Memorandum

Date: April 20, 2018

To: Christian Johanningmeier, City of Columbia Water & Light

From: Brian Weis, P.E., Burns & McDonnell
Theresa Collins, Burns & McDonnell

Re: More's Lake Inflow Flood Control System Plan

STATE OF MISSOURI
BRIAN CHRISTOPHER WEIS
NUMBER PE-2011000962
PROFESSIONAL ENGINEER

04/20/18

Burns & McDonnell has prepared this memorandum for the City of Columbia Missouri Water & Light Department (City) to analyze the More's Lake Coal Combustion Residuals (CCR) Impoundment for adequate management of inflow resulting from the design storm event.

Facility Description and Status

The More's Lake CCR Impoundment (Facility) is located at the Columbia Municipal Power Plant (Plant) at 1501 Business Loop 70 East, Columbia, Missouri 65201. The Facility was originally constructed as a farm pond in the late 1800s. From 1945 to 2015, it was used as an impoundment for Plant CCR material. The Plant ceased burning coal in 2015 and is in the process of clean-closing the impoundment. Approximately 90 percent of the CCR material has been removed to date and the impoundment is currently being maintained in a dewatered state to facilitate the closure-by-removal process. Completion of the impoundment clean closure is expected to occur in 2018 or 2019. The Facility will remain in a dewatered state until clean closure status is certified. The resulting pond will be restored to normal levels and the property will potentially be dedicated as a City park.

Hydrologic Analysis

Drainage Area and Base Flow Overview

The Facility is situated such that upgradient areas to the east and southeast drain to the impoundment through overland flow, small channels, and piping. The Plant at times discharges small quantities of process water at a rate of 0.67 cubic feet per second (cfs). For modeling purposes, this discharge is considered a base flow into the impoundment. The process water does not contain CCR material. The impoundment drainage area is shown in Figure 1, attached. The drainage area includes a small residential area (offsite) to the east, a small segment of Bowling Street, a grassy area adjacent to the impoundment, and areas of the Plant to the southeast.

Basis of Design

Per 40 CFR Part 257.82, the design storm is selected based on the impoundment hazard classification. A 2014 report entitled *Assessment of Dam Safety of Coal Combustion Surface Impoundments – Final Report* [1] identified the More's Lake impoundment as having a high hazard

[1] CDM Smith, Inc. *Assessment of Dam Safety of Coal Combustion Surface Impoundments – Final Report.* April 8, 2014

potential. The design storm for a high hazard impoundment is the probable maximum flood (PMF), defined in 40 CFR Part 257.53 as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin.

The PMF is estimated using the Probable Maximum Precipitation (PMP). The PMP is published in the National Oceanic and Atmospheric Administration's Hydrometeorological Report No. 51. The 24-hour PMP storm for small drainages in this region is 34.7 inches.

Methodology

A model of the More's Lake Impoundment was created in Bentley® PondPack V8i software using the United States Department of Agriculture's Soil Conservation Service (SCS) hydrograph method. The models contain the drainage area (acres), the impoundment capacity (volume), the outfall pipe parameters (dimensions and elevation), and the impoundment overflow structure (broad crested weir dimensions). An elevation-area table defines the available storage volume. The table was populated based on the approximate grades of the impoundment bottom surface.

Existing Conditions

Two 10-inch outfall pipes located in the southwestern corner of the Facility provide the primary means of discharge for the impoundment (see Figure 1). The outfall pipes are routed horizontally through the impoundment dam; the inlets are configured with a 90-degree bend facing upward. Flow from both pipes converge in a manhole northwest of the dam. The inlet rim elevation of the discharge pipes (above the 90-degree bends) is 766.5 feet above mean sea level (amsl). The impoundment does not have a typical emergency spillway constructed near the dam. Instead, emergency overflow is routed along the east side of the plant. If an overflow occurs, there is a risk that water could enter the Plant. The top of dam elevation is 770.5 amsl and the emergency overflow point near the northeast corner of the Plant is approximately 769.5 amsl.

Since dewatering of the impoundment began in 2016, a surface water elevation of 750 to 752 amsl has generally been maintained within the dewatered basin. This surface water elevation has been confirmed by several field observations over the intervening time period. Following precipitation events, the impoundment water surface has been observed at higher elevations ranging from approximately 757 to 758 amsl. When higher elevations are observed, the water surface elevation is subsequently lowered by pumping water through treatment (filtration) prior to discharging at approximately 200-210 gallons per minute via the 10-inch outlet pipes.

Modeled Flood Control Plan Scenarios

Two impoundment drainage scenarios were modeled for management of inflows resulting from the PMF event. One scenario represents the current impoundment (i.e., no grading modifications)

remaining in a dewatered condition to facilitate clean closure. The second scenario represents the planned final impoundment condition in which grading east of the impoundment would result in a large flat area conducive to a park setting. To improve hydraulics for both scenarios, it is recommended that the 90-degree bend be removed from the primary outlet pipes, resulting in horizontally projecting pipes with an invert elevation of 765.6 amsl. This modification was assumed for both model scenarios, described in further detail below.

Scenario 1: Existing Dewatered Condition (Temporary):
The Facility flood control system was modeled assuming the current impoundment conditions, pending clean closure, with the impoundment basin remaining in a dewatered condition until the clean closure can be certified. To represent the most severe combination of conditions for this scenario, the model was configured assuming fully saturated soil conditions. The initial water surface for modeling the PMP was conservatively set at an elevation of 761.5 amsl. Modeled conditions for Scenario 1 are shown in Figure 2.

Scenario 2: Planned Final Condition (Permanent):
A large berm located directly east of the impoundment previously provided secondary containment for large fuel oil tanks which have been removed (see Figure 1). The City plans to remove the remaining portions of the berm and lower the elevation of the area east of the impoundment. The material removed would be placed further east, along the Bowling Street embankment. This grading would provide for a future park area and will also provide more storage volume for inflow flood water. Modeled conditions for Scenario 2 are shown in Figure 3.

The inputs to the PMP model scenarios and results are summarized in Table 1.

Table 1 – Impoundment Model Input and Results

Scenario	SCS Curve No.	Drainage Area (Acres)	Lag Time (Mins.)	Inflow Volume (acre-feet)	Initial Water Surface Elevation (amsl)	Final Water Surface Elevation (amsl)	Primary Outlet Pipes Peak Flowrate (cfs)	Overflow Peak Flowrate (cfs)
1. Existing Dewatered Condition	98	14.8	5.0	43.9	761.5	768.6	7.6	0
2. Planned Final Condition	98	14.8	5.0	43.9	765.6	770.0	9.3	17.4

Summary of Results

The model shows that inflow resulting from the PMF is contained within the impoundment in Scenario 1, as long as the impoundment remains in a dewatered state. Measures should be implemented to maintain water surface elevations below 758 amsl under normal conditions. Maintaining a lower water surface will provide a contingent storage volume in the event that excessive wet weather, pump equipment problems, clogging, or other unexpected issues precede the PMP. Additional recommended measures include the following:

- Perform daily inspections to monitor the water surface elevation and to confirm the system is operating sufficiently.
- Install and maintain a depth gauge for easy monitoring of water surface elevation by inspectors. Gauge should be surveyed and tied to elevations referenced herein.
- Ensure a backup pump system is available to be installed if the dedicated system fails or needs maintenance.
- Remove 90-degree bends from the inlet ends of both 10-inch outlet pipes.
- The dewatering pump piping is currently routed to the entrance of the outlet pipes, which may obstruct flow from the impoundment pool. Reconfiguring of the pump piping will be necessary upon removal of the 90-degree bends from the inlet ends of the 10-inch pipes. Ensure reconfigured pump piping does not obstruct flow in the primary outlet pipes during rain events.

Scenario 2 results show that water would exceed the overflow point northeast of the Plant. As modeled, the depth of flow in this area could reach up to 6 inches and flow at a rate of 17.4 cfs. Prior to establishing Scenario 2 as the final condition, further investigation should confirm safe conveyance of the overflow water to the south of the Plant. If it is determined that the current emergency overflow path presents an unacceptable risk to City personnel or property, a secondary outlet should be designed and implemented prior to establishing Scenario 2 as the final condition.

Model reports have been included as attachments.

Attachments:

Figure 1 – Aerial Site Map
Figure 2 – Existing Drainage Area
Figure 3 – Drainage Scenario 2
Model Reports – Scenario 1
Model Reports – Scenario 2

Figures

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0 200 400

SCALE IN FEET

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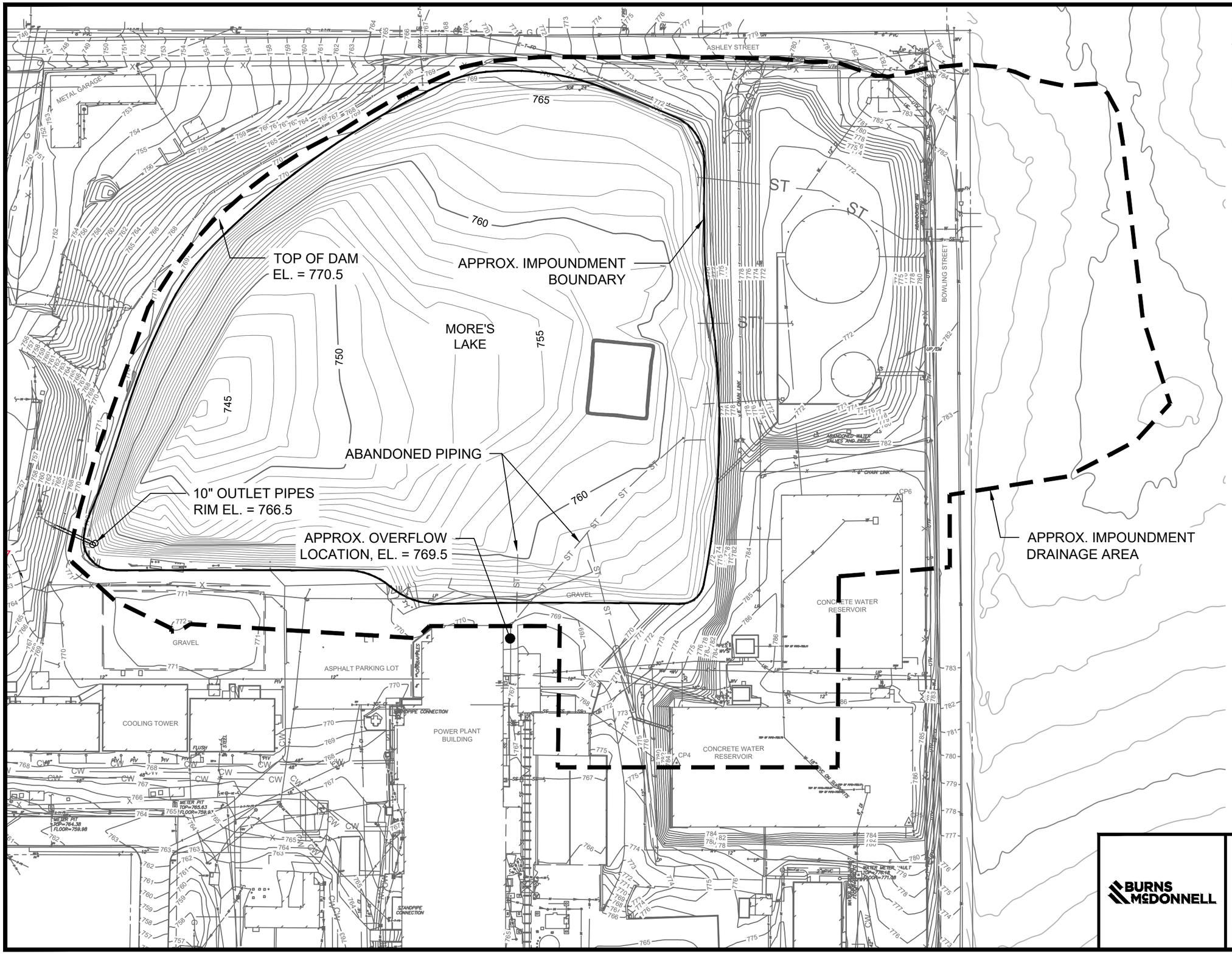
FIGURE 1
AERIAL SITE MAP
MORE'S LAKE
COLUMBIA, MISSOURI

COPYRIGHT © 2016 BURNS & McDONNELL ENGINEERING COMPANY, INC.

Z:\CLIENTS\ENS\COLUMBIAMO\106274_MORESLAKEFLOOD\DESIGN\CADD\DWGS\STUDY FIGURES\FIGURE 1 - COPY.DWG BWEIS



NOTES:

1. TOPOGRAPHIC CONTOUR INTERVAL 1 FOOT.

2. SOURCE OF TOPOGRAPHIC DATA SHOWN IS AS FOLLOWS:
- AREA EAST OF BOWLING STREET FROM CITY AERIAL SURVEY GIS DATA, OBTAINED FROM CITY UTILITIES DEPARTMENT.
- AREA WITHIN POND BOUNDARY REPRESENTS APPROXIMATE POND BOTTOM SURFACE, BASED ON TEST PITS AND HISTORICAL DATA
- DATA SHOWN FOR ALL OTHER AREAS FROM TOPOGRAPHIC SURVEY BY ENGINEERING SURVEYS AND SERVICES, 2014.
- ELEVATION REFERENCE ABOVE MEAN SEA LEVEL (AMSL).

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0 100' 200'

SCALE IN FEET

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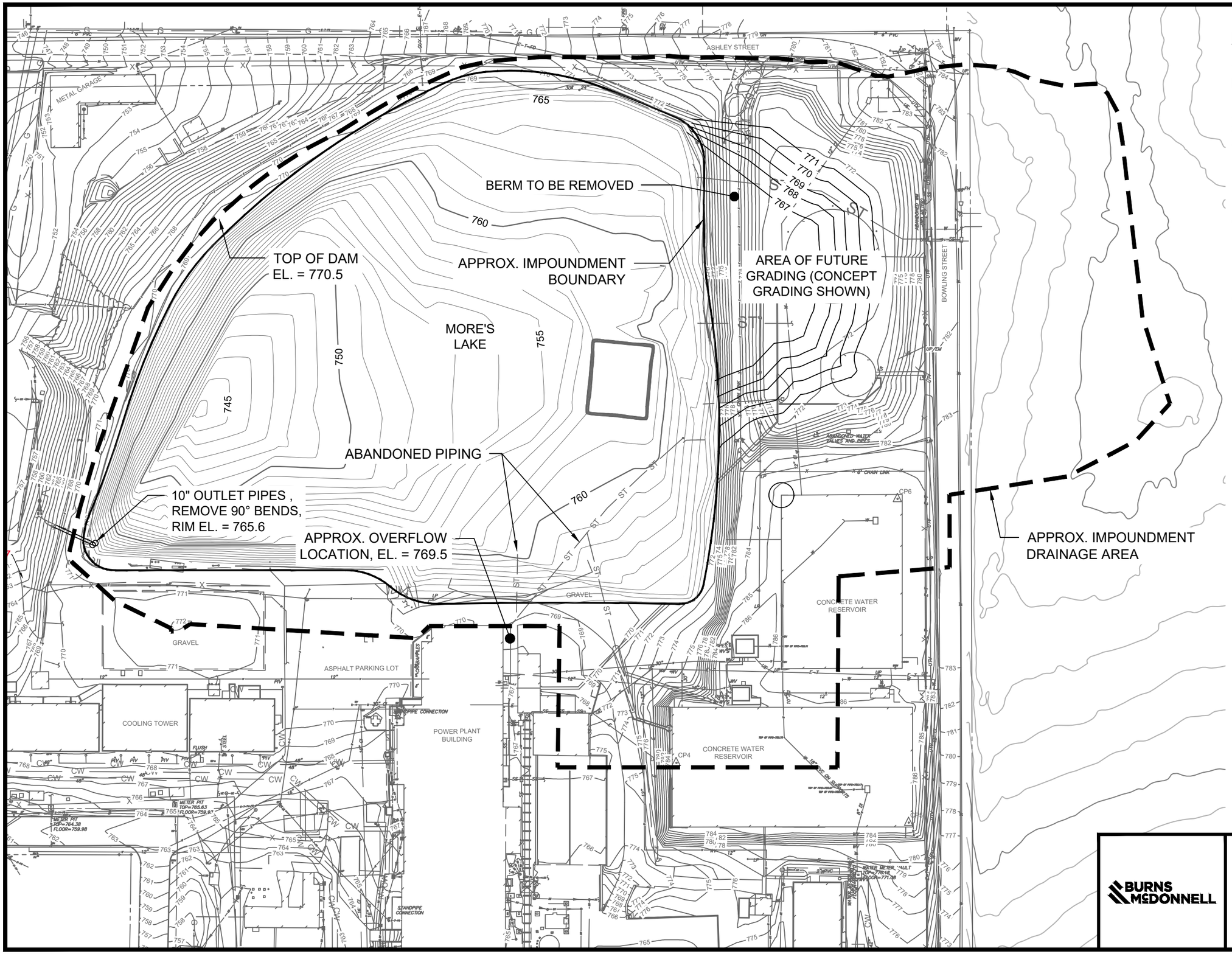
FIGURE 2
EXISTING CONDITIONS
MORE'S LAKE
COLUMBIA, MISSOURI

COPYRIGHT © 2016 BURNS & McDONNELL ENGINEERING COMPANY, INC.

Z:\CLIENTS\ENS\COLUMBIAMO\106274_MORESLAKEFLOOD\DESIGN\CADD\DWGS\STUDY FIGURES\FIGURE 2.DWG TMCOLLINS



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- ELEVATION REFERENCE ABOVE MEAN SEA LEVEL (AMSL).

N

0 100' 200'

SCALE IN FEET

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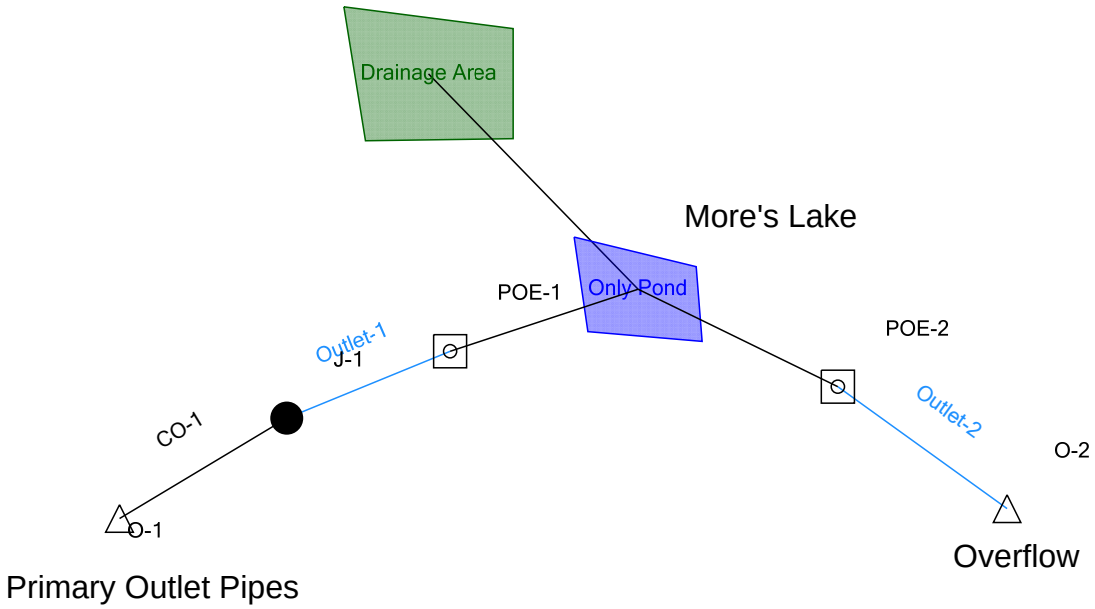
FIGURE 3
DRAINAGE SCENARIO 2
MORE'S LAKE
COLUMBIA, MISSOURI

COPYRIGHT © 2016 BURNS & McDONNELL ENGINEERING COMPANY, INC.

Z:\CLIENTS\ENS\COLUMBIAMO\106274_MORESLAKEFLOOD\DESIGN\CADD\DWGS\STUDY FIGURES\FIGURE 3.DWG TMCOLLINS

Model Reports – Scenario 1

Model Diagram



Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
Drainage Area	Base	10,000	43.880	11.900	663.17

Node Summary

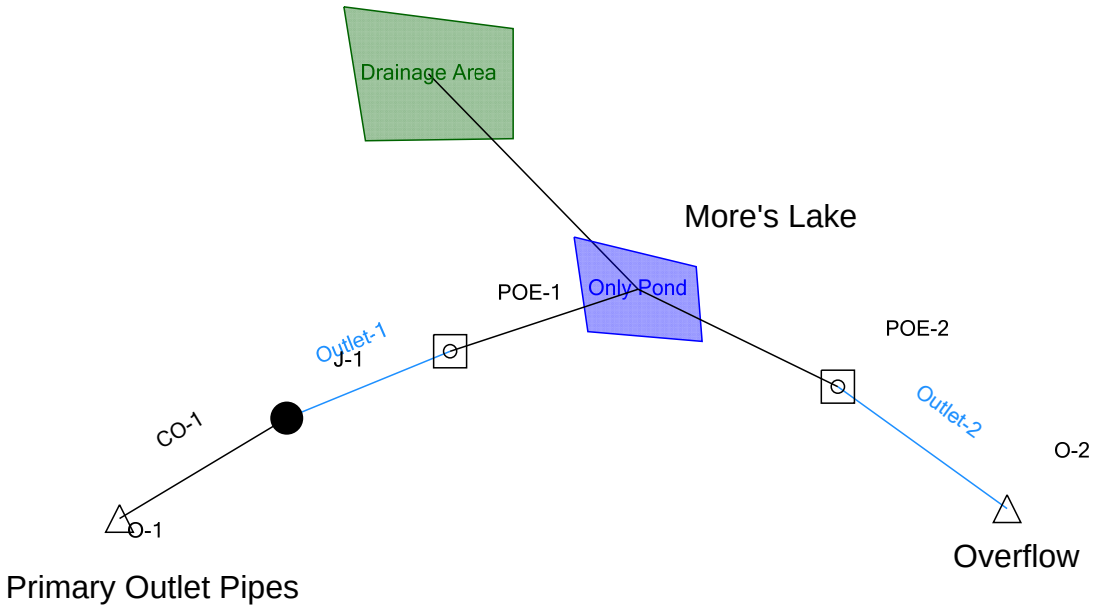
Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
J-1	Base	10,000	7.240	19.950	7.58
O-1	Base	10,000	5.242	12.000	5.27
O-2	Base	10,000	0.000	0.000	0.00

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Only Pond (IN)	Base	10,000	43.880	11.900	663.17	(N/A)	(N/A)
Only Pond (OUT)	Base	10,000	7.240	19.950	7.58	768.62	46.438

Model Reports – Scenario 2

Model Diagram



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Drainage Area	Base	10,000	43.880	11.900	663.17

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
J-1	Base	10,000	10.563	13.450	9.33
O-1	Base	10,000	6.802	9.200	5.27
O-2	Base	10,000	6.618	13.450	17.11

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Only Pond (IN)	Base	10,000	43.880	11.900	663.17	(N/A)	(N/A)
Only Pond (OUT)	Base	10,000	17.181	13.450	26.43	770.00	30.315