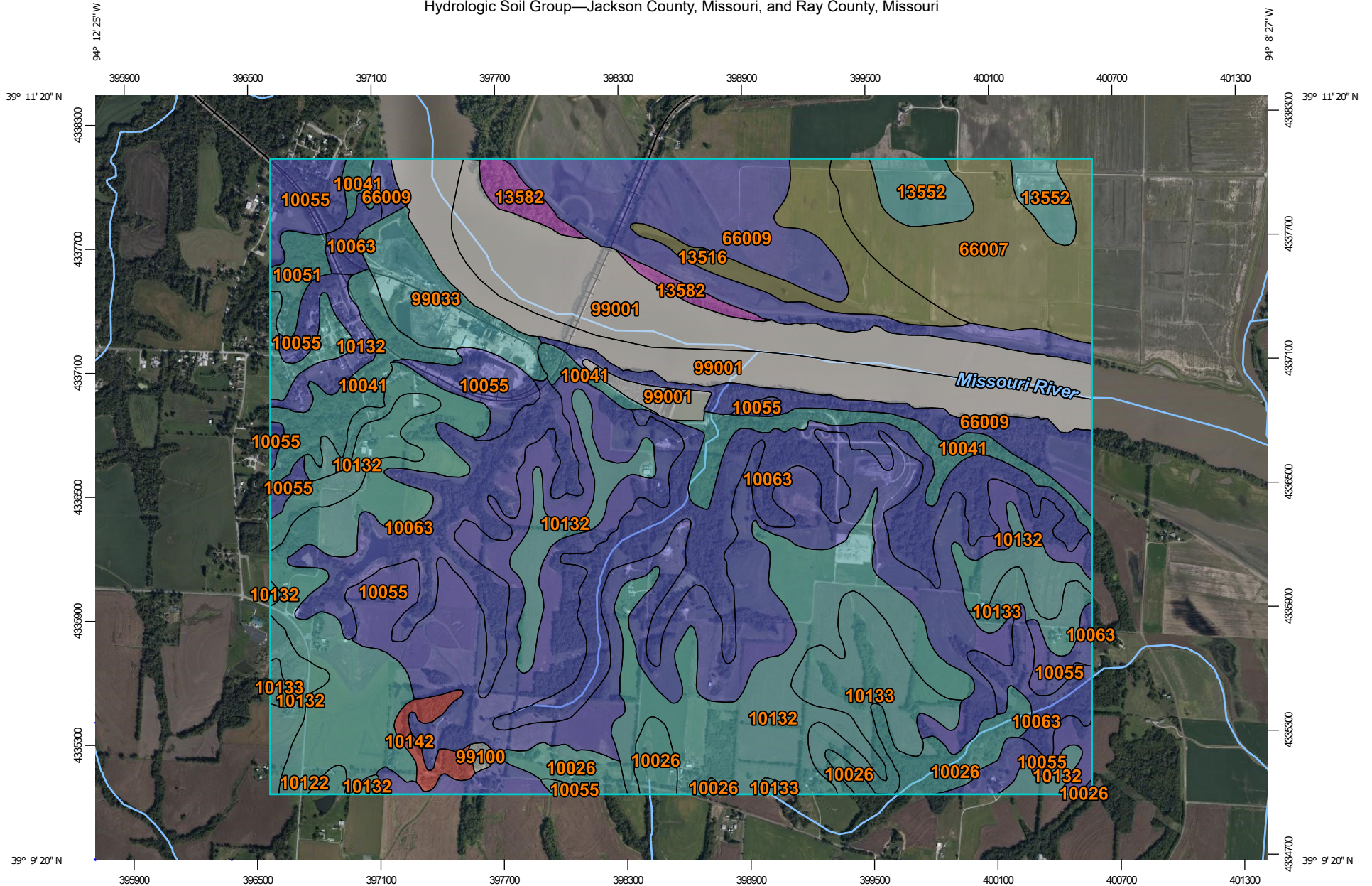
CALCULATION NO.: C - 001
REVISION: A
REVIEWED BY:

RUN-ON CONTROLS

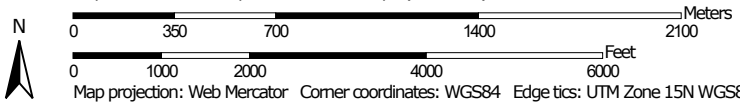
Storm Water System Component		Capacity	Peak Flow (25-yr, 24-hr event)	Calculated Excess Capacity	Units
Area 7	Exterior Ditch	88.8	9.8	79.1	cfs
	2x36" CHDPE	313.6	37.7	275.9	cfs
Area 8	Exterior Ditch	80.8	4.0	76.8	cfs
Area 9	Exterior Ditch	269.0	7.1	261.9	cfs
	18" CMP	11.5	7.1	4.4	cfs
Area 10	Exterior Ditch	505.6	9.0	496.5	cfs

Reference 2

Hydrologic Soil Group—Jackson County, Missouri, and Ray County, Missouri



Map Scale: 1:26,100 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N 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.

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: Jackson County, Missouri
 Survey Area Data: Version 22, May 29, 2020

Soil Survey Area: Ray County, Missouri
 Survey Area Data: Version 20, May 29, 2020

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Sep 6, 2019—Nov 16, 2019

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
10026	Higginsville silt loam, 5 to 9 percent slopes	C	81.9	2.7%
10041	Knox silt loam, 14 to 20 percent slopes, eroded	C	126.7	4.2%
10051	Knox silt loam, 20 to 35 percent slopes, eroded	C	20.8	0.7%
10055	Knox silt loam, 5 to 9 percent slopes, eroded	B	680.3	22.3%
10063	Knox silty clay loam, 9 to 14 percent slopes, severely eroded	B	398.0	13.1%
10122	Sharpsburg silt loam, 5 to 9 percent slopes, eroded	C	4.3	0.1%
10132	Sibley silt loam, 2 to 5 percent slopes	C	386.1	12.7%
10133	Sibley silt loam, 5 to 9 percent slopes	C	305.8	10.0%
10142	Snead-Rock outcrop complex, 5 to 14 percent slopes	D	18.5	0.6%
66009	Haynie silt loam, 0 to 2 percent slopes, occasionally flooded	B	76.6	2.5%
99001	Water		161.8	5.3%
99033	Udarents-Urban land complex, 2 to 9 percent slopes	C	69.3	2.3%
99100	Pits, gravel and quarry		3.2	0.1%
Subtotals for Soil Survey Area			2,333.5	76.6%
Totals for Area of Interest			3,048.3	100.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
13516	Gilliam silt loam, 0 to 2 percent slopes, occasionally flooded	C/D	74.0	2.4%
13552	Modale silt loam, 0 to 2 percent slopes, occasionally flooded	C	53.1	1.7%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
13582	Sarpy loamy fine sand, 0 to 2 percent slopes, occasionally flooded	A	28.0	0.9%
66007	Leta silty clay, 0 to 2 percent slopes, occasionally flooded	C/D	163.3	5.4%
66009	Haynie silt loam, 0 to 2 percent slopes, occasionally flooded	B	199.0	6.5%
99001	Water		197.2	6.5%
Subtotals for Soil Survey Area			714.6	23.4%
Totals for Area of Interest			3,048.3	100.0%

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Reference 3



NOAA Atlas 14, Volume 8, Version 2
Location name: Sibley, Missouri, USA*
Latitude: 39.1723°, Longitude: -94.1635°
Elevation: 835.42 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

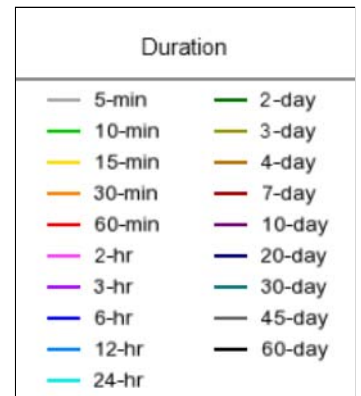
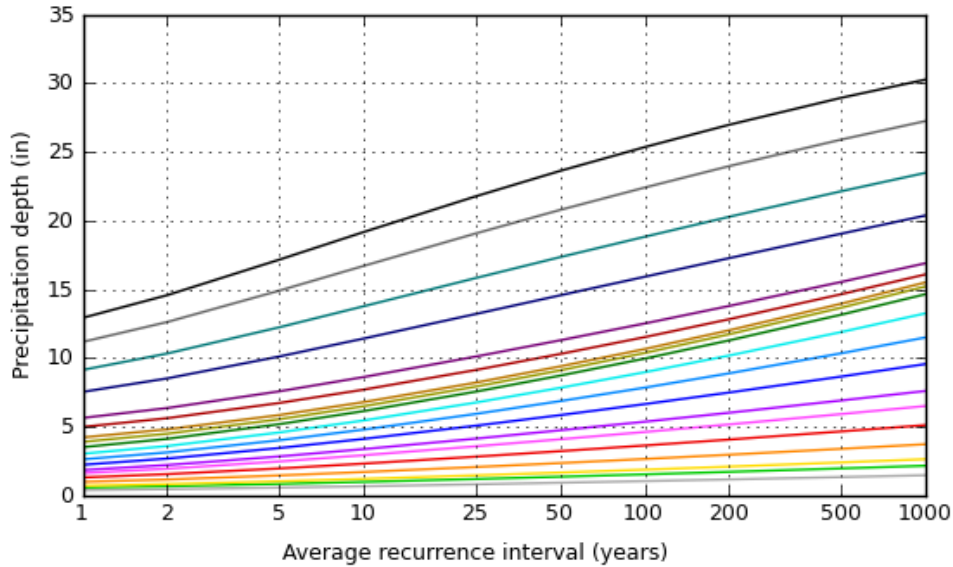
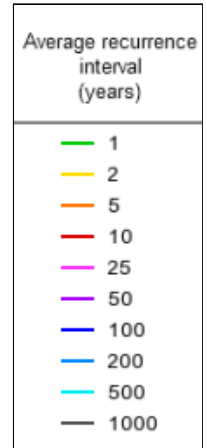
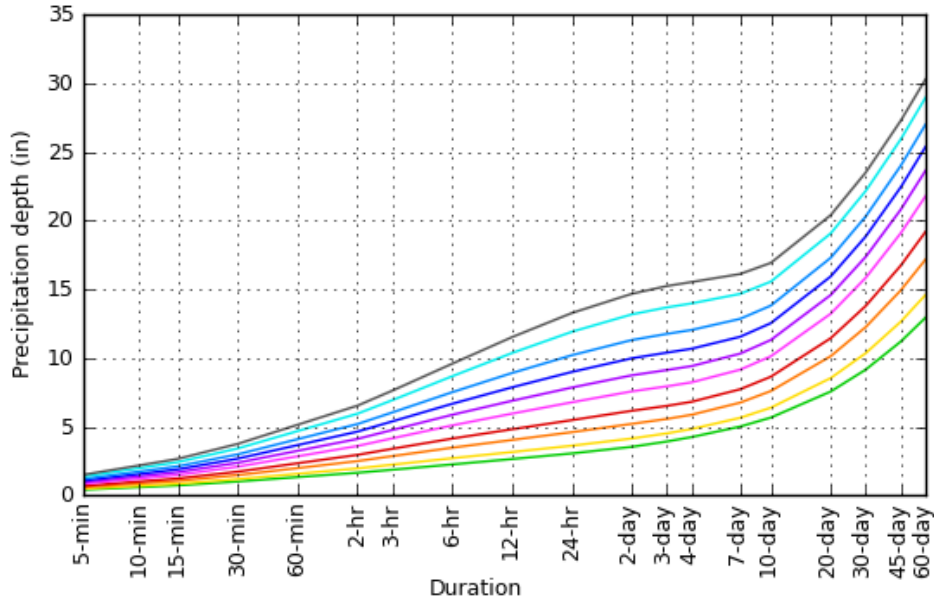
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.405 (0.320-0.514)	0.472 (0.373-0.600)	0.587 (0.463-0.748)	0.686 (0.538-0.878)	0.829 (0.631-1.10)	0.943 (0.701-1.26)	1.06 (0.764-1.45)	1.19 (0.819-1.65)	1.36 (0.903-1.94)	1.49 (0.966-2.15)
10-min	0.592 (0.469-0.753)	0.692 (0.547-0.879)	0.860 (0.678-1.10)	1.00 (0.788-1.29)	1.21 (0.924-1.60)	1.38 (1.03-1.84)	1.55 (1.12-2.12)	1.74 (1.20-2.42)	1.98 (1.32-2.84)	2.18 (1.41-3.15)
15-min	0.723 (0.572-0.918)	0.843 (0.667-1.07)	1.05 (0.826-1.34)	1.23 (0.961-1.57)	1.48 (1.13-1.96)	1.68 (1.25-2.25)	1.89 (1.36-2.58)	2.12 (1.46-2.95)	2.42 (1.61-3.46)	2.66 (1.72-3.84)
30-min	1.01 (0.797-1.28)	1.18 (0.933-1.50)	1.47 (1.16-1.88)	1.72 (1.35-2.21)	2.09 (1.59-2.75)	2.37 (1.77-3.17)	2.67 (1.92-3.64)	2.98 (2.06-4.16)	3.41 (2.27-4.88)	3.74 (2.43-5.41)
60-min	1.33 (1.05-1.68)	1.57 (1.24-2.00)	1.98 (1.56-2.52)	2.33 (1.83-2.99)	2.84 (2.16-3.75)	3.24 (2.41-4.33)	3.65 (2.63-4.98)	4.08 (2.82-5.70)	4.67 (3.11-6.68)	5.13 (3.33-7.42)
2-hr	1.64 (1.31-2.07)	1.96 (1.56-2.47)	2.49 (1.98-3.15)	2.94 (2.32-3.74)	3.59 (2.75-4.71)	4.11 (3.07-5.44)	4.64 (3.36-6.28)	5.19 (3.61-7.19)	5.94 (3.99-8.43)	6.52 (4.27-9.37)
3-hr	1.86 (1.49-2.34)	2.23 (1.78-2.81)	2.86 (2.27-3.60)	3.39 (2.69-4.29)	4.15 (3.19-5.42)	4.76 (3.58-6.28)	5.38 (3.92-7.26)	6.04 (4.22-8.33)	6.93 (4.67-9.79)	7.62 (5.01-10.9)
6-hr	2.25 (1.81-2.81)	2.70 (2.17-3.37)	3.47 (2.78-4.34)	4.13 (3.30-5.19)	5.09 (3.95-6.62)	5.86 (4.44-7.70)	6.66 (4.89-8.94)	7.51 (5.30-10.3)	8.67 (5.90-12.2)	9.58 (6.35-13.6)
12-hr	2.64 (2.14-3.27)	3.15 (2.55-3.90)	4.03 (3.25-5.01)	4.81 (3.86-5.99)	5.95 (4.66-7.70)	6.88 (5.26-8.99)	7.86 (5.82-10.5)	8.90 (6.34-12.2)	10.4 (7.11-14.5)	11.5 (7.69-16.2)
24-hr	3.05 (2.49-3.75)	3.61 (2.95-4.44)	4.60 (3.74-5.67)	5.47 (4.43-6.77)	6.77 (5.35-8.72)	7.85 (6.05-10.2)	8.98 (6.71-11.9)	10.2 (7.33-13.8)	11.9 (8.24-16.5)	13.3 (8.94-18.6)
2-day	3.53 (2.90-4.31)	4.14 (3.40-5.05)	5.20 (4.26-6.36)	6.15 (5.01-7.56)	7.57 (6.02-9.67)	8.73 (6.78-11.3)	9.97 (7.50-13.1)	11.3 (8.19-15.2)	13.2 (9.20-18.2)	14.7 (9.96-20.4)
3-day	3.92 (3.23-4.76)	4.51 (3.72-5.48)	5.56 (4.57-6.77)	6.51 (5.32-7.96)	7.93 (6.34-10.1)	9.12 (7.12-11.7)	10.4 (7.85-13.6)	11.7 (8.55-15.8)	13.7 (9.60-18.8)	15.2 (10.4-21.1)
4-day	4.24 (3.51-5.13)	4.83 (3.99-5.85)	5.87 (4.83-7.12)	6.81 (5.58-8.30)	8.22 (6.60-10.4)	9.41 (7.37-12.0)	10.7 (8.10-14.0)	12.0 (8.79-16.1)	14.0 (9.84-19.1)	15.5 (10.6-21.4)
7-day	5.00 (4.16-6.02)	5.64 (4.69-6.79)	6.74 (5.59-8.14)	7.72 (6.36-9.35)	9.14 (7.36-11.5)	10.3 (8.11-13.1)	11.5 (8.80-14.9)	12.8 (9.43-17.0)	14.7 (10.4-19.9)	16.1 (11.1-22.1)
10-day	5.66 (4.72-6.78)	6.38 (5.32-7.65)	7.59 (6.31-9.13)	8.63 (7.14-10.4)	10.1 (8.15-12.6)	11.3 (8.91-14.2)	12.5 (9.57-16.1)	13.8 (10.2-18.2)	15.6 (11.1-21.0)	16.9 (11.7-23.1)
20-day	7.55 (6.35-8.99)	8.53 (7.17-10.2)	10.1 (8.48-12.1)	11.4 (9.53-13.7)	13.2 (10.7-16.2)	14.6 (11.5-18.1)	15.9 (12.2-20.2)	17.3 (12.8-22.5)	19.1 (13.6-25.4)	20.4 (14.3-27.7)
30-day	9.15 (7.73-10.8)	10.3 (8.73-12.3)	12.2 (10.3-14.6)	13.8 (11.5-16.4)	15.8 (12.8-19.3)	17.4 (13.8-21.4)	18.8 (14.5-23.8)	20.3 (15.1-26.2)	22.1 (15.9-29.4)	23.5 (16.5-31.7)
45-day	11.2 (9.49-13.2)	12.6 (10.7-14.9)	14.9 (12.6-17.6)	16.7 (14.0-19.9)	19.1 (15.5-23.1)	20.8 (16.6-25.5)	22.4 (17.3-28.1)	24.0 (17.9-30.8)	25.9 (18.7-34.1)	27.3 (19.3-36.7)
60-day	12.9 (11.0-15.2)	14.6 (12.4-17.2)	17.2 (14.5-20.2)	19.2 (16.2-22.7)	21.8 (17.7-26.2)	23.6 (18.9-28.9)	25.4 (19.7-31.7)	27.0 (20.2-34.5)	28.9 (20.9-38.0)	30.3 (21.5-40.6)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

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PF graphical

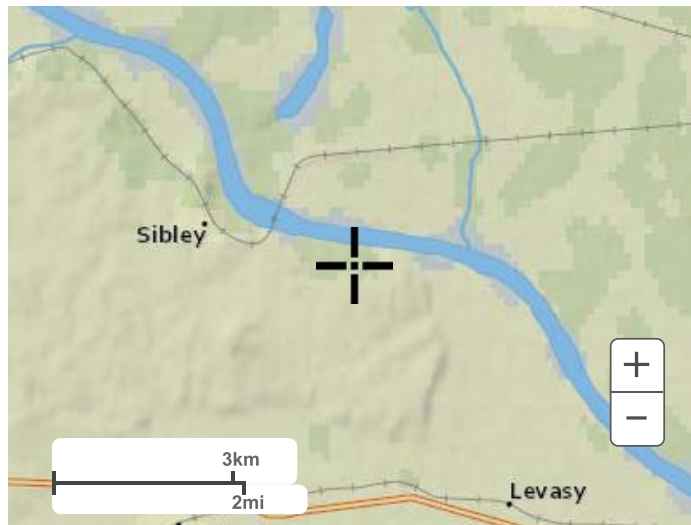
PDS-based depth-duration-frequency (DDF) curves
 Latitude: 39.1723°, Longitude: -94.1635°



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Maps & aerials

Small scale terrain



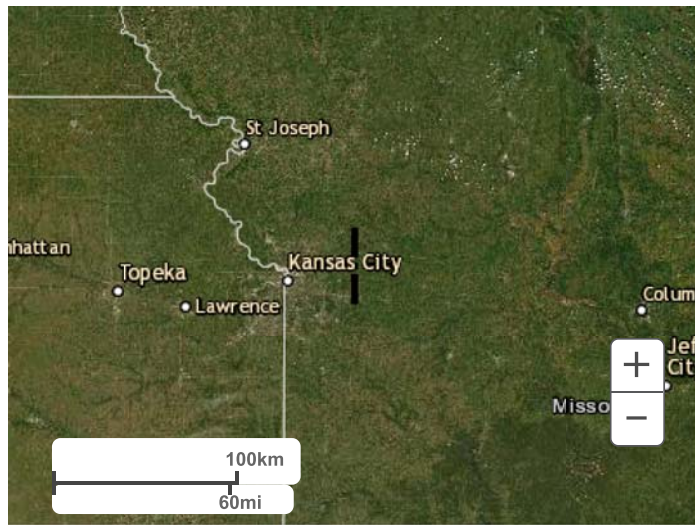
Large scale terrain



Large scale map



Large scale aerial

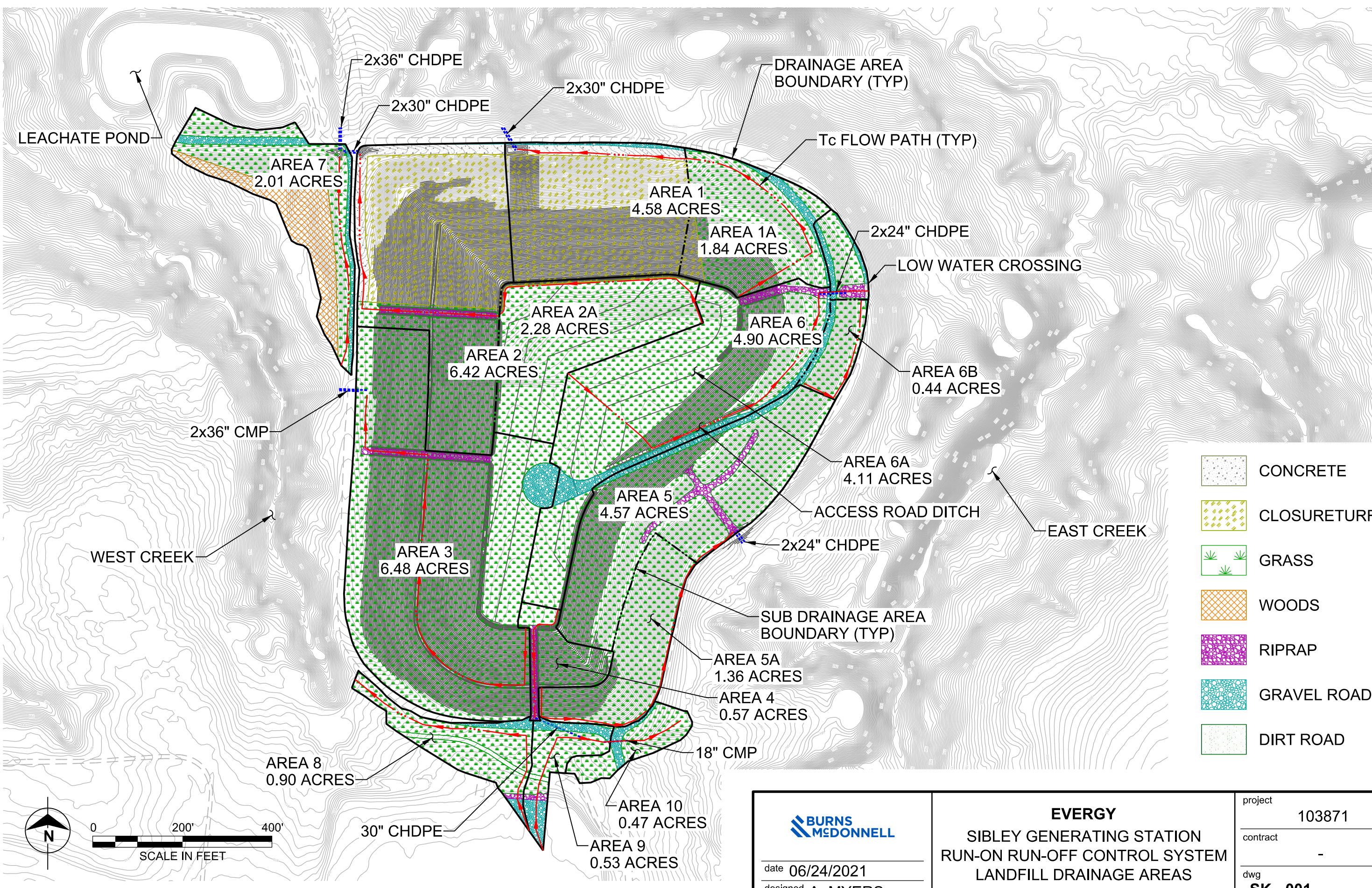


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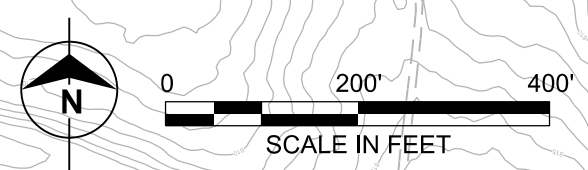
[US Department of Commerce](#)
[National Oceanic and Atmospheric Administration](#)
[National Weather Service](#)
[National Water Center](#)
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov


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ATTACHMENT 2 – SK-001 – LANDFILL DRAINAGE AREAS



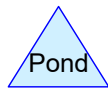
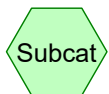
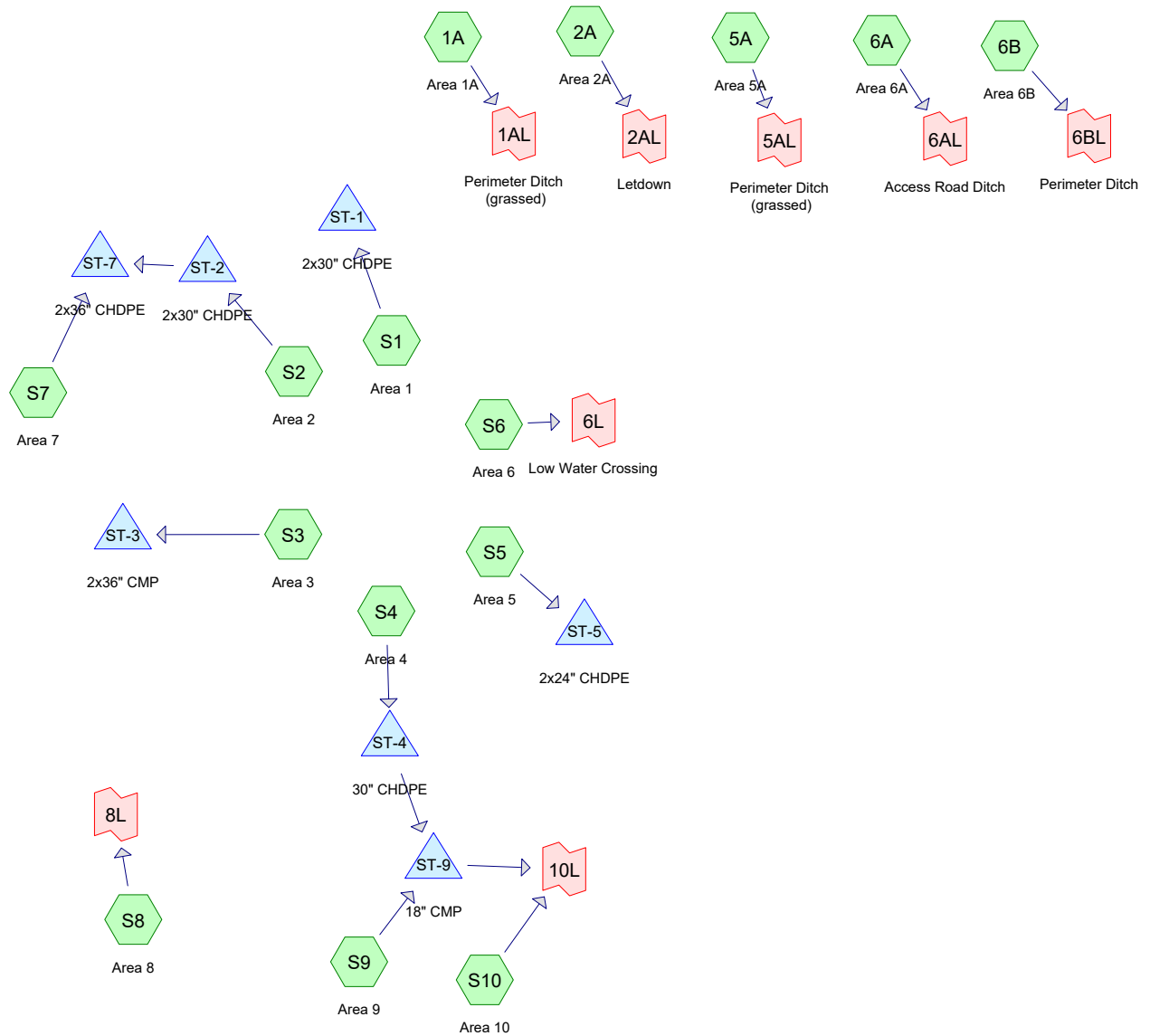
-  CONCRETE
-  CLOSURETURF
-  GRASS
-  WOODS
-  RIPRAP
-  GRAVEL ROAD
-  DIRT ROAD



 date 06/24/2021 designed A. MYERS	EVERGY SIBLEY GENERATING STATION RUN-ON RUN-OFF CONTROL SYSTEM LANDFILL DRAINAGE AREAS	project 103871
		contract -
		dwg SK - 001 rev -

6/30/2021

ATTACHMENT 3 – HYDROCAD REPORT FOR 25-YEAR, 24-HOUR STORM EVENT



Routing Diagram for Sibley Landfill RORO
 Prepared by Burns and McDonnell, Printed 6/30/2021
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Sibley Landfill RORO

Prepared by Burns and McDonnell

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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.870	61	>75% Grass cover, Good, HSG B (S10, S7, S8, S9)
29.630	74	>75% Grass cover, Good, HSG C (1A, 2A, 5A, 6A, 6B, S1, S2, S3, S4, S5, S6)
5.235	95	ClosureTurf (1A, 2A, 6A, S1, S2, S6)
0.138	82	Dirt roads, HSG B (S8, S9)
0.462	96	Gravel surface, HSG B (S10, S7, S8, S9)
1.324	96	Gravel surface, HSG C (1A, 5A, 6A, 6B, S1, S2, S3, S5, S6)
0.724	89	Riprap (6A, S2, S3, S4, S5, S6)
0.022	85	Riprap (S8, S9)
0.643	98	Unconnected pavement, HSG C (S1, S2, S5, S6)
0.784	55	Woods, Good, HSG B (S7)

Sibley Landfill RORO

Prepared by Burns and McDonnell

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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Time span=0.00-72.00 hrs, dt=0.03 hrs, 2401 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 1A: Area 1A	Runoff Area=80,031 sf 0.00% Impervious Runoff Depth=4.16" Flow Length=563' Tc=6.0 min CN=77 Runoff=13.32 cfs 0.637 af
Subcatchment 2A: Area 2A	Runoff Area=99,274 sf 0.00% Impervious Runoff Depth=3.95" Flow Length=567' Tc=17.6 min CN=75 Runoff=10.71 cfs 0.750 af
Subcatchment 5A: Area 5A	Runoff Area=59,350 sf 0.00% Impervious Runoff Depth=3.84" Flow Length=628' Tc=7.7 min CN=74 Runoff=8.68 cfs 0.436 af
Subcatchment 6A: Area 6A	Runoff Area=179,194 sf 0.00% Impervious Runoff Depth=4.05" Flow Length=806' Tc=18.8 min CN=76 Runoff=19.15 cfs 1.389 af
Subcatchment 6B: Area 6B	Runoff Area=19,189 sf 0.00% Impervious Runoff Depth=4.16" Flow Length=310' Tc=6.0 min CN=77 Runoff=3.19 cfs 0.153 af
Subcatchment S1: Area 1	Runoff Area=199,395 sf 4.91% Impervious Runoff Depth=5.37" Flow Length=840' Tc=6.4 min CN=88 Runoff=39.83 cfs 2.048 af
Subcatchment S10: Area 10	Runoff Area=20,559 sf 0.00% Impervious Runoff Depth=3.02" Flow Length=131' Slope=0.1000 '/' Tc=6.0 min CN=66 Runoff=2.54 cfs 0.119 af
Subcatchment S2: Area 2	Runoff Area=279,804 sf 6.37% Impervious Runoff Depth=4.81" Flow Length=1,223' Tc=18.9 min UI Adjusted CN=83 Runoff=34.84 cfs 2.575 af
Subcatchment S3: Area 3	Runoff Area=282,268 sf 0.00% Impervious Runoff Depth=3.95" Flow Length=1,078' Tc=13.4 min CN=75 Runoff=34.76 cfs 2.132 af
Subcatchment S4: Area 4	Runoff Area=24,788 sf 0.00% Impervious Runoff Depth=4.05" Flow Length=282' Tc=14.5 min CN=76 Runoff=3.02 cfs 0.192 af
Subcatchment S5: Area 5	Runoff Area=199,299 sf 0.06% Impervious Runoff Depth=3.95" Flow Length=738' Tc=8.2 min CN=75 Runoff=29.34 cfs 1.505 af
Subcatchment S6: Area 6	Runoff Area=213,384 sf 0.13% Impervious Runoff Depth=4.05" Flow Length=918' Tc=19.1 min CN=76 Runoff=22.61 cfs 1.655 af
Subcatchment S7: Area 7	Runoff Area=87,595 sf 0.00% Impervious Runoff Depth=2.73" Flow Length=482' Slope=0.0417 '/' Tc=6.0 min CN=63 Runoff=9.77 cfs 0.457 af
Subcatchment S8: Area 8	Runoff Area=39,062 sf 0.00% Impervious Runoff Depth=3.02" Flow Length=642' Tc=11.2 min CN=66 Runoff=3.99 cfs 0.226 af
Subcatchment S9: Area 9	Runoff Area=39,062 sf 0.00% Impervious Runoff Depth=3.02" Flow Length=323' Tc=8.1 min CN=66 Runoff=4.47 cfs 0.226 af
Pond ST-1: 2x30" CHDPE	Peak Elev=777.97' Storage=543 cf Inflow=39.83 cfs 2.048 af 30.0" Round Culvert x 2.00 n=0.012 L=58.7' S=0.0300 '/' Outflow=39.64 cfs 2.048 af

Sibley Landfill RORO*Type II 24-hr 25-yr, 24-hr Rainfall=6.77"*

Prepared by Burns and McDonnell

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Pond ST-2: 2x30" CHDPE	Peak Elev=766.25' Storage=531 cf Inflow=34.84 cfs 2.575 af 30.0" Round Culvert x 2.00 n=0.012 L=37.0' S=0.0300 '/' Outflow=34.81 cfs 2.575 af
Pond ST-3: 2x36" CMP	Peak Elev=785.00' Storage=4,403 cf Inflow=34.76 cfs 2.132 af Outflow=32.87 cfs 2.132 af
Pond ST-4: 30" CHDPE	Peak Elev=812.77' Storage=18 cf Inflow=3.02 cfs 0.192 af 30.0" Round Culvert n=0.012 L=112.5' S=0.0178 '/' Outflow=3.02 cfs 0.192 af
Pond ST-5: 2x24" CHDPE	Peak Elev=798.91' Storage=336 cf Inflow=29.34 cfs 1.505 af 24.0" Round Culvert x 2.00 n=0.012 L=33.0' S=0.1000 '/' Outflow=29.15 cfs 1.505 af
Pond ST-7: 2x36" CHDPE	Peak Elev=764.53' Storage=257 cf Inflow=37.69 cfs 3.033 af 36.0" Round Culvert x 2.00 n=0.012 L=51.0' S=0.0471 '/' Outflow=37.68 cfs 3.033 af
Pond ST-9: 18" CMP	Peak Elev=806.79' Storage=231 cf Inflow=7.12 cfs 0.418 af 18.0" Round Culvert n=0.025 L=53.1' S=0.0446 '/' Outflow=6.99 cfs 0.418 af
Link 1AL: Perimeter Ditch (grassed)	Inflow=13.32 cfs 0.637 af Primary=13.32 cfs 0.637 af
Link 2AL: Letdown	Inflow=10.71 cfs 0.750 af Primary=10.71 cfs 0.750 af
Link 5AL: Perimeter Ditch (grassed)	Inflow=8.68 cfs 0.436 af Primary=8.68 cfs 0.436 af
Link 6AL: Access Road Ditch	Inflow=19.15 cfs 1.389 af Primary=19.15 cfs 1.389 af
Link 6BL: Perimeter Ditch	Inflow=3.19 cfs 0.153 af Primary=3.19 cfs 0.153 af
Link 6L: Low Water Crossing	Inflow=22.61 cfs 1.655 af Primary=22.61 cfs 1.655 af
Link 8L:	Inflow=3.99 cfs 0.226 af Primary=3.99 cfs 0.226 af
Link 10L:	Inflow=9.11 cfs 0.537 af Primary=9.11 cfs 0.537 af

Sibley Landfill RORO

Prepared by Burns and McDonnell

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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment 1A: Area 1A

Runoff = 13.32 cfs @ 11.97 hrs, Volume= 0.637 af, Depth= 4.16"

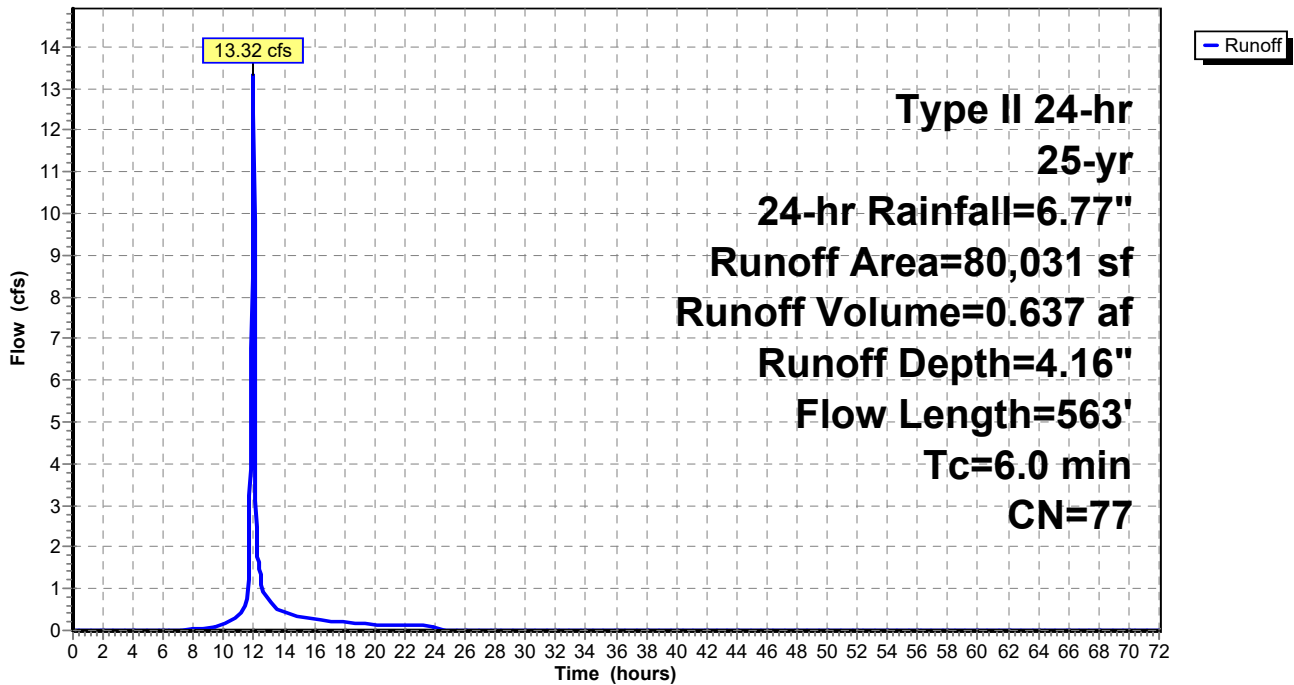
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
5,321	95	ClosureTurf
70,046	74	>75% Grass cover, Good, HSG C
4,664	96	Gravel surface, HSG C
80,031	77	Weighted Average
80,031		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	191	0.3333	0.63		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
0.9	372	0.0667	7.05	26.45	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 '/' Top.W=9.00' n= 0.030 Earth, grassed & winding
5.9	563	Total, Increased to minimum Tc = 6.0 min			

Subcatchment 1A: Area 1A

Hydrograph



Sibley Landfill RORO

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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment 2A: Area 2A

Runoff = 10.71 cfs @ 12.10 hrs, Volume= 0.750 af, Depth= 3.95"

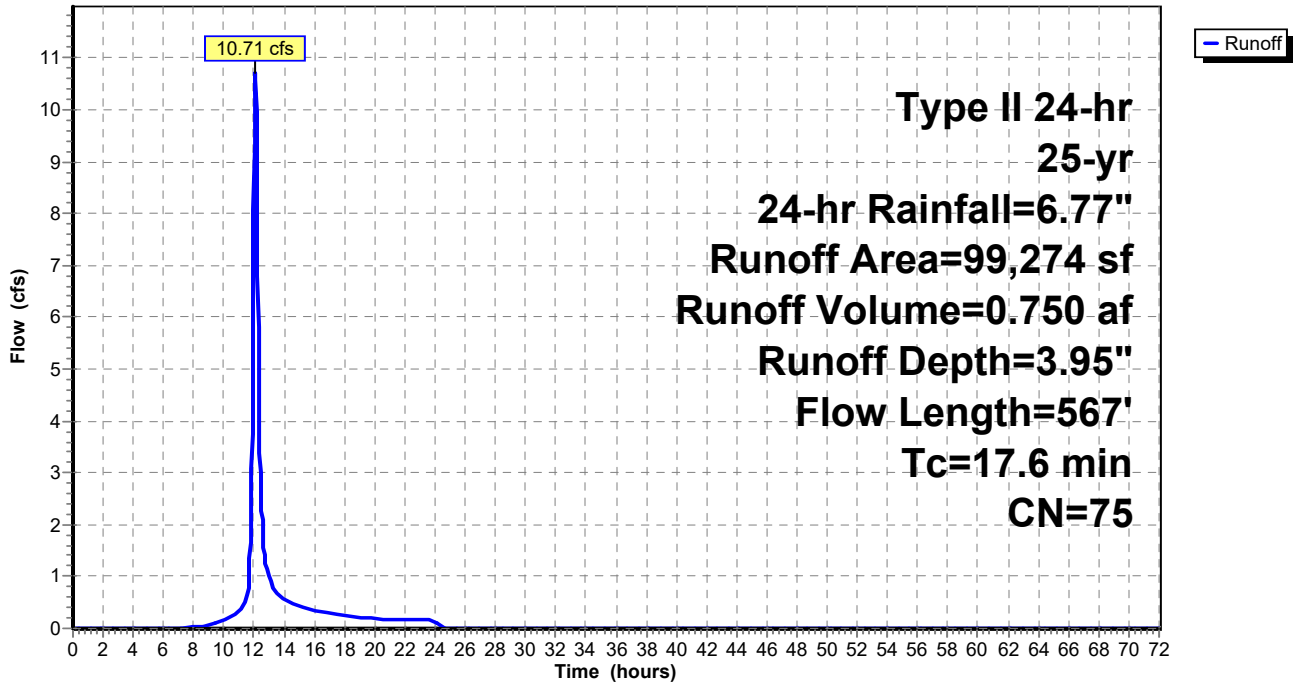
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
* 3,242	95	ClosureTurf
96,032	74	>75% Grass cover, Good, HSG C
99,274	75	Weighted Average
99,274		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	119	0.0200	0.19		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
7.0	448	0.0050	1.06		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
17.6	567	Total			

Subcatchment 2A: Area 2A

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment 5A: Area 5A

Runoff = 8.68 cfs @ 11.99 hrs, Volume= 0.436 af, Depth= 3.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
58,402	74	>75% Grass cover, Good, HSG C
948	96	Gravel surface, HSG C
59,350	74	Weighted Average
59,350		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1	66	0.3333	0.51		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
2.0	114	0.0025	0.95	0.71	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 '/' Top.W=3.00' n= 0.030 Earth, grassed & winding
0.4	142	0.0833	5.48	4.11	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 '/' Top.W=3.00' n= 0.030 Earth, grassed & winding
3.2	306	0.0069	1.58	1.18	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 '/' Top.W=3.00' n= 0.030 Earth, grassed & winding
7.7	628	Total			

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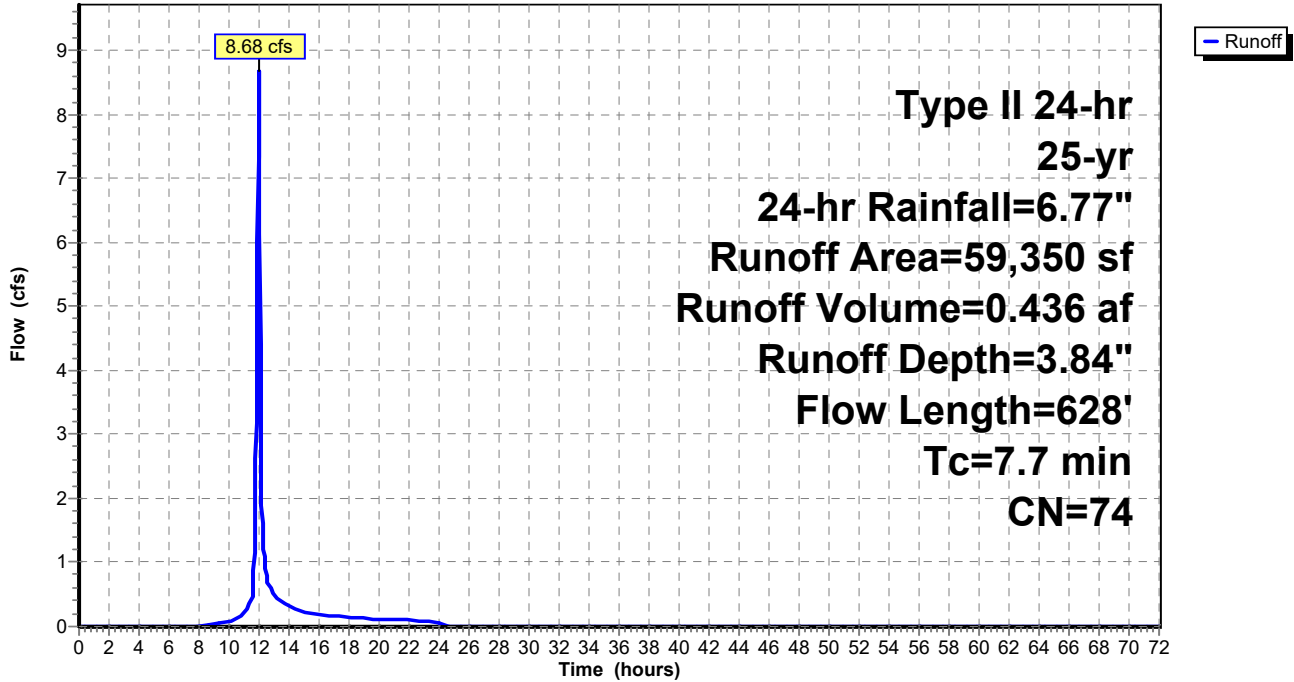
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Subcatchment 5A: Area 5A

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment 6A: Area 6A

Runoff = 19.15 cfs @ 12.11 hrs, Volume= 1.389 af, Depth= 4.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
164,278	74	>75% Grass cover, Good, HSG C
11,009	96	Gravel surface, HSG C
* 3,836	89	Riprap
* 71	95	ClosureTurf
179,194	76	Weighted Average
179,194		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.4	221	0.0200	0.21		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
0.1	35	0.3333	8.66		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.3	178	0.1000	8.63	32.38	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 ' Top.W=9.00' n= 0.030 Stream, clean & straight
0.4	76	0.0132	3.14	11.76	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 ' Top.W=9.00' n= 0.030 Stream, clean & straight
0.6	296	0.1000	8.63	32.38	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 ' Top.W=9.00' n= 0.030 Stream, clean & straight
18.8	806	Total			

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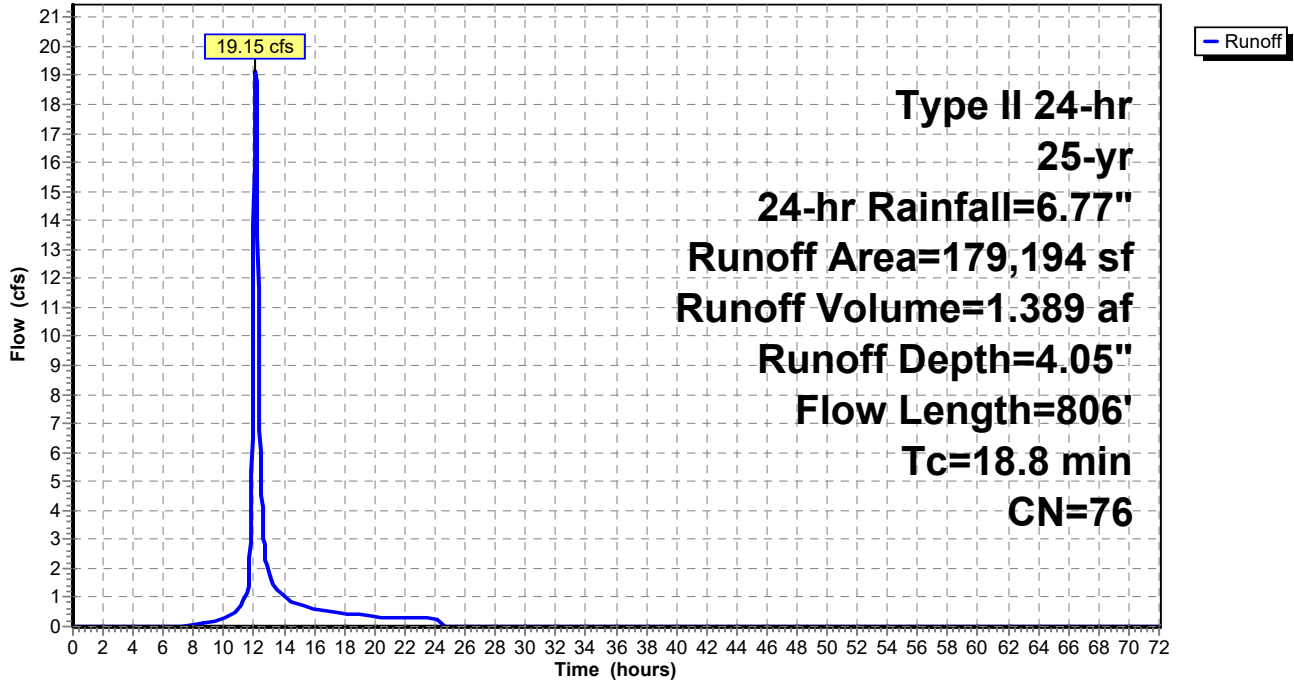
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Subcatchment 6A: Area 6A

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment 6B: Area 6B

Runoff = 3.19 cfs @ 11.97 hrs, Volume= 0.153 af, Depth= 4.16"

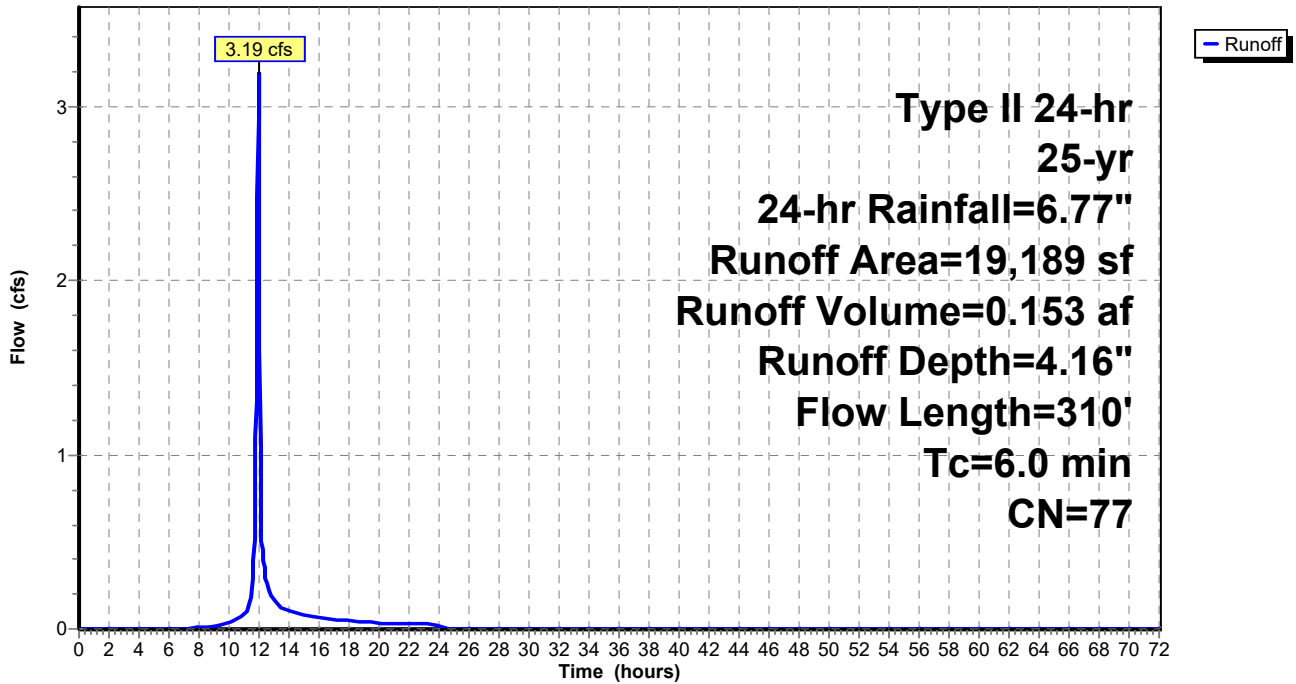
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
16,416	74	>75% Grass cover, Good, HSG C
2,773	96	Gravel surface, HSG C
19,189	77	Weighted Average
19,189		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.5	78	0.3333	0.53		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
1.3	232	0.0150	3.06	14.92	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 & 12.0 ' Top.W=13.50' n= 0.030 Stream, clean & straight
3.8	310	Total, Increased to minimum Tc = 6.0 min			

Subcatchment 6B: Area 6B

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S1: Area 1

Runoff = 39.83 cfs @ 11.97 hrs, Volume= 2.048 af, Depth= 5.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
* 112,498	95	ClosureTurf
70,046	74	>75% Grass cover, Good, HSG C
7,055	96	Gravel surface, HSG C
9,796	98	Unconnected pavement, HSG C
199,395	88	Weighted Average
189,599		95.09% Pervious Area
9,796		4.91% Impervious Area
9,796		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	191	0.3333	0.63		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
0.9	372	0.0667	7.05	26.45	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 '/' Top.W=9.00' n= 0.030 Earth, grassed & winding
0.5	277	0.0400	9.64	36.14	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 '/' Top.W=9.00' n= 0.017 Concrete, unfinished
6.4	840	Total			

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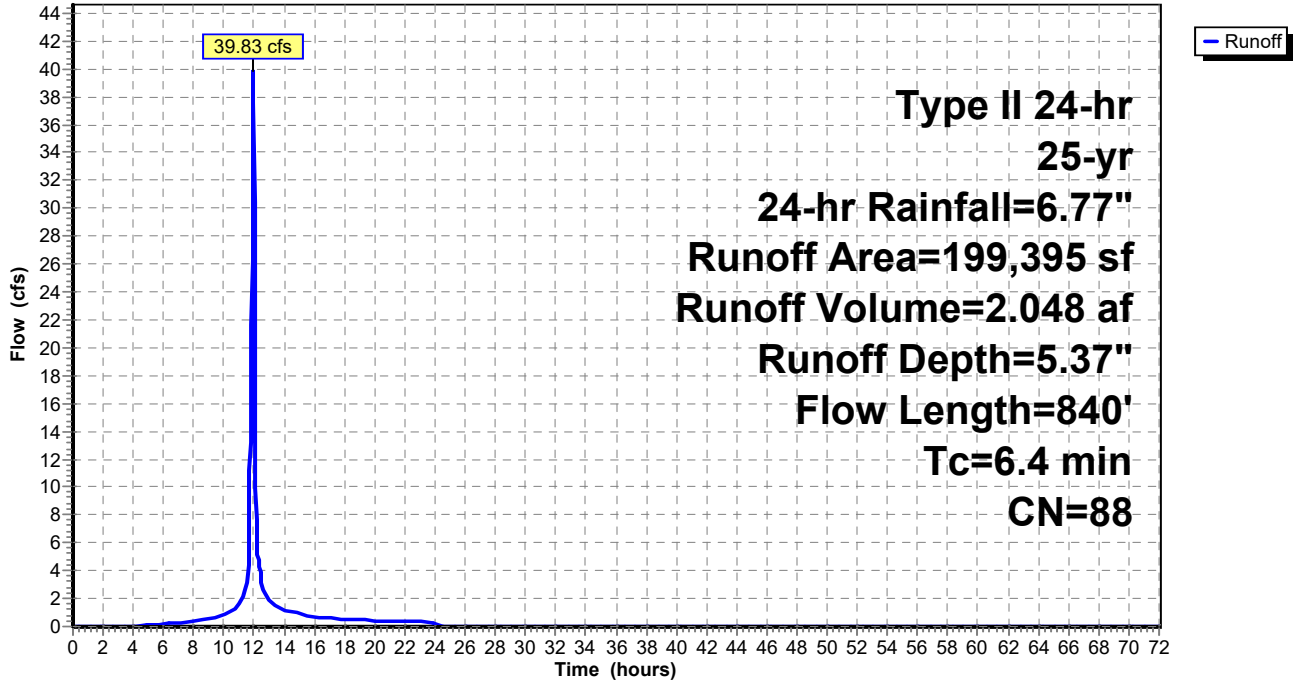
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Subcatchment S1: Area 1

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S10: Area 10

Runoff = 2.54 cfs @ 11.97 hrs, Volume= 0.119 af, Depth= 3.02"

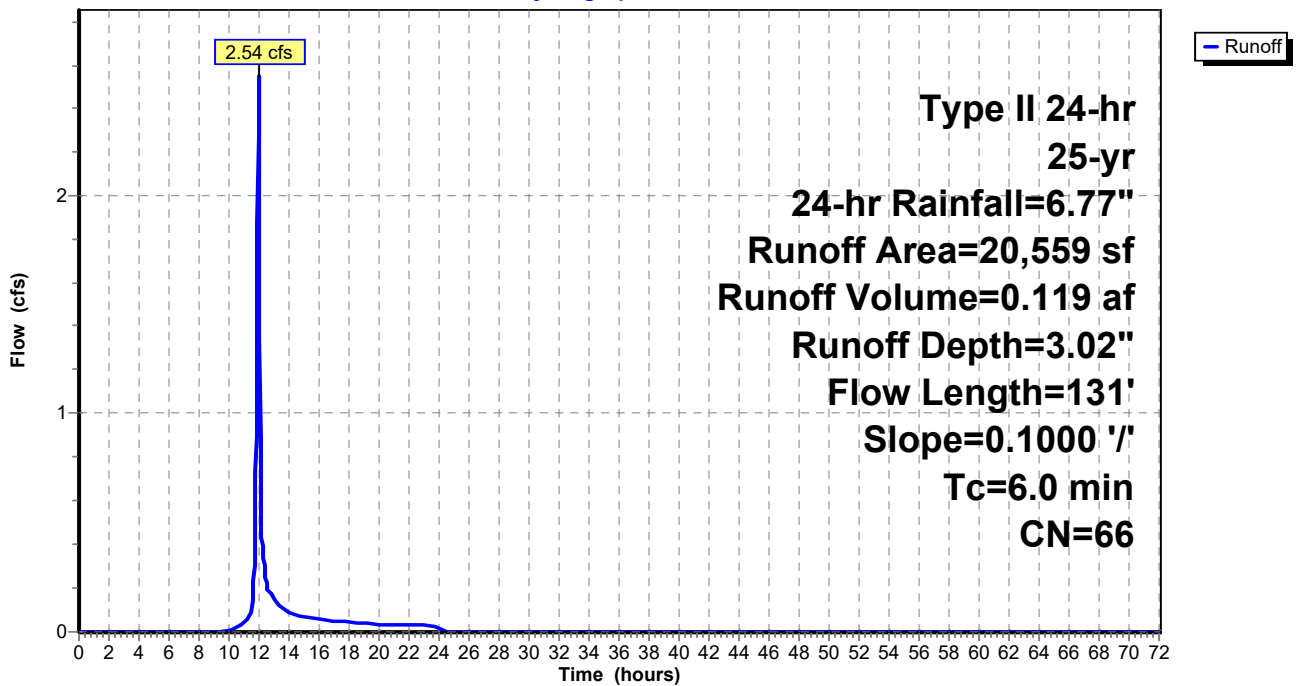
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
17,682	61	>75% Grass cover, Good, HSG B
2,877	96	Gravel surface, HSG B
20,559	66	Weighted Average
20,559		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	131	0.1000	8.96	41.42	Trap/Vee/Rect Channel Flow, Bot.W=8.00' D=0.50' Z= 2.0 & 3.0 '/' Top.W=10.50' n= 0.030 Earth, grassed & winding
0.2	131	Total, Increased to minimum Tc = 6.0 min			

Subcatchment S10: Area 10

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S2: Area 2

Runoff = 34.84 cfs @ 12.11 hrs, Volume= 2.575 af, Depth= 4.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

	Area (sf)	CN	Adj	Description
*	106,822	95		ClosureTurf
	150,080	74		>75% Grass cover, Good, HSG C
	341	96		Gravel surface, HSG C
	17,828	98		Unconnected pavement, HSG C
*	4,733	89		Riprap
	279,804	84	83	Weighted Average, UI Adjusted
	261,976			93.63% Pervious Area
	17,828			6.37% Impervious Area
	17,828			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	119	0.0200	0.19		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
7.0	448	0.0050	1.06		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.6	275	0.3333	7.16	41.16	Trap/Vee/Rect Channel Flow, Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00' n= 0.069 Riprap, 6-inch
0.2	47	0.0667	3.87		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.5	334	0.0667	11.36	75.26	Trap/Vee/Rect Channel Flow, Bot.W=8.00' D=0.50' Z= 15.0 & 6.0 '/' Top.W=18.50' n= 0.017 Concrete, unfinished
18.9	1,223	Total			

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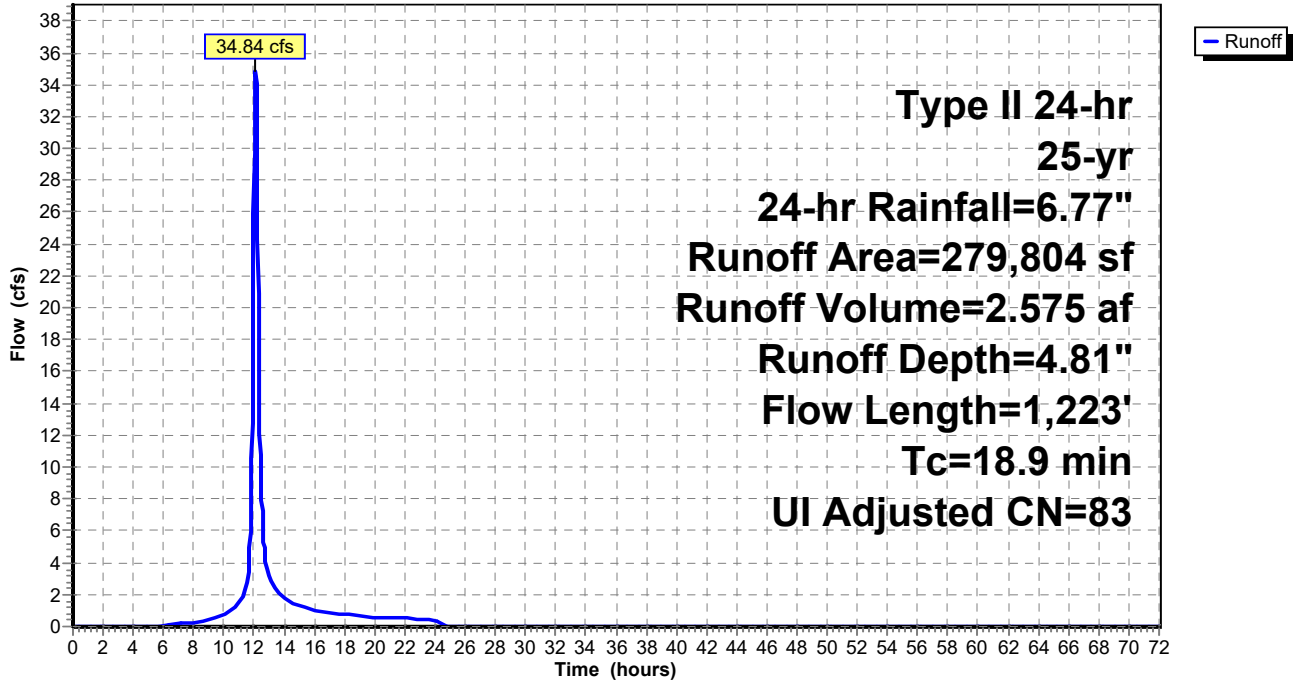
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Subcatchment S2: Area 2

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S3: Area 3

Runoff = 34.76 cfs @ 12.05 hrs, Volume= 2.132 af, Depth= 3.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
270,655	74	>75% Grass cover, Good, HSG C
6,319	96	Gravel surface, HSG C
* 5,294	89	Riprap
282,268	75	Weighted Average
282,268		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	127	0.3333	0.58		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
7.6	680	0.0100	1.50		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
1.3	130	0.3333	1.67	0.85	Trap/Vee/Rect Channel Flow, Bot.W=10.00' D=0.05' Z= 3.0 '/' Top.W=10.30' n= 0.069 Riprap, 6-inch
0.9	141	0.0050	2.75	38.45	Trap/Vee/Rect Channel Flow, Bot.W=8.00' D=1.00' Z= 6.0 '/' Top.W=20.00' n= 0.030 Earth, grassed & winding
13.4	1,078	Total			

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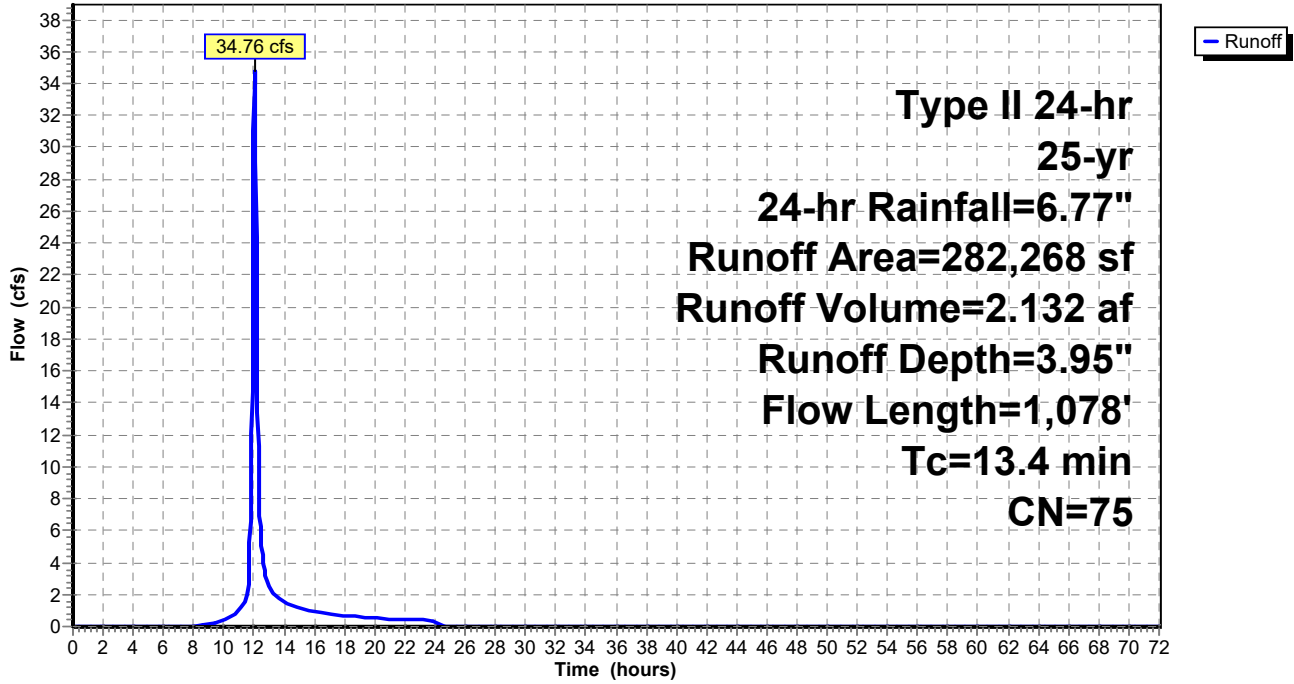
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Subcatchment S3: Area 3

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S4: Area 4

Runoff = 3.02 cfs @ 12.06 hrs, Volume= 0.192 af, Depth= 4.05"

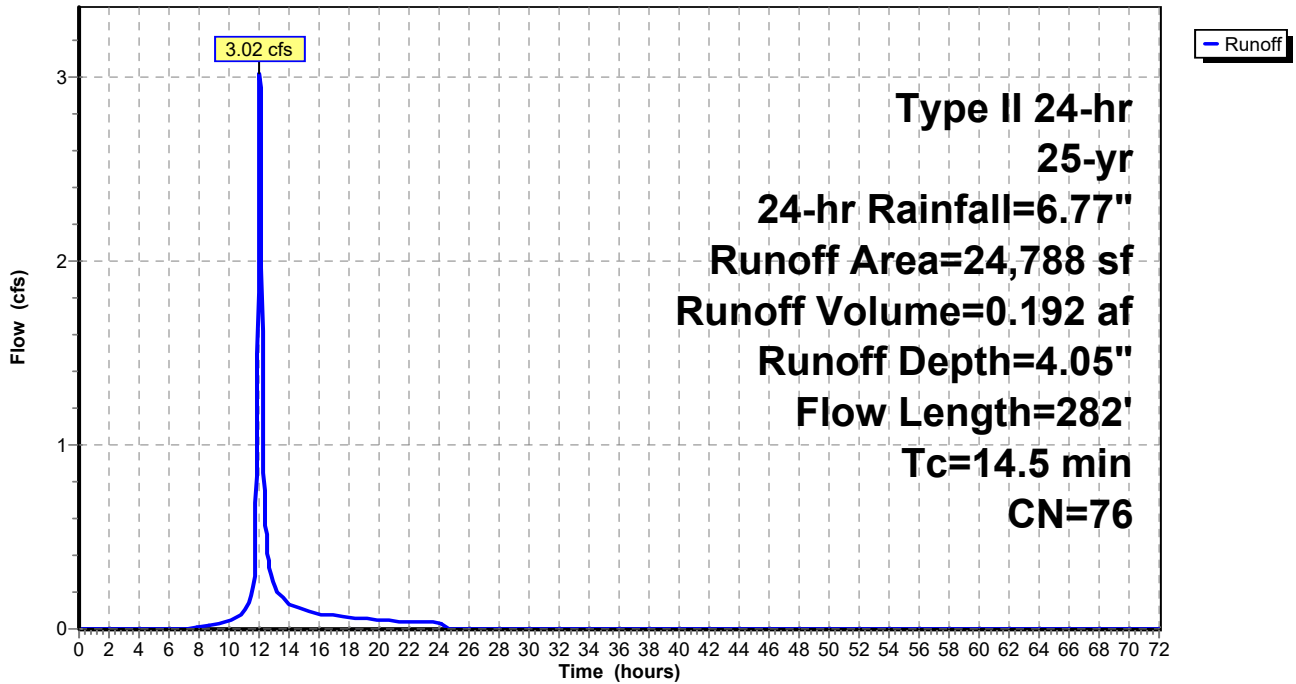
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
20,919	74	>75% Grass cover, Good, HSG C
* 3,869	89	Riprap
24,788	76	Weighted Average
24,788		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.0	84	0.0050	0.10		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
0.5	198	0.3333	7.16	41.16	Trap/Vee/Rect Channel Flow, Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00' n= 0.069 Riprap, 6-inch
14.5	282	Total			

Subcatchment S4: Area 4

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S5: Area 5

Runoff = 29.34 cfs @ 12.00 hrs, Volume= 1.505 af, Depth= 3.95"

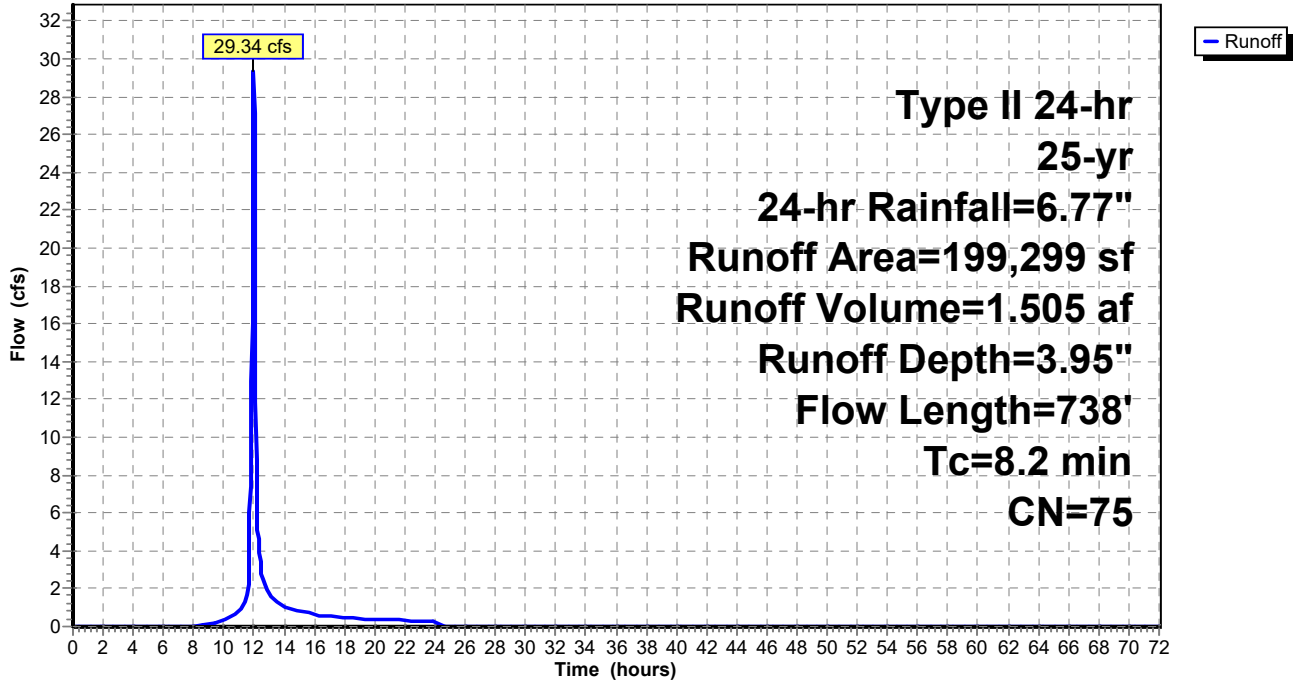
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
183,765	74	>75% Grass cover, Good, HSG C
7,101	96	Gravel surface, HSG C
* 8,306	89	Riprap
127	98	Unconnected pavement, HSG C
199,299	75	Weighted Average
199,172		99.94% Pervious Area
127		0.06% Impervious Area
127		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1	66	0.3333	0.51		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
2.0	114	0.0025	0.95	0.71	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 '/' Top.W=3.00' n= 0.030 Earth, grassed & winding
0.4	142	0.0833	5.48	4.11	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 '/' Top.W=3.00' n= 0.030 Earth, grassed & winding
3.2	306	0.0069	1.58	1.18	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 '/' Top.W=3.00' n= 0.030 Earth, grassed & winding
0.5	110	0.0400	3.80	2.85	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 '/' Top.W=3.00' n= 0.030 Earth, grassed & winding
8.2	738	Total			

Subcatchment S5: Area 5

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S6: Area 6

Runoff = 22.61 cfs @ 12.12 hrs, Volume= 1.655 af, Depth= 4.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

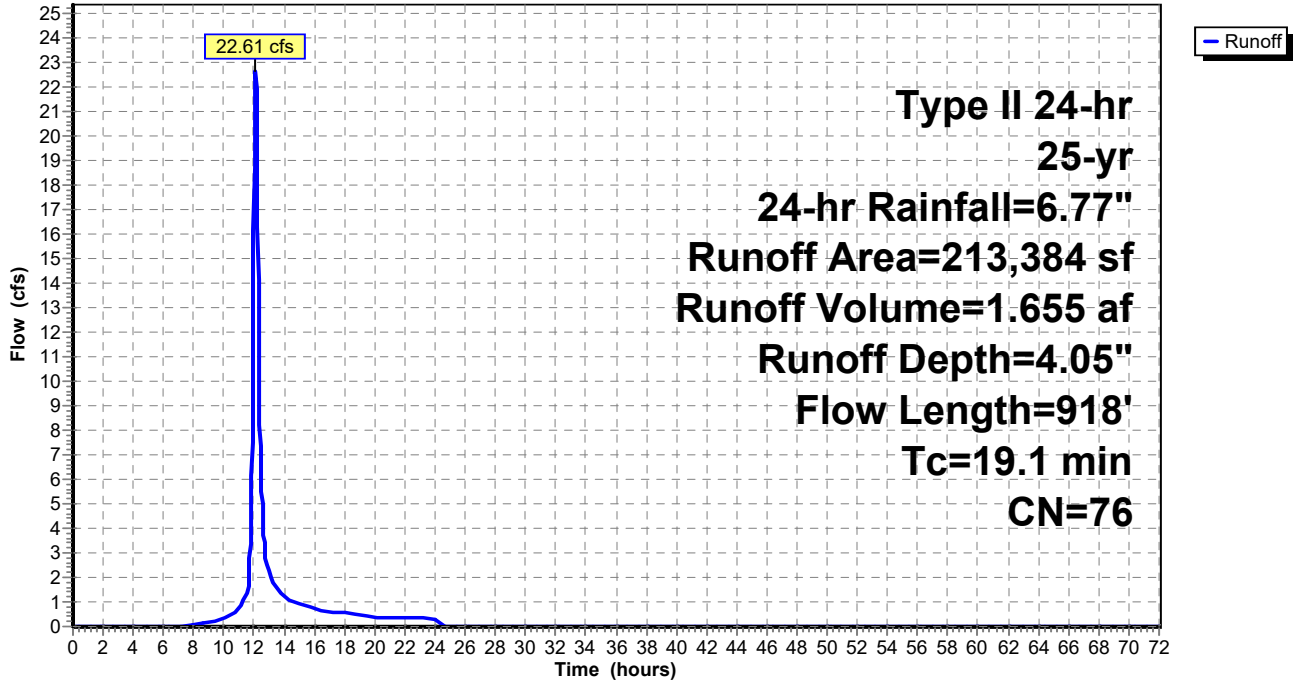
Area (sf)	CN	Description
190,065	74	>75% Grass cover, Good, HSG C
17,473	96	Gravel surface, HSG C
* 5,505	89	Riprap
270	98	Unconnected pavement, HSG C
* 71	95	ClosureTurf
213,384	76	Weighted Average
213,114		99.87% Pervious Area
270		0.13% Impervious Area
270		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.4	221	0.0200	0.21		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
0.1	35	0.3333	8.66		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.3	178	0.1000	8.63	32.38	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 '/' Top.W=9.00' n= 0.030 Stream, clean & straight
0.4	76	0.0132	3.14	11.76	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 '/' Top.W=9.00' n= 0.030 Stream, clean & straight
0.6	296	0.1000	8.63	32.38	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 '/' Top.W=9.00' n= 0.030 Stream, clean & straight
0.2	61	0.0214	5.48	17.21	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.025 Corrugated metal
0.1	42	0.3333	7.16	41.16	Trap/Vee/Rect Channel Flow, Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00' n= 0.069 Riprap, 6-inch
0.0	9	0.1000	19.60	195.98	Trap/Vee/Rect Channel Flow, Bot.W=15.00' D=0.50' Z= 10.0 '/' Top.W=25.00' n= 0.013 Concrete, trowel finish

19.1 918 Total

Subcatchment S6: Area 6

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S7: Area 7

Runoff = 9.77 cfs @ 11.98 hrs, Volume= 0.457 af, Depth= 2.73"

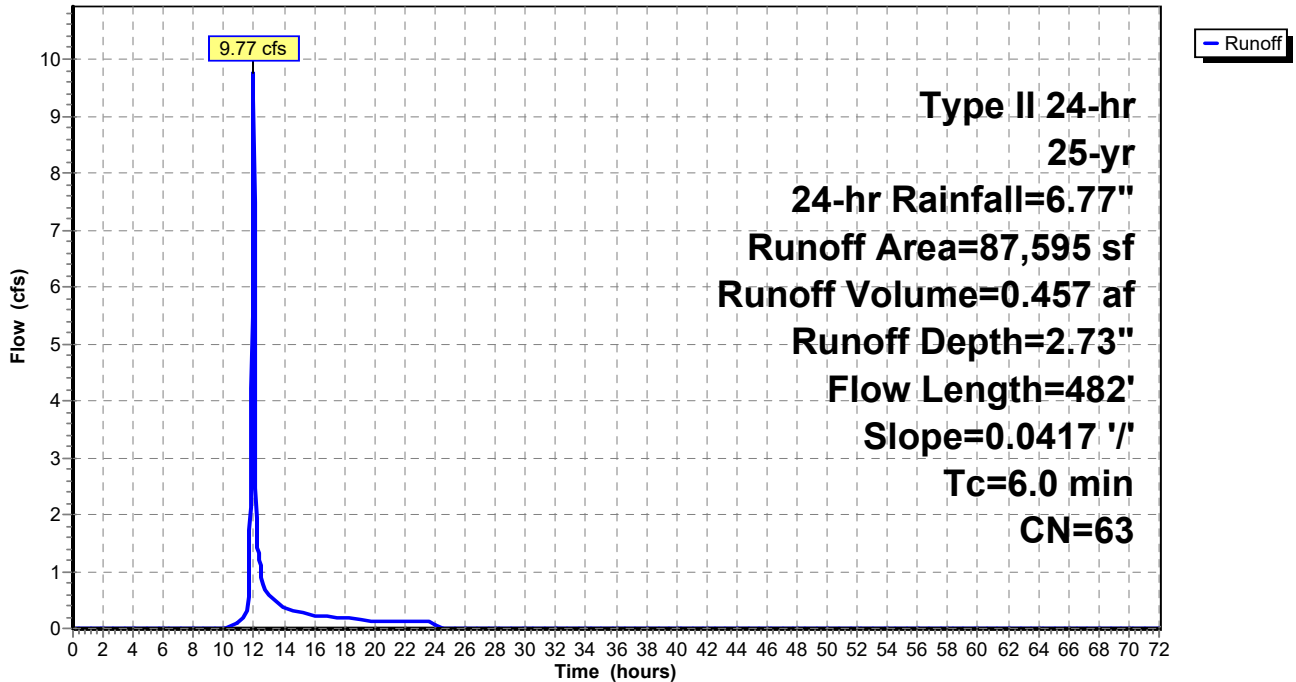
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
34,143	55	Woods, Good, HSG B
43,697	61	>75% Grass cover, Good, HSG B
9,755	96	Gravel surface, HSG B
87,595	63	Weighted Average
87,595		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0	482	0.0417	4.00	13.99	Trap/Vee/Rect Channel Flow, Bot.W=0.00' D=0.50' Z= 3.0 & 25.0 ' Top.W=14.00' n= 0.030 Earth, grassed & winding
2.0	482	Total, Increased to minimum Tc = 6.0 min			

Subcatchment S7: Area 7

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S8: Area 8

Runoff = 3.99 cfs @ 12.03 hrs, Volume= 0.226 af, Depth= 3.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
3,009	82	Dirt roads, HSG B
31,821	61	>75% Grass cover, Good, HSG B
3,745	96	Gravel surface, HSG B
* 487	85	Riprap
39,062	66	Weighted Average
39,062		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	76	0.0213	1.42		Sheet Flow, Smooth surfaces n= 0.011 P2= 3.61"
0.1	13	0.1000	1.85		Sheet Flow, Smooth surfaces n= 0.011 P2= 3.61"
3.0	42	0.0590	0.23		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
6.0	59	0.0200	0.16		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
1.2	452	0.0500	6.11	22.90	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 3.0 '/' Top.W=9.00' n= 0.030 Earth, grassed & winding
11.2	642	Total			

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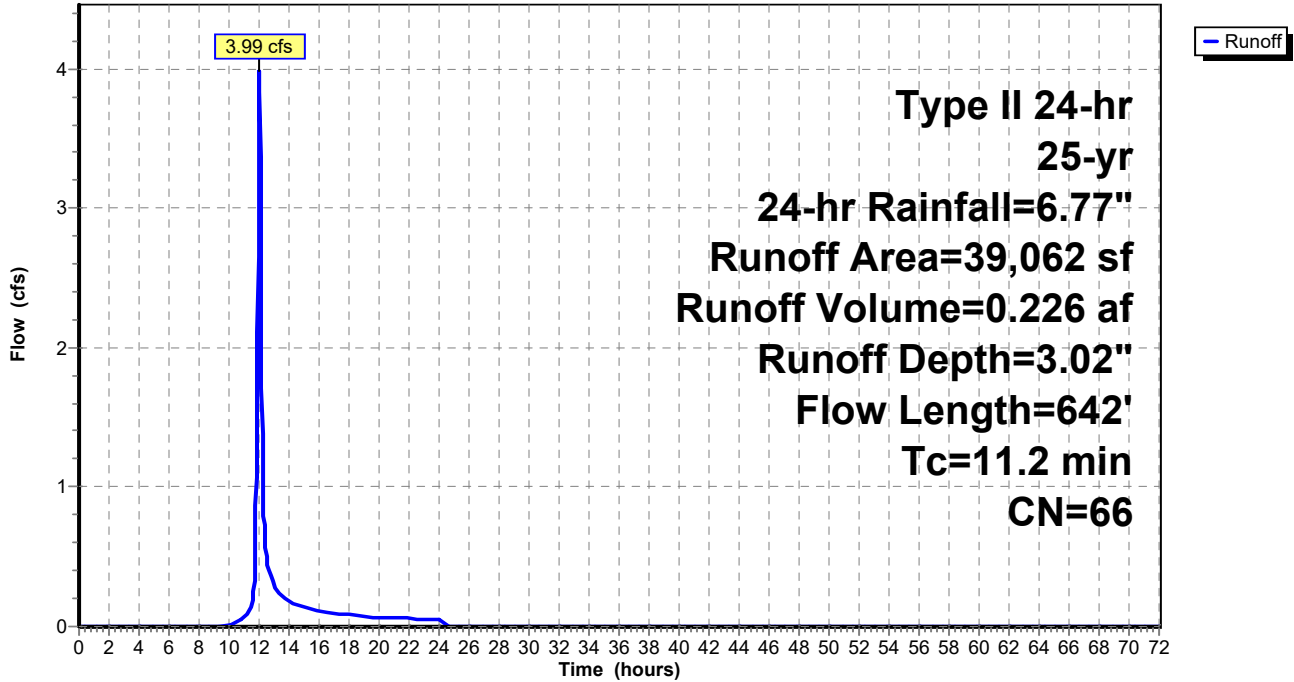
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Subcatchment S8: Area 8

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Subcatchment S9: Area 9

Runoff = 4.47 cfs @ 12.00 hrs, Volume= 0.226 af, Depth= 3.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

Area (sf)	CN	Description
3,009	82	Dirt roads, HSG B
31,821	61	>75% Grass cover, Good, HSG B
3,745	96	Gravel surface, HSG B
* 487	85	Riprap
39,062	66	Weighted Average
39,062		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2	115	0.0050	0.86		Sheet Flow, Smooth surfaces n= 0.011 P2= 3.61"
0.1	15	0.1250	2.08		Sheet Flow, Smooth surfaces n= 0.011 P2= 3.61"
1.8	30	0.1000	0.27		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
3.7	58	0.0667	0.26		Sheet Flow, Grass: Short n= 0.150 P2= 3.61"
0.3	105	0.0500	6.26	21.91	Trap/Vee/Rect Channel Flow, Bot.W=6.00' D=0.50' Z= 2.0 '/' Top.W=8.00' n= 0.030 Earth, grassed & winding
8.1	323	Total			

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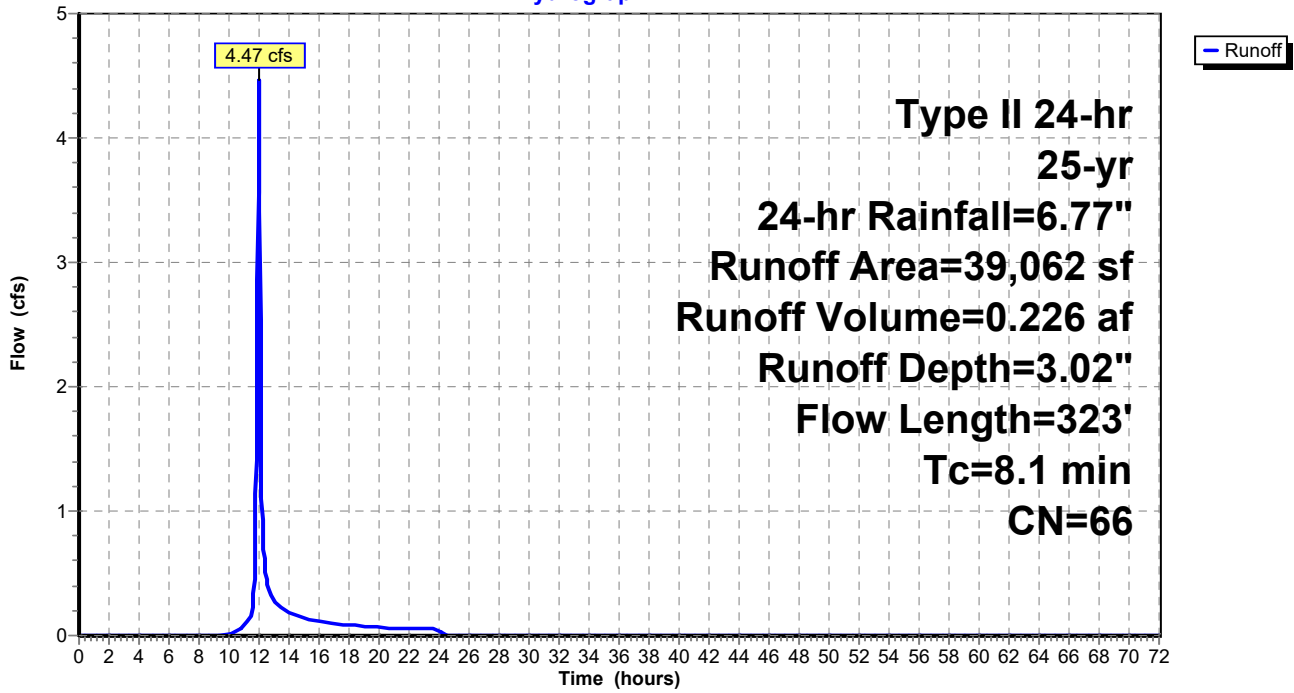
Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Subcatchment S9: Area 9

Hydrograph



Sibley Landfill RORO

Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Pond ST-1: 2x30" CHDPE

Inflow Area = 4.577 ac, 4.91% Impervious, Inflow Depth = 5.37" for 25-yr, 24-hr event
 Inflow = 39.83 cfs @ 11.97 hrs, Volume= 2.048 af
 Outflow = 39.64 cfs @ 11.98 hrs, Volume= 2.048 af, Atten= 0%, Lag= 0.3 min
 Primary = 39.64 cfs @ 11.98 hrs, Volume= 2.048 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Peak Elev= 777.97' @ 11.98 hrs Surf.Area= 543 sf Storage= 543 cf
 Flood Elev= 779.00' Surf.Area= 916 sf Storage= 1,294 cf

Plug-Flow detention time= 0.9 min calculated for 2.048 af (100% of inflow)
 Center-of-Mass det. time= 0.3 min (784.8 - 784.5)

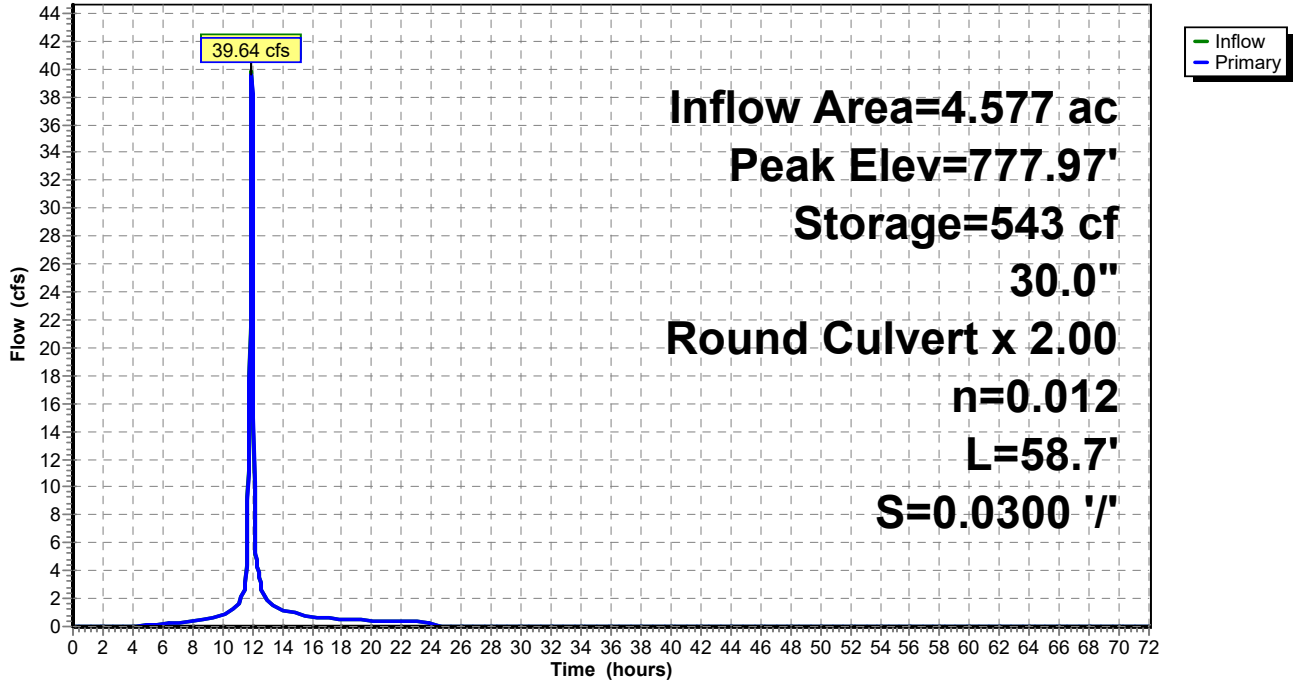
Volume	Invert	Avail.Storage	Storage Description
#1	776.00'	1,294 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
776.00	53	0	0
777.00	257	155	155
778.00	552	405	560
779.00	916	734	1,294

Device	Routing	Invert	Outlet Devices
#1	Primary	776.00'	30.0" Round Culvert X 2.00 L= 58.7' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 776.00' / 774.24' S= 0.0300 ' S= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 4.91 sf

Primary OutFlow Max=39.23 cfs @ 11.98 hrs HW=777.96' (Free Discharge)
 ↑1=Culvert (Inlet Controls 39.23 cfs @ 4.76 fps)

Pond ST-1: 2x30" CHDPE

Hydrograph



Sibley Landfill RORO

Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Pond ST-2: 2x30" CHDPE

Inflow Area = 6.423 ac, 6.37% Impervious, Inflow Depth = 4.81" for 25-yr, 24-hr event
 Inflow = 34.84 cfs @ 12.11 hrs, Volume= 2.575 af
 Outflow = 34.81 cfs @ 12.12 hrs, Volume= 2.575 af, Atten= 0%, Lag= 0.4 min
 Primary = 34.81 cfs @ 12.12 hrs, Volume= 2.575 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Peak Elev= 766.25' @ 12.12 hrs Surf.Area= 530 sf Storage= 531 cf
 Flood Elev= 766.75' Surf.Area= 722 sf Storage= 840 cf

Plug-Flow detention time= 0.9 min calculated for 2.575 af (100% of inflow)
 Center-of-Mass det. time= 0.3 min (810.8 - 810.5)

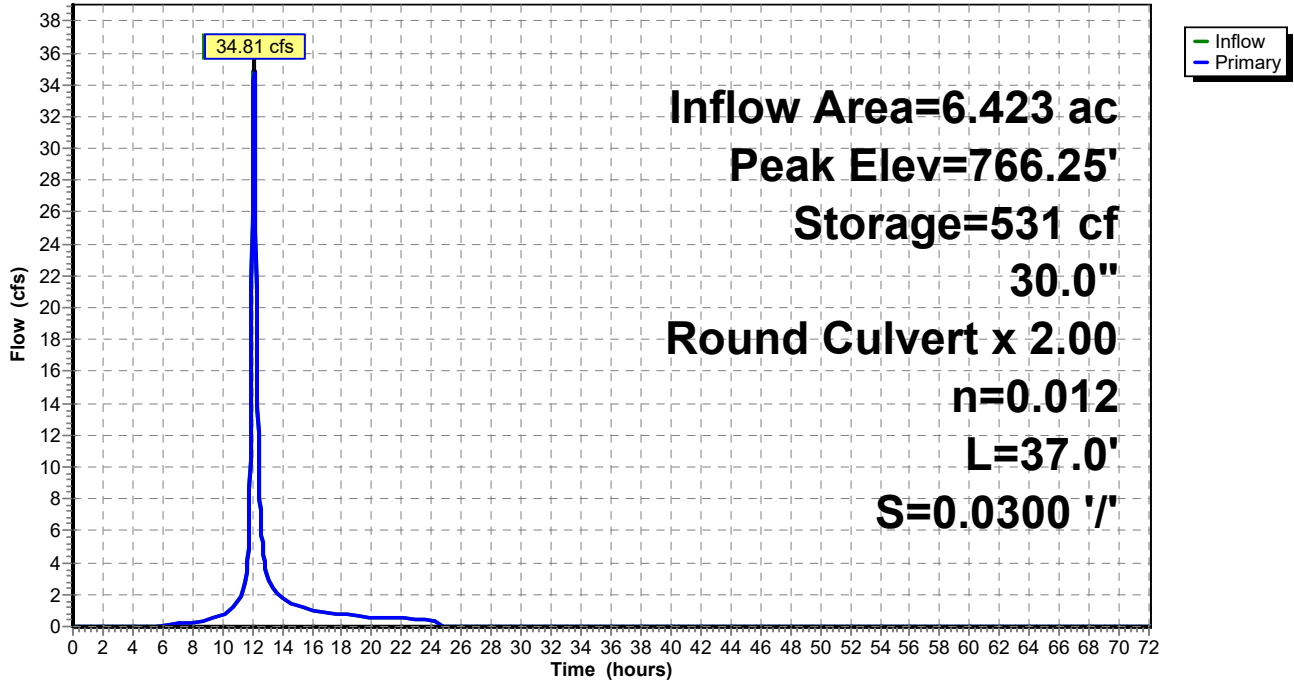
Volume	Invert	Avail.Storage	Storage Description
#1	764.00'	1,033 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
764.00	31	0	0
765.00	173	102	102
766.00	439	306	408
766.50	618	264	672
767.00	825	361	1,033

Device	Routing	Invert	Outlet Devices
#1	Primary	764.13'	30.0" Round Culvert X 2.00 L= 37.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 764.13' / 763.02' S= 0.0300 1' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf

Primary OutFlow Max=34.71 cfs @ 12.12 hrs HW=766.25' TW=764.52' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 34.71 cfs @ 3.91 fps)

Pond ST-2: 2x30" CHDPE

Hydrograph



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Summary for Pond ST-3: 2x36" CMP

Inflow Area = 6.480 ac, 0.00% Impervious, Inflow Depth = 3.95" for 25-yr, 24-hr event
 Inflow = 34.76 cfs @ 12.05 hrs, Volume= 2.132 af
 Outflow = 32.87 cfs @ 12.09 hrs, Volume= 2.132 af, Atten= 5%, Lag= 2.2 min
 Primary = 32.87 cfs @ 12.09 hrs, Volume= 2.132 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Peak Elev= 785.00' @ 12.09 hrs Surf.Area= 4,347 sf Storage= 4,403 cf
 Flood Elev= 786.00' Surf.Area= 7,229 sf Storage= 10,176 cf

Plug-Flow detention time= 2.3 min calculated for 2.131 af (100% of inflow)
 Center-of-Mass det. time= 2.3 min (827.2 - 824.9)

Volume	Invert	Avail.Storage	Storage Description
#1	782.80'	10,176 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
782.80	1	0	0
784.00	2,019	1,212	1,212
785.00	4,340	3,180	4,392
786.00	7,229	5,785	10,176

Device	Routing	Invert	Outlet Devices
#1	Primary	783.30'	36.0" Round Culvert L= 63.2' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 783.30' / 782.90' S= 0.0063 1' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 7.07 sf
#2	Primary	782.80'	36.0" Round Culvert L= 44.0' CMP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 782.80' / 782.10' S= 0.0159 1' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 7.07 sf

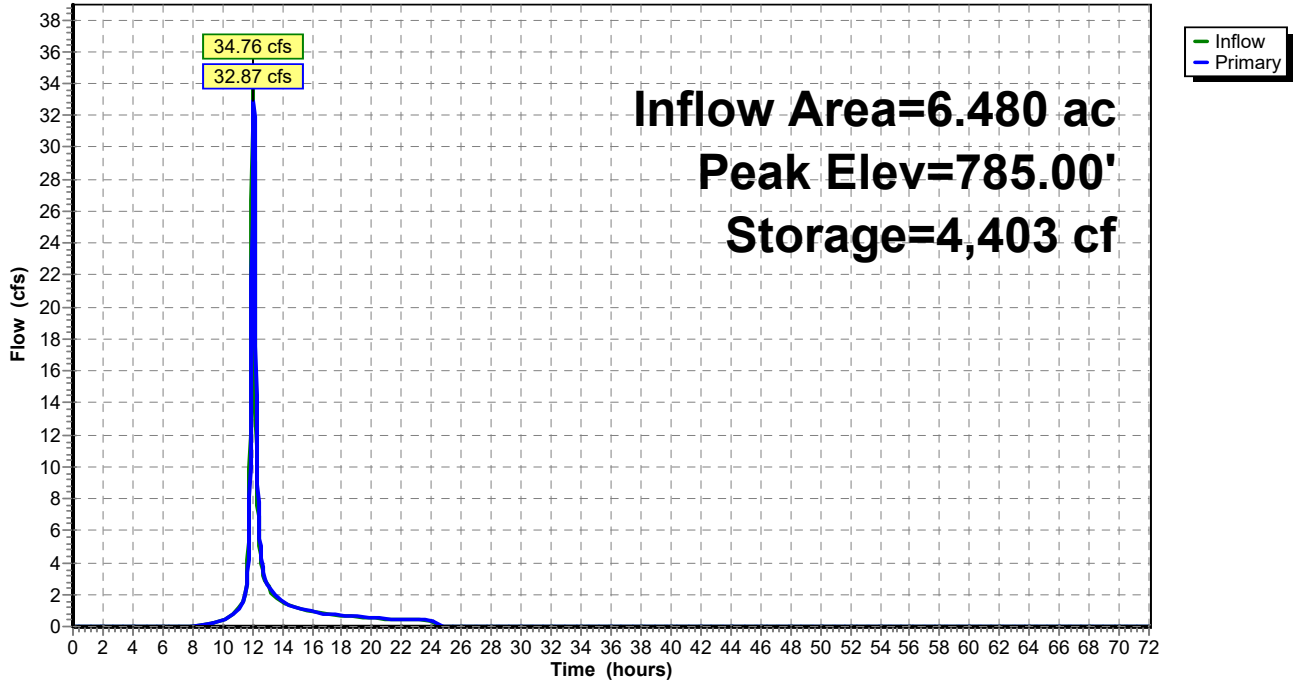
Primary OutFlow Max=32.85 cfs @ 12.09 hrs HW=785.00' (Free Discharge)

1=Culvert (Barrel Controls 10.63 cfs @ 3.71 fps)

2=Culvert (Barrel Controls 22.22 cfs @ 5.57 fps)

Pond ST-3: 2x36" CMP

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Pond ST-4: 30" CHDPE

Inflow Area = 0.569 ac, 0.00% Impervious, Inflow Depth = 4.05" for 25-yr, 24-hr event
 Inflow = 3.02 cfs @ 12.06 hrs, Volume= 0.192 af
 Outflow = 3.02 cfs @ 12.07 hrs, Volume= 0.192 af, Atten= 0%, Lag= 0.1 min
 Primary = 3.02 cfs @ 12.07 hrs, Volume= 0.192 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Peak Elev= 812.77' @ 12.07 hrs Surf.Area= 46 sf Storage= 18 cf

Plug-Flow detention time= 0.1 min calculated for 0.192 af (100% of inflow)
 Center-of-Mass det. time= 0.1 min (823.7 - 823.6)

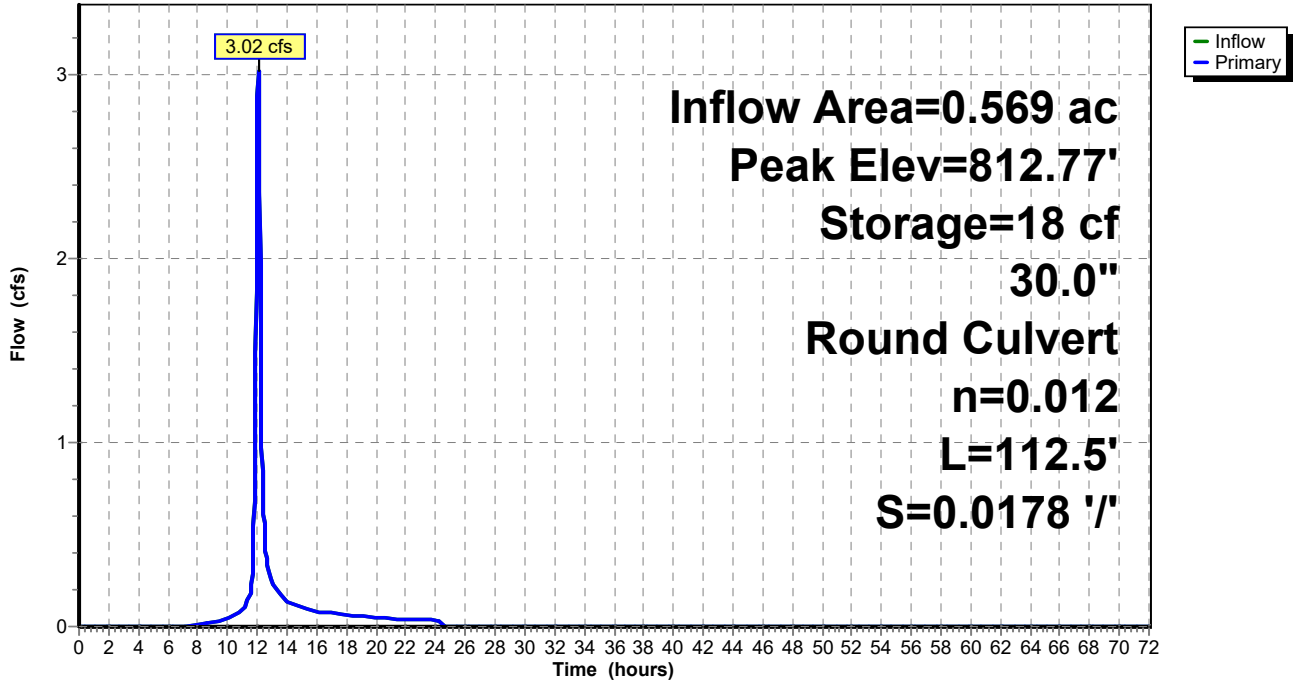
Volume	Invert	Avail.Storage	Storage Description
#1	812.00'	162 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
812.00	1	0	0
813.00	59	30	30
814.00	204	132	162

Device	Routing	Invert	Outlet Devices
#1	Primary	812.00'	30.0" Round Culvert L= 112.5' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 812.00' / 810.00' S= 0.0178 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf

Primary OutFlow Max=3.01 cfs @ 12.07 hrs HW=812.77' TW=806.69' (Dynamic Tailwater)
 ↑1=Culvert (Inlet Controls 3.01 cfs @ 2.35 fps)

Pond ST-4: 30" CHDPE

Hydrograph



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Summary for Pond ST-5: 2x24" CHDPE

Inflow Area = 4.575 ac, 0.06% Impervious, Inflow Depth = 3.95" for 25-yr, 24-hr event
 Inflow = 29.34 cfs @ 12.00 hrs, Volume= 1.505 af
 Outflow = 29.15 cfs @ 12.00 hrs, Volume= 1.505 af, Atten= 1%, Lag= 0.4 min
 Primary = 29.15 cfs @ 12.00 hrs, Volume= 1.505 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Peak Elev= 798.91' @ 12.00 hrs Surf.Area= 445 sf Storage= 336 cf
 Flood Elev= 799.00' Surf.Area= 474 sf Storage= 376 cf

Plug-Flow detention time= 0.1 min calculated for 1.504 af (100% of inflow)
 Center-of-Mass det. time= 0.1 min (820.2 - 820.1)

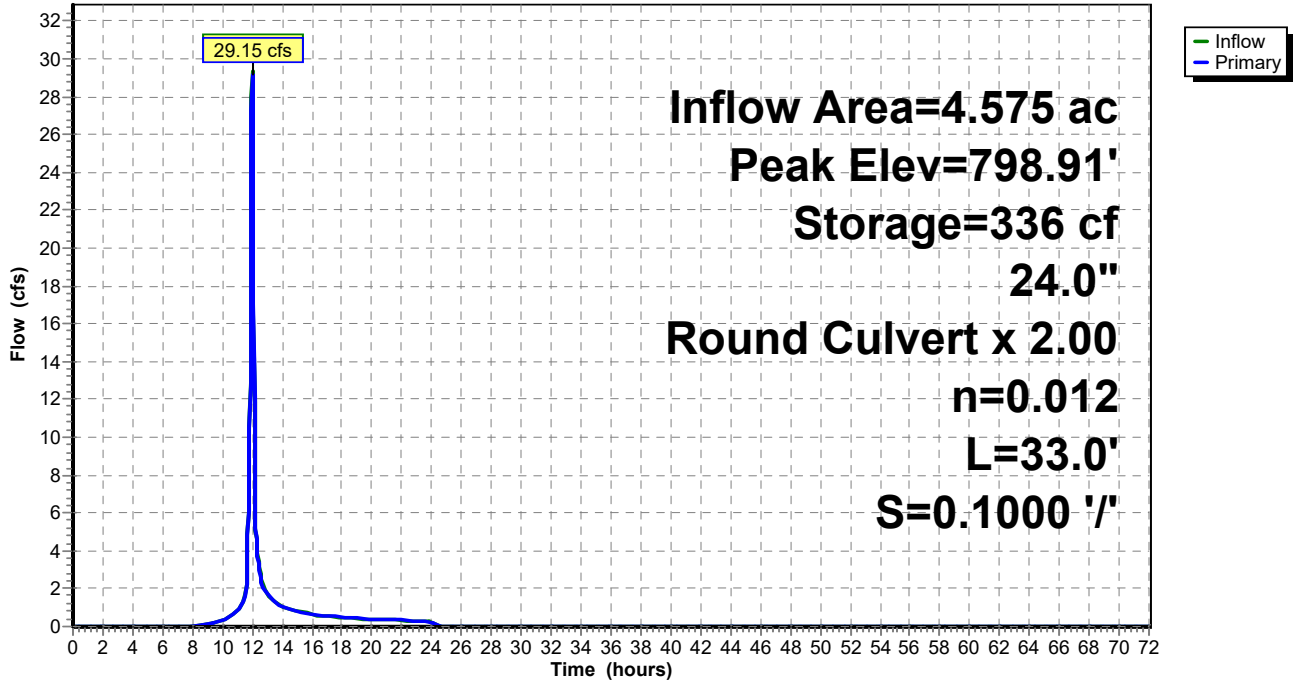
Volume	Invert	Avail.Storage	Storage Description
#1	797.00'	376 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
797.00	9	0	0
798.00	134	72	72
799.00	474	304	376

Device	Routing	Invert	Outlet Devices
#1	Primary	797.00'	24.0" Round Culvert X 2.00 L= 33.0' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 797.00' / 793.70' S= 0.1000 ' S= 0.1000 ' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=29.03 cfs @ 12.00 hrs HW=798.91' (Free Discharge)
 ↑1=Culvert (Inlet Controls 29.03 cfs @ 4.70 fps)

Pond ST-5: 2x24" CHDPE

Hydrograph



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Summary for Pond ST-7: 2x36" CHDPE

Inflow Area = 8.434 ac, 4.85% Impervious, Inflow Depth = 4.31" for 25-yr, 24-hr event
 Inflow = 37.69 cfs @ 12.09 hrs, Volume= 3.033 af
 Outflow = 37.68 cfs @ 12.09 hrs, Volume= 3.033 af, Atten= 0%, Lag= 0.1 min
 Primary = 37.68 cfs @ 12.09 hrs, Volume= 3.033 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Peak Elev= 764.53' @ 12.09 hrs Surf.Area= 329 sf Storage= 257 cf

Plug-Flow detention time= 0.1 min calculated for 3.031 af (100% of inflow)
 Center-of-Mass det. time= 0.1 min (816.1 - 816.0)

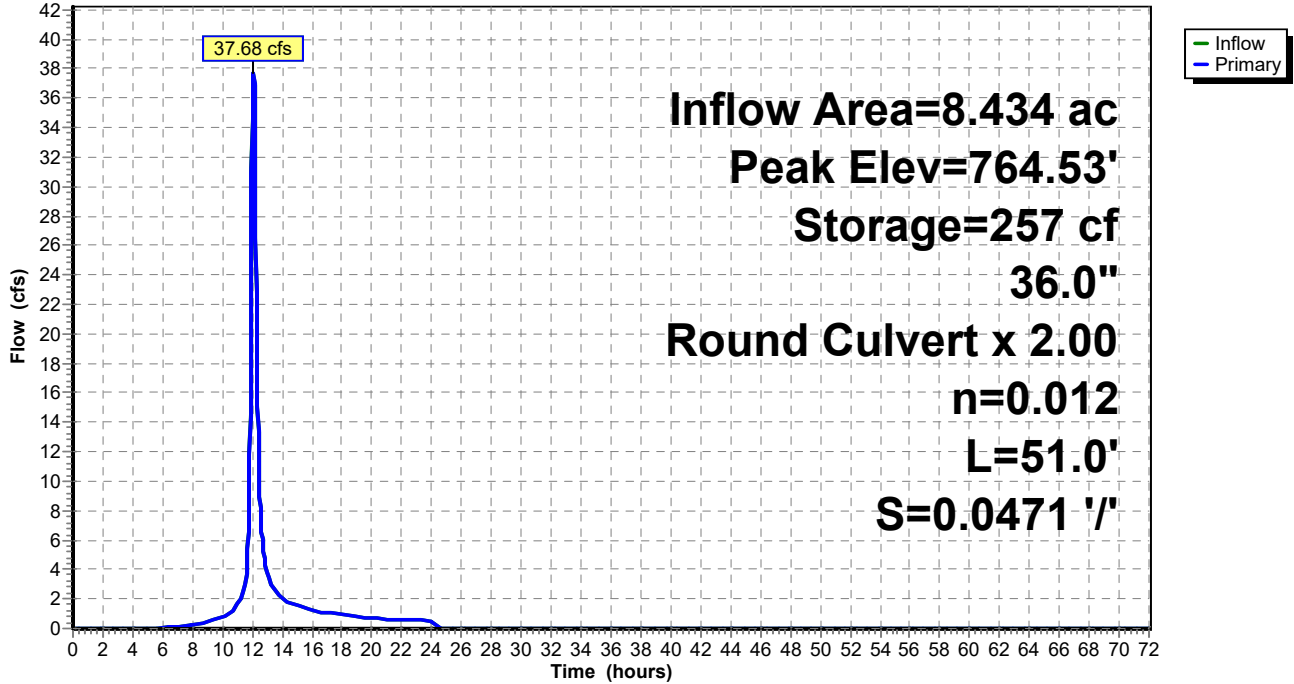
Volume	Invert	Avail.Storage	Storage Description
#1	762.80'	1,071 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
762.80	0	0	0
763.00	45	5	5
764.00	188	117	121
765.00	455	322	443
766.00	802	629	1,071

Device	Routing	Invert	Outlet Devices
#1	Primary	762.80'	36.0" Round Culvert X 2.00 L= 51.0' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 762.80' / 760.40' S= 0.0471 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 7.07 sf

Primary OutFlow Max=37.66 cfs @ 12.09 hrs HW=764.53' (Free Discharge)
 ↑1=Culvert (Inlet Controls 37.66 cfs @ 4.47 fps)

Pond ST-7: 2x36" CHDPE

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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Summary for Pond ST-9: 18" CMP

Inflow Area = 1.466 ac, 0.00% Impervious, Inflow Depth = 3.42" for 25-yr, 24-hr event
 Inflow = 7.12 cfs @ 12.02 hrs, Volume= 0.418 af
 Outflow = 6.99 cfs @ 12.03 hrs, Volume= 0.418 af, Atten= 2%, Lag= 1.1 min
 Primary = 6.99 cfs @ 12.03 hrs, Volume= 0.418 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs
 Peak Elev= 806.79' @ 12.03 hrs Surf.Area= 255 sf Storage= 231 cf

Plug-Flow detention time= 1.4 min calculated for 0.418 af (100% of inflow)
 Center-of-Mass det. time= 1.0 min (833.6 - 832.6)

Volume	Invert	Avail.Storage	Storage Description
#1	804.50'	1,876 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

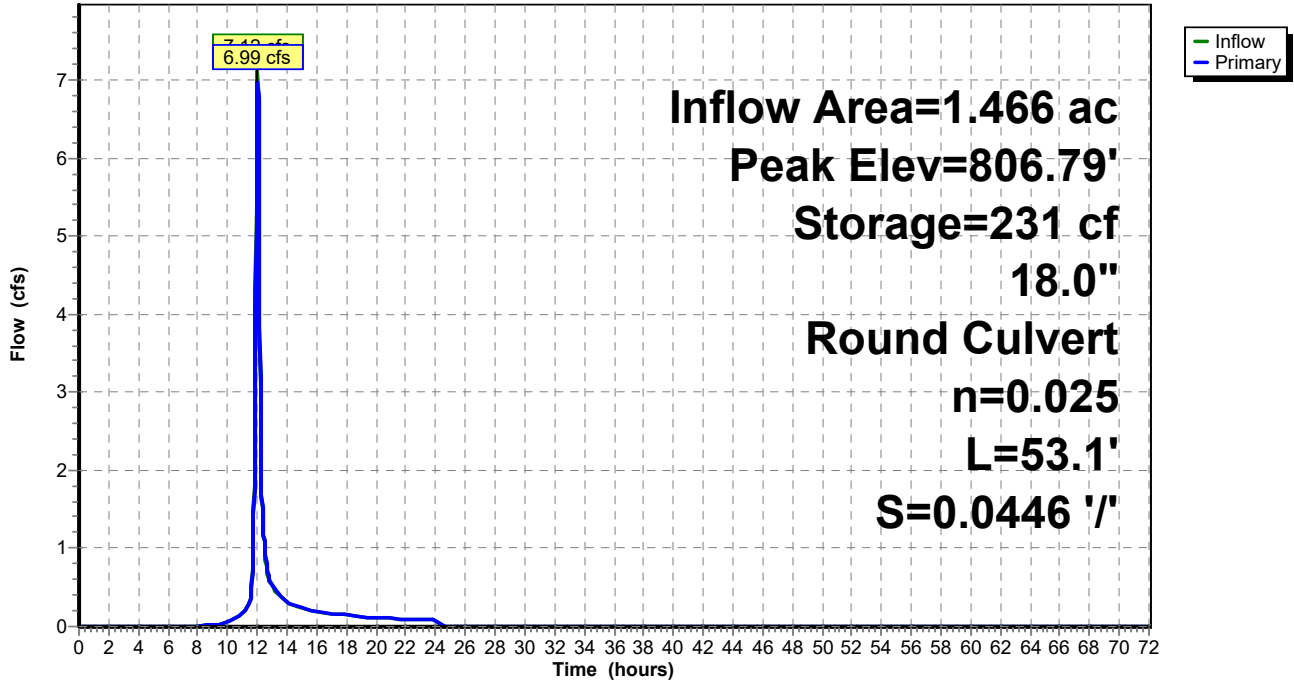
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
804.50	10	0	0
805.00	50	15	15
806.00	100	75	90
807.00	296	198	288
808.00	727	512	800
809.00	1,426	1,077	1,876

Device	Routing	Invert	Outlet Devices
#1	Primary	804.96'	18.0" Round Culvert L= 53.1' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 804.96' / 802.59' S= 0.0446 ' S= 0.0446 ' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 1.77 sf

Primary OutFlow Max=6.96 cfs @ 12.03 hrs HW=806.78' TW=0.00' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 6.96 cfs @ 3.94 fps)

Pond ST-9: 18" CMP

Hydrograph



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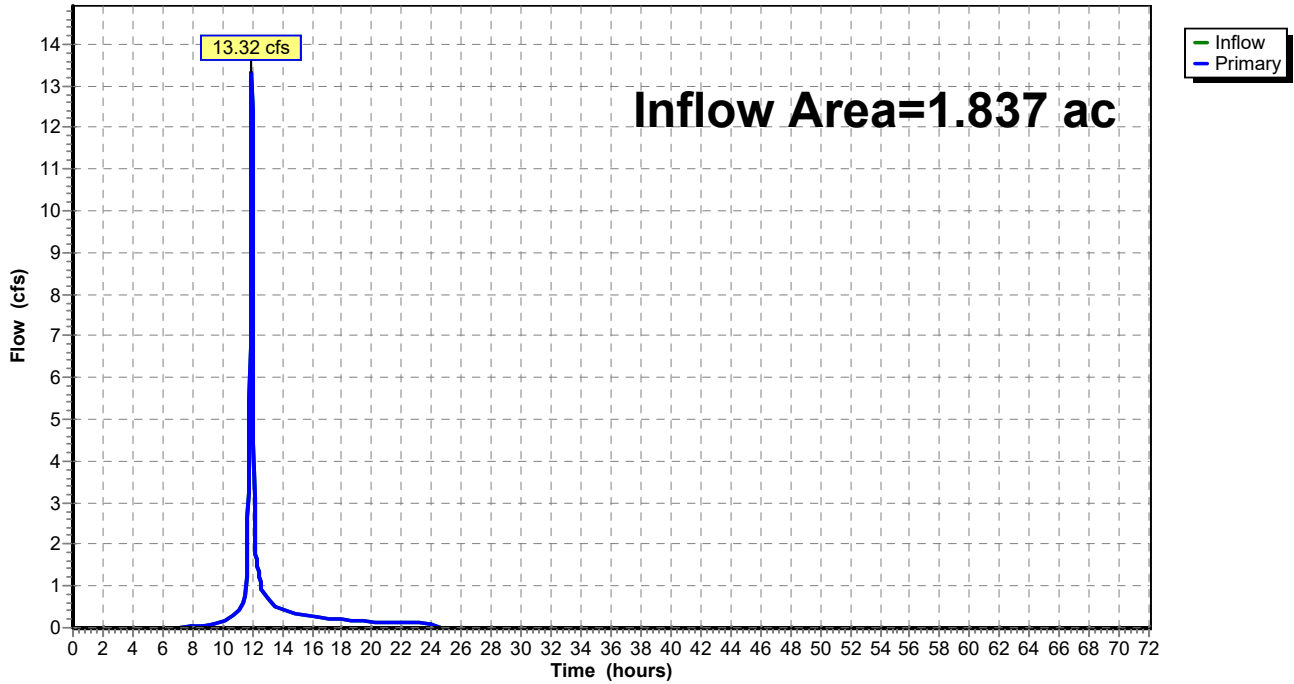
Summary for Link 1AL: Perimeter Ditch (grassed)

Inflow Area = 1.837 ac, 0.00% Impervious, Inflow Depth = 4.16" for 25-yr, 24-hr event
Inflow = 13.32 cfs @ 11.97 hrs, Volume= 0.637 af
Primary = 13.32 cfs @ 11.97 hrs, Volume= 0.637 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 1AL: Perimeter Ditch (grassed)

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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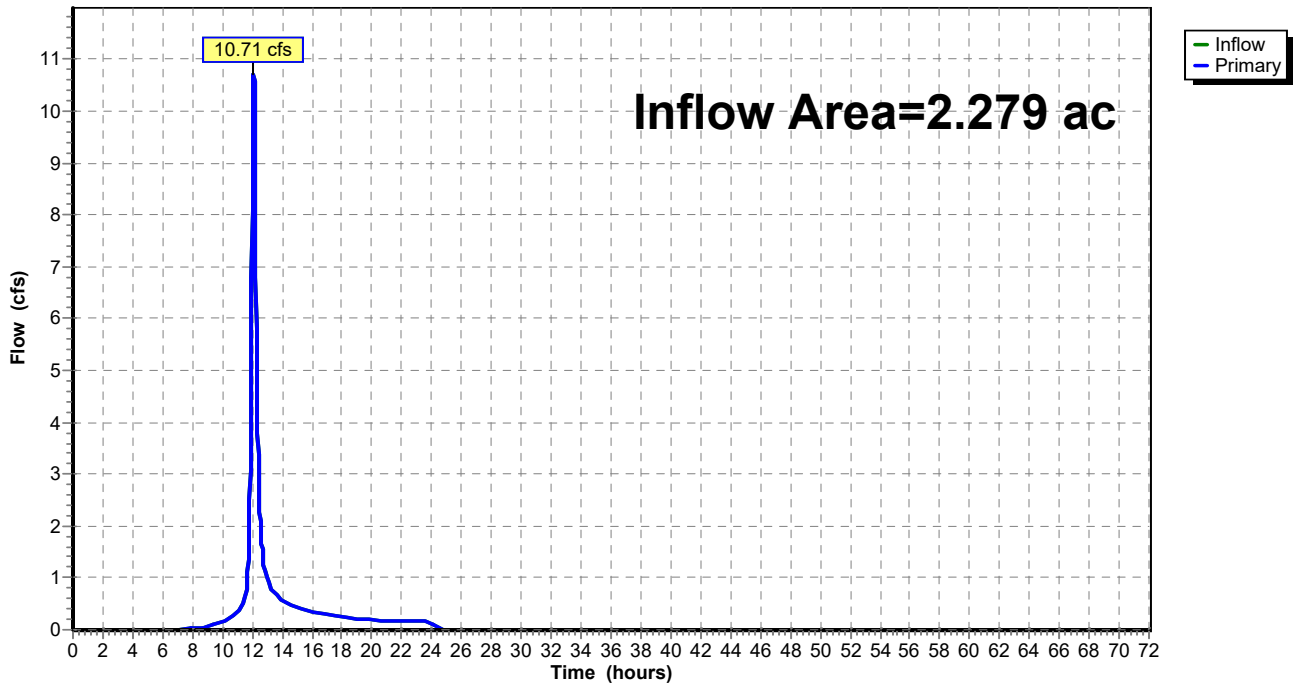
Summary for Link 2AL: Letdown

Inflow Area = 2.279 ac, 0.00% Impervious, Inflow Depth = 3.95" for 25-yr, 24-hr event
Inflow = 10.71 cfs @ 12.10 hrs, Volume= 0.750 af
Primary = 10.71 cfs @ 12.10 hrs, Volume= 0.750 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 2AL: Letdown

Hydrograph



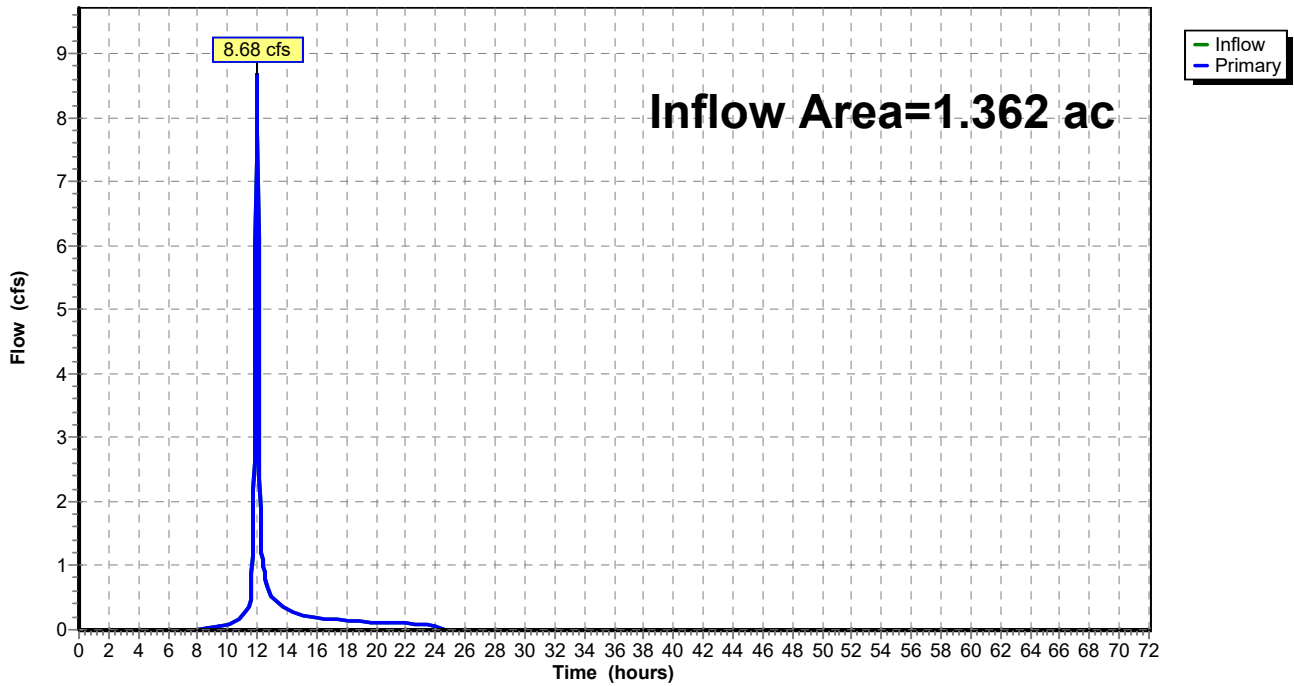
Summary for Link 5AL: Perimeter Ditch (grassed)

Inflow Area = 1.362 ac, 0.00% Impervious, Inflow Depth = 3.84" for 25-yr, 24-hr event
Inflow = 8.68 cfs @ 11.99 hrs, Volume= 0.436 af
Primary = 8.68 cfs @ 11.99 hrs, Volume= 0.436 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 5AL: Perimeter Ditch (grassed)

Hydrograph



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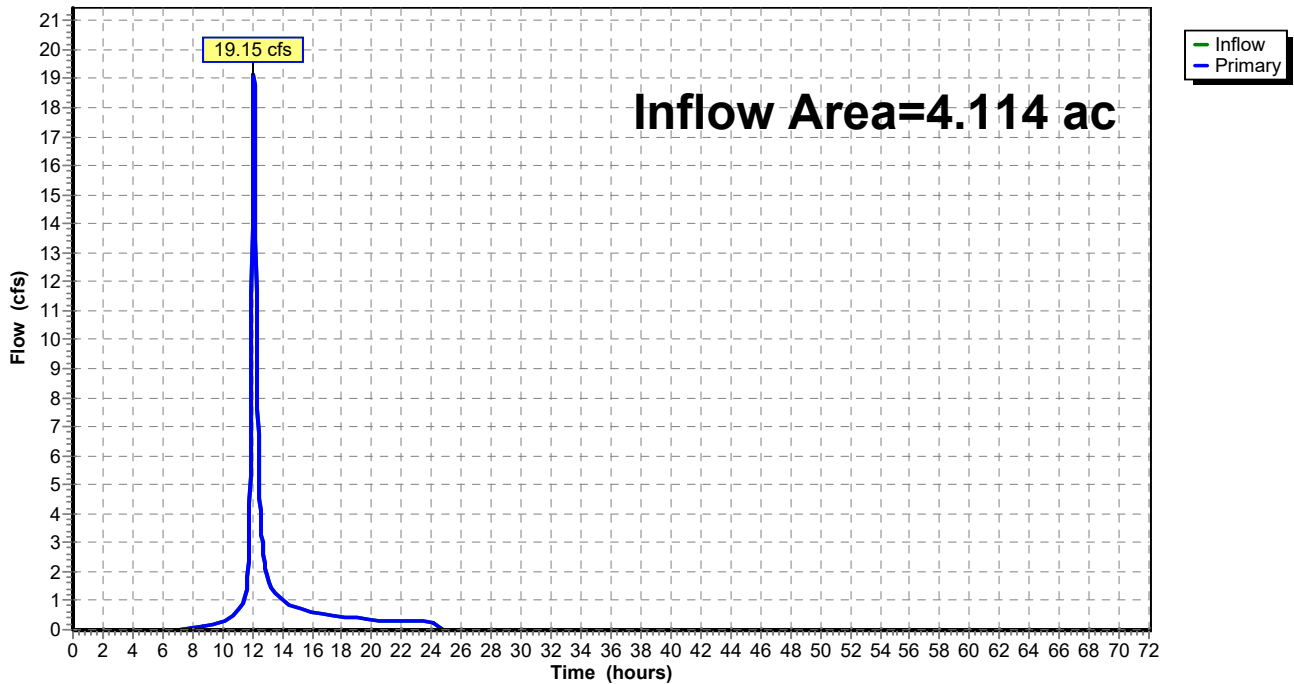
Summary for Link 6AL: Access Road Ditch

Inflow Area = 4.114 ac, 0.00% Impervious, Inflow Depth = 4.05" for 25-yr, 24-hr event
Inflow = 19.15 cfs @ 12.11 hrs, Volume= 1.389 af
Primary = 19.15 cfs @ 12.11 hrs, Volume= 1.389 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 6AL: Access Road Ditch

Hydrograph



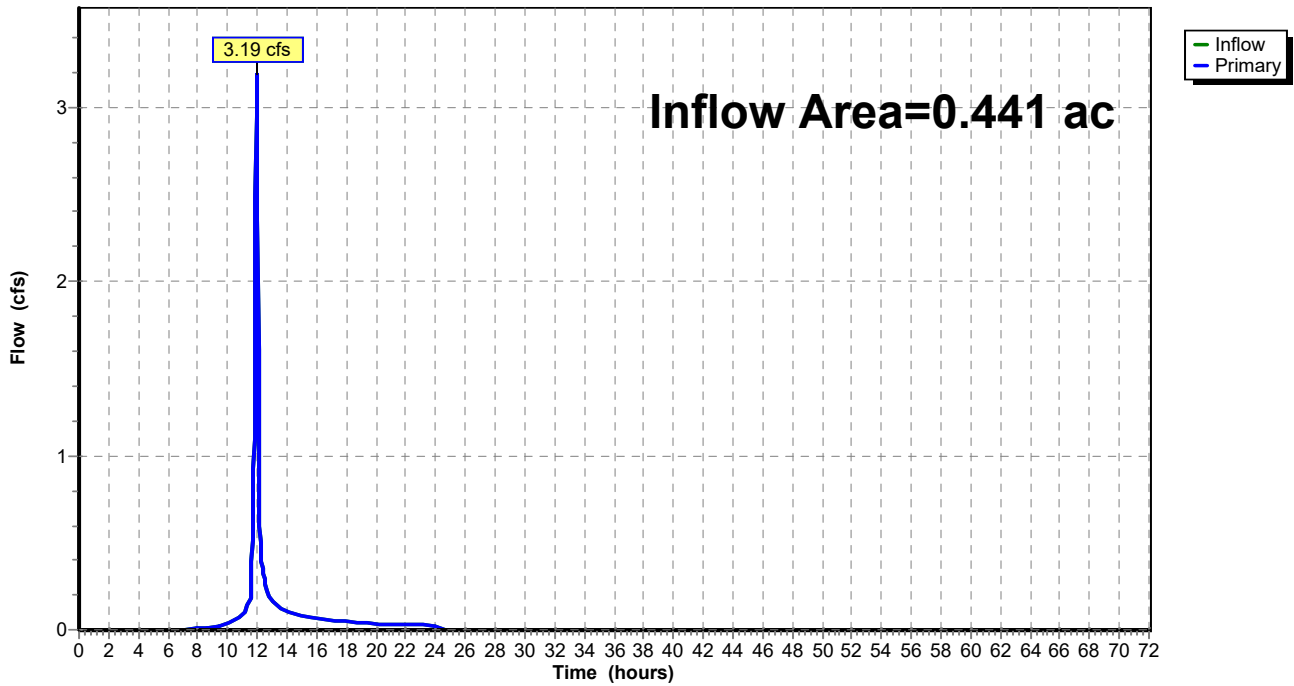
Summary for Link 6BL: Perimeter Ditch

Inflow Area = 0.441 ac, 0.00% Impervious, Inflow Depth = 4.16" for 25-yr, 24-hr event
Inflow = 3.19 cfs @ 11.97 hrs, Volume= 0.153 af
Primary = 3.19 cfs @ 11.97 hrs, Volume= 0.153 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 6BL: Perimeter Ditch

Hydrograph



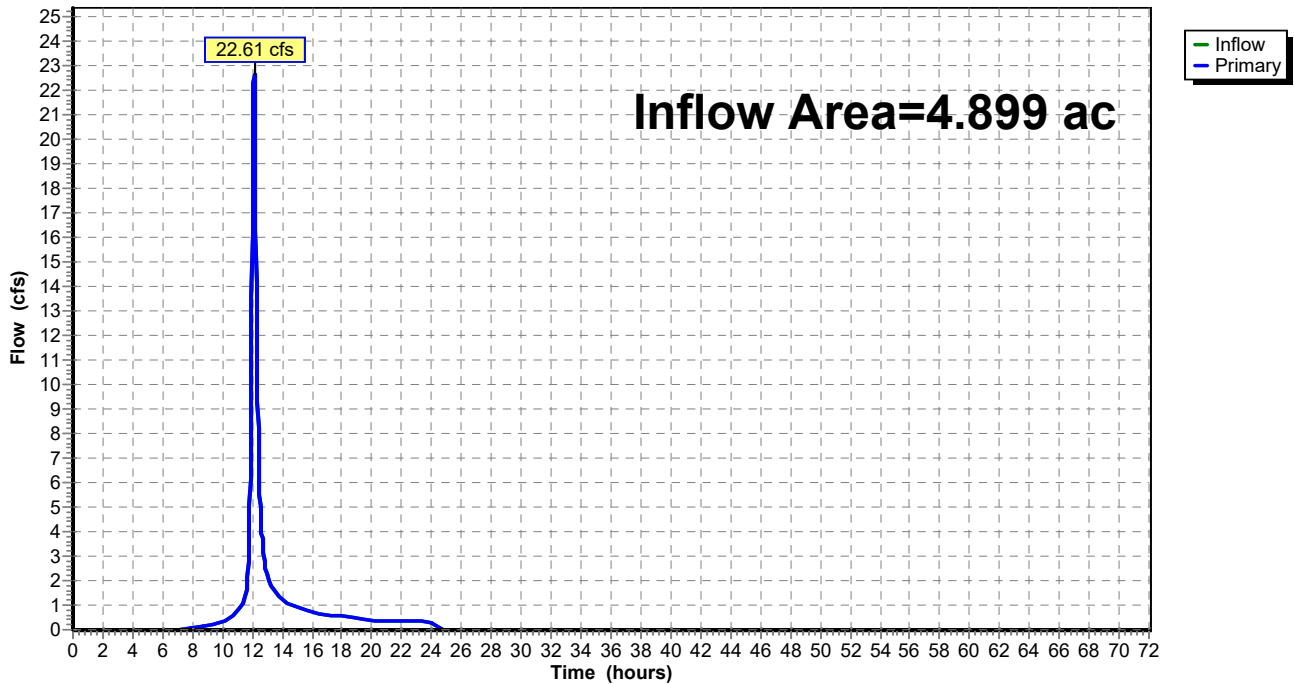
Summary for Link 6L: Low Water Crossing

Inflow Area = 4.899 ac, 0.13% Impervious, Inflow Depth = 4.05" for 25-yr, 24-hr event
Inflow = 22.61 cfs @ 12.12 hrs, Volume= 1.655 af
Primary = 22.61 cfs @ 12.12 hrs, Volume= 1.655 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 6L: Low Water Crossing

Hydrograph



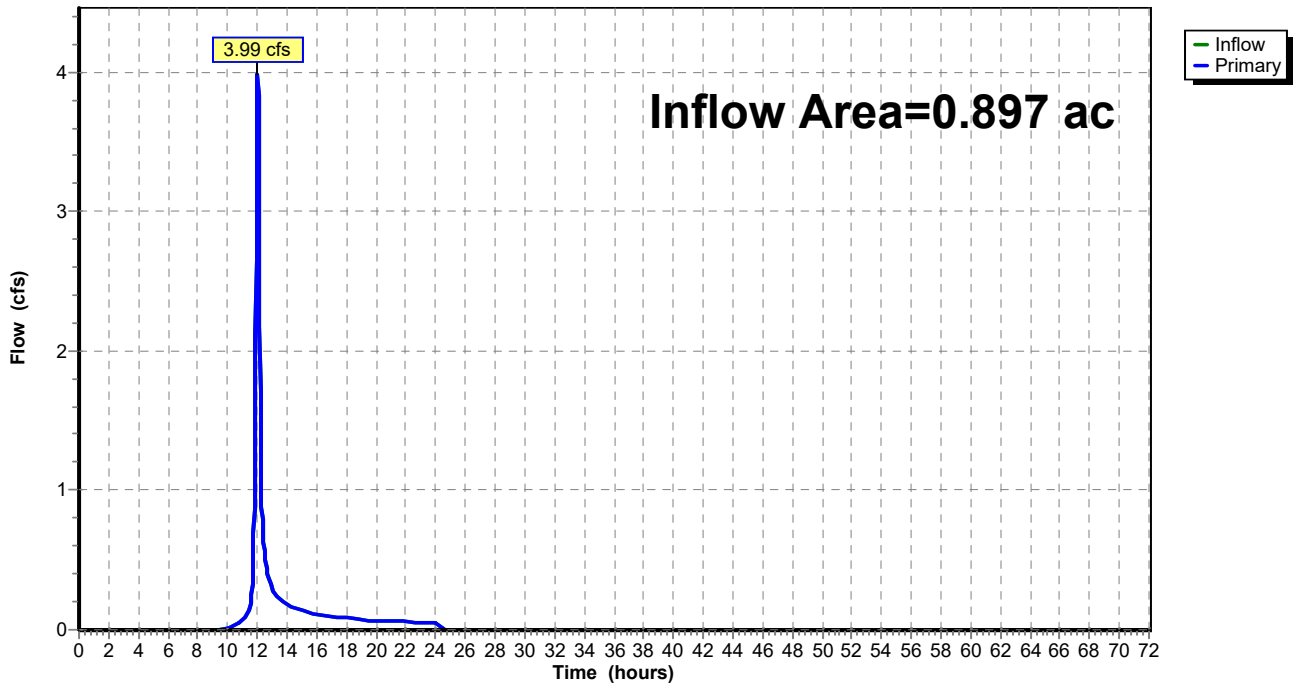
Summary for Link 8L:

Inflow Area = 0.897 ac, 0.00% Impervious, Inflow Depth = 3.02" for 25-yr, 24-hr event
Inflow = 3.99 cfs @ 12.03 hrs, Volume= 0.226 af
Primary = 3.99 cfs @ 12.03 hrs, Volume= 0.226 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 8L:

Hydrograph



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Type II 24-hr 25-yr, 24-hr Rainfall=6.77"

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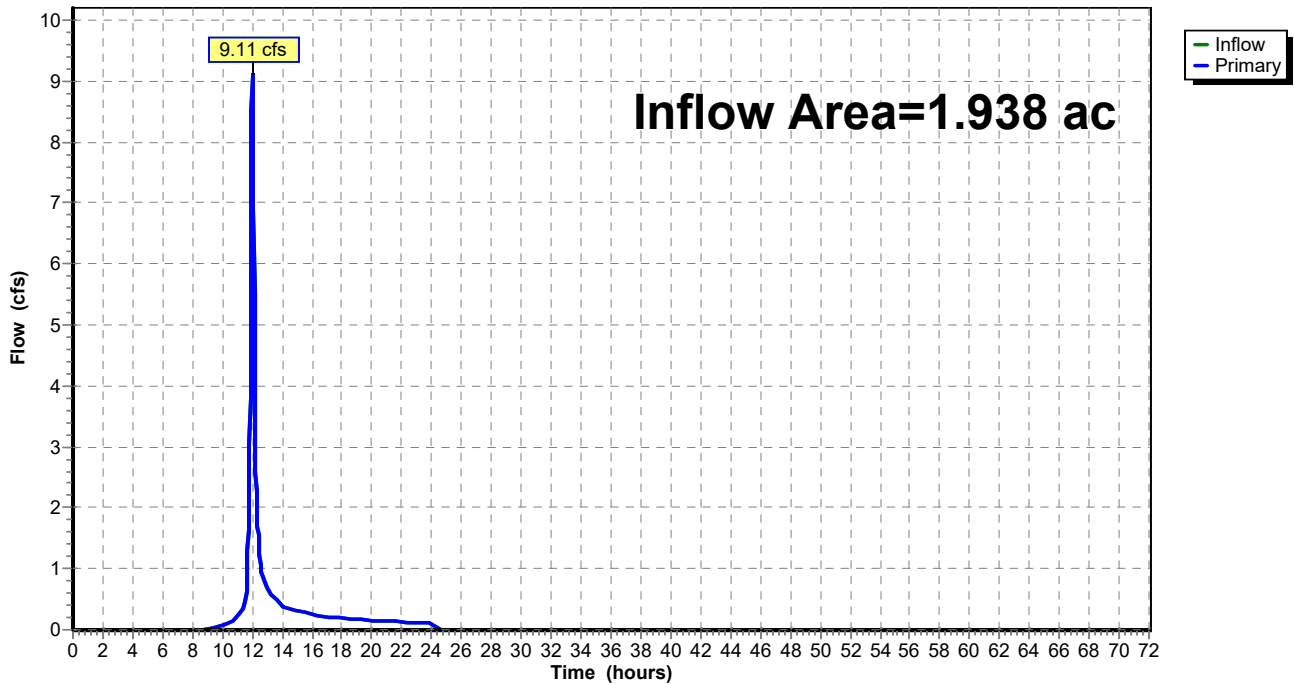
Summary for Link 10L:

Inflow Area = 1.938 ac, 0.00% Impervious, Inflow Depth = 3.32" for 25-yr, 24-hr event
Inflow = 9.11 cfs @ 12.01 hrs, Volume= 0.537 af
Primary = 9.11 cfs @ 12.01 hrs, Volume= 0.537 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.03 hrs

Link 10L:

Hydrograph



ATTACHMENT 4 – FLOWMASTER WORKSHEETS

Worksheet for Letdown Channel

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.069
Channel Slope	0.333
Normal Depth	24.0
Left Side Slope	3.000
Right Side Slope	3.000
Bottom Width	10.00
Results	
Discharge	500.96
Flow Area	32.0
Wetted Perimeter	22.6
Hydraulic Radius	17.0
Top Width	22.00
Critical Depth	37.6
Critical Slope	0.057
Velocity	15.65
Velocity Head	3.81
Specific Energy	5.81
Froude Number	2.288
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	37.6
Channel Slope	0.333
Critical Slope	0.057

Worksheet for A1 Perimeter Ditch - Paved

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.017
Channel Slope	0.040
Normal Depth	24.0
Left Side Slope	3.000
Right Side Slope	3.000
Bottom Width	6.00
Results	
Discharge	496.39
Flow Area	24.0
Wetted Perimeter	18.6
Hydraulic Radius	15.4
Top Width	18.00
Critical Depth	42.7
Critical Slope	0.003
Velocity	20.68
Velocity Head	6.65
Specific Energy	8.65
Froude Number	3.158
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	42.7
Channel Slope	0.040
Critical Slope	0.003

Worksheet for A1 Perimeter Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.067
Normal Depth	24.0
Left Side Slope	3.000
Right Side Slope	3.000
Bottom Width	6.00
Results	
Discharge	363.15
Flow Area	24.0
Wetted Perimeter	18.6
Hydraulic Radius	15.4
Top Width	18.00
Critical Depth	36.7
Critical Slope	0.011
Velocity	15.13
Velocity Head	3.56
Specific Energy	5.56
Froude Number	2.310
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	36.7
Channel Slope	0.067
Critical Slope	0.011

Worksheet for A1 30" CHDPE - 3%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.012
Channel Slope	0.030
Normal Depth	30.0
Diameter	30.0
Discharge	76.96
Results	
Discharge	76.96
Normal Depth	30.0
Flow Area	4.9
Wetted Perimeter	7.9
Hydraulic Radius	7.5
Top Width	0.00
Critical Depth	29.5
Percent Full	100.0
Critical Slope	0.027
Velocity	15.68
Velocity Head	3.82
Specific Energy	6.32
Froude Number	(N/A)
Maximum Discharge	82.79
Discharge Full	76.96
Slope Full	0.030
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	30.0
Critical Depth	29.5
Channel Slope	0.030
Critical Slope	0.027

Worksheet for A2 Perimeter Ditch - Paved

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.017
Channel Slope	0.067
Normal Depth	12.0
Left Side Slope	15.000
Right Side Slope	6.000
Bottom Width	8.00
Results	
Discharge	308.59
Flow Area	18.5
Wetted Perimeter	29.1
Hydraulic Radius	7.6
Top Width	29.00
Critical Depth	22.5
Critical Slope	0.004
Velocity	16.68
Velocity Head	4.32
Specific Energy	5.32
Froude Number	3.682
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	12.0
Critical Depth	22.5
Channel Slope	0.067
Critical Slope	0.004

Worksheet for A2 30" CHDPE - 3%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.012
Channel Slope	0.030
Normal Depth	30.0
Diameter	30.0
Discharge	76.96
Results	
Discharge	76.96
Normal Depth	30.0
Flow Area	4.9
Wetted Perimeter	7.9
Hydraulic Radius	7.5
Top Width	0.00
Critical Depth	29.5
Percent Full	100.0
Critical Slope	0.027
Velocity	15.68
Velocity Head	3.82
Specific Energy	6.32
Froude Number	(N/A)
Maximum Discharge	82.79
Discharge Full	76.96
Slope Full	0.030
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	30.0
Critical Depth	29.5
Channel Slope	0.030
Critical Slope	0.027

Worksheet for A3 Perimeter Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.005
Normal Depth	24.0
Left Side Slope	6.000
Right Side Slope	6.000
Bottom Width	8.00
Results	
Discharge	161.45
Flow Area	40.0
Wetted Perimeter	32.3
Hydraulic Radius	14.8
Top Width	32.00
Critical Depth	19.1
Critical Slope	0.013
Velocity	4.04
Velocity Head	0.25
Specific Energy	2.25
Froude Number	0.636
Flow Type	Subcritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	19.1
Channel Slope	0.005
Critical Slope	0.013

Worksheet for A3 36" CMP - 0.63%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.025
Channel Slope	0.006
Normal Depth	36.0
Diameter	36.0
Discharge	27.53
Results	
Discharge	27.53
Normal Depth	36.0
Flow Area	7.1
Wetted Perimeter	9.4
Hydraulic Radius	9.0
Top Width	0.00
Critical Depth	20.4
Percent Full	100.0
Critical Slope	0.017
Velocity	3.89
Velocity Head	0.24
Specific Energy	3.24
Froude Number	(N/A)
Maximum Discharge	29.61
Discharge Full	27.53
Slope Full	0.006
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	0.0
Downstream Velocity	0.00
Upstream Velocity	0.00
Normal Depth	36.0
Critical Depth	20.4
Channel Slope	0.006
Critical Slope	0.017

Worksheet for A4 30" CHDPE - 1.8%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.012
Channel Slope	0.018
Normal Depth	30.0
Diameter	30.0
Discharge	59.28
Results	
Discharge	59.28
Normal Depth	30.0
Flow Area	4.9
Wetted Perimeter	7.9
Hydraulic Radius	7.5
Top Width	0.00
Critical Depth	28.7
Percent Full	100.0
Critical Slope	0.015
Velocity	12.08
Velocity Head	2.27
Specific Energy	4.77
Froude Number	(N/A)
Maximum Discharge	63.77
Discharge Full	59.28
Slope Full	0.018
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	30.0
Critical Depth	28.7
Channel Slope	0.018
Critical Slope	0.015

Worksheet for A5 Perimeter Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.007
Normal Depth	9.0
Left Side Slope	3.000
Right Side Slope	3.000
Bottom Width	3.00
Results	
Discharge	10.40
Flow Area	3.9
Wetted Perimeter	7.7
Hydraulic Radius	6.1
Top Width	7.50
Critical Depth	7.1
Critical Slope	0.018
Velocity	2.64
Velocity Head	0.11
Specific Energy	0.86
Froude Number	0.642
Flow Type	Subcritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	9.0
Critical Depth	7.1
Channel Slope	0.007
Critical Slope	0.018

Worksheet for A5 24" CHDPE - 10%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.012
Channel Slope	0.100
Normal Depth	24.0
Diameter	24.0
Discharge	77.50
Results	
Discharge	77.50
Normal Depth	24.0
Flow Area	3.1
Wetted Perimeter	6.3
Hydraulic Radius	6.0
Top Width	0.00
Critical Depth	24.0
Percent Full	100.0
Critical Slope	0.097
Velocity	24.67
Velocity Head	9.46
Specific Energy	11.46
Froude Number	(N/A)
Maximum Discharge	83.36
Discharge Full	77.50
Slope Full	0.100
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	24.0
Channel Slope	0.100
Critical Slope	0.097

Worksheet for A6 Access Road Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.100
Normal Depth	12.0
Left Side Slope	3.000
Right Side Slope	3.000
Bottom Width	6.00
Results	
Discharge	114.31
Flow Area	9.0
Wetted Perimeter	12.3
Hydraulic Radius	8.8
Top Width	12.00
Critical Depth	20.3
Critical Slope	0.013
Velocity	12.70
Velocity Head	2.51
Specific Energy	3.51
Froude Number	2.586
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	12.0
Critical Depth	20.3
Channel Slope	0.100
Critical Slope	0.013

Worksheet for A6 24" CHDPE - 2.1%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.012
Channel Slope	0.021
Normal Depth	24.0
Diameter	24.0
Discharge	35.85
Results	
Discharge	35.85
Normal Depth	24.0
Flow Area	3.1
Wetted Perimeter	6.3
Hydraulic Radius	6.0
Top Width	0.00
Critical Depth	23.1
Percent Full	100.0
Critical Slope	0.019
Velocity	11.41
Velocity Head	2.02
Specific Energy	4.02
Froude Number	(N/A)
Maximum Discharge	38.56
Discharge Full	35.85
Slope Full	0.021
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	23.1
Channel Slope	0.021
Critical Slope	0.019

Worksheet for A6 Low Water Crossing

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.100
Normal Depth	12.0
Left Side Slope	10.000
Right Side Slope	10.000
Bottom Width	10.00

Results	
Discharge	550.46
Flow Area	20.0
Wetted Perimeter	30.1
Hydraulic Radius	8.0
Top Width	30.00
Critical Depth	28.8
Critical Slope	0.002
Velocity	27.52
Velocity Head	11.77
Specific Energy	12.77
Froude Number	5.943
Flow Type	Supercritical

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

GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	12.0
Critical Depth	28.8
Channel Slope	0.100
Critical Slope	0.002

Worksheet for A6 Perimeter Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.015
Normal Depth	12.0
Left Side Slope	3.000
Right Side Slope	12.000
Bottom Width	6.00
Results	
Discharge	60.61
Flow Area	13.5
Wetted Perimeter	21.2
Hydraulic Radius	7.6
Top Width	21.00
Critical Depth	11.9
Critical Slope	0.015
Velocity	4.49
Velocity Head	0.31
Specific Energy	1.31
Froude Number	0.987
Flow Type	Subcritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	12.0
Critical Depth	11.9
Channel Slope	0.015
Critical Slope	0.015

Worksheet for A7 Exterior Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.042
Normal Depth	12.0
Left Side Slope	3.000
Right Side Slope	25.000
Results	
Discharge	88.82
Flow Area	14.0
Wetted Perimeter	28.2
Hydraulic Radius	6.0
Top Width	28.00
Critical Depth	14.4
Critical Slope	0.016
Velocity	6.34
Velocity Head	0.63
Specific Energy	1.63
Froude Number	1.582
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	12.0
Critical Depth	14.4
Channel Slope	0.042
Critical Slope	0.016

Worksheet for A7 36" CHDPE - 4.7%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.012
Channel Slope	0.047
Normal Depth	36.0
Diameter	36.0
Discharge	156.81
Results	
Discharge	156.81
Normal Depth	36.0
Flow Area	7.1
Wetted Perimeter	9.4
Hydraulic Radius	9.0
Top Width	0.00
Critical Depth	35.8
Percent Full	100.0
Critical Slope	0.044
Velocity	22.18
Velocity Head	7.65
Specific Energy	10.65
Froude Number	(N/A)
Maximum Discharge	168.68
Discharge Full	156.81
Slope Full	0.047
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	36.0
Critical Depth	35.8
Channel Slope	0.047
Critical Slope	0.044

Worksheet for A8 Exterior Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.050
Normal Depth	12.0
Left Side Slope	3.000
Right Side Slope	3.000
Bottom Width	6.00
Results	
Discharge	80.83
Flow Area	9.0
Wetted Perimeter	12.3
Hydraulic Radius	8.8
Top Width	12.00
Critical Depth	16.8
Critical Slope	0.014
Velocity	8.98
Velocity Head	1.25
Specific Energy	2.25
Froude Number	1.828
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	12.0
Critical Depth	16.8
Channel Slope	0.050
Critical Slope	0.014

Worksheet for A9 Exterior Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.050
Normal Depth	24.0
Left Side Slope	2.000
Right Side Slope	2.000
Bottom Width	6.00
Results	
Discharge	269.00
Flow Area	20.0
Wetted Perimeter	14.9
Hydraulic Radius	16.1
Top Width	14.00
Critical Depth	34.7
Critical Slope	0.012
Velocity	13.45
Velocity Head	2.81
Specific Energy	4.81
Froude Number	1.984
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	34.7
Channel Slope	0.050
Critical Slope	0.012

Worksheet for A9 18" CMP - 4.5%

Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity
Input Data	
Roughness Coefficient	0.025
Channel Slope	0.045
Normal Depth	18.0
Diameter	18.0
Discharge	11.53
Results	
Discharge	11.53
Normal Depth	18.0
Flow Area	1.8
Wetted Perimeter	4.7
Hydraulic Radius	4.5
Top Width	0.00
Critical Depth	15.5
Percent Full	100.0
Critical Slope	0.041
Velocity	6.53
Velocity Head	0.66
Specific Energy	2.16
Froude Number	(N/A)
Maximum Discharge	12.41
Discharge Full	11.53
Slope Full	0.045
Flow Type	Undefined
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	18.0
Critical Depth	15.5
Channel Slope	0.045
Critical Slope	0.041

Worksheet for A10 Exterior Ditch - Grassed

Project Description	
Friction Method	Manning Formula
Solve For	Discharge
Input Data	
Roughness Coefficient	0.030
Channel Slope	0.100
Normal Depth	24.0
Left Side Slope	2.000
Right Side Slope	3.000
Bottom Width	8.00
Results	
Discharge	505.56
Flow Area	26.0
Wetted Perimeter	18.8
Hydraulic Radius	16.6
Top Width	18.00
Critical Depth	42.1
Critical Slope	0.011
Velocity	19.44
Velocity Head	5.88
Specific Energy	7.88
Froude Number	2.852
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	42.1
Channel Slope	0.100
Critical Slope	0.011



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