ENVIRONMENTAL • GEOTECHNICAL
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RUN-ON RUN-OFF CONTROL SYSTEM PLAN

AREA 3 RWS TYPE I LANDFILL, FP 77-04
HOOSIER ENERGY REC, INC.
MEROM GENERATING STATION
SULLIVAN COUNTY, SULLIVAN, INDIANA

ATC PROJECT NO. 170LF00302

OCTOBER 14, 2016

PREPARED FOR:

HOOSIER ENERGY REC, INC.
MEROM GENERATING STATION
P.O. BOX 908
BLOOMINGTON, INDIANA 47402-0908
ATTENTION: LON PETTS

ENVIRONMENTAL • GEOTECHNICAL
BUILDING SCIENCES • MATERIALS TESTING

October 14, 2016

Lon Petts
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Re: **Run-On Run-Off Control System (ROROCS) Plan**
Merom Generating Station
Area 3 Type I RWS Landfill
Sullivan County, Sullivan, Indiana
ATC Project No. 170LF00302

Dear Mr. Petts:

ATC Group Services LLC (ATC) is pleased to present the following Run-On Run-Off Control System (ROROCS) Plan for the Merom Generating Station, Area 3 Type I Restricted Waste Landfill located at 550 West Old Highway 54, Sullivan, Indiana 47882.

As required by 40 CFR §257.81, the owner or operator of a coal combustion residuals (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.

Contained here within is a summary report which demonstrates that the Merom Generating Station Area 3 Landfill design measures are compliant with the CCR Rule.

We appreciate the opportunity to assist you with this project. If you have any questions concerning information contained in this report, please do not hesitate to call the undersigned at 317.849.4990.

Sincerely,
ATC Group Services LLC

Charles Dewes /BM

Charles Dewes, E.I., CFM
Project Engineer

Donald Bryenton

Donald Bryenton, P.E.
Principal Engineer

DONALD LEE BRYENTON
REGISTERED
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17877
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Senior Project Engineer

RUN-ON RUN-OFF CONTROL SYSTEM PLAN

HOOSIER ENERGY
MEROM GENERATING STATION
AREA 3 TYPE I RESTRICTED WASTE LANDFILL

OCTOBER 14, 2016

PREPARED BY:

ATC
ENVIRONMENTAL • GEOTECHNICAL
BUILDING SCIENCES • MATERIALS TESTING

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INTRODUCTION

The Hoosier Energy Merom Generating Station Area 3 Type I Restricted Waste Landfill (Merom Area 3 Landfill) is permitted by the Indiana Department of Environmental Management (IDEM) under Permit FP-77-04 and is regulated under Indiana Administrative Code 329 IAC, Article 10. The facility is located in Sullivan County, Indiana, in Section 2 of Gill Township and within Township-7-North / Range-10-West (See Figure 1). The permitted facility Solid Waste Boundary includes an area of approximately 112.0 acres.

As part of the approved 2010 Permit from IDEM for the Merom Area 3 Landfill, a number of Stormwater and Erosion Control measures were modelled to demonstrate that sufficient capacity exists to handle the design storm. This ROROCS Plan will summarize the results of the 2010 modelling to demonstrate that the run-on and run-off controls are compliant with the CCR Rule.

ENGINEERING COMPUTATION METHOD

The run-off flow from the surface of the landfill cover was calculated using modelling computations which employ the use of the Soil Conservation Service (SCS) TR-55 Curve Number method. The curve number selected for the modelling procedure is 78 based on a grass-covered surface in good condition. The SCS equations can be found with references in Appendix C.

Storm Data

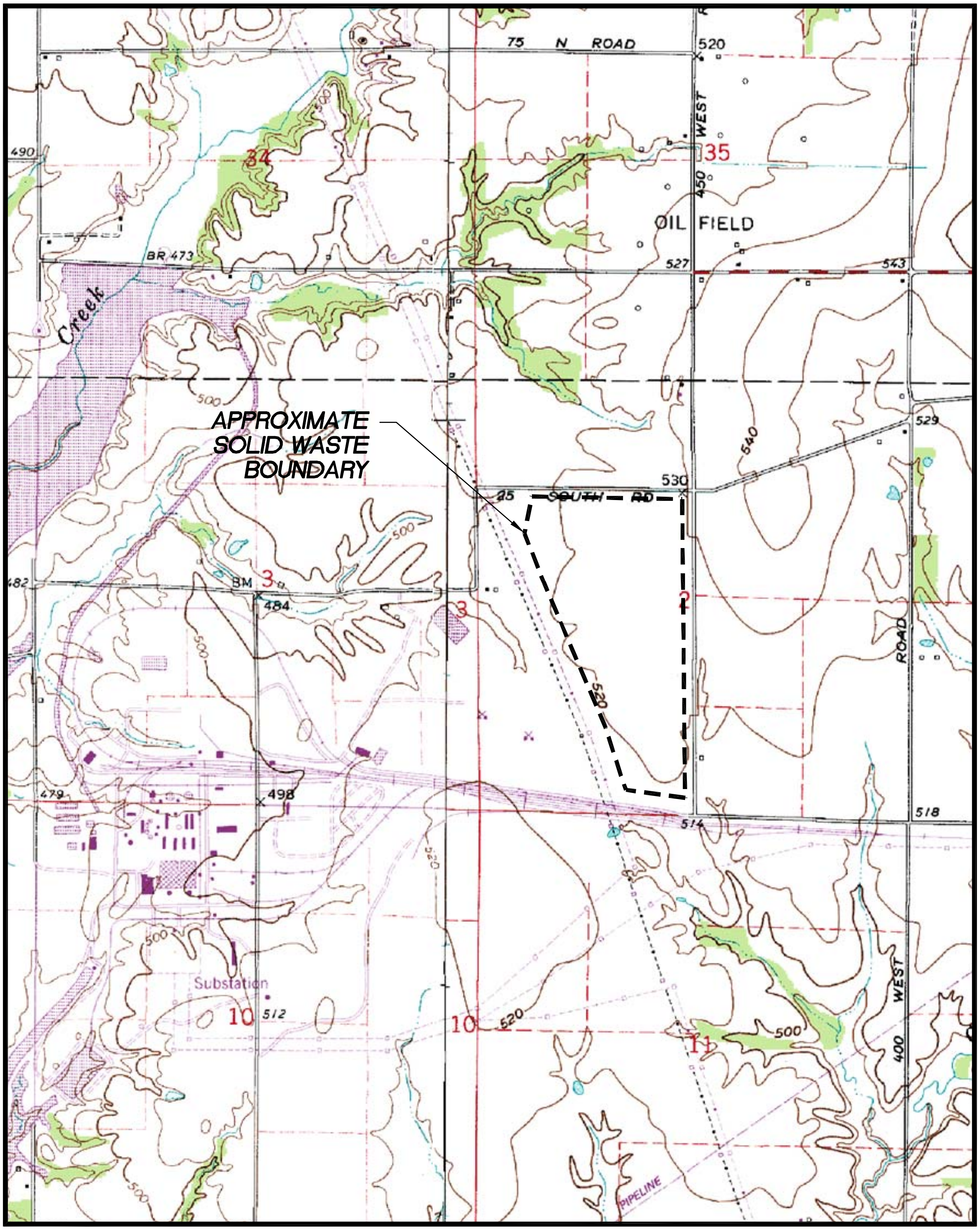
The storm event data that was used for the engineering computations and modelling is the 24-Hour, 25-Year storm from the NOAA (National Oceanic and Atmospheric Administration) TP 40 isohyetal curves for the State of Indiana published on the Indiana Department of Natural Resources (IDNR) website. The TP-40 isohyetal map can be found with modelling in Appendix B.

Based on the TP 40 curve, the 24-Hour Duration, 25-Year Frequency rainfall amount for Sullivan County, Indiana, where the Merom Area 3 Landfill is located, is approximately 5.2 inches.

Modeling Procedure

Sub-drainage area flows were determined for the combination of the existing landfill and the proposed expansion area using the SEDCAD4 computer model developed by R.C. Warner of the University of Kentucky and P.J. Schwab of the Civil Soft Design. The sub-drainage area flows are based on drainage area, elevation change across the drainage area, flow path length, and soil cover characteristics.

Individual surface water control features were modelled using SEDCAD4 to determine the depth of flow and flow area in the conveyance structure. The surface water controls with the greatest drainage areas (highest loading conditions) were modelled to demonstrate that all other features of the same type, by extension, have sufficient capacity. Flow depths and resulting freeboard computations are summarized in Appendix A (Capacity Tables).



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VICINITY MAP

VICINITY MAP
AREA 3 RESTRICTED WASTE LANDFILL
MEROM GENERATING STATION

Project Number: 170LF00301		Drn. By: WS
Drawing File: SEE LOWER LEFT		Ckd. By: CD
Date: 10/16	Scale: 1" = 2000'	App'd By: DB
ATC		Figure: 1

H:\2016\HOOSIER ENERGY\MEROM GENERATING STATION\170LF00301\170LF00301-MEROM-VIC.DWG, VIC

RUN-ON CONTROL SYSTEM SUMMARY

The EPA definition of run-on flow is defined as:

"…Any liquid that drains over land onto any part of a CCR landfill or any lateral expansion of a CCR landfill. In surface water hydrology, run-on is a quantity of surface run-off, or excess rain, snowmelt, or other sources of water, which flows from an upstream catchment area onto a specific downstream location."

Run-on protection for the Merom Area 3 Landfill consists of grading and perimeter controls which shut out flows from adjacent areas and outside watersheds. The surrounding watershed is mostly flat and the landfill area is outside of any significant floodplain area, therefore the potential for run-on flow is low. The run-on controls described below prevent outside flow from reaching the interim and final cover areas.

Perimeter Controls

A perimeter haul road is built approximately 3-5 feet above the natural grade at the base of the landfill. This haul road provides protection from outside run-on flows during major storm events.

RUN-OFF CONTROL SYSTEM SUMMARY

Run-off control measures for the Merom Area 3 Landfill are designed to safely discharge run-off flow away from the cover to prevent ponding, erosion, and excessive infiltration. The run-off control measures for Merom Area 3 Landfill include top-of-slope berms, side slope berms, drop inlets, downdrains, perimeter ditches, and retention basins.

Interim Conditions

Flow from the interim cells will drain to berms and downdrains which discharge to the perimeter ditch system. Flow from the perimeter ditch will route to the West Sediment Basin Area. Overflow from the spillway is discharged to an NPDES outfall area.

A typical diversion berm on the landfill side slopes has a depth of two (2) feet with 4H:1V and 3H:1V channel sideslopes (See Detail #1, Appendix C). Diversion berms drain to either 12" or 18"-diameter downdrain pipes, depending on the drainage area size.

The perimeter ditch has a 12-foot bottom width with 3H:1V sideslopes and 3-foot depth (See Detail #2, Appendix C). The perimeter ditches, berms, downdrain pipes, and retention pond (West Sediment Basin) were found to have sufficient capacity and/or freeboard to handle the design storm. Capacity calculations are provided in Appendix A.

Final Cover Conditions

Once final cover is complete additional diversion berms, downdrains, and perimeter ditch segments will be constructed to supplement the existing stormwater control features. The final cover run-on and run-off controls will be the same type as those used during the interim conditions.

CONCLUSION

The Merom Generating Station Area 3 Type I Restricted Waste Landfill Run-On Control System prevents flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm and the Run-Off Control System is able to collect and control the water volume resulting from the 24-hour, 25-year storm.

Appendix A: Capacity Tables

Appendix B: Modelling Results

Appendix C: References and Plan Sheets

Appendix A: Capacity Tables

CAPACITY TABLES

Section #1 Largest Drainage Area = 1.5 acres

SEDCAD ID	Feature Type	Channel Depth (ft.)	Flow Depth (ft.)	Freeboard (ft.)
#2	Top-of-Slope Berm	2	0.38	1.62
#9	Top-of-Slope Berm	2	0.68	1.32

Section #2 Largest Drainage Area = 1.23 acres

SEDCAD ID	Feature Type	Channel Depth (ft.)	Flow Depth (ft.)	Freeboard (ft.)
#9	Side Slope Berm	2	0.92	1.08

Section #3 Largest Drainage Area = 1.2 acres

SEDCAD ID	Feature Type	Channel Depth (ft.)	Flow Depth (ft.)	Freeboard (ft.)
#2	Perimeter Ditch	3	0.35	2.65
#9	Perimeter Ditch	3	0.35	2.65

CAPACITY TABLES

Section #4 Largest Drainage Area = 7.0 acres

SEDCAD ID	Feature Type	Pipe Area (ft^2)	Flow Area (ft^2)	Available Flow Area (ft^2)
#9	Downdrain Pipe 18"	1.76625	0.75	1.01625
#10	Downdrain Pipe 18"	1.76625	0.75	1.01625

SEDCAD #6 Largest Drainage Area = 3.0 acres

SEDCAD ID	Feature Type	Pipe Area (ft^2)	Flow Area (ft^2)	Available Flow Area (ft^2)
#10	Downdrain Pipe 12"	0.785	0.39	0.395
#11	Downdrain Pipe 12"	0.785	0.39	0.395

SEDCAD #8 Largest Drainage Area = 182.6 acres

SEDCAD ID	Feature Type	Channel Depth (ft.)	Flow Depth (ft.)	Freeboard (ft.)
#9	West Sediment Basin	10	4.9	5.1

Appendix B: Modelling Results

Stormwater Runoff Calculations

STORM WATER RUNOFF CALCULATIONS

The erosion and stormwater control structures described in this section have been designed, as required, to limit soil erosion to less than 5 tons-per-acre-per-year and adequately convey the 25-year/24-hour storm event (5.2", IDNR 1994, attached). A 100-year/24-hour storm event (6.3", IDNR 1994, attached) was considered for the design of the sedimentation pond emergency overflow weir. Sedimentation rate estimates are included at the end of this section. Soil erosion estimates are attached in a separate calculations section.

Sub-drainage area flows were determined for the combination of the existing landfill and the proposed expansion area using the SEDCAD4 computer model developed by R.C. Warner of the University of Kentucky and P.J. Schwab of Civil Soft Design. The sub-drainage area flows are based on drainage area, elevation change across the drainage area, flow path length, and soil cover characteristics.

Side-slope diversion-berm channels, top-of-landfill diversion-berm channels, road culvert channels, and downdrain pipes were individually input into the SEDCAD4 computer models, using the worst-case conditions with the largest drainage areas, to show that these components could adequately convey their portions of a 25-year/24-hour storm. These worst-case models are discussed below:

- **Top-of-landfill diversion-berm channels.** At three locations, two diversion berms are paired to enter a single downdrain pipe. The first of the paired berms has a slope of about 5%, a v-shape with 3H:1V and 50H:1V sideslopes, and a length of up to 800 ft along the west edge of the 5%-sloped portion of the final cover. The second of the paired berms has a 1% slope, a v-shape with 3H:1V and 20H:1V sideslopes, and a length of about 200 ft (drains east to west) across the final cover. An attached SEDCAD4 output (#1) shows that the 5%-sloped berm conveys the 25-year/24-hour storm flow (4.5 cfs at a velocity of 1.2 fps and a flow depth of 0.4 feet from a maximum of 1.5 acres) and that the 1%-sloped berm conveys the 25-year/24-hour storm flow (4.5 cfs at a velocity of 0.8 fps and a flow depth of 0.7 feet at a maximum of 1.5 acres). Each pair of top-of-landfill channel enters one of two drop inlets which each consist of a debris guard over a minimum-18-inch-diameter, drop-inlet pipe that is drained into a downdrain pipe.

- **Side-slope diversion-berm channels** lie on the 4H:1V-sloped, grass-covered, final cover sideslopes. The 90-ft-horizontal spaces between channels are based on erosion control calculations provided in the "Final Cover Soil Loss Estimates" section of this major permit modification application. These channels have 2% slopes, are v-shaped with 4H:1V and 3H:1V sideslopes, and are up to 600 ft in length. An attached SEDCAD4 output (#2) shows that at a maximum 1.2 acres, this channel conveys a 25-year/24-hour storm flow of 3.7 cfs at a velocity of 1.2 fps and a flow depth of 0.9 feet. Each sideslope berm enters its own drop inlet which consists of a debris guard over a 12 to 18-inch-diameter, drop-inlet pipe that is drained into a downdrain pipe.

- **Road culvert channels** lie at the base of the 4H:1V-sloped, grass-covered, final cover sideslopes. These channels have 1% slopes with 12-ft-wide bottoms, 3H:1V sideslopes, and are up to 250 ft in length. The attached SEDCAD4 output (#3) shows that at a maximum 1.2 acres, each channel conveys a 25-year/24-hour storm flow of 3.6 cfs at a velocity of 0.8+ fps and a flow depth of 0.4 feet. Two of these 250-ft road culvert channels will drain to two drop inlets which consist of a debris guards over two 18-inch-diameter drop inlet pipes that are drained by a single 18-inch-diameter, 4.7%-minimum-sloped, road culvert pipe that drains into a sedimentation basin.

- **Pairs of 18-inch-diameter downdrain pipes** will be placed to serve drainage areas of 14 acres or less. Output #4 shows that a drainage area of 14 acres (7 acres per pipe) produces a 25-year/24-hour peak runoff of about 42 cfs (21 cfs per pipe). Along the west side of the landfill, each pair of 18-inch-diameter pipes will flow under the perimeter road (at a slope of 3.6%) and then drain into a 1%-sloped, 3H:1V-sidesloped, 12-ft-bottom channel that flows under the power-transmission lines with a maximum depth of flow of 1.0 ft and a maximum flow velocity of 2.7 fps. Output #5 shows that on a 4H:1V slope, each 18-inch-diameter pipe can convey 21 cfs at about one-half full. The locations of these 18-inch-pipe pairs are shown on the surface-water drainage plan.

- **Pairs of 12-inch-diameter downdrain pipes** will be placed to serve drainage areas of 6 acres or less. Output #6 shows that a drainage area of 6 acres (3 acres per pipe) produces a 25-year/24-hour peak runoff of about 18 cfs (9 cfs per pipe). Output #7 shows that on a 4H:1V slope, each 12-inch-diameter pipe can convey 9 cfs at about one-half full. The locations of these 12-inch-pipe pairs are shown on the surface-water drainage plan.

Design flows from the East, North, and West drainage areas are routed to the West Sedimentation Basin. Output #8 (25-year/24-hour event) is attached and shows that:

- The East's 47.7-acre drainage area's 25-year/24-hour storm-runoff flow of 142 cfs is carried, at a depth of about 2.9 feet and a velocity of 3.3 fps, by a 0.3%-sloped, 3H:1V sidesloped, 12-ft-bottom perimeter channel along the east and south side of the landfill. This channel flows under the power transmission lines and then encounters three 48-inch culverts that pass under the haul road. These pipes drain into a 0.3%-sloped, 4H:1V sideslope, 12-ft-bottom, channel with a velocity of 3.3 fps and a flow depth of 2.4 feet that in turn drains into the West Sedimentation Basin.

- The North's 37.9-acre drainage area's runoff flow of 112 cfs is carried, at a depth of about 1.8 feet and a velocity of 3.7 fps, by a 0.6%-sloped, 3H:1V sidesloped, 12-ft-bottom perimeter channel along the north side of the landfill before it is drained into the West Detention Basin.

- The West's 49.6-acre drainage area's runoff flow is carried under the haul road by previously-described road culverts and downdrain pipe. These pipes drain into several drainage channels, with 1%-slopes, 4H:1V sideslopes, and 12-ft-bottoms, that drain under the power-transmission lines into the West Sediment Basin.

- The West Sedimentation Basin uses a 24-inch diameter culvert with an invert at EL 504.0 as a principal spillway and a broad-crested weir with a 50-ft secondary-spillway crest at EL 508.0 The 25-year/24-hour storm flow shown in Output #8 reaches a maximum at EL 507.7 and drains out during a period greater than 24 hours. The flow from this culvert encounters a riprap-lined energy dissipater before entering a 50-ft-wide, 0.2%-sloped channels that flows a short distance to an existing drainage channel.

West Sedimentation Basin Emergency Overflow was modeled in Output #9 using the same structures and interconnections as the previously-described Output #8 model with the exception that the primary outlet for the West Sedimentation Basin has been assumed to be blocked so that only the emergency overflow can provide drainage. When a 100-year/24-hour rainfall event occurs, flow over the emergency spillway reaches a maximum at EL 510.0 (2 feet below the pond crest height of EL 512.0). Flow down the emergency overflow (20%-sloped, 5H:1V sidesloped, and a 50-ft-channel-bottom – all protected by a turf reinforcement mat or riprap) is estimated to have a 0.9-ft depth at 9.2 fps before encountering a riprap-lined energy dissipater and then entering a 50-ft-wide, 0.2%-sloped channel that flows a short distance to an existing drainage channel.

West Sedimentation Basin's sediment storage volume is determined by using a rate of 0.3 inches of sediment per year for an average drainage-area slope of 5% during a period of 3 years. The following equation will be used for the West sedimentation basin:

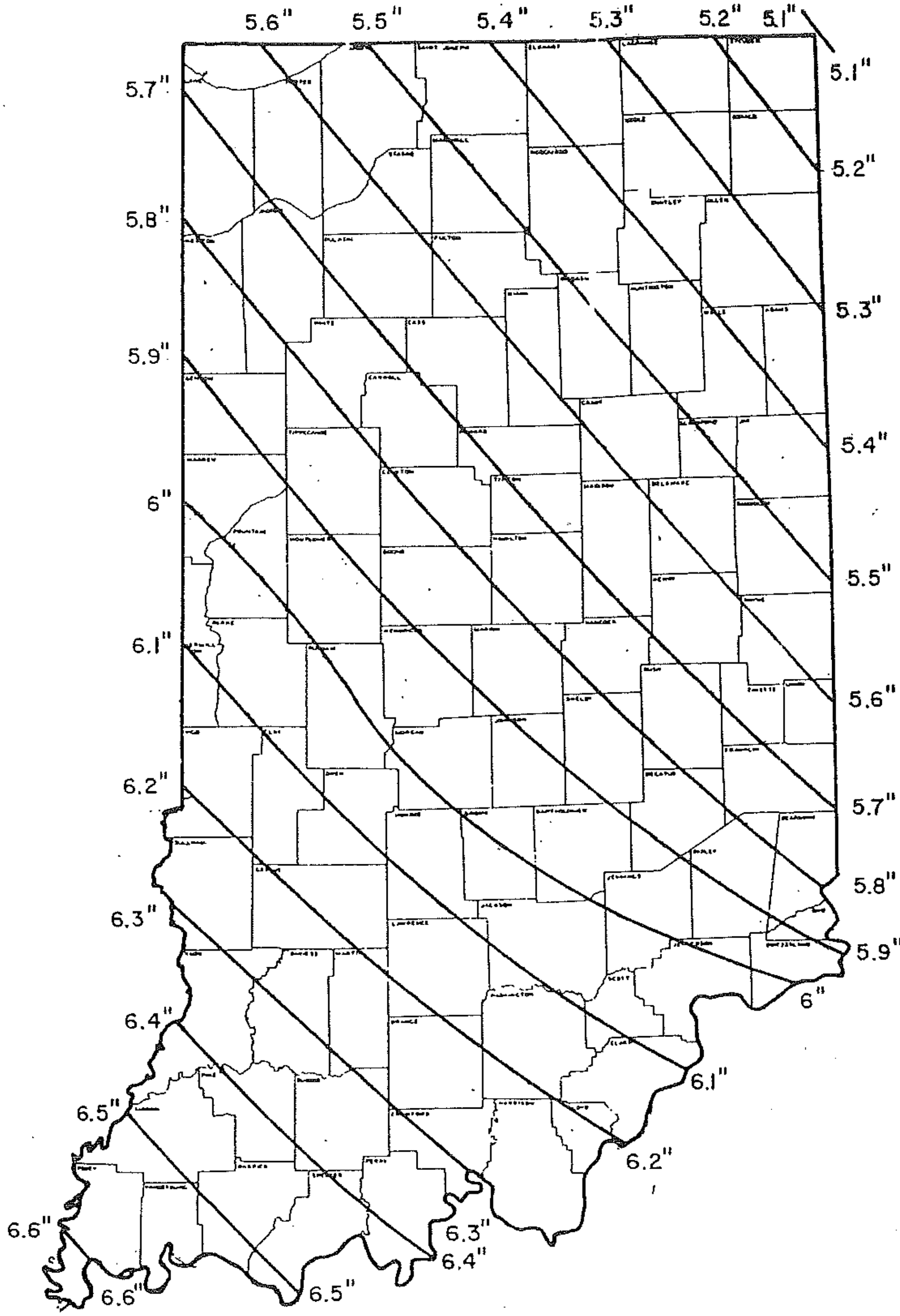
Sediment depth in basin = (drainage area) (0.3"/year) (3 years) / (basin area)

Sed. Basin sediment-storage depth = (183 acres) (0.3") (3) / (6 acres) = 28 inches

Sed. Basin permanent pool @ EL 504 minus 28 inches = EL 501.7

Documentation

RAINFALL – 100 YEAR FREQUENCY – 24 HOUR DURATION

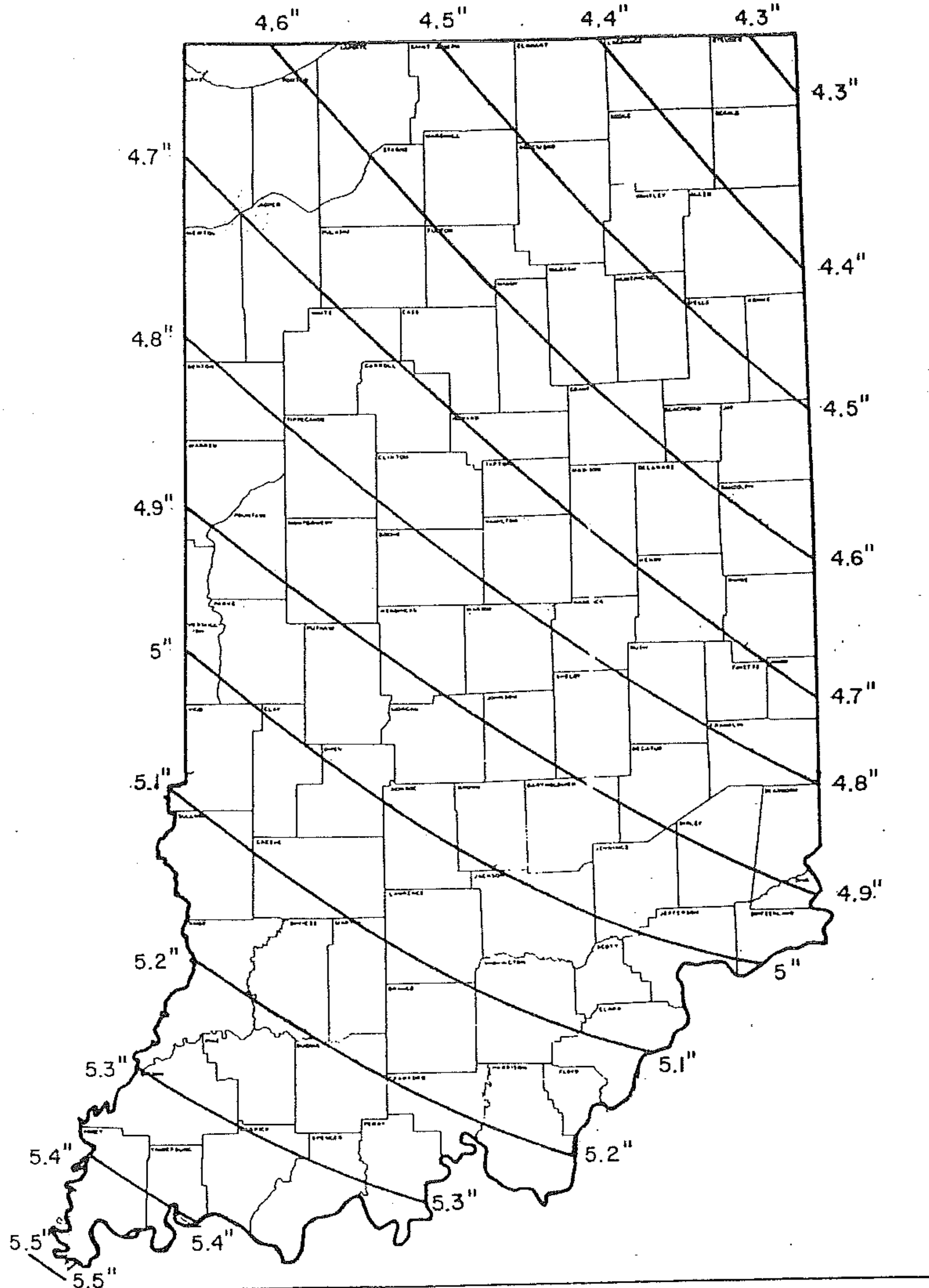


REFERENCE
TECHNICAL PAPER NO. 40
NATIONAL WEATHER SERVICE

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

APRIL 1979

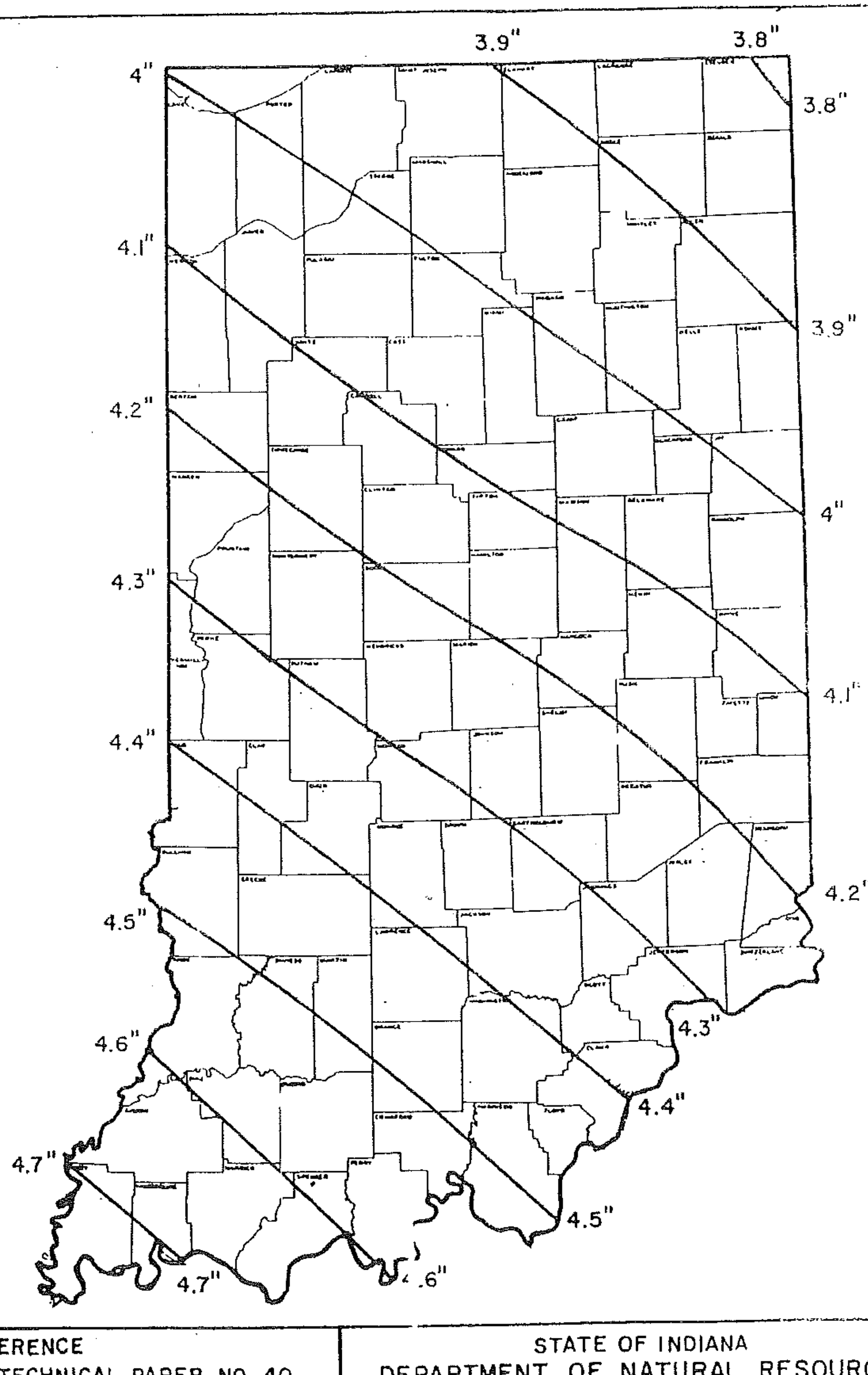
RAINFALL – 25 YEAR FREQUENCY – 24 HOUR DURATION



REFERENCE TECHNICAL PAPER NO. 40 NATIONAL WEATHER SERVICE	STATE OF INDIANA DEPARTMENT OF NATURAL RESOURCES DIVISION OF WATER

APRIL 1979

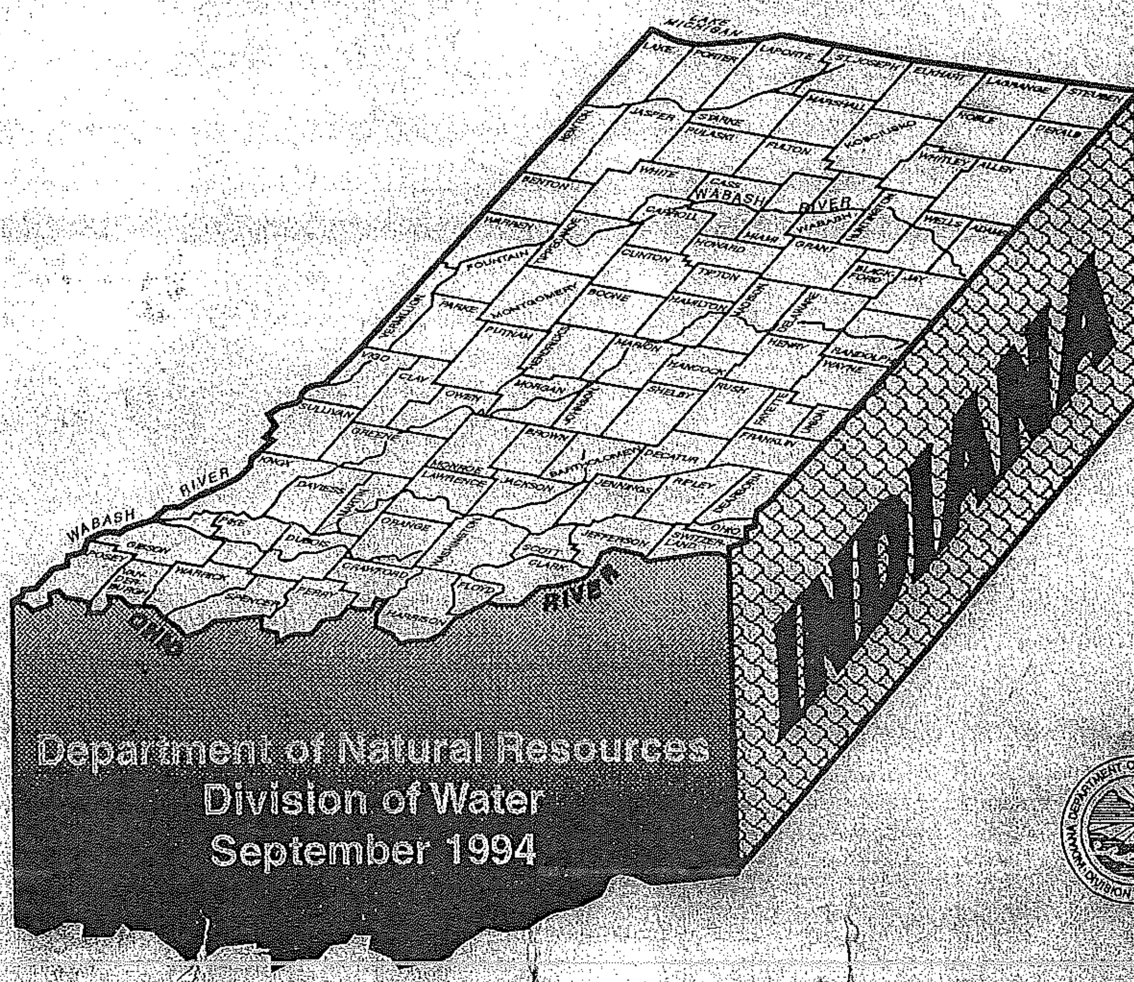
RAINFALL - 10 YEAR FREQUENCY - 24 HOUR DURATION



REFERENCE	STATE OF INDIANA
TECHNICAL PAPER NO. 40 NATIONAL WEATHER SERVICE	DEPARTMENT OF NATURAL RESOURCES DIVISION OF WATER

APRIL 1979

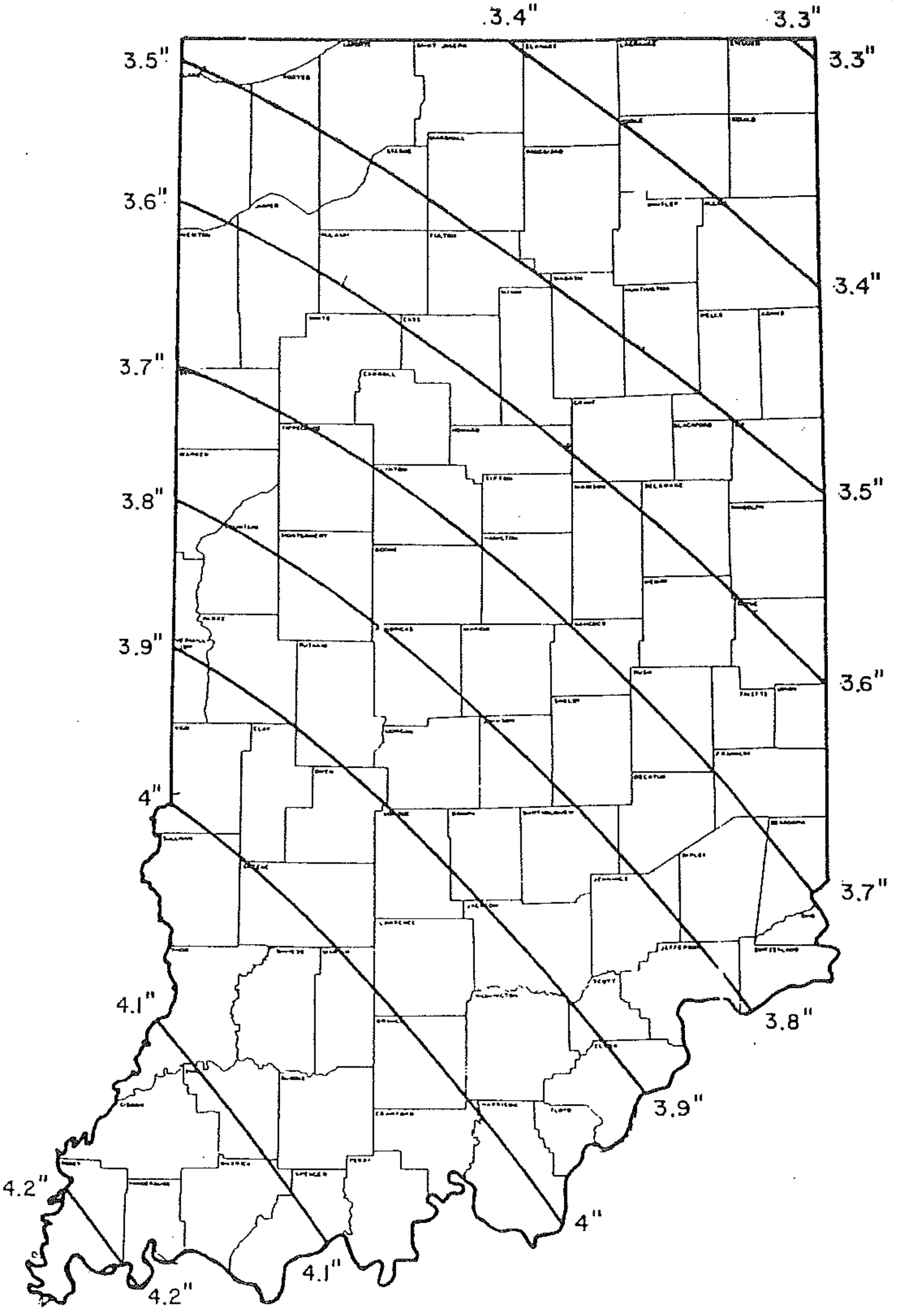
RAINFALL FREQUENCY FOR INDIANA



Department of Natural Resources
Division of Water
September 1994

$ 3.00

RAINFALL – 5 YEAR FREQUENCY – 24 HOUR DURATION



REFERENCE	STATE OF INDIANA
TECHNICAL PAPER NO. 40 NATIONAL WEATHER SERVICE	DEPARTMENT OF NATURAL RESOURCES DIVISION OF WATER

APRIL 1979

Sedcad Output #1
Top-of-landfill
diversion-berm
channels with
25 year/24 hour flow

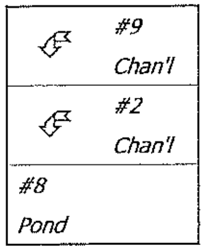
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.200 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#2	==>	#8	0.000	0.000	
Pond	#8	==>	End	0.000	0.000	
Channel	#9	==>	#8	0.000	0.000	



Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#9		1.500	1.500	4.46	0.36
#2		1.500	1.500	4.46	0.36
#8	In	0.000	3.000	8.92	0.72
	Out			8.95	0.72

Structure Detail:

Structure #9 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	20.0:1	1.0	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	4.46 cfs		4.46 cfs	
Depth:	0.68 ft		1.20 ft	
Top Width:	15.59 ft		27.69 ft	
Velocity:	0.84 fps		0.27 fps	
X-Section Area:	5.29 sq ft		16.67 sq ft	
Hydraulic Radius:	0.338		0.600	
Froude Number:	0.26		0.06	
Roughness Coefficient:	0.0855		0.3959	

Structure #2 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	50.0:1	5.0	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	4.46 cfs		4.46 cfs	
Depth:	0.38 ft		0.69 ft	
Top Width:	19.98 ft		36.41 ft	
Velocity:	1.18 fps		0.36 fps	

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
X-Section Area:	3.77 sq ft		12.51 sq ft	
Hydraulic Radius:	0.188		0.343	
Froude Number:	0.48		0.11	
Roughness Coefficient:	0.0922		0.4565	

Structure #8 (Pond)

Pond Inputs:

Initial Pool Elev:	680.01
Initial Pool:	0.00 ac-ft

Drop Inlet

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev
16.00	2.00	16.00	22.00	25.00	0.0140	680.01

Drop Inlet

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev
16.50	2.00	16.50	22.00	25.00	0.0120	680.01

Pond Results:

Peak Elevation:	680.49
Dewater Time:	0.50 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
680.00	0.001	0.000	0.000		
680.01	0.001	0.000	0.000		Spillway #1 Spillway #2
680.49	0.011	0.003	8.948	12.00	Peak Stage
680.50	0.011	0.003	9.047		
681.00	0.030	0.012	13.803		
681.50	0.058	0.034	16.934		

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
682.00	0.096	0.072	19.570	
682.50	0.144	0.132	21.891	
683.00	0.200	0.217	23.988	

Detailed Discharge Table

Elevation	Drop Inlet (cfs)	Drop Inlet (cfs)	Combined Total Discharge (cfs)
680.00	0.000	0.000	0.000
680.01	0.000	0.000	0.000
680.50	4.454	4.593	9.047
681.00	6.689	7.114	13.803
681.50	8.206	8.727	16.934
682.00	9.484	10.086	19.570
682.50	10.609	11.282	21.891
683.00	11.625	12.363	23.988

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#9	1	1.500	0.000	0.000	0.000	78.000	TR55	4.46	0.360
	Σ	**1.500**						**4.46**	**0.360**
#2	1	1.500	0.000	0.000	0.000	78.000	TR55	4.46	0.360
	Σ	**1.500**						**4.46**	**0.360**
#8	1	0.000	0.000	0.000	0.000	1.000	TR55	0.00	0.000
	Σ	**3.000**						**8.92**	**0.721**

Sedcad Output #2
Side-slope
Diversion berm
channels. with
25 year 24 hour flow

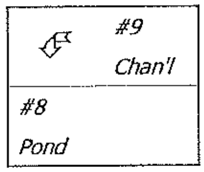
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.200 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Pond	#8	==>	End	0.000	0.000	
Channel	#9	==>	#8	0.000	0.000	



Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#9		1.230	1.230	3.66	0.30
#8	In	0.000	1.230	3.66	0.30
	Out			3.68	0.30

Structure Detail:

Structure #9 (Vegetated Channel)

Triangular Vegetated Channel Inputs:

Material: Grass mixture

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	4.0:1	1.0	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	3.66 cfs		3.66 cfs	
Depth:	0.92 ft		1.53 ft	
Top Width:	6.45 ft		10.71 ft	
Velocity:	1.23 fps		0.45 fps	
X-Section Area:	2.97 sq ft		8.19 sq ft	
Hydraulic Radius:	0.443		0.736	
Froude Number:	0.32		0.09	
Roughness Coefficient:	0.0702		0.2716	

Structure #8 (Pond)

Pond Inputs:

Initial Pool Elev:	680.01
Initial Pool:	0.00 ac-ft

Drop Inlet

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev
11.80	2.00	11.80	22.00	1.00	0.0140	680.01

Drop Inlet

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev
11.80	2.00	11.80	22.00	1.00	0.0120	680.01

Pond Results:

Peak Elevation:	680.36
Dewater Time:	0.50 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
680.00	0.001	0.000	0.000		
680.01	0.001	0.000	0.000		Spillway #1 Spillway #2
680.36	0.002	0.001	3.685	12.00	Peak Stage
680.50	0.002	0.001	5.119		
681.00	0.004	0.003	7.277		
681.50	0.006	0.005	8.927		
682.00	0.009	0.009	10.317		
682.50	0.021	0.016	11.540		
683.00	0.037	0.030	12.646		

Detailed Discharge Table

Elevation	Drop Inlet (cfs)	Drop Inlet (cfs)	Combined Total Discharge (cfs)
680.00	0.000	0.000	0.000
680.01	0.000	0.000	0.000
680.50	2.560	2.560	5.119
681.00	3.638	3.638	7.277
681.50	4.464	4.464	8.927
682.00	5.158	5.158	10.317
682.50	5.770	5.770	11.540
683.00	6.323	6.323	12.646

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#9	1	1.230	0.000	0.000	0.000	78.000	TR55	3.66	0.295
	Σ	**1.230**						**3.66**	**0.295**
#8	1	0.000	0.000	0.000	0.000	1.000	TR55	0.00	0.000
	Σ	**1.230**						**3.66**	**0.295**

Sedcad Output #3
Road Culvert and
Channels with
25yr/24hour flows

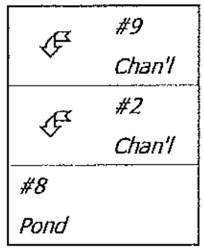
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.200 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#2	==>	#8	0.000	0.000	
Pond	#8	==>	End	0.000	0.000	
Channel	#9	==>	#8	0.000	0.000	



Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#9		1.200	1.200	3.57	0.29
#2		1.200	1.200	3.57	0.29
#8	In	0.100	2.500	7.44	0.60
	Out			7.27	0.60

Structure Detail:

Structure #9 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	3.0:1	3.0:1	1.0	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	3.57 cfs		3.57 cfs	
Depth:	0.35 ft		0.76 ft	
Top Width:	14.09 ft		16.59 ft	
Velocity:	0.78 fps		0.33 fps	
X-Section Area:	4.55 sq ft		10.94 sq ft	
Hydraulic Radius:	0.320		0.649	
Froude Number:	0.24		0.07	
Roughness Coefficient:	0.0889		0.3420	

Structure #2 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	3.0:1	3.0:1	1.0	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	3.57 cfs		3.57 cfs	
Depth:	0.35 ft		0.76 ft	
Top Width:	14.09 ft		16.59 ft	
Velocity:	0.78 fps		0.33 fps	

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
X-Section Area:	4.55 sq ft		10.94 sq ft	
Hydraulic Radius:	0.320		0.649	
Froude Number:	0.24		0.07	
Roughness Coefficient:	0.0889		0.3420	

Structure #8 (Pond)

Pond Inputs:

Initial Pool Elev:	616.01
Initial Pool:	0.00 ac-ft

Drop Inlet

Riser Diameter (in)	Riser Height (ft)	Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev
16.50	2.00	16.50	75.00	1.00	0.0140	616.01

Pond Results:

Peak Elevation:	617.05
Dewater Time:	0.00 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
616.00	0.001	0.000	0.000		
616.01	0.001	0.000	0.000		Spillway #1
616.50	0.005	0.001	4.593		
617.00	0.011	0.005	7.114		
617.05	0.013	0.006	7.267	0.05	Peak Stage
617.50	0.019	0.012	8.727		
618.00	0.030	0.025	10.086		
618.50	0.044	0.043	11.282		
619.00	0.060	0.069	12.363		
619.50	0.079	0.104	13.357		
620.00	0.100	0.148	14.282		

Detailed Discharge Table

Elevation	Drop Inlet (cfs)	Combined Total Discharge (cfs)
616.00	0.000	0.000
616.01	0.000	0.000
616.50	4.593	4.593
617.00	7.114	7.114
617.50	8.727	8.727
618.00	10.086	10.086
618.50	11.282	11.282
619.00	12.363	12.363
619.50	13.357	13.357
620.00	14.282	14.282

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#9	1	1.200	0.000	0.000	0.000	78.000	TR55	3.57	0.288
	Σ	**1.200**						**3.57**	**0.288**
#2	1	1.200	0.000	0.000	0.000	78.000	TR55	3.57	0.288
	Σ	**1.200**						**3.57**	**0.288**
#8	1	0.100	0.000	0.000	0.000	78.000	TR55	0.30	0.024
	Σ	**2.500**						**7.44**	**0.600**

Output #4
18-inch-diameter
downdrain pipes
with 25yr/24hr
Flow.

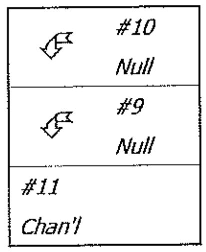
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.200 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#9	==>	#11	0.000	0.000	
Null	#10	==>	#11	0.000	0.000	
Channel	#11	==>	End	0.000	0.000	



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#10	7.000	7.000	20.82	1.68
#9	7.000	7.000	20.82	1.68
#11	0.000	14.000	41.64	3.36

Structure Detail:

Structure #10 (Null)

Structure #9 (Null)

Structure #11 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	4.0:1	4.0:1	1.0	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	41.64 cfs		41.64 cfs	
Depth:	0.97 ft		1.59 ft	
Top Width:	19.79 ft		24.75 ft	
Velocity:	2.69 fps		1.42 fps	
X-Section Area:	15.48 sq ft		29.29 sq ft	
Hydraulic Radius:	0.773		1.165	
Froude Number:	0.54		0.23	
Roughness Coefficient:	0.0466		0.1159	

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#10	1	7.000	0.000	0.000	0.000	78.000	TR55	20.82	1.681
	Σ	**7.000**						**20.82**	**1.681**
#9	1	7.000	0.000	0.000	0.000	78.000	TR55	20.82	1.681
	Σ	**7.000**						**20.82**	**1.681**
#11	Σ	**14.000**						**41.64**	**3.363**

Output #5
18-inch pipe
one-half full
at 25yr/24hr
flow and
full flow
at 100y/24hr
flow

CIRCULAR CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

Flow Rate (cubic feet per second)	21
Channel Bottom Slope (feet per foot)	.25
Manning`s Roughness Coefficient (n-value)	0.013
Channel Diameter (feet)	1.38
*** RESULTS ***	
NORMAL DEPTH (FEET)	0.69
Flow Velocity (feet per second)	28.10
Froude Number	6.728
Velocity Head (feet)	12.26
Energy Head (feet)	12.95
Cross-Sectional Area of Flow (square feet)	0.75
Top Width of Flow (feet)	1.38

Hazen-Williams friction loss equation is valid for water at temperatures typical of city water supply systems (40 to 75 °F; 4 to 25 °C).

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Design of Circular Water Pipes Calculator Table of Hazen-Williams Coefficients (C) Unit Conversions

$$V = k\,C\,R_h^{0.63}\,S^{0.54} \quad \text{where} \quad S = \frac{h_f}{L} \ \ \& \ \ Q = VA \ \ \& \ \ R_h = \frac{D}{4} \ \text{for circular pipe}$$

Click to Calculate

Calculate:
- ○ Discharge and Velocity
- ○ Pipe Diameter (Q known)
- ○ Pipe Diameter (V known)
- ◉ Energy (Head) Loss (Q known)
- ○ Energy (Head) Loss (V known)
- ○ Pipe Length (Q known)
- ○ Pipe Length (V known)
- ○ Hazen-Williams Coefficient (Q kno
- ○ Hazen-Williams Coefficient (V kno

Select Units:
- ◉ Use feet and seconds units
- ○ Use meters and seconds units

k = 1.318

Discharge, Q (ft³/s):	27
Velocity, V (ft/s):	18.051600350687565
Pipe Diameter, D (ft):	1.38
Pipe Length, L (ft):	100.0
Hazen Williams Coefficient, C:	140
Energy (Head) Loss, hf (ft):	4.674285643848096
Energy Slope, S (ft/ft):	0.046742856438489605

k is a unit conversion factor.
k=1.318 for English units (feet and seconds). k=0.85 for SI units (meters and seconds)
R_h=hydraulic radius=D/4 for circular pipe

The Hazen-Williams method is only valid for water flowing at ordinary temperatures (about 40 to 75 °F). For other liquids or gases, the Darcy-Weisbach method should be used. Major loss (h_f) is the energy (or head) loss (expressed in length units - think of it as energy per unit weight of fluid) due to friction between the moving fluid and the duct. It is also known as friction loss. The Darcy-Weisbach method is generally considered more accurate than the Hazen-Williams method. However, the Hazen-Williams method is very popular, especially among civil engineers, since its friction coefficient (C) is not a function of velocity or duct diameter. Hazen-Williams is simpler than Darcy-Weisbach for calculations where you are solving for flowrate, velocity, or diameter. More Discussion and References.

Applet HazenWilliams started Internet

Output #6
12-inch downdrain
pipes with
25 year/24 hour
flow.

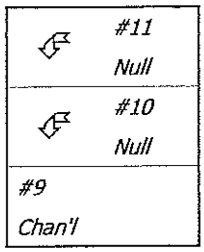
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.200 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#9	==>	End	0.000	0.000	
Null	#10	==>	#9	0.000	0.000	
Null	#11	==>	#9	0.000	0.000	



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#11	3.000	3.000	8.92	0.72
#10	3.000	3.000	8.92	0.72
#9	0.000	6.000	17.85	1.44

Structure Detail:

Structure #11 (Null)

Structure #10 (Null)

Structure #9 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	4.0:1	4.0:1	2.0	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	17.85 cfs		17.85 cfs	
Depth:	0.56 ft		1.00 ft	
Top Width:	16.46 ft		20.01 ft	
Velocity:	2.25 fps		1.11 fps	
X-Section Area:	7.92 sq ft		16.02 sq ft	
Hydraulic Radius:	0.478		0.791	
Froude Number:	0.57		0.22	
Roughness Coefficient:	0.0570		0.1616	

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#11	1	3.000	0.000	0.000	0.000	78.000	TR55	8.92	0.721
	Σ	**3.000**						**8.92**	**0.721**
#10	1	3.000	0.000	0.000	0.000	78.000	TR55	8.92	0.721
	Σ	**3.000**						**8.92**	**0.721**
#9	1	0.000	0.000	0.000	0.000	1.000	TR55	0.00	0.000
	Σ	**6.000**						**17.85**	**1.441**

Output # 7

12-inch pipe one-half full at 25yr/24 hour flow and full flow at 100yr/24 hr flow

CIRCULAR CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

Flow Rate (cubic feet per second)	9
Channel Bottom Slope (feet per foot)	.25
Manning`s Roughness Coefficient (n-value)	0.013
Channel Diameter (feet)	.98
*** RESULTS ***	
NORMAL DEPTH (FEET)	0.51
Flow Velocity (feet per second)	22.84
Froude Number	6.346
Velocity Head (feet)	8.10
Energy Head (feet)	8.61
Cross-Sectional Area of Flow (square feet)	0.39
Top Width of Flow (feet)	0.98

Major Loss Calculation for Water in Pipes using Hazen-Williams Friction Loss Equation

Hazen-Williams friction loss equation is valid for water at temperatures typical of city water supply systems (40 to 75 °F; 4 to 25 °C).

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Design of Circular Water Pipes Calculator Table of Hazen-Williams Coefficients (C) Unit Conversions

$$V = k\,C\,R_h^{0.63}\,S^{0.54} \quad \text{where} \quad S = \frac{h_f}{L} \;\&\; Q = VA \;\&\; R_h = \frac{D}{4} \text{ for circular pipe}$$

Click to Calculate

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Calculate:	Select Units:	
○ Discharge and Velocity	● Use feet and seconds units	
○ Pipe Diameter (Q known)	○ Use meters and seconds units	
○ Pipe Diameter (V known)		k = 1.318
● Energy (Head) Loss (Q known)	Discharge, Q (ft³/s):	12
○ Energy (Head) Loss (V known)	Velocity, V (ft/s):	15.90886561518321
○ Pipe Length (Q known)	Pipe Diameter, D (ft):	.98
○ Pipe Length (V known)	Pipe Length, L (ft):	100.0
○ Hazen-Williams Coefficient (Q kn	Hazen Williams Coefficient, C:	140
○ Hazen-Williams Coefficient (V kno	Energy (Head) Loss, hf (ft):	5.51468383709598
	Energy Slope, S (ft/ft):	0.0551468383709598

k is a unit conversion factor:
k=1.318 for English units (feet and seconds). k=0.85 for SI units (meters and seconds)
R_h=hydraulic radius=D/4 for circular pipe

The Hazen-Williams method is only valid for water flowing at ordinary temperatures (about 40 to 75 °F). For other liquids or gases, the Darcy-Weisbach method

Applet HazenWilliams started Internet

Output #8
25 year / 24 hour
Flow into West
Sediment Pond.

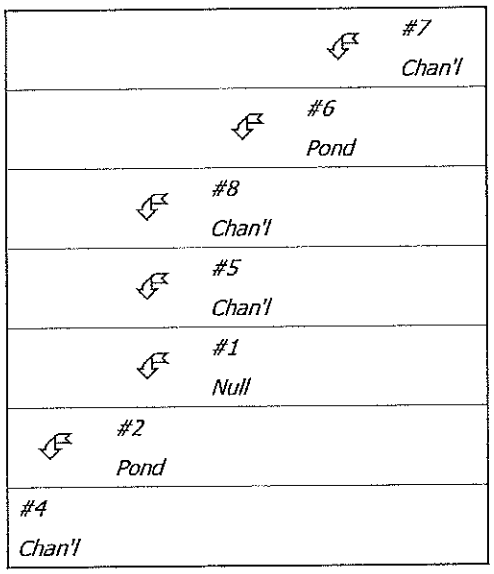
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	5.300 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	0.000	0.000	
Pond	#2	==>	#4	0.000	0.000	
Channel	#4	==>	End	0.000	0.000	
Channel	#5	==>	#2	0.000	0.000	
Pond	#6	==>	#8	0.000	0.000	
Channel	#7	==>	#6	0.000	0.000	
Channel	#8	==>	#2	0.000	0.000	



Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#7		47.700	47.700	145.71	11.80
#6	In	7.200	54.900	167.70	13.58
	Out			165.28	13.58
#8		5.000	59.900	180.55	14.82
#5		37.800	37.800	115.47	9.35
#1		49.600	49.600	151.51	12.27
#2	In	35.300	182.600	555.37	45.17
	Out			20.39	38.65
#4		1.000	183.600	40.90	45.41

Structure Detail:

Structure #7 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	3.0:1	3.0:1	0.3	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	145.71 cfs		145.71 cfs	
Depth:	2.46 ft		3.50 ft	
Top Width:	26.75 ft		33.03 ft	
Velocity:	3.06 fps		1.85 fps	
X-Section Area:	47.62 sq ft		78.91 sq ft	
Hydraulic Radius:	1.729		2.310	
Froude Number:	0.40		0.21	
Roughness Coefficient:	0.0351		0.0705	

Structure #6 (Pond)

Pond Inputs:

Initial Pool Elev:	510.01
Initial Pool:	0.10 ac-ft

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev	Entrance Loss Coefficient	Tailwater Depth (ft)
43.00	200.00	1.00	0.0120	509.01	0.90	3.40

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev	Entrance Loss Coefficient	Tailwater Depth (ft)
43.00	200.00	1.00	0.0120	509.01	0.90	3.40

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev	Entrance Loss Coefficient	Tailwater Depth (ft)
43.00	200.00	1.00	0.0120	509.01	0.90	3.40

Pond Results:

Peak Elevation:	512.78
Dewater Time:	0.50 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
509.00	0.100	0.000	0.000		
509.01	0.100	0.001	0.000		Spillway #1 Spillway #2 Spillway #3
509.50	0.100	0.050	0.000		
510.00	0.100	0.100	0.000		
510.01	0.100	0.101	0.000		
510.50	0.109	0.152	40.939	11.95	
511.00	0.118	0.209	63.203		
511.50	0.128	0.271	88.456		
512.00	0.138	0.337	116.377		
512.50	0.149	0.409	146.757		
512.78	0.155	0.453	165.281	0.05	Peak Stage
513.00	0.159	0.486	179.401		
513.50	0.171	0.568	208.015		
514.00	0.182	0.657	233.574		
514.50	0.194	0.751	256.714		
515.00	0.207	0.851	277.873		
515.01	0.207	0.853	278.283		
515.50	0.230	0.960	297.624		

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
516.00	0.255	1.082	316.065	
516.50	0.281	1.216	333.477	
517.00	0.309	1.363	350.043	
517.50	0.337	1.524	365.867	
518.00	0.367	1.701	381.035	
518.50	0.399	1.892	395.623	
519.00	0.431	2.099	409.694	
519.50	0.465	2.323	423.303	
520.00	0.500	2.565	436.496	

Detailed Discharge Table

Elevation	Straight Pipe (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
509.00	0.000	0.000	0.000	0.000
509.01	0.000	0.000	0.000	0.000
509.50	0.000	0.000	0.000	0.000
510.00	0.000	0.000	0.000	0.000
510.01	0.000	0.000	0.000	0.000
510.50	(3)>13.646	(3)>13.646	(3)>13.646	40.939
511.00	(3)>21.068	(3)>21.068	(3)>21.068	63.203
511.50	(3)>29.485	(3)>29.485	(3)>29.485	88.456
512.00	(3)>38.792	(3)>38.792	(3)>38.792	116.377
512.50	(3)>48.919	(3)>48.919	(3)>48.919	146.757
513.00	(3)>59.800	(3)>59.800	(3)>59.800	179.401
513.50	(5)>69.338	(5)>69.338	(5)>69.338	208.015
514.00	(5)>77.858	(5)>77.858	(5)>77.858	233.574
514.50	(5)>85.571	(5)>85.571	(5)>85.571	256.714
515.00	(5)>92.624	(5)>92.624	(5)>92.624	277.873
515.01	(5)>92.761	(5)>92.761	(5)>92.761	278.283
515.50	(5)>99.208	(5)>99.208	(5)>99.208	297.624
516.00	(5)>105.355	(5)>105.355	(5)>105.355	316.065
516.50	(5)>111.159	(5)>111.159	(5)>111.159	333.477
517.00	(5)>116.681	(5)>116.681	(5)>116.681	350.043
517.50	(5)>121.956	(5)>121.956	(5)>121.956	365.867
518.00	(5)>0.000	(5)>0.000	(5)>0.000	381.035
518.50	(5)>0.000	(5)>0.000	(5)>0.000	395.623
519.00	(5)>0.000	(5)>0.000	(5)>0.000	409.694
519.50	(5)>0.000	(5)>0.000	(5)>0.000	423.303

Elevation	Straight Pipe (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
520.00	(5)>0.000	(5)>0.000	(5)>0.000	436.496

Structure #8 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	4.0:1	4.0:1	0.3	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	180.55 cfs		180.55 cfs	
Depth:	2.48 ft		3.47 ft	
Top Width:	31.80 ft		39.78 ft	
Velocity:	3.33 fps		2.01 fps	
X-Section Area:	54.20 sq ft		89.88 sq ft	
Hydraulic Radius:	1.672		2.212	
Froude Number:	0.45		0.24	
Roughness Coefficient:	0.0345		0.0690	

Structure #5 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	3.0:1	3.0:1	0.6	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	115.47 cfs		115.47 cfs	
Depth:	1.76 ft		2.55 ft	
Top Width:	22.58 ft		27.32 ft	
Velocity:	3.79 fps		2.30 fps	
X-Section Area:	30.50 sq ft		50.22 sq ft	
Hydraulic Radius:	1.317		1.784	
Froude Number:	0.57		0.30	
Roughness Coefficient:	0.0357		0.0719	

Structure #1 (Null)

Structure #2 (Pond)

Pond Inputs:

Initial Pool Elev:	504.00
Initial Pool:	13.49 ac-ft

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev	Entrance Loss Coefficient	Tailwater Depth (ft)
22.00	50.00	1.00	0.0120	504.00	0.90	0.00

Pond Results:

Peak Elevation:	507.74
Dewater Time:	3.15 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
502.00	6.300	0.000	0.000		
502.50	6.519	3.205	0.000		
503.00	6.742	6.520	0.000		
503.50	6.969	9.948	0.000		
504.00	7.200	13.490	0.000		Spillway #1
504.50	7.418	17.144	1.365	32.40*	
505.00	7.639	20.908	3.841	11.86*	

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
505.50	7.863	24.783	7.058	8.85	
506.00	8.090	28.771	10.860	5.50	
506.50	8.308	32.871	14.260	3.95	
507.00	8.529	37.080	17.005	3.30	
507.50	8.753	41.400	19.368	4.75	
507.74	8.863	43.542	20.388	4.90	Peak Stage
508.00	8.980	45.834	21.479		
508.50	9.199	50.378	23.401		
509.00	9.420	55.033	25.180		
509.50	9.644	59.798	26.845		
510.00	9.870	64.677	28.408		
510.50	10.099	69.669	29.878		
511.00	10.330	74.776	31.288		
511.50	10.564	79.999	32.650		
512.00	10.800	85.340	33.933		

**Designates time(s) to dewater have been extrapolated beyond the 50 hour hydrograph limit.*

Detailed Discharge Table

Elevation	Straight Pipe (cfs)	Combined Total Discharge (cfs)
502.00	0.000	0.000
502.50	0.000	0.000
503.00	0.000	0.000
503.50	0.000	0.000
504.00	0.000	0.000
504.50	(3)>1.365	1.365
505.00	(3)>3.841	3.841
505.50	(3)>7.058	7.058
506.00	(3)>10.860	10.860
506.50	(5)>14.260	14.260
507.00	(5)>17.005	17.005
507.50	(5)>19.368	19.368
508.00	(5)>21.479	21.479
508.50	(5)>23.401	23.401
509.00	(5)>25.180	25.180
509.50	(5)>26.845	26.845
510.00	(5)>28.408	28.408
510.50	(5)>29.878	29.878

Elevation	Straight Pipe (cfs)	Combined Total Discharge (cfs)
511.00	(5)>31.288	31.288
511.50	(5)>32.650	32.650
512.00	(5)>33.933	33.933

Structure #4 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
50.00	5.0:1	5.0:1	0.2	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	40.90 cfs		40.90 cfs	
Depth:	0.86 ft		1.63 ft	
Top Width:	58.59 ft		66.31 ft	
Velocity:	0.88 fps		0.43 fps	
X-Section Area:	46.64 sq ft		94.85 sq ft	
Hydraulic Radius:	0.794		1.423	
Froude Number:	0.17		0.06	
Roughness Coefficient:	0.0651		0.1955	

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#7	1	47.700	0.000	0.000	0.000	78.000	TR55	145.71	11.798
	Σ	**47.700**						**145.71**	**11.798**
#6	1	7.200	0.000	0.000	0.000	78.000	TR55	21.99	1.781
	Σ	**54.900**						**167.70**	**13.579**
#8	1	5.000	0.000	0.000	0.000	78.000	TR55	15.27	1.237
	Σ	**59.900**						**180.55**	**14.816**
#5	1	37.800	0.000	0.000	0.000	78.000	TR55	115.47	9.350
	Σ	**37.800**						**115.47**	**9.350**
#1	1	49.600	0.000	0.000	0.000	78.000	TR55	151.51	12.268
	Σ	**49.600**						**151.51**	**12.268**
#2	1	35.300	0.000	0.000	0.000	78.000	TR55	107.83	8.731
	Σ	**182.600**						**555.37**	**45.166**
#4	1	1.000	0.000	0.000	0.000	78.000	TR55	3.05	0.247
	Σ	**183.600**						**40.90**	**45.413**

Output #9
100 year / 24 hour
Flow into West
Sediment Pond.

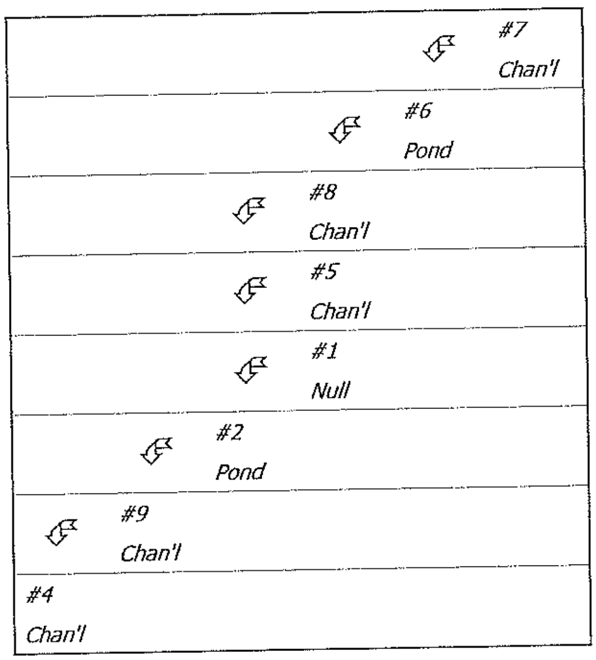
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 24 hr
Rainfall Depth:	6.300 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	0.000	0.000	
Pond	#2	==>	#9	0.000	0.000	
Channel	#4	==>	End	0.000	0.000	
Channel	#5	==>	#2	0.000	0.000	
Pond	#6	==>	#8	0.000	0.000	
Channel	#7	==>	#6	0.000	0.000	
Channel	#8	==>	#2	0.000	0.000	
Channel	#9	==>	#4	0.000	0.000	



Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#7		47.700	47.700	184.23	15.28
#6	In	7.200	54.900	212.04	17.59
	Out			208.85	17.59
#8		5.000	59.900	228.17	19.19
#5		37.800	37.800	146.00	12.11
#1		49.600	49.600	191.57	15.89
#2	In	35.300	182.600	702.08	58.51
	Out			451.46	58.47
#9		0.100	182.700	451.53	58.54
#4		1.000	183.700	453.01	58.86

Structure Detail:

Structure #7 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	3.0:1	3.0:1	0.3	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	184.23 cfs		184.23 cfs	
Depth:	2.70 ft		3.74 ft	
Top Width:	28.18 ft		34.47 ft	
Velocity:	3.40 fps		2.12 fps	
X-Section Area:	54.16 sq ft		87.01 sq ft	
Hydraulic Radius:	1.864		2.438	
Froude Number:	0.43		0.23	
Roughness Coefficient:	0.0332		0.0637	

Structure #6 (Pond)

Pond Inputs:

Initial Pool Elev:	510.01
Initial Pool:	0.10 ac-ft

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev	Entrance Loss Coefficient	Tailwater Depth (ft)
43.00	200.00	1.00	0.0120	509.01	0.90	3.40

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev	Entrance Loss Coefficient	Tailwater Depth (ft)
43.00	200.00	1.00	0.0120	509.01	0.90	3.40

Straight Pipe

Barrel Diameter (in)	Barrel Length (ft)	Barrel Slope (%)	Manning's n	Spillway Elev	Entrance Loss Coefficient	Tailwater Depth (ft)
43.00	200.00	1.00	0.0120	509.01	0.90	3.40

Pond Results:

Peak Elevation:	513.52
Dewater Time:	0.50 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
509.00	0.100	0.000	0.000		
509.01	0.100	0.001	0.000		Spillway #1 Spillway #2 Spillway #3
509.50	0.100	0.050	0.000		
510.00	0.100	0.100	0.000		
510.01	0.100	0.101	0.000		
510.50	0.109	0.152	40.939	11.50	
511.00	0.118	0.209	63.203	0.45	
511.50	0.128	0.271	88.456		
512.00	0.138	0.337	116.377		
512.50	0.149	0.409	146.757		
513.00	0.159	0.486	179.401		
513.50	0.171	0.568	208.015		
513.52	0.171	0.571	208.854	0.05	Peak Stage
514.00	0.182	0.657	233.574		
514.50	0.194	0.751	256.714		
515.00	0.207	0.851	277.873		
515.01	0.207	0.853	278.283		
515.50	0.230	0.960	297.624		

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
516.00	0.255	1.082	316.065	
516.50	0.281	1.216	333.477	
517.00	0.309	1.363	350.043	
517.50	0.337	1.524	365.867	
518.00	0.367	1.701	381.035	
518.50	0.399	1.892	395.623	
519.00	0.431	2.099	409.694	
519.50	0.465	2.323	423.303	
520.00	0.500	2.565	436.496	

Detailed Discharge Table

Elevation	Straight Pipe (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
509.00	0.000	0.000	0.000	0.000
509.01	0.000	0.000	0.000	0.000
509.50	0.000	0.000	0.000	0.000
510.00	0.000	0.000	0.000	0.000
510.01	0.000	0.000	0.000	0.000
510.50	(3)>13.646	(3)>13.646	(3)>13.646	40.939
511.00	(3)>21.068	(3)>21.068	(3)>21.068	63.203
511.50	(3)>29.485	(3)>29.485	(3)>29.485	88.456
512.00	(3)>38.792	(3)>38.792	(3)>38.792	116.377
512.50	(3)>48.919	(3)>48.919	(3)>48.919	146.757
513.00	(3)>59.800	(3)>59.800	(3)>59.800	179.401
513.50	(5)>69.338	(5)>69.338	(5)>69.338	208.015
514.00	(5)>77.858	(5)>77.858	(5)>77.858	233.574
514.50	(5)>85.571	(5)>85.571	(5)>85.571	256.714
515.00	(5)>92.624	(5)>92.624	(5)>92.624	277.873
515.01	(5)>92.761	(5)>92.761	(5)>92.761	278.283
515.50	(5)>99.208	(5)>99.208	(5)>99.208	297.624
516.00	(5)>105.355	(5)>105.355	(5)>105.355	316.065
516.50	(5)>111.159	(5)>111.159	(5)>111.159	333.477
517.00	(5)>116.681	(5)>116.681	(5)>116.681	350.043
517.50	(5)>121.956	(5)>121.956	(5)>121.956	365.867
518.00	(5)>127.012	(5)>127.012	(5)>127.012	381.035
518.50	(5)>131.874	(5)>131.874	(5)>131.874	395.623
519.00	(5)>136.565	(5)>136.565	(5)>136.565	409.694
519.50	(5)>141.101	(5)>141.101	(5)>141.101	423.303

Elevation	Straight Pipe (cfs)	Straight Pipe (cfs)	Straight Pipe (cfs)	Combined Total Discharge (cfs)
520.00	(5)>145.499	(5)>145.499	(5)>145.499	436.496

Structure #8 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	4.0:1	4.0:1	0.3	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	228.17 cfs		228.17 cfs	
Depth:	2.71 ft		3.70 ft	
Top Width:	33.66 ft		41.62 ft	
Velocity:	3.69 fps		2.30 fps	
X-Section Area:	61.79 sq ft		99.28 sq ft	
Hydraulic Radius:	1.800		2.334	
Froude Number:	0.48		0.26	
Roughness Coefficient:	0.0327		0.0625	

Structure #5 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
12.00	3.0:1	3.0:1	0.6	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	146.00 cfs		146.00 cfs	
Depth:	1.94 ft		2.73 ft	
Top Width:	23.64 ft		28.40 ft	
Velocity:	4.22 fps		2.64 fps	
X-Section Area:	34.57 sq ft		55.23 sq ft	
Hydraulic Radius:	1.424		1.886	
Froude Number:	0.62		0.33	
Roughness Coefficient:	0.0337		0.0649	

Structure #1 (Null)

Structure #2 (Pond)

Pond Inputs:

Initial Pool Elev:	508.00
Initial Pool:	45.83 ac-ft

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
508.00	12.00	5.00:1	5.00:1	50.00

Pond Results:

Peak Elevation:	510.01
Dewater Time:	1.61 days

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
502.00	6.300	0.000	0.000	
502.50	6.519	3.205	0.000	
503.00	6.742	6.520	0.000	
503.50	6.969	9.948	0.000	
504.00	7.200	13.490	0.000	
504.50	7.418	17.144	0.000	
505.00	7.639	20.908	0.000	
505.50	7.863	24.783	0.000	

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)	
506.00	8.090	28.771	0.000		
506.50	8.308	32.871	0.000		
507.00	8.529	37.080	0.000		
507.50	8.753	41.400	0.000		
508.00	8.980	45.834	0.000		Spillway #1
508.01	8.984	45.924	0.201	5.41*	
508.10	9.024	46.734	2.011	12.45	
508.50	9.199	50.378	10.053	8.85	
509.00	9.420	55.033	132.185	11.15	
509.50	9.644	59.799	273.717	0.60	
510.00	9.870	64.677	448.894		
510.01	9.874	64.738	451.459	0.25	Peak Stage
510.50	10.099	69.669	658.992		
511.00	10.330	74.776	903.443		
511.50	10.564	79.999	1,182.174		
512.00	10.800	85.340	1,495.392		

Detailed Discharge Table

Elevation	Emergency Spillway (cfs)	Combined Total Discharge (cfs)
502.00	0.000	0.000
502.50	0.000	0.000
503.00	0.000	0.000
503.50	0.000	0.000
504.00	0.000	0.000
504.50	0.000	0.000
505.00	0.000	0.000
505.50	0.000	0.000
506.00	0.000	0.000
506.50	0.000	0.000
507.00	0.000	0.000
507.50	0.000	0.000
508.00	0.000	0.000
508.01	0.201	0.201
508.10	2.011	2.011
508.50	10.053	10.053
509.00	132.185	132.185
509.50	273.717	273.717

Elevation	Emergency Spillway (cfs)	Combined Total Discharge (cfs)
510.00	448.894	448.894
510.50	658.992	658.992
511.00	903.443	903.443
511.50	1,182.174	1,182.174
512.00	1,495.392	1,495.392

Structure #9 (Riprap Channel)

Trapezoidal Riprap Channel Inputs:

Material: Riprap

Bottom Width (ft)}	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
50.00	5.0:1	5.0:1	20.0			

Riprap Channel Results:

PADER Method - Steep Slope Design

	w/o Freeboard	w/ Freeboard
Design Discharge:	451.53 cfs	
Depth:	0.90 ft	
Top Width:	59.01 ft	
Velocity:	9.19 fps	
X-Section Area:	49.11 sq ft	
Hydraulic Radius:	0.830	
Froude Number:	1.78	
Manning's n:	0.0640	
Dmin:	5.00 in	
D50:	9.00 in	
Dmax:	12.00 in	

Structure #4 (Vegetated Channel)

Trapezoidal Vegetated Channel Inputs:

Material: Grass mixture

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Retardance Classes	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
50.00	5.0:1	5.0:1	0.2	D, B				5.0

Vegetated Channel Results:

	Stability Class D w/o Freeboard	Stability Class D w/ Freeboard	Capacity Class B w/o Freeboard	Capacity Class B w/ Freeboard
Design Discharge:	453.01 cfs		453.01 cfs	
Depth:	2.35 ft		3.33 ft	
Top Width:	73.53 ft		83.26 ft	
Velocity:	3.12 fps		2.04 fps	
X-Section Area:	145.33 sq ft		221.61 sq ft	
Hydraulic Radius:	1.964		2.641	
Froude Number:	0.39		0.22	
Roughness Coefficient:	0.0335		0.0623	

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#7	1	47.700	0.000	0.000	0.000	78.000	TR55	184.23	15.284
	Σ	**47.700**						**184.23**	**15.284**
#6	1	7.200	0.000	0.000	0.000	78.000	TR55	27.81	2.307
	Σ	**54.900**						**212.04**	**17.591**
#8	1	5.000	0.000	0.000	0.000	78.000	TR55	19.31	1.602
	Σ	**59.900**						**228.17**	**19.194**
#5	1	37.800	0.000	0.000	0.000	78.000	TR55	146.00	12.112
	Σ	**37.800**						**146.00**	**12.112**
#1	1	49.600	0.000	0.000	0.000	78.000	TR55	191.57	15.893
	Σ	**49.600**						**191.57**	**15.893**
#2	1	35.300	0.000	0.000	0.000	78.000	TR55	136.34	11.311
	Σ	**182.600**						**702.08**	**58.510**
#9	1	0.100	0.000	0.000	0.000	78.000	TR55	0.39	0.032
	Σ	**182.700**						**451.53**	**58.542**
#4	1	1.000	0.000	0.000	0.000	78.000	TR55	3.86	0.320
	Σ	**183.700**						**453.01**	**58.863**

Appendix C: References and Plan Sheets

Section 1:	SCS Method
Section 2:	FEMA Floodplain Boundary Map
Section 3:	Plan Sheets

Appendix C, Section 1: SCS Method

United States
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Natural
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Urban Hydrology for Small Watersheds

TR-55

Chapter 2 Estimating Runoff

SCS runoff curve number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[eq. 2-1]}$$

where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
I_a = initial abstraction (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil texture is given in appendix A for determining the HSG classification for disturbed soils.

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{[eq. 3-4]}$$

where:

V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/p_w
a = cross sectional flow area (ft^2)
p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.

- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

- The minimum T_c used in TR-55 is 0.1 hour.

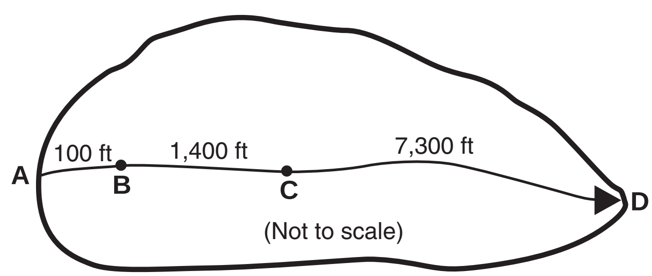
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

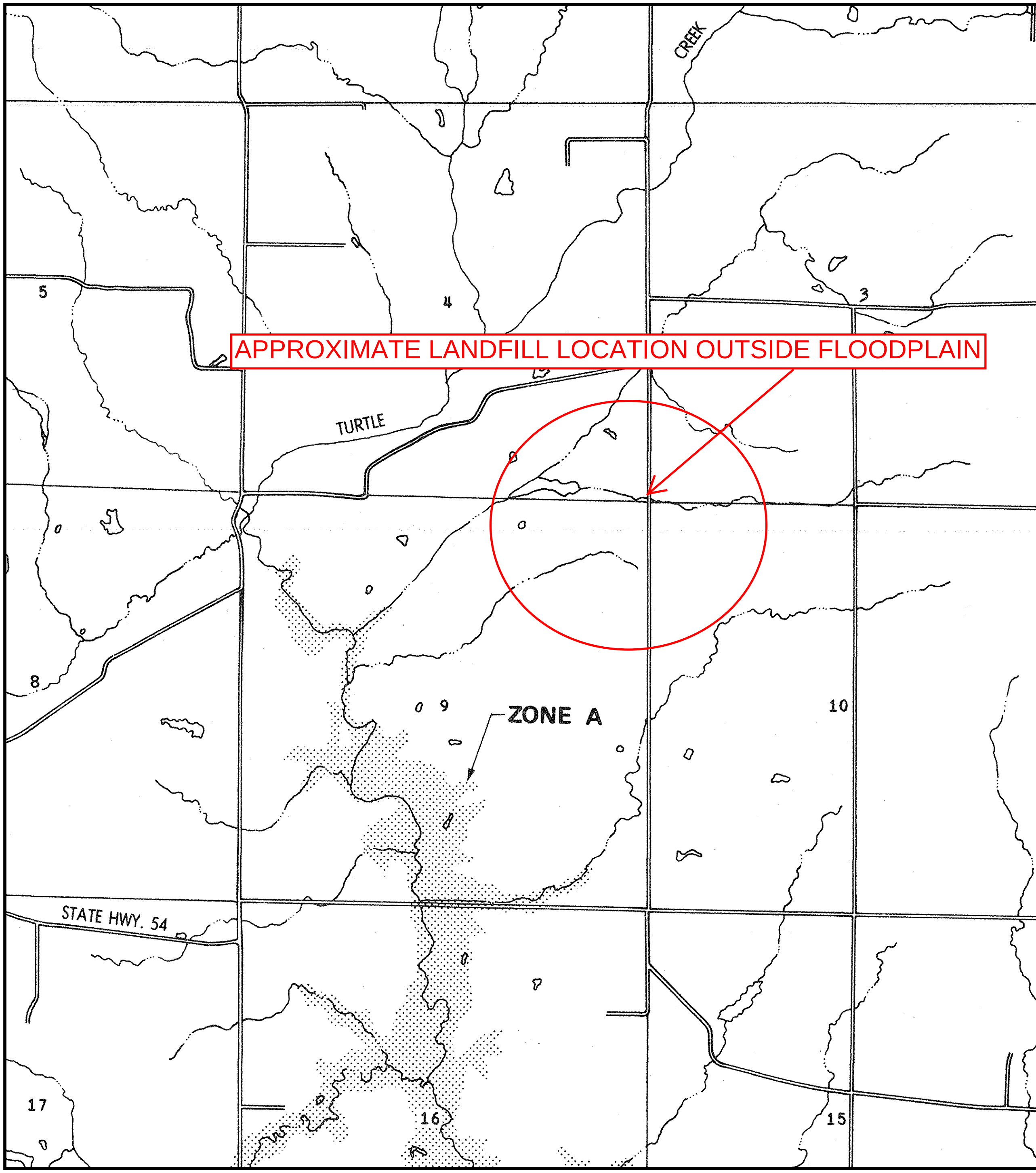
The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB: Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft. Segment BC: Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1,400 ft. Segment CD: Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7,300 ft.

See figure 3-2 for the computations made on worksheet 3.



Appendix C, Section 2: FEMA Floodplain Boundary Map



APPROXIMATE SCALE IN FEET

2000 0

FLOOD HAZARD BOUNDARY MAP

SULLIVAN COUNTY INDIANA

UNINC. AREAS

PAGE 3 OF 6

(SEE MAP INDEX FOR PAGES NOT PRINTED)

EFFECTIVE DATE:
MARCH 23, 1979

COMMUNITY–PANEL NUMBER

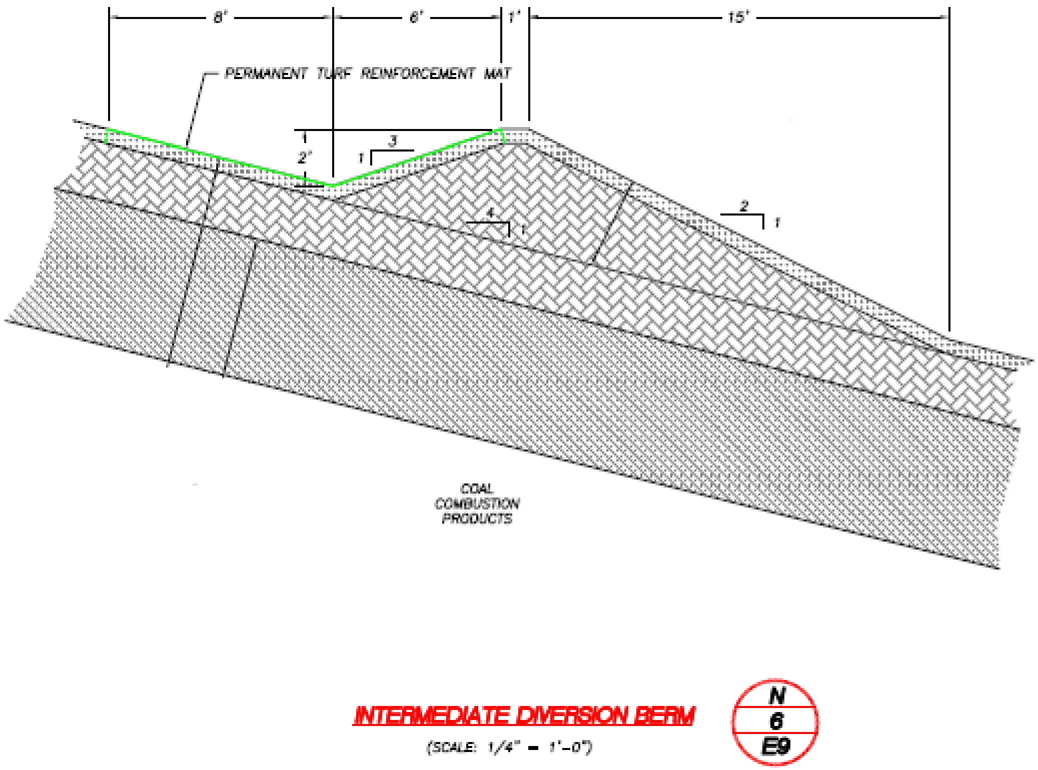
180410 0003 A

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

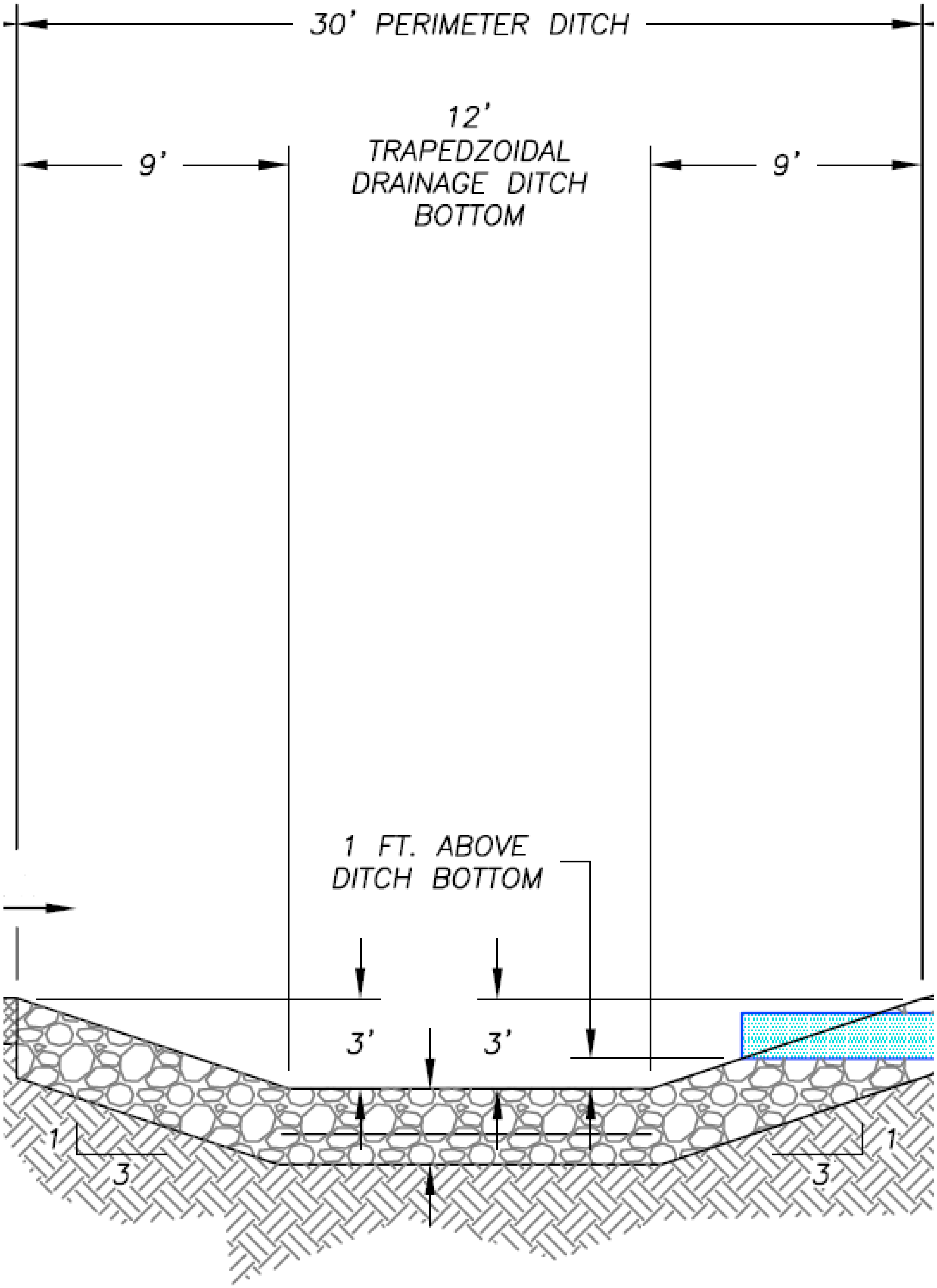
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

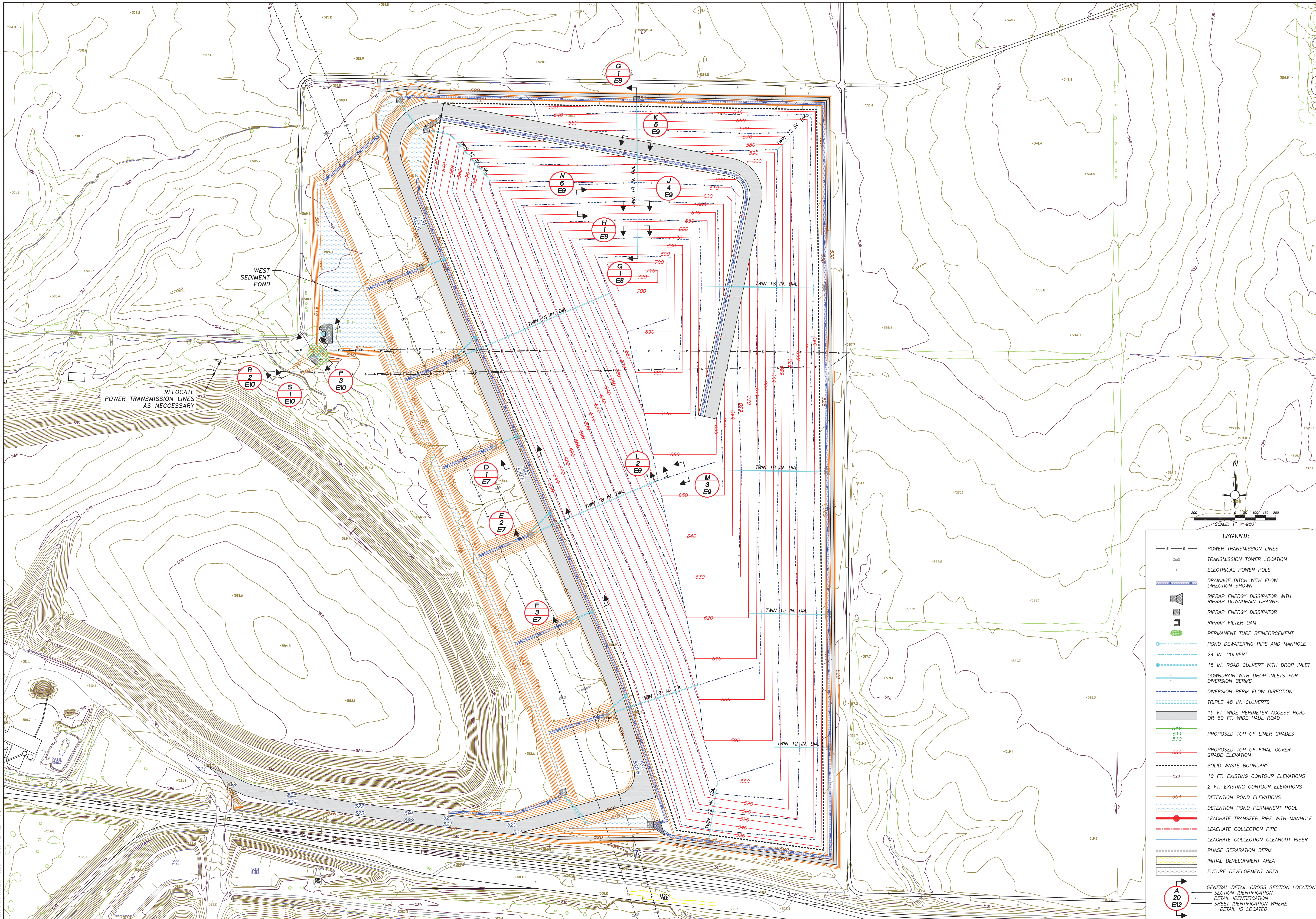
Appendix C, Section 3: Plan Sheets

Surface Water Control – Detail #1 – Intermediate Diversion Berm



Surface Water Control – Detail #2 – Perimeter Ditch





Revision:

Project Number: 86.24019.0014
Drawing File: SEE LOWER LEFT
Date: 11/09
Scale: AS SHOWN
Drn. By: SP
Ckd. By: DS
App'd By:

Company Name:
HOOSIER ENERGY
MEROM GENERATING STATION
SULLIVAN COUNTY, INDIANA

ATC ASSOCIATES INC.
7988 Centerpoint Drive, Suite 100
Indianapolis, Indiana 46256-3345
317.849.4990, Fax 317.849.4278, www.atcassociates.com

Drawing Title:
STORMWATER MANAGEMENT PLAN WITH
DETAIL CROSS SECTION LOCATIONS
AREA 3 RESTRICTED WASTE LANDFILL
HOOSIER ENERGY MEROM GENERATING STATION

Sheet:
E5