STRUCTURAL INTEGRITY CRITERIA & HYDROLOGIC/HYDRAULIC CAPACITY ASSESSMENT

SIOUX ENERGY CENTER
CCR UNIT - SCPD

Sioux Energy Center
8501 North State Route 94
West Alton, MO 63386

Contents

STRUCTURAL INEGRITY CRITERIA & HYDROLOGIC/ HYDRAULIC CAPACITY ASSESSMENT - SIOUX ENERGY CENTER

I. Introduction

Ameren Missouri has evaluated the Sioux Energy Center's ("SEC" or "Sioux") coal combustion residual ("CCR") surface impoundments in accordance with the operating and design criteria set forth below:

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

For this periodic assessment, Ameren Missouri retained the engineering firm Reitz & Jens, Inc. to evaluate Sioux's active CCR surface impoundment SCPD to determine whether this unit conforms to good engineering practices[1] with respect to the following criteria: liner design criteria; hazard potential classification; structural stability assessment; safety factor assessment; and 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**

Sioux currently utilizes one (1) surface impoundment, SCPD, for the management of process waters along with gypsum from the facility's flue gas desulfurization system (FGD). Three other surface impoundments, SCPA, SCPB and SCPC, no longer receive process water or CCRs, have been dewatered and are closed. The active surface impoundment, SCPD, occupies approximately 40 acres. The facility also uses a Recycle Pond to manage stormwater and discharge waters from SCPD, but such impoundment does not collect or manage CCR and is not subject to 40 CFR §257 requirements.

SCPD was placed into service in 2022 and receives process water used to sluice gypsum. The impoundment stores gypsum and discharges decant water into the Recycle Pond. Water collected in the Recycle Pond is returned to the plant for reuse. The impoundment is formed by a compacted earth fill ring dam that is capped by 2 feet of impervious clay and HDPE liner. SCPD is subject to Missouri Solid Waste regulations and requirements.

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

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

B. **Embankment Levee**

SCPD has an area of 40 acres, and the length of the embankment dam is 5,283 feet. The embankment has a maximum height of 24 feet. Embankment fill consists of compacted layers of clay and silt with varying amounts of sand. Fill material was compacted to a minimum of 95% of the maximum dry unit weight determined from the Standard Proctor Moisture-Density Test (ASTM D698). Fill placement was monitored, and moisture-density tests were obtained during construction. The upstream and downstream slopes have a steepness of 3H to 1V. The crest elevation of the embankment for SCPD is approximately elevation 446 feet. Construction of SCPD included the placement of separation layer or 5 feet of clay fill to elevate the base of the clay liner a minimum of 5 feet above the lowest site elevation prior to construction and the top of coarse-grain soil observed in the historical boring logs or during construction.

III. Structural Integrity Assessment

A. **Liner Design Criteria – 40 CFR §257.72**

For new CCR surface impoundments must be constructed with liner systems that meets the specified design and performance standards in *40 CFR 257.70*. The owner or operator must obtain certification from a qualified professional engineer that the liner system has been designed and constructed in accordance with *40 CFR 257.72*.

The bottom of SCPD and the upstream slopes are covered with 2 feet of compacted clay liner that has a maximum hydraulic conductivity of 1x10-7 cm/sec which is overlain by 80 MIL HDPE. The clay and HDPE liners had appropriate quality control and quality assurance during construction to verify that they both meet the required design criteria set forth in 40 CFR 257.72.

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

The CCR surface impoundment SCPD at the Sioux Energy Center was designed and constructed with a liner which meets the requirements of §257.72, Liner Design Criteria for new CCR Surface Impoundments. The SCPD liner consists of two feet of compacted soil with a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec which is overlain by an 80 MIL HDPE liner.

CCR Unit	Existing liner meets requirements of 40 CFR 257.72
SCPD	Yes

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C. **Hazard Potential Classification – 40 CFR §257.74(a)(2)**

Every five (5) years, an owner or operator of a 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.

The active surface impoundment, SCPD, at Sioux is classified as having a *low hazard potential.* Failure of SCPD would result in the release of water and CCR into the surrounding Ameren property and adjacent agricultural fields. The failure of the impoundment is not expected to cause a loss of human life, and the economic, environmental and lifeline losses are expected to be low and generally 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 –Hazard Potential Classification

The Hazard Potential Classification Assessment was conducted for active CCR surface impoundment SCPD at the Sioux Energy Center in accordance with the requirements of 40 CFR 257.74(a). The CCR surface impoundment is low hazard potential because failure of the impoundment is not expected to cause a loss of human life, and the economic, environmental 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
SCPD	Low

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D. **Structure Stability Assessment – 40 CFR §257.74(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 upstream slopes for SCPD are overlain with an HDPE liner and the downstream slopes are vegetated. Vegetative management protocols are set forth in the Operations and Maintenance Procedures and have been implemented to minimize erosion while facilitating the visibility of slopes during inspections.

The initial periodic structural stability assessment found no structural stability deficiencies, no significant issues with the operations and maintenance, and that the design and construction of the embankments and spillways were adequate for the range of loading conditions under which the CCR unit should be subjected.

1. Engineering Certification – Initial Structural Stability Assessment

The Initial Structural Stability Assessment was conducted for the active CCR surface impoundment SCPD at the Sioux Energy Center. The structural stability assessment was completed in general accordance with 40 CFR Part §257.74(d)(1). Assessment of the CCR Unit found no structural stability deficiencies, no significant issues with the current operations and maintenance, and that the design and construction are adequate. The engineering support for this certification has been placed in the operating record.

Requirement	SCPD
Periodic assessment was completed in general accordance with the requirements of 40 CFR Part §257.74(d)(1)	Yes

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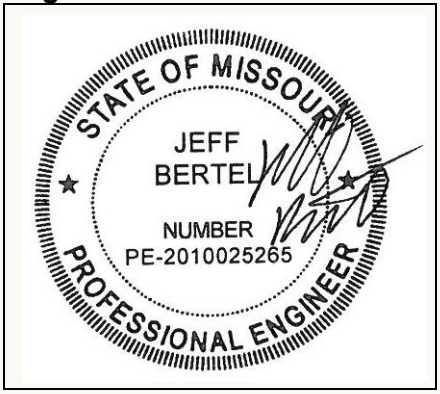

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E. **Safety Factor Assessment – 40 CFR §257.74(e)**

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 SCPD and calculated the following values:

Table 2

Ponds	Maximum Storage Pool (FOS)	Maximum Surcharge Pool (FOS)	Seismic (FOS)	Liquefaction (FOS)
SCPD	1.84	1.84	1.48	1.74

The calculated factors of safety for the critical cross-section at SCPD shown above ***meet or exceed*** the minimum factors of safety for each loading condition required by 40 CFR §257.74(e).

1. Engineering Certification – Safety Factor Assessment

The Safety Factor Assessment was conducted for the active CCR surface impoundment SCPD at the Sioux Energy Center. The Safety Factor Assessment for SCPD shows that the critical cross section for this Unit meets or exceeds the minimum factors of safety specified in 40 CFR Part §257.74(e)(1) as summarized below. The engineering support for this certification has been placed in the operating record.

Requirement	SCPD
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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F. 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.

The initial inflow design flood control system plan was developed for SCPD. Pertinent data regarding the SCPD 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[2] (feet)	Upstream Slope Steepness (H:V)	Downstream Slope Steepness (H:V)
SCPD	40.3	446.0	5,283	441.1	442.0	3H:1V	3H:1V

Reitz & Jens performed a modeling analysis for SCPD 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 7.21 inches[3] as an estimated 24-hour, 100-year precipitation event. The spillway discharge locations are depicted on Figure 1. SCPD discharges into the Recycle Pond, and water from the Recycle Pond is recirculated back to the plant for reuse.

The total volume of stormwater from the 24-hour, 100-year precipitation event and 24 hours of normal process water flow raise the level of SCPD to elevation 442.0 feet assuming there is no flow through the spillway. The peak pool level is 3.0 feet below the crest of the emergency spillway.

Provided that the outlet works remain functional, the SCPD's inflow design control system adequately manages flow through the CCR unit 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 SCPD will be managed so that the available storage is more than that assumed in the hydrologic and hydraulic models.

G. Inflow Design Flood Control System Capacity Plan

The inflow design flood control system has been evaluated for SCPD at the Sioux 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, 4.0 feet of freeboard exists in SCPD.* 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:

- **SCPD** - normal pool elevation should be maintained no higher than elevation 441.1 feet to maintain a maximum surcharge pool at elevation 442.0 feet.

[2] Calculated based on 100-year flood event modeling demonstration.
[3] Huff, F.A. and J.R. Angel. (1992). "Rainfall Frequency Atlas of the Midwest." Bulletin 71, Midwestern Climate Center and Illinois State Water Survey.

- If the water level exceeds the maximum surcharge pool elevation, special inspections by the Dam Safety Group of the primary spillway should be completed, and temporary measures implemented to prevent the water from overtopping the Pond embankments until the primary spillway is functioning as designed. Such measures could include cessation of generation, the addition of fill, sandbags, pumps, siphons etc.
- Prior to the next scheduled evaluation of the Periodic Inflow Design Flood Control System Plan, topographic surveys should be completed on the interior of SCPD to confirm the necessary water storage is available.
- Pool level 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 SCPD at the Sioux Energy Center. The inflow design flood control system plan was completed in general accordance with 40 CFR Part §257.82 using the 100-year design flood for low hazard potential CCR surface impoundments.

Requirement	SCPD
The periodic inflow design flood control system plan meets the requirements of 40 CFR Part §257.82	Yes

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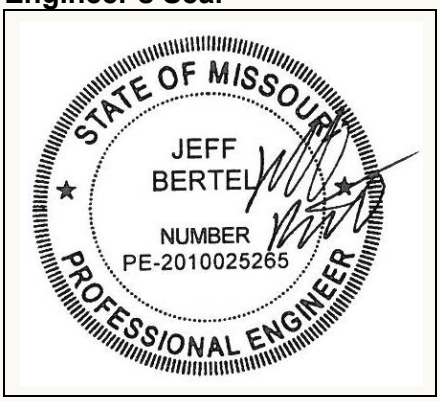

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IV. Construction Summary – *40 CFR 257.73(c)*

The Sioux Energy Center is located along the Mississippi River, approximately 14 miles upstream of the confluence with the Missouri River. The Mississippi River is immediately to the north of the Sioux Energy Center and the Missouri River is about 1 mile to the south. Poeling Lake, which connects to the Mississippi River, is located immediately to the west of the closed SCPB and SCPA. The Mississippi River has a watershed area of approximately 170,000 square miles at the site and the Missouri River has a watershed area of approximately 500,000 square miles at their confluence. The Sioux Energy Center does not receive stormwater run-on from areas outside of the facility.

A. Owner and Operator

The CCR Units at the Sioux Energy Center are owned and operated by Ameren Missouri. The Sioux Energy Center plant personnel have primary responsibility for CCR unit operation. The Sioux Energy Center is located at 8501 North State Route 94, West Alton, Missouri 63386. The Ameren Missouri Dam Safety Group performs CCR unit inspections and reviews all updates to the Operations and Maintenance Manual.

B. SCPD (Cell 2)

The SCPD was brought online in 2022. The CCR Unit was constructed in two parts, consisting of two connected cells, labeled “Interim” and “Primary”. The Interim and Primary cells are separated by a lined embankment but connected with a spillway through the embankment. The Interim cell was completed in 2022, and the Primary cell was completed in 2023. As-built drawings are presented in Appendix A. The Flue Gas Desulfurization (FGD) system produces gypsum as a byproduct. The FGD gypsum slurry is pumped to SCPD where it is managed for long-term or permanent storage. The SCPD does not receive any additional stormwater run-off outside its bounded area. The gypsum slurry discharges into the cell at the approximate midpoint of the west embankment. The gypsum settles out into SCPD and the decant water flows into the Recycle Pond through a set of triple box culverts. SCPD and the Recycle Pond are separated by an embankment. Triple box culverts connect SCPD with the Recycle Pond, and the culverts control the normal water level in SCPD to el. 441.1. SCPD also has two emergency spillways on the north side of the impoundment. The bottom and side slopes of SCPD are lined with 80-mil HDPE liner, which was constructed over 24 inches of compacted, impervious clay. The SCPD embankment upstream and downstream slopes have a steepness of 3H to 1V and the crest elevation is approximately 446 feet.

a. Foundation and Abutment Geology

The uppermost stratum is generally clays and silty clays with scattered seams and layers of low plastic silt, underlain by silts. The thickness of these fine-grain deposits ranged from 0 to 24 feet, but generally between about 5 to 10 feet. Clay soils are almost all high plastic. The fine-grain soils are firm to stiff, with undrained cohesive shear strengths of 500 psf to over 2000 psf.

The upper fine-grain soils are underlain by sandy silts, silty fine sands, and fine sands, generally to a depth of 30 feet. These upper sandy soils are generally loose to medium-dense. The upper sandy soils are underlain by fine to coarse, poorly-graded sands and well-graded sands, with some silty sands and gravelly sands at greater depths. Limestone bedrock is at a depth of about 115 feet. The lower sands generally ranged from medium-dense to very dense, increasing in density with increasing depth.

b. Embankment Material

Embankment fill consists of compacted layers of clay and silt with varying amounts of sand. Fill material was compacted to a minimum of 95% of the maximum dry unit weight determined from the Standard Proctor Moisture-Density Test (ASTM D698). Fill placement was monitored, and moisture-density tests were obtained during construction. The upstream and downstream slopes have a steepness of 3H to 1V. The crest elevation of the embankment for SCPD is approximately elevation 446 feet.

The bottom of SCPD and the upstream slopes are covered with 2 feet of compacted clay liner that has a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec. Clay for the liner was obtained on site. The compaction criteria for the clay liner was developed using the "Daniel Method." Fill placement was monitored, and moisture-density tests were obtained during construction.

C. Surveillance, Maintenance and Repair of the CCR Units

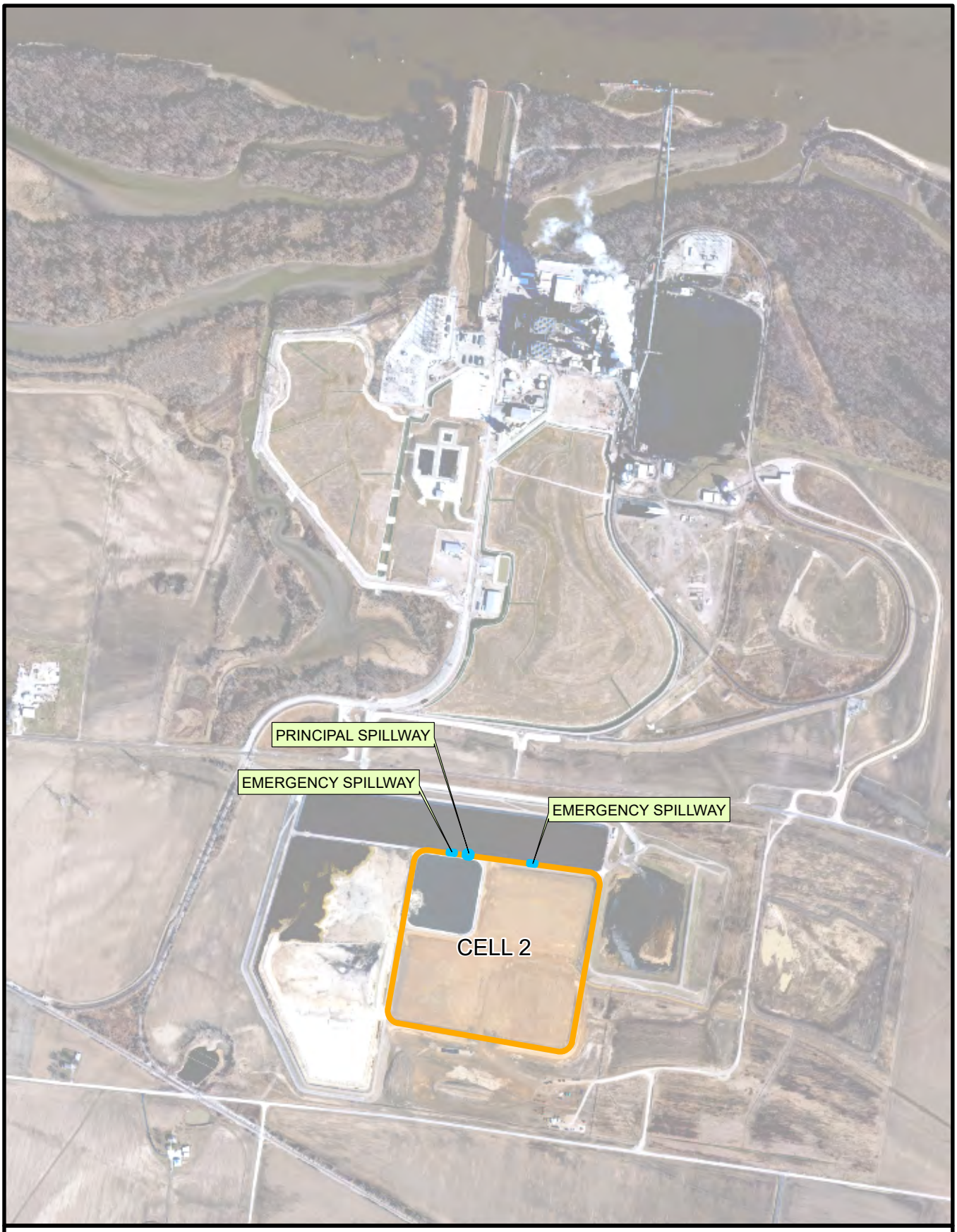
The Sioux UWL Cells 1, 2 & 4A and Recycle Pond Operations and Maintenance Manuals outline objectives, responsibilities, and procedures for Ameren personnel who are responsible for the management of the Sioux CCR units. The embankments of the CCR units are visually inspected weekly by Ameren plant operations staff. Ameren Missouri Dam Safety Group personnel perform annual inspections and periodic inspections[4] or assessments with plant operations staff. In addition, the Ameren Missouri Dam Safety Group may conduct unannounced safety inspections.

The Operations and Maintenance Manuals require 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 Manuals specify the minimum maintenance activities and require that maintenance activities be documented. The Operations and Maintenance Manuals further specify that no alterations or repairs to structural elements should be made without the approval of the Chief Dam Safety Engineer.

D. Instrumentation

Pool level readings are documented in weekly inspection reports.

[4] 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.



Legend
Embankment
Spillway

N

0 500 1,000 Feet

AMEREN MISSOURI
SIOUX ENERGY CENTER
ACTIVE CCR SURFACE IMPOUNDMENT
FIGURE 1

Ameren MISSOURI

REITZ & JENS, INC. CONSULTING ENGINEERS

Document Path: \\server01\projects\Ameren\ue\2023012434\dwg\Figure 1 CCR Reports\gis\AMRN-SIOUX-FIGURE 1.mxd