STRUCTURAL INTEGRITY CRITERIA & HYDROLOGIC/ HYDRAULIC CAPACITY ASSESSMENT RUSH ISLAND ENERGY CENTER

Rush Island Energy Center
100 Big Hollow Road
Festus, MO 63028

Contents

STRUCTURAL INEGRITY CRITERIA & HYDROLOGIC/ HYDRAULIC CAPACITY ASSESSMENT – RUSH ISLAND ENERGY CENTER

I. Introduction

Ameren Missouri has evaluated the Rush Island Energy Center's ("Rush Island") active surface impoundment in accordance with the following operating and design criteria requirements:

§257.71, Liner Design Criteria;
§257.73(c)(1), History of Construction;
§257.73(a)(2), Periodic Hazard Potential Classification;
§257.73(d)(1), Periodic Structural Stability Assessment;
§257.73(e)(1), Periodic Safety Factor Assessment;
§257.82, Initial Hydrologic and Hydraulic Capacity Requirements; and

For this initial assessment, Ameren Missouri retained the engineering firm Reitz & Jens, Inc. to evaluate Rush Island's active surface impoundment to determine whether such units conform to good engineering practices[1] with respect to the following criteria: liner design criteria; hazard potential classification; structural stability assessment; safety factor assessment; and initial hydrologic and hydraulic capacity requirements. Such criteria will be reassessed every five years until such time as the units are closed in accordance with regulatory requirements. Engineering calculations, diagrams modeling, and work papers supporting this assessment have been placed in the facility's operating record.

II. Background

A. Active Ponds

There is one active surface impoundment at Rush Island, which is called RCPA. The surface impoundment is used to store and manage CCR and process waters prior to discharge through Outfall #002 of NPDES permit number MO-0000043. The CCR stored within the surface impoundment is bottom and fly ash. RCPA is regulated by the MDNR because the height of the perimeter impoundment exceeds 35 feet and therefore the impoundment is subject to Missouri's dam safety regulations (MO Operating Permit ID MO-40179). RCPA was created as part of the original construction of the Rush facility in 1976. It encompasses an area of approximately 114 acres and is surrounded by a ring dam or embankment.

The location of the facility and impoundment is depicted on Figure 1, United States Geological Services ("USGS") topographical quadrangle map. Various design and operational features of the CCR units, including water flow path, is set forth on Figure 2.

[1] Based on engineering codes, widely accepted standards, or a practice widely recommended through the industry. See *40 CFR 25.53, Definitions*.

B. Embankment Dam

The RCPA embankment dam has a crest length of 9,750 feet, a minimum crown width of 14 feet, and 3 horizontal (H) to 1 vertical (V) side slopes. The maximum dam height is 46.0 feet. The RCPA is divided by an internal berm constructed of CCR. The 85 acre area to the north of the berm is used for sedimentation and disposal, and the 29 acre area to the south of the berm is used for final sedimentation "polishing" and water detention.

III. Structural Integrity Assessment

A. Liner Design Criteria – 40 CFR §257.71

For existing CCR surface impoundments constructed with liner systems, an owner/operator of such units must determine if such liner complies with the specified design and performance standards. At Rush Island, the RCPA was constructed without a liner system and is an unlined surface impoundment.

1. Engineering Certification – Liner Design Criteria for Existing CCR Surface Impoundments

The existing CCR surface impoundment RCPA at the Rush Island Energy Center was evaluated to determine if it was constructed with a liner which meets the requirements of §257.71, Liner Design Criteria for Existing CCR Surface Impoundments. The existing liner system does not have a 2-foot layer of compacted soil with hydraulic conductivity of no more than 1 x 10^{-7} cm/sec.

CCR Unit	Existing liner meets requirements of 40 CFR 257.71
RCPA	No

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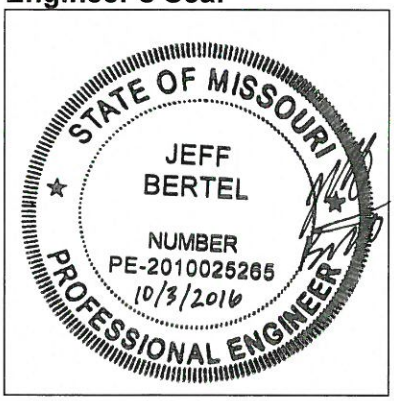

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B. Periodic Hazard Potential Classification – 40 CFR §257.73(a)(2)

Every five (5) years, an owner or operator of a coal combustion residual ("CCR") unit must update the hazard potential of CCR units and certify the results by a qualified professional engineer. The classification categories are based upon criteria established by the Federal Emergency Management Agency (FEMA) and range as follows: *low hazard potential, significant hazard potential, and high hazard potential.* The FEMA classification system categorizes a dam based on the probability of loss of human life and the impacts on economic, environmental, and lifeline facilities should the dam fail. The specific categories are defined as follows:

> *(1) High hazard potential CCR surface impoundment means a diked surface impoundment where failure or mis-operation will probably cause loss of human life.*
>
> *(2) Significant hazard potential CCR surface impoundment means a diked surface impoundment where failure or mis-operation results in no probable loss of human life, but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns.*
>
> *(3) Low hazard potential CCR surface impoundment means a diked surface impoundment where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the surface impoundment owner's property.*

40 CFR §257.53

The active pond at Rush Island is classified as having a *low hazard potential* because any structural failure would not be expected to cause a loss of human life.

- **RCPA** - Failure of RCPA would result in the release of water and CCR into the Mississippi River and potentially Isle du Bois Creek. Any such failure should not cause loss of life or significant environmental impacts. The nearest dwelling is located 1.4 miles due west in an upland bluff area. Economic and lifeline losses of the impoundment would generally be limited to the owner.

Since none of the active impoundments are classified as *high or significant potential hazards*, an emergency action plan does not need to be prepared. The hazard classification of these units must be re-evaluated every five (5) years.

1. Engineering Certification – Periodic Hazard Potential Classification

The 2015 Periodic Hazard Potential Classification Assessment was conducted for active CCR surface impoundment RCPA at the Rush Island Energy Center was conducted in accordance with the requirements of 40 CFR 257.73(a). The CCR surface impoundment is low hazard potential because failure of the impoundment is not expected to cause a loss of human life or significant environmental impacts. Economic and lifeline losses are expected to be low and generally limited to the owner. The hazard potential classification was completed in general accordance with *Federal Guidelines for Dam Safety: Hazard Potential Classification for Dams* by the Federal Emergency Management Agency (January 2004). The engineering support for this certification has been placed in the operating record.

CCR Unit	Hazard Potential Classification
RCPA	Low

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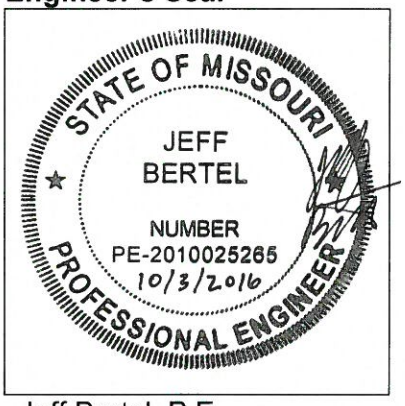

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C. Periodic Structure Stability Assessment – 40 CFR §257.73(d)

The owner or operator of a CCR unit must inspect and certify that the design construction, operation and maintenance of a CCR unit are in accordance with good engineering practices. Such engineering assessment includes the following: stable foundations and abutments; slope protection to protect against surface erosion, wave action, and adverse effects of sudden drawdown; berm compaction is sufficient to withstand the range of loading conditions, including low pool of an adjacent water body or sudden drawdown; adequately vegetated slopes and surrounding areas; adequate spillway capacity, operation and maintenance; spillways constructed, operated, and maintained to adequately manage the design flow event; and structural integrity and functionality of hydraulic structures underlying the base of CCR unit or passing through the dike .

The RCPA upstream slopes in the disposal area are primarily covered with ash and not subject to wave loading, and the majority of the upstream slopes of the polish pond are armored with riprap. The downstream slopes are vegetated or armored with riprap. Vegetative management protocols

are set forth in the Operations and Maintenance Procedures and have been implemented so as to minimize erosion while facilitating the visibility of slopes during inspections.

The engineering team reviewed pertinent geotechnical data. The team also visually inspected the interior and exterior embankment slopes, and adjacent foundation soil of the RCPA for signs of instability. None were observed. In addition, hydraulic structures (i.e. spillways, overflow pipes and ditches) were inspected to confirm proper maintenance and operation. No significant deficiencies of the structures were observed. (Some of the piping was under water and not available for visible inspection.) Recommended and ongoing activities include general maintenance (i.e. seeding for vegetative cover, erosion repair, animal control, sediment removal).

1. Engineering Certification – Periodic Structural Stability Assessment

The 2015 Initial Periodic Structural Stability Assessment was conducted for the active CCR surface impoundment RCPA at the Rush Island Energy Center. The structural stability assessment was completed in general accordance with 40 CFR Part §257.73(d)(1). Assessment of the Unit found no structural stability deficiencies, no significant issues with the current operations and maintenance, and that the design and construction are adequate, however some corrective measures were recommended. The engineering support for this certification has been placed in the operating record.

Requirement	RCPA
Initial periodic assessment was completed in general accordance with the requirements of 40 CFR Part §257.73(d)(1)	Yes

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D. Safety Factor Assessment – 40 CFR §257.73(e)

All active CCR units must have calculated Factors of Safety (FOS) that meet or exceed the following designated values:

Table 1

Loading Conditions	Minimum FOS
Maximum Storage Pool	1.50
Maximum Surcharge Pool	1.40
Seismic	1.00
Liquefaction	1.20

Reitz & Jens performed stability analysis on the active CCR surface impoundment and calculated the following values:

Table 2

Ponds	Maximum Storage Pool (FOS)	Maximum Surcharge Pool (FOS)	Seismic (FOS)	Liquefaction (FOS)
RCPA	1.51	1.42	1.07	1.29

The calculated factors of safety for the critical cross-section identified above ***meet or exceed*** the minimum factors of safety for each loading condition required by 40 CFR §257.73(e).

1. Engineering Certification – Safety Factor Assessment

The 2015 Periodic Safety Factor Assessment was conducted for the active CCR surface impoundment RCPA at the Rush Island Energy Center. The Periodic Safety Factor Assessment for the active CCR Unit at the Rush Island Energy Center shows that the critical cross section for the Unit meet or exceed the minimum factors of safety specified in 40 CFR Part §257.73(e)(1) as summarized below. The engineering support for this certification has been placed in the operating record.

Requirement	RCPA
The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.	≥1.50
The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.	≥1.40
The calculated seismic factor of safety must equal or exceed 1.00.	≥1.00
The calculated liquefaction factor of safety must equal or exceed 1.20.	≥1.20

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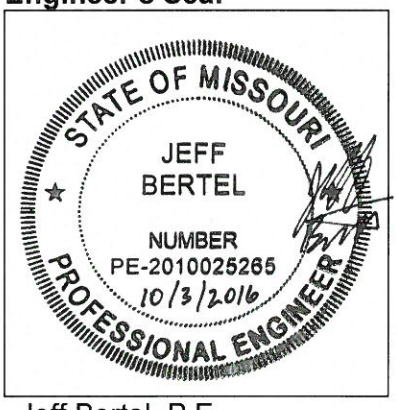

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E. Hydrologic and Hydraulic Capacity Requirements - 40 CFR §257.82

Flood control system plans must be adequate to manage the inflow from a designated flood event. Such plans must be updated and verified every five (5) years. The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge from the design flood event.

Pertinent data regarding the active surface impoundments is set forth below:

Table 3

CCR Unit	Maximum Surface Area (acres)	Levee Crest Elevation (feet)	Crest Length (feet)	Normal Pool Elevation (feet)	Maximum Surcharge Pool (feet)	Upstream Slope Steepness (H:V)	Downstream Slope Steepness (H:V)
RCPA	114	408.2 to 412.2	9750	398.0	404.6	3H:1V	3H:1V

Reitz & Jens performed a modeling analysis using the 100-year flood event for low hazard potential surface impoundments as the design flood as required by 40 CFR §257.82(a)(3)(iii). The hydrologic and hydraulic modeling analysis assumed rainfall of 7.1 inches[2] as an estimated 24-hour, 100-year precipitation event. As depicted on Figure 2, water flows through an internal ditch running along the west side of the impoundment to the polish pond.

For the RCPA, peak pool (maximum surcharge) level within the pond is estimated to occur in 24.5 hours after the start of the storm event. Peak water levels during a 100-year flood event are projected to rise to elevation 403.01 feet with a functional spillway or elevation 404.56 feet if flow through the spillway is ignored. The freeboard during the 100-year flood event is between 2.64 and 4.19 feet **below** the crest of the emergency spillway (el. 407.2 feet). The pool level should return to within 0.5 feet of normal pool elevation within about 100 hours. Accordingly, the facility's inflow design control system adequately manages flow through the CCR units during and following a 100-year flood event as required by 40 CFR §257.82. Outlet works and spillways should be maintained in proper condition to ensure normal pool elevation and to lower pool levels if necessary. The CCR in the ponds will be managed so that the available storage is at least as great as that assumed in the hydrologic and hydraulic models.

[2] Huff, F.A. and J.R. Angel. (1992). "Rainfall Frequency Atlas of the Midwest." Bulletin 71, Midwestern Climate Center and Illinois State Water Survey.

F. Inflow Design Flood Control System Capacity Plan

The initial inflow design flood control system has been evaluated for the RCPA at the Rush Island Energy Center. Based on the hydrologic and hydraulic capacity calculations, the inflow control system for this pond can adequately handle and discharge the 100-Year design flood event. *Specifically, 3.64 feet of freeboard exists.* So as to properly maintain such inflow storage capacity, the following measures of the *Inflow Design Flood Control System Plan* have been incorporated into the Operations and Maintenance Manual and should be observed:

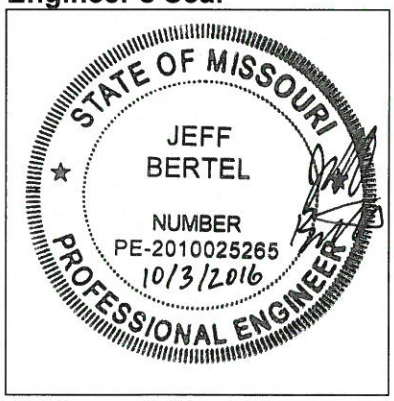
- **RCPA** - normal pool elevation should be maintained no higher than elevation 398 feet to maintain a maximum surcharge pool at elevation 404.6 feet.
- If the water levels exceed the maximum surcharge pool elevations, special inspections by the Dam Safety Group of the primary spillway should be completed.
- Prior to the next scheduled evaluation of the Periodic Inflow Design Flood Control System Plan, topographic surveys should be completed on the interior of the pond to confirm the necessary water storage is available.
- Staff gage readings should be recorded during weekly inspections to confirm the assumed normal pool elevations.

1. Engineer's Certification – Hydrologic and Hydraulic Capacity

The initial inflow design flood control system plan was completed for the active CCR surface impoundment RCPA at the Rush Island Energy Center. The initial inflow design flood control system plan was completed in general accordance with 40 CFR Part §257(e)(1) using the 100-year design flood for low hazard potential CCR surface impoundments.

Requirement	RCPA
The initial inflow design flood control system plan meet the requirements of 40 CFR Part §257.82	Yes

Engineer's Seal



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IV. Construction Summary – *40 CFR 257.73(c)*

The Rush Island Energy Center is located in southern Jefferson County, Missouri, in the Mississippi River floodplain. The plant is south of the City of Festus and north of the City of Bloomsdale. The Rush Island Energy Center has one active surface impoundment, RCPA. The Rush Island Energy Center is located adjacent to the Mississippi River within 100-year floodplain at approximately river mile 139.5 above the mouth of the Ohio River. According to the current Flood Insurance Rate Map (FIRM), the regulatory 100-year flood elevation at the site is el. 405 to 406 feet. The Mississippi River is to the east of the CCR unit. Isle du Bois Creek runs along the south side of the CCR unit. The outfall discharges into the Mississippi River.

A. Owner and Operator

The CCR Units at the Rush Island Energy Center are owned and operated by Ameren Missouri. Rush Island Energy Center plant personnel have the primary responsibility of CCR unit operation. The Rush Island Energy Center is located at 100 Big Hollow Road in Festus, Missouri 63028. The Ameren Missouri Dam Safety Group performs CCR unit inspections, and reviews all updates to the Operations and Maintenance Manual.

B. RCPA

RCPA manages fly and bottom ash, process water and stormwater from the plant property. The principal spillway for the RCPA is located in the polish pond and consists of a 24-inch diameter HDPE conduit. A check valve is installed on the downstream end and the invert elevation is approximately 372.5 feet. Flow through this pipe and the pool elevation is regulated by two motor operated butterfly valves. The RCPA also contains an emergency spillway which is located in the disposal area. The emergency spillway crest elevation is at 407.2 feet. The RCPA impounds bottom and fly ash. The estimated maximum depth of CCR in the unit is approximately 100 feet.

1. Foundation and Abutment Geology

The foundation soils generally consist of an upper stratum of clays and silts 10 to 30 feet thick underlain by fine to coarse sand about 80 to 120 feet thick. Some gravel exists in the lower part of the sand stratum. Silt and clay lenses are also present in the sand formation. Limestone rock exists beneath the alluvium, and the depth to rock generally decreases from east to west.

2. Embankment Material

There are no construction documents or records for the RCPA ring dam. The embankment fill was constructed of the less permeable material excavated from the interior of the impoundment. Borings through the embankment show the embankment fill generally consists of clays and silts with varying amounts of sand.

3. 1991 Ash Pond Discharge, Piping & Sampling Modifications

The original plans for the principal spillway reflect two, 36-inch diameter CMP conduits. Per 1991 as-built plans, the northern most conduit was slip-lined with a 24-inch diameter HDPE pipe, along with new butterfly valves, duckbill valve, concrete headwall and anchor pad, and grouted riprap. The southern conduit was abandoned and grouted closed.

4. Ash Pond Interior Berm Construction

During the period from 1999 to 2002, Ameren Missouri constructed from compacted bottom ash, an interior berm thereby dividing the ash pond into two segments. The north side is used for primarily for settlement and ash disposal, and the south side for water detention and secondary settlement.

5. 2008 Monopole Construction

In 2007 and 2008, Ameren Missouri constructed a transmission line across the plant property to serve an industrial facility located south of its property boundary. Transmission line towers are just upstream and adjacent to the embankment dam on the west side of the impoundment. The transmission line consists of monopole towers with drilled pier foundations. The bottoms of the tower foundations are at least 45 feet below the top of the dam. Geotechnical analysis indicates that such towers have no effect on pond stability.

6. 2010 Riprap Placement and Emergency Spillway Construction

In 2010, Ameren Missouri installed riprap on portions of the upstream and downstream slopes to repair and prevent erosion. Approximately 180 lineal feet of riprap was installed on the downstream slopes and 1,300 lineal feet on the upstream slopes. The banks of the outlet channel were also armored with riprap. At the same time an emergency spillway was constructed near the northwest corner of the impoundment. The emergency spillway is a 75-foot wide broad crested weir. Portions of the upstream and downstream slopes adjacent to the spillway are armored with riprap.

7. 2010 MDNR Permit Registration

The RCPA was permitted as a Class III Industrial Water Retention Dam by MDNR in 2010. The surface impoundment was inspected in 2015 by the MDNR Dam and Reservoir Safety Program and the operating permit was extended for 5 years to 2020.

8. 2013 Isle du Bois Creek Bank Erosion Repairs

On January 31, 2013, and following a high flow event on the Isle du Bois Creek, significant bank erosion occurred near the creek's confluence with the Mississippi River. Bank erosion occurred on an outside bend in the creek just before the confluence, which encroached upon the south side of the RCPA embankment and caused sloughing of the downstream slope. Ameren rebuilt the eroded section by first constructing a riprap dike to prevent further erosion, and then placing compacted soil fill behind the dike.

9. 2015 Slope Rehabilitation

An inspection in early 2015 identified erosion features and a small shallow slide on the east embankment slope. Approximately 1,500 lineal feet of the east embankment downstream slope was graded so that the slope was uniformly 3H to 1V and armored with riprap. The extents of the shallow slide were excavated, and the slope rebuilt with fill compacted in lifts. In addition, woody vegetation was cleared on the west side of the embankment.

10. 2015 Slurry Wall and Operational Changes

To address seepage occurring at the toe of the downstream slope on the east side of the pond, in 2015 a slurry wall approximately 1,300 feet long and 30 feet deep was constructed. The wall started approximately 75 feet north of the double swing gate and continued south. A "wetting head" used to condition and pneumatically transport fly ash was subsequently relocated further inside of the pond.

C. Surveillance, Maintenance and Repair of the CCR Units

The Operations and Maintenance Manual outlines objectives, responsibilities, and procedures for Ameren personnel who are responsible for the management of the CCR units. The embankments of the CCR units are visually inspected weekly by Ameren plant operations staff. Ameren Missouri Dam Safety Group personnel perform annual inspections and periodic inspections[3] or assessments with plant operations staff. In addition, the Ameren Missouri Dam Safety Group may conduct unannounced safety inspections.

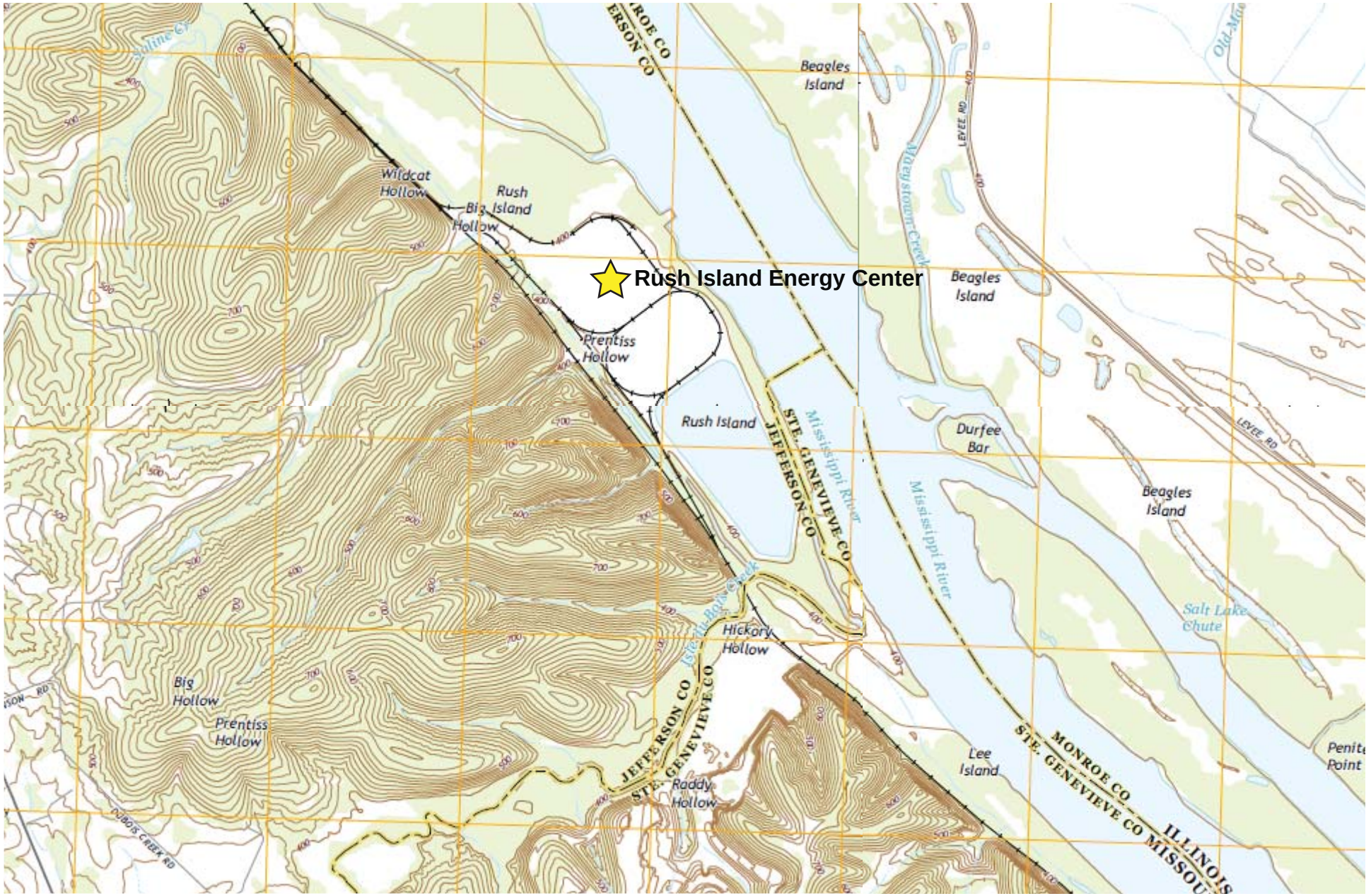
The Operations and Maintenance Manual requires that timely repairs must be made after problem areas are identified. The plant engineer is to specify the work to be completed using Ameren's Work Control Process and provide direction to correct items noted in the operation and maintenance, and engineering inspections. The work request by the plant engineer will be reviewed with the Dam Safety Group to ensure proper emphasis has been placed on the request. The Operations and Maintenance Manual specifies the minimum maintenance activities and requires that maintenance activities be documented. The Operations and Maintenance Manual further specifies that no alterations or repairs to structural elements should be made without the approval of the Chief Dam Safety Engineer and the concurrence of the MDNR Water Resources Center.

D. Instrumentation

A staff gage is installed in RCPA. Staff gage readings are documented in weekly inspection reports.

Piezometers have been installed upstream and downstream of the embankment for water level monitoring for the design of a proposed landfill overfill. The planned overfill is no longer in consideration. Monthly piezometer readings were provided by Ameren in a draft format. The status of future monitoring is uncertain at the time of this report.

[3] The annual and periodic inspection reports contain the following information: depth of impounded water; storage capacity; modifications from last inspection, if any, CCR depth; volume of impounded water and CCR; changes to the downstream watershed, if any.



Ameren Missouri
Rush Island Energy Center
CCR Unit Evaluation
USGS 7.5 minute quadrangle map

Legend:

- Pond Footprint
- Primary Flow Path
- Emergency Spillway Flow Path

CCR UNIT	MAXIMUM SURFACE ELEVATION (ACRES)	DAM CREST ELEVATION (FEET)	CREST LENGTH (FEET)	NORMAL POOL ELEVATION (FEET)	MAXIMUM SURCHARGE POOL (FEET)	UPSTREAM SLOPE STEEPNESS (H:V)	DOWNSTREAM SLOPE STEEPNESS (H:V)
RCPA	114.0	408.2 to 412.2	9750	398.0	404.6	3H:1V	3H:1V

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Rush Island Energy Center

CCR Unit Evaluation

Figure 2 - Operational Data