SCS ENGINEERS

CCR Surface Impoundment Hydrologic and Hydraulic Capacity Evaluation

Indianapolis Power & Light Company

Harding Street Generating Station

Prepared for:

Indianapolis Power & Light Company

ipl an AES company

Harding Street Station
3700 South Harding Street
Indianapolis, Indiana 46221

Prepared by:

SCS ENGINEERS
2830 Dairy Drive
Madison, Wisconsin 53718-6751
(608) 224-2830

October 13, 2016
File No. 25216140

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Prepared for:

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1.0 INTRODUCTION

SCS Engineers (SCS) performed hydrologic and hydraulic capacity evaluations of the CCR (coal combustion residuals) surface impoundments at the Indianapolis Power & Light Company (IPL) Harding Street Generating Station (HS) in Indianapolis, Indiana. These analyses were performed in accordance with the Federal Register CFR 257.82, "Hydraulic and hydraulic capacity requirements for CCR surface impoundments". **Figure 1** shows the location of the HS. CFR 257.82 is included in **Appendix A**. The layout of the CCR surface impoundments at the HS is shown in **Figure 2**.

There are three CCR surface impoundments at the HS, Ponds 1, 2A/2B, and 3. Pond 1 is full of CCR up to the bottom of the outlet. A berm between Ponds 2A and 2B has been removed to create one pond, Pond 2A/2B. The HS generating station has been converted to a gas powered generating station and no CCR is currently discharged to the CCR surface impoundments. Pumps located in basement sumps within the generating station, pump water to Pond 1, when needed.

IP&L is in the process of developing plans to permanently close the CCR surface impoundments.

2.0 HYDROLOGIC AND HYDRAULIC ANALYSIS

A hydraulic analysis was performed in accordance with the "General Guidelines for New Dams and Improvements to Existing Dams in Indiana", published by the Indiana Department of Natural Resources, Division of Water, January 1, 2001. The hydraulic analysis was performed using HydroCAD storm water modeling software.

According to the General Guidelines, if the time of concentration (Tc) is less than 6 hours, the 6-hour probable maximum precipitation (PMP) should be used to analyze the spillway system. The ponds at the HS are contained within the containment berms, and the Tc for each pond is less than 6 hours. A Type B design storm was used in the HydroCAD model.

The hydraulic analysis evaluates the hydraulic capacity of the CCR impoundment outlet and ensures that the outlet is capable of safely passing the runoff from the design storm event without embankment overtopping and failing. The design storm event is determined by the hazardous classification of the impoundment.

According to IPL personnel, Pond 2A/2B is in the Low Significant Hazard classification and Ponds 1 and 3 are in the Significant Hazard Classification. According to CFR 257.82(3 (ii)), for a low hazard potential CCR impoundment, the inflow design flood is the 100-year storm event and for a significant hazard potential CCR surface impoundment, the inflow design flood is the 1,000-year storm event.

Because CCR surface impoundments Ponds 2 and 4 are out of service, they will not be evaluated in this analysis. Runoff from Ponds 2 drains to Pond 2A/2B and runoff from Pond 4 drains to Pond 3, therefore, Ponds 2 and 4 are included in the evaluation of Pond 2A/2B and Pond 3.

According to the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation Frequency Estimate (**Appendix B**), for the Indianapolis Indiana area, the 6-hour, 100-year storm event is 4.83 inches of precipitation, the 6-hour, 1,000-year storm event is 7.04 inches of precipitation.

Results

The input parameters and output of the HydroCAD model are included in **Appendix C**. The results of the hydraulic analysis are summarized below:

100 –year Storm Event

Pond	Berm Elevation	Maximum Water Height	Freeboard (ft)
2A/2B	685	682.45	2.55

1,000 –year Storm Event

Pond	Berm Elevation	Maximum Water Height	Freeboard (ft)
1	685	683.52	1.48
3	684	680.29	3.71

Ponds 2A/2B, 1, and 3 can safely pass the storm event and maintain a minimum of 1.0 foot of freeboard between the water surface and the top of the berm.

3.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

PROFESSIONAL ENGINEER CERTIFICATION

"I, David Hendron, hereby certify that I am a licensed professional engineer in the State of Indiana in accordance with the requirements of Indiana Administrative Code Title 864; and that, to the best of my knowledge, all information contained in this document is correct."

Signature ______________________

Title and PE Number Senior Engineer PE10000050

Date 13 October 2016

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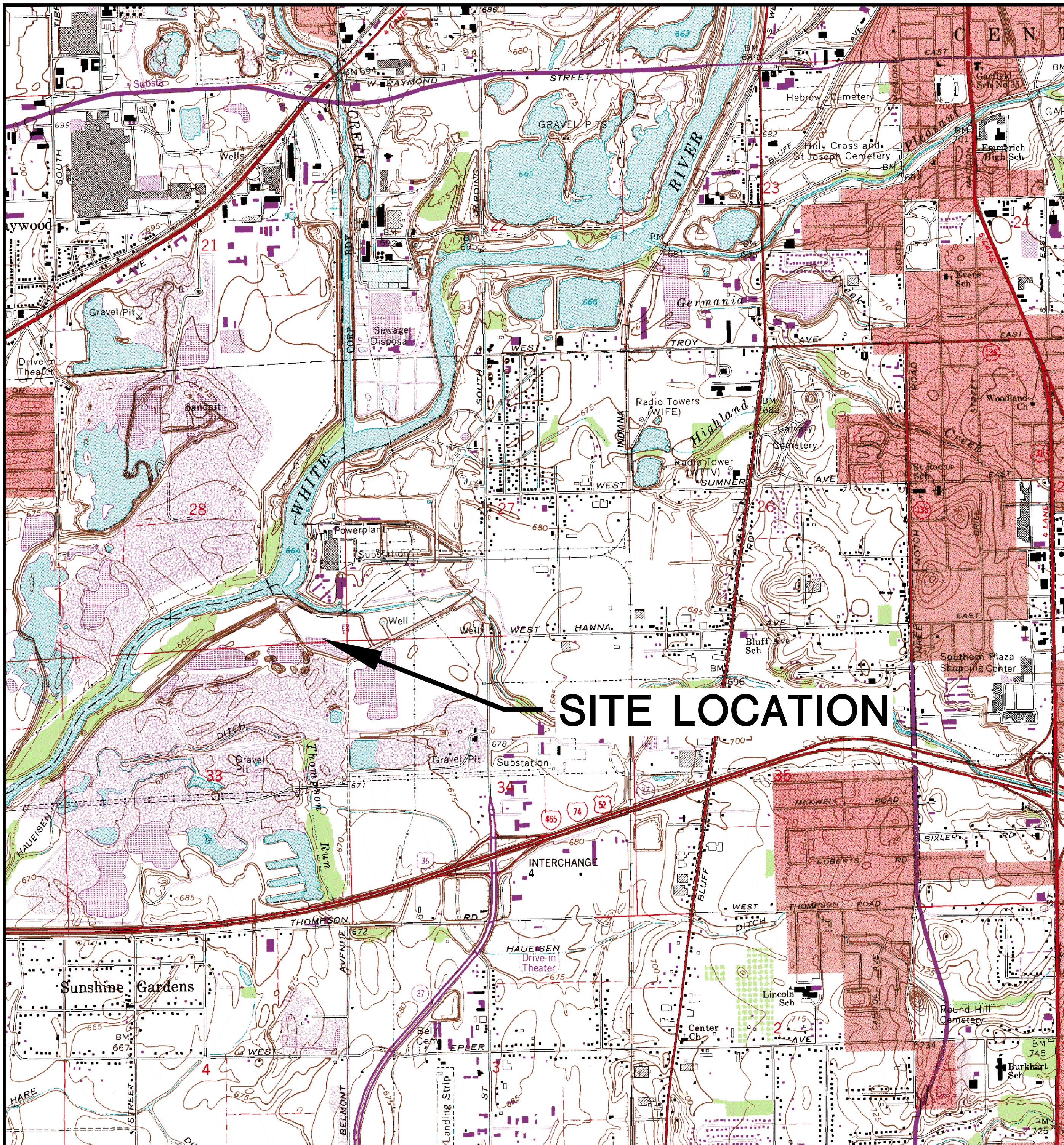
FIGURES



N

MAYWOOD QUADRANGLE
INDIANA – MARION CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
1986
SCALE: 1" = 2,000'

QUADRANGLE LOCATION

CLIENT	INDIANAPOLIS POWER & LIGHT COMPANY	SITE	HARDING STREET GENERATING STATION 3700 SOUTH HARDING STREET INDIANAPOLIS, INDIANA	SITE LOCATION MAP

PROJECT NO.	25216140	DRAWN BY:	KG	ENGINEER: SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718-6751 PHONE (608) 224-2830	FIGURE
DRAWN:	01/27/12	CHECKED BY:	DH		1
REVISED:	09/29/16	APPROVED BY:			

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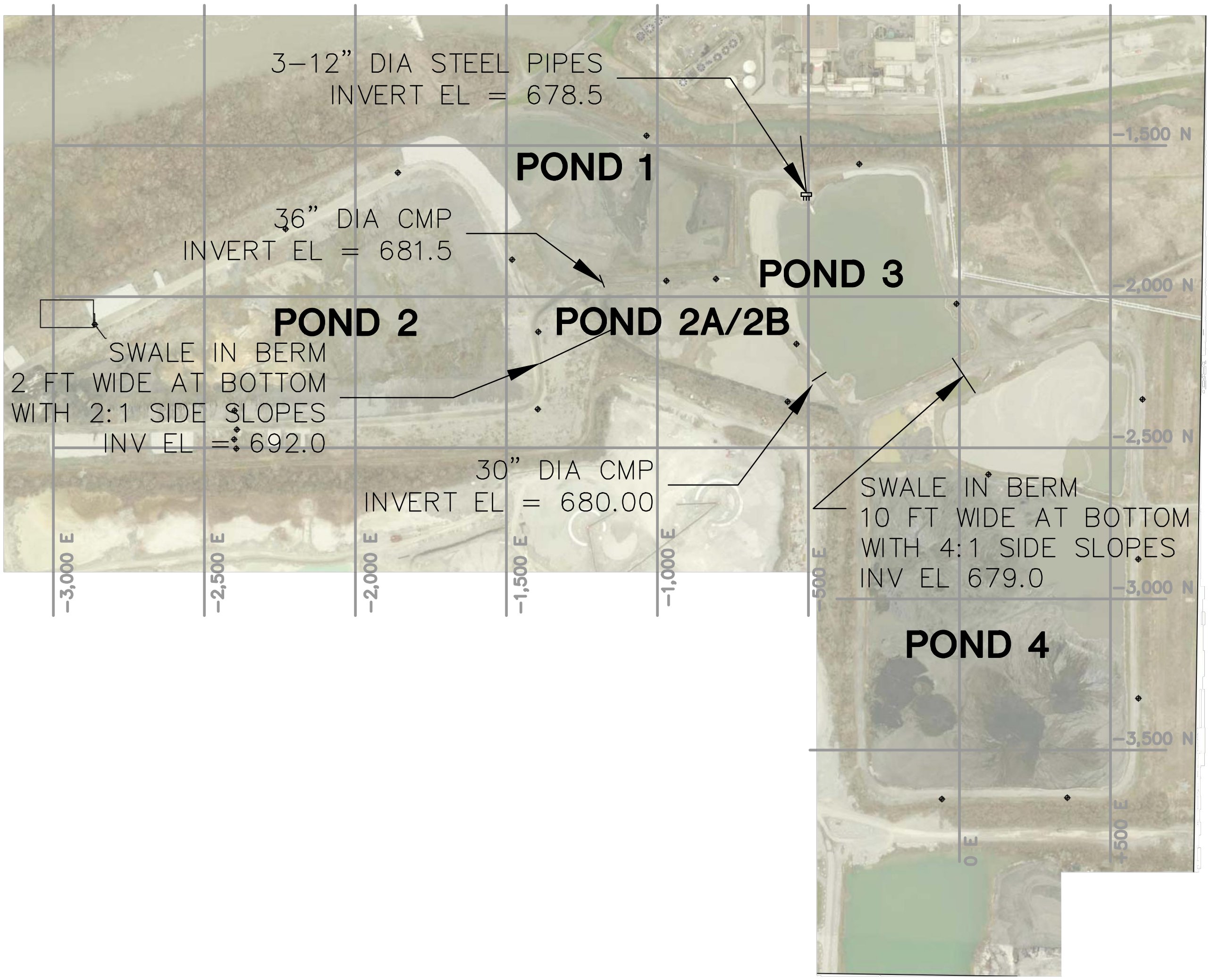

NOTES:

1. BORING LOCATIONS ARE BASED ON DRAWINGS PROVIDED BY IPL.
2. ON-SITE COORDINATE SYSTEM DEVELOPED FROM IPL DRAWING "HARDING STREET ASH PONDS – PIEZOMETER_TEST BORE LOCATIONS" DATED DEC. 6, 2011.

N

600 0 600

SCALE: 1" = 600'

CLIENT	INDIANAPOLIS POWER & LIGHT COMPANY	SITE	HARDING STREET GENERATING STATION 3700 SOUTH HARDING STREET INDIANAPOLIS, INDIANA	CCR SURFACE IMPOUNDMENT HYDRAULIC STRUCTURES AND INFORMATION MAP

PROJECT NO.	25216140	DRAWN BY:	KG/KP	ENGINEER	SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718-6751 PHONE: (608) 224-2830	FIGURE
DRAWN:	09/08/16	CHECKED BY:				2
REVISED:		APPROVED BY:				

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APPENDIX A

Federal Register 40 CFR 257.82

follow to periodically assess the effectiveness of the control plan.

(5) The owner or operator of a CCR unit must prepare an initial CCR fugitive dust control plan for the facility no later than October 19, 2015, or by initial receipt of CCR in any CCR unit at the facility if the owner or operator becomes subject to this subpart after October 19, 2015. The owner or operator has completed the initial CCR fugitive dust control plan when the plan has been placed in the facility's operating record as required by § 257.105(g)(1).

(6) *Amendment of the plan.* The owner or operator of a CCR unit subject to the requirements of this section may amend the written CCR fugitive dust control plan at any time provided the revised plan is placed in the facility's operating record as required by § 257.105(g)(1). The owner or operator must amend the written plan whenever there is a change in conditions that would substantially affect the written plan in effect, such as the construction and operation of a new CCR unit.

(7) The owner or operator must obtain a certification from a qualified professional engineer that the initial CCR fugitive dust control plan, or any subsequent amendment of it, meets the requirements of this section.

(c) *Annual CCR fugitive dust control report.* The owner or operator of a CCR unit must prepare an annual CCR fugitive dust control report that includes a description of the actions taken by the owner or operator to control CCR fugitive dust, a record of all citizen complaints, and a summary of any corrective measures taken. The initial annual report must be completed no later than 14 months after placing the initial CCR fugitive dust control plan in the facility's operating record. The deadline for completing a subsequent report is one year after the date of completing the previous report. For purposes of this paragraph (c), the owner or operator has completed the annual CCR fugitive dust control report when the plan has been placed in the facility's operating record as required by § 257.105(g)(2).

(d) The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in § 257.105(g), the notification requirements specified in § 257.106(g), and the internet requirements specified in § 257.107(g).

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

(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain:

(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and

(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

(b) Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under § 257.3–3.

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

(2) *Amendment of the plan.* The owner or operator may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility's operating record as required by § 257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.

(3) *Timeframes for preparing the initial plan*—(i) *Existing CCR landfills.* The owner or operator of the CCR unit must prepare the initial run-on and run-off control system plan no later than October 17, 2016.

(ii) *New CCR landfills and any lateral expansion of a CCR landfill.* The owner or operator must prepare the initial run-on and run-off control system plan no later than the date of initial receipt of CCR in the CCR unit.

(4) *Frequency for revising the plan.* The owner or operator of the CCR unit must prepare periodic run-on and run-off 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 subsequent 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 a periodic run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by § 257.105(g)(3).

(5) The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic run-on and run-off control system plans meet the requirements of this section.

(d) The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in § 257.105(g), the notification requirements specified in § 257.106(g), and the internet requirements specified in § 257.107(g).

§ 257.82 Hydrologic and hydraulic capacity requirements for CCR surface impoundments.

(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 (2) of this section.

(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.

(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.

(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.

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

(c) *Inflow design flood control system plan*—(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).

(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.

(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.

(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.

(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).

(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.

(d) The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in § 257.105(g), the notification requirements specified in § 257.106(g), and the internet requirements specified in § 257.107(g).

§ 257.83 Inspection requirements for CCR surface impoundments.

(a) *Inspections by a qualified person.* (1) All CCR surface impoundments and any lateral expansion of a CCR surface impoundment must be examined by a qualified person as follows:

(i) At intervals not exceeding seven days, inspect for any appearances of actual or potential structural weakness and other conditions which are disrupting or have the potential to disrupt the operation or safety of the CCR unit;

(ii) At intervals not exceeding seven days, inspect the discharge of all outlets of hydraulic structures which pass underneath the base of the surface impoundment or through the dike of the CCR unit for abnormal discoloration, flow or discharge of debris or sediment; and

(iii) At intervals not exceeding 30 days, monitor all CCR unit instrumentation.

(iv) The results of the inspection by a qualified person must be recorded in the facility's operating record as required by § 257.105(g)(5).

(2) *Timeframes for inspections by a qualified person*—(i) *Existing CCR surface impoundments.* The owner or operator of the CCR unit must initiate the inspections required under paragraph (a) of this section no later than October 19, 2015.

(ii) *New CCR surface impoundments and any lateral expansion of a CCR surface impoundment.* The owner or operator of the CCR unit must initiate the inspections required under paragraph (a) of this section upon initial receipt of CCR by the CCR unit.

(b) Annual i*nspections by a qualified professional engineer.* (1) If the existing or new CCR surface impoundment or any lateral expansion of the CCR surface impoundment is subject to the periodic structural stability assessment requirements under § 257.73(d) or § 257.74(d), the CCR unit must additionally be inspected on a periodic basis by a qualified professional engineer to ensure that the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering standards. The inspection must, at a minimum, include:

(i) A review of available information regarding the status and condition of the CCR unit, including, but not limited to, files available in the operating record (*e.g.*, CCR unit design and construction information required by §§ 257.73(c)(1) and 257.74(c)(1), previous periodic structural stability assessments required under §§ 257.73(d) and 257.74(d), the results of inspections by a qualified person, and results of previous annual inspections);

(ii) A visual inspection of the CCR unit to identify signs of distress or malfunction of the CCR unit and appurtenant structures; and

(iii) A visual inspection of any hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit for structural integrity and continued safe and reliable operation.

(2) *Inspection report.* The qualified professional engineer must prepare a report following each inspection that addresses the following:

(i) Any changes in geometry of the impounding structure since the previous annual inspection;

(ii) The location and type of existing instrumentation and the maximum recorded readings of each instrument since the previous annual inspection;

(iii) The approximate minimum, maximum, and present depth and elevation of the impounded water and CCR since the previous annual inspection;

(iv) The storage capacity of the impounding structure at the time of the inspection;

(v) The approximate volume of the impounded water and CCR at the time of the inspection;

(vi) Any appearances of an actual or potential structural weakness of the CCR unit, in addition to any existing conditions that are disrupting or have the potential to disrupt the operation and safety of the CCR unit and appurtenant structures; and

(vii) Any other change(s) which may have affected the stability or operation of the impounding structure since the previous annual inspection.

(3) *Timeframes for conducting the initial inspection*—(i) *Existing CCR surface impoundments.* The owner or operator of the CCR unit must complete the initial inspection required by paragraphs (b)(1) and (2) of this section no later than January 18, 2016.

(ii) *New CCR surface impoundments and any lateral expansion of a CCR surface impoundment.* The owner or operator of the CCR unit must complete the initial annual inspection required by paragraphs (b)(1) and (2) of this section is completed no later than 14 months

APPENDIX B

Precipitation Estimate

www.nws.noaa.gov

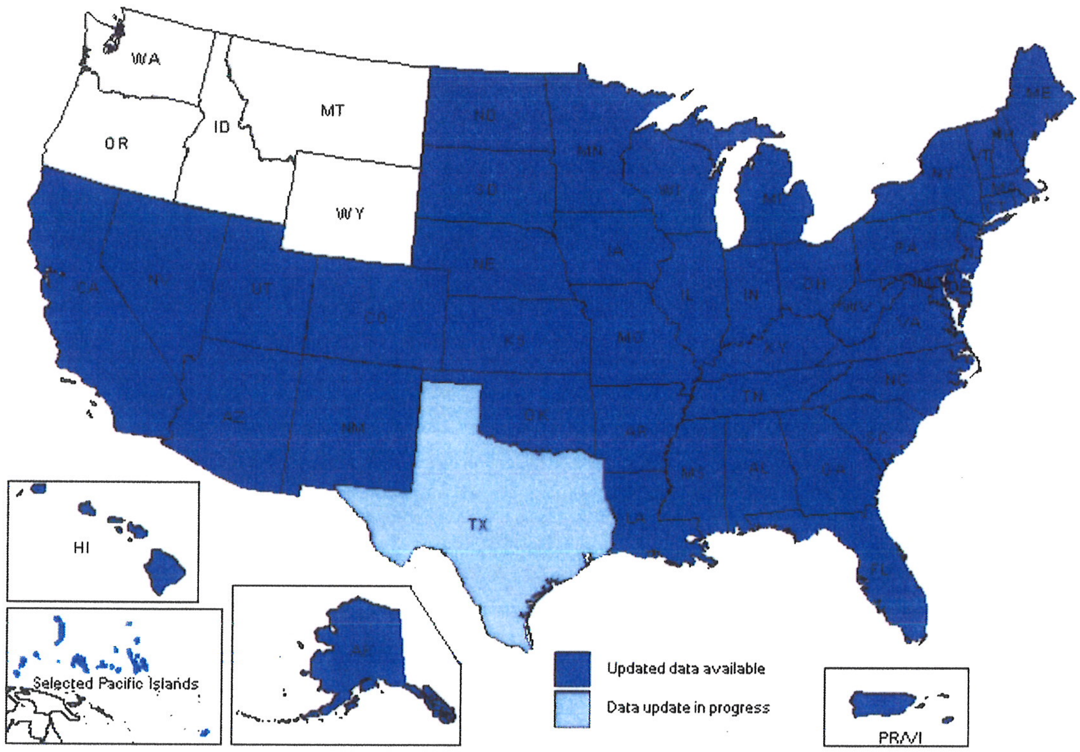
NOAA's National Weather Service

Hydrometeorological Design Studies Center

Precipitation Frequency Data Server (PFDS)

USA.gov

State: Choose a state (or click map) | Load



Precipitation Frequency Data Server (PFDS)

The Precipitation Frequency Data Server (PFDS) is a point-and-click interface developed to deliver NOAA Atlas 14 precipitation frequency estimates and associated information. Upon clicking a state on the map above or selecting a state name from the drop-down menu, an interactive map of that state will be displayed. From there, a user can identify a location for which precipitation frequency estimates are needed.

Estimates and their confidence intervals can be displayed directly as tables or graphs via separate tabs. Links to supplementary information (such as ASCII grids of estimates, associated temporal distributions of heavy rainfall, time series data at observation sites, cartographic maps, etc.) can also be found.

NOAA Atlas 14 documents provide additional information on the underlying data and functioning of the PFDS.

PFDS is compatible with all modern web browsers. However, some browsers offer a smoother experience than others. We recommend Chrome, Firefox, Internet Explorer 10+, and Safari.

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Water Prediction (OWP)
1325 East West Highway
Silver Spring, MD 20910
Page Author: HDSC webmaster

NOAA Atlas 14, Volume 2, Version 3
Location name: Indianapolis, Indiana, USA*
Latitude: 39.7067°, Longitude: -86.1957°
Elevation: 679.83 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.381 (0.343-0.425)	0.453 (0.408-0.506)	0.542 (0.487-0.605)	0.613 (0.549-0.682)	0.703 (0.625-0.784)	0.775 (0.683-0.866)	0.844 (0.738-0.945)	0.917 (0.793-1.03)	1.01 (0.863-1.15)	1.09 (0.911-1.24)
10-min	0.592 (0.532-0.661)	0.708 (0.637-0.789)	0.843 (0.757-0.939)	0.946 (0.847-1.05)	1.08 (0.956-1.20)	1.18 (1.04-1.31)	1.27 (1.11-1.42)	1.37 (1.18-1.54)	1.49 (1.27-1.69)	1.58 (1.33-1.80)
15-min	0.725 (0.652-0.810)	0.865 (0.780-0.965)	1.04 (0.930-1.15)	1.16 (1.04-1.30)	1.33 (1.18-1.48)	1.45 (1.28-1.62)	1.58 (1.38-1.77)	1.70 (1.47-1.91)	1.86 (1.58-2.10)	1.98 (1.66-2.25)
30-min	0.960 (0.863-1.07)	1.16 (1.04-1.29)	1.42 (1.27-1.58)	1.62 (1.45-1.80)	1.88 (1.67-2.09)	2.08 (1.83-2.32)	2.28 (1.99-2.55)	2.48 (2.15-2.79)	2.76 (2.35-3.12)	2.96 (2.49-3.38)
60-min	1.17 (1.05-1.31)	1.42 (1.28-1.59)	1.78 (1.60-1.98)	2.06 (1.84-2.29)	2.43 (2.16-2.71)	2.74 (2.42-3.06)	3.05 (2.66-3.41)	3.37 (2.92-3.79)	3.81 (3.24-4.31)	4.16 (3.49-4.74)
2-hr	1.38 (1.24-1.54)	1.66 (1.50-1.86)	2.09 (1.88-2.33)	2.43 (2.17-2.70)	2.91 (2.58-3.23)	3.30 (2.90-3.67)	3.71 (3.22-4.13)	4.15 (3.55-4.62)	4.76 (3.99-5.34)	5.25 (4.33-5.94)
3-hr	1.46 (1.31-1.63)	1.76 (1.59-1.97)	2.22 (2.00-2.48)	2.59 (2.32-2.88)	3.11 (2.76-3.46)	3.55 (3.12-3.94)	4.01 (3.48-4.47)	4.50 (3.84-5.03)	5.19 (4.34-5.86)	5.76 (4.72-6.55)
6-hr	1.73 (1.57-1.93)	2.09 (1.89-2.33)	2.64 (2.38-2.94)	3.08 (2.77-3.42)	3.72 (3.31-4.12)	4.26 (3.74-4.72)	4.83 (4.19-5.36)	5.44 (4.64-6.06)	6.33 (5.26-7.09)	7.04 (5.73-7.96)
12-hr	2.06 (1.87-2.28)	2.48 (2.26-2.75)	3.08 (2.80-3.41)	3.57 (3.23-3.94)	4.25 (3.81-4.69)	4.82 (4.27-5.31)	5.41 (4.74-5.97)	6.02 (5.20-6.69)	6.90 (5.83-7.72)	7.59 (6.30-8.55)
24-hr	2.44 (2.28-2.62)	2.92 (2.73-3.14)	3.58 (3.33-3.84)	4.08 (3.80-4.38)	4.76 (4.42-5.11)	5.30 (4.91-5.69)	5.84 (5.39-6.27)	6.39 (5.87-6.85)	7.12 (6.50-7.80)	7.68 (6.98-8.64)
2-day	2.84 (2.66-3.04)	3.40 (3.18-3.64)	4.14 (3.87-4.43)	4.71 (4.39-5.03)	5.47 (5.09-5.84)	6.07 (5.63-6.47)	6.66 (6.16-7.12)	7.27 (6.69-7.77)	8.07 (7.39-8.63)	8.68 (7.91-9.30)
3-day	3.04 (2.85-3.24)	3.63 (3.40-3.87)	4.39 (4.12-4.68)	4.98 (4.66-5.31)	5.77 (5.40-6.15)	6.39 (5.96-6.80)	7.02 (6.52-7.47)	7.64 (7.07-8.14)	8.47 (7.80-9.03)	9.11 (8.35-9.72)
4-day	3.23 (3.04-3.44)	3.85 (3.63-4.10)	4.64 (4.37-4.94)	5.25 (4.94-5.58)	6.08 (5.70-6.45)	6.72 (6.29-7.13)	7.37 (6.88-7.82)	8.01 (7.45-8.51)	8.87 (8.21-9.43)	9.53 (8.79-10.1)
7-day	3.82 (3.59-4.07)	4.54 (4.26-4.84)	5.45 (5.11-5.80)	6.17 (5.78-6.56)	7.14 (6.67-7.58)	7.91 (7.37-8.39)	8.69 (8.07-9.22)	9.47 (8.78-10.1)	10.5 (9.72-11.2)	11.4 (10.4-12.1)
10-day	4.36 (4.10-4.65)	5.17 (4.87-5.52)	6.19 (5.83-6.60)	6.99 (6.57-7.45)	8.07 (7.56-8.59)	8.92 (8.34-9.49)	9.77 (9.12-10.4)	10.6 (9.90-11.3)	11.8 (10.9-12.6)	12.7 (11.7-13.6)
20-day	5.96 (5.63-6.33)	7.05 (6.65-7.49)	8.31 (7.84-8.82)	9.29 (8.75-9.86)	10.6 (9.95-11.2)	11.6 (10.9-12.3)	12.6 (11.8-13.3)	13.6 (12.7-14.4)	14.9 (13.8-15.8)	15.8 (14.7-16.8)
30-day	7.34 (6.93-7.77)	8.64 (8.16-9.15)	10.1 (9.48-10.6)	11.1 (10.5-11.8)	12.6 (11.8-13.3)	13.6 (12.8-14.4)	14.7 (13.8-15.6)	15.7 (14.7-16.7)	17.1 (15.9-18.1)	18.1 (16.7-19.2)
45-day	9.28 (8.79-9.81)	10.9 (10.3-11.5)	12.6 (11.9-13.3)	13.8 (13.1-14.6)	15.5 (14.6-16.3)	16.7 (15.7-17.6)	17.9 (16.8-18.8)	19.0 (17.8-20.0)	20.4 (19.1-21.6)	21.4 (20.0-22.7)
60-day	11.1 (10.5-11.7)	13.0 (12.3-13.8)	14.9 (14.1-15.8)	16.4 (15.5-17.3)	18.2 (17.2-19.2)	19.6 (18.5-20.7)	21.0 (19.7-22.1)	22.2 (20.9-23.5)	23.9 (22.3-25.2)	25.0 (23.4-26.5)

[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.

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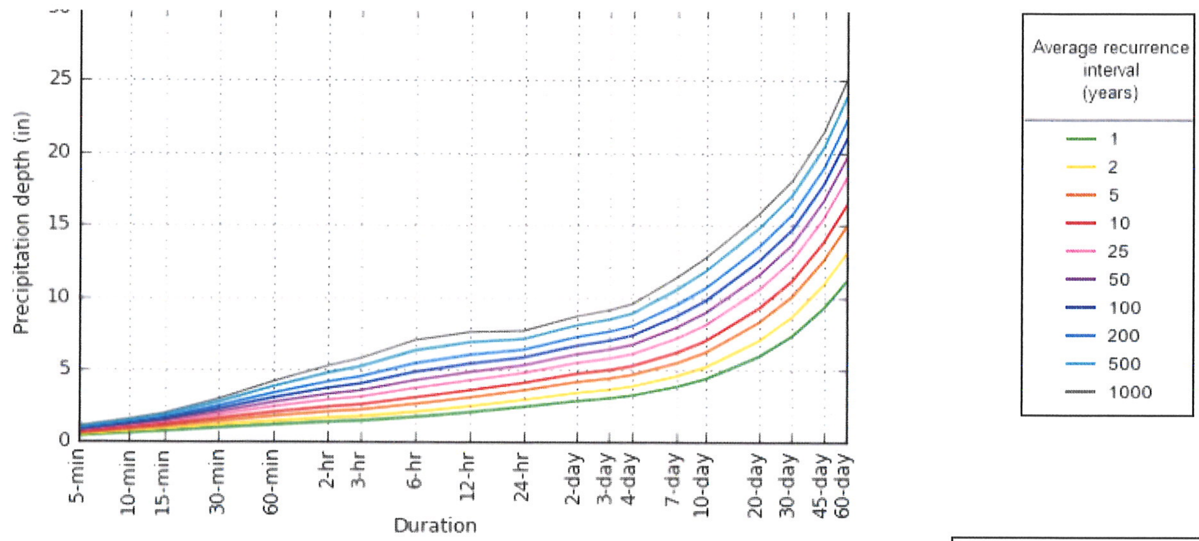
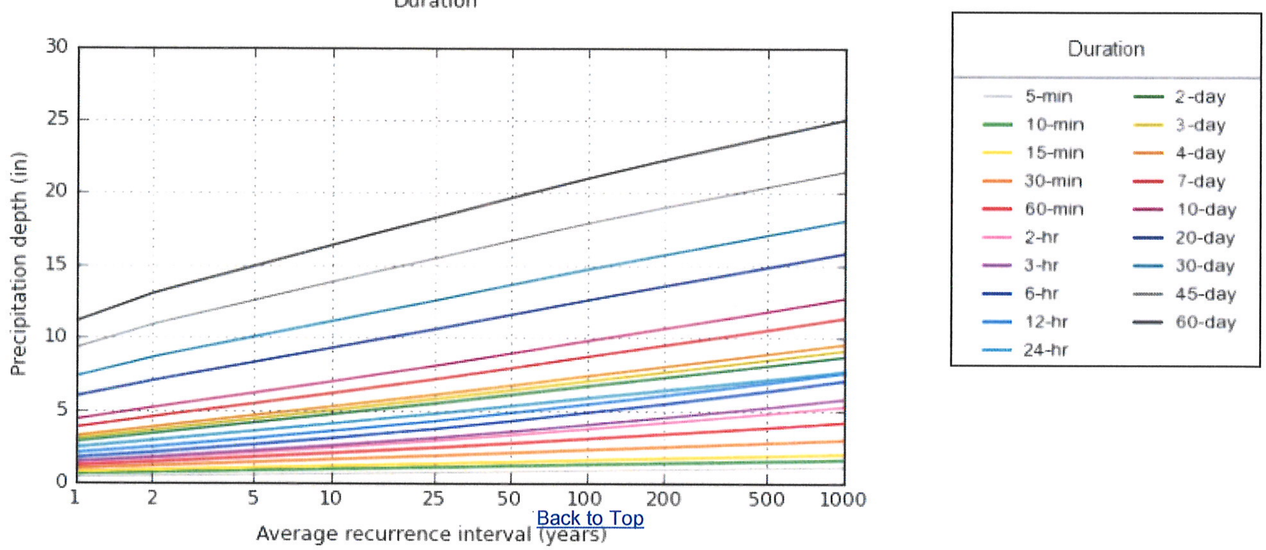
PF graphical





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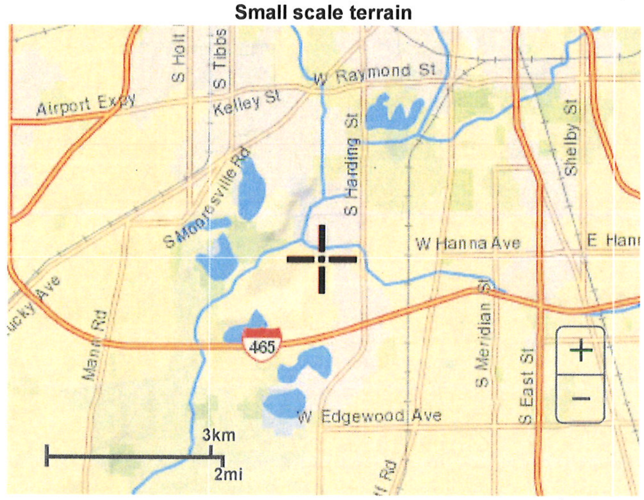
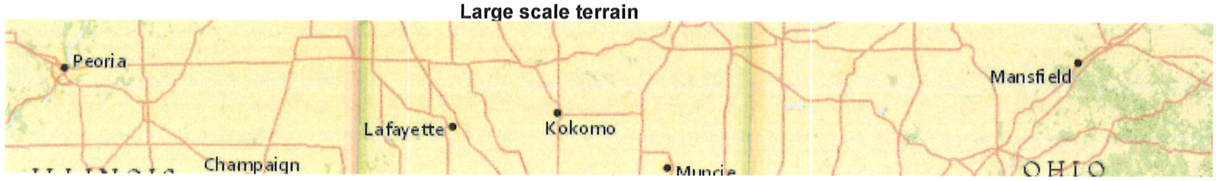
NOAA Atlas 14, Volume 2, Version 3 Created (GMT): Wed Sep 28 16:20:47 2016

Maps & aerials

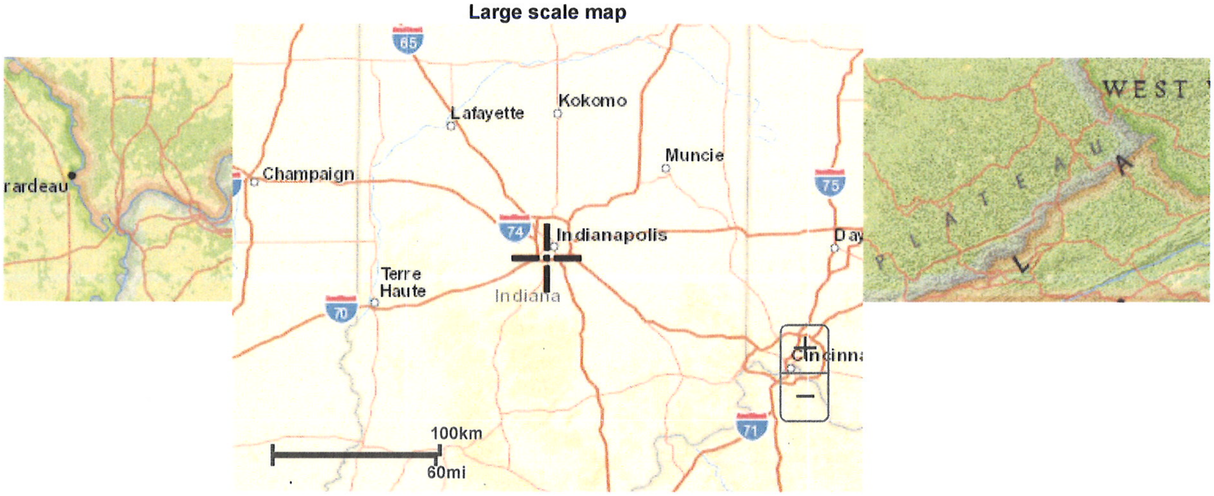
Small scale terrain



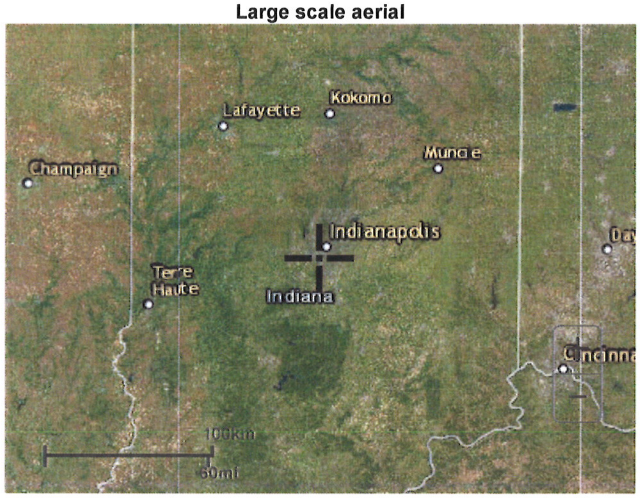
Large scale terrain



Large scale map



Large scale aerial



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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
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Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX C

HydroCAD Model Analysis

Purpose

Determine if the CCR ponds at IP&L Harding Street Generating Station can adequately manage flow into and out of the ponds during the design storm event, specified by 40 CFR 257.82.

Approach

Determine the storage capacity of each basin. Use HydroCAD to generate the runoff hydrograph, route the hydrograph through the ponds and outlet structures and determine the maximum water elevation and outflow from each pond. HydroCAD uses the TR-20 methodologies to generate the hydrograph. The ponds are shown in Figure 2.

Assumptions

* The Harding Street Generating Station has been converted to burning natural gas. No CCR is sent to the CCR ponds. There is a small amount of rain water that is pumped to Pond 1 from sumps within the station.

* The berms around the CCR ponds are all above the surrounding topography and there is no run-on into the CCR ponds.

* Ponds 2 and 4 are out of service. Runoff from Pond 2 drains to Pond 2A/2B and runoff from Pond 4 drains to Pond 3, therefore Ponds 2 and 4 are included in the hydraulic analysis.

* The elevation of the crest of the berm around each pond is below. Crest elevations based on survey information provided by IP&L.

Pond	Crest Elevation
1	685
2	714
2A/2B	685
3	684
4	683

* The berm separating Ponds 2A and 2B has been partially removed and this is now one pond, Pond 2A/2B.

* The berms separating ponds 4, 4A and 4B have been removed and now this is one pond, Pond 4.

* Ponds 1 and 4 have been filled with CCR to the bottom of the outlet structure. The CCR slopes to the outlet at a slope of approximately 0.25%.

* Pond 2 has been filled with CCR to the bottom of the outlet structure. The CCR slopes to the outlet at a slope of approximately 0.3%

* According to IP&L personnel, Pond 2A/2B is classified as a low hazard potential, Ponds 1 and 3 are significant hazard potential, and Ponds 2 and 4 are high hazard potential.

* Structures classified as high hazard are required to contain the probable maximum flood (PMP) without overtopping. Structures classified as significant hazards are required to contain the 1,000-yr storm event without overtopping. Structures classified as low hazards are required to contain the 100-yr storm event without overtopping.

* According to the General Guidelines for New Dams and Improvements to Existing Dams in Indiana 2001, for a time of concentration (Tc) less than 6 hours, the 6-hour storm event is used. All of the ponds at Harding Street Station have a Tc less than 6 hours.

* According to NOAA Atlas 14, the 1,000 year storm event for Indianapolis, Indiana = 7.04 inches of precipitation for the 6-hr storm.

SCS ENGINEERS

Sheet No. 2			
Calc. No.			
Rev. No.			
Job No. 25216140.00	Job IP&L - Harding Street Station	By KRG	Date 9/27/16
Client IP&L	Subject CCR Impoundment Hydraulic Study	Chk'd BP	Date 10/12/16

* According to NOAA Atlas 14, the 100 year storm event for Indianapolis, Indiana = 4.83 inches of precipitation for the 6-hr storm.

* There is an area near the station where stormwater is collected and pumped to the CCR ponds. According to IP&L personnel, this flow is assumed to be a constant flow of 44 gpm (0.1 cfs) into Pond 1.

* The General Guidelines for New Dams and Improvements to Existing Dams in Indiana, 2001, call for a Type B storm event.

* **Outlets** Information from IP&L survey information and 8/23/16 SCS Engineers site visit

Pond 1	Pond 1 discharges to Pond 2A/2B via a 36" dia. CMP culvert at EL 681.5
Pond 2	Pond 2 discharges to Pond 2A/2B via a swale cut in the berm with a 2 foot wide bottom at elevation 692.0 and 2:1 side slopes. This swale leads from the outlet of Pond 2 to Pond 2A/2B.
Pond 2A/2B	Pond 2B discharges to Pond 3 via a 30" dia. CMP culvert at EL = 680.0
Pond 4	Pond 4 discharges to Pond 3 via swale excavated in the berm that is 10 ft wide at the bottom at EL = 679.0 and 4:1 side slopes.
Pond 3	Pond 3 discharges to a concrete structure via a 5-foot long rectangular weir at elevation 678.5. The outlet of the concrete structure is three 12" diameter corrugated metal pipes that lead to the White River.

The area of contours for each pond was determined using AutoCAD to trace the outline of each pond and determine the area of the contours within the pond.

Pond 1

Elevation	Area (ac)
685	7.3
683	1.0
681	0.1

Pond 2

Elevation	Area (ac)
714	20.6
710	19.4
705	18.0
697	15.7
696	14.5
695	12.0
694	8.5
693	4.2
692	0.0

Pond 2A/2B

Elevation	Area (ac)
685	3.9
683	3.6
681	3.2
679	2.9

Pond 3

Elevation	Area (ac)
684	8.8
680	8.1
676	7.4
672	6.8

Pond 4

Elevation	Area (ac)
683	28.2
682	24.0
681	15.8
680	7.8
679	0.1

Results from HydroCAD (100-yr Storm Event)

Pond	Water Elevation in Pond	Pond Freeboard (ft)	Pond Discharge Rate (cfs)
Pond 2A/2B	682.45	2.55	15.6

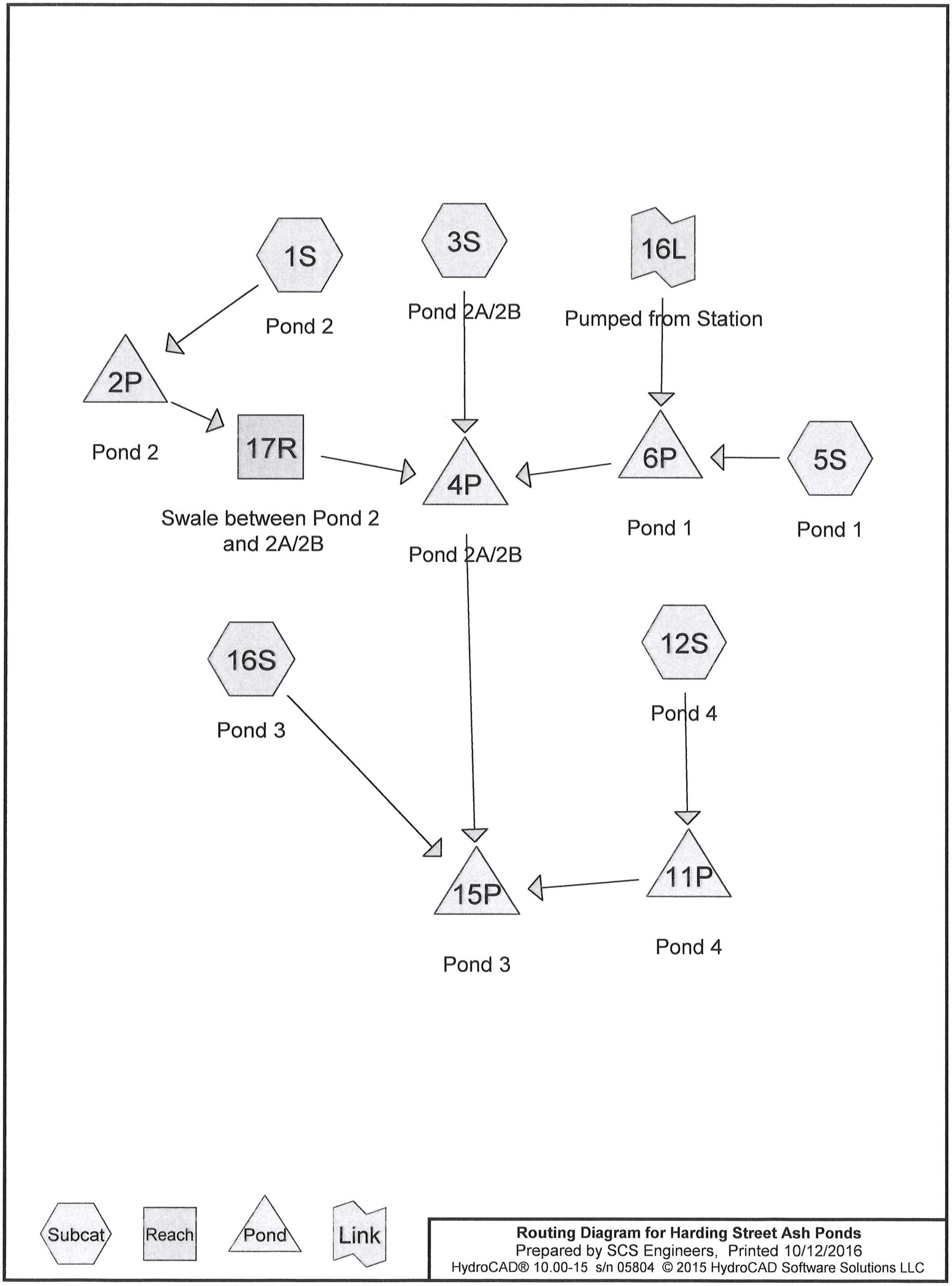
Results from HydroCAD (1,000-yr Storm Event)

Pond	Water Elevation in Pond	Pond Freeboard (ft)	Pond Discharge Rate (cfs)
Pond 1	683.52	1.48	12.5
Pond 3	680.29	3.71	25.0

A freeboard amount of 1.0 foot or greater is considered adequate to prevent overtopping of the pond.
From Part 650 Engineering Field Handbook by USDA Natural Resources Conservation Service (NRCS), Chapter 11 - Ponds and Reservoirs.

Therefore, all of the ponds at Harding Street Station have adequate freeboard for the design storm event.

Harding Street Station – Ash Ponds
Routing Diagram for HydroCAD Model



Routing Diagram for Harding Street Ash Ponds
Prepared by SCS Engineers, Printed 10/12/2016
HydroCAD® 10.00-15 s/n 05804 © 2015 HydroCAD Software Solutions LLC

100-yr Storm Event
Pond 2A/2B Modeling for Low Hazard Structures

Summary for Subcatchment 1S: Pond 2

Runoff = 66.50 cfs @ 2.69 hrs, Volume= 8.291 af, Depth= 4.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 100-yr Rainfall=4.83"

	Area (ac)	CN	Description
*	20.600	100	Ash
	20.600		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	100	0.0030	0.62		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.92"
24.0	1,600	0.0030	1.11		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
26.7	1,700	Total			

Summary for Pond 2P: Pond 2

Inflow Area = 20.600 ac,100.00% Impervious, Inflow Depth = 4.83" for 100-yr event
Inflow = 66.50 cfs @ 2.69 hrs, Volume= 8.291 af
Outflow = 66.50 cfs @ 2.69 hrs, Volume= 8.292 af, Atten= 0%, Lag= 0.0 min
Primary = 66.50 cfs @ 2.69 hrs, Volume= 8.292 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 694.39' @ 2.69 hrs Surf.Area= 9.873 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (187.5 - 187.5)

Volume	Invert	Avail.Storage	Storage Description
#1	692.00'	0.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc) 355.350 af Overall x 0.0% Voids

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
692.00	0.000	0.000	0.000
693.00	4.200	2.100	2.100
694.00	8.500	6.350	8.450
695.00	12.000	10.250	18.700
696.00	14.500	13.250	31.950
697.00	15.700	15.100	47.050
705.00	18.000	134.800	181.850
710.00	19.400	93.500	275.350
714.00	20.600	80.000	355.350

Device	Routing	Invert	Outlet Devices
#1	Primary	692.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.00 4.00 6.00 10.00 22.00 Width (feet) 2.00 10.00 18.00 26.00 42.00 90.00

Primary OutFlow Max=66.44 cfs @ 2.69 hrs HW=694.39' TW=693.10' (Dynamic Tailwater)
↑—**1=Custom Weir/Orifice** (Weir Controls 66.44 cfs @ 4.10 fps)

Summary for Subcatchment 3S: Pond 2A/2B

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 14.76 cfs @ 2.38 hrs, Volume= 1.570 af, Depth= 4.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 100-yr Rainfall=4.83"

	Area (ac)	CN	Description
*	3.900	100	
	3.900		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					**Direct Entry, Pond 2A**

Summary for Pond 4P: Pond 2A/2B

Inflow Area = 31.800 ac,100.00% Impervious, Inflow Depth > 4.86" for 100-yr event
Inflow = 80.16 cfs @ 2.69 hrs, Volume= 12.875 af
Outflow = 15.55 cfs @ 5.04 hrs, Volume= 10.600 af, Atten= 81%, Lag= 140.5 min
Primary = 15.55 cfs @ 5.04 hrs, Volume= 10.600 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Starting Elev= 680.00' Surf.Area= 3.050 ac Storage= 2.975 af
Peak Elev= 682.45' @ 5.04 hrs Surf.Area= 3.490 ac Storage= 10.955 af (7.980 af above start)

Plug-Flow detention time= 442.1 min calculated for 7.625 af (59% of inflow)
Center-of-Mass det. time= 275.3 min (487.9 - 212.6)

Volume	Invert	Avail.Storage	Storage Description
#1	679.00'	20.400 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
679.00	2.900	0.000	0.000
681.00	3.200	6.100	6.100
683.00	3.600	6.800	12.900
685.00	3.900	7.500	20.400

Device	Routing	Invert	Outlet Devices
#1	Primary	680.00'	**30.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 680.00' / 679.80' S= 0.0040 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf

Primary OutFlow Max=15.55 cfs @ 5.04 hrs HW=682.45' TW=679.78' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 15.55 cfs @ 4.02 fps)

Summary for Subcatchment 5S: Pond 1

Runoff = 27.03 cfs @ 2.49 hrs, Volume= 2.938 af, Depth= 4.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 100-yr Rainfall=4.83"

	Area (ac)	CN	Description
*	7.300	100	Ash
	7.300		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.3	100	0.0200	1.31		**Sheet Flow, Ash** Smooth surfaces n= 0.011 P2= 2.92"
9.4	510	0.0020	0.91		**Shallow Concentrated Flow, Ash** Paved Kv= 20.3 fps
10.7	610	Total			

Summary for Pond 6P: Pond 1

Inflow Area = 7.300 ac,100.00% Impervious, Inflow Depth > 5.10" for 100-yr event
Inflow = 27.13 cfs @ 2.49 hrs, Volume= 3.104 af
Outflow = 9.48 cfs @ 2.88 hrs, Volume= 3.014 af, Atten= 65%, Lag= 23.4 min
Primary = 9.48 cfs @ 2.88 hrs, Volume= 3.014 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Starting Elev= 681.50' Surf.Area= 0.325 ac Storage= 0.106 af
Peak Elev= 683.25' @ 2.88 hrs Surf.Area= 1.790 ac Storage= 1.450 af (1.343 af above start)

Plug-Flow detention time= 146.2 min calculated for 2.908 af (94% of inflow)
Center-of-Mass det. time= 110.7 min (306.1 - 195.5)

Volume	Invert	Avail.Storage	Storage Description
#1	681.00'	9.400 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
681.00	0.100	0.000	0.000
683.00	1.000	1.100	1.100
685.00	7.300	8.300	9.400

Device	Routing	Invert	Outlet Devices
#1	Primary	681.50'	**36.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 681.50' / 681.40' S= 0.0020 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 7.07 sf

Primary OutFlow Max=9.48 cfs @ 2.88 hrs HW=683.25' TW=681.75' (Dynamic Tailwater)
└─**1=Culvert** (Barrel Controls 9.48 cfs @ 3.19 fps)

Summary for Pond 11P: Pond 4

Inflow Area = 28.200 ac,100.00% Impervious, Inflow Depth = 4.83" for 100-yr event
Inflow = 93.42 cfs @ 2.66 hrs, Volume= 11.351 af
Outflow = 41.88 cfs @ 3.05 hrs, Volume= 11.346 af, Atten= 55%, Lag= 23.4 min
Primary = 41.88 cfs @ 3.05 hrs, Volume= 11.346 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 679.99' @ 3.09 hrs Surf.Area= 7.724 ac Storage= 3.874 af

Plug-Flow detention time= 135.9 min calculated for 11.346 af (100% of inflow)
Center-of-Mass det. time= 135.8 min (321.0 - 185.2)

Volume	Invert	Avail.Storage	Storage Description
#1	679.00'	61.750 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
679.00	0.100	0.000	0.000
680.00	7.800	3.950	3.950
681.00	15.800	11.800	15.750
682.00	24.000	19.900	35.650
683.00	28.200	26.100	61.750

Device	Routing	Invert	Outlet Devices
#1	Primary	679.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 4.00 Width (feet) 10.00 42.00

Primary OutFlow Max=41.87 cfs @ 3.05 hrs HW=679.99' TW=679.20' (Dynamic Tailwater)
└─**1=Custom Weir/Orifice** (Weir Controls 41.87 cfs @ 3.03 fps)

Summary for Subcatchment 12S: Pond 4

Runoff = 93.42 cfs @ 2.66 hrs, Volume= 11.351 af, Depth= 4.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 100-yr Rainfall=4.83"

	Area (ac)	CN	Description
*	28.200	100	Ash
	28.200		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	100	0.0025	0.57		**Sheet Flow, Ash** Smooth surfaces n= 0.011 P2= 2.92"
21.3	1,300	0.0025	1.02		**Shallow Concentrated Flow, Ash** Paved Kv= 20.3 fps
24.2	1,400	Total			

Summary for Pond 15P: Pond 3

Inflow Area = 68.800 ac,100.00% Impervious, Inflow Depth > 4.45" for 100-yr event
Inflow = 59.95 cfs @ 3.08 hrs, Volume= 25.488 af
Outflow = 23.66 cfs @ 6.02 hrs, Volume= 21.473 af, Atten= 61%, Lag= 177.0 min
Primary = 23.66 cfs @ 6.02 hrs, Volume= 21.473 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Starting Elev= 678.50' Surf.Area= 7.837 ac Storage= 47.447 af
Peak Elev= 679.83' @ 6.02 hrs Surf.Area= 8.070 ac Storage= 57.999 af (10.552 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 215.5 min (583.9 - 368.4)

Volume	Invert	Avail.Storage	Storage Description
#1	672.00'	93.200 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
672.00	6.800	0.000	0.000
676.00	7.400	28.400	28.400
680.00	8.100	31.000	59.400
684.00	8.800	33.800	93.200

Device	Routing	Invert	Outlet Devices
#1	Device 2	678.50'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#2	Primary	673.00'	**12.0" Round Culvert X 3.00** L= 100.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 673.00' / 672.00' S= 0.0100 '/' Cc= 0.900 n= 0.012 Steel, smooth, Flow Area= 0.79 sf

Primary OutFlow Max=23.66 cfs @ 6.02 hrs HW=679.83' (Free Discharge)
↑—**2=Culvert** (Passes 23.66 cfs of 24.18 cfs potential flow)
  ↑—**1=Sharp-Crested Rectangular Weir** (Weir Controls 23.66 cfs @ 3.77 fps)

Summary for Link 16L: Pumped from Station

Inflow	=	0.10 cfs @	0.00 hrs, Volume=	0.165 af	
Primary	=	0.10 cfs @	0.00 hrs, Volume=	0.165 af,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs

Constant Inflow= 0.10 cfs

Summary for Subcatchment 16S: Pond 3

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 33.30 cfs @ 2.38 hrs, Volume= 3.542 af, Depth= 4.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 100-yr Rainfall=4.83"

	Area (ac)	CN	Description
*	8.800	100	
	8.800		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					**Direct Entry, Pond 3**

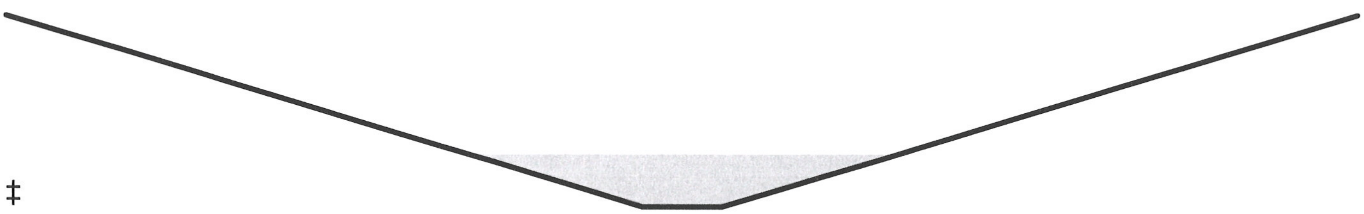
Summary for Reach 17R: Swale between Pond 2 and 2A/2B

Inflow Area = 20.600 ac,100.00% Impervious, Inflow Depth = 4.83" for 100-yr event
Inflow = 66.50 cfs @ 2.69 hrs, Volume= 8.292 af
Outflow = 66.48 cfs @ 2.69 hrs, Volume= 8.292 af, Atten= 0%, Lag= 0.2 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Max. Velocity= 9.37 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 5.32 fps, Avg. Travel Time= 0.6 min

Peak Storage= 1,419 cf @ 2.69 hrs
Average Depth at Peak Storage= 1.10'
Bank-Full Depth= 4.00' Flow Area= 72.0 sf, Capacity= 1,472.08 cfs

2.00' x 4.00' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 4.0 '/' Top Width= 34.00'
Length= 200.0' Slope= 0.0350 '/'
Inlet Invert= 692.00', Outlet Invert= 685.00'



‡

1,000-yr Storm Event
Pond 1 and 3 Modeling for Significant Hazard Structures

Summary for Subcatchment 1S: Pond 2

Runoff = 96.92 cfs @ 2.69 hrs, Volume= 12.085 af, Depth= 7.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 1,000-yr Rainfall=7.04"

	Area (ac)	CN	Description
*	20.600	100	Ash
	20.600		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.7	100	0.0030	0.62		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.92"
24.0	1,600	0.0030	1.11		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
26.7	1,700	Total			

Summary for Pond 2P: Pond 2

Inflow Area = 20.600 ac,100.00% Impervious, Inflow Depth = 7.04" for 1,000-yr event
Inflow = 96.92 cfs @ 2.69 hrs, Volume= 12.085 af
Outflow = 96.92 cfs @ 2.69 hrs, Volume= 12.085 af, Atten= 0%, Lag= 0.0 min
Primary = 96.92 cfs @ 2.69 hrs, Volume= 12.085 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 694.84' @ 2.69 hrs Surf.Area= 11.441 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (187.5 - 187.5)

Volume	Invert	Avail.Storage	Storage Description
#1	692.00'	0.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc) 355.350 af Overall x 0.0% Voids

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
692.00	0.000	0.000	0.000
693.00	4.200	2.100	2.100
694.00	8.500	6.350	8.450
695.00	12.000	10.250	18.700
696.00	14.500	13.250	31.950
697.00	15.700	15.100	47.050
705.00	18.000	134.800	181.850
710.00	19.400	93.500	275.350
714.00	20.600	80.000	355.350

Device	Routing	Invert	Outlet Devices
#1	Primary	692.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.00 4.00 6.00 10.00 22.00 Width (feet) 2.00 10.00 18.00 26.00 42.00 90.00

Primary OutFlow Max=96.84 cfs @ 2.69 hrs HW=694.84' TW=693.30' (Dynamic Tailwater)
↑—**1=Custom Weir/Orifice** (Weir Controls 96.84 cfs @ 4.44 fps)

Summary for Subcatchment 3S: Pond 2A/2B

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 21.51 cfs @ 2.38 hrs, Volume= 2.288 af, Depth= 7.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 1,000-yr Rainfall=7.04"

	Area (ac)	CN	Description
*	3.900	100	
	3.900		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					**Direct Entry, Pond 2A**

Summary for Pond 4P: Pond 2A/2B

Inflow Area = 31.800 ac,100.00% Impervious, Inflow Depth > 7.07" for 1,000-yr event
Inflow = 115.53 cfs @ 2.69 hrs, Volume= 18.724 af
Outflow = 21.39 cfs @ 5.19 hrs, Volume= 16.091 af, Atten= 81%, Lag= 150.1 min
Primary = 21.39 cfs @ 5.19 hrs, Volume= 16.091 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Starting Elev= 680.00' Surf.Area= 3.050 ac Storage= 2.975 af
Peak Elev= 683.29' @ 4.89 hrs Surf.Area= 3.643 ac Storage= 13.933 af (10.958 af above start)

Plug-Flow detention time= 396.1 min calculated for 13.116 af (70% of inflow)
Center-of-Mass det. time= 267.4 min (487.0 - 219.6)

Volume	Invert	Avail.Storage	Storage Description
#1	679.00'	20.400 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
679.00	2.900	0.000	0.000
681.00	3.200	6.100	6.100
683.00	3.600	6.800	12.900
685.00	3.900	7.500	20.400

Device	Routing	Invert	Outlet Devices
#1	Primary	680.00'	**30.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 680.00' / 679.80' S= 0.0040 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf

Primary OutFlow Max=21.39 cfs @ 5.19 hrs HW=683.28' TW=680.21' (Dynamic Tailwater)
└─**1=Culvert** (Barrel Controls 21.39 cfs @ 4.37 fps)

Summary for Subcatchment 5S: Pond 1

Runoff = 39.40 cfs @ 2.49 hrs, Volume= 4.283 af, Depth= 7.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 1,000-yr Rainfall=7.04"

	Area (ac)	CN	Description
*	7.300	100	Ash
	7.300		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.3	100	0.0200	1.31		**Sheet Flow, Ash** Smooth surfaces n= 0.011 P2= 2.92"
9.4	510	0.0020	0.91		**Shallow Concentrated Flow, Ash** Paved Kv= 20.3 fps
10.7	610	Total			

Summary for Pond 6P: Pond 1

Inflow Area = 7.300 ac,100.00% Impervious, Inflow Depth > 7.31" for 1,000-yr event
Inflow = 39.50 cfs @ 2.49 hrs, Volume= 4.448 af
Outflow = 12.46 cfs @ 2.93 hrs, Volume= 4.351 af, Atten= 68%, Lag= 26.5 min
Primary = 12.46 cfs @ 2.93 hrs, Volume= 4.351 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Starting Elev= 681.50' Surf.Area= 0.325 ac Storage= 0.106 af
Peak Elev= 683.52' @ 2.93 hrs Surf.Area= 2.648 ac Storage= 2.054 af (1.948 af above start)

Plug-Flow detention time= 175.2 min calculated for 4.245 af (95% of inflow)
Center-of-Mass det. time= 148.9 min (337.5 - 188.6)

Volume	Invert	Avail.Storage	Storage Description
#1	681.00'	9.400 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
681.00	0.100	0.000	0.000
683.00	1.000	1.100	1.100
685.00	7.300	8.300	9.400

Device	Routing	Invert	Outlet Devices
#1	Primary	681.50'	**36.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 681.50' / 681.40' S= 0.0020 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 7.07 sf

Primary OutFlow Max=12.46 cfs @ 2.93 hrs HW=683.52' TW=682.55' (Dynamic Tailwater)
└─**1=Culvert** (Barrel Controls 12.46 cfs @ 3.48 fps)

Summary for Pond 11P: Pond 4

Inflow Area = 28.200 ac,100.00% Impervious, Inflow Depth = 7.04" for 1,000-yr event
Inflow = 136.16 cfs @ 2.66 hrs, Volume= 16.544 af
Outflow = 57.36 cfs @ 3.01 hrs, Volume= 16.153 af, Atten= 58%, Lag= 21.3 min
Primary = 57.36 cfs @ 3.01 hrs, Volume= 16.153 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Peak Elev= 680.29' @ 6.37 hrs Surf.Area= 10.116 ac Storage= 6.544 af

Plug-Flow detention time= 238.0 min calculated for 16.137 af (98% of inflow)
Center-of-Mass det. time= 234.0 min (419.2 - 185.2)

Volume	Invert	Avail.Storage	Storage Description
#1	679.00'	61.750 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
679.00	0.100	0.000	0.000
680.00	7.800	3.950	3.950
681.00	15.800	11.800	15.750
682.00	24.000	19.900	35.650
683.00	28.200	26.100	61.750

Device	Routing	Invert	Outlet Devices
#1	Primary	679.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 4.00 Width (feet) 10.00 42.00

Primary OutFlow Max=57.36 cfs @ 3.01 hrs HW=680.21' TW=679.47' (Dynamic Tailwater)
↑—**1=Custom Weir/Orifice** (Weir Controls 57.36 cfs @ 3.19 fps)

Summary for Subcatchment 12S: Pond 4

Runoff = 136.16 cfs @ 2.66 hrs, Volume= 16.544 af, Depth= 7.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 1,000-yr Rainfall=7.04"

	Area (ac)	CN	Description
*	28.200	100	Ash
	28.200		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	100	0.0025	0.57		**Sheet Flow, Ash** Smooth surfaces n= 0.011 P2= 2.92"
21.3	1,300	0.0025	1.02		**Shallow Concentrated Flow, Ash** Paved Kv= 20.3 fps
24.2	1,400	Total			

Summary for Pond 15P: Pond 3

Inflow Area = 68.800 ac,100.00% Impervious, Inflow Depth > 6.52" for 1,000-yr event
Inflow = 85.92 cfs @ 3.03 hrs, Volume= 37.407 af
Outflow = 24.98 cfs @ 6.50 hrs, Volume= 31.164 af, Atten= 71%, Lag= 208.4 min
Primary = 24.98 cfs @ 6.50 hrs, Volume= 31.164 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Starting Elev= 678.50' Surf.Area= 7.837 ac Storage= 47.447 af
Peak Elev= 680.29' @ 6.50 hrs Surf.Area= 8.150 ac Storage= 61.732 af (14.285 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 219.0 min (631.9 - 413.0)

Volume	Invert	Avail.Storage	Storage Description
#1	672.00'	93.200 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
672.00	6.800	0.000	0.000
676.00	7.400	28.400	28.400
680.00	8.100	31.000	59.400
684.00	8.800	33.800	93.200

Device	Routing	Invert	Outlet Devices
#1	Device 2	678.50'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#2	Primary	673.00'	**12.0" Round Culvert X 3.00** L= 100.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 673.00' / 672.00' S= 0.0100 '/' Cc= 0.900 n= 0.012 Steel, smooth, Flow Area= 0.79 sf

Primary OutFlow Max=24.98 cfs @ 6.50 hrs HW=680.29' (Free Discharge)
└─**2=Culvert** (Barrel Controls 24.98 cfs @ 10.60 fps)
  └─**1=Sharp-Crested Rectangular Weir** (Passes 24.98 cfs of 36.27 cfs potential flow)

Summary for Link 16L: Pumped from Station

Inflow	=	0.10 cfs @	0.00 hrs, Volume=	0.165 af
Primary	=	0.10 cfs @	0.00 hrs, Volume=	0.165 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs

Constant Inflow= 0.10 cfs

Summary for Subcatchment 16S: Pond 3

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 48.53 cfs @ 2.38 hrs, Volume= 5.163 af, Depth= 7.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs
Type B 6-hr 1,000-yr Rainfall=7.04"

	Area (ac)	CN	Description
*	8.800	100	
	8.800		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					**Direct Entry, Pond 3**

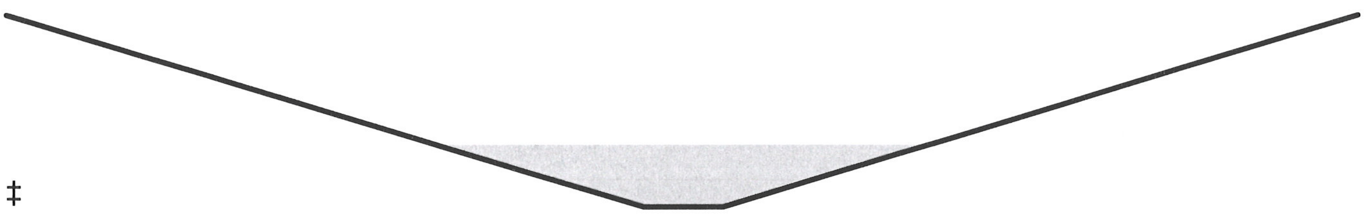
Summary for Reach 17R: Swale between Pond 2 and 2A/2B

Inflow Area = 20.600 ac,100.00% Impervious, Inflow Depth = 7.04" for 1,000-yr event
Inflow = 96.92 cfs @ 2.69 hrs, Volume= 12.085 af
Outflow = 96.90 cfs @ 2.69 hrs, Volume= 12.085 af, Atten= 0%, Lag= 0.2 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.02 hrs / 3
Max. Velocity= 10.31 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 5.87 fps, Avg. Travel Time= 0.6 min

Peak Storage= 1,879 cf @ 2.69 hrs
Average Depth at Peak Storage= 1.30'
Bank-Full Depth= 4.00' Flow Area= 72.0 sf, Capacity= 1,472.08 cfs

2.00' x 4.00' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 4.0 '/' Top Width= 34.00'
Length= 200.0' Slope= 0.0350 '/'
Inlet Invert= 692.00', Outlet Invert= 685.00'



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