ALLIANT ENERGY
Interstate Power and Light Company
Lansing Generating Station

CCR SURFACE IMPOUNDMENT

INFLOW DESIGN FLOOD CONTROL PLAN

Report Issued: September 2, 2016
Revision 0

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EXECUTIVE SUMMARY

This Inflow Flood Control Plan (Report) is prepared in accordance with the requirements of the United States Environmental Protection Agency (USEPA) published Final Rule for Hazardous and

Solid Waste Management System – Disposal of Coal Combustion Residual from Electric Utilities (40 CFR Parts 257 and 261, also known as the CCR Rule) published on April 17, 2015 and effective October 19, 2015.

This Report assesses the hydrologic and hydraulic capacity requirements for the CCR unit at Lansing Generating Station in Lansing, Iowa in accordance with §257.82 of the CCR Rule. For purposes of this Report, a CCR unit is defined as any existing CCR surface impoundment. Primarily, the Report documents how the inflow design flood control system has been designed and constructed to meet the CCR Rule section §257.82.

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1 Introduction

The owner or operator of the Coal Combustion Residual (CCR) unit must conduct an initial and periodic inflow design flood control system plan to determine if each CCR unit adequately manages flow into and from each CCR unit during and following the peak discharge of the inflow design flood. The inflow design flood is selected based on the hazard potential classification (§257.73(a)(2)) for each CCR unit.

This Report is prepared in accordance with the requirements of §257.82 of the CCR Rule.

1.1 CCR Rule Applicability

The CCR Rule requires an initial and periodic inflow design flood control system plan certified by a qualified professional engineer (PE) for all existing CCR surface impoundments. This report is the initial inflow design flood control system plan.

1.2 Hydrologic and Hydraulic Capacity Applicability

The Lansing Generating Station (LAN) in Lansing, Iowa (Figure 1) has one existing CCR surface impoundment, identified as the LAN Upper Ash Pond.

2 FACILITY DESCRIPTION

LAN is located approximately three miles southeast of Lansing, Iowa on the western shore of the Mississippi River in Allamakee County, at 2320 Power Plant Drive, Lansing, Iowa (Figure 1).

LAN is a fossil-fueled electric generating station that has used four steam turbine electric generating units throughout its history. Unit 1, Unit 2, and Unit 3 were retired by 2014 and Unit 4 is the only operating unit. Sub-bituminous coal is the primary fuel for producing steam at LAN. The CCR at LAN is categorized into three types: bottom ash, fly ash, and scrubber byproduct. Fly ash is collected by electrostatic precipitators and pneumatically conveyed to an onsite fly ash silo, which is equipped with a baghouse for dust control. The fly ash is then either transported off-site for beneficial reuse, landfilled (in the case of high loss on ignition), or sluiced to LAN Upper Ash Pond (typically during startup and shutdown). Bottom ash is sluiced to a surface impoundment identified as the LAN Upper Ash Pond, Figure 2, where it is dredged, dewatered, and transported to the onsite landfill. The LAN Upper Ash Pond is located south of the generating plant and is the only existing CCR surface impoundment. Scrubber byproduct consists of fly ash, unreacted lime, and activated carbon. Scrubber byproduct is collected in the byproduct silo prior to being landfilled.

A previous CCR surface impoundment at LAN, identified as the Lower Ash Pond, was located west of the generating plant and north of Power Plant Drive. The Lower Ash Pond was closed in September 2015 by removing the CCR from the surface impoundment via hydraulic dredge and sluicing the CCR to the south end of the LAN Upper Ash Pond. CCR was removed from the Lower Ash Pond prior to backfilling the surface impoundment.

General Facility Information:

Date of Initial Facility Operations:	1946
NPDES Permit Number:	IA0300100

Latitude / Longitude:	41°56'38.43"N 91°38'22.39"W
Nameplate Ratings:	Unit 1 (1948): 16.6 MW (Retired)
	Unit 2 (1949): 11.4 MW (Retired)
	Unit 3 (1957): 35.8 MW (Retired)
	Unit 4 (1977): 270 MW

2.1 LAN Upper Ash Pond

The LAN Upper Ash Pond is located southwest of the generating plant and south of Power Plant Drive. The LAN Upper Ash Pond receives influent flows from the Unit 4 boiler floor sumps, water treatment sumps, fly ash hydroveyor system, storm water runoff from the active dry ash landfill and hillside east of the impoundment, as well as sluiced fly ash and bottom ash. The LAN Upper Ash Pond is the only receiver of sluiced CCR at LAN. The CCR is sluiced from the generating plant to the south east corner of the LAN Upper Ash Pond, Figure 2. The sluiced CCR discharges into the southeast corner of the LAN Upper Ash Pond where the majority of the CCR settles. Ongoing maintenance dredging is conducted in the southern portion of the LAN Upper Ash Pond. The dredged CCR is temporarily stockpiled and dewatered prior to being transported to the on-site active dry ash landfill located south of the LAN Upper Ash Pond.

The sluiced water that is discharged into the LAN Upper Ash Pond flows to the west prior to flowing north through a series of five interconnected settling ponds separated by intermediate dikes. The intermediate dikes have 30-inch diameter corrugated metal pipes on the west and east sides, which hydraulically connect the five settling ponds. The water from each settling pond flows north until it enters the large open settling area of the LAN Upper Ash Pond. The north end of the LAN Upper Ash Pond has a concrete wet well and overflow weir structure that controls the LAN Upper Ash Ponds water level, and is identified as Weir Box #1. The water in the LAN Upper Ash Pond overflows a stop log weir into Weir Box #1, and then through a 146 foot long 24 inch diameter corrugated metal pipe under Power Plant Drive, and into Weir Box #2. The water leaves Weir box 2 through a 225 foot long 24-inch diameter high density polyethylene pipe, which connects Weir Box #2 to Weir Box #3 in the backfilled former Lower Ash Pond.

The water flows through Weir Box #3 and discharges to the west through a 77 foot long 24-inch diameter corrugated metal pipe into Unnamed Creek #1. Unnamed Creek #1 flows to the north into Unnamed Creek #2 which then discharges into the Mississippi River. The National Pollution Discharge Elimination System (NPDES) Outfall 002 monitoring location, which consists of flow monitoring instrumentation, is located at Weir Box #1 and compliance samples are collected from Weir Box #3.

The total surface area of the LAN Upper Ash Pond is approximately 11.5 acres and has an embankment height of approximately 20 feet from the crest to the toe of the downstream slope at its greatest height. The area of the entire CCR Unit inclusive of the impoundment and the dredging and dewatering areas is approximately 17 acres. The interior storage depth of the LAN Upper Ash Pond is approximately 28 feet. The volume of impounded CCR and water within the LAN Upper Ash Pond is approximately 587,000 cubic yards.

3 HYDROLOGIC AND HYDRAULIC CAPACITY- §257.82(a)

This Report provides hydrologic and hydraulic capacity information for the inflow design flood control systems which is to:

1. Adequately manage flow into each CCR unit during and following the peak discharge inflow of the specified design flood,
2. Adequately manage flow from each CCR unit during and following the peak discharge inflow of the specified design flood; and,
3. Handle discharge from the CCR unit in accordance with National Pollutant Discharge Elimination System (NPDES) regulations 40 CFR 257.3-3.

3.1 Hazard Classification and Design Storm

The LAN Upper Ash Pond is classified as significant hazard potential due to the risk that the impoundment contents could enter into the Unnamed Creek #2 which is the discharge of the LAN station condenser cooling water and travel from there directly into the Mississippi River. Additionally, as identified in the Hazard Potential Classification, Allamakee County Highway X-52 (Great River Road), immediately west of the LAN Upper Ash Pond, has the potential to become engulfed if a failure of the west embankment were to occur.

The design storm for the LAN Upper Ash Pond is the 1,000 year return event SCS Type II 24 hour storm as defined in 40 CFR 257.82 (3) (ii). The total rainfall for the event selected from the National Oceanographic and Atmospheric Administration's probabilistic map for the LAN site coordinates is 12.1 inches for the 1000 year event, Appendix A.

3.2 Hydrologic and Hydraulic Capacity Methods

The 1,000 year SCS Type II storm was routed through the LAN Upper Ash Pond through its discharge weir at Weir Box # 1, Figure 1. The routing was completed using the program Hydraflow by Intelisolve[1]. Hydraflow uses the unit hydrograph method to generate a Type II distribution rainfall for the drainage area to the LAN Upper Ash Pond.

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[1] Intelisolve, Pond Routing Software Hydraflow, 2002

Hydraflow routes the rainfall hydrograph through the outlet structure storing water within the impoundment in accordance with the reservoir capacity of the impoundment. The proportion of runoff to rainfall for the drainage watershed is input based on characteristics of the watershed area. The drainage areas of the watershed include 54 acres of 19% slope hillside, 16 acres of ash landfill, 11.5 acres of open pond water, and 5.5 acres of embankment, Appendix B.

3.3 Hydrologic and Hydraulic Capacity Input and Assumptions

This section identifies the input and assumptions for the hydrologic and hydraulic capacity calculations. The input for each sub-drainage area of the LAN Upper Ash Pond are:

Sub-Area	Acreage	Curve Number (CN)	Slope (%)	Hydraulic Length (ft)
Wooded Side Slope	54	60	19	
Ash Landfill	16	86		
LAN Upper Ash Pond	11.5	100		
Ash Pond Embankments	5.5	77		
Weighted Average	87	72	19	2,150

The slope and hydraulic length for the steep hillside are allowed to control the arrival of the peak water from rainfall due to the larger percentage of acreage from the wooded area and the steepness of the land.

The outlets from the four small ponds in the south end of the LAN Upper Ash Pond are not controlling flow and if the ponds fill water will overflow the center dividing embankments to reach the larger northern part of the LAN Upper Ash Pond. The storage of the smaller ponds is allotted to the larger pond as the pond fills and backs up into the smaller ponds, Appendix B. The outlet from the LAN Upper Ash Pond is through the four foot wide overflow in Weir Box #1. This overflow weir is adjustable and is normally operated with the weir set at elevation 648 feet NAVD 1988.

During normal LAN operation, the process water flow to the Upper Ash Pond is 3,500 gallons per minute (8 cubic feet per second). Based on the overflow weir equation[2] with a weir coefficient of 3.3 the normal operating elevation of the water in the LAN Upper Ash Pond is 648.7 feet. The operating water elevation in the LAN Upper Ash Pond north section is the starting elevation for storage of the 1,000 year rainfall event.

As discharge from the overflow weir increases, the wet well fills with water until the weir becomes submerged and the outlet from the impoundment becomes controlled by the outlet pipe from the bottom of Weir Box #1, Appendix B. The flow for the full outlet piping consisting of two sections of CMP and one section of HDPE as described in Section 2.0 is controlled by head loss under Bernoulli's law and includes the losses from velocity, entrance effects, and friction. The flow equation is:

$$\text{Head Loss (ft)} = (1 + k_e + 29*(n)^2*L/R^{1.33})*V^2/2g$$

Where: ke = entrance loss coefficient (0.5 for flush face)
n = mannings friction factor (0.009 for HDPE and 0.015 for CMP)
L = Pipe length in feet (see section 2.0)
R = Hydraulic radius (Area divided by Perimeter of Pipe)
V = Velocity (feet/second)
g = gravity (32.2 ft/sec^2)

The calculation is performed for a flooded tailwater in the Unnamed Creek #1 equivalent to elevation 623. The tailwater elevation is equal to the 2 year return period flood water in the Mississippi river3 which controls the tailwater at the discharge. The flood water assumption is reasonable considering the river flood stage is not likely to correspond to the 1,000 year local rainfall event.

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[2] Q (flow in cfs) = weir coefficient * length of weir * (head (ft))^2
[3] USACE Upper Mississippi River Flow Frequency Predictions for Lock and Dam #9

A combined outlet control curve that operates by overflow weir control to approximately elevation 650 in the impoundment and then converts to outlet pipe control is shown in Appendix B along with the calculations to generate the outlet curve.

The storage capacity of the LAN Upper Ash Pond is generated by digitizing the area of the impoundment at varying storage elevations above 648 feet. The volume includes the storage available in the smaller ponds to the south of the overall impoundment area as water elevation floods those ponds. The storage curve calculations are shown in Appendix B.

No exfiltration of water from the LAN Upper Ash Pond is allowed during the storm routing. Actual evidence from inflow and outflows to the impoundment indicates that exfiltration occurs. However, the amount is less than normal operating flow and will not increase dramatically during storm routing.

4 Inflow Design Flood Control System Plan

The 87 acres of storm water flow into the LAN Upper Ash Pond will discharge from the outlet at a flow of 33.5 cubic feet per second during peak storm flow. The LAN Upper Ash Pond will store 37.5 acre feet of water during the event and the maximum water elevation will reach 652.4 feet. The minimum crest elevation of the embankment is elevation 654 on the north embankment with a resultant freeboard of a little over 1.5 foot at the peak of the storm flow.

The maximum flow includes the 8.0 cfs of base flow which was adjusted into the outlet control as shown in Appendix B.

The results of the storm routing through the LAN Upper Ash Pond using Hydraflow are presented in Appendix C.

5 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

To meet the requirements of 40 CFR 257.82(c)(5), I Mark W. Loerop hereby certify that I am a licensed professional engineer in the State of Iowa; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in 40 CFR 257.82.

LICENSED PROFESSIONAL ENGINEER
MARK W. LOEROP
22197
IOWA

By: ____________________

Name: MARK LOEROP

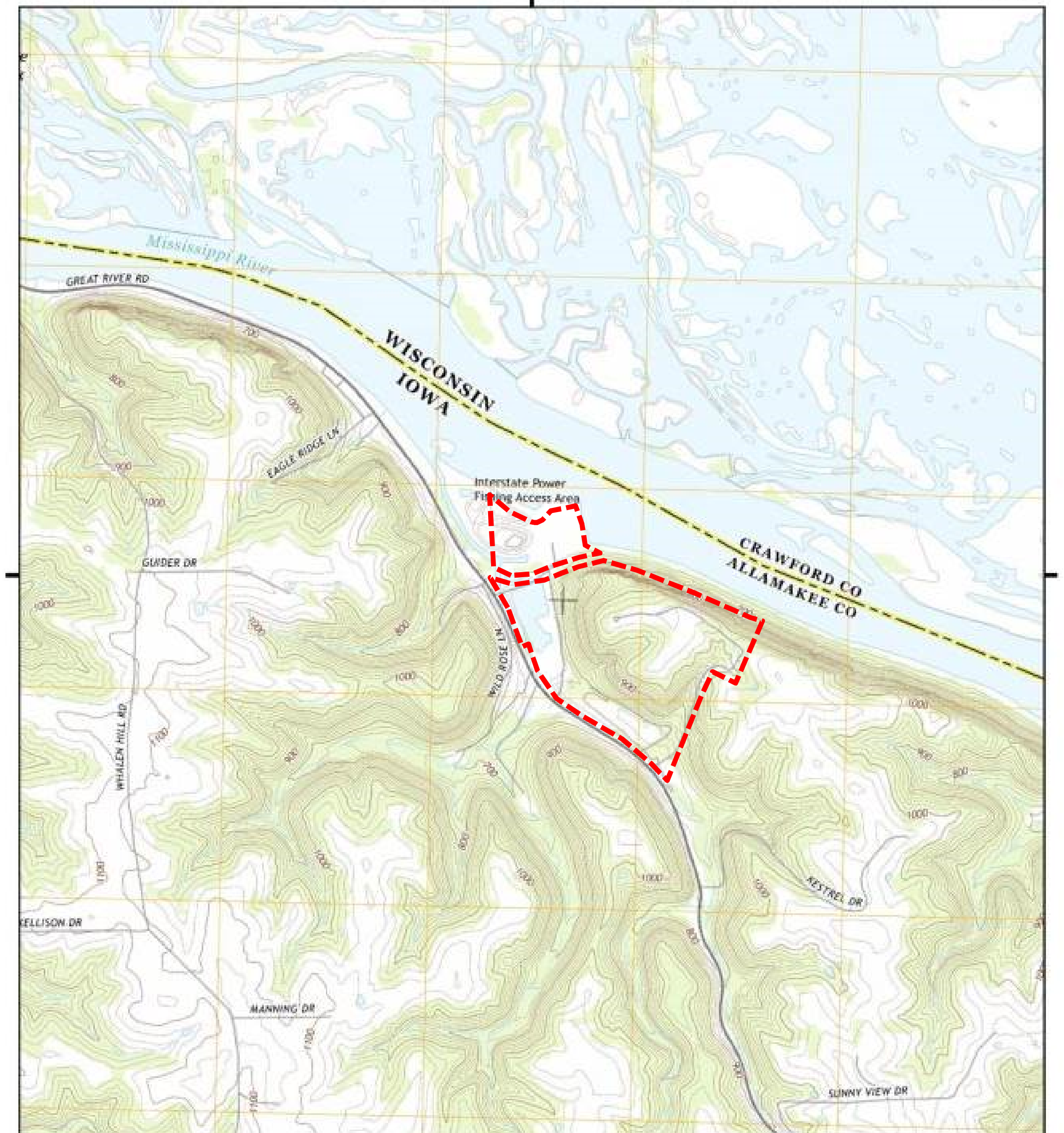
Date: 09-02-2016

FIGURES

Alliant Energy
Interstate Power and Light Company
Lansing Generating Station
Lansing, Iowa

Inflow Design Flood Control System Plan

Historical Topo Map 2013



This report includes information from the following map sheet(s).

Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Lansing, 2013, 7.5-minute

SITE NAME: Lasing Generating Station
ADDRESS: 2364-2366 Power Plant Dr
Lansing, IA 52151
CLIENT: Environmental Site Assessors

N

4555570 - 1 page 5

Historical Aerial Photo

Approximate Property Boundary

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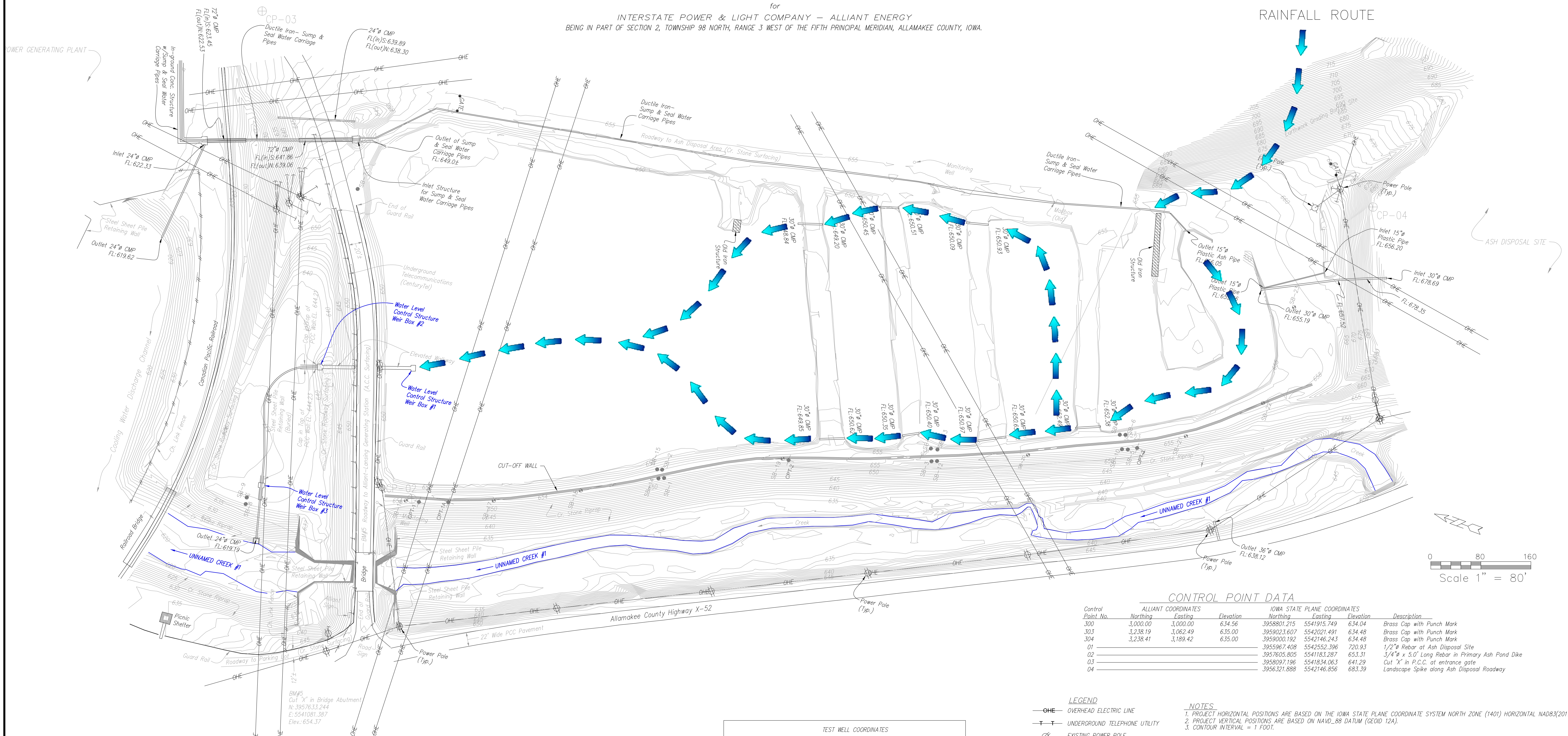
Site Location	Drawing
Lansing Generating Station	Figure 1
Intersate Power and Light Company	Date 6/7/2016

UPPER AND LOWER CCR POND TOPOGRAPHIC SURVEY AND LOWER CCR POND BATHYMETRY
at
ALLIANT LANSING POWER GENERATING STATION
for
INTERSTATE POWER & LIGHT COMPANY – ALLIANT ENERGY
BEING IN PART OF SECTION 2, TOWNSHIP 98 NORTH, RANGE 3 WEST OF THE FIFTH PRINCIPAL MERIDIAN, ALLAMAKEE COUNTY, IOWA.



CONTROL POINT DATA

Control Point No.	ALLIANT COORDINATES Northing	Easting	Elevation	IOWA STATE PLANE COORDINATES Northing	Easting	Elevation	Description
300	3,000.00	3,000.00	634.56	3958801.215	5541915.749	634.04	Brass Cap with Punch Mark
303	3,238.19	3,062.49	635.00	3959023.607	5542021.491	634.48	Brass Cap with Punch Mark
304	3,238.41	3,189.42	635.00	3959000.192	5542146.243	634.48	Brass Cap with Punch Mark
01				3955967.408	5542552.396	720.93	1/2"ø Rebar at Ash Disposal Site
02				3957605.805	5541183.287	653.31	3/4"ø x 5.0' Long Rebar in Primary Ash Pond Dike
03				3958097.196	5541834.063	641.29	Cut 'X' in P.C.C. at entrance gate
04				3956321.888	5542146.856	683.39	Landscape Spike along Ash Disposal Roadway

TEST WELL COORDINATES

WELL ID	Northing	Easting	TOP Elevation	Ground Elevation
SB-1	3957238.28	5541352.23	653.36	653.26
SB-2	3957245.81	5541363.76	652.66	652.63
SB-3	3956845.82	5541523.57	656.39	655.37
SB-4	3956853.80	5541542.37	655.88	655.34
SB-5	3956557.49	5541648.53	656.70	655.80
SB-6	3956569.09	5541669.35	656.19	655.97
SB-7	3957856.52	5541618.95	653.45	653.33
SB-8	3957852.40	5541084.50	641.74	638.43
SB-9	3957854.40	5541094.88	640.63	638.52
SB-10	NS	NS	656.38	655.85
SB-11	NS	NS	656.38	656.17
SB-12	NS	NS	656.40	655.44
SB-13	NS	NS	656.43	655.27
SB-14	NS	NS	654.37	653.15
SB-15	NS	NS	652.75	652.67

LEGEND

- OHE — OVERHEAD ELECTRIC LINE
- T — UNDERGROUND TELEPHONE UTILITY
- EXISTING POWER POLE
- SB — TEMPORARY WELL LOCATION
- SB — SOIL BORING LOCATION
- CPT — CONE PENETROMETER TEST LOCATION
- CP — CONTROL POINT

NOTES

1. PROJECT HORIZONTAL POSITIONS ARE BASED ON THE IOWA STATE PLANE COORDINATE SYSTEM NORTH ZONE (1401) HORIZONTAL NAD83(2011).
2. PROJECT VERTICAL POSITIONS ARE BASED ON NAVD_88 DATUM (GEOID 12A).
3. CONTOUR INTERVAL = 1 FOOT.

NOTE:
1. SURVEY INFORMATION PROVIDED ABOVE WAS COMPILED BY MOHN SURVEYING, INC. 1890 GREAT RIVER ROAD LANSING, IOWA 52151, APRIL 2015.
2. ALLIANT ENERGY REQUIRES 20 FEET OVERHEAD SEPARATION DISTANCE FOR EQUIPMENT OPERATING UNDER POWERLINES.

REV	DATE	BY	APP	DESCRIPTION
5				
4				
3				
2				
1				

SCALE: AS SHOWN — DATE: 5-19-16
DRAWN BY: JFD — CHECKED BY: CTS — APPROVED BY: MWL

HARD HAT SERVICES™
Engineering, Construction and Management Solutions

CLIENT / LOCATION
INTERSTATE POWER AND LIGHT (IPL)
LANSING GENERATING STATION PROJECT
2320 POWER PLANT DR
LANSING, IA 52151

DRAWING DESCRIPTION
INFLOW FLOOD CONTROL
SITE PLAN

JOB 154.018.012.002
SHT. FIGURE 2
DWG. 154.018.012.002-D2

APPENDIX A – NOAA Storm Frequency

Alliant Energy
Interstate Power and Light Company
Lansing Generating Station
Lansing, Iowa

Inflow Design Flood Control System Plan

NOAA Atlas 14, Volume 8, Version 2
Location name: Lansing, Iowa, US*
Latitude: 43.3333°, Longitude: -91.1683°
Elevation: 653 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

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	0.384 (0.308–0.481)	0.447 (0.358–0.560)	0.552 (0.440–0.692)	0.641 (0.509–0.807)	0.767 (0.591–0.996)	0.867 (0.653–1.14)	0.969 (0.707–1.30)	1.08 (0.755–1.48)	1.22 (0.825–1.72)	1.33 (0.878–1.90)
10-min	0.563 (0.451–0.704)	0.654 (0.524–0.819)	0.808 (0.645–1.01)	0.938 (0.745–1.18)	1.12 (0.866–1.46)	1.27 (0.957–1.67)	1.42 (1.04–1.90)	1.58 (1.11–2.16)	1.79 (1.21–2.51)	1.95 (1.29–2.78)
15-min	0.686 (0.550–0.859)	0.798 (0.639–0.999)	0.985 (0.786–1.24)	1.14 (0.909–1.44)	1.37 (1.06–1.78)	1.55 (1.17–2.03)	1.73 (1.26–2.32)	1.92 (1.35–2.64)	2.18 (1.47–3.06)	2.38 (1.57–3.39)
30-min	0.938 (0.752–1.17)	1.10 (0.881–1.38)	1.37 (1.09–1.72)	1.60 (1.27–2.01)	1.92 (1.48–2.49)	2.17 (1.63–2.85)	2.42 (1.77–3.25)	2.69 (1.89–3.69)	3.05 (2.06–4.28)	3.32 (2.19–4.73)
60-min	1.21 (0.970–1.52)	1.42 (1.14–1.78)	1.78 (1.42–2.24)	2.10 (1.67–2.64)	2.55 (1.97–3.33)	2.92 (2.21–3.85)	3.31 (2.42–4.45)	3.71 (2.61–5.11)	4.27 (2.89–6.02)	4.71 (3.11–6.71)
2-hr	1.48 (1.20–1.84)	1.74 (1.41–2.16)	2.20 (1.77–2.73)	2.60 (2.09–3.25)	3.19 (2.50–4.14)	3.68 (2.81–4.82)	4.19 (3.09–5.61)	4.73 (3.36–6.49)	5.50 (3.75–7.71)	6.10 (4.05–8.64)
3-hr	1.66 (1.35–2.04)	1.95 (1.59–2.40)	2.46 (2.00–3.04)	2.93 (2.36–3.63)	3.63 (2.86–4.70)	4.22 (3.24–5.51)	4.85 (3.60–6.47)	5.53 (3.94–7.56)	6.49 (4.46–9.09)	7.27 (4.85–10.3)
6-hr	1.96 (1.62–2.39)	2.29 (1.88–2.79)	2.88 (2.37–3.53)	3.45 (2.81–4.23)	4.33 (3.46–5.59)	5.08 (3.96–6.62)	5.91 (4.44–7.87)	6.82 (4.92–9.30)	8.13 (5.64–11.4)	9.21 (6.18–12.9)
12-hr	2.27 (1.89–2.74)	2.61 (2.17–3.15)	3.26 (2.71–3.95)	3.90 (3.22–4.74)	4.92 (3.99–6.33)	5.81 (4.58–7.53)	6.81 (5.17–9.01)	7.91 (5.76–10.7)	9.52 (6.65–13.2)	10.9 (7.33–15.1)
24-hr	2.58 (2.17–3.08)	2.94 (2.47–3.51)	3.65 (3.06–4.37)	4.34 (3.62–5.22)	5.46 (4.48–6.97)	6.46 (5.14–8.30)	7.56 (5.80–9.94)	8.80 (6.46–11.9)	10.6 (7.48–14.7)	12.1 (8.25–16.8)
2-day	2.94 (2.50–3.47)	3.33 (2.83–3.93)	4.09 (3.47–4.85)	4.83 (4.08–5.76)	6.03 (4.99–7.60)	7.08 (5.69–9.00)	8.25 (6.38–10.7)	9.55 (7.07–12.7)	11.5 (8.12–15.7)	13.0 (8.92–17.9)
3-day	3.21	3.62	4.42	5.18	6.40	7.47	8.65	9.96	11.9	13.5

	(2.75-3.77)	(3.11-4.26)	(3.77-5.20)	(4.40-6.13)	(5.33-8.01)	(6.03-9.43)	(6.72-11.2)	(7.40-13.2)	(8.46-16.2)	(9.25-18.4)
4-day	**3.45** (2.98-4.03)	**3.89** (3.35-4.55)	**4.71** (4.04-5.52)	**5.50** (4.69-6.48)	**6.74** (5.62-8.38)	**7.82** (6.33-9.81)	**9.01** (7.02-11.6)	**10.3** (7.69-13.6)	**12.2** (8.73-16.6)	**13.8** (9.52-18.8)
7-day	**4.08** (3.55-4.73)	**4.59** (3.99-5.32)	**5.52** (4.78-6.41)	**6.38** (5.49-7.45)	**7.70** (6.45-9.44)	**8.82** (7.18-10.9)	**10.0** (7.87-12.8)	**11.4** (8.51-14.9)	**13.3** (9.51-17.9)	**14.8** (10.3-20.1)
10-day	**4.66** (4.08-5.37)	**5.23** (4.58-6.03)	**6.26** (5.45-7.23)	**7.18** (6.22-8.34)	**8.58** (7.21-10.4)	**9.74** (7.96-12.0)	**11.0** (8.64-13.9)	**12.3** (9.27-16.0)	**14.3** (10.2-19.1)	**15.8** (11.0-21.4)
20-day	**6.38** (5.65-7.27)	**7.14** (6.31-8.14)	**8.43** (7.43-9.64)	**9.55** (8.36-11.0)	**11.2** (9.45-13.3)	**12.5** (10.3-15.1)	**13.8** (11.0-17.2)	**15.3** (11.5-19.6)	**17.2** (12.5-22.8)	**18.8** (13.2-25.2)
30-day	**7.86** (7.01-8.90)	**8.79** (7.83-9.96)	**10.3** (9.17-11.7)	**11.6** (10.3-13.3)	**13.5** (11.4-15.9)	**14.9** (12.3-17.9)	**16.4** (13.0-20.2)	**17.9** (13.6-22.8)	**19.9** (14.5-26.2)	**21.5** (15.1-28.8)
45-day	**9.78** (8.78-11.0)	**11.0** (9.83-12.3)	**12.9** (11.5-14.5)	**14.5** (12.8-16.4)	**16.6** (14.2-19.4)	**18.2** (15.2-21.7)	**19.9** (15.9-24.3)	**21.5** (16.4-27.2)	**23.6** (17.2-30.9)	**25.2** (17.8-33.6)
60-day	**11.4** (10.3-12.8)	**12.9** (11.6-14.4)	**15.1** (13.6-17.0)	**16.9** (15.1-19.1)	**19.4** (16.6-22.5)	**21.2** (17.7-25.1)	**23.0** (18.4-28.0)	**24.8** (18.9-31.1)	**27.0** (19.7-35.0)	**28.6** (20.3-38.0)

[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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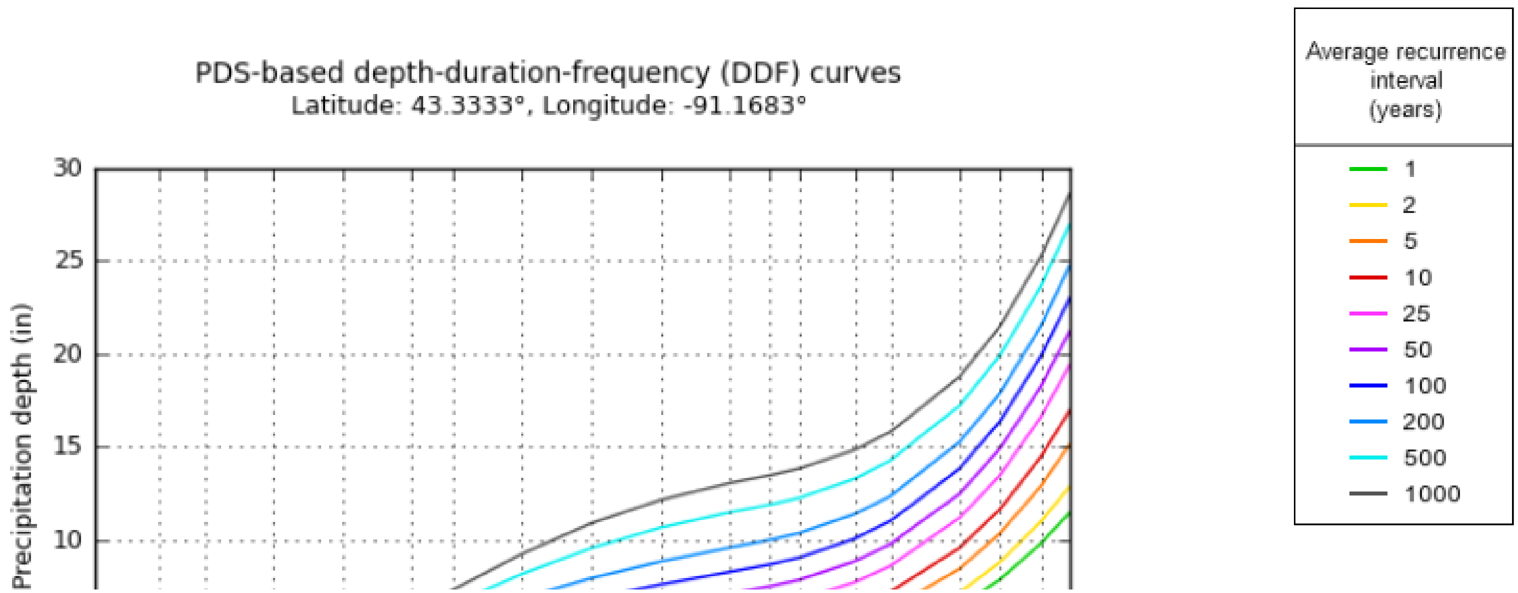
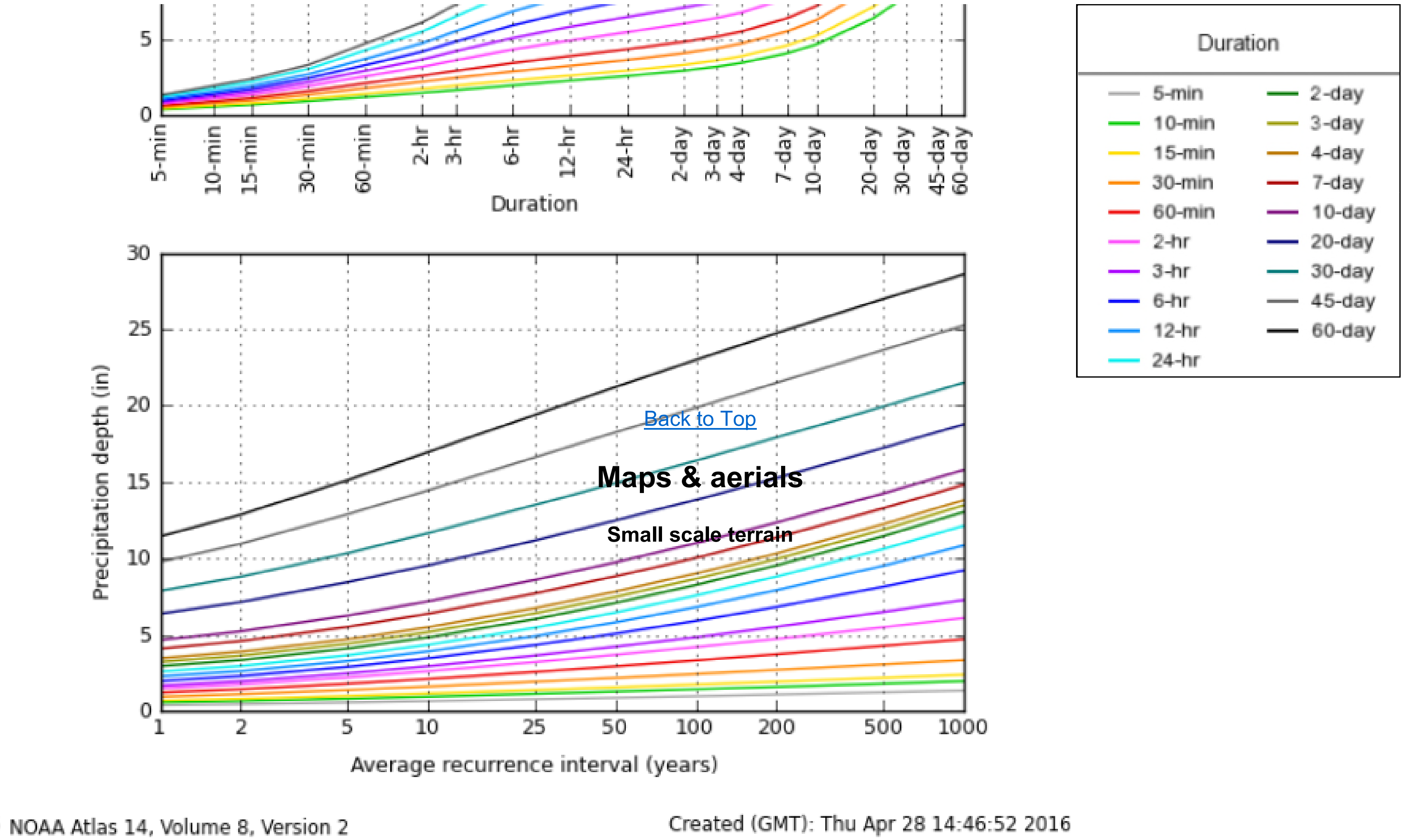
PF graphical





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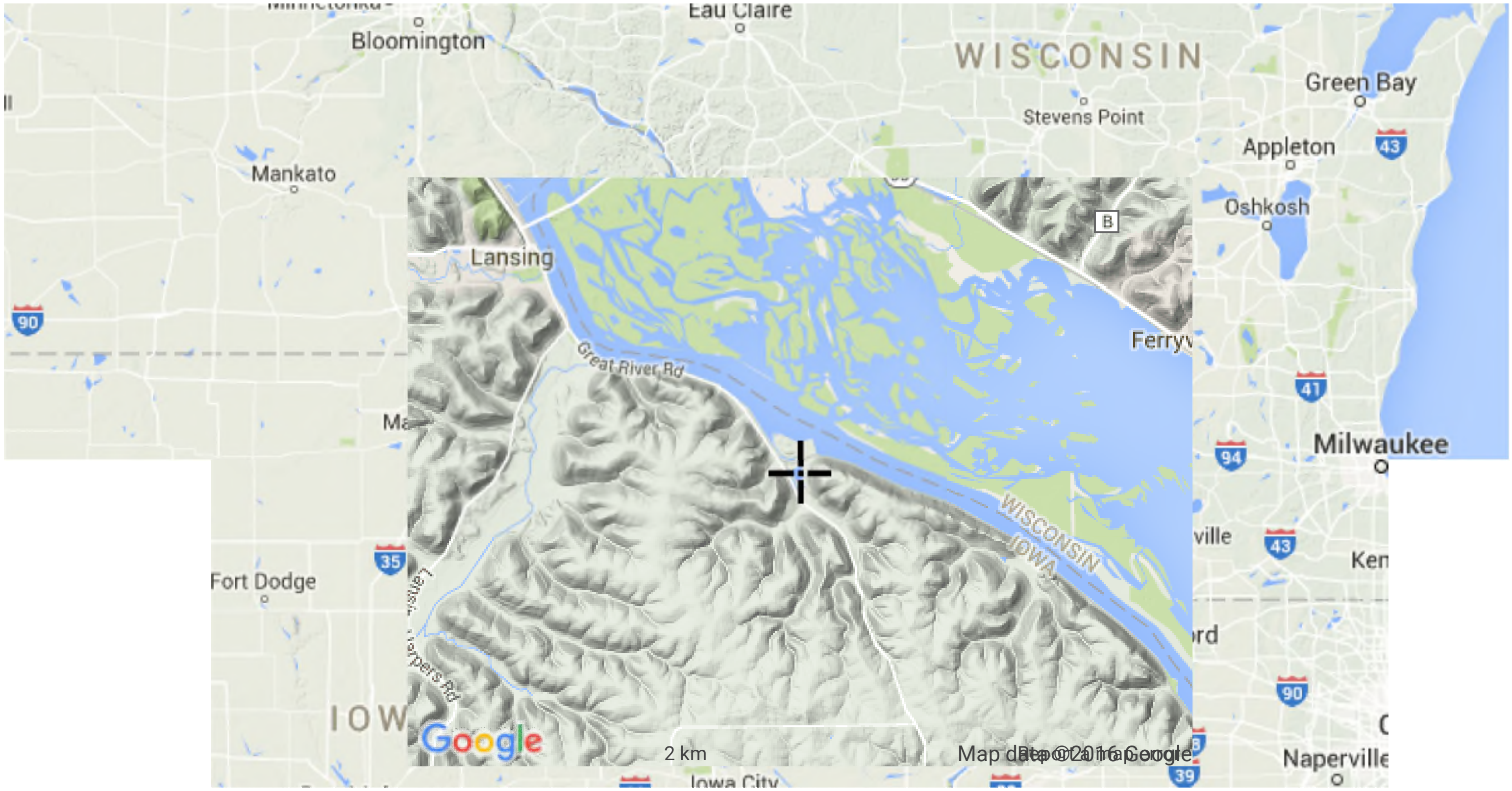
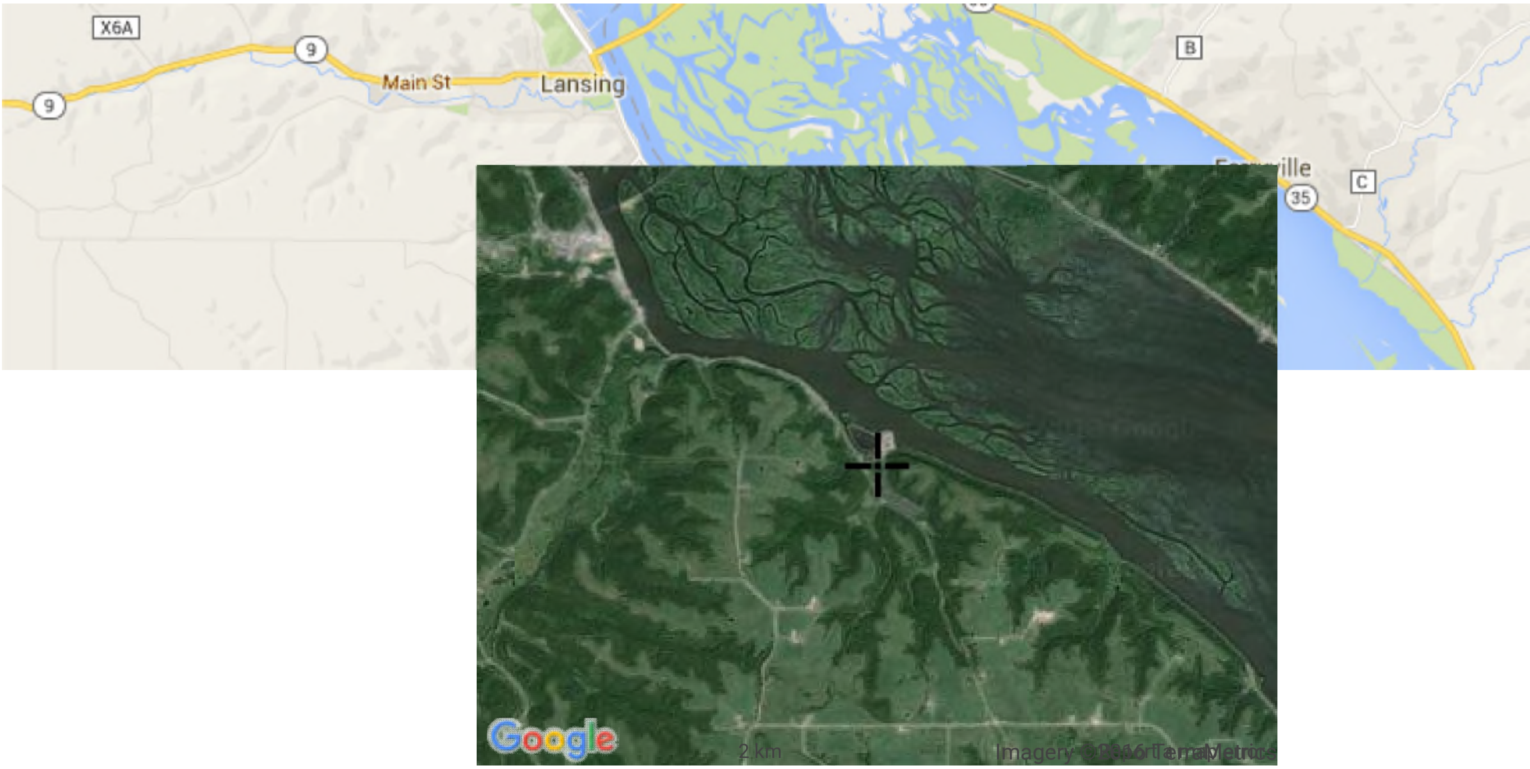
Maps & aerials

Small scale terrain



Large scale map



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

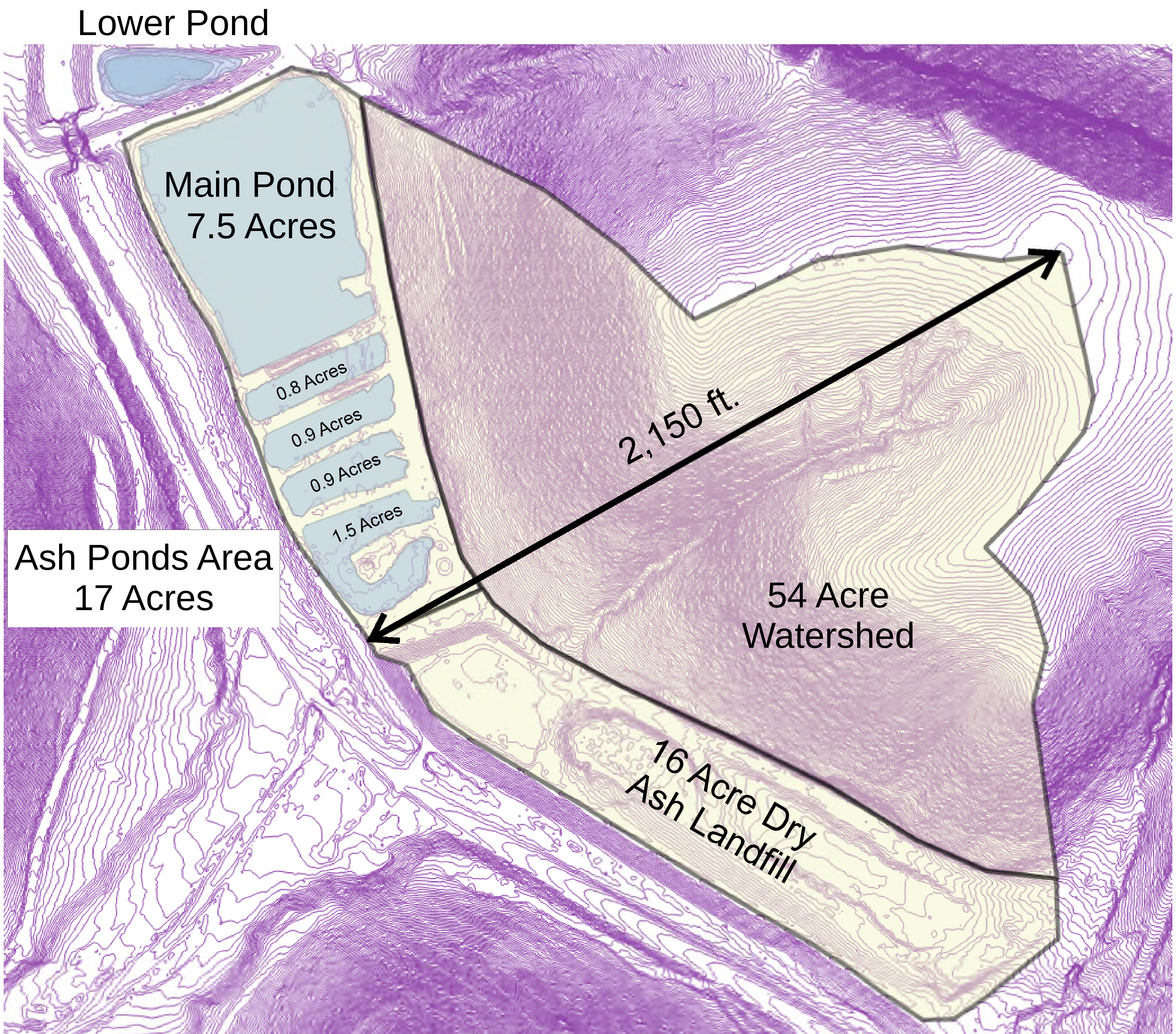
APPENDIX B – Outfall Drawings

Alliant Energy
Interstate Power and Light Company
Lansing Generating Station
Lansing, Iowa

Inflow Design Flood Control System Plan

Lansing Iowa Power Station

Ash Ponds and Surface Drainage Areas



REFERENCE:

Iowa LiDAR Mapping Project
http://www.geotree.uni.edu/lidar/
Accessed 1/30/2015

Meta Data:
http://www.geotree.uni.edu/lidar/static/iowa_lidar_metadata.html

Derived Data:
http://www.geotree.uni.edu/lidar/static/derived_products_metadata.html

QGIS v2.6.1 Used for Measurements
http://qgis.org

TCW 2/11/2015

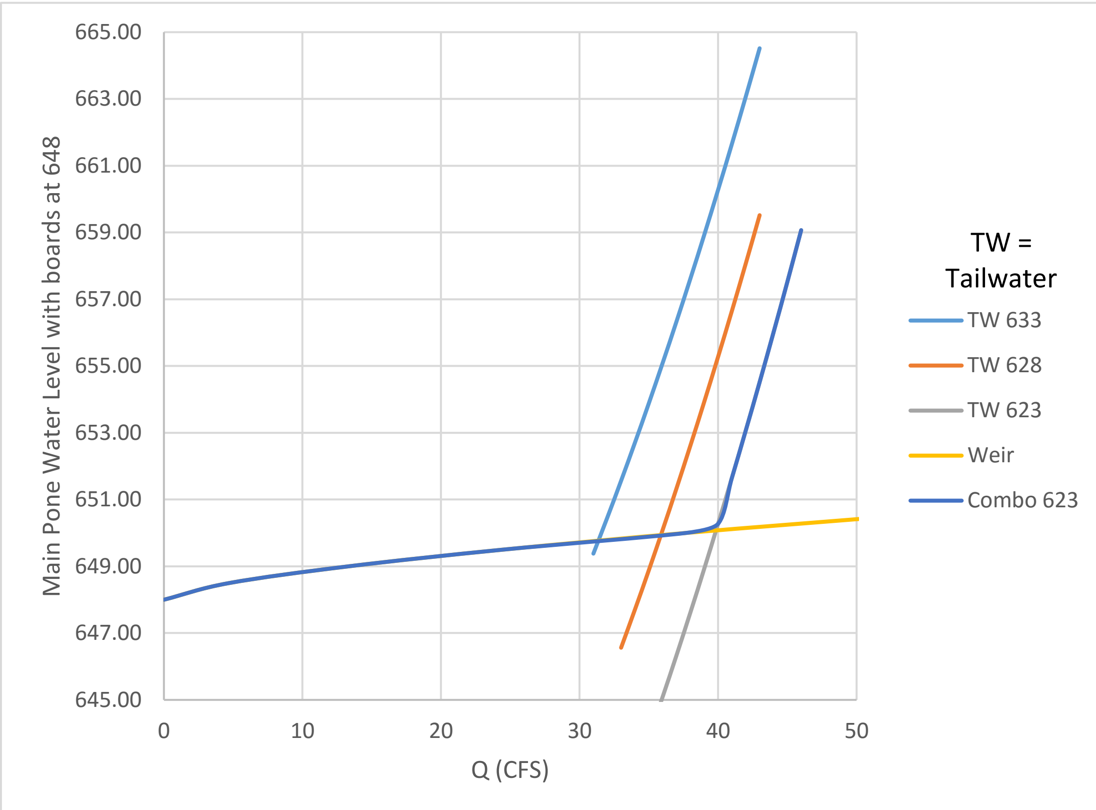
LGS - Main Pond Outlet Head Loss

Outlet Control Equations

2	FT = Pipe Diameter Steel
0.50	FT = Rh Steel
1.84	FT = Pipe Diameter HDPE
0.46	FT =Rh HDPE
0.015	= n steel
0.009	= n HDPE
0.5	=Ke

				dH NG		dH NG		dH NG
				Ft		Ft		Ft
				4.295649		6.34121		5.83986
		Required	Section 1		Section 2		Section 1	
Q	Tail Water	Head	V	dH	V	dH	V	dH
CFS	Ft	Ft	FPS	Ft	FPS	Ft	FPS	Ft
31	633	649.38	9.87	4.18	11.66	6.30	9.87	5.89
32	633	650.45	10.19	4.46	12.03	6.72	10.19	6.28
33	633	651.56	10.50	4.74	12.41	7.14	10.50	6.68
34	633	652.70	10.82	5.03	12.79	7.58	10.82	7.09
35	633	653.88	11.14	5.33	13.16	8.04	11.14	7.51
36	633	655.09	11.46	5.64	13.54	8.50	11.46	7.95
37	633	656.34	11.78	5.96	13.91	8.98	11.78	8.40
38	633	657.61	12.10	6.28	14.29	9.47	12.10	8.86
39	633	658.93	12.41	6.62	14.67	9.98	12.41	9.33
40	633	660.27	12.73	6.96	15.04	10.50	12.73	9.81
41	633	661.65	13.05	7.31	15.42	11.03	13.05	10.31
42	633	663.07	13.37	7.68	15.80	11.57	13.37	10.82
43	633	664.52	13.69	8.05	16.17	12.13	13.69	11.34
33	628	646.56	10.50	4.74	12.41	7.14	10.50	6.68
34	628	647.70	10.82	5.03	12.79	7.58	10.82	7.09
35	628	648.88	11.14	5.33	13.16	8.04	11.14	7.51
36	628	650.09	11.46	5.64	13.54	8.50	11.46	7.95
37	628	651.34	11.78	5.96	13.91	8.98	11.78	8.40
38	628	652.61	12.10	6.28	14.29	9.47	12.10	8.86
39	628	653.93	12.41	6.62	14.67	9.98	12.41	9.33
40	628	655.27	12.73	6.96	15.04	10.50	12.73	9.81
41	628	656.65	13.05	7.31	15.42	11.03	13.05	10.31
42	628	658.07	13.37	7.68	15.80	11.57	13.37	10.82
43	628	659.52	13.69	8.05	16.17	12.13	13.69	11.34
33	623	641.56	10.50	4.74	12.41	7.14	10.50	6.68
34	623	642.70	10.82	5.03	12.79	7.58	10.82	7.09
35	623	643.88	11.14	5.33	13.16	8.04	11.14	7.51
36	623	645.09	11.46	5.64	13.54	8.50	11.46	7.95

37	623	646.34	11.78	5.96	13.91	8.98	11.78	8.40
38	623	647.61	12.10	6.28	14.29	9.47	12.10	8.86
39	623	648.93	12.41	6.62	14.67	9.98	12.41	9.33
40	623	650.27	12.73	6.96	15.04	10.50	12.73	9.81
41	623	651.65	13.05	7.31	15.42	11.03	13.05	10.31
42	623	653.07	13.37	7.68	15.80	11.57	13.37	10.82
43	623	654.52	13.69	8.05	16.17	12.13	13.69	11.34
44	623	656.00	14.01	8.42	16.55	12.70	14.01	11.87
45	623	657.52	14.32	8.81	16.92	13.29	14.32	12.42
46	623	659.07	14.64	9.21	17.30	13.88	14.64	12.98



Weir Equation

Q = Cw * L * H^1.5

H=0 at 648' (in 2015 report)

H Ft	Q CFS
648.0	0.0
648.5	4.7
649.0	13.3
649.5	24.5
650.0	37.7
650.5	52.7

Combo Discharge Curve with low Tailwater

648.0	0.0	Weir Control
648.5	4.7	
649.0	13.3	
649.5	24.5	
650.0	37.7	
650.3	40.0	Outlet Controled
651.7	41.0	
653.1	42.0	

654.5	43.0
656.0	44.0
657.5	45.0
659.1	46.0

Subtract Base flow from Combo Discharge Curve
Use Base Flow of 8.0 CFS
=> Raise H at Q = 0 to 0.711853 Feet

648.7	0.0	
649.0	5.3	= 13.3 - 8.0 for example
649.5	16.5	
650.0	29.7	
650.3	32.0	
651.7	33.0	
653.1	34.0	
654.5	35.0	
656.0	36.0	
657.5	37.0	
659.1	38.0	

ASH POND STORAGE CAPACITY

Reference: Contours shown on page 187 of 219 as reported in "LGS Slope Stability and Hydraulic Analysis Report - Revision 1.pdf"

Main Pond Contour Areas calculated by QGIS
(After converting the actual contour line to a polygon)

Elevation	Acres
650	7.53
652	8.12

Note: Cut-Off wall drawing 154021SW-02 includes 648 & 649' contours showing that the not much surface area is lost at the lower elevations.

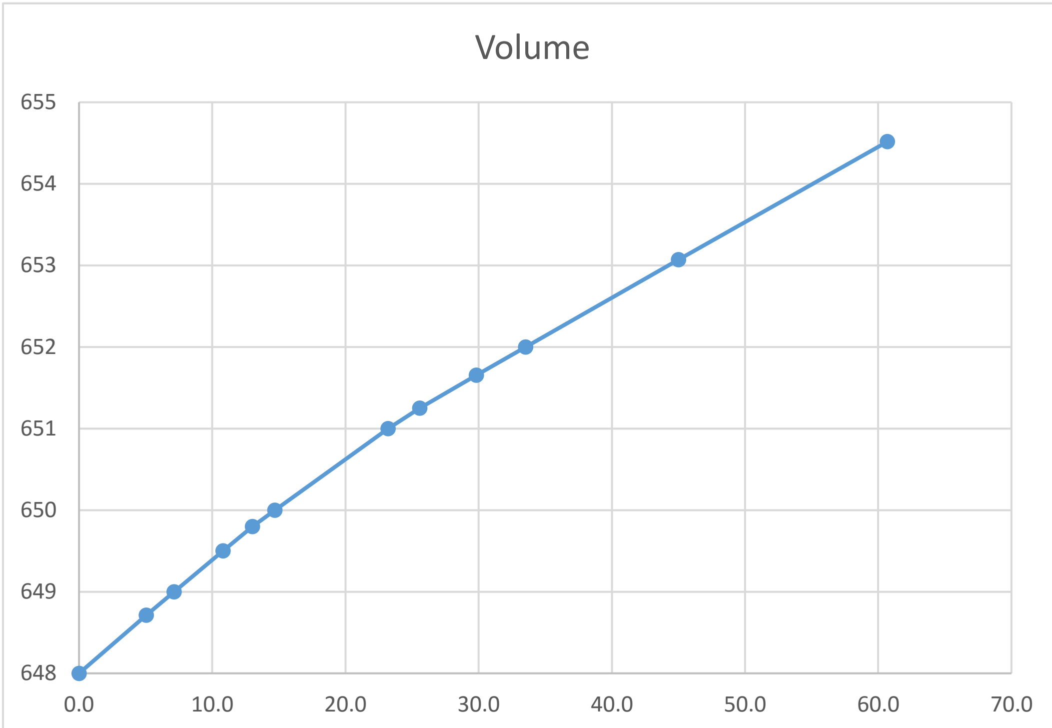
Referring to said Cut-Off wall drawing, the smaller ponds effectively add capacity to the pond as the water level rises above the connecting pipe invert elevations.

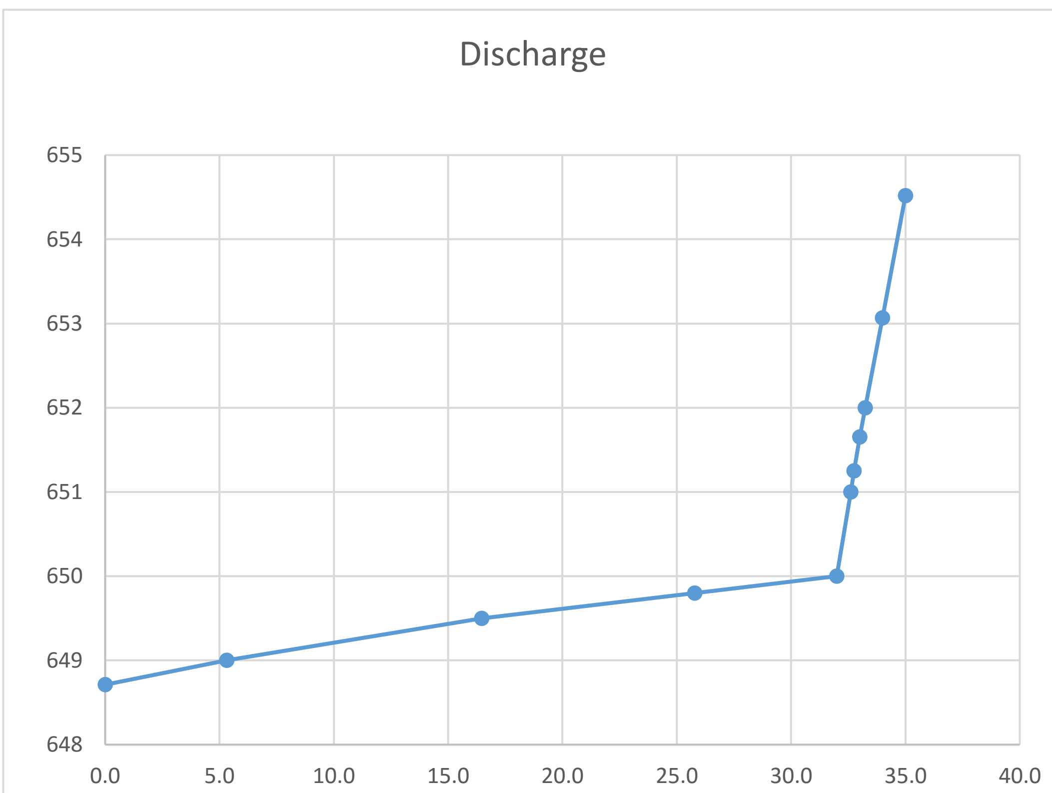
Pond	Lowest outlet Invert	With Base Flow (+0.6')	Area (acres)	assume areas constant with depth
4	649.20	649.80	0.82	
3	650.40	651.00	0.86	
2	650.65	651.25	0.90	
1	652.38	652.98	Ignore	

Combined Storage versus Elevation

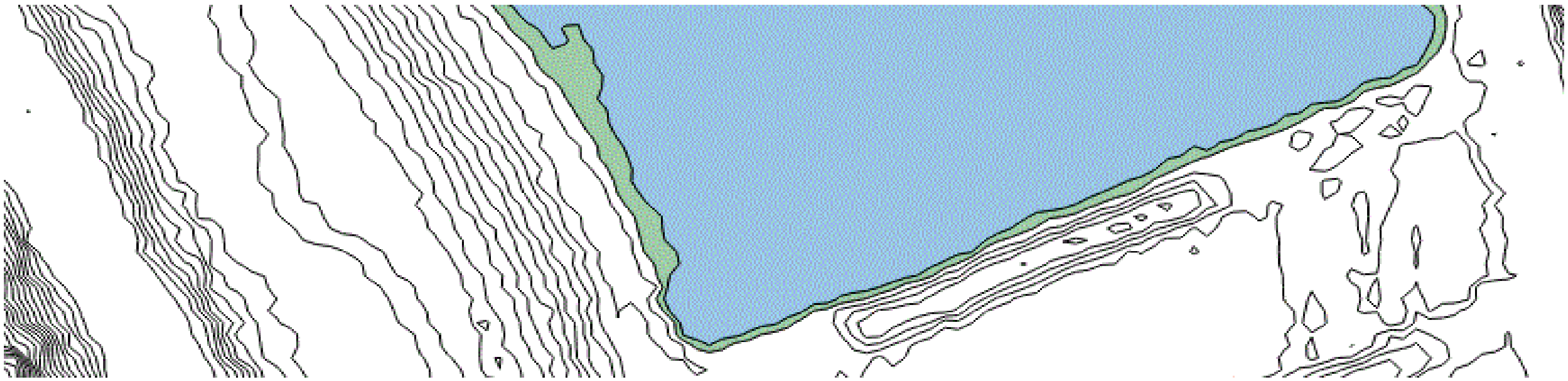
Main Pond Areas interpolated and conservatively extrapolated (above 652' & below 650')

Elevation Feet	Main Acres	dVolume Acre-Feet	Volume Acre-Feet	Pond 4 Volume	Pond 3 Volume	Pond 2 Volume	Total Volume	Discharge (above base flow) CFS	
648.00	7.00	0	0				0.00	0	
648.71	7.19	5.05	5.05				5.05	0.0	
649.00	7.27	2.08	7.13				7.13	5.3	
649.50	7.40	3.67	10.80				10.80	16.5	
649.80	7.48	2.23	13.03	0			13.03	25.8	Interpolated Q
650.00	**7.53**	1.50	14.53	0.16			14.70	32	
651.00	7.83	7.68	22.21	0.98	0		23.20	32.6	Interpolated Q
651.25	7.90	1.97	24.18	1.19	0.22	0	25.58	32.8	Interpolated Q
651.65	8.02	3.21	27.39	1.52	0.56	0.36	29.84	33	
652.00	**8.12**	2.79	30.19	1.80	0.86	0.68	33.53	33.2	Interpolated Q
653.07	8.20	8.72	38.91	2.68	1.78	1.64	45.00	34	
654.52	8.30	11.95	50.86	3.87	3.03	2.94	60.69	35	


Volume
655
654
653
652
651
650
649
648
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0


Discharge
655
654
653
652
651
650
649
648
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0

Main Ash Pond 650 & 652 Contours




7.57 acres @ 650’
0.82 acres

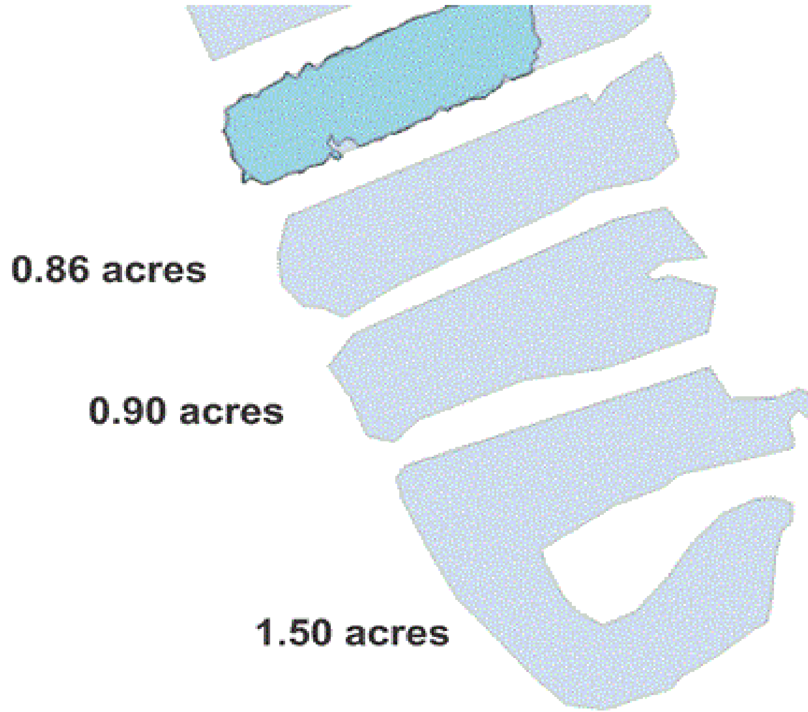
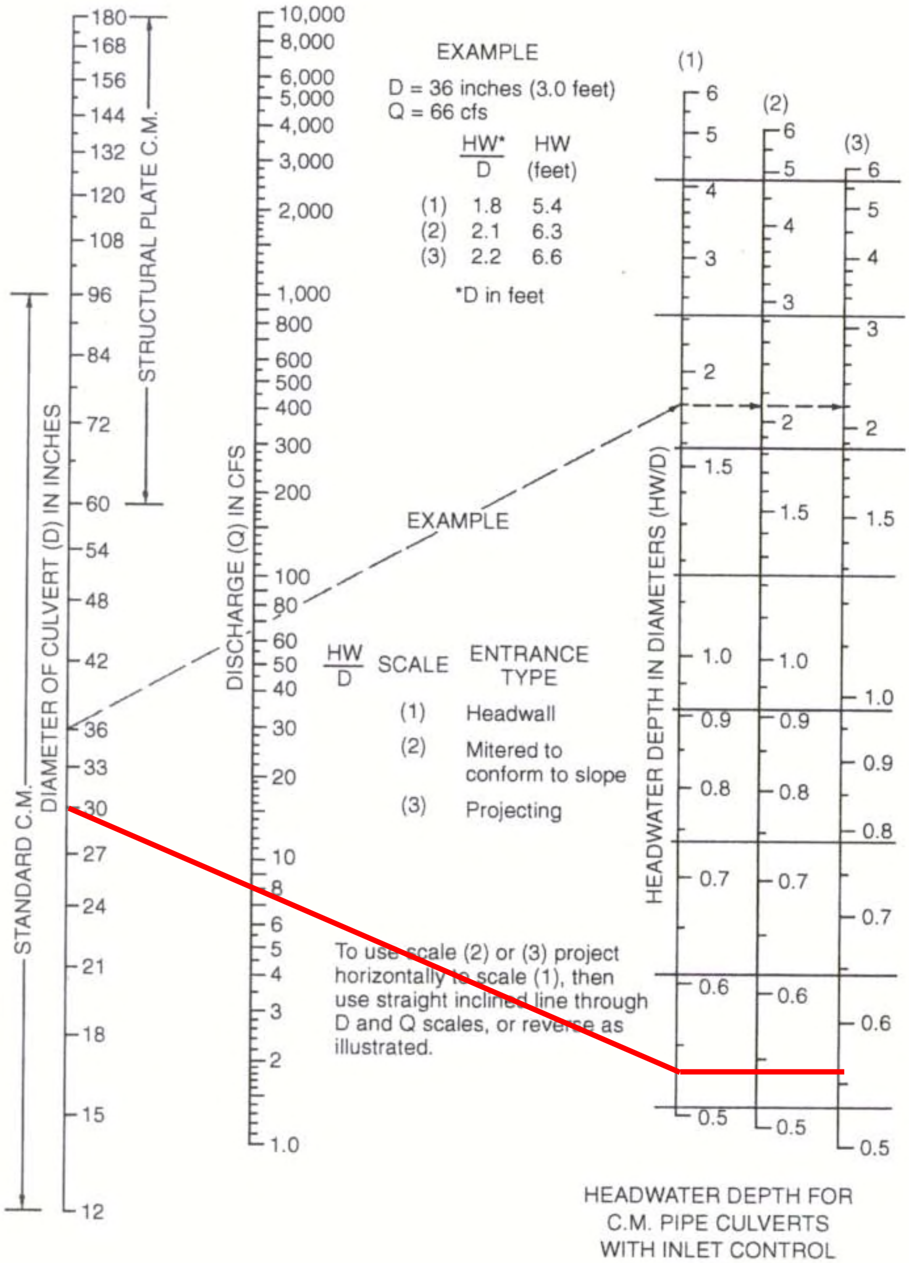

0.86 acres
0.90 acres
1.50 acres

Figure 7: Inlet Control Nomograph



Bureau of Public Roads, Jan. 1963.

NOTES

1. FOR GENERAL NOTES SEE DWG. S-
2. ALL GRATINGS, CURB ANGLES, HANDRAIL & HANDRAIL POSTS SHALL BE GALVANIZED.
3. STOP LOG TIMBER SHALL BE - DENSE SELECTED STRUCTURAL GRADE DOUGLAS-FIR AND BE TREATED WITH CREOSOTE PRESERVATIVE, 1" MIN. PENETRATION & CREOSOTE RETENTION OF 8.0 LBS PER CUBIC FOOT.
4. FURNISH ONE "SECTION" OF STOP LOG WHICH CONSISTS OF 3-5½"x11½" WIDE TIMBERS FASTENED TOGETHER AS A UNIT AS INDICATED IN S.&L. STD. DWG. 1743-6 FOR BOTTOM PART OF EACH "SET". COAT HEAVILY WITH BITUMINOUS PAINT BETWEEN TIMBERS. FURNISH SINGLE 5½"x11½" WIDE STOP LOGS FOR ALL OTHERS.

REFERENCE DRAWINGS

S-215	WEIR BOX Nº1, Nº2 & Nº3 - SECTIONS & DETAILS

Drawing Release Record

Rev.	Date	Init.	Description
	3-28-74	ASC	FOR MATERIAL ONLY
A	5-28-74	ASC	FOR CONSTRUCTION
B	9-5-74	ASC	STOP LOGS CHG'D
C	9-25-74		DIMENSIONS CHANGED
D	7-7-75	ASC	REV. ELEVATIONS, REV. PILING
E	2-25-75		COMPACTED GRAVEL FILL ADDED

I hereby certify that this plan, specification or report was prepared by me or under my direct personal supervision and that I am a duly registered Professional Engineer under the laws of the State of Iowa.

Signed [signature] Date 8-14 1974

R. N. Bergstrom, P.E., Iowa Reg. No. 4480

R. N. BERGSTROM REGISTERED 4480 IOWA PROFESSIONAL ENGINEER

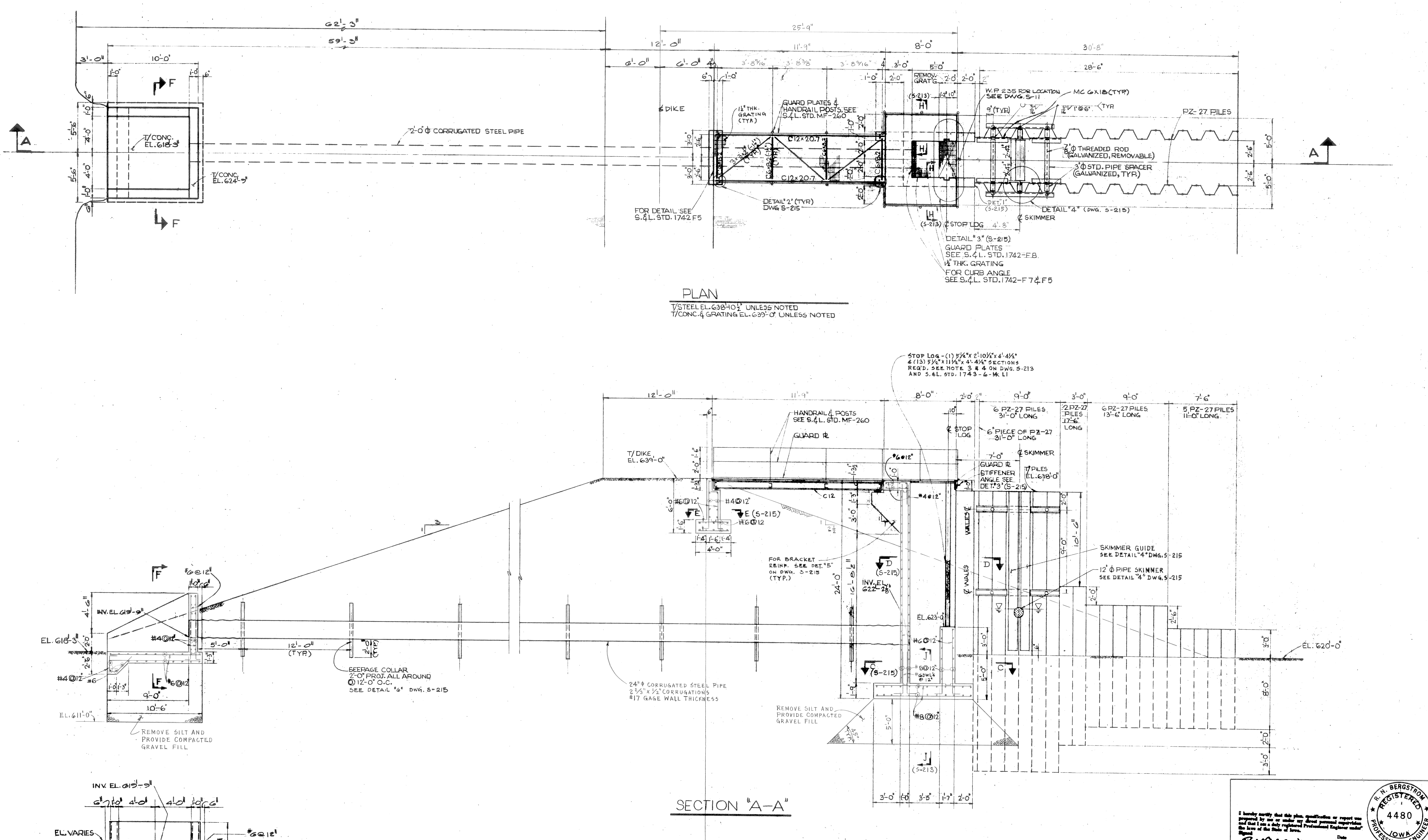
WEIR BOX NO.1 & NO.2 - PLAN SECTIONS & DETAILS ASH SETTLING BASIN

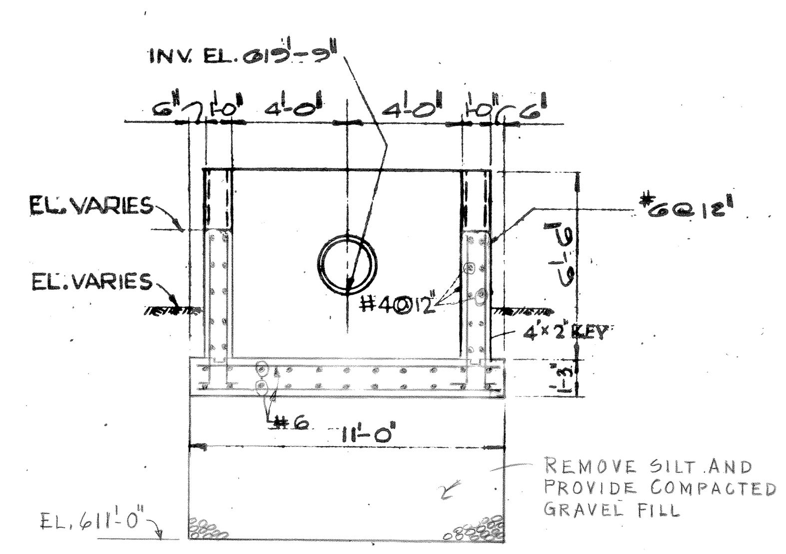
LANSING POWER STATION UNIT 4
INTERSTATE POWER CO.
LANSING, IOWA

SCALE ¼"=1'-0" UNLESS NOTED
DRAWN S.J.C. 12-13-73
CHECKED S.K. JUNG 8/12/74
ENGINEER [signature] 8-12-74
APPROVED [signature] 8.14.74
JOB NO. 4644

SARGENT & LUNDY ENGINEERS CHICAGO

DRAWING NO. S-213





NOTES

1. FOR GENERAL NOTES SEE DWG. S-
2. ALL GRATINGS, CURB ANGLES, HANDRAILS & HANDRAIL POSTS SHALL BE GALVANIZED.

REFERENCE DRAWINGS

S-215	WEIR BOX NO 1, NO 2, & NO 3 - SECTIONS & DETAILS
S-11	SITE DEVELOPMENT, PLANT FILL-UNIT 4

Drawing Release Record

Rev.	Date	Init.	Description
	3-28-74	ASC	FOR MATERIAL ONLY
A	6-21-74	ASC	FOR CONSTRUCTION
B	9-5-74	ASC	STOP LOGS CHG'D
C	9-25-74	ASC	DIM. CHANGED
D	7-25-75	ASC	COMPACTED GRAVEL FILL ADDED
E	1-30-76	ASC	DIM'S CHANGED

I hereby certify that this plan, specification or report was prepared by me or under my direct personal supervision and that I am a duly registered Professional Engineer under the laws of the State of Iowa.
Signed [signature] Date 8-19 1974
R. N. Bergstrom, P.E., Iowa Reg. No. 4480

R. N. BERGSTROM REGISTERED 4480 IOWA PROFESSIONAL ENGINEER

WEIR BOX NO. 3 - PLAN & SECTIONS ASH SETTLING BASIN

LANSING POWER STATION UNIT 4 INTERSTATE POWER CO. LANSING, IOWA

SCALE ¼" = 1'-0" UNLESS NOTED
DRAWN A. HUQ 3-11-74
CHECKED S. K. JUNG 8/12/74
ENGINEER [signature] 8-12-74
APPROVED [signature] 8-14-74
JOB NO. 4644

SARGENT & LUNDY ENGINEERS CHICAGO

DRAWING NO. S-214

APPENDIX C – Hydraulic Analysis

Alliant Energy
Interstate Power and Light Company
Lansing Generating Station
Lansing, Iowa

Inflow Design Flood Control System Plan

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (acft)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (acft)	Hydrograph description
1	SCS Runoff	815.80	6	720	57.917	----	------	------	Hillside & Landfill + Pond Area
2	Reservoir	33.48	6	858	52.866	1	652.37	37.493	Ash Ponds

Proj. file: Lansing Iowa 13.gpw	Return Period: 1,000 yr	Run date: 05-07-2016

Hyd. No. 1

Hillside & Landfill + Pond Area

Hydrograph type	= SCS Runoff	Peak discharge	= 815.80 cfs
Storm frequency	= 1,000 yrs	Time interval	= 6 min
Drainage area	= 87.00 ac	Curve number	= 72
Basin Slope	= 19.0 %	Hydraulic length	= 2150 ft
Tc method	= LAG	Time of conc. (Tc)	= 17 min
Total precip.	= 12.10 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 57.917 acft

Hydrograph Discharge Table

Time -- (min	Outflow cfs)	Time -- (min	Outflow cfs)	Time -- (min	Outflow cfs)
516	8.27	924	26.24	1332	11.23
528	9.44	936	24.97	1344	11.14
540	10.70	948	23.70	1356	11.05
552	11.85	960	22.43	1368	10.95
564	12.60	972	21.36	1380	10.86
576	13.26	984	20.77	1392	10.77
588	14.64	996	20.32	1404	10.68
600	16.67	1008	19.87	1416	10.59
612	19.09	1020	19.42	1428	10.50
624	22.14	1032	18.97	1440	10.41
636	25.63	1044	18.52		
648	30.29	1056	18.06		
660	36.02	1068	17.61	...End	
672	41.56	1080	17.15		
684	55.68	1092	16.70		
696	88.11	1104	16.24		
708	304.04	1116	15.78		
720	815.80 <<	1128	15.32		
732	467.57	1140	14.86		
744	135.07	1152	14.40		
756	96.65	1164	13.94		
768	73.99	1176	13.48		
780	63.78	1188	13.02		
792	55.62	1200	12.56		
804	49.93	1212	12.19		
816	45.01	1224	12.04		
828	40.80	1236	11.95		
840	37.16	1248	11.86		
852	34.15	1260	11.77		
864	32.52	1272	11.68		
876	31.27	1284	11.59		
888	30.02	1296	11.50		
900	28.77	1308	11.41		
912	27.51	1320	11.32		

Hyd. No. 2

Ash Ponds

Hydrograph type	= Reservoir	Peak discharge	= 33.48 cfs
Storm frequency	= 1,000 yrs	Time interval	= 6 min
Inflow hyd. No.	= 1	Reservoir name	= Ponds (Base Start)
Max. Elevation	= 652.37 ft	Max. Storage	= 37.493 acft

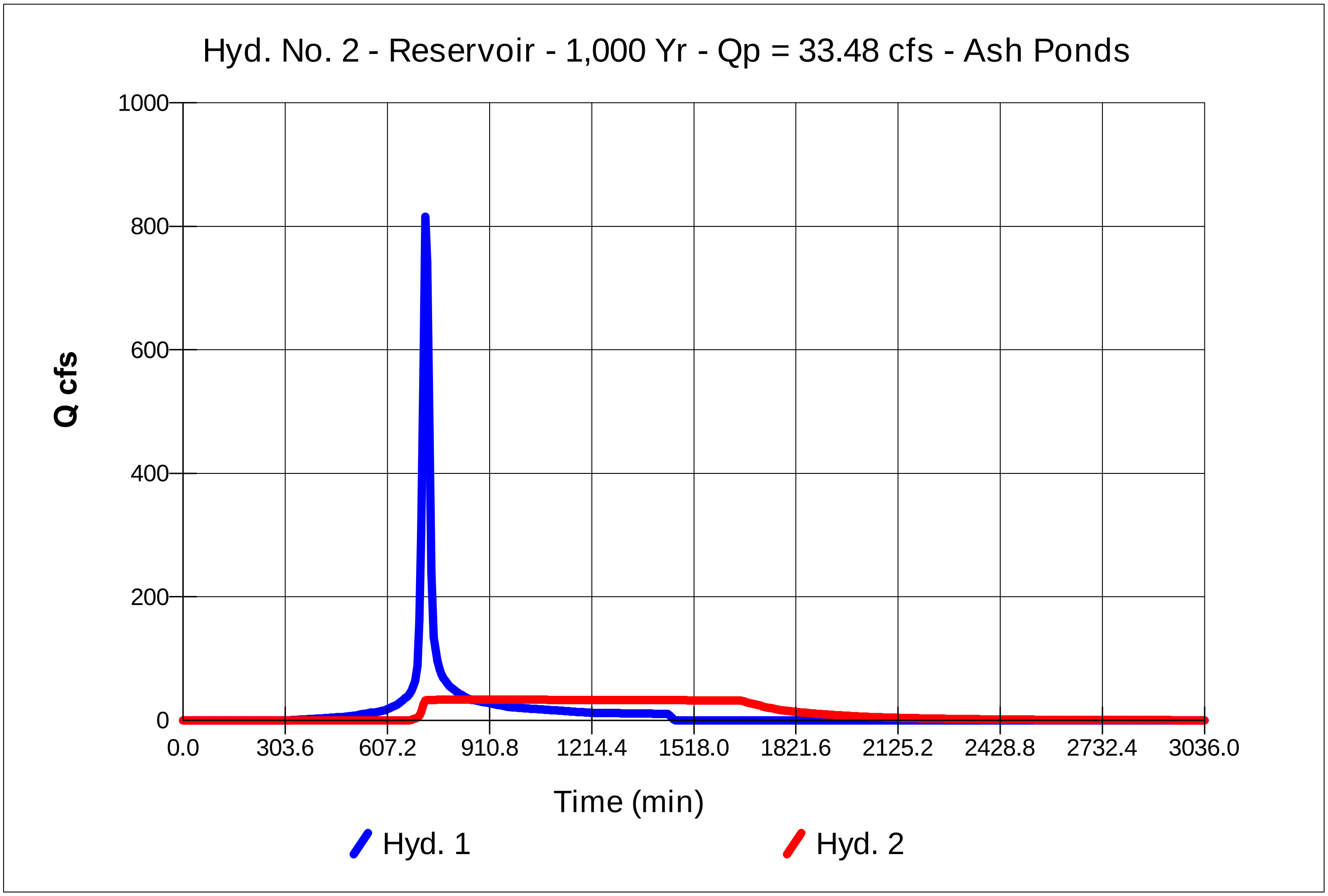
Storage Indication method used.

Outflow hydrograph volume = 52.866 acft

Hydrograph Discharge Table

Time (min)	Inflow cfs	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	Outflow cfs
720	815.80 <<	650.46	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.28
780	63.78	652.25	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.39
840	37.16	652.37	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.47
900	28.77	652.36	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.47
960	22.43	652.30	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.42
1020	19.42	652.20	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.35
1080	17.15	652.08	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.26
1140	14.86	651.95	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.17
1200	12.56	651.80	-----	-----	-----	-----	-----	-----	-----	-----	-----	33.08
1260	11.77	651.63	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.99
1320	11.32	651.47	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.91
1380	10.86	651.30	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.82
1440	10.41	651.11	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.69
1500	0.00	650.82	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.49
1560	0.00	650.51	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.31
1620	0.00	650.20	-----	-----	-----	-----	-----	-----	-----	-----	-----	32.12
1680	0.00	649.89	-----	-----	-----	-----	-----	-----	-----	-----	-----	28.57
1740	0.00	649.63	-----	-----	-----	-----	-----	-----	-----	-----	-----	20.50
1800	0.00	649.43	-----	-----	-----	-----	-----	-----	-----	-----	-----	15.03
1860	0.00	649.28	-----	-----	-----	-----	-----	-----	-----	-----	-----	11.68
1920	0.00	649.17	-----	-----	-----	-----	-----	-----	-----	-----	-----	9.07
1980	0.00	649.08	-----	-----	-----	-----	-----	-----	-----	-----	-----	7.05
2040	0.00	649.01	-----	-----	-----	-----	-----	-----	-----	-----	-----	5.48
2100	0.00	648.95	-----	-----	-----	-----	-----	-----	-----	-----	-----	4.41
2160	0.00	648.91	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.58
2220	0.00	648.87	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.90
2280	0.00	648.84	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.35
2340	0.00	648.81	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.90

...End


Hyd. No. 2 - Reservoir - 1,000 Yr - Qp = 33.48 cfs - Ash Ponds
Q cfs
1000
800
600
400
200
0
0.0
303.6
607.2
910.8
1214.4
1518.0
1821.6
2125.2
2428.8
2732.4
3036.0
Time (min)
Hyd. 1
Hyd. 2

Reservoir Report

Hydraflow Hydrographs by Intelisolve

Reservoir No. 3 - Ponds (Base Flow Start)

Pond Data

Pond storage is based on known values

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (acft)	Total storage (acft)
0.00	648.00	00	0.000	0.000
0.71	648.71	00	5.050	5.050
1.00	649.00	00	2.080	7.130
1.50	649.50	00	3.670	10.800
1.80	649.80	00	2.230	13.030
2.00	650.00	00	1.670	14.700
3.00	651.00	00	8.500	23.200
3.25	651.25	00	2.380	25.580
3.65	651.65	00	4.260	29.840
4.00	652.00	00	3.690	33.530
5.07	653.07	00	11.470	45.000
6.52	654.52	00	15.690	60.690

Culvert / Orifice Structures

		[A]	[B]	[C]	[D]
Rise in	=	0.0	0.0	0.0	0.0
Span in	=	0.0	0.0	0.0	0.0
No. Barrels	=	0	0	0	0
Invert El. ft	=	0.00	0.00	0.00	0.00
Length ft	=	0.0	0.0	0.0	0.0
Slope %	=	0.00	0.00	0.00	0.00
N-Value	=	.000	.000	.000	.000
Orif. Coeff.	=	0.00	0.00	0.00	0.00
Multi-Stage	=	n/a	No	No	No

Weir Structures

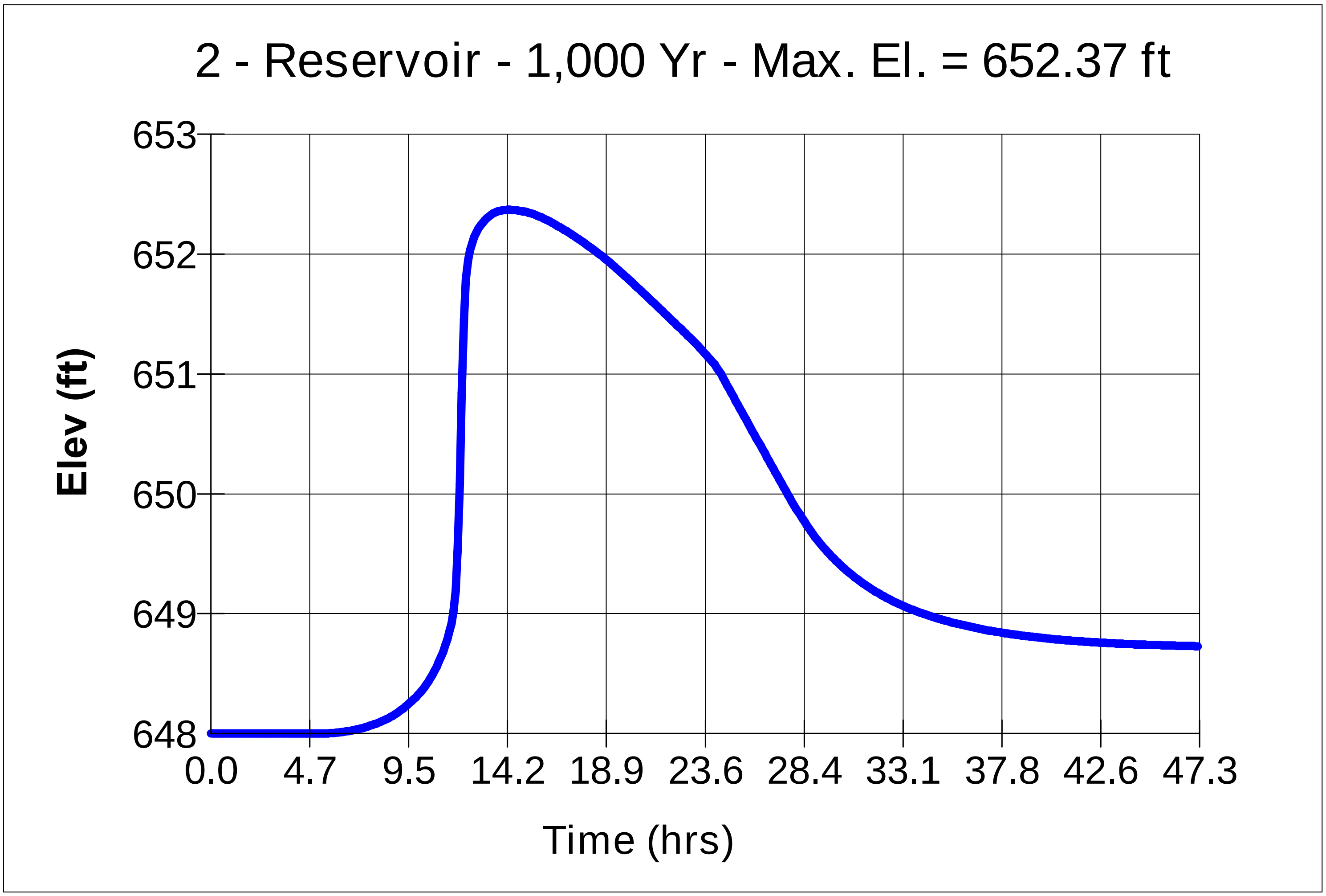
		[A]	[B]	[C]	[D]
Crest Len ft	=	4.00	0.00	0.00	0.00
Crest El. ft	=	648.00	0.00	0.00	0.00
Weir Coeff.	=	3.33	0.00	0.00	0.00
Weir Type	=	Rect	---	---	---
Multi-Stage	=	No	No	No	No

Exfiltration Rate = 0.00 in/hr/sqft Tailwater Elev. = 0.00 ft

Note: All outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage acft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	Total cfs
0.00	0.000	648.00	---	---	---	---	0.00	---	---	---	---	0.00
0.71	5.050	648.71	---	---	---	---	0.00	---	---	---	---	0.00
1.00	7.130	649.00	---	---	---	---	0.00	---	---	---	---	5.30
1.50	10.800	649.50	---	---	---	---	0.00	---	---	---	---	16.50
1.80	13.030	649.80	---	---	---	---	0.00	---	---	---	---	25.80
2.00	14.700	650.00	---	---	---	---	0.00	---	---	---	---	32.00
3.00	23.200	651.00	---	---	---	---	0.00	---	---	---	---	32.60
3.25	25.580	651.25	---	---	---	---	0.00	---	---	---	---	32.80
3.65	29.840	651.65	---	---	---	---	0.00	---	---	---	---	33.00
4.00	33.530	652.00	---	---	---	---	0.00	---	---	---	---	33.20
5.07	45.000	653.07	---	---	---	---	0.00	---	---	---	---	34.00
6.52	60.690	654.52	---	---	---	---	0.00	---	---	---	---	35.00


2 - Reservoir - 1,000 Yr - Max. El. = 652.37 ft
Elev (ft)
653
652
651
650
649
648
0.0
4.7
9.5
14.2
18.9
23.6
28.4
33.1
37.8
42.6
47.3
Time (hrs)