Jeffrey Energy Center
FGD Landfill 1A/1B & 1C
Run-On and Run-Off Control System Plan

Jeffrey Energy Center
25905 Jeffrey Rd.
St. Marys, Kansas

Prepared for:

Evergy Kansas Central, Inc.

SCS ENGINEERS

25221144.00 | October 2022

40 Shuman Blvd, Ste 216
Naperville, IL 60563

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PLAN REVIEW/AMENDMENT LOG

Date of Review	Reviewer Name	Amendment Required (YES/NO)	Sections Amended and Reason
October 2016 (Revision 0)	CB&I Environmental & Infrastructure, Inc.	N/A	Initial Plan
October 2021 (Revision 1)	SCS Engineers	YES	All sections revised / updated as part of the 5-year periodic review process.
October 2022 (Revision 2)	SCS Engineers	YES	Plan revised to include Phase 1C.

PROFESSIONAL ENGINEER CERTIFICATION

I, Richard D. Southorn, hereby certify that this Run-On and Run-Off Control System Plan meets the requirements of 40 CFR §257.81, was prepared by me or under my direct supervision, and that I am a duly licensed Professional Engineer under the laws of the State of Kansas.

This plan has been prepared as an update to the initial Run-On and Run-Off Control System Plan that was certified on October 17, 2016 and subsequently updated and certified October 8, 2021.

Richard D. Southorn, PE

License No. PE 25201

Expires 4/30/2023

1.0 INTRODUCTION

The FGD Landfill (Landfill) is an existing coal combustion residual (CCR) landfill located at Evergy's Jeffrey Energy Center (JEC) near St. Marys, Kansas. This Run-on and Run-off Control System Plan (RORO Plan) documents that the Landfill's run-on and run-off control systems for the active portions of the landfill (currently Phases 1A, 1B and 1C) meet the applicable requirements of Title 40 Code of Federal Regulations (CFR) §257.81[1] of the CCR Rule.

2.0 REGULATORY REQUIREMENTS

40 CFR §257.81 Run-on and run-off controls for CCR landfills.

(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 the CCR unit must be handled in accordance with the surface water requirements under 40 CFR §257.3-3[1].

(c) Run-on and run-off control system plan

(1) Content of the plan. The owner or operator must prepare initial and periodic run-on and run-off control system plans for the CCR unit according to the timeframes specified in paragraphs (c)(3) and (4) of this section. These plans must document how the run-on and run-off control systems have been designed and constructed to meet the applicable requirements of this section. Each plan must be supported by appropriate engineering calculations. The owner or operator has completed the initial run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by 40 CFR §257.105(g)(3).

With reference to 40 CFR §257.81(c) above, the Initial RORO Plan was required to be developed no later than October 17, 2016 for existing landfills (40 CFR §257.81(c)(3)(i))[1]. Updates to the RORO Plan are required whenever there is a change in conditions that would substantially affect the written plan in effect (40 CFR §257.81(2)[1], or within five years of the previous plan (40 CFR §257.81(c)(4))[1].

The owner or operator must obtain a certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority stating that the initial and periodic RORO Plans meet the requirements of 40 CFR §257.81[1].

3.0 2022 RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN UPDATE

This document has been prepared as an update to the 2021 RORO Plan to incorporate Phase 1C, which will become operational in 2022. This plan has been developed to reflect run-on and run-off controls that will be used for active areas of the landfill, including Phases 1A, 1B, and 1C. As such, this plan replaces the previous RORO Plan. The current run-on and run-off control systems at the Landfill have been reviewed as part of this 2022 update and have been found to meet the requirements of 40 CFR §257.81(a)[1], as outlined in Section 2.0.

Conveyance features that comprise the run-on and run-off control systems at the Landfill are depicted in **Figure 1**. Storm water calculations supporting the below discussion are included in **Appendices A through C.**

3.1 RUN-ON CONTROL SYSTEM

The active portion of the Landfill is surrounded by a containment berm that is designed to prevent contact water run-off. This containment berm is approximately four feet higher than the surrounding exterior grades at its lowest point. The surrounding grades outside of this berm all slope away from the active area of the Landfill. Inactive areas with final cover outside of the containment berm are not included in this evaluation.

3.2 RUN-OFF CONTROL SYSTEM

As mentioned in Section 3.1, a containment berm has been constructed around the entire active disposal area. Phase 1A/1B and Phase 1C are separated by an approximately 15-foot tall berm. The active portion of Phase 1A/1B ranges between four feet (in the south) and twenty feet (in the north) below the containment berm. The active portion of Phase 1C ranges between four feet (in the south) and forty feet (in the north) below the containment berm. The active areas are graded to flow to the north. Direct precipitation falling on the active portion of the Landfill (contact water) is fully contained within the berm.

Within Phase 1A/1B, contact water flows over the surface of the active area and temporarily collects in the north. It is then conveyed through a pipe and discharges into a downchute lined with riprap. The downchute is also used to control and convey non-contact water that falls on the Phase 1B and 1C final cover system. The downchute discharges into the South Bypass Ditch, which ultimately drains to Tower Hill Lake. The run-off control system is depicted in **Figure1**.

In Phase 1C, contact water flows north over the active area and accumulates at the low spot along the toe of the containment berm. From there, contact water will gradually infiltrate through the protective cover layer and leachate collection system, where it will be conveyed to the Contact Water Basin. The Contact Water Basin ultimately drains to Tower Hill Lake. The run-off control system is depicted in **Figure1**.

Tower Hill Lake is located immediately to the northwest of the Landfill and is permitted to receive non-contact water, contact water, and leachate from the JEC, including multiple landfills and surface impoundments under the facility's National Pollutant Discharge Elimination System (NPDES) Permit. In accordance with 40 CFR §257.81(b)[1], this is consistent with the surface water requirements under 40 CFR §257.3-3[1].

3.3 HYDROLOGIC AND HYDRAULIC ANALYSIS

Engineering calculations to evaluate the run-off control system at the Landfill consist of a hydrologic and hydraulic storm water model prepared using HydroCAD storm water modeling software. Run-on analyses are not applicable because all surrounding areas slope away from the active area of the Landfill. The run-off control system model for the Landfill is provided in **Appendix B**. A regional model evaluating the capacity within Tower Hill Lake is provided in **Appendix C**. Information used to prepare the HydroCAD storm water model is summarized below.

3.3.1 Rainfall Data

Rainfall amounts for the 25-year, 24-hour storm were obtained from the Rainfall Intensity Tables for Counties in Kansas (2014) prepared by Kansas Department of Transportation. This document provides rainfall intensities for various durations and recurrence intervals, displayed in rainfall intensity tables for each county in Kansas. The rainfall intensity table applicable to the Landfill is the table prepared for Pottawatomie County (**Appendix A**). The 25-year, 24-hour rainfall amount for the Landfill was determined to be 6.00-inches, based on a rainfall rate of 0.25 inches/hour for 24 hours.

The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), Technical Release 55 (TR-55) was consulted to determine the appropriate storm water distribution pattern to model the rainfall depth in HydroCAD. According to TR-55[2], the Type-II 24-hour storm distribution is appropriate for all counties located in Kansas.

3.3.2 Model Input Parameters

Subcatchment areas (also known as watersheds) were delineated using AutoCAD Civil3D 2020 (AutoCAD) based on topographic divides within the analyzed area. Run-off from each subcatchment area was calculated using the NRCS-SCS Technical Release 20 (TR-20) method that utilizes curve numbers and flow length parameters to calculate storm water run-off. These areas are depicted in **Figure 1**.

For the regional Tower Hill Lake model, the subcatchment area was delineated using the United States Geological Survey (USGS) 7.5-minutre topographic quadrangle map. This subcatchment area is depicted in **Figure 2**.

The Curve number (CN) is a parameter used to determine the amount of runoff that will occur from a surface. High CN values indicate that the majority of rainfall will run off with minimal losses. Lower values correspond to an increased ability of rainfall to infiltrate the ground surface, leading to lower run off rates.

A curve number of 92 was selected for all areas with surficial FGD material, based on a review of the Hydrologic Evaluation of Landfill Performance (HELP) model completed as part of the 2009 Solid Waste Permit Application.

For Landfill covers associated with the regional Tower Hill Lake model, the soil type and ground cover were considered to select the appropriate curve number using NRCS lookup tables. According to the NRCS Web Soil Survey for Pottawatomie County[3], the predominant soil type within the JEC footprint is Hydrologic Soil Group D (HSG-D). HSG-D soils provide the highest curve numbers of all soil types. Therefore, all subcatchment areas have been modeled with this soil type designation.

The land cover applicable for the regional Tower Hill Lake model consists of open space with good grass cover (CN=80) and water surface (CN=98).

The time of concentration, defined as the longest amount of time a waterdrop would take to travel from the headwater of a subcatchment area to its downstream edge, was delineated in AutoCAD and entered for the subcatchment in HydroCAD.

3.3.3 Conveyance Features

Direct precipitation falling on the active portion of the Landfill collects within the containment berm system and discharges to Tower Hill Lake through a pipe, rip-rap lined downchute, and the South Bypass Ditch. Key attributes used in the Landfill run-off HydroCAD model for each conveyance feature are summarized below:

- Perimeter Berm System and Active Disposal Area (HydroCAD Nodes - P1AB and P1C)
  - Modeled with incremental detention volume using minor and major contour intervals
- Discharge Pipe (HydroCAD Node - P1AB)
  - 24-in. diameter, high-density polyethylene (HDPE) pipe from Perimeter Berm System to the Permanent Downchute.
- Permanent Downchute (HydroCAD Node - D1AB)
  - 2-ft. deep channel, 10-ft. wide bottom, with 3H:1V sideslopes.
  - Ditch lining designated as 1-ft. diameter riprap.
- South Bypass Ditch (HydroCAD Node - SBD)
  - Modeled as "Link" that directly connects the flow from the Permanent Ditch to Tower Hill Lake.
- Terrace Bench (HydroCAD Nodes – TB1, TB2, TB3)
  - Terrace benches are designed to drain the final cover slopes of the landfill and convey runoff to the Permanent Downchute where it eventually reaches the South Bypass Ditch.
  - 1-ft deep, v-notch bench with 4H:1V interior slope and 20H:1V outer slope. The benches drain to the permanenet downchute with slopes between 2-3%.

These conveyance paths are modeled in HydroCAD to demonstrate the run-on/run-off control system is appropriately sized to accommodate the 25-year, 24-hour storm event.

Tower Hill Lake is designed to serve as the run-off control pond for the Landfill and other portions of the JEC. Tower Hill Lake was modeled with incremental detention volume defined by contour intervals between the normal water elevation (approximate elevation 1,146.0 ft. MSL) to the lowest elevation of the perimeter berm (approximate elevation 1,166.0 ft. MSL). Tower Hill Lake is modeled to demonstrate the run-off control system is appropriately sized to accommodate total discharge rate from the Landfill for the 25-year, 24-hour storm event.

3.4 RESULTS AND CONCLUSIONS

The surrounding grades proximate to Phases 1A/1B and 1C all slope away from the active area of the landfill. Therefore, there is no potential for storm water run-on to enter the active area of the landfill.As such, the landfill meets the requirements of 40 CFR §257.81(a)(1)[1].

The HydroCAD storm water model of the Landfill was developed to evaluate whether the peak flow run-off from the 25-year, 24-hour storm event could be accommodated without overtopping the run-off control systems.

The Landfill run-off control system is designed and constructed to divert contact water in a controlled manner to Tower Hill Lake. Based on the results of the HydroCAD storm water model, the run-off control system was determined to accommodate the 25-year, 24-hour storm event without overtopping and meets the requirements of 40 CFR §257.81(a)(2)[1]. The peak depth and freeboard remaining within each conveyance feature is summarized below:

Table 1 – Conveyance Feature Sizing		
Conveyance Feature Designation	**Peak Depth (feet)**	**Freeboard (feet)**
Phase 1A/1B		
Perimeter Berm System	1.65 (north area)	18.35 (relative to high water level location)
Permanent Downchute	0.49’	1.51’
Phase 1C		
Perimeter Berm System	13.7 (north area)	14.3 (relative to high point in active area - 1222’ MSL)

Based on the results from the regional HydroCAD model, Tower Hill Lake is designed to collect and control the water volume resulting from the 25-year, 24-hour storm event for the Landfill and other portions of the JEC without overtopping. The peak depth and freeboard remaining within Tower Hill Lake is summarized below:

Table 2 – Tower Hill Lake Capacity		
Peak Rise in Water Elevation (feet)	**Available Freeboard (feet)**	**Remaining Capacity (acre-feet)**
2.70	17.30	2,804.6

4.0 CERTIFICATIONS

Richard D. Southorn, a licensed Professional Engineer in the State of Kansas, has overseen the preparation of this Run-On and Run-Off Control System Plan. A certification statement in accordance with 40 CFR §257.81(c)(5)[1] is provided on **Page iii** of this plan.

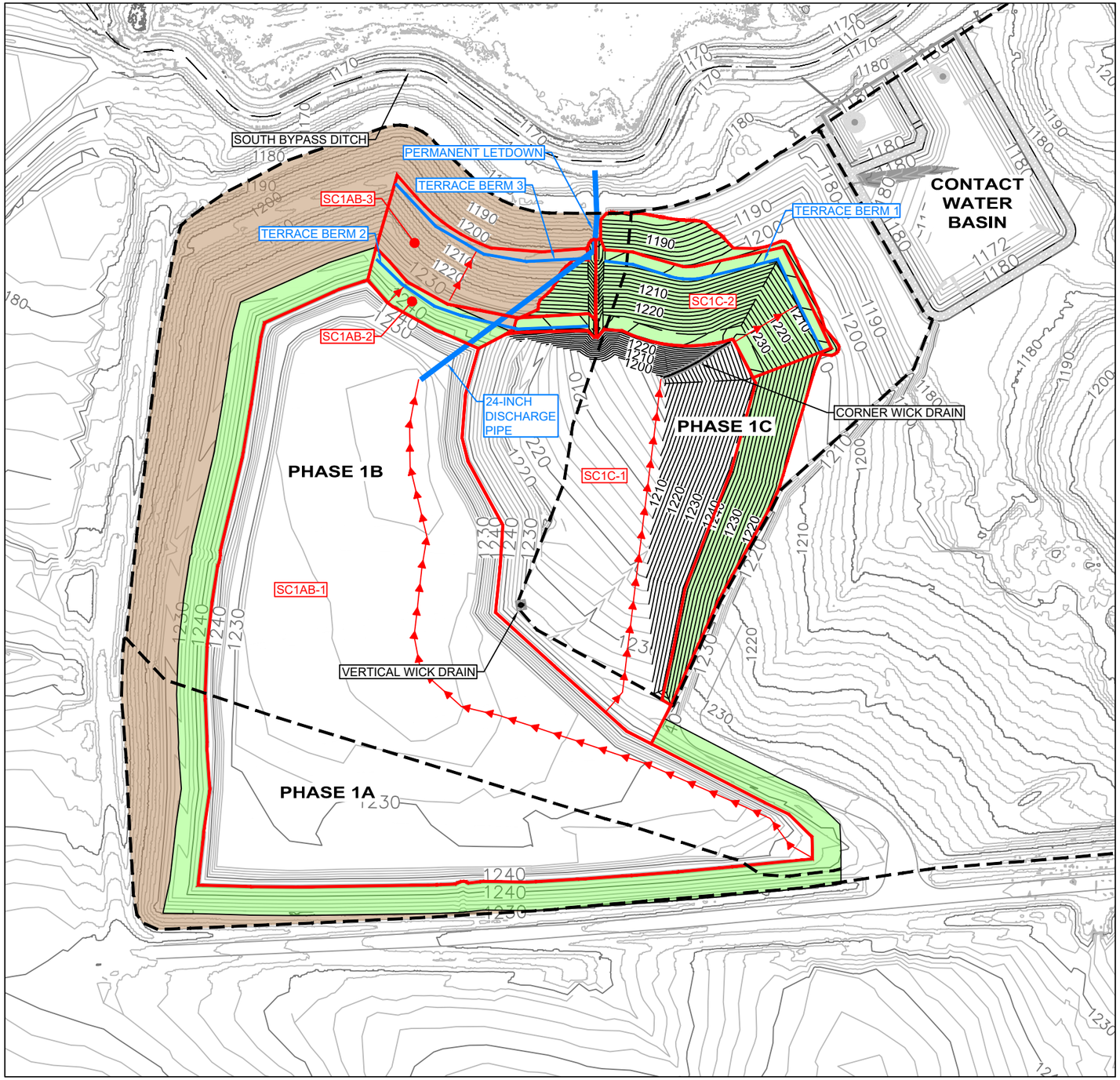
5.0 REFERENCES

1. U.S. Environmental Protection Agency, Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments, Title 40 Code of Federal Regulations Part §257. Federal Register 80, Subpart D, dated April 17, 2015.
2. USDA Natural Resources Conservation Service, Technical Release 55, dated June 1986.
3. USDA Natural Resources Conservation Service, Web Soil Survey for Pottawatomie County https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm, dated 2021.

Figures

Figure 1. FGD Landfill 1A/1B and 1C Run-On and Run-Off Control System

Figure 2. Regional Control System – Tower Hill Lake



N

LEGEND

- SUBCATCHMENT BOUNDARY
- APPROXIMATE PHASE BOUNDARY
- SOUTH BYPASS DITCH
- WATER CONVEYANCE FEATURE LOCATION
- TIME OF CONCENTRATION FLOW PATH
- CONTAINMENT BERM
- FINAL COVER
- SC1AB-1 SUBCATCHMENT NUMBER

NOTES

1. EXISTING SITE TOPOGRAPHY DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS (PEC) IN DECEMBER 2020

250 0 250

SCALE: 1" = 250'

PROJECT NO.	25221144	DRAWN BY:	NV
DRAWN:	08/24/2022	CHECKED BY:	RDS
REVISED:	_	APPROVED BY:	

ENGINEER: SCS ENGINEERS
40 SHUMAN BLVD, STE 216, NAPERVILLE, IL 60563
PHONE: (331) 806-4300

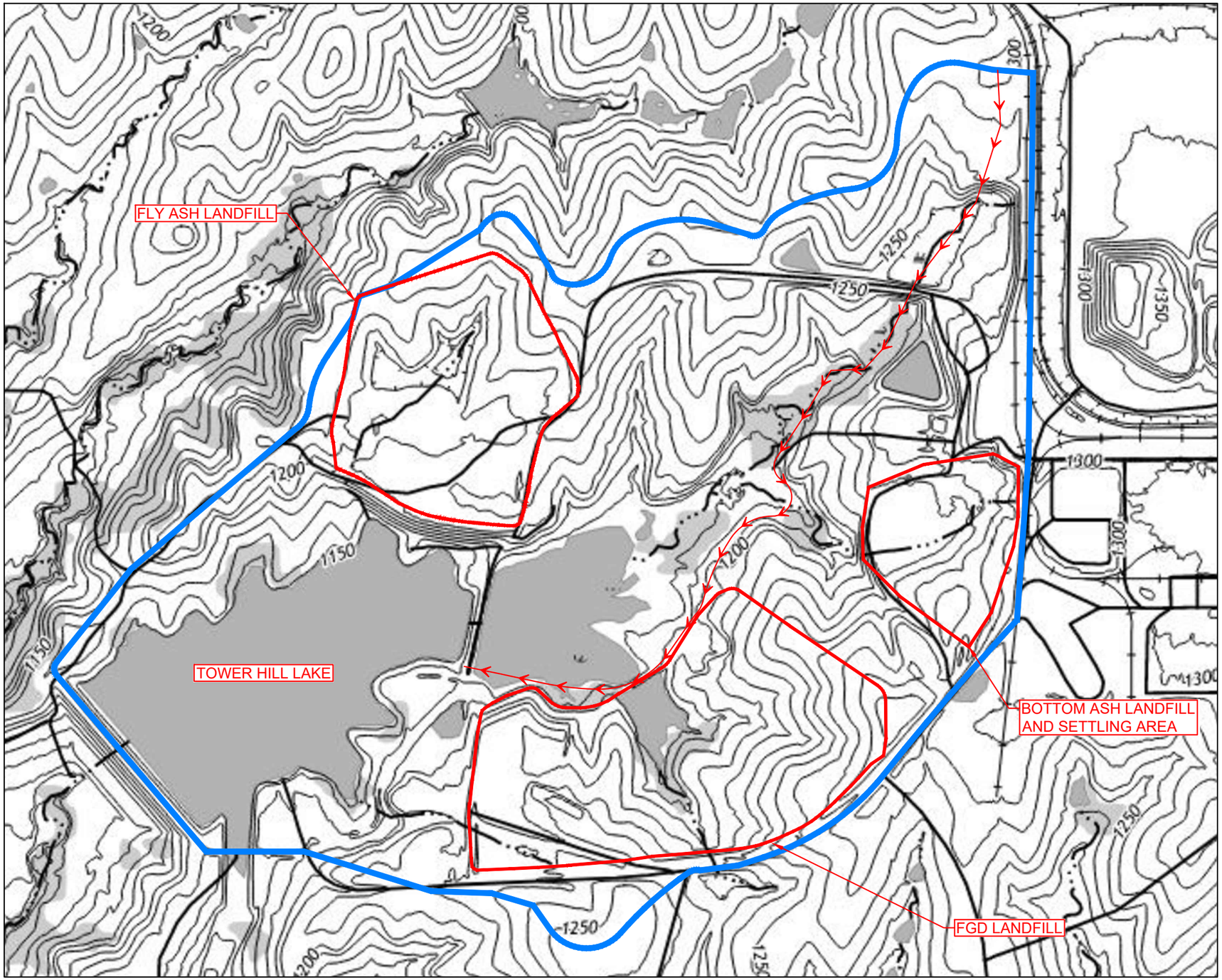
CLIENT: evergy

SITE: JEFFREY ENERGY CENTER
ST. MARYS, KS

RUN-ON AND RUN-OFF PLAN
SUBCATCHMENT AREA

FIGURE
1 OF 2

I:\25221144.00\Drawings\Ph1C\Figures\RORO\Site Layout-HydroCAD.dwg, 10/7/2022 11:01:43 AM



LEGEND

- CCR UNIT BOUNDARY
- WATERSHED BOUNDARY
- TIME OF CONCENTRATION

NOTES:

1. FIGURE ADAPTED FROM USGS 7.5–MINUTE TOPOGRAPHIC QUADRANGLE FROM EMMETT AND LECLEDE, KS (2018).
2. ALL BOUNDARIES ARE APPROXIMATE.

N

1000 0 1000

SCALE: 1" = 1000'

PROJECT NO.	25221157	DRAWN BY:	SJL
DRAWN:	08/26/2021	CHECKED BY:	RDS
REVISED:		APPROVED BY:	

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718–6751
PHONE: (608) 224–2830

CLIENT: evergy

SITE: JEFFREY ENERGY CENTER
ST. MARYS, KS

JEFFREY ENERGY CENTER
REGIONAL CONTROL SYSTEM
TOWER HILL LAKE

FIGURE
2 OF 2

Appendices

Appendix A	Rainfall Intensity Table for Kansas Counties
Appendix B	FGD Landfill 1A/1B and 1C Run-On and Run-Off Control System – HydroCAD Output Files
Appendix C	Regional Control System Tower Hill Lake – HydroCAD Output Files

Appendix A Rainfall Intensity Table for Kansas Counties

MEMO

Kansas
Department of Transportation
Bureau of Road Design

ROAD MEMORANDUM NO. 16-03

DATE: September 2, 2016

SUBJECT: *Rainfall Intensity Tables*

The publication, *Rainfall Intensity Tables for Counties in Kansas*, dated June 1997, has recently be updated and replaced by *Rainfall Intensity Tables for Counties in Kansas (2014)*.

The new tables were developed from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Volume 8 (Perica et al. 2013) which was recently released by the National Weather Service (NWS) Hydro Meteorological Design Studies Center. The new tables provide rainfall intensities for durations from 5 minutes to 24 hours and various recurrence intervals from 1-500 years.

The *Rainfall Intensity Tables for Counties in Kansas (2014)* supersede the previous rainfall tables based on TP-40 and HYDRO-35 (McEnroe 1997). The new rainfall tables are available on the Kansas Department of Transportation's (KDOT) website at http://kart.ksdot.org.

If you have any questions, please contact John Hobelman at (785) 368-8791.

Scott W. King, P.E., Chief
Bureau of Road Design

SWK:js
By e-mail: American Council of Engineering Companies
Federal Highway Administration
Kansas Contractors Association (kca@ink.org)
Active Consultants
Director of Engineering & Design
Director of Operations
District Engineers
Area Engineers
Chief, Bureau of Local Projects
Chief, Bureau of Right of Way
Chief, Bureau of Transportation Safety & Technology
Chief, Bureau of Construction & Materials
Chief, Bureau of Maintenance
Chief, Bureau of Structures and Geotechnical Services
Road Design/Squad Leaders
Coordinating Section

Rainfall Intensity Tables for Counties in Kansas

(December, 2014 Edition)

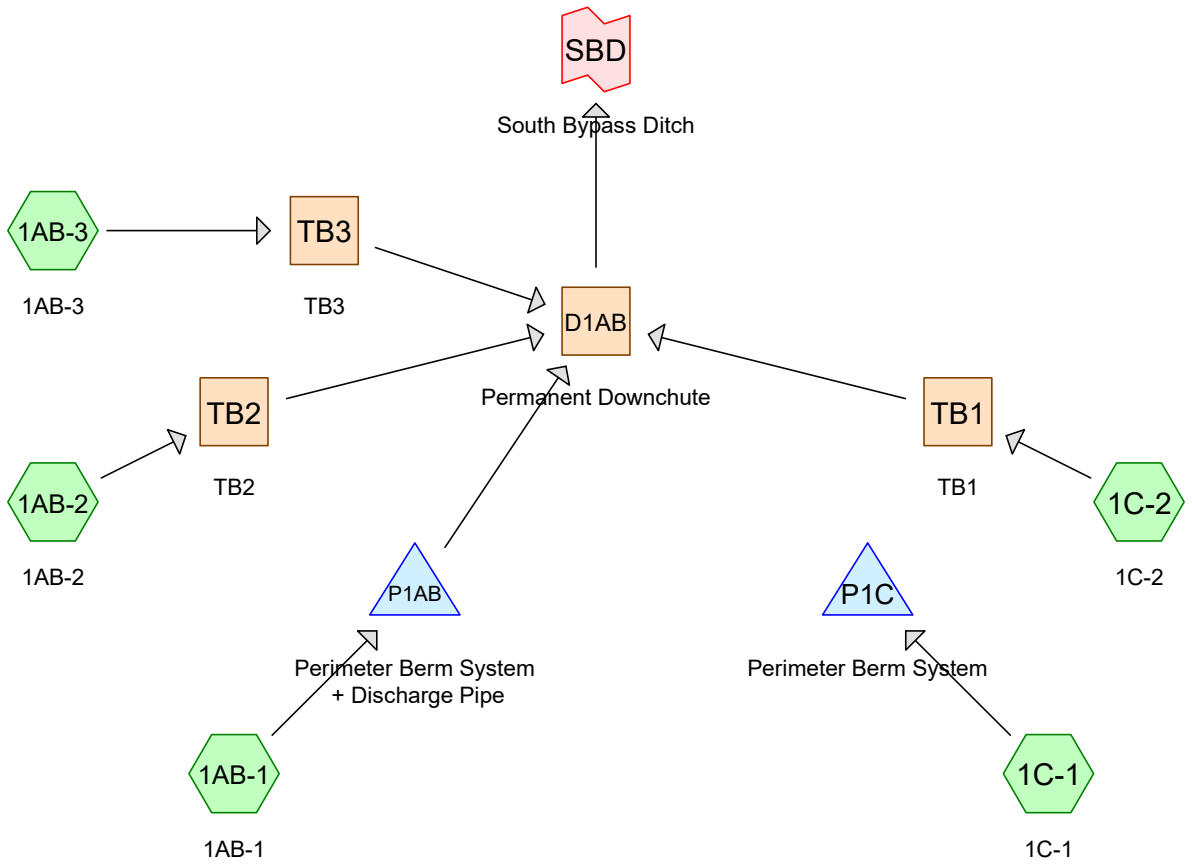
RAINFALL INTENSITY TABLE

POTTAWATOMIE COUNTY, KANSAS

This table contains average rainfall intensities in inches per hour.

DURATION	AVERAGE RECURRENCE INTERVAL								
(H:M)	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	200 yr	500 yr
3:15	0.58	0.68	0.87	1.03	1.27	1.47	1.68	1.91	2.22
3:30	0.55	0.65	0.82	0.98	1.21	1.40	1.59	1.81	2.11
3:45	0.52	0.61	0.78	0.93	1.15	1.33	1.52	1.72	2.00
4:00	0.49	0.58	0.74	0.88	1.09	1.26	1.44	1.64	1.91
4:15	0.47	0.56	0.71	0.84	1.04	1.21	1.38	1.56	1.82
4:30	0.45	0.53	0.68	0.81	1.00	1.16	1.32	1.50	1.74
4:45	0.43	0.51	0.65	0.78	0.96	1.11	1.27	1.44	1.67
5:00	0.42	0.49	0.63	0.74	0.92	1.06	1.22	1.38	1.61
5:15	0.40	0.47	0.60	0.72	0.89	1.02	1.17	1.33	1.54
5:30	0.39	0.46	0.58	0.69	0.85	0.99	1.13	1.28	1.49
5:45	0.37	0.44	0.56	0.67	0.82	0.95	1.09	1.23	1.43
6:00	0.36	0.43	0.54	0.64	0.80	0.92	1.05	1.19	1.38
6:30	0.34	0.40	0.51	0.61	0.75	0.86	0.99	1.12	1.30
7:00	0.32	0.38	0.48	0.57	0.70	0.81	0.93	1.05	1.22
7:30	0.30	0.36	0.46	0.54	0.67	0.77	0.88	0.99	1.15
8:00	0.29	0.34	0.43	0.51	0.63	0.73	0.83	0.94	1.09
8:30	0.27	0.32	0.41	0.49	0.60	0.70	0.79	0.90	1.04
9:00	0.26	0.31	0.39	0.47	0.57	0.66	0.76	0.85	0.99
9:30	0.25	0.30	0.38	0.45	0.55	0.63	0.72	0.81	0.94
10:00	0.24	0.28	0.36	0.43	0.53	0.61	0.69	0.78	0.90
10:30	0.23	0.27	0.35	0.41	0.50	0.58	0.66	0.75	0.86
11:00	0.22	0.26	0.33	0.40	0.49	0.56	0.64	0.72	0.83
11:30	0.21	0.25	0.32	0.38	0.47	0.54	0.61	0.69	0.80
12:00	0.21	0.24	0.31	0.37	0.45	0.52	0.59	0.66	0.77
13:00	0.19	0.23	0.29	0.34	0.42	0.48	0.55	0.62	0.72
14:00	0.18	0.22	0.27	0.32	0.39	0.45	0.51	0.58	0.67
15:00	0.17	0.20	0.26	0.30	0.37	0.43	0.48	0.55	0.63
16:00	0.16	0.19	0.24	0.29	0.35	0.40	0.46	0.52	0.59
17:00	0.16	0.18	0.23	0.27	0.33	0.38	0.43	0.49	0.56
18:00	0.15	0.18	0.22	0.26	0.32	0.36	0.41	0.46	0.53
19:00	0.14	0.17	0.21	0.25	0.30	0.35	0.39	0.44	0.51
20:00	0.14	0.16	0.20	0.24	0.29	0.33	0.37	0.42	0.49
21:00	0.13	0.15	0.19	0.23	0.28	0.32	0.36	0.40	0.46
22:00	0.13	0.15	0.19	0.22	0.27	0.30	0.34	0.39	0.45
23:00	0.12	0.14	0.18	0.21	0.26	0.29	0.33	0.37	0.43
24:00	0.12	0.14	0.17	0.20	0.25	0.28	0.32	0.36	0.41

Appendix B FGD Landfill 1A/1B and 1C Run-On and Run-Off Control System – HydroCAD Output Files



Subcat Reach Pond Link

Routing Diagram for FGD Landfill
Prepared by SCS Engineers, Printed 8/24/2022

Summary for Subcatchment 1AB-1: 1AB-1

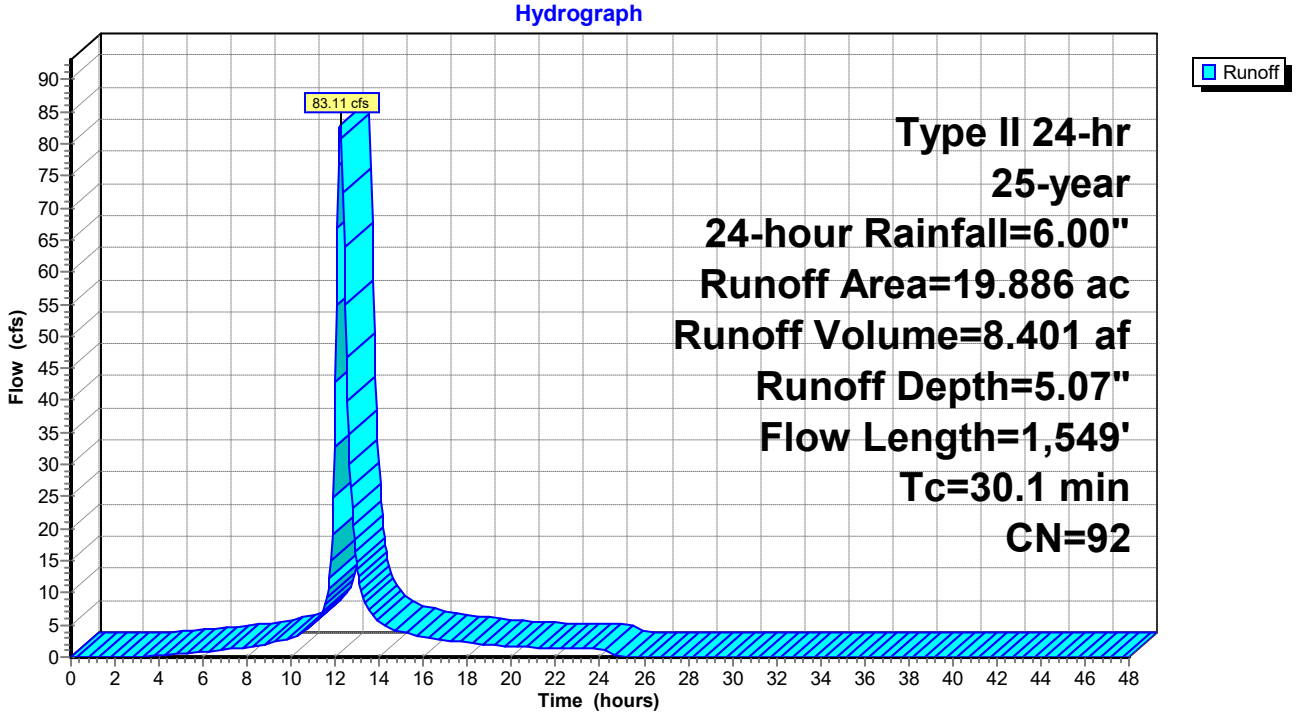
Runoff = 83.11 cfs @ 12.23 hrs, Volume= 8.401 af, Depth= 5.07"
Routed to Pond P1AB : Perimeter Berm System + Discharge Pipe

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-year, 24-hour Rainfall=6.00"

	Area (ac)	CN	Description
*	19.886	92	CCR Material, HSG-D
	19.886		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	100	0.0367	0.54		**Sheet Flow,** Fallow n= 0.050 P2= 3.36"
27.0	1,449	0.0080	0.89		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
30.1	1,549	Total			

Subcatchment 1AB-1: 1AB-1



Summary for Subcatchment 1AB-2: 1AB-2

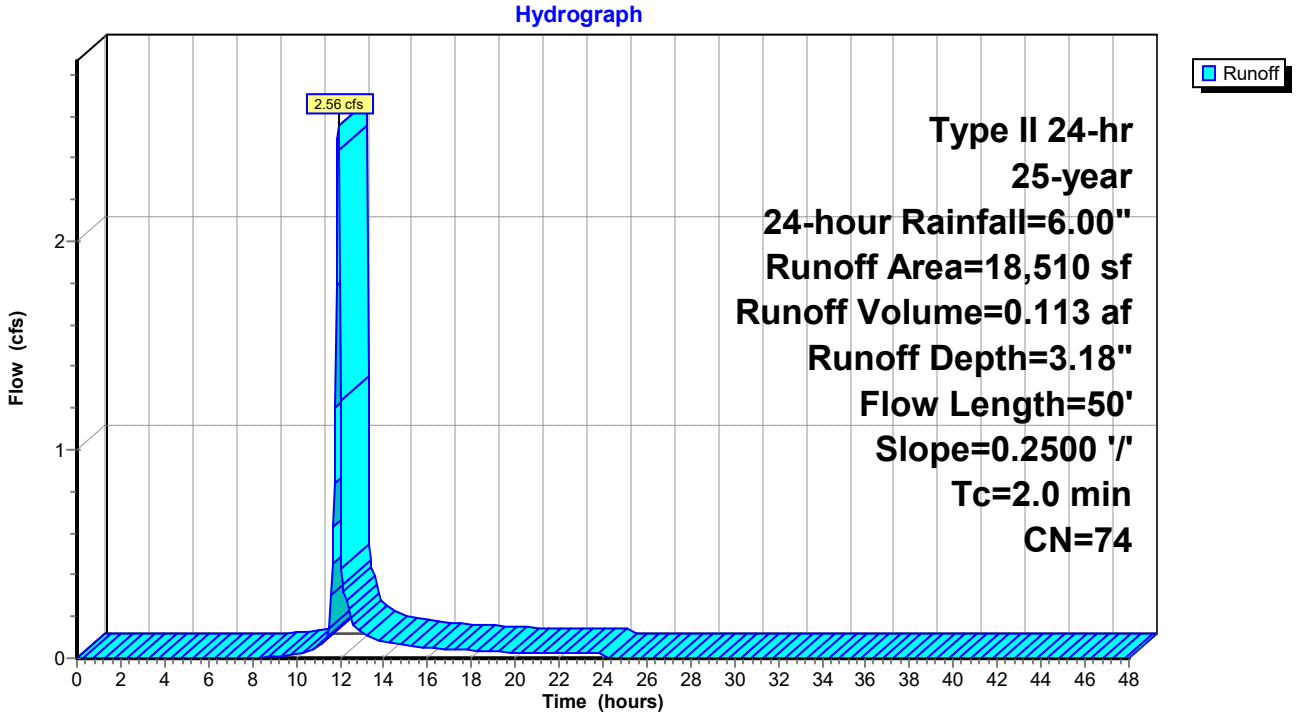
Runoff = 2.56 cfs @ 11.92 hrs, Volume= 0.113 af, Depth= 3.18"
Routed to Reach TB2 : TB2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-year, 24-hour Rainfall=6.00"

Area (sf)	CN	Description
18,510	74	>75% Grass cover, Good, HSG C
18,510		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.0	50	0.2500	0.42		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"

Subcatchment 1AB-2: 1AB-2



Summary for Subcatchment 1AB-3: 1AB-3

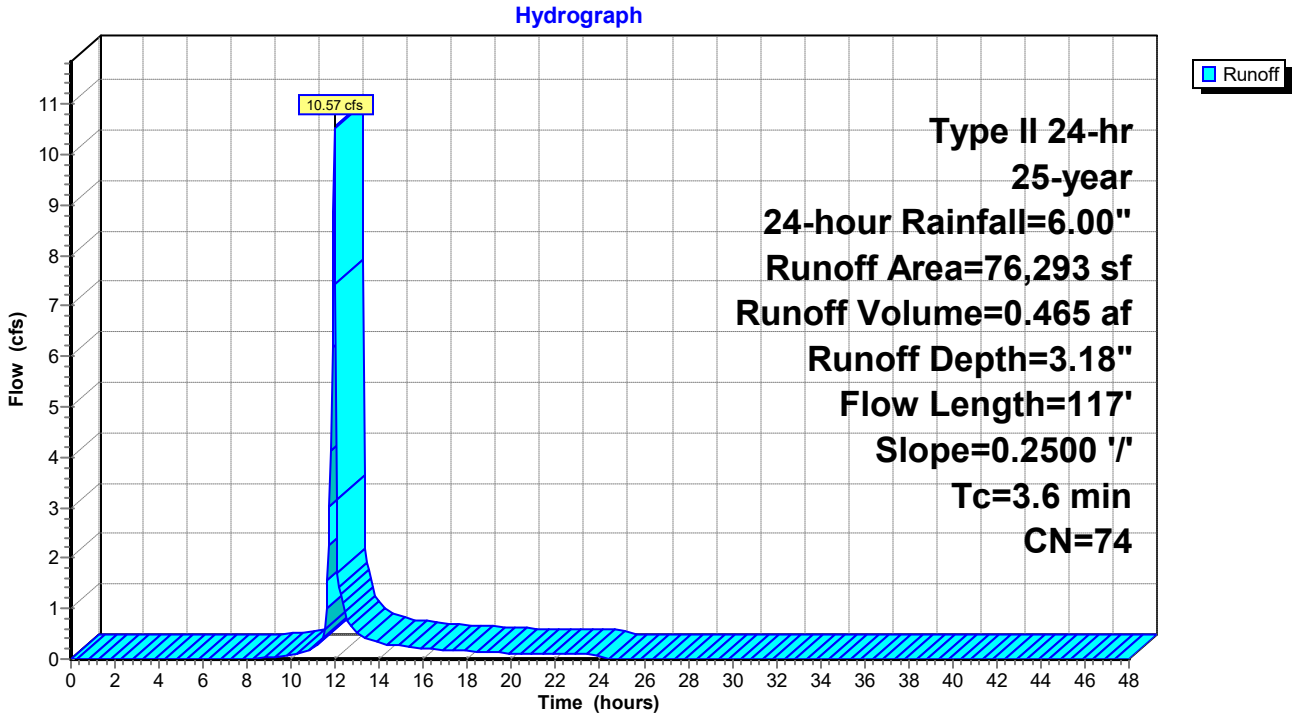
Runoff = 10.57 cfs @ 11.94 hrs, Volume= 0.465 af, Depth= 3.18"
Routed to Reach TB3 : TB3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-year, 24-hour Rainfall=6.00"

Area (sf)	CN	Description
76,293	74	>75% Grass cover, Good, HSG C
76,293		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	100	0.2500	0.48		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
0.1	17	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.6	117	Total			

Subcatchment 1AB-3: 1AB-3



Summary for Subcatchment 1C-1: 1C-1

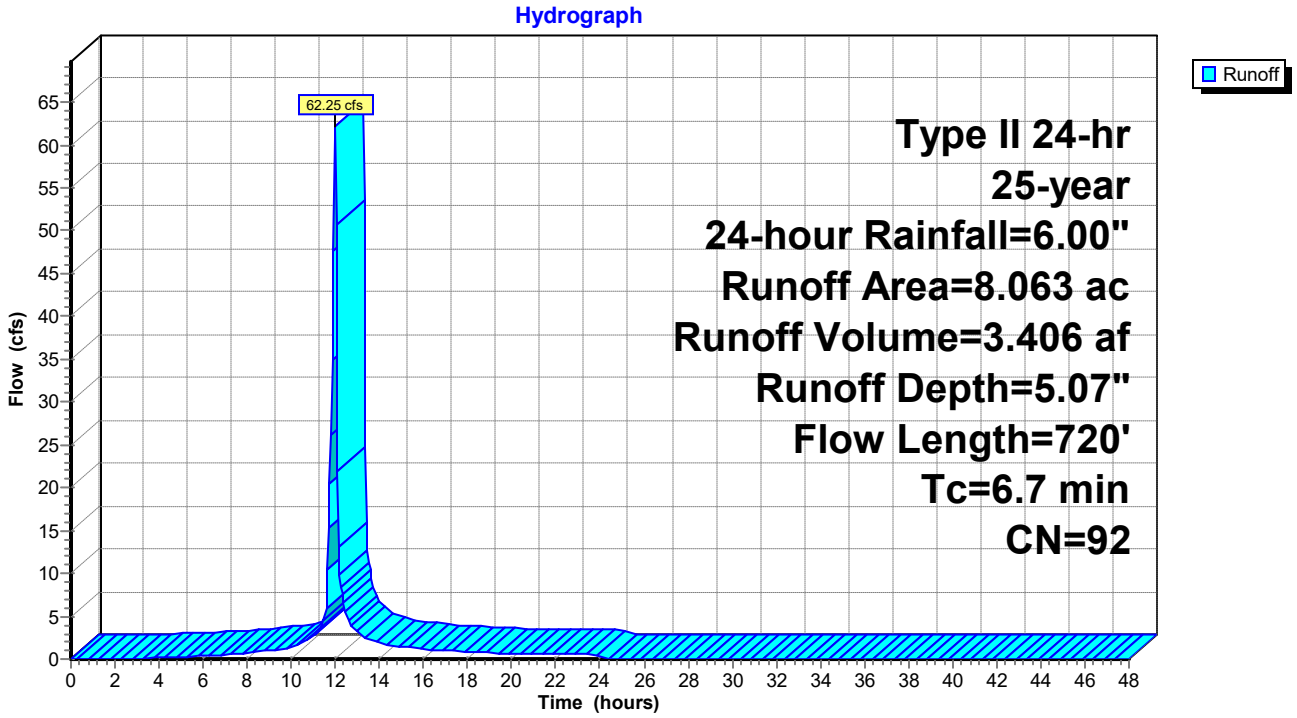
Runoff = 62.25 cfs @ 11.97 hrs, Volume= 3.406 af, Depth= 5.07"
Routed to Pond P1C : Perimeter Berm System

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-year, 24-hour Rainfall=6.00"

	Area (ac)	CN	Description
*	8.063	92	CCR Material
	8.063		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.6	100	0.0600	0.65		**Sheet Flow,** Fallow n= 0.050 P2= 3.36"
4.1	620	0.0650	2.55		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
6.7	720	Total			

Subcatchment 1C-1: 1C-1



Summary for Subcatchment 1C-2: 1C-2

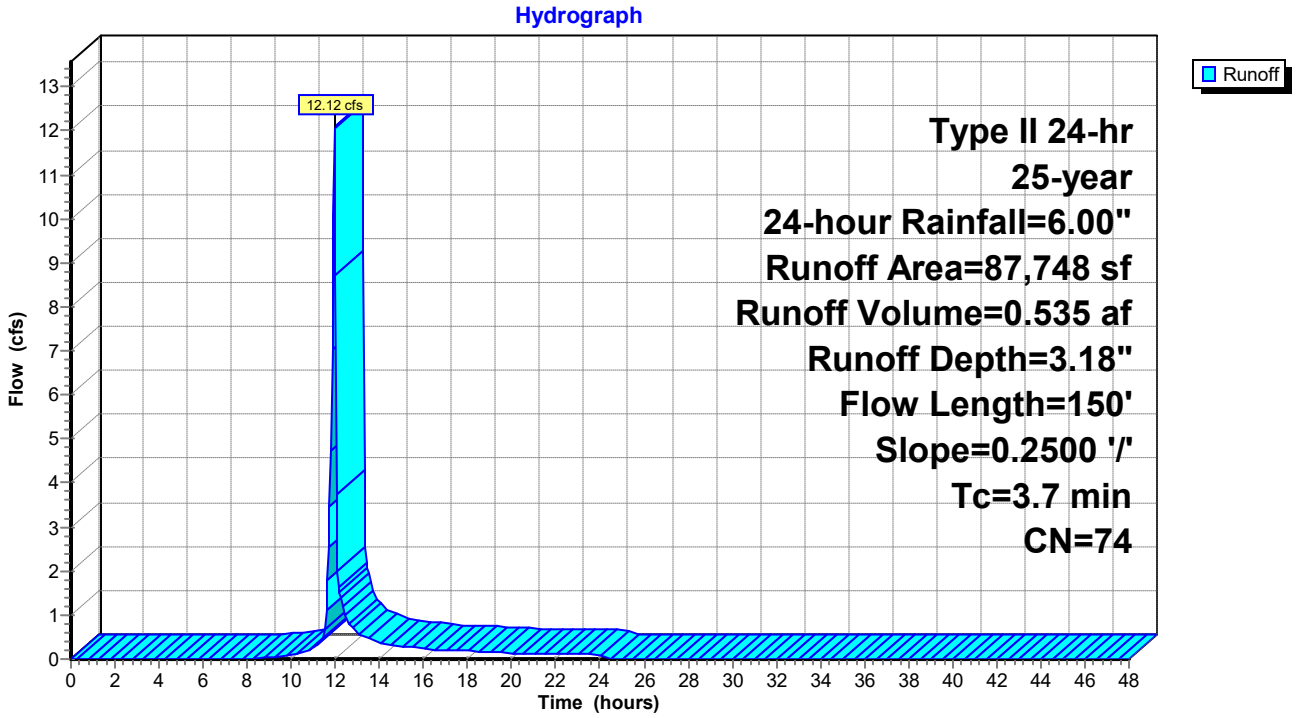
Runoff = 12.12 cfs @ 11.94 hrs, Volume= 0.535 af, Depth= 3.18"
Routed to Reach TB1 : TB1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-year, 24-hour Rainfall=6.00"

Area (sf)	CN	Description
87,748	74	>75% Grass cover, Good, HSG C
87,748		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	100	0.2500	0.48		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
0.2	50	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.7	150	Total			

Subcatchment 1C-2: 1C-2



Summary for Reach D1AB: Permanent Downchute

Inflow Area = 24.077 ac, 0.00% Impervious, Inflow Depth > 4.65" for 25-year, 24-hour event
Inflow = 25.26 cfs @ 12.01 hrs, Volume= 9.324 af
Outflow = 24.27 cfs @ 12.04 hrs, Volume= 9.322 af, Atten= 4%, Lag= 1.9 min
Routed to Link SBD : South Bypass Ditch

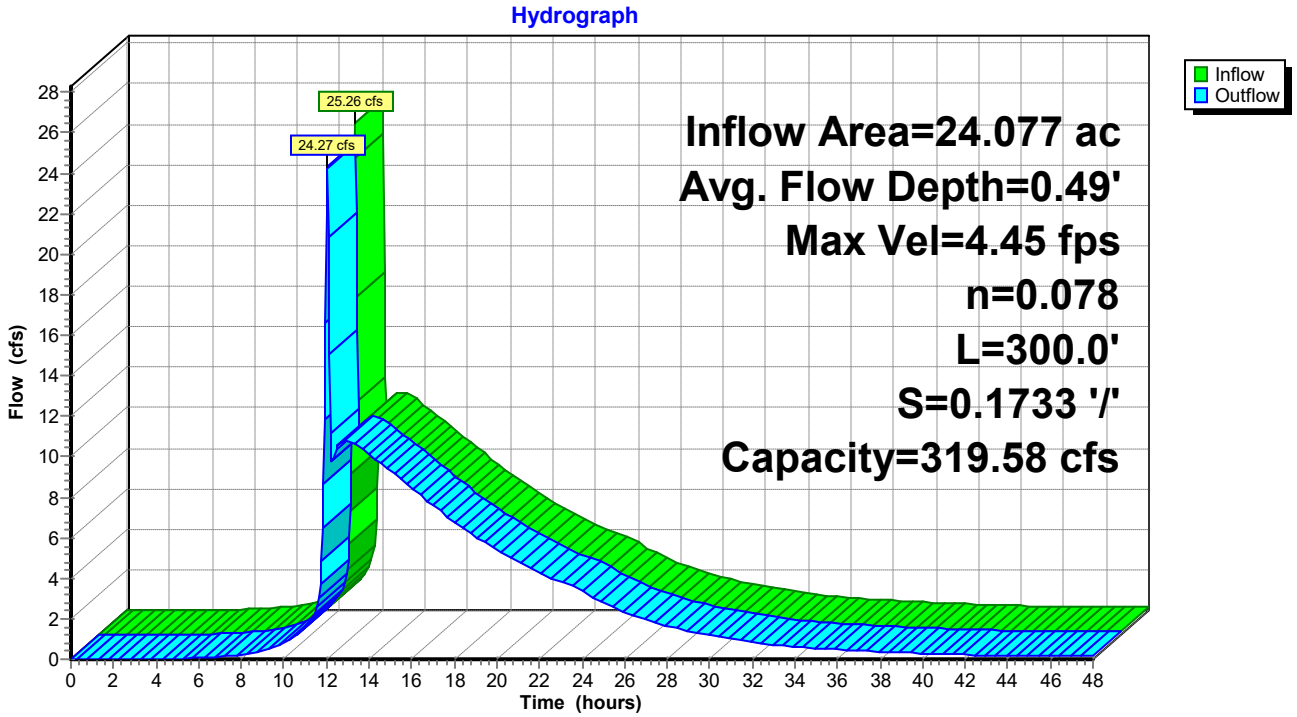
Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.45 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.55 fps, Avg. Travel Time= 3.2 min

Peak Storage= 1,670 cf @ 12.03 hrs
Average Depth at Peak Storage= 0.49' , Surface Width= 12.92'
Bank-Full Depth= 2.00' Flow Area= 32.0 sf, Capacity= 319.58 cfs

10.00' x 2.00' deep channel, n= 0.078 Riprap, 12-inch
Side Slope Z-value= 3.0 '/' Top Width= 22.00'
Length= 300.0' Slope= 0.1733 '/'
Inlet Invert= 1,224.00', Outlet Invert= 1,172.00'

‡

Reach D1AB: Permanent Downchute



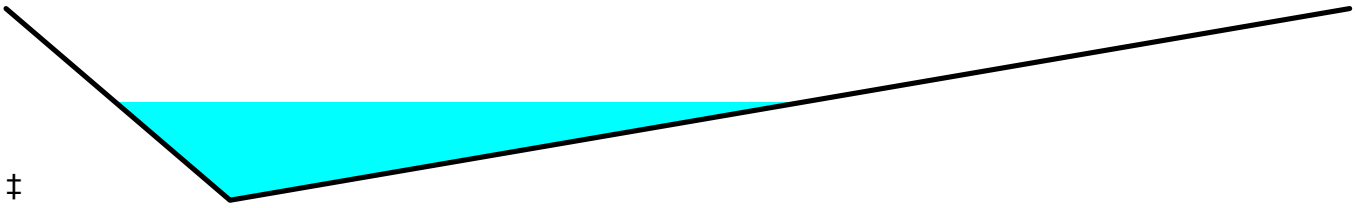
Summary for Reach TB1: TB1

Inflow Area = 2.014 ac, 0.00% Impervious, Inflow Depth = 3.18" for 25-year, 24-hour event
Inflow = 12.12 cfs @ 11.94 hrs, Volume= 0.535 af
Outflow = 10.69 cfs @ 12.02 hrs, Volume= 0.535 af, Atten= 12%, Lag= 4.7 min
Routed to Reach D1AB : Permanent Downchute

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.40 fps, Min. Travel Time= 2.9 min
Avg. Velocity = 1.13 fps, Avg. Travel Time= 8.6 min

Peak Storage= 1,833 cf @ 11.97 hrs
Average Depth at Peak Storage= 0.51' , Surface Width= 12.29'
Bank-Full Depth= 1.00' Flow Area= 12.0 sf, Capacity= 64.20 cfs

0.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 4.0 20.0 '/' Top Width= 24.00'
Length= 583.0' Slope= 0.0206 '/'
Inlet Invert= 1,210.00', Outlet Invert= 1,198.00'



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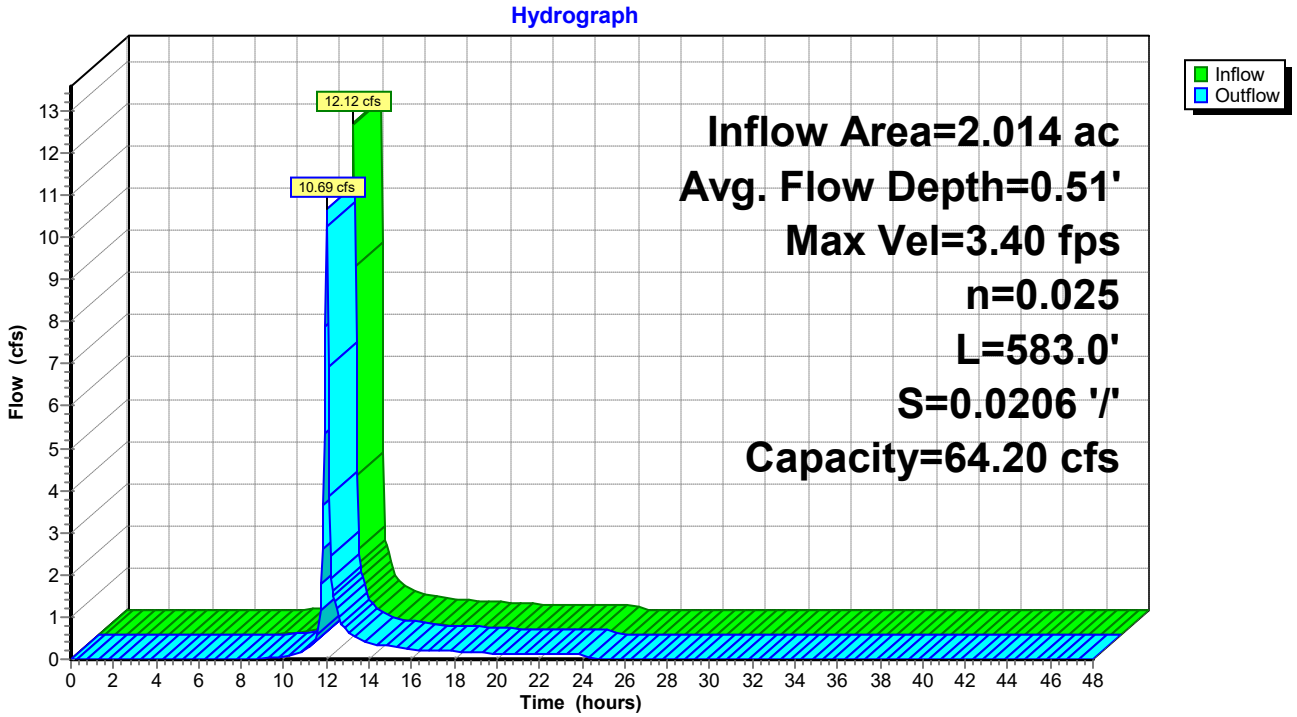
Reach TB1: TB1



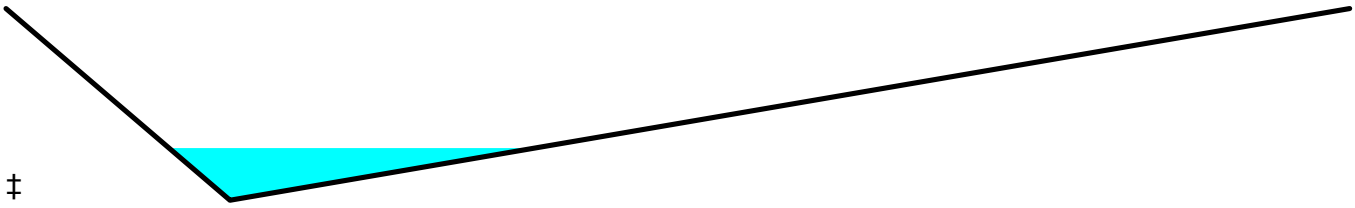
Summary for Reach TB2: TB2

Inflow Area = 0.425 ac, 0.00% Impervious, Inflow Depth = 3.18" for 25-year, 24-hour event
Inflow = 2.56 cfs @ 11.92 hrs, Volume= 0.113 af
Outflow = 2.34 cfs @ 12.00 hrs, Volume= 0.113 af, Atten= 9%, Lag= 4.8 min
Routed to Reach D1AB : Permanent Downchute

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.65 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 0.91 fps, Avg. Travel Time= 8.9 min

Peak Storage= 431 cf @ 11.95 hrs
Average Depth at Peak Storage= 0.27' , Surface Width= 6.52'
Bank-Full Depth= 1.00' Flow Area= 12.0 sf, Capacity= 75.87 cfs

0.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 4.0 20.0 '/' Top Width= 24.00'
Length= 487.0' Slope= 0.0287 '/'
Inlet Invert= 1,238.00', Outlet Invert= 1,224.00'



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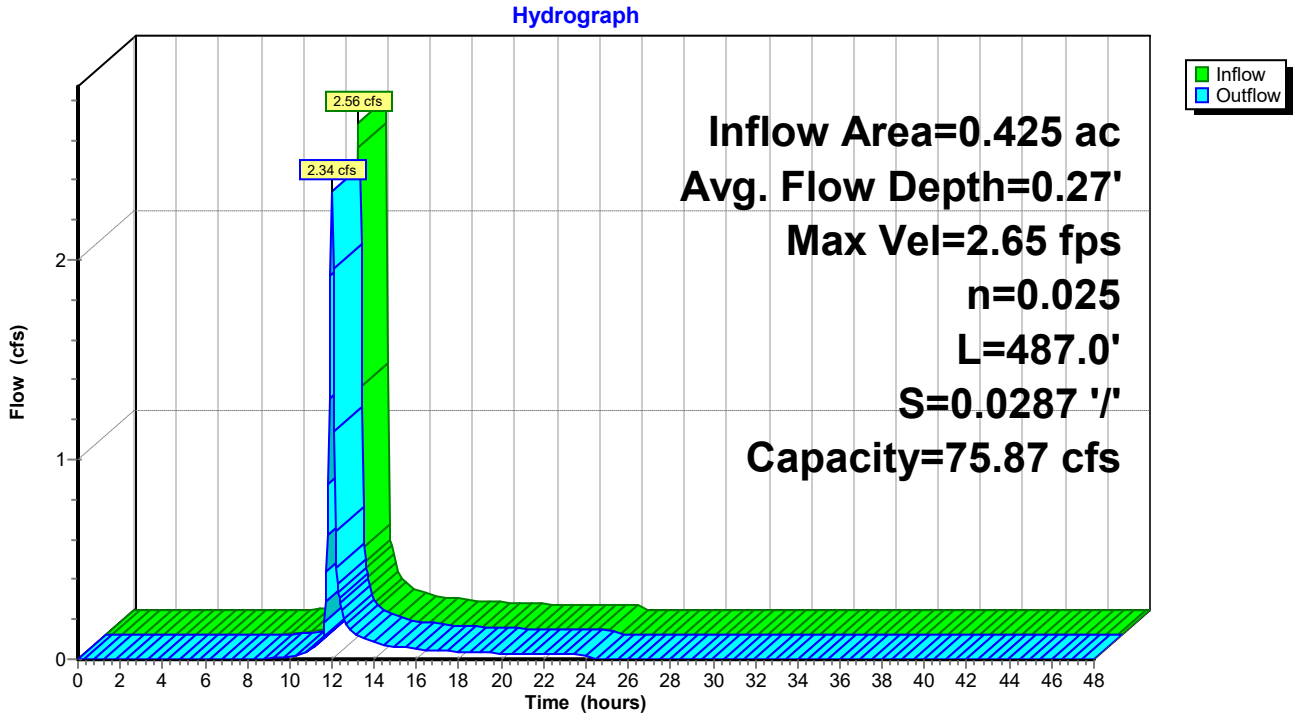
Reach TB2: TB2



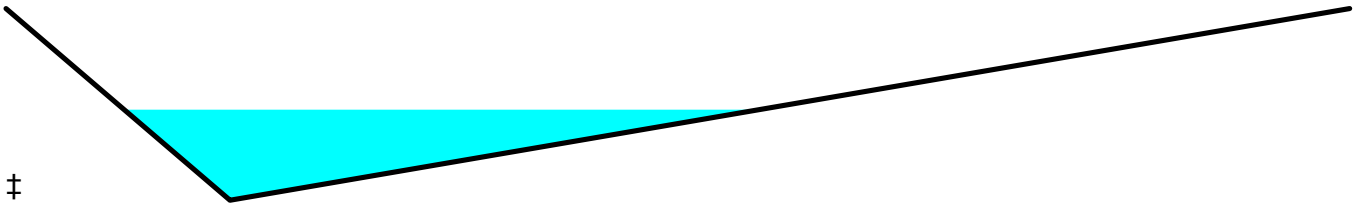
Summary for Reach TB3: TB3

Inflow Area = 1.751 ac, 0.00% Impervious, Inflow Depth = 3.18" for 25-year, 24-hour event
Inflow = 10.57 cfs @ 11.94 hrs, Volume= 0.465 af
Outflow = 9.40 cfs @ 12.00 hrs, Volume= 0.465 af, Atten= 11%, Lag= 3.5 min
Routed to Reach D1AB : Permanent Downchute

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.61 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 1.22 fps, Avg. Travel Time= 6.3 min

Peak Storage= 1,246 cf @ 11.97 hrs
Average Depth at Peak Storage= 0.47' , Surface Width= 11.33'
Bank-Full Depth= 1.00' Flow Area= 12.0 sf, Capacity= 71.81 cfs

0.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 4.0 20.0 '/' Top Width= 24.00'
Length= 466.0' Slope= 0.0258 '/'
Inlet Invert= 1,208.00', Outlet Invert= 1,196.00'



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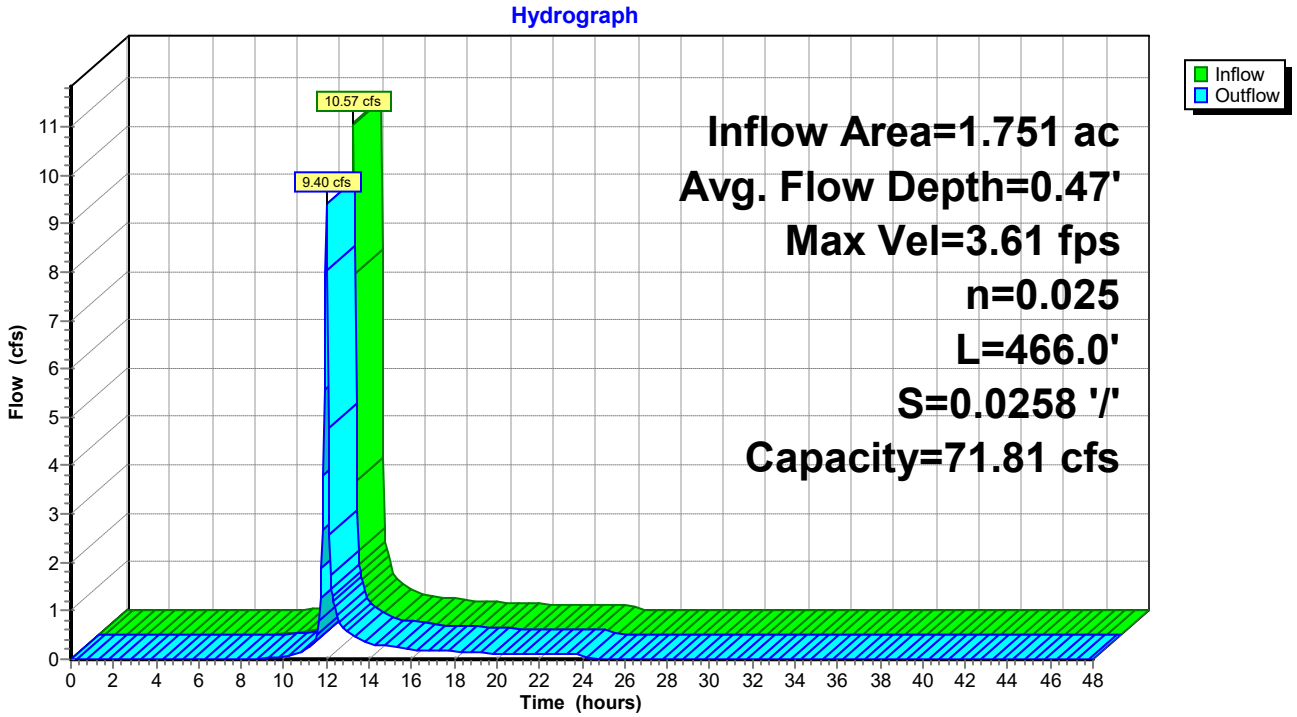
Reach TB3: TB3



Summary for Pond P1AB: Perimeter Berm System + Discharge Pipe

Inflow Area = 19.886 ac, 0.00% Impervious, Inflow Depth = 5.07" for 25-year, 24-hour event
Inflow = 83.11 cfs @ 12.23 hrs, Volume= 8.401 af
Outflow = 9.52 cfs @ 13.25 hrs, Volume= 8.211 af, Atten= 89%, Lag= 61.3 min
Primary = 9.52 cfs @ 13.25 hrs, Volume= 8.211 af
Routed to Reach D1AB : Permanent Downchute

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1,223.65' @ 13.25 hrs Surf.Area= 4.876 ac Storage= 4.898 af

Plug-Flow detention time= 379.1 min calculated for 8.211 af (98% of inflow)
Center-of-Mass det. time= 364.8 min (1,160.9 - 796.1)

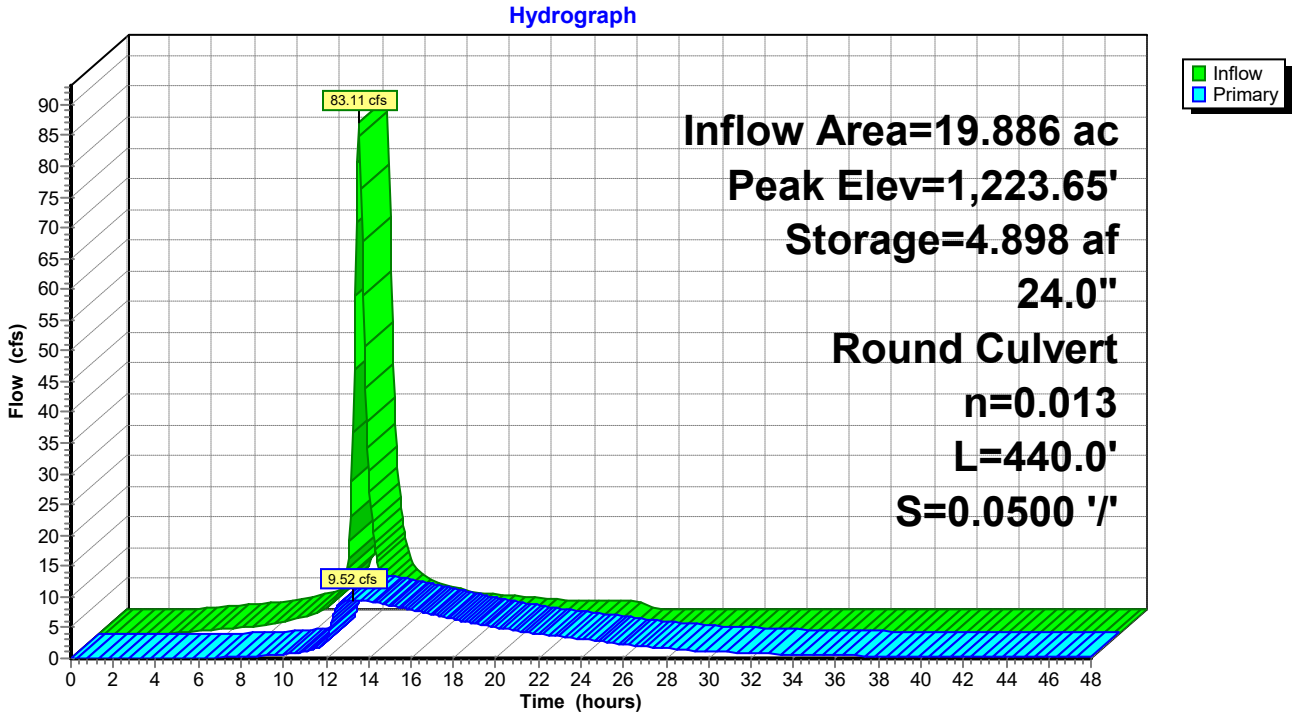
Volume	Invert	Avail.Storage	Storage Description
#1	1,222.00'	268.652 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,222.00	1.077	0.000	0.000
1,224.00	5.695	6.772	6.772
1,226.00	8.592	14.287	21.059
1,228.00	10.822	19.414	40.473
1,230.00	12.859	23.681	64.154
1,232.00	15.858	28.717	92.871
1,234.00	16.828	32.686	125.557
1,236.00	17.373	34.201	159.758
1,238.00	17.898	35.271	195.029
1,240.00	18.403	36.301	231.330
1,242.00	18.919	37.322	268.652

Device	Routing	Invert	Outlet Devices
#1	Primary	1,222.00'	**24.0" Round Temp Contact Water Pipe** L= 440.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,222.00' / 1,200.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=9.53 cfs @ 13.25 hrs HW=1,223.65' (Free Discharge)
↑—**1=Temp Contact Water Pipe** (Inlet Controls 9.53 cfs @ 3.45 fps)

Pond P1AB: Perimeter Berm System + Discharge Pipe



Summary for Pond P1C: Perimeter Berm System

Inflow Area = 8.063 ac, 0.00% Impervious, Inflow Depth = 5.07" for 25-year, 24-hour event
Inflow = 62.25 cfs @ 11.97 hrs, Volume= 3.406 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

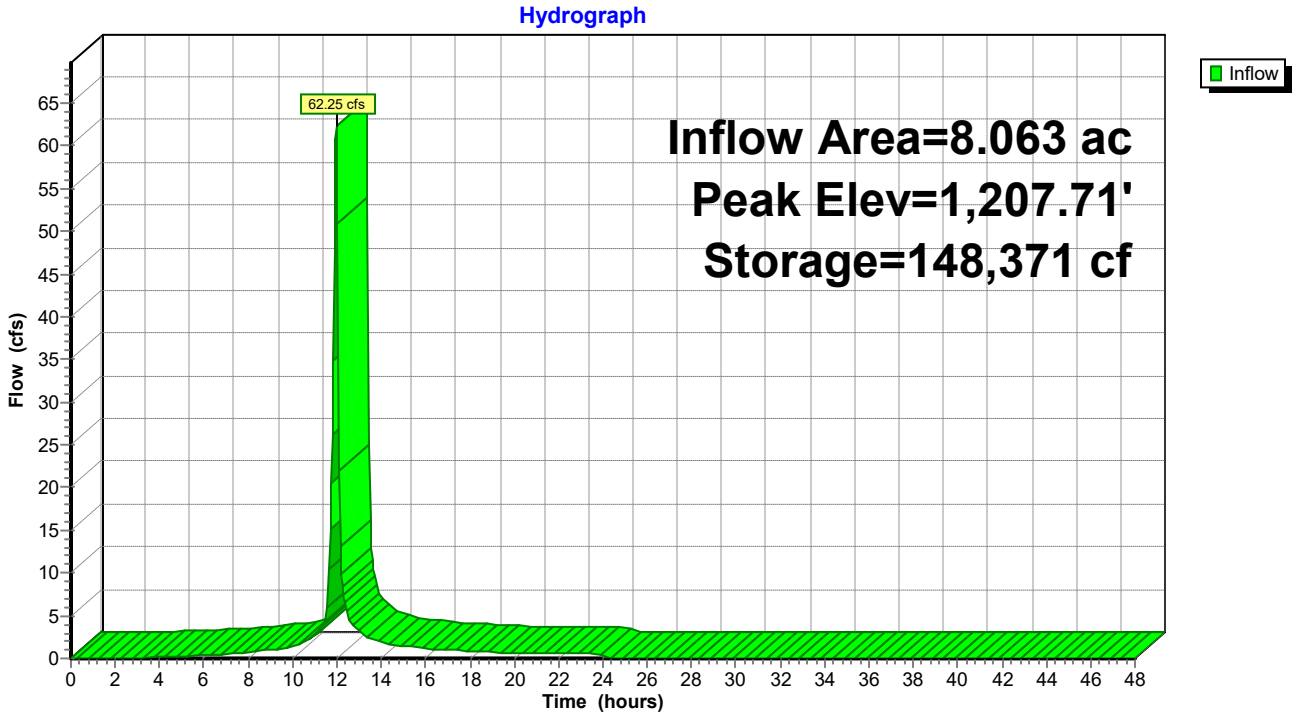
Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1,207.71' @ 24.40 hrs Surf.Area= 34,975 sf Storage= 148,371 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,194.00'	1,376,254 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,194.00	98	0	0
1,196.00	644	742	742
1,198.00	1,803	2,447	3,189
1,200.00	4,367	6,170	9,359
1,202.00	10,293	14,660	24,019
1,204.00	17,804	28,097	52,116
1,206.00	26,132	43,936	96,052
1,208.00	36,461	62,593	158,645
1,210.00	48,572	85,033	243,678
1,212.00	61,471	110,043	353,721
1,214.00	76,408	137,879	491,600
1,216.00	92,836	169,244	660,844
1,218.00	109,656	202,492	863,336
1,220.00	127,853	237,509	1,100,845
1,222.00	147,556	275,409	1,376,254

Pond P1C: Perimeter Berm System

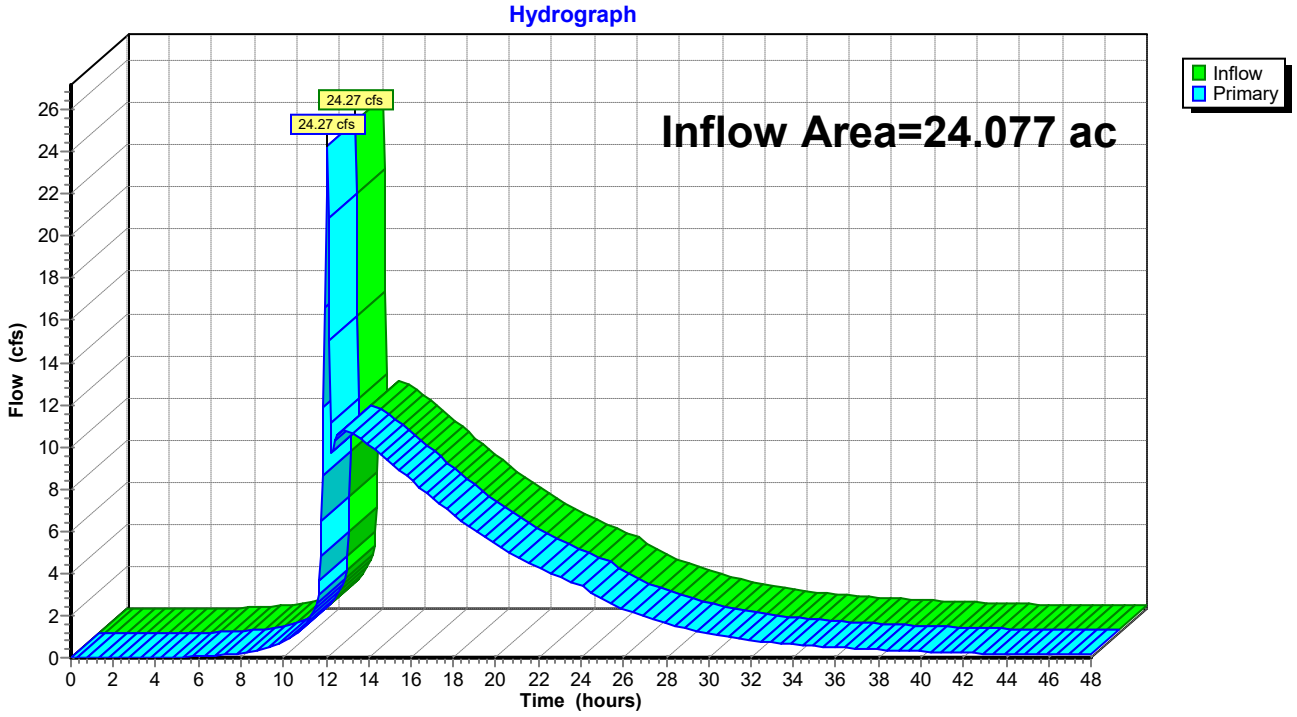


Summary for Link SBD: South Bypass Ditch

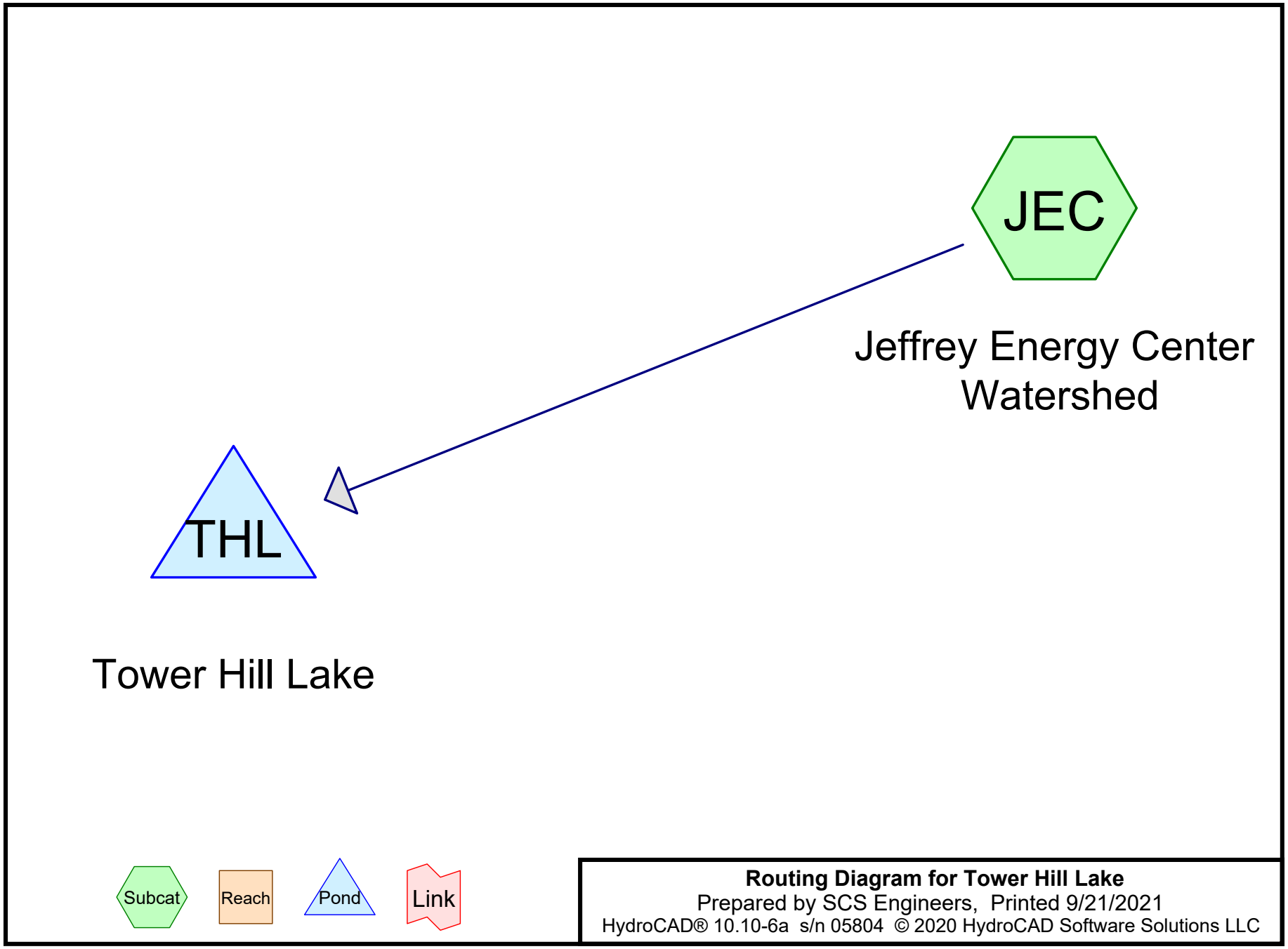
Inflow Area = 24.077 ac, 0.00% Impervious, Inflow Depth > 4.65" for 25-year, 24-hour event
Inflow = 24.27 cfs @ 12.04 hrs, Volume= 9.322 af
Primary = 24.27 cfs @ 12.04 hrs, Volume= 9.322 af, Atten= 0%, Lag= 0.0 min
Routed to nonexistent node THL

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Link SBD: South Bypass Ditch



Appendix C Regional Control System Tower Hill Lake – HydroCAD Output Files



Routing Diagram for Tower Hill Lake
Prepared by SCS Engineers, Printed 9/21/2021

Summary for Subcatchment JEC: Jeffrey Energy Center Watershed

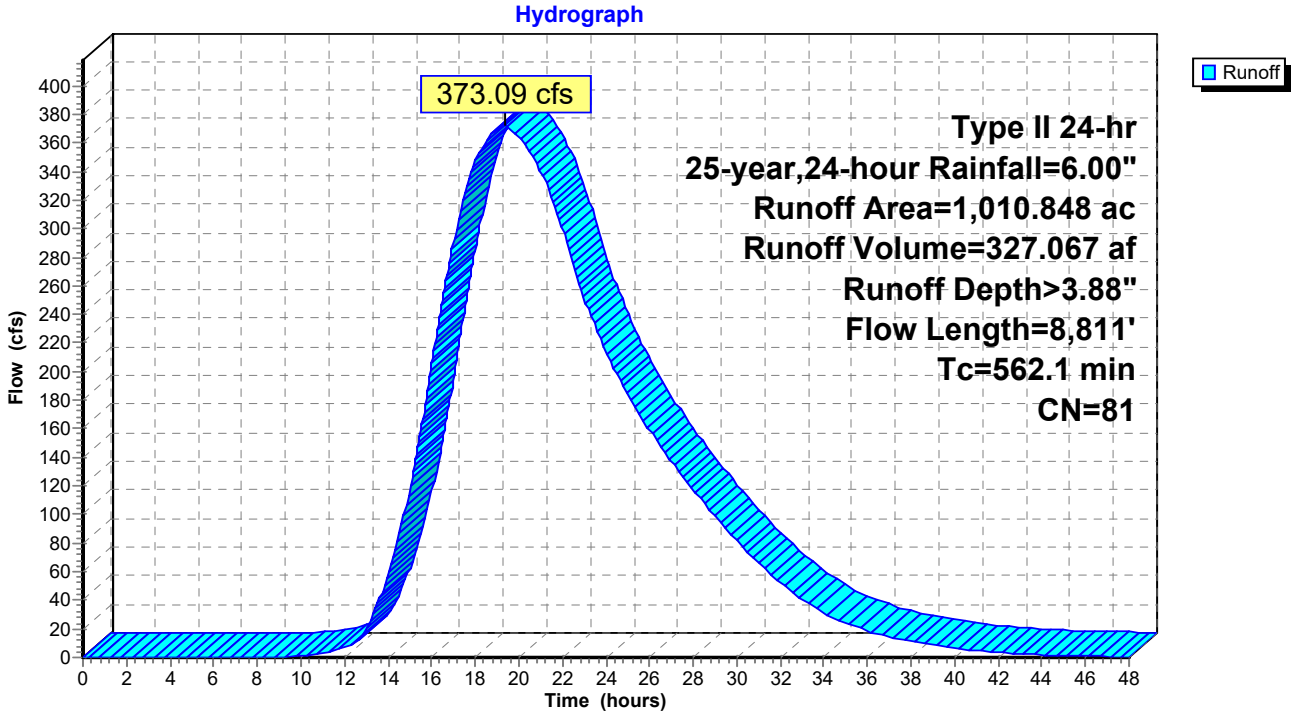
Runoff = 373.09 cfs @ 19.35 hrs, Volume= 327.067 af, Depth> 3.88"
Routed to Pond THL : Tower Hill Lake

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-year,24-hour Rainfall=6.00"

Area (ac)	CN	Description
934.496	80	>75% Grass cover, Good, HSG D
76.352	98	Water Surface, 0% imp, HSG D
1,010.848	81	Weighted Average
1,010.848		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.2	100	0.0400	0.23		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
13.5	1,138	0.0400	1.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
541.4	7,573	0.1000	0.23	6.99	**Channel Flow,** Area= 30.0 sf Perim= 4,737.0' r= 0.01' n= 0.069 Riprap, 6-inch
562.1	8,811	Total			

Subcatchment JEC: Jeffrey Energy Center Watershed



Summary for Pond THL: Tower Hill Lake

Inflow Area = 1,010.848 ac, 0.00% Impervious, Inflow Depth > 3.88" for 25-year,24-hour event
Inflow = 373.09 cfs @ 19.35 hrs, Volume= 327.067 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 1,148.70' @ 48.00 hrs Surf.Area= 124.166 ac Storage= 327.058 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,146.00'	2,804.565 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,146.00	117.180	0.000	0.000
1,148.00	122.922	240.102	240.102
1,150.00	126.458	249.380	489.482
1,152.00	130.703	257.161	746.643
1,154.00	134.795	265.498	1,012.141
1,156.00	138.961	273.756	1,285.897
1,158.00	143.457	282.418	1,568.315
1,160.00	148.544	292.001	1,860.316
1,162.00	154.180	302.724	2,163.040
1,164.00	160.146	314.326	2,477.366
1,166.00	167.053	327.199	2,804.565

Pond THL: Tower Hill Lake