Jeffrey Energy Center
Bottom Ash Landfill
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

25221157.00 | October 2021

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.

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 a periodic update to the initial Run-On and Run-Off Control System Plan that was certified on October 17, 2016.

Oct. 8, 2021

Richard D. Southorn, PE

License No. PE 25201

Expires 4/30/2023

1.0 INTRODUCTION

The Bottom Ash Landfill (Landfill) is an existing coal combustion residual (CCR) landfill located at Evergy's Jeffrey Energy Center near St. Marys, Kansas. This Run-on and Run-off Control System Plan documents that the Landfill's run-on and run-off control systems have been designed and constructed to meet the applicable requirements of Title 40 Code of Federal Regulations (CFR) §257.81[1] of the CCR Rule.

2.0 REGULATORY REQUIREMENTS

<u>40 CFR §257.81 Run-on and run-off controls for CCR landfills.</u>

(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 Run-On and Run-Off Control System Plan (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 2021 RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN UPDATE

This document has been prepared as the periodic update to the initial RORO Plan. This plan has been developed to reflect run-on and run-off controls that being used at the Landfill at the time of this report. As such, this plan will replace the previous RORO Plan. The current run-on and run-off control systems at the Landfill have been reviewed as part of this 2021 Periodic RORO Plan 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 Landfill is located within a defined CCR Unit Boundary under Permit No. 359, issued by the Kansas Department of Health and Environment (KDHE) Bureau of Waste Management (BWM). The Landfill is located directly to the south of the Bottom Ash Settling Area and is physically separated by a drainage channel and berm. The Landfill is located between railroad tracks to the east and a roadway along the south and west. The railroad tracks and south roadway serve as a perimeter barrier between the Landfill and areas of potential non-contact water (storm water) run-on from the southeast and southwest areas adjacent to the Landfill. The location of the Landfill is shown on Figure 1.

As shown in Figure 1, non-contact water run-on from the adjacent power block area east-northeast of the Landfill is collected and conveyed beneath the railroad tracks through a culvert. The culvert discharges into the drainage channel that separates the Landfill and the Bottom Ash Settling Area. This drainage channel conveys water to the west, where it ultimately discharges through two culverts into a branch of the South Bypass Ditch. A small amount of non-contact water that falls on the western slope of the railroad tracks drains onto the Landfill. This non-contact water is managed by the ditch between the Landfill and Bottom Ash Settling Area as contact water. The South Bypass Ditch discharges into Tower Hill Lake.

Tower Hill Lake 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]. The run-on control system is depicted in Figure 1.

3.2 RUN-OFF CONTROL SYSTEM

Contact and non-contact water from the Landfill is directed into drainage channels that merge and ultimately discharge into the adjacent branch of the South Bypass Ditch. The drainage channel located along the northern border of the Landfill conveys both contact-water and non-contact water. Drainage channels located along the southwest border only convey contact water run-off from the Landfill. Contact water and non-contact water collected in the South Bypass Ditch discharge into Tower Hill Lake.

As indicated in the previous section, Tower Hill Lake is permitted to receive non-contact water, contact water, and leachate from multiple CCR units (including the Landfill). 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-on and run-off control systems at the Landfill consist of a hydrologic and hydraulic storm water model prepared using HydroCAD storm water modeling software. The run-on and 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 80 was selected for all areas with surficial bottom ash, based on typical curve numbers for this CCR material. For areas outside of the Landfill, 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 Jeffrey Energy Center 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 strip of land between the Landfill and railroad tracks is well vegetated. Therefore, a curve number of 80 was used for this area. For the power block area to the east of the railroad tracks, the ground surface is primarily gravel, reflecting a curve number of 96.

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 each subcatchment in HydroCAD.

3.3.3 Conveyance Features

Key attributes used in the HydroCAD model for each conveyance feature are summarized below:

- Culvert Location 1 (HydroCAD Node – C1)
  - Modeled as a 42-inch corrugated metal pipe at 0.2% slope.
- Drainage Channel 1 (HydroCAD Node – DC1)
  - Modeled as a 1-ft. deep channel with 6-ft. bottom width and 4H:1V sideslopes.
  - Ditch lining designated as concrete.
- Culvert Location 2 (HydroCAD Node – C2)
  - Modeled as a 42-inch corrugated metal pipe at 27.4% slope.
- Drainage Channel 2 (HydroCAD Node – DC2)
  - Modeled as a 4-ft. deep channel with 10-ft. bottom width and 4H:1V sideslopes.
  - Ditch lining designated as CCR material without vegetation.
- Drainage Channel 3 (HydroCAD Node – DC3)
  - Modeled as a 1-ft. deep channel with 2-ft. bottom width and 10H:1V sideslopes.
  - Ditch lining designated as CCR material with vegetation.
- Drainage Channel 4 (HydroCAD Node – DC4)
  - Modeled as a 4-ft. deep channel with 10-ft. bottom width and 4H:1V sideslopes.
  - Ditch lining designated as CCR material without vegetation.
- Drainage Channel 5 (HydroCAD Node – DC5)
  - Modeled as a 1-ft. deep channel with 2-ft. bottom width and 3H:1V sideslopes.
  - Ditch lining designated as CCR material without vegetation.
- Culvert Location 3 (HydroCAD Node – C3)
  - Modeled as two (2) 24-inch high-density polyethylene (HDPE) pipe with smooth interior at 8.9% slope.
- Culvert Location 4 (HydroCAD Node – C4)
  - Modeled as two (2) 36-inch high-density polyethylene (HDPE) pipe with smooth interior at 5.5% slope.
- Branch of the South Bypass ditch (HydroCAD Node – SBD)
  - Modeled as a link node to collect all water from the modeled areas.

These conveyance features are modeled in HydroCAD to demonstrate the run-on and run-off control systems are 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 Jeffrey Energy Center. 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 HydroCAD storm water model of the Landfill was developed to evaluate whether the peak flow from the 25-year, 24-hour storm event could be accommodated without overtopping the run-on control systems.

Run-On and Run-off Control System

The run-on control system is designed and constructed to divert storm water away from the active portions of the Landfill and into Tower Hill Lake. Based on the results of the HydroCAD storm water model, the run-on control system was determined to accommodate the 25-year, 24-hour storm event without overtopping. 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)
C1	3.50	0.00 (Full Flow)
DC1	0.46	0.54
C2	1.30	2.20
DC2	0.97	3.03
DC3	0.92	0.08
DC4	1.37	2.63
DC5	0.63	0.37
C3	0.47	1.53
C4	2.34	0.66

Based on the results from the HydroCAD model, the run-on control system is designed to prevent run-on from the power block area to the active portion of the Landfill during the peak discharge from the 25-year, 24-hour storm event and meets the requirements of 40 CFR §257.81(a)(1)[1]. Run-on from the strip of land between the Landfill and the railroad tracks is managed in the run-off control system channel between the Landfill and the Bottom Ash Settling Area, which is adequately sized. 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].

Regional Control System – Tower Hill Lake

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 Jeffrey Energy Center without overtopping. The peak rise in water elevation and freeboard remaining within Tower Hill Lake is summarized below:

Table 2 – Tower Hill Lake Capacity		
Peak Rise in Water Elevation (feet)	Remaining Freeboard (feet)	Remaining Capacity (acre-feet)
2.70	17.30	2,804,237.85

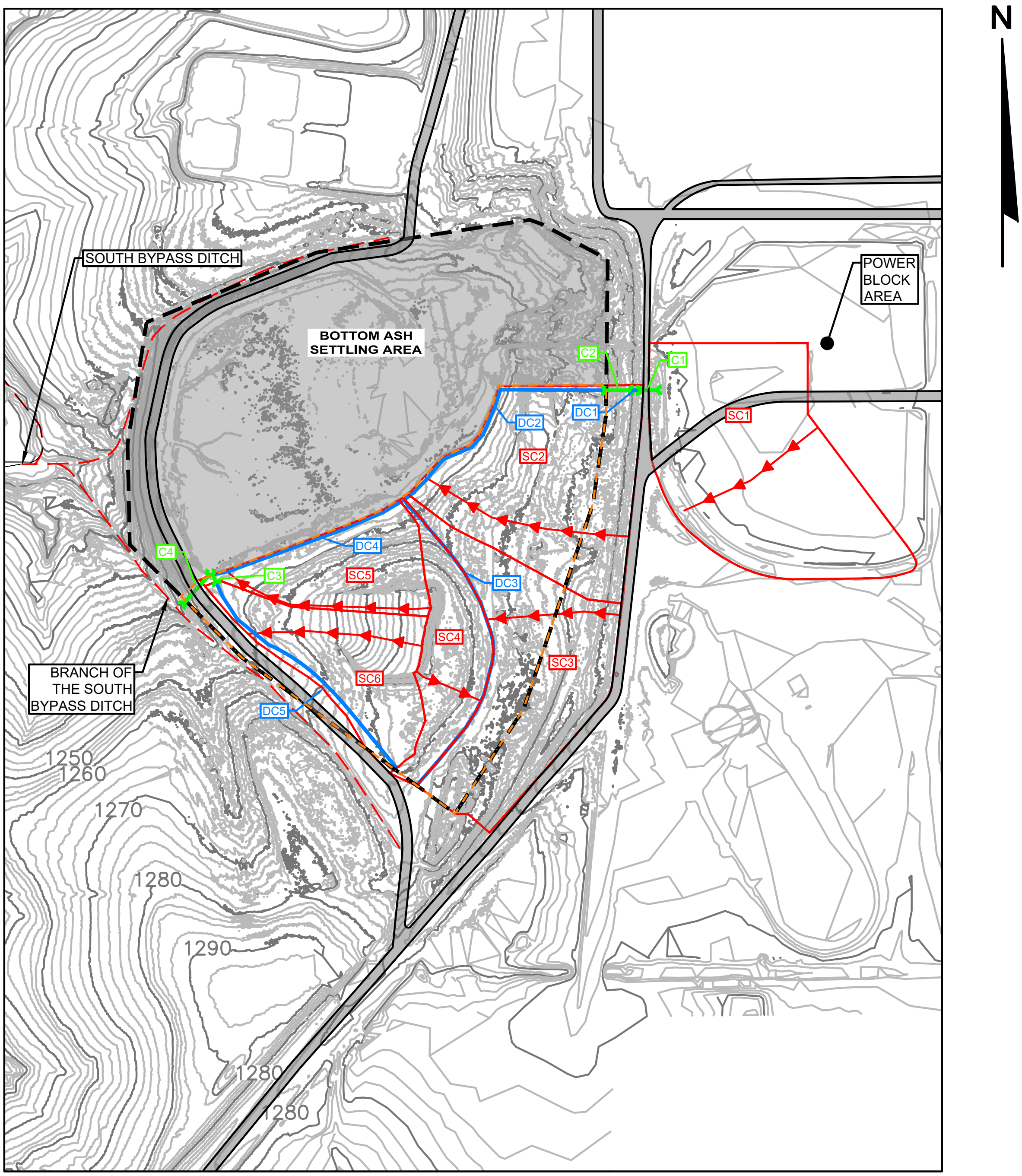
4.0 CERTIFICATIONS

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, as revised.
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



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

LEGEND

- APPROXIMATE CCR UNIT BOUNDARY
- APPROXIMATE BOTTOM ASH LANDFILL BOUNDARY
- SUBCATCHMENT BOUNDARY
- DRAINAGE CHANNEL LOCATION
- WATER CULVERT(S) LOCATION
- TIME OF CONCENTRATION FLOW PATH
- APPROXIMATE ROADWAY / RAILROAD LOCATION

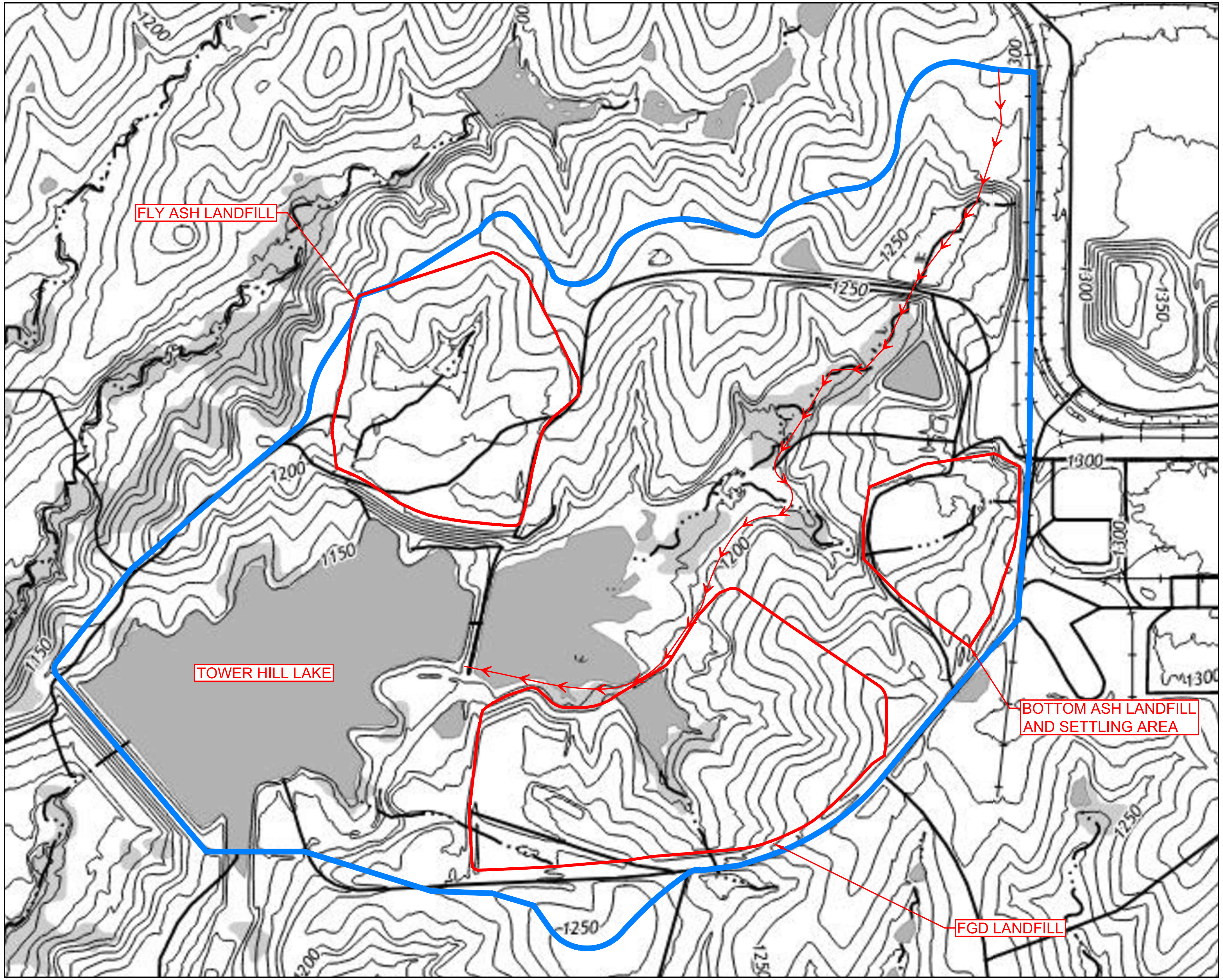
500 0 500

SCALE: 1" = 500'

CLIENT	evergy	SITE	JEFFREY ENERGY CENTER ST. MARYS, KS	RUN–ON RUN–OFF PLAN SUBCATCHMENT DELINEATION

PROJECT NO.	25221157	DRAWN BY:	NV	ENGINEER	SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718–6751 PHONE: (608) 224–2830	FIGURE
DRAWN:	09/15/2021	CHECKED BY:	SJL			1 OF 2
REVISED:	–	APPROVED BY:	RDS			

I:\25221157.00\Drawings\Site Layout-HydroCAD (JEC RORO).dwg, 9/24/2021 8:46:02 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	Bottom Ash Landfill 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

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

Kansas Department of Transportation

(December, 2014 Edition)

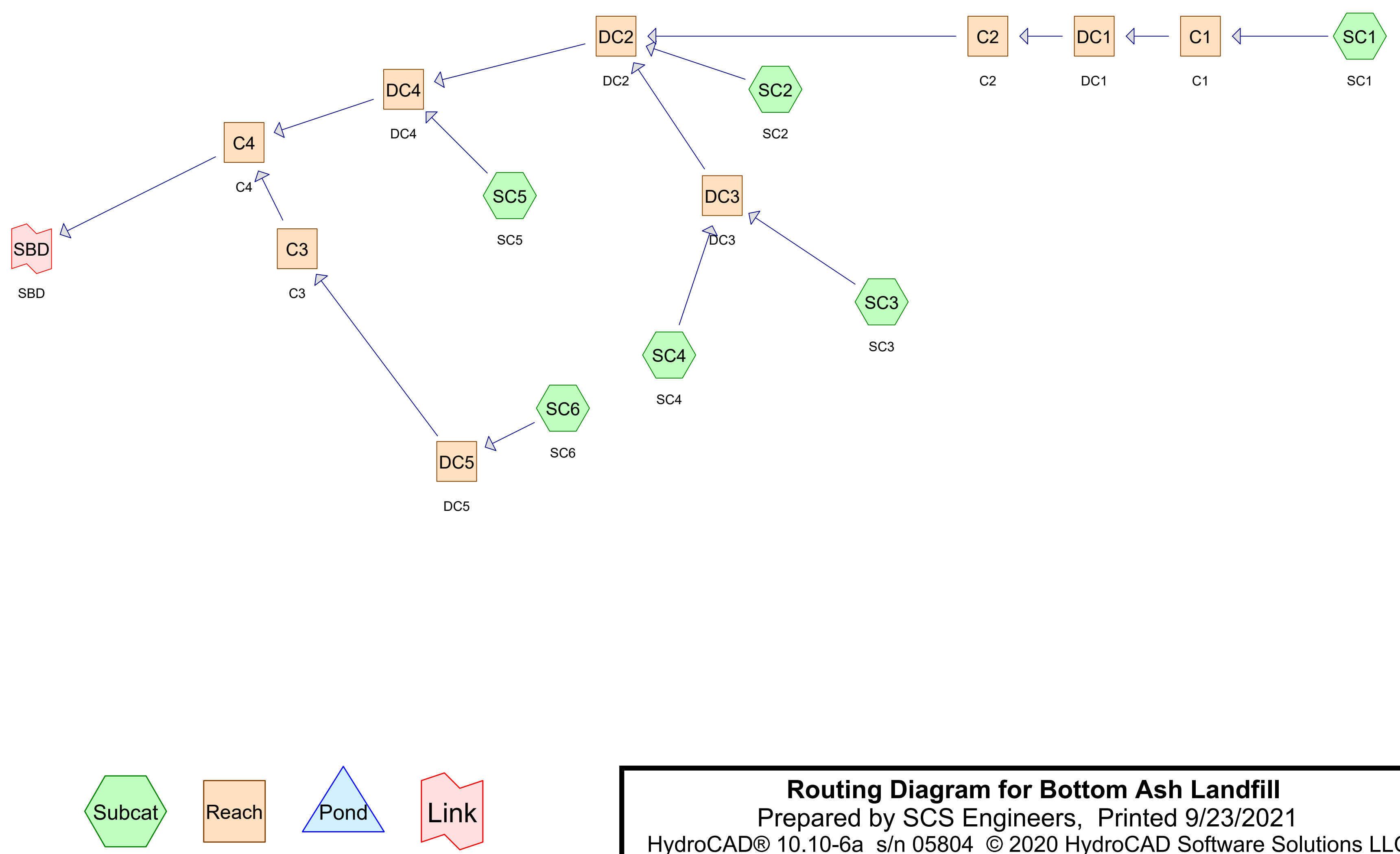
RAINFALL INTENSITY TABLE

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 Bottom Ash Landfill Run-On and Run-Off Control System – HydroCAD Output Files



Routing Diagram for Bottom Ash Landfill
Prepared by SCS Engineers, Printed 9/23/2021
HydroCAD® 10.10-6a s/n 05804 © 2020 HydroCAD Software Solutions LLC

Summary for Subcatchment SC1: SC1

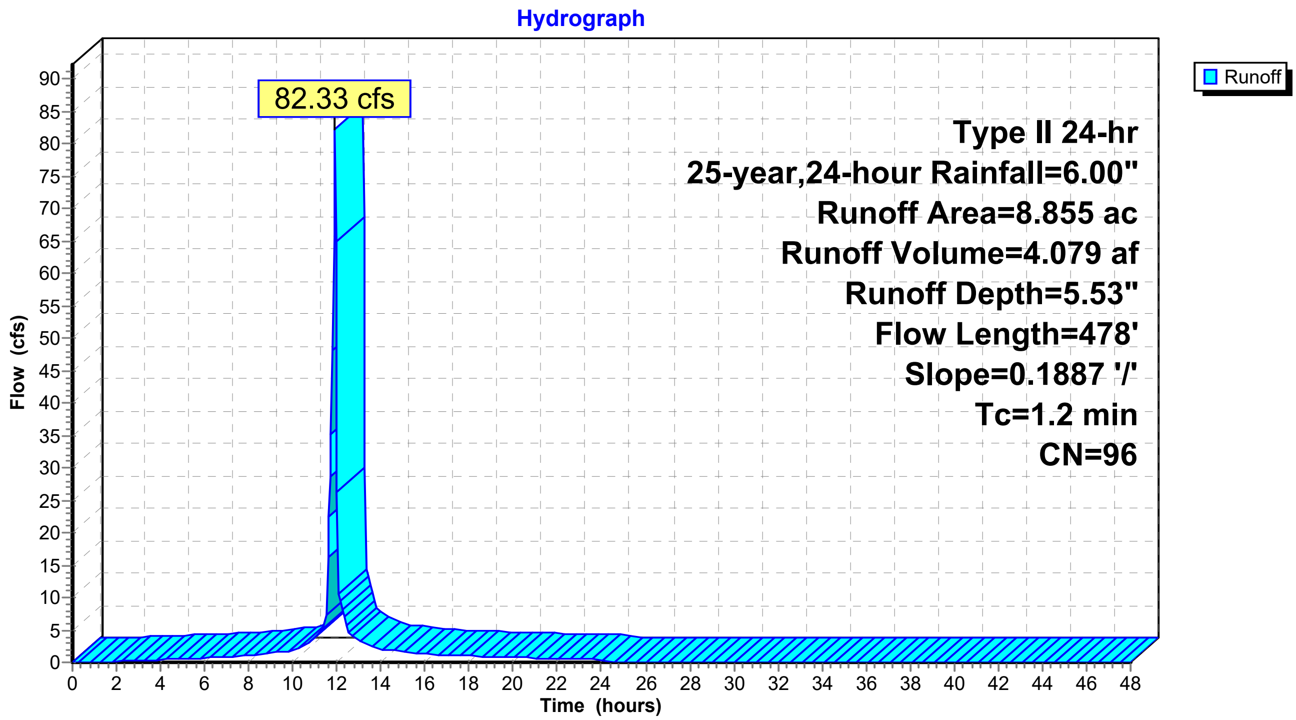
Runoff = 82.33 cfs @ 11.90 hrs, Volume= 4.079 af, Depth= 5.53"
Routed to Reach C1 : C1

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
8.855	96	Gravel surface, HSG D
8.855		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	100	0.1887	3.46		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.36"
0.7	378	0.1887	8.82		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.2	478	Total			

Subcatchment SC1: SC1



Summary for Subcatchment SC2: SC2

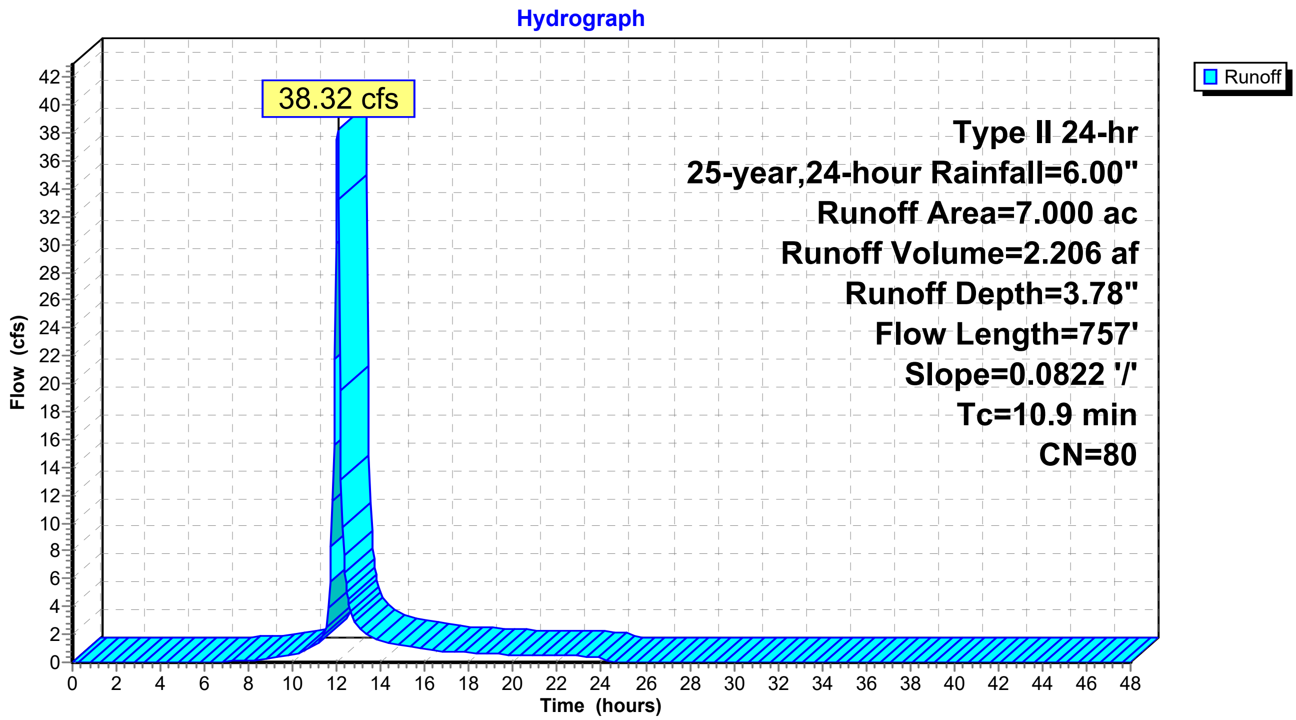
Runoff = 38.32 cfs @ 12.02 hrs, Volume= 2.206 af, Depth= 3.78"
Routed to Reach DC2 : DC2

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
7.000	80	>75% Grass cover, Good, HSG D
7.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	100	0.0822	0.31		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
5.5	657	0.0822	2.01		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.9	757	Total			

Subcatchment SC2: SC2



Summary for Subcatchment SC3: SC3

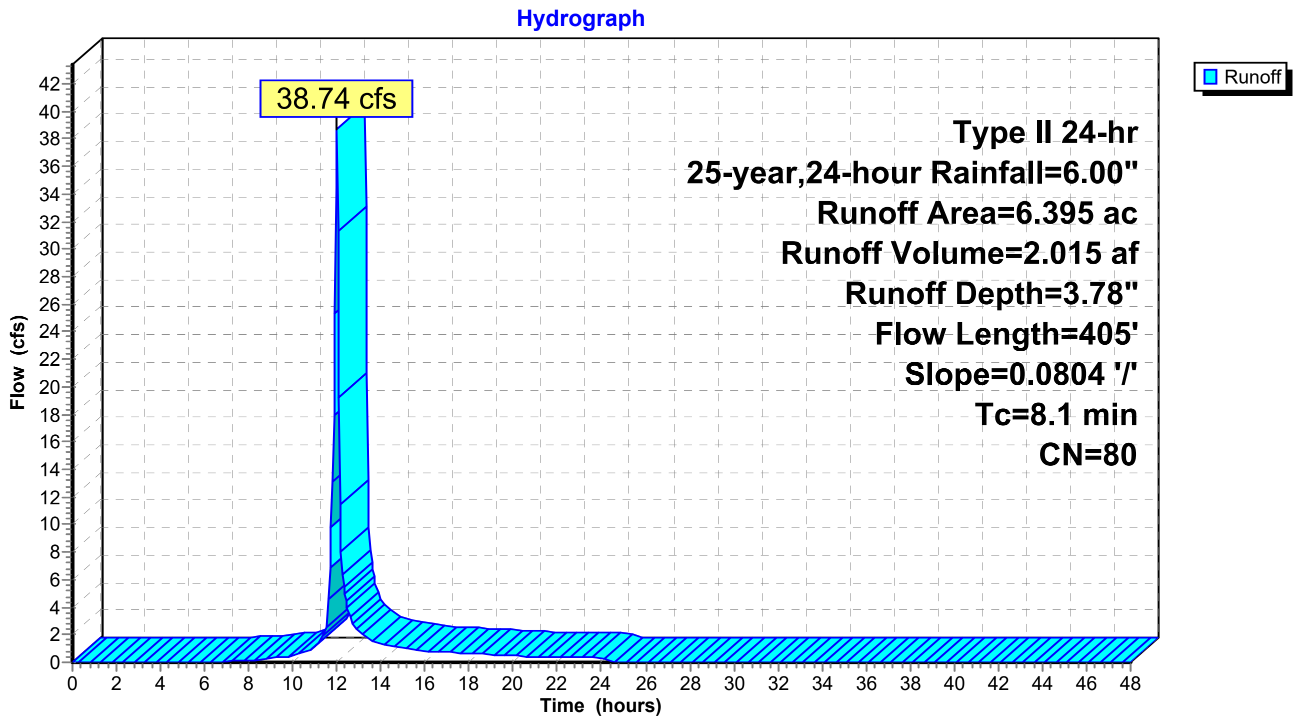
Runoff = 38.74 cfs @ 11.99 hrs, Volume= 2.015 af, Depth= 3.78"
Routed to Reach DC3 : DC3

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
6.395	80	>75% Grass cover, Good, HSG D
6.395		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	100	0.0804	0.30		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
2.6	305	0.0804	1.98		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
8.1	405	Total			

Subcatchment SC3: SC3



Summary for Subcatchment SC4: SC4

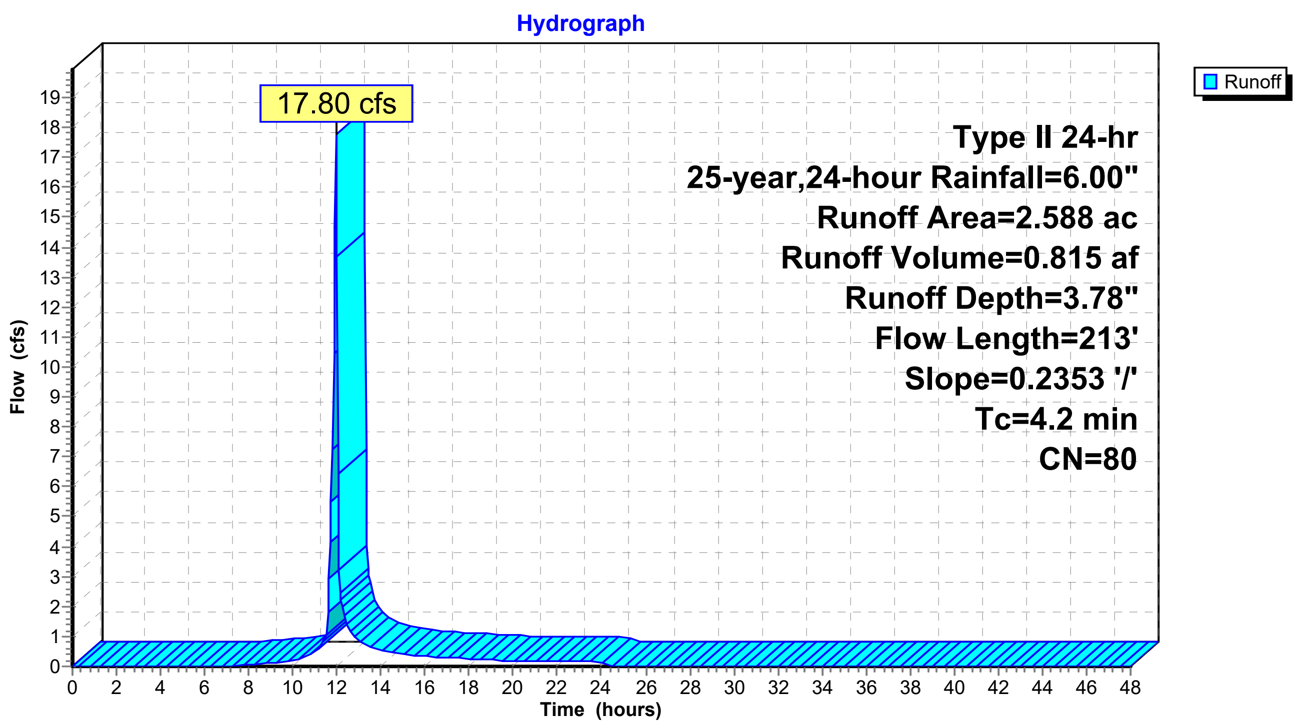
Runoff = 17.80 cfs @ 11.95 hrs, Volume= 0.815 af, Depth= 3.78"
Routed to Reach DC3 : DC3

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
2.588	80	>75% Grass cover, Good, HSG D
2.588		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	100	0.2353	0.47		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
0.6	113	0.2353	3.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.2	213	Total			

Subcatchment SC4: SC4



Summary for Subcatchment SC5: SC5

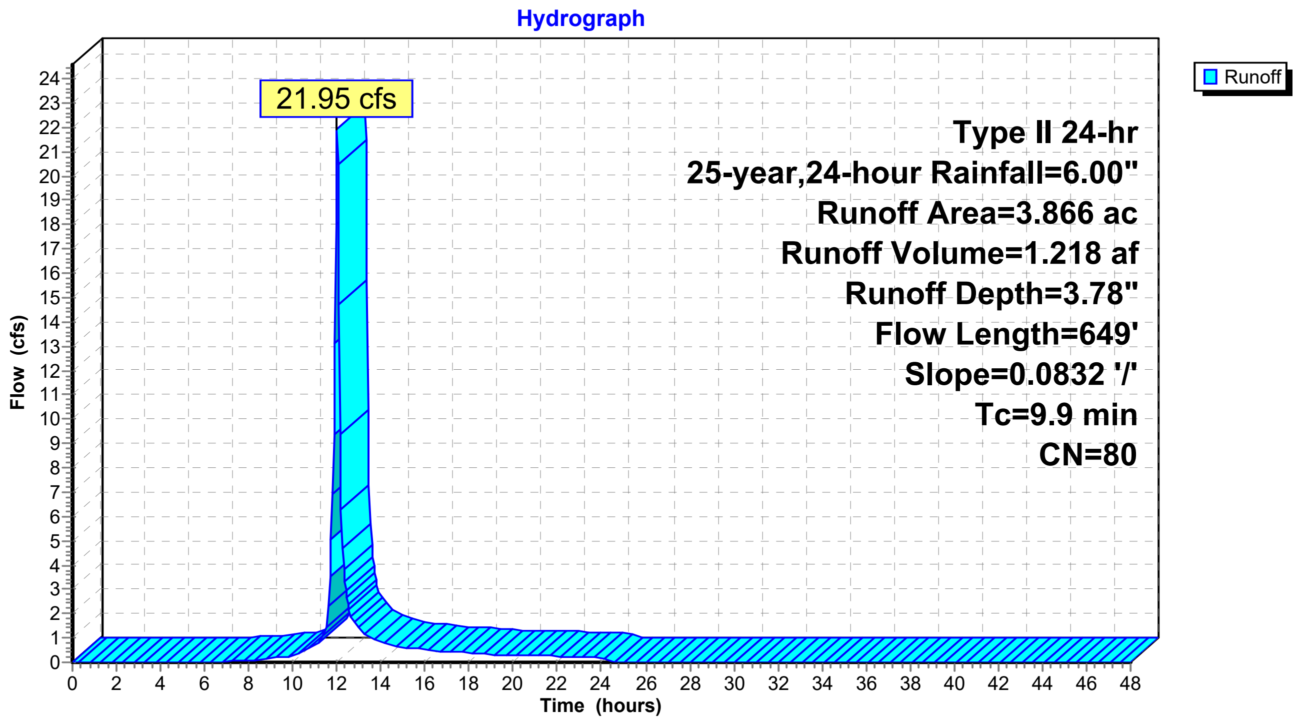
Runoff = 21.95 cfs @ 12.01 hrs, Volume= 1.218 af, Depth= 3.78"
Routed to Reach DC4 : DC4

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
3.866	80	>75% Grass cover, Good, HSG D
3.866		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.4	100	0.0832	0.31		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
4.5	549	0.0832	2.02		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.9	649	Total			

Subcatchment SC5: SC5



Summary for Subcatchment SC6: SC6

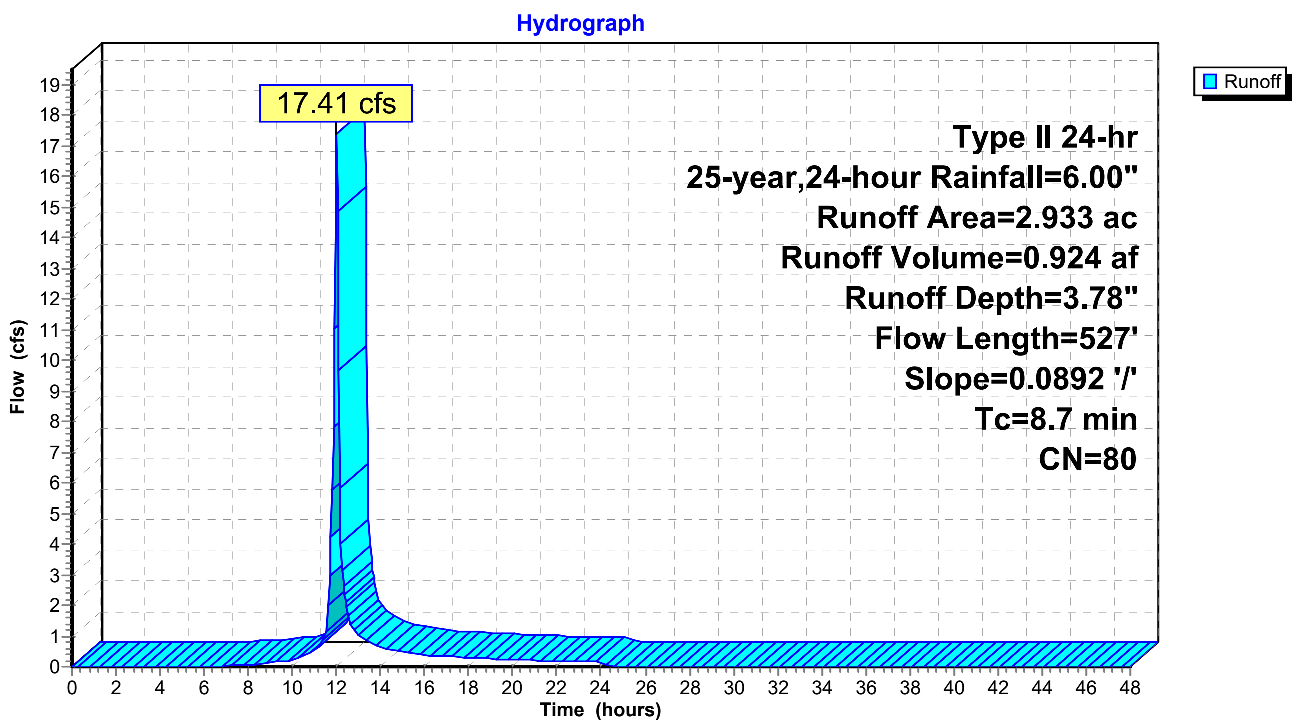
Runoff = 17.41 cfs @ 12.00 hrs, Volume= 0.924 af, Depth= 3.78"
Routed to Reach DC5 : DC5

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
2.933	80	>75% Grass cover, Good, HSG D
2.933		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	100	0.0892	0.32		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.36"
3.4	427	0.0892	2.09		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
8.7	527	Total			

Subcatchment SC6: SC6



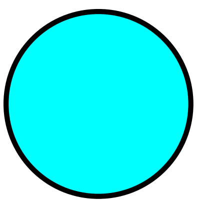
Summary for Reach C1: C1

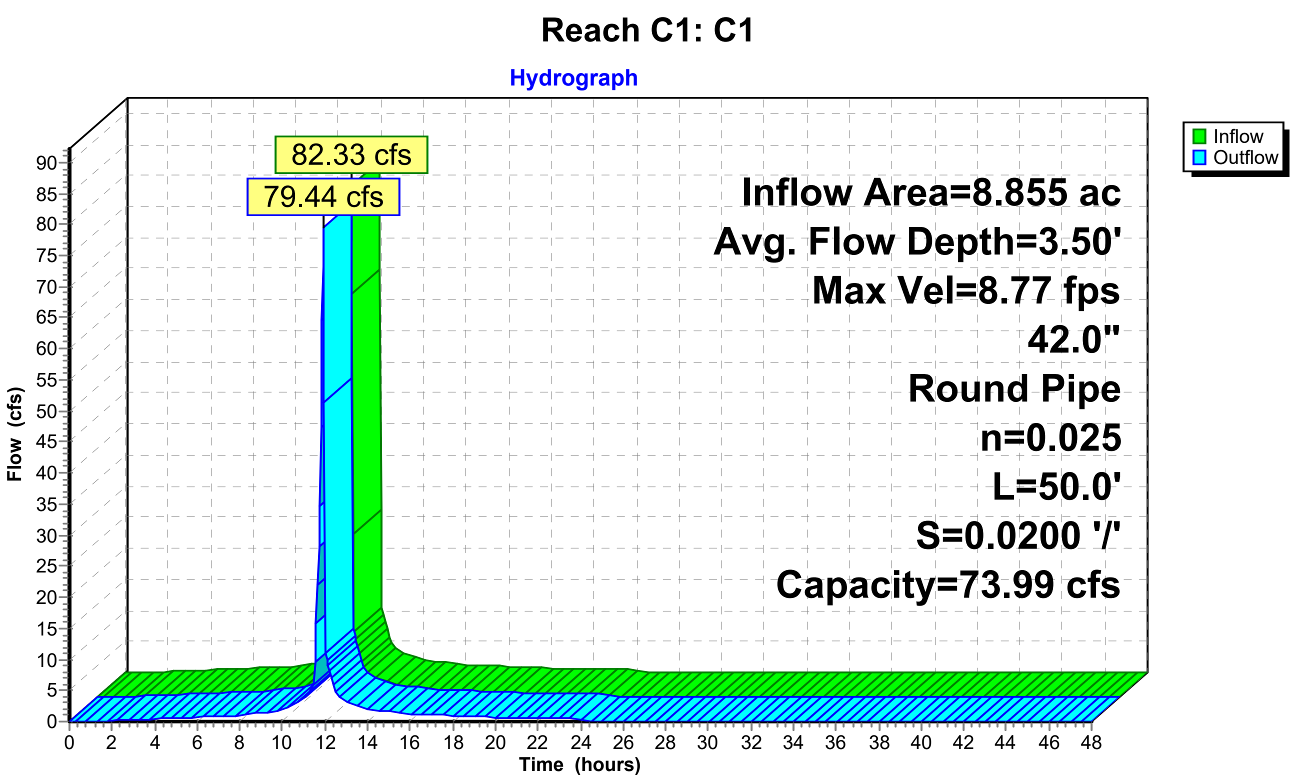
Inflow Area = 8.855 ac, 0.00% Impervious, Inflow Depth = 5.53" for 25-year,24-hour event
Inflow = 82.33 cfs @ 11.90 hrs, Volume= 4.079 af
Outflow = 79.44 cfs @ 11.93 hrs, Volume= 4.079 af, Atten= 4%, Lag= 1.5 min
Routed to Reach DC1 : DC1

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.77 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.82 fps, Avg. Travel Time= 0.3 min

Peak Storage= 483 cf @ 11.91 hrs
Average Depth at Peak Storage= 3.50'
Bank-Full Depth= 3.50' Flow Area= 9.6 sf, Capacity= 73.99 cfs

42.0" Round Pipe
n= 0.025 Corrugated metal
Length= 50.0' Slope= 0.0200 '/'
Inlet Invert= 1,292.00', Outlet Invert= 1,291.00'





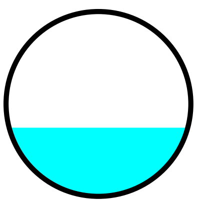
Summary for Reach C2: C2

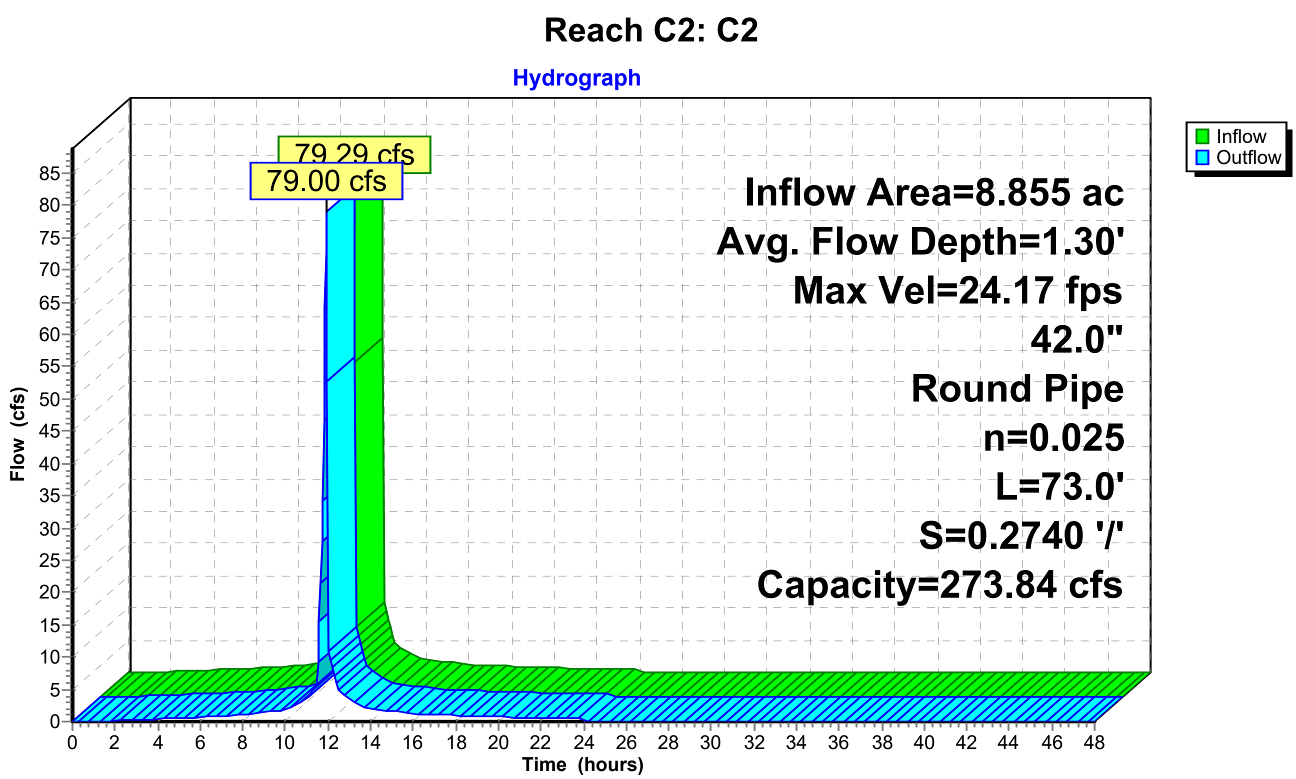
Inflow Area = 8.855 ac, 0.00% Impervious, Inflow Depth = 5.53" for 25-year,24-hour event
Inflow = 79.29 cfs @ 11.93 hrs, Volume= 4.079 af
Outflow = 79.00 cfs @ 11.93 hrs, Volume= 4.079 af, Atten= 0%, Lag= 0.0 min
Routed to Reach DC2 : DC2

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 24.17 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 7.05 fps, Avg. Travel Time= 0.2 min

Peak Storage= 236 cf @ 11.93 hrs
Average Depth at Peak Storage= 1.30' , Surface Width= 3.38'
Bank-Full Depth= 3.50' Flow Area= 9.6 sf, Capacity= 273.84 cfs

42.0" Round Pipe
n= 0.025 Corrugated metal
Length= 73.0' Slope= 0.2740 '/'
Inlet Invert= 1,286.00', Outlet Invert= 1,266.00'





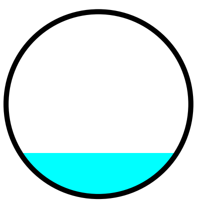
Summary for Reach C3: C3

Inflow Area = 2.933 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-year,24-hour event
Inflow = 16.24 cfs @ 12.06 hrs, Volume= 0.924 af
Outflow = 16.22 cfs @ 12.06 hrs, Volume= 0.924 af, Atten= 0%, Lag= 0.0 min
Routed to Reach C4 : C4

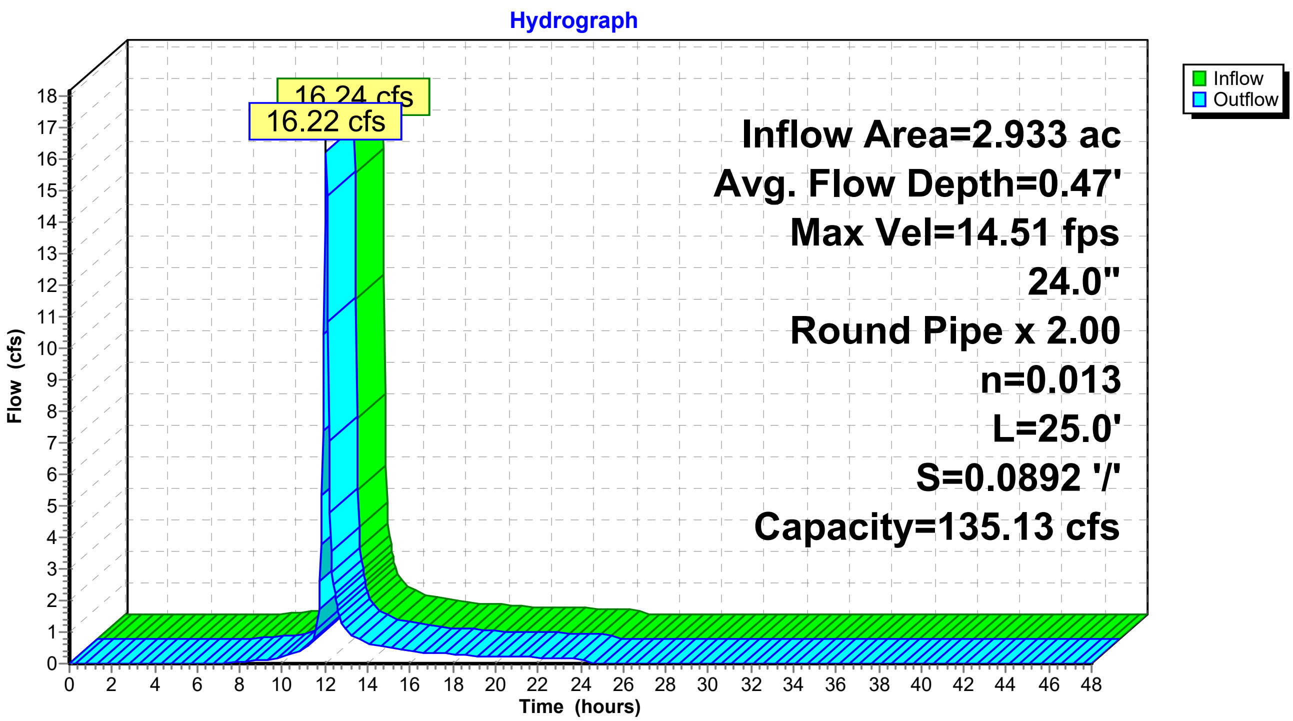
Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 14.51 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 4.25 fps, Avg. Travel Time= 0.1 min

Peak Storage= 28 cf @ 12.06 hrs
Average Depth at Peak Storage= 0.47' , Surface Width= 3.39'
Bank-Full Depth= 2.00' Flow Area= 6.3 sf, Capacity= 135.13 cfs

A factor of 2.00 has been applied to the storage and discharge capacity
24.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 25.0' Slope= 0.0892 '/'
Inlet Invert= 1,240.00', Outlet Invert= 1,237.77'



Reach C3: C3



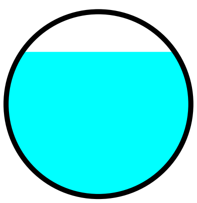
Summary for Reach C4: C4

Inflow Area = 31.637 ac, 0.00% Impervious, Inflow Depth = 4.27" for 25-year,24-hour event
Inflow = 155.22 cfs @ 12.04 hrs, Volume= 11.258 af
Outflow = 154.81 cfs @ 12.05 hrs, Volume= 11.258 af, Atten= 0%, Lag= 0.2 min
Routed to Link SBD : SBD

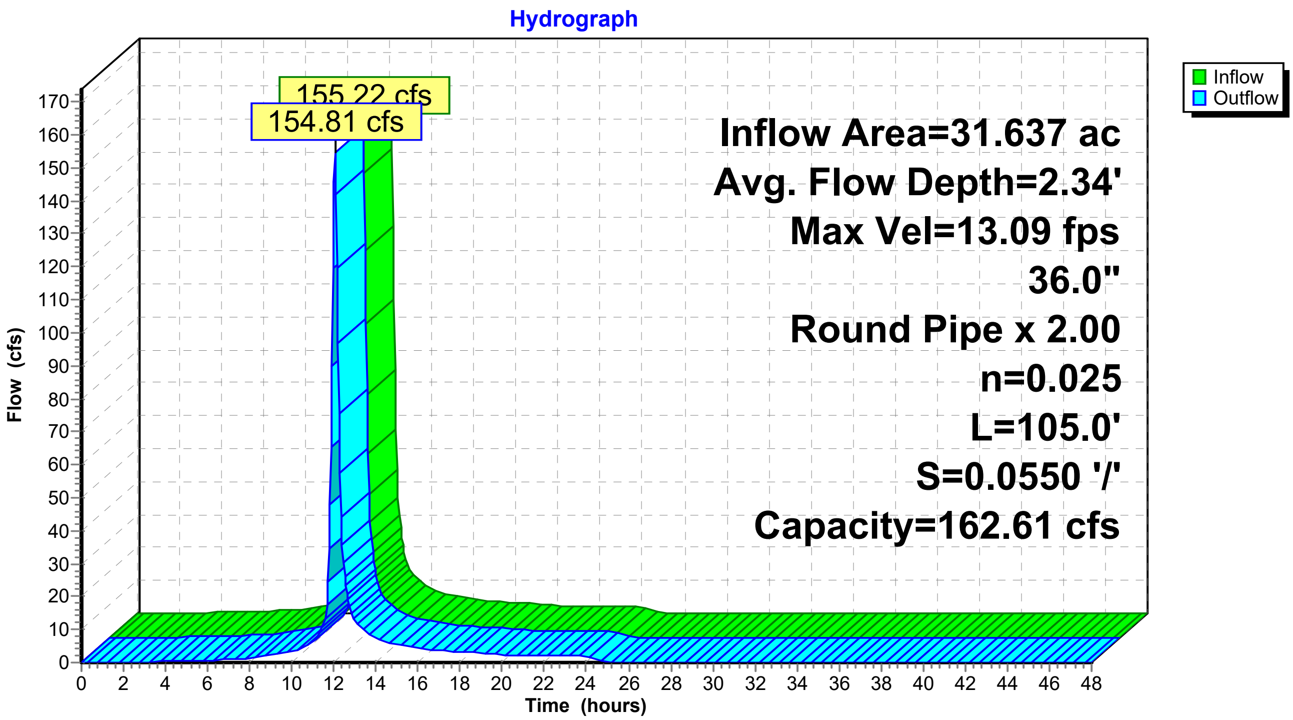
Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 13.09 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.75 fps, Avg. Travel Time= 0.5 min

Peak Storage= 1,245 cf @ 12.04 hrs
Average Depth at Peak Storage= 2.34' , Surface Width= 4.96'
Bank-Full Depth= 3.00' Flow Area= 14.1 sf, Capacity= 162.61 cfs

A factor of 2.00 has been applied to the storage and discharge capacity
36.0" Round Pipe
n= 0.025 Corrugated metal
Length= 105.0' Slope= 0.0550 '/'
Inlet Invert= 1,237.77', Outlet Invert= 1,232.00'



Reach C4: C4



Summary for Reach DC1: DC1

Inflow Area = 8.855 ac, 0.00% Impervious, Inflow Depth = 5.53" for 25-year,24-hour event
Inflow = 79.44 cfs @ 11.93 hrs, Volume= 4.079 af
Outflow = 79.29 cfs @ 11.93 hrs, Volume= 4.079 af, Atten= 0%, Lag= 0.0 min
Routed to Reach C2 : C2

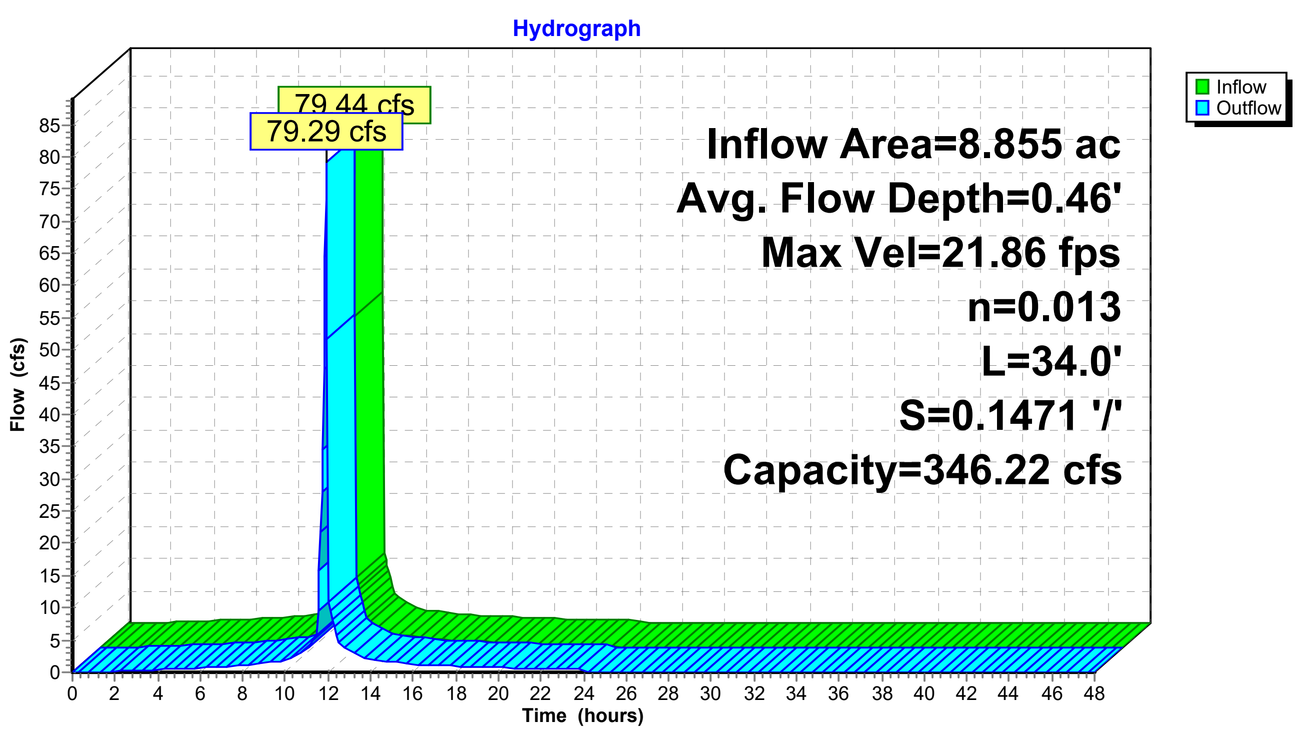
Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 21.86 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 5.01 fps, Avg. Travel Time= 0.1 min

Peak Storage= 121 cf @ 11.93 hrs
Average Depth at Peak Storage= 0.46' , Surface Width= 9.67'
Bank-Full Depth= 1.00' Flow Area= 10.0 sf, Capacity= 346.22 cfs

6.00' x 1.00' deep channel, n= 0.013 Concrete, trowel finish
Side Slope Z-value= 4.0 '/' Top Width= 14.00'
Length= 34.0' Slope= 0.1471 '/'
Inlet Invert= 1,291.00', Outlet Invert= 1,286.00'

‡

Reach DC1: DC1



Summary for Reach DC2: DC2

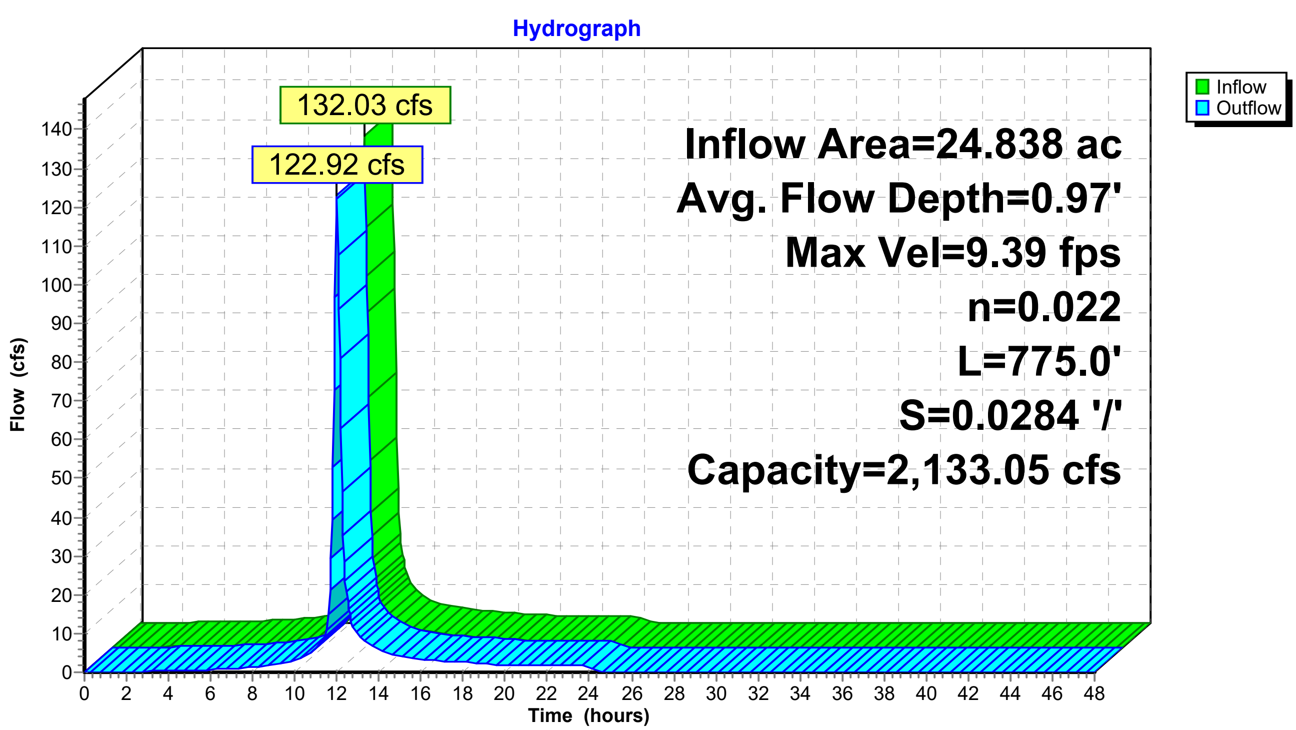
Inflow Area = 24.838 ac, 0.00% Impervious, Inflow Depth = 4.40" for 25-year,24-hour event
Inflow = 132.03 cfs @ 11.95 hrs, Volume= 9.115 af
Outflow = 122.92 cfs @ 11.99 hrs, Volume= 9.115 af, Atten= 7%, Lag= 2.4 min
Routed to Reach DC4 : DC4

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.39 fps, Min. Travel Time= 1.4 min
Avg. Velocity = 2.25 fps, Avg. Travel Time= 5.7 min

Peak Storage= 10,483 cf @ 11.96 hrs
Average Depth at Peak Storage= 0.97' , Surface Width= 17.79'
Bank-Full Depth= 4.00' Flow Area= 104.0 sf, Capacity= 2,133.05 cfs

10.00' x 4.00' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 4.0 '/' Top Width= 42.00'
Length= 775.0' Slope= 0.0284 '/'
Inlet Invert= 1,266.00', Outlet Invert= 1,244.00'

‡



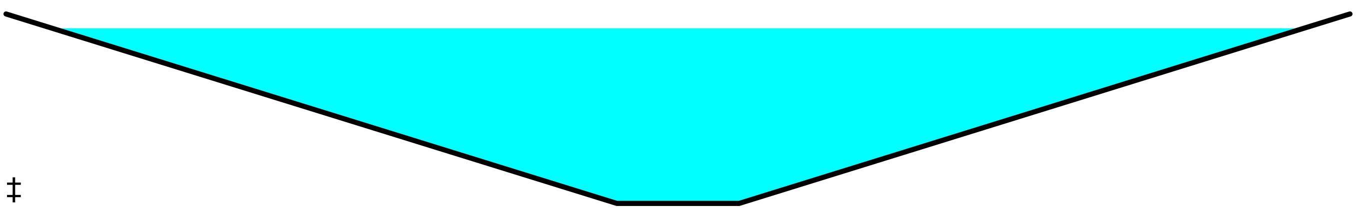
Summary for Reach DC3: DC3

Inflow Area = 8.983 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-year,24-hour event
Inflow = 54.12 cfs @ 11.98 hrs, Volume= 2.831 af
Outflow = 48.38 cfs @ 12.07 hrs, Volume= 2.831 af, Atten= 11%, Lag= 5.7 min
Routed to Reach DC2 : DC2

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.74 fps, Min. Travel Time= 3.5 min
Avg. Velocity = 1.38 fps, Avg. Travel Time= 12.2 min

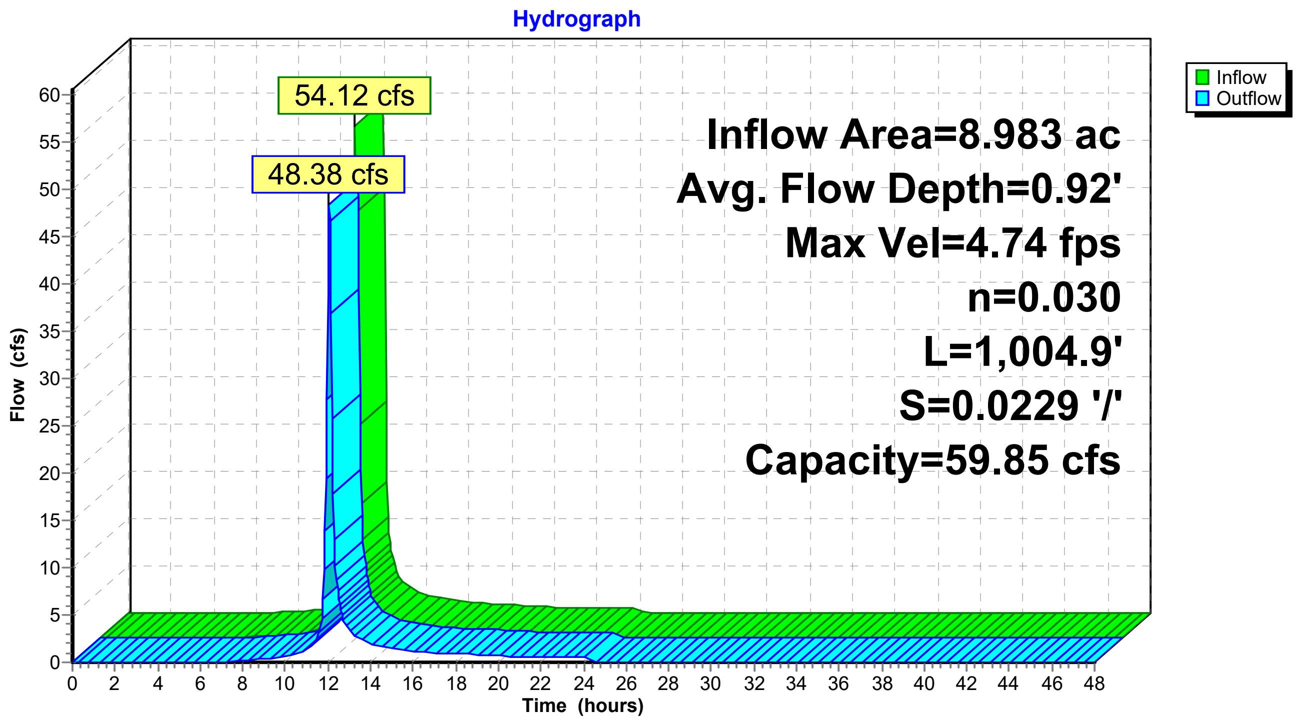
Peak Storage= 10,438 cf @ 12.01 hrs
Average Depth at Peak Storage= 0.92' , Surface Width= 20.48'
Bank-Full Depth= 1.00' Flow Area= 12.0 sf, Capacity= 59.85 cfs

2.00' x 1.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 10.0 '/' Top Width= 22.00'
Length= 1,004.9' Slope= 0.0229 '/'
Inlet Invert= 1,267.00', Outlet Invert= 1,244.00'



‡

Reach DC3: DC3



Summary for Reach DC4: DC4

Inflow Area = 28.704 ac, 0.00% Impervious, Inflow Depth = 4.32" for 25-year,24-hour event
Inflow = 144.34 cfs @ 11.99 hrs, Volume= 10.333 af
Outflow = 139.17 cfs @ 12.04 hrs, Volume= 10.333 af, Atten= 4%, Lag= 2.8 min
Routed to Reach C4 : C4

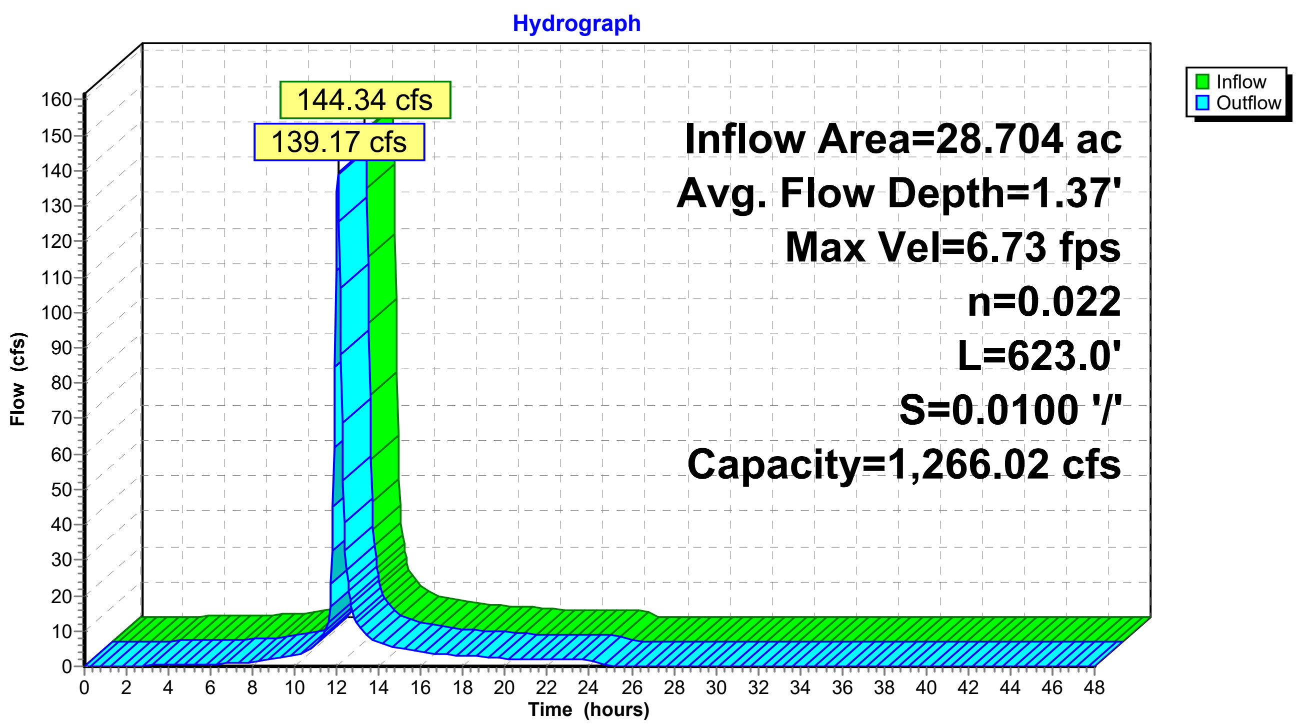
Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.73 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.61 fps, Avg. Travel Time= 6.5 min

Peak Storage= 13,193 cf @ 12.01 hrs
Average Depth at Peak Storage= 1.37' , Surface Width= 20.95'
Bank-Full Depth= 4.00' Flow Area= 104.0 sf, Capacity= 1,266.02 cfs

10.00' x 4.00' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 4.0 '/' Top Width= 42.00'
Length= 623.0' Slope= 0.0100 '/'
Inlet Invert= 1,244.00', Outlet Invert= 1,237.77'

‡

Reach DC4: DC4



Summary for Reach DC5: DC5

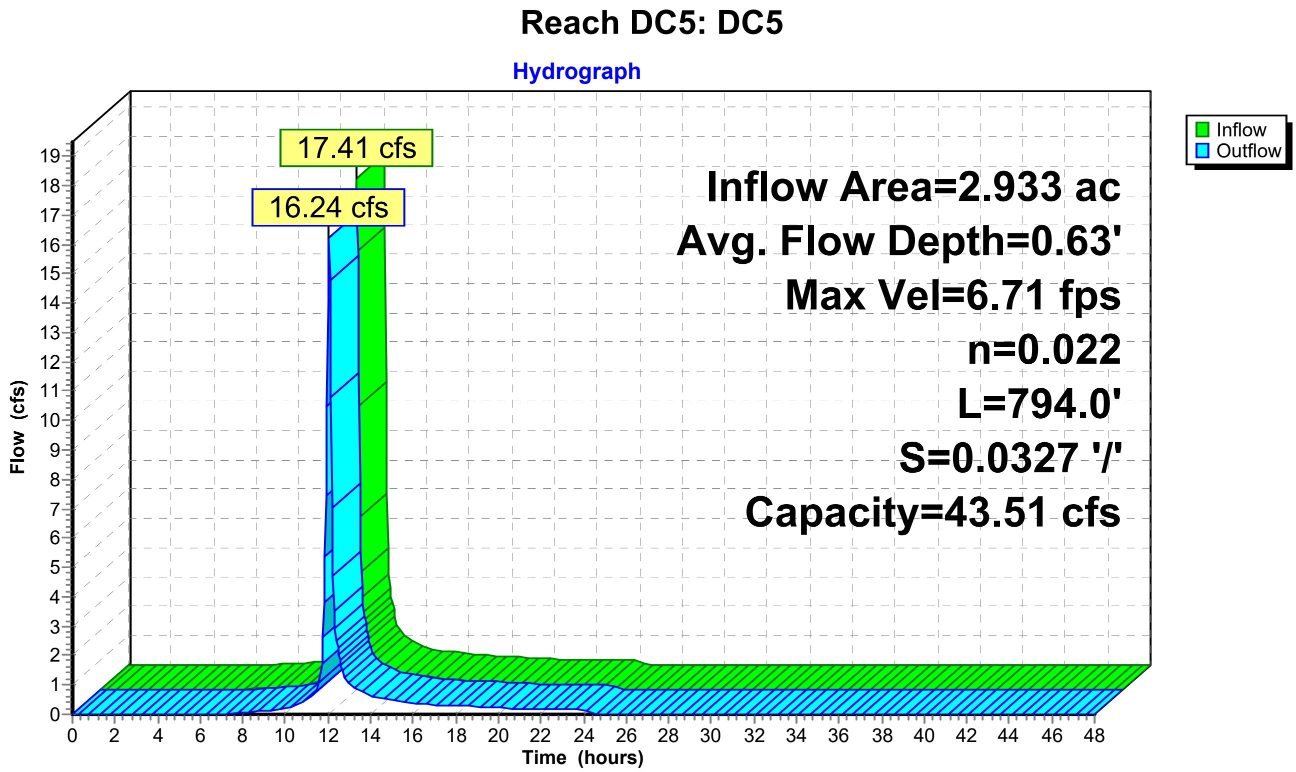
Inflow Area = 2.933 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-year,24-hour event
Inflow = 17.41 cfs @ 12.00 hrs, Volume= 0.924 af
Outflow = 16.24 cfs @ 12.06 hrs, Volume= 0.924 af, Atten= 7%, Lag= 3.4 min
Routed to Reach C3 : C3

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.71 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 1.82 fps, Avg. Travel Time= 7.3 min

Peak Storage= 1,957 cf @ 12.02 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 5.80'
Bank-Full Depth= 1.00' Flow Area= 5.0 sf, Capacity= 43.51 cfs

2.00' x 1.00' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 3.0 '/' Top Width= 8.00'
Length= 794.0' Slope= 0.0327 '/'
Inlet Invert= 1,266.00', Outlet Invert= 1,240.00'

‡

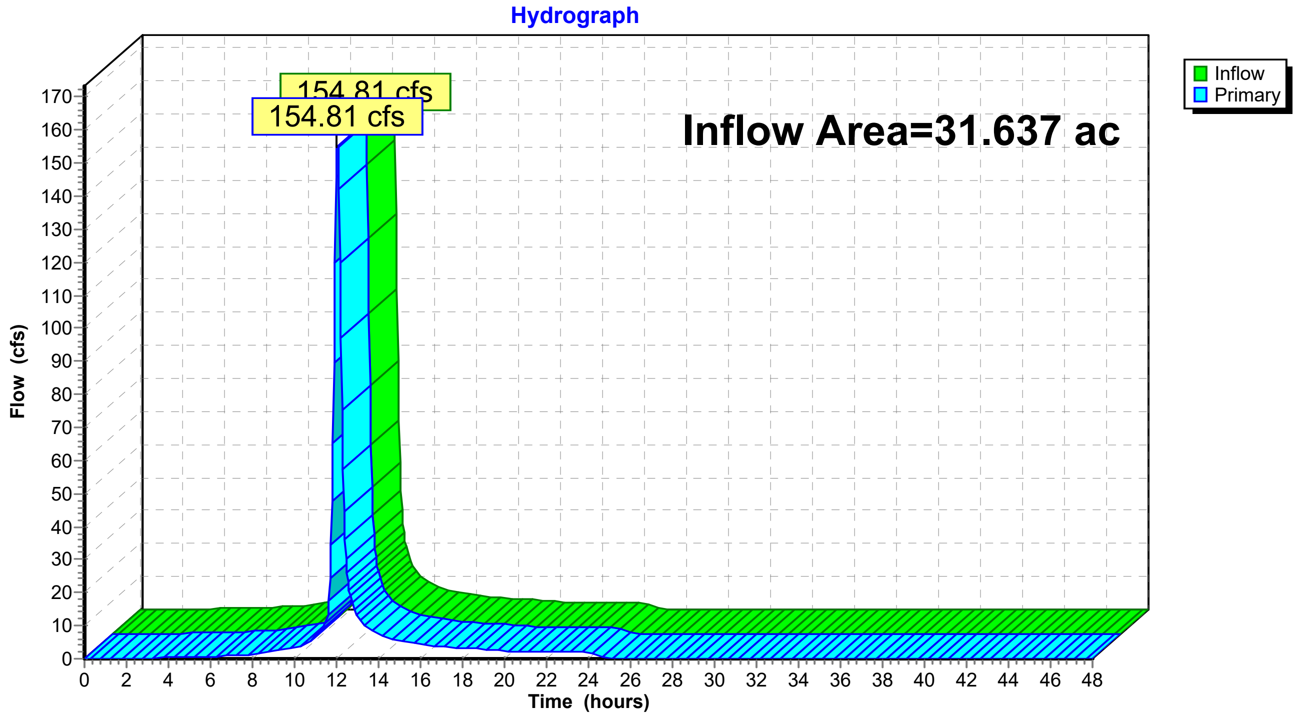


Summary for Link SBD: SBD

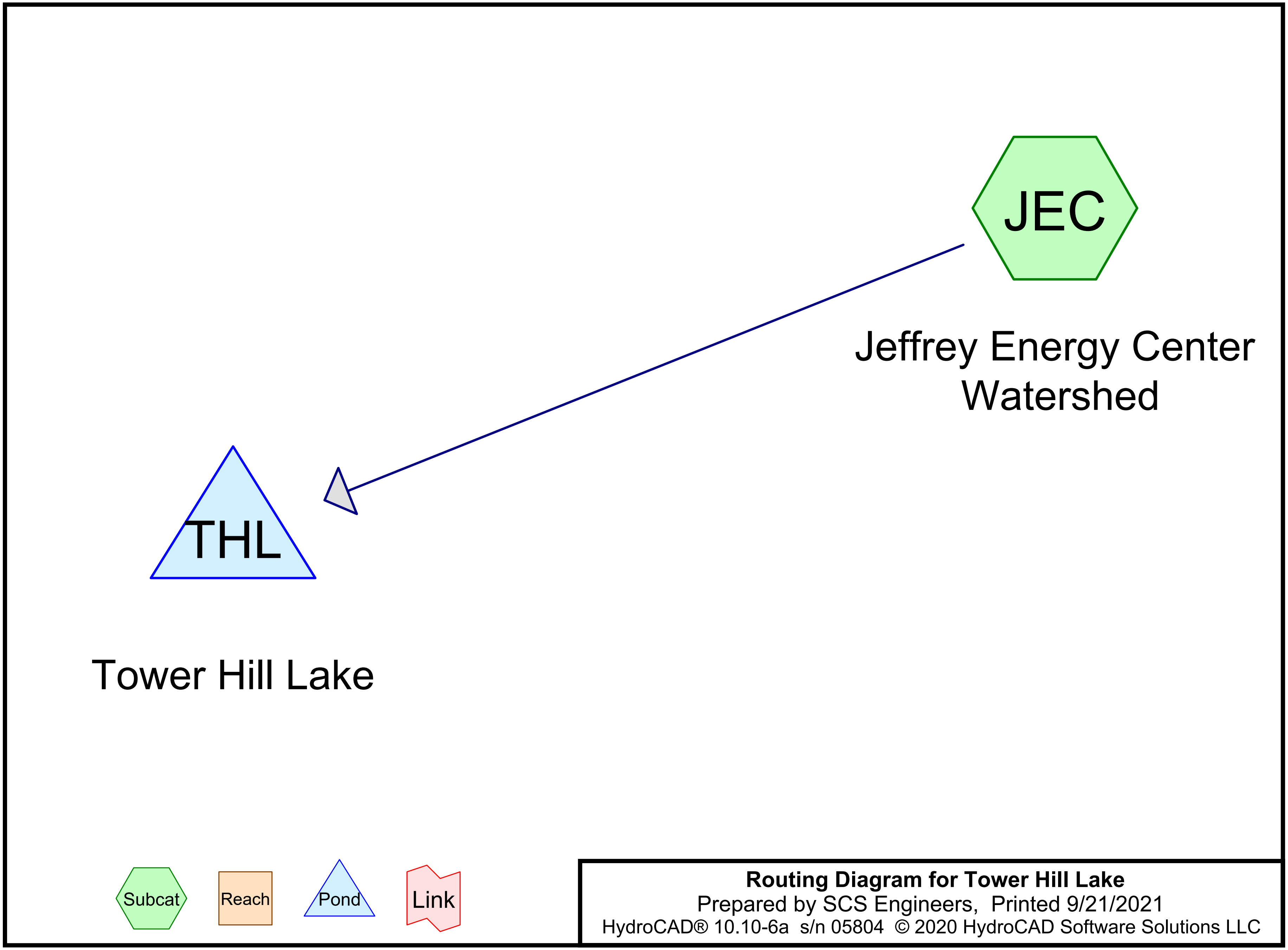
Inflow Area = 31.637 ac, 0.00% Impervious, Inflow Depth = 4.27" for 25-year,24-hour event
Inflow = 154.81 cfs @ 12.05 hrs, Volume= 11.258 af
Primary = 154.81 cfs @ 12.05 hrs, Volume= 11.258 af, Atten= 0%, Lag= 0.0 min

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

Link SBD: SBD



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
HydroCAD® 10.10-6a s/n 05804 © 2020 HydroCAD Software Solutions LLC

Summary for Subcatchment JEC: Jeffrey Energy Center Watershed

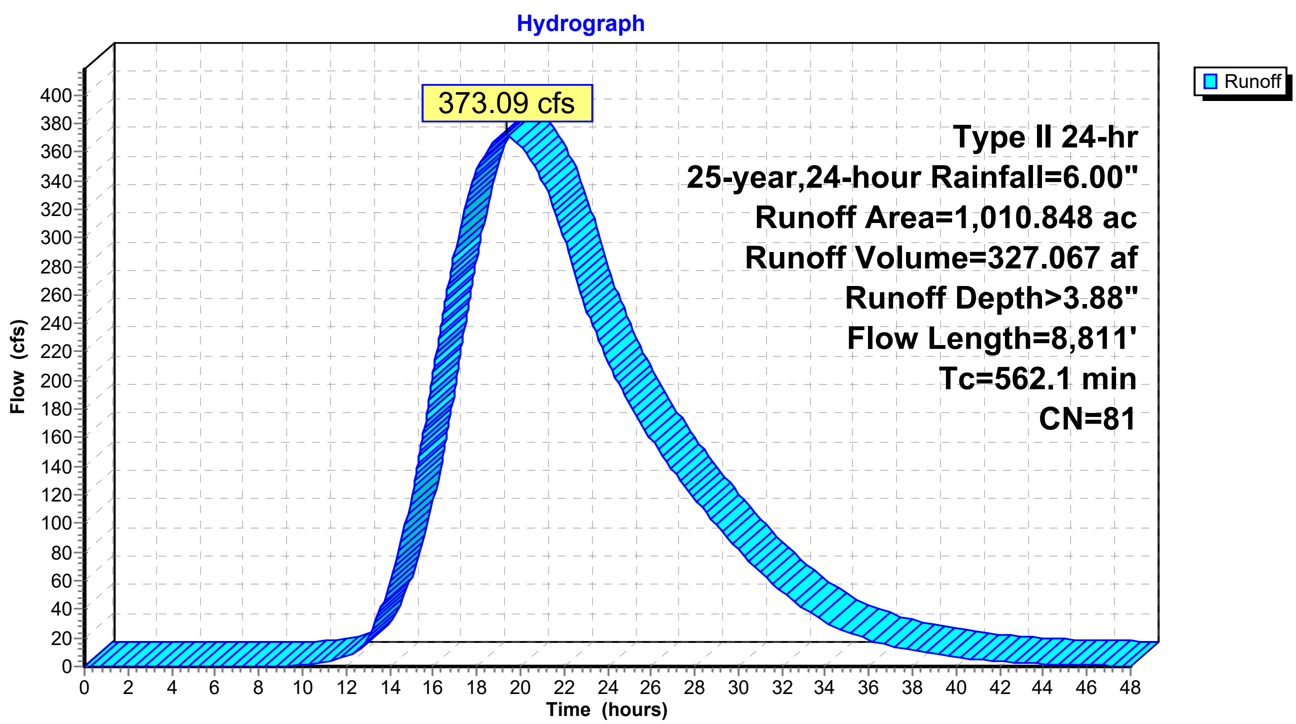
Runoff = 373.09 cfs @ 19.35 hrs, Volume= 327.067 af, Depth> 3.88"
Routed to Pond THL : Tower Hill Lake

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