HALEY & ALDRICH, INC.
6500 Rockside Road
Suite 200
Cleveland, OH 44131
216.739.0555

MEMORANDUM

17 April 2018
File No. 128064-006

SUBJECT: Inflow Design Flood Control System Plan
Pond 001 - Cell 002 West
Associated Electric Cooperative, Inc.
Thomas Hill Energy Center
Clifton Hill, Missouri

Haley & Aldrich, Inc. (Haley & Aldrich) has developed this Inflow Design Flood (IDF) Control System Plan (Plan) on behalf of Associated Electric Cooperative, Inc. (AECI) for the inactive coal combustion residuals (CCR) surface impoundment referred to as Cell 002 West at the Thomas Hill Energy Center (THEC) in Clifton Hill, Missouri. This has been completed based on requirements of the Environmental Protection Agency (EPA) 40 CFR Parts 257 and 261, "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities" (CCR Rule), specifically section §257.82. Based on the USEPA's issued CCR Rule Partial Vacatur in 2016, the Cell 002 West impoundment at THEC is subject to applicable requirements of the CCR Rule. The inactive status of the impoundment is understood to no longer make the unit exempt from several portions of the CCR Rule. Cell 002 West existing conditions and supporting documentation has been reviewed and associated storm water modeling and analysis performed to satisfy the Inflow Design Flood Control System Plan requirements of CCR Rule section §257.82 as described below.

§257.82(a): The owner or operator of an existing or new CCR surface impoundment or any lateral expansion of a CCR surface impoundment must design, construct, operate, and maintain an inflow design flood control system as specified in paragraphs (a)(1) and (a)(2) of this section.

§257.82(a)(1): The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood specified in paragraph (a)(3) of this section.

Cell 002 West is a surface impoundment with an approximate footprint of 16 acres located south of Cell 001. The Cell 001 footprint and associated staging area north of Cell 002 West prevent surface water from draining into Cell 002 West. Likewise, a drainage divide to the northeast of Cell 002 West directs minor drainage overland to the unit with the remaining drainage area directed to the adjacent Cell 002 East. A conveyance channel located west of Cell 002 West collects any additional drainage from the west and diverts that water to Cell 003 which is south of Cell 002 West. Since the unit has ceased receiving plant process water flows, and the limiting overland flow potential due to the adjacent site features, the only inflow to the unit consists of direct precipitation within the unit footprint.

§257.82(a)(2): The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood specified in paragraph (a)(3) of this section.

Discharge from the impoundment is managed by a primary spillway consisting of a 15-inch corrugated metal pipe (CMP) with an upstream invert elevation at approximately 718.0 ft. The outlet control structures are detailed in the Gredell Engineering Resources, Inc. – Figure 1, dated September 2015 (note that material type and pipe location was changed and the emergency spillway pipe was not installed). Pertinent pages providing the required information have been provided as **Appendix A**. The critical berm elevation for the impoundment analysis is the separator berm between Cell 002 West and Cell 002 East at an approximate elevation of 720.0 ft.

Hydrologic and hydraulic modeling for this Cell 002 West IDF Control System Plan was performed using HydroCAD Stormwater Modeling System, version 10.00-12 (HydroCAD) in conjunction with the appropriate IDF as dictated by the CCR Rule in section §257.82(a)(3).

When Cell 002 West is maintained at its normal WSEL (El. 718.0), the results of the HydroCAD analysis confirm the IDF control system for Cell 002 West adequately manages flow into the impoundment during and following the IDF peak discharge. The peak level and resulting freeboard in Cell 002 West during the 100-year flood is noted in Table 1 below. The HydroCAD model simulation output is provided as **Appendix B**. **Table I** summarizes the effects of the IDF peak discharge during normal operation of the impoundment. See **Figure 1** for the Cell 002 West for the existing site plan.

Table I: HydroCAD Output Summary

Peak flood level (ft)	718.80
Minimum Dike Elevation (ft)	720.00
Minimum freeboard (ft)	1.20
Peak inflow (cfs)	137.51

§257.82(a)(3): The inflow design flood is:

i. For a high hazard potential CCR surface impoundment, as determined under § 257.73(a)(2) or § 257.74(a)(2), the probable maximum flood;

ii. For a significant hazard potential CCR surface impoundment, as determined under § 257.73(a)(2) or § 257.74(a)(2), the 1,000-year flood;

iii. For a low hazard potential CCR surface impoundment, as determined under § 257.73(a)(2) or § 257.74(a)(2), the 100-year flood; or

iv. For an incised CCR surface impoundment, the 25-year flood.

Cell 002 West was determined to be low hazard potential as determined per the Hazard Potential Classification Assessment performed under separate cover; therefore, the design

event is the 100-year, 24-hour storm. The 100-year storm characteristics were detailed in the NOAA Atlas 14, Volume 8, Version 2 Point Precipitation Frequency Estimates: MO dated 31 August 2016 and prepared by the National Weather Service. Pertinent pages providing the required information have been provided as **Appendix C**.

§257.82(b): Discharge from the CCR unit must be handled in accordance with the surface water requirements under § 257.3–3.

§257.3-3(a): For purposed of section 4004(a) of the Act, a facility shall not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under section 402 of the Clean Water Act, as amended.

§257.3-3(b): For purposed of section 4004(a) of the Act, a facility shall not cause a discharge of dredged material or fill material to waters of the United States that is in violation of the requirements under section 404 of the Clean Water Act, as amended.

§257.3-3(c): A facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the Administrator under section 208 of the Clean Water Act, as amended.

Discharge from the Cell 002 West is managed through downstream ponds that ultimately discharge through the facility's National Pollution Discharge Elimination System (NPDES) permit, which was prepared by the Missouri Department of Natural Resources.

§257.82(c)(1): Content of the plan. The owner or operator must prepare initial and periodic inflow design flood 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 inflow design flood control system has been designed and constructed to meet the requirements of this section. Each plan must be supported by appropriate engineering calculations. The owner or operator of the CCR unit has completed the inflow design flood control system plan when the plan has been placed in the facility's operating record as required by § 257.105(g)(4).

This document and all attachments serve as the Initial Inflow Design Flood Control Plan and will be placed in the facility's operating record. Periodic Plans will be prepared and placed in the facility operating record at 5-year increments or whenever there is a change in conditions that would affect the Plan.

§257.82(c)(2): Amendment of the plan. The owner or operator of the CCR unit may amend the written inflow design flood control system plan at any time provided the revised plan is placed in the facility's operating record as required by § 257.105(g)(4). The owner or operator must amend the written inflow design flood control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.

The IDF Plan will be amended at least 60 days prior to a planned change in the operation of the facility or the CCR impoundment, or no later than 60 days after an unanticipated event requires the need to revise the IDF Plan. If the Plan needs to be revised after closure activities have commenced, the Plan will be revised no later than 30 days following the triggering event.

Any amendments to the Plan will include written certification from a qualified professional engineer that the initial and any amendments to the IDF Plan meet the requirements of the CCR Rule.

A record of amendments to the Plan will be tracked below. The latest version of the IDF Plan will be noted on the front cover of the Plan.

Version	Date	Description of Changes Made
1	17 April 2018	Initial Issuance

§257.82(c)(3): Timeframes for preparing the initial plan

i. *Existing CCR surface impoundments. The owner or operator of the CCR unit must prepare the initial inflow design flood control system plan no later than October 17, 2016.*

Per EPA 40 CFR Part 257 – "Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Extension of Compliance Deadlines for Certain Inactive Surface Impoundments; Response to Partial Vacatur" October 17, 2016 deadline is not applicable. See excerpt below:

257.100(e)(4)(ii): No later than April 17, 2018, prepare the initial inflow design flood control system plan as set forth in § 257.82(c).

This Plan has been prepared within the specified timeframe.

ii. New CCR surface impoundments and any lateral expansion of a CCR surface impoundment. The owner or operator must prepare the initial inflow design flood control system plan no later than the date of initial receipt of CCR in the CCR unit.

Not Applicable – Cell 002 West is an existing inactive CCR impoundment.

§257.82(c)(4): Frequency for revising the plan. The owner or operator must prepare periodic inflow design flood control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first periodic plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed an inflow design flood control system plan when the plan has been placed in the facility's operating record as required by § 257.105(g)(4).

This IDF Plan or any subsequent IDF Plan will be assessed and amended whenever there is a change in operation of the CCR impoundment that would substantially affect the IDF Plan or when unanticipated events necessitate a revision of the Plan either before or after closure activities have commenced.

§257.82(c)(5): The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic inflow design flood control system plans meet the requirements of this section.

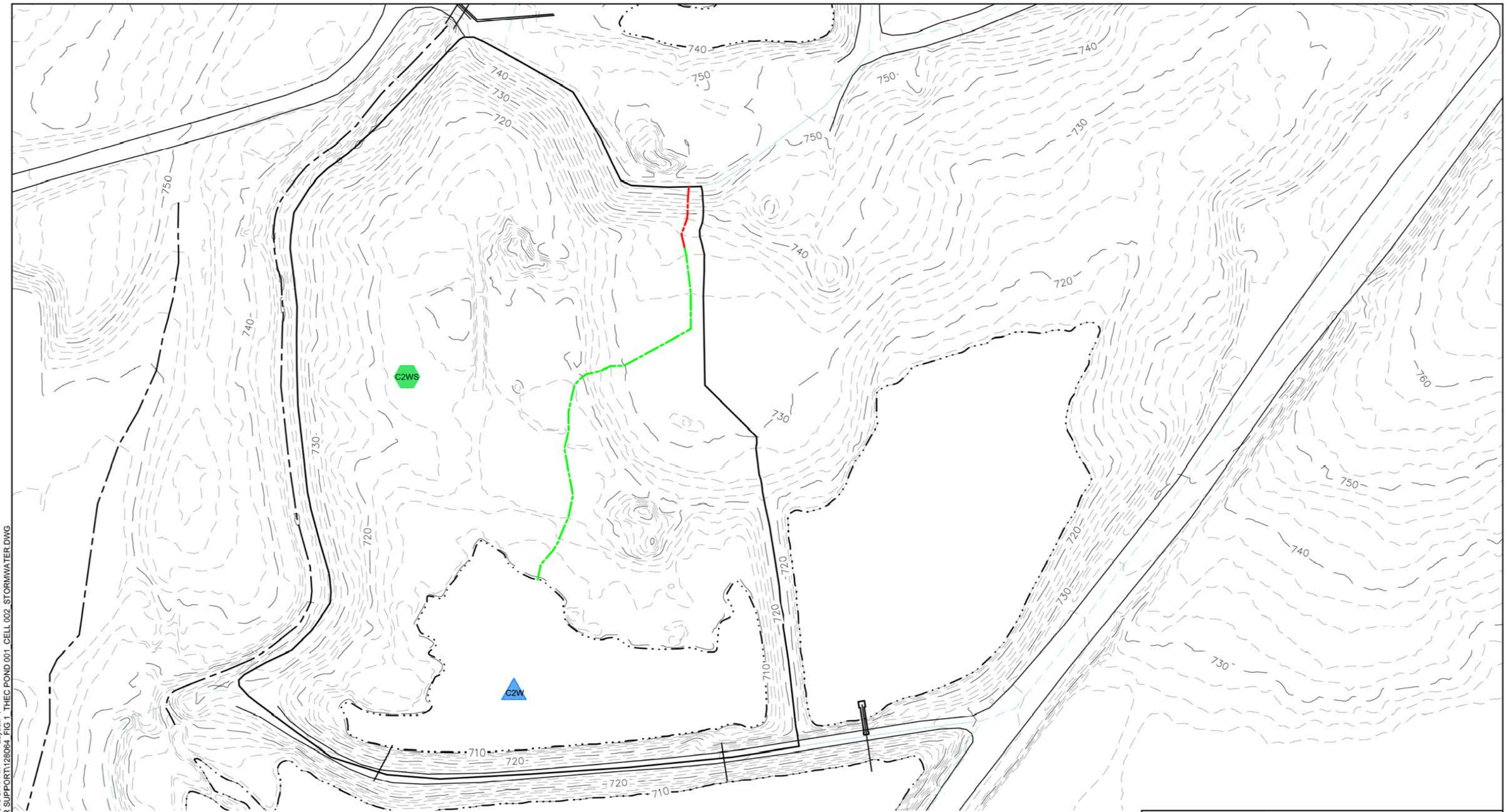
I certify that the design of the flood control system referenced in this Inflow Design Flood Control System Plan for AECI's Pond 001 - Cell 002 West at the Thomas Hill Energy Center meets the USEPA's CCR Rule requirements of §257.82.

Signed: _____
Certifying Engineer

Print Name: Steven F. Putrich
Missouri License No.: 2014035813
Title: Project Principal
Company: Haley & Aldrich, Inc.

Professional Engineer's Seal and date:

HALEY ALDRICH



LEGEND

- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- HYDROCAD SHEET FLOW
- HYDROCAD SHALLOW CONCENTRATED FLOW
- HYDROCAD WATERSHED BOUNDARY
- C2WS — HYDROCAD SUBCATCHMENT
- C2W — HYDROCAD POND

NOTES

1. AERIAL SURVEY USED TO DEVELOP TOPOGRAPHY WAS PERFORMED BY PICTOMETRY INTERNATIONAL CORP. OF ROCHESTER, NEW YORK BETWEEN 29 FEBRUARY 2016 AND 11 APRIL 2016.

N

0 150 300
SCALE IN FEET

HALEY ALDRICH

AECI, THOMAS HILL ENERGY CENTER
CLIFTON HILL, MISSOURI

POND 001 - CELL 002 WEST INFLOW FLOOD CONTROL PLAN EXISTING CONDITIONS DRAINAGE

SCALE: AS SHOWN
APRIL 2018

FIGURE 1

LUCAS, ANDY Printed: 4/9/2018 3:41 PM Layout: 1
M:\WORKING\128064-AECI THEC CCR SUPPORT\128064_FIG 1_THEC POND 001_CELL 002_STORMWATER.DWG

Appendix A
Outlet Control Structures Details

NOTES:

1. EXISTING CONTOURS SHOWN WERE SURVEYED BY MARK ROBERTSON, PLS ON OCTOBER 4, 2013 & FEBRUARY 13, 2015. EXCLUDING THE CELL 2 SEPARATION BERM GRADING WHICH IS SHOWN AS EXISTING FOR PROPOSED GRADING TIE IN.
2. PROPOSED CONTOURS REPRESENT TOP OF SOIL.
3. CELL 2 - CELL 3 DAM NORTH SLOPE VARIES AND DOES NOT EXCEED 3:1.

LEGEND

EXISTING CONTOUR ——720——

PROPOSED FINAL GRADE CONTOUR ——710——

ESTIMATED CUT/FILL VOLUMES
CUT - 12,600 CY
FILL - 0 CY
NET - 12,600 CY (CUT)

POND 001
CELL 2
EASTERN BASIN

CELL 2 SEPARATION BERM GRADING

POND 001
CELL 2
WESTERN BASIN

POND 001
CELL 3

0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
11+85.28

FLOWLINE ELEV. 719.0'
FLOWLINE ELEV. 718.0'
FLOWLINE ELEV. 716.5'
FLOWLINE ELEV. 716.5'

EMERGENCY OUTLET 56 LF - 15" ADS HP PIPE

15'x6' RIP-RAP EROSION PROTECTION BLANKET

PROPOSED TOP OF CELL 2 - CELL 3 DAM CENTERLINE

PRIMARY OUTLET 54 LF - 15" ADS HP PIPE

15'x6' RIP-RAP EROSION PROTECTION BLANKET

EXISTING OUTLET

EXISTING ROAD

VARIES
3:1
25'R

DRAFT
10/1/15

Thomas R. Gredell, P.E.
EN-21137

#	DATE	REVISION DESCRIPTION	BY

CELL 2 - CELL 3 DAM
GRADING PLAN
POND 001 - CELL 2
SEPARATION BERM

PROJECT NAME: AEC/THEC
FILE NAME: SEPARATION BERM
SHEET # 5 OF 7

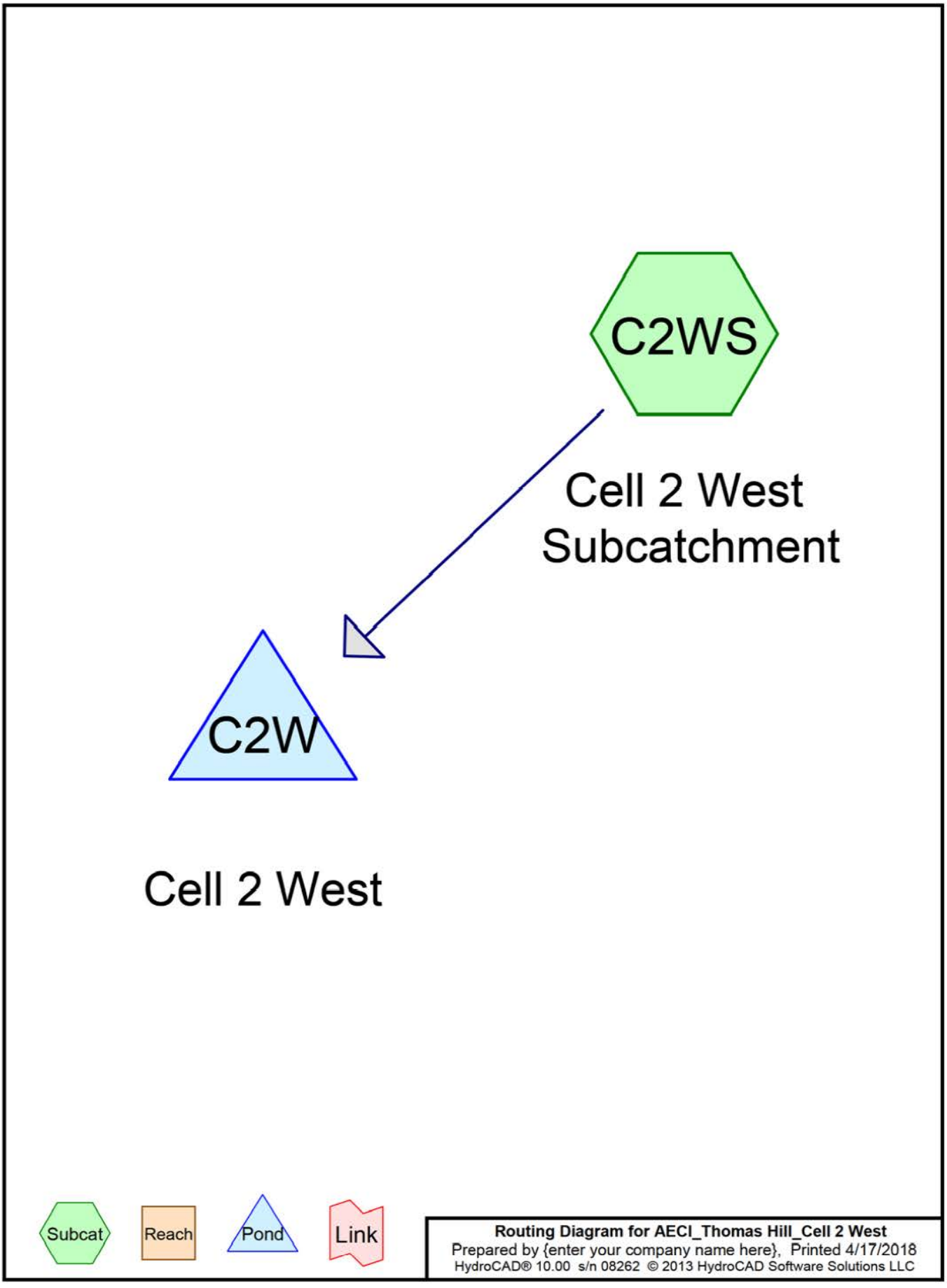
THOMAS HILL ENERGY CENTER
ac
associated electric cooperative, inc.

SURVEYED	DESIGNED	DRAWN	CHECKED	APPROVED	DATE	SCALE
NA	MW	AJK	AR	TRG	10/2015	AS NOTED

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING LAND - AIR - WATER
1505 East High Street
Jefferson City, Missouri
Telephone: (573) 659-9078
Facsimile: (573) 659-9079
MO CORP. ENGINEERING LICENSE NO. E-2001001669-D

M:\Shared\CAD\Files\AEC\THEC\AEC-THEC ASH VOLUME\POND 001 CELL 2 - SEPARATION BERM\SEPARATION BERM.DWG, CELL 2 - CELL 3 DAM GRADING PLAN, 10/1/2015 2:45:34 PM

Appendix B
HydroCAD Simulation Output



Routing Diagram for AECI_Thomas Hill_Cell 2 West
Prepared by {enter your company name here}, Printed 4/17/2018

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
13.845	84	50-75% Grass cover, Fair, HSG D (C2WS)
2.687	98	Water Surface, HSG A (C2WS)
16.532	**86**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
2.687	HSG A	C2WS
0.000	HSG B	
0.000	HSG C	
13.845	HSG D	C2WS
0.000	Other	
16.532		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	13.845	0.000	13.845	50-75% Grass cover, Fair	C2WS
2.687	0.000	0.000	0.000	0.000	2.687	Water Surface	C2WS
2.687	**0.000**	**0.000**	**13.845**	**0.000**	**16.532**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	C2W	718.00	716.50	100.0	0.0150	0.025	15.0	0.0	0.0

Time span=0.00-144.00 hrs, dt=0.01 hrs, 14401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment C2WS: Cell 2 West Runoff Area=720,134 sf 16.25% Impervious Runoff Depth=6.25"
Flow Length=2,301' Tc=12.7 min CN=86 Runoff=137.51 cfs 8.616 af

Pond C2W: Cell 2 West Peak Elev=718.80' Storage=2,132,222 cf Inflow=137.51 cfs 8.616 af
15.0" Round Culvert n=0.025 L=100.0' S=0.0150 '/' Outflow=1.85 cfs 6.867 af

Total Runoff Area = 16.532 ac Runoff Volume = 8.616 af Average Runoff Depth = 6.25"
83.75% Pervious = 13.845 ac 16.25% Impervious = 2.687 ac

Summary for Subcatchment C2WS: Cell 2 West Subcatchment

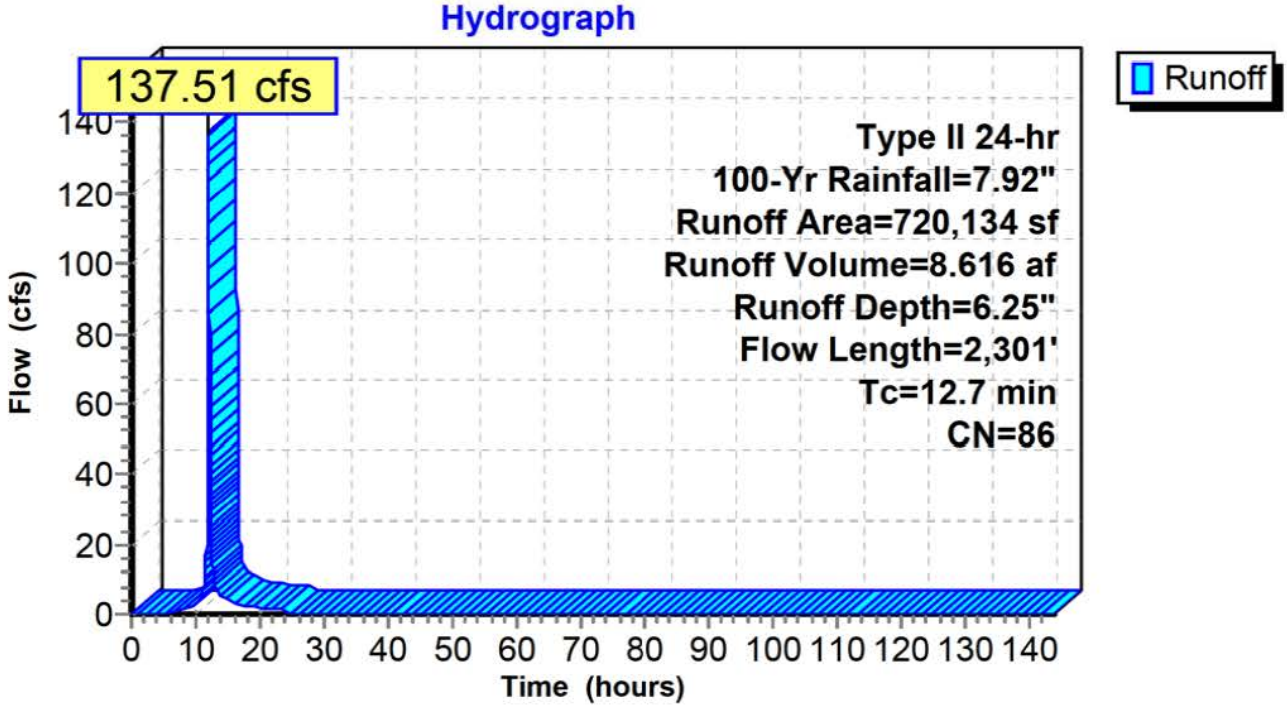
Runoff = 137.51 cfs @ 12.04 hrs, Volume= 8.616 af, Depth= 6.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-144.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-Yr Rainfall=7.92"

Area (sf)	CN	Description
117,048	98	Water Surface, HSG A
603,086	84	50-75% Grass cover, Fair, HSG D
720,134	86	Weighted Average
603,086		83.75% Pervious Area
117,048		16.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	100	0.2830	0.44		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.56"
1.8	158	0.0424	1.44		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
7.1	2,043	0.0020	4.80	240.05	**Channel Flow,** Area= 50.0 sf Perim= 20.6' r= 2.43' n= 0.025 Earth, clean & winding
12.7	2,301	Total			

Subcatchment C2WS: Cell 2 West Subcatchment



Summary for Pond C2W: Cell 2 West

Primary and secondary outlets per Gerdell Engineering Resources, Inc. Figure 1 (9/2015). Length estimated per Google Earth Pro.

Inflow Area = 16.532 ac, 16.25% Impervious, Inflow Depth = 6.25" for 100-Yr event
Inflow = 137.51 cfs @ 12.04 hrs, Volume= 8.616 af
Outflow = 1.85 cfs @ 19.60 hrs, Volume= 6.867 af, Atten= 99%, Lag= 453.8 min
Primary = 1.85 cfs @ 19.60 hrs, Volume= 6.867 af

Routing by Sim-Route method, Time Span= 0.00-144.00 hrs, dt= 0.01 hrs
Starting Elev= 718.00' Surf.Area= 366,107 sf Storage= 1,828,767 cf
Peak Elev= 718.80' @ 19.60 hrs Surf.Area= 393,181 sf Storage= 2,132,222 cf (303,456 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 2,138.8 min (2,929.8 - 791.1)

Volume	Invert	Avail.Storage	Storage Description
#1	709.00'	2,628,834 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

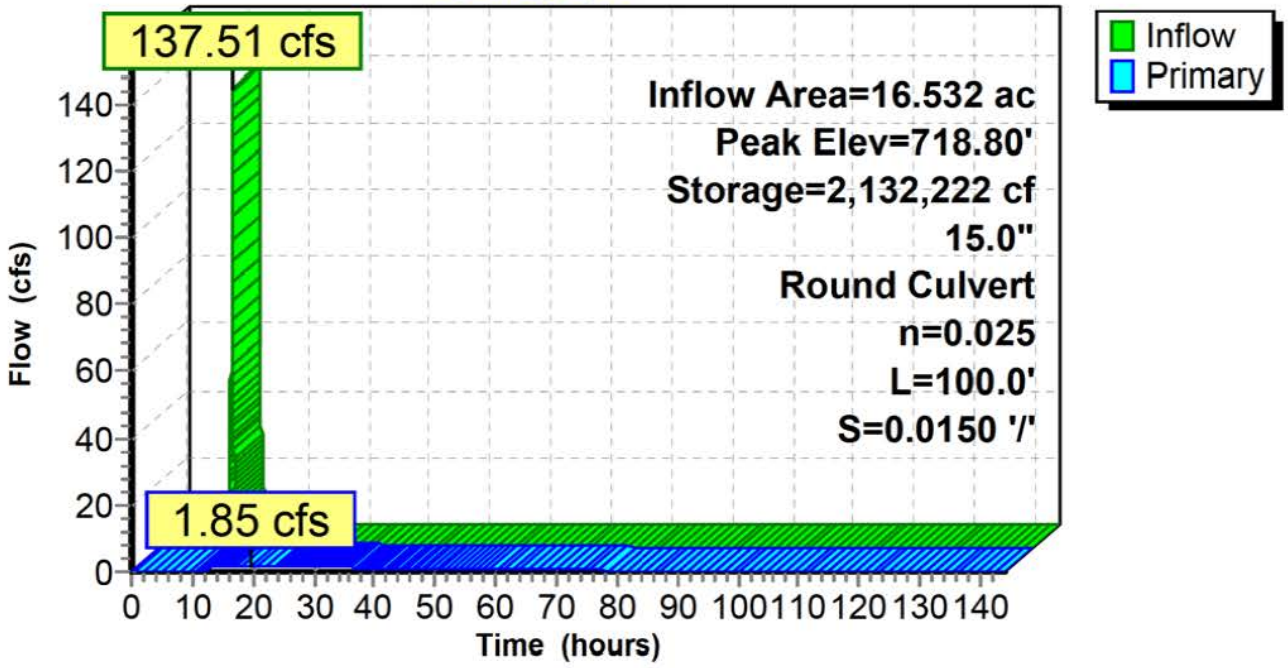
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
709.00	117,048	0	0
710.00	122,755	119,902	119,902
711.00	137,155	129,955	249,857
712.00	164,173	150,664	400,521
713.00	189,474	176,824	577,344
714.00	205,932	197,703	775,047
715.00	218,644	212,288	987,335
716.00	260,367	239,506	1,226,841
717.00	288,689	274,528	1,501,369
718.00	366,107	327,398	1,828,767
719.00	399,978	383,043	2,211,809
720.00	434,072	417,025	2,628,834

Device	Routing	Invert	Outlet Devices
#1	Primary	718.00'	**15.0" Round Culvert** L= 100.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 718.00' / 716.50' S= 0.0150 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 1.23 sf

Primary OutFlow Max=1.85 cfs @ 19.60 hrs HW=718.80' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 1.85 cfs @ 3.18 fps)

Pond C2W: Cell 2 West

Hydrograph



Appendix C
NOAA Rainfall Data

General Info
Homepage
Current Projects
FAQ
Glossary

Precipitation Frequency (PF)
PF Data Server
- PF in GIS Format
- PF Maps
- Temporal Distr.
- Time Series Data
- PFDS Perform.

PF Documents

Probable Maximum Precipitation (PMP)
PMP Documents

Miscellaneous
Publications
AEP Storm Analysis
Record Precipitation

Contact Us
Inquiries
List-server

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: MO

DATA DESCRIPTION

Data type: precipitation depth | Units: english | Time series type: partial duration

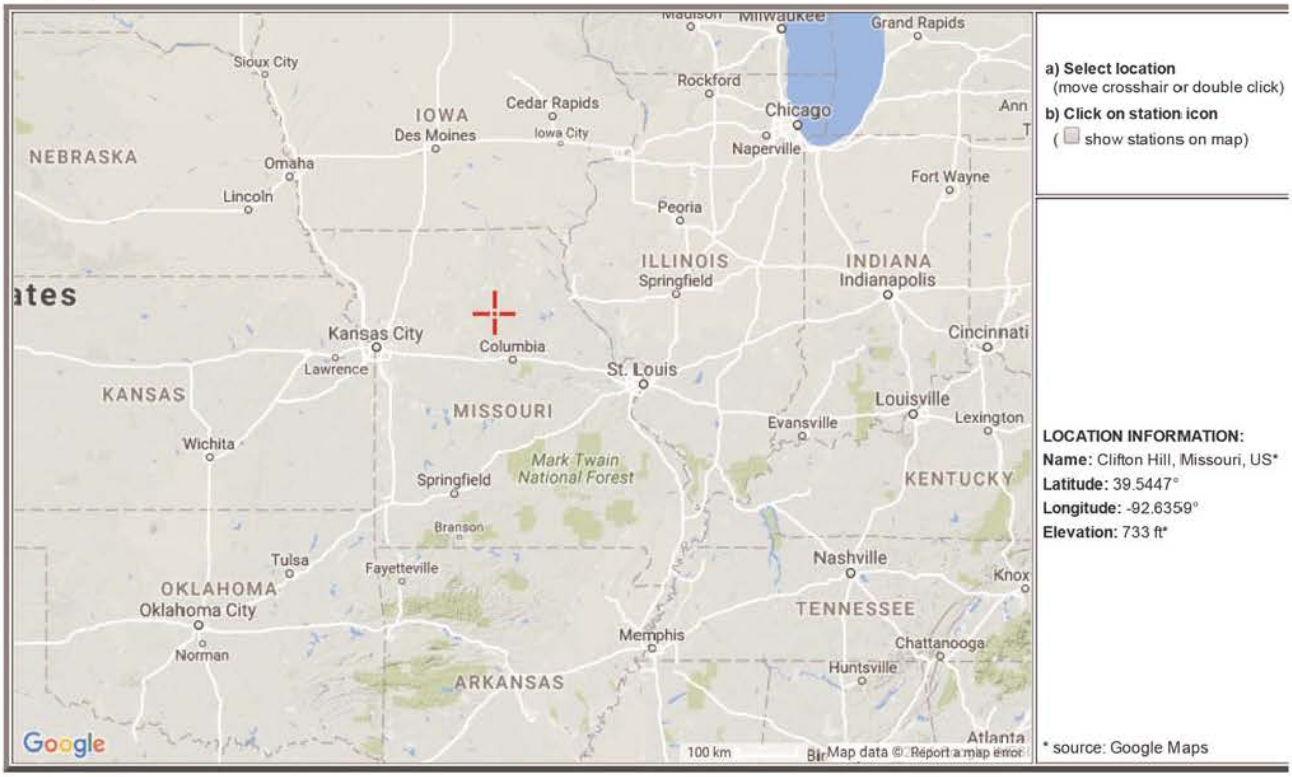
SELECT LOCATION

1. Manually:

a) Enter location (decimal degrees, use "-" for S and W): latitude: 39.544661 longitude: -92.635891 submit

b) Select station (click here for a list of stations used in frequency analysis for MO): select station

2. Use map:



a) Select location
(move crosshair or double click)
b) Click on station icon
(show stations on map)

LOCATION INFORMATION:
Name: Clifton Hill, Missouri, US*
Latitude: 39.5447°
Longitude: -92.6359°
Elevation: 733 ft*

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 8, Version 2

PF tabular | PF graphical | Supplementary information | Print Page

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.405 (0.328-0.498)	0.468 (0.378-0.576)	0.570 (0.459-0.703)	0.654 (0.524-0.810)	0.769 (0.594-0.975)	0.857 (0.647-1.10)	0.944 (0.688-1.24)	1.03 (0.721-1.39)	1.15 (0.770-1.58)	1.23 (0.808-1.72)
10-min	0.593 (0.480-0.729)	0.685 (0.554-0.843)	0.834 (0.673-1.03)	0.958 (0.767-1.19)	1.13 (0.870-1.43)	1.25 (0.947-1.61)	1.38 (1.01-1.81)	1.51 (1.05-2.03)	1.68 (1.13-2.31)	1.80 (1.18-2.52)
15-min	0.723 (0.585-0.890)	0.835 (0.676-1.03)	1.02 (0.820-1.26)	1.17 (0.936-1.45)	1.37 (1.06-1.74)	1.53 (1.16-1.96)	1.69 (1.23-2.21)	1.84 (1.29-2.47)	2.05 (1.38-2.81)	2.20 (1.44-3.08)
30-min	1.02 (0.827-1.26)	1.19 (0.965-1.47)	1.47 (1.19-1.81)	1.70 (1.36-2.10)	2.00 (1.54-2.53)	2.23 (1.68-2.86)	2.45 (1.79-3.21)	2.68 (1.87-3.59)	2.97 (1.99-4.08)	3.18 (2.08-4.44)
60-min	1.29 (1.05-1.59)	1.54 (1.25-1.90)	1.96 (1.58-2.41)	2.30 (1.84-2.85)	2.79 (2.16-3.56)	3.17 (2.40-4.09)	3.56 (2.60-4.68)	3.96 (2.77-5.33)	4.49 (3.02-6.20)	4.91 (3.21-6.85)
2-hr	1.57 (1.28-1.92)	1.89 (1.54-2.31)	2.44 (1.98-2.99)	2.91 (2.35-3.58)	3.58 (2.79-4.55)	4.11 (3.13-5.28)	4.66 (3.43-6.11)	5.24 (3.69-7.02)	6.02 (4.08-8.26)	6.63 (4.38-9.20)
3-hr	1.73 (1.41-2.10)	2.10 (1.72-2.56)	2.75 (2.24-3.36)	3.31 (2.68-4.06)	4.14 (3.25-5.26)	4.81 (3.68-6.17)	5.51 (4.08-7.21)	6.25 (4.43-8.37)	7.28 (4.96-9.97)	8.09 (5.36-11.2)
6-hr	2.06 (1.70-2.49)	2.50 (2.06-3.03)	3.27 (2.68-3.97)	3.96 (3.22-4.82)	4.97 (3.95-6.31)	5.81 (4.49-7.43)	6.71 (5.00-8.74)	7.66 (5.48-10.2)	9.00 (6.19-12.3)	10.1 (6.72-13.8)

12-hr	2.49 (2.06-2.99)	2.95 (2.44-3.55)	3.77 (3.11-4.54)	4.50 (3.69-5.44)	5.57 (4.45-7.01)	6.46 (5.03-8.20)	7.41 (5.57-9.59)	8.42 (6.06-11.1)	9.83 (6.81-13.3)	11.0 (7.38-14.9)
24-hr	2.95 (2.46-3.52)	3.42 (2.85-4.08)	4.24 (3.52-5.08)	4.97 (4.11-5.98)	6.06 (4.88-7.57)	6.97 (5.46-8.77)	7.92 (6.00-10.2)	8.95 (6.50-11.8)	10.4 (7.25-13.9)	11.5 (7.82-15.6)
2-day	3.38 (2.84-4.01)	3.88 (3.25-4.61)	4.76 (3.98-5.66)	5.54 (4.61-6.62)	6.70 (5.43-8.30)	7.66 (6.05-9.58)	8.68 (6.61-11.1)	9.77 (7.14-12.7)	11.3 (7.94-15.0)	12.5 (8.54-16.8)
3-day	3.67 (3.10-4.34)	4.22 (3.56-4.99)	5.17 (4.34-6.13)	6.02 (5.02-7.16)	7.26 (5.89-8.94)	8.28 (6.55-10.3)	9.35 (7.15-11.9)	10.5 (7.70-13.6)	12.1 (8.54-16.0)	13.4 (9.17-17.9)
4-day	3.94 (3.33-4.64)	4.52 (3.81-5.33)	5.52 (4.65-6.53)	6.41 (5.37-7.61)	7.72 (6.28-9.47)	8.79 (6.97-10.9)	9.91 (7.60-12.5)	11.1 (8.17-14.4)	12.8 (9.04-16.9)	14.1 (9.70-18.8)
7-day	4.64 (3.94-5.44)	5.28 (4.48-6.19)	6.38 (5.40-7.50)	7.37 (6.20-8.69)	8.80 (7.21-10.7)	9.98 (7.97-12.3)	11.2 (8.66-14.1)	12.5 (9.29-16.1)	14.4 (10.2-18.9)	15.9 (11.0-21.0)
10-day	5.28 (4.50-6.16)	5.97 (5.09-6.98)	7.17 (6.09-8.40)	8.23 (6.95-9.68)	9.79 (8.04-11.9)	11.1 (8.86-13.6)	12.4 (9.60-15.5)	13.8 (10.3-17.7)	15.8 (11.3-20.7)	17.4 (12.1-22.9)
20-day	7.11 (6.10-8.24)	8.02 (6.88-9.31)	9.57 (8.18-11.1)	10.9 (9.27-12.7)	12.8 (10.6-15.4)	14.3 (11.6-17.4)	15.9 (12.4-19.7)	17.6 (13.1-22.3)	19.8 (14.3-25.7)	21.6 (15.1-28.3)
30-day	8.64 (7.45-9.98)	9.78 (8.42-11.3)	11.7 (10.0-13.5)	13.2 (11.3-15.4)	15.5 (12.8-18.4)	17.2 (13.9-20.7)	18.9 (14.8-23.3)	20.8 (15.6-26.1)	23.2 (16.7-29.9)	25.1 (17.6-32.7)
45-day	10.6 (9.17-12.2)	12.0 (10.4-13.8)	14.3 (12.4-16.5)	16.2 (13.9-18.8)	18.8 (15.6-22.3)	20.8 (16.9-24.9)	22.8 (17.8-27.9)	24.8 (18.6-30.9)	27.3 (19.8-35.0)	29.3 (20.7-38.0)
60-day	12.3 (10.6-14.1)	14.0 (12.1-16.0)	16.6 (14.4-19.2)	18.8 (16.2-21.7)	21.7 (18.0-25.6)	23.9 (19.4-28.5)	26.1 (20.4-31.7)	28.1 (21.2-35.0)	30.8 (22.4-39.2)	32.8 (23.2-42.5)

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

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

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in csv format: precipitation frequency estimates ▾ Submit

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