TECHNICAL MEMORANDUM

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GROUNDWATER AND GEOCHEMICAL MODELING SUMMARY FOR AMEREN SIOUX ENERGY CENTER CORRECTIVE MEASURES ASSESSMENT

1.0 INTRODUCTION

Golder Associates Inc. (Golder) is pleased to submit this Technical Memorandum summarizing modeling results under various closure scenarios at the Ameren Missouri (Ameren) Sioux Energy Center (SEC) in St. Charles County Missouri. As part of the SEC Corrective Measures Assessment (CMA), the fate and transport of metals under various closure scenarios were investigated through modeling and this memo summarizes these tasks conducted in support of the CMA.

2.0 GROUNDWATER FLOW MODEL

2.1 Introduction

Golder has developed a groundwater flow model for the SEC. There have been many groundwater samples, surface water samples, and groundwater elevation measurements collected at the SEC and these sampling locations which were used to generate the model are shown in Figure 1. The area covered by the groundwater flow model is shown in Figure 2. The purpose of this groundwater model summary is to document model setup, calibration and prediction results, and related data. This summary is being provided for the use of Ameren, Haley & Aldrich, and Golder staff familiar with the site and the model and is not intended as a detailed report for regulatory review or other purposes.

2.2 General Setting

The groundwater modeling is focused on modeling flow and transport in the alluvium underlying the SEC and bounded by the adjacent reach of the Mississippi and Missouri Rivers (Figure 2).

2.3 Groundwater Modeling Objectives

The objectives of the modeling analysis are to:

- Synthesize the most recent hydrogeologic data into an integrated conceptual and numerical framework for evaluating remedial strategies at the Site
- Use the groundwater model to predict and compare groundwater conditions resulting from different remedial alternatives for the SCPA
- Use the groundwater model to predict future Molybdenum concentrations after capping and closing the SCPA.

2.4 TECHNICAL APPROACH

The hydrogeologic conceptual model and model framework are described in this section.

2.4.1 Data Sources

1. The primary data sources used were as follows:
2. Golder (2017a, 2017b, 2017c, 2017d, 2018a, 2018b, 2018c, 2018d, 2018e, 2019a, 2019b, 2019c, 2019d, 2019e) general hydrogeology, geology, aquifer slug test results, potentiometric maps, water quality data, aerial photographs, ash pile geometry.
3. Haley & Aldrich (2018) surface water data.
4. Gredell (2006, 2009) general hydrogeology, geology, aquifer slug testing results, potentiometric maps, water quality data, groundwater elevation measurements.
5. United States Geological Survey (USGS): river gauge data.
6. Rietz & Jens, Inc., and Gredell Engineering Resources (2014) Utility Waste Landfill design.
7. Electric Power Research Institute (EPRI 1998), SCPA water balance, water quality data, ash pile geometry.

A summary of the model input data derived from these and other sources is provided in Table 1.

Table 1: Model Import Data Ranges

Parameter	Reported Range	Model Values	Data Source
Groundwater Elevations	413.2 to 435.5 ft MSL	413.8 to 433.0 ft MSL	Golder 2017 (a-d), 2018 (a-d), and 2019 (a-e), Gredell 2006 and 2009
Missouri and Mississippi River Elevations (ft MSL)	**USGS Gauges** St. Charles Gauge – 417.08 - 453.15 Grafton Gauge – 417.94 – 441.96 Alton Gauge – 407.83 – 437.76 St. Louis Gauge – 374.26 – 429.05	**Calculated Model Values (Average Annual Levels at Plant)** Missouri River – 413.2 – 425.3 Mississippi River – 417.5 - 420.7	USGS Gauges 06935956, 05587450, 05587541, 07010000
Saturated Layer Thickness			
Layer 1	NA	0 to 36 feet	Layer thickness based on Boring Logs (Golder 2017 (a-d), Golder 2018 (a-d), Golder 2019 (a-e), Gredell 2006,
Layer 2		25 to 32 feet	
Layer 3		6 to 27 feet	
Layer 4		23 feet	
Layer 5		25 feet	
Layer 6		65 feet	
Infiltration rate			
SCPA Pond - Active	0.04	From 0.015 to 0.03 ft/day (66-131 in/yr)	EPRI 1998, Calibrated Values
SCPA Pond Capped - 1.0E-7cm/sec Cap, 1.5 feet thick	NA	0.00023 ft/day (1.0 in/yr)	Data from Rush Island (Golder, 2019), Haley and Aldrich 2018

Non-ponded areas (natural recharge)	2 to 22 in/yr	0.00059 ft/day (2.5 in/yr)	Owuor et al., 2016, USGS 2001 and 2010, Calibrated Values
Horizontal Hydraulic Conductivity (Kx, Ky) cm/sec			
Top stratum (silts/clays)	1.0E-4 to 1.0E-6	9.9E-04	Fetter, C.W., 2001, Calibrated Values
Shallow Alluvium (sands and silts)	Minimum: 5.6E-03 Maximum: 2.6E-02 Geomean: 1.6E-02	2.6E-02	Golder 2017(a-d), Calibrated Values
Intermediate Alluvium (sands)	Minimum: 8.8E-03 Maximum: 4.0E-02 Geomean: 1.8E-02	4.0E-02	Golder 2017(a-d), Calibrated Values
Fly Ash (SCPA)	Minimum: 2.1E-07 Maximum: 4.9E-03	1.8E-04	Golder 2018e, Calibrated Values
Bottom Ash (SCPA)	Minimum: 1.1E-05 Maximum: 4.9E-03	1.8E-04	Golder 2018e, Calibrated Values
Upper Bedrock (limestone)	1.0E-02 to 1.0E-08	9.9E-07	Fetter, C.W., 2001, Calibrated Values
Embankment	1.0E-3 to 1.0E-9	2.7E-06	Fetter, C.W., 2001, Calibrated Values
Other Parameters			
Specific yield/effective transport porosity of alluvial aquifer	0.16 to 0.46	0.25	Morris and Johnson (1967)

Notes:
1) NA = Not applicable
2) ft MSL - feet above mean sea level
3) in/yr - inches per year
4) cm/sec - centimeters per second
5) SEC – Sioux Energy Center
6) ft/day – feet per day

2.5 Conceptual Model

The Site is located in the floodplain between the Mississippi and Missouri Rivers and lies on alluvial deposits associated with these rivers. The alluvial deposits comprise the surficial alluvial aquifer, which lies unconformably on top of bedrock and is typically 100 to 130 feet thick. Overall, this aquifer is described as a fining upwards sequence of stratified sands and gravels with varying amounts of silts and clays. Drilling in the alluvial aquifer identified different sub-units, including flood basin deposits, floodplain deposits, natural levee deposits, and channel deposits along with volumetrically less important loess deposits. Grain sizes of the alluvial deposits are highly variable.

Bedrock below the alluvial aquifer includes Mississippian-aged rocks of the Meramecian Series. Formations include primarily limestone, dolomite, and shale and are comprised of the Salem Formation, Warsaw Formation, and the Osagean aged Burlington-Keokuk Formation.

Groundwater generally flows from the higher water elevations of either of the Mississippi and Missouri Rivers towards the lower water elevation river with a slight component of west to east flow in the downriver direction. River elevations in both rivers change frequently and there is not a constant river with a higher elevation, therefore there are multiple directions of groundwater flow.

Hydraulic sources (inflows) consist primarily of recharge from precipitation, groundwater inflows from the west (up-river) to the east, inflows from the Mississippi and Missouri Rivers, and seepage from the SCPA. Hydraulic sinks (outflows) includes discharge to rivers.

2.6 Selection of Computer Code

The numerical computer code MODFLOW – developed by the United States Geological Survey (USGS) – was selected for much of this analysis because it is well suited to represent a wide range of hydrologic and hydrogeologic conditions, has been widely tested and accepted in the professional hydrology community and by regulatory agencies, and has been scrutinized closely in a number of legal proceedings over the past 20 years. In total, five software packages were used for the groundwater investigation:

- Groundwater flow: USGS software package MODFLOW (McDonald and Harbaugh 1988, Harbaugh and McDonald 1996, Harbaugh et al. 2000, Harbaugh 2005). MODFLOW-2005 was used in the analyses presented here.
- Groundwater transport: USGS software package MT3DMS (Zheng and Wang, 1999).
- Particle tracking: USGS software package MODPATH (Pollock 2012)
- Parameter estimation: PEST (Doherty 2010 and 2016)
- Graphical user interface: Groundwater Vistas (Environmental Simulations 2017, Rumbaugh and Rumbaugh 2011).

2.7 Groundwater Model Construction

The model grid was oriented to align with the SCPA and river bank with the primary flow direction of the Mississippi River (Figure 3). The gird sizes are uniform horizontally (100 ft by 100 ft) and vary with the geologic layer thicknesses and SCPA geometry in the vertical. The six layers modeled are shown in Figures 4 and 5 along with their hydraulic conductivities.

Model boundary conditions include: recharge at the ground surface and on the surface of the SCPA (Figure 6), river boundary conditions at the rivers, creeks, and small ponds (Figure 7), and general head boundary conditions at the east and west boundaries of the model to allow inflows from the east and outflows to the west. The Mississippi and Missouri Rivers and small ponds were assumed to have a riverbed with a hydraulic conductivity of 9.9 E-5 cm/sec and a thickness of 5 feet. The levels in the rivers fluctuate and affect groundwater flow patterns in the alluvium. Recharge rates were assumed to vary across the SCPA based on inflow and outflow locations as seen in historical aerial photos. General head boundaries were used on the east and west sides of the model in order to allow flow from west to east. These general head boundaries used the calibrated hydraulic conductivities inside the model domain and:

- The western general head boundary: relative head value to the upriver Grafton gauge
- The eastern general head boundary; relative head value to the confluence of the Mississippi and Missouri Rivers.

Groundwater flow was calibrated using a steady state flow model and then checked in a transient analysis. A transient flow model was constructed to complete the transport and closure alternative analyses. To complete this modeling, average annual river levels were calculated for the Mississippi and Missouri rivers from 1987 through 2018 based on available USGS river gauge data. This sequence of 32-years of annually-varying river levels was then applied in future and past years where river conditions are unknown.

2.8 Flow Calibration

Flow model calibration was carried out for July 28, 2018 for which 77 groundwater elevations within the alluvial aquifer (at various depths) were available as targets. In addition, 5 pore-water elevations within the SCPA were used from March 9, 2018. This combination was used because there were more targets available in the July 2018 event in the alluvial aquifer and the river levels were more representative of average conditions. Additionally, Pore-water elevations were only collected in February and March of 2018 before the piezometers were abandoned, however, the pond elevation in the SCPA was the same on both March 9, 2018 and July 28, 2018. Therefore, these levels are deemed representative of what pond conditions were in July 2018.

Manual and automated parameter estimation approaches were used to derive reasonable estimates of hydraulic conductivities and natural recharge rates that produce groundwater elevations close to the observed data. The results are summarized in Figure 8. The average head residual is less than 1 feet and the normalized root mean square error in the model is 9.7%. It should be noted that observed groundwater elevations varied from 411.5 – 419.3 feet above mean sea level (ft MSL) in the alluvial aquifer and from 426.5 – 433.4 ft MSL in the SCPA pore-water. The calibrated model was found to be acceptable for current purposes.

The calibrated parameters were then used in combination with annually-varying river levels to check the model calibration and provide the basis for flow and transport predictions. Predicted transient groundwater elevations for all of the monitored locations, together with the observed data (black dot), are provided in Appendix A. These data show that the model is also well calibrated under transient flow conditions,

2.9 Flow Model Predictions

The calibrated model was used to predict flows from the SCPA, flows rates in the alluvium, flows to/from the river and to optimize recovery well placement and pumping rates for alternate closure scenarios. The scenarios modeled are summarized in Table 2 and Figures 9 to 13.

Table 2: Summary of Groundwater Flow Model Predictions for Future Scenarios

Future Prediction Model Scenario	Related Figure	Number of Wells	Well Pumping Rate	Total Pumping Rate	Slurry Wall?
Units	NA	NA	(gpm)	(gpm)	NA
SCPA Cap of 1x10^{-7} cm/sec	10	--	--	--	No
SCPA Cap, Hydraulic Containment with Pumping Wells	11	5	3.0	15.0	No
SCPA Cap, Hydraulic Containment with Slurry Wall (100 FT BGS to top of bedrock) and Pumping Wells	12	5	1.0	5.0	Yes
SCPA Cap, Hydraulic Containment with Slurry Wall (150 FT BGS, 50 feet into bedrock) and Pumping Wells	13	5	1.0	5.0	Yes

Notes:
1) cm/sec = centimeters per second
2) FT BGS = feet below ground surface
3) gpm = gallons per minute
4) In all future model scenarios, the SCPA was modeled as drained, inactive, and capped with recharge through the cap to the SCPA of 1-inch per year for a 1.5 feet thick 1 x 10^{-7} cm/s soil cover.
5) Hydraulic head control was predicted using proposed pumping wells placed with approximately 500-1000 foot spacing (see reference figures for locations). Each proposed well screen extends from near surface to deep alluvium (layers 1-4).
6) SCPA hydraulic containment was evaluated using predicted flow velocity vectors and predicted pumping well capture of particles distributed along the outside edge and within the southern portions of the SCPA in each model ash layer (see figure 9).
7) The proposed slurry wall was modeled as constructed along the west and south sides of the SCPA from the very shallow alluvium to the top of bedrock (Figure 12) as well as 50 feet into bedrock (Figure 13). The slurry was modeled as 2 feet thick in diameter and a hydraulic conductivity of 1 x 10-6 cm/s.

Groundwater pumping rates are low because:

- The infiltration rate through the capped SCPA is relatively low
- Under capped conditions, the hydraulic gradient is low (nearly flat)
- Under pumping conditions, a hydraulic divide is predicted to develop between the Southern half the SCPA and the Mississippi River to the north, reducing the possibility of pumping river water
- For slurry wall cases, pumping rates are reduced a small amount because the small amount of inflow from the south is reduced
- Additionally, there was no noticeable difference of particles leaving the SCPA between the 100-foot-deep and the 150-foot-deep slurry wall scenarios.

2.9.1 Post Closure Flow Around the SCPA

A mass balance analysis was completed to estimate the flow around, verses into the SCPA, after the CCR Unit has equilibrated with the adjacent alluvial aquifer and the recharge into the pond has decreased due to capping and closing the SCPA. This analysis uses the river levels from 1987 through 2018 under capped and closed conditions and takes an average flow from the different hydrostratigraphic units. As shown on Table 3, approximately 87% of groundwater flow is estimated to go around the SCPA and only 13% of groundwater flows into the SCPA. Flow into the SCPA is estimated to be 2.3 gallons per minute on average and flow around the pond is estimated to be 17.5 gallons per minute. The results are illustrated in Figure 14 showing groundwater flow vectors that demonstrate a preferential flow around and under the SCPA rather than into the SCPA.

Table 3: Model Estimates of Flow Around vs. Into SCPA After Closure

Average Flow direction	Average Flow (Cubic Feet per Day)	Average Flow (Gallons Per Minute)
Flow from NW Alluvial Zone into SCPA	101	0.5
Flow from NE Alluvial Zone into SCPA	122	0.6
Flow from SW Alluvial Zone into SCPA	90	0.5
Flow from SE Alluvial Zone into SCPA	134	0.7
Average Flow from Alluvial Aquifer into SCPA	**447**	**2.3**
Flow from SCPA into NW Alluvial Zone	515	2.7
Flow from SCPA into NE Alluvial Zone	507	2.6
Flow from SCPA into SW Alluvial Zone	438	2.3
Flow from SCPA into SE Alluvial Zone	667	3.5
Average Flow from SCPA into Alluvial Aquifer	**2126**	**11**
Flow from NW Alluvial Zone into NE Alluvial Zone	826	4.3
Flow from NE Alluvial Zone into NW Alluvial Zone	187	1
Flow from NE Alluvial Zone into SW Alluvial Zone	318	1.6
Flow from SW Alluvial Zone into NE Alluvial Zone	243	1.3
Flow from NE Alluvial Zone into SE Alluvial Zone	430	2.2
Flow from SE Alluvial Zone into NE Alluvial Zone	291	1.5
Flow from SW Alluvial Zone into SE Alluvial Zone	796	4.1
Flow from SE Alluvial Zone into SW Alluvial Zone	278	1.4
Average Total Flow Around the SCPA	**3368**	**17.5**
Percent Flow Around vs Through the SCPA	**86.9%**	

Notes:

1) See Figure 14 for information on the different Hydrostratigraphic Units.
2) NE – Northeast, NW – Northwest, SE – Southeast, SW – Southwest.

2.10 Transport Model Analysis

This section describes the transport modeling analyses conducted for the SCPA contaminant source area. The SCPB, SCPC and SCL4A where not modeled as a source area because they are all lined with geomembrane liners while the SCPA is unlined. Based on drilling data and historical images, the SCPA has historically been managed with the bottom ash contained in the north portions of the CCR unit while and the fly ash has been historically managed in the southern portion of the unit. In 1993, the SCPB was built to the east of the SCPA and fly ash was then managed in the SCPB and not the SCPA.

Molybdenum was selected as the primary constituent for transport analysis because it is the only Appendix IV parameter that is present at a Statistically Significant Level in accordance with the CCR Rule. The primary Molybdenum transport mechanisms are advection and mixing due to natural and pond recharge, advection and mixing under varying natural hydraulic gradients controlled by river water elevations and buffering and/or precipitation due to interaction between Molybdenum in porewater and aquifer solids.

Transport model setup details include:

Aquifer bulk densities based on results from Golder 2018e

- Layer 1:1.7 g/mL
- Layer 2: 1.8 g/mL
- Layers 3 to 6: 1.92 g/mL

- Uniform effective porosity of 0.25
- Longitudinal, transverse and vertical dispersivity were assumed to have values of 1,000, 100, and 10 ft, respectively
- Linear sorption represented by a partition coefficient (Kd) in the aquifer of 1.1 mL/g (Allison and Allison, 2005).
- Molybdenum Concentrations as shown below in Table 4.

Table 4: Molybdenum Concentration Data Ranges

Parameter	Reported Range	Model Values	Data Source
Molybdenum Concentrations (µg/L)			
Mississippi River	Minimum: Non-Detect Maximum: 2.3 Mean: 1.406	1.4	Haley and Aldrich 2018
Missouri River	Minimum: 2.6 Maximum: 3.6 Mean: 2.97	3	Haley and Aldrich 2018
Background (BMW-1S, BMW-3S, BMW-1D, and BMW-3D)	Minimum: Non-Detect Maximum: 9.3 Mean: 1.753	2	Golder 2018 (a-d), Golder 2019 (a-e),
Bottom Ash (Northern SCPA)	26.5	26.5	Golder 2019b
Fly Ash / Mixed Ash (Southern SCPA)	1,760 - 56,6000	17,000 (western) 4,000 (central) 2,500 (eastern)	Golder 2019b

Molybdenum data from November 2018 and January 2018 were included as calibration targets in the model using 73 locations within the alluvial aquifer. During transport model calibration the unknown historical pond levels and concentrations were varied across expected ranges, but the hydraulic parameters were unchanged. The resulting simulated plume, together with the mapped plumes for shallow, intermediate, and deep alluvium are shown in Figures 15-17.

The transport model calibration results are summarized in Figure 18. The average molybdenum concentration residual is less than 30 µg/L and the normalized root mean square error is 6.0%. It should be noted that observed molybdenum concentrations varied from Non-detect (1/2 method detection limit at 0.45) – 4,000 µg/L in the alluvial aquifer. The calibrated model was found to be acceptable for current purposes.

Predictive simulations were used to assess future plume movement under existing and capped-pond conditions. The predicted future molybdenum concentrations in groundwater were found to be sensitive to the assumed partition coefficient and the infiltration rate through the cap. SCPA ash pore-water concentrations after capping and closure were simulated in two different ways:

- With a concentration that remained constant prior to and after closing the SCPA
- With a concentration that was reduced to zero directly after closing the SCPA

Reality is likely to fall somewhere between these two cases. In both of these scenarios, the recharge through the cap was assumed to be reduced to 1 inch/year (0.000229 feet per day). After capping the heads in the pond and flow out of the base of the pond are predicted to gradually decrease over time. Predicted concentrations for groundwater concentrations in the alluvium for these two scenarios are provided in Figures 19, 20, and 21. These figures show that in monitoring wells directly adjacent to the pond, molybdenum concentrations can range about 10-20% in concentration depending on the attenuation of the residual molybdenum left in the SCPA after closure. Model predicted plume maps looking at the first scenario (constant concentration) are provided in Appendix B and represent a worst-case scenario for residual molybdenum concentrations.

Model estimated concentrations in the plume were predicted to:

- Continue to slowly increase in extent at the edge (corresponding to historical migration from the uncapped pond)
- Slowly decrease in the aquifer beneath and close to the pond as molybdenum flux from the pond decreases. Adjacent to the pond, molybdenum concentrations are estimated to decrease about 75% over 200 years.
- Continue to have molybdenum concentrations that are greater than the site Ground Water Protection Standard (GWPS) within the property boundary to the west, south, and east of the SCPA.
- Pumping effects on the future molybdenum plume were not evaluated.
- model assumes the median Kd value from Allison (2005) for this site. If site specific soil testing were completed and a lower Kd value was determined, molybdenum concentrations would decline at a faster rate after closure.

3.0 GEOCHEMICAL ASSESSMENT

3.1 Overview

Groundwater was evaluated to determine the feasibility of Monitored Natural Attenuation (MNA) as part of the Assessment of Corrective Measures (ACM) for the SEC. The structure of this feasibility evaluation closely follows the USEPA guidance on using MNA as a remedial strategy (USEPA 2007a and 2007b) and considers best practices from the Interstate Technology Regulatory Council (ITRC) document: "A Decision Framework for Applying Monitored Natural Attenuation Processes to Metals and Radionuclides in Groundwater" (ITRC 2010).

3.2 Approach

To assess the geochemical feasibility of MNA at the ACM screening level, laboratory analyses of groundwater collected in November 2018 for samples in the alluvial aquifer and in January 2018 for pore-water samples collected in the SCPA and SCPB. This data provided a comprehensive geochemical dataset. Historical molybdenum concentrations in groundwater from March 2016 to November 2018 was used for plume stability evaluation (Golder 2018a, 2018b, 2018c, 2018d, 2019a, 2019b, 2019c, and 2019d). Monitoring wells and piezometers selected for this evaluation included CCR rule (monitoring) wells for the SCPA and SCPB, nature and extent monitoring wells, and pore-water piezometers from inside the ash impoundment (Table 5). Parameters (description of laboratory methods is included in the above references) included in the geochemical assessment included field parameters (pH, dissolved oxygen, oxidation reduction potential (ORP), conductivity, and temperature), Appendix III and IV parameters, and major Cations and Anions.

Table 5: Monitoring Wells and Piezometers Included in the Geochemical Assessment

CCR Rule Wells	Nature and Extent Wells	Pore-water Piezometers
SCPA -S-UMW-1D, S-UMW-2D, S-UMW-3D, S-UMW-4D, S-UMW-5D, S-UMW-6D, **SCPB** -S-LMW-1S, S-LMW-2S, S-LMW-3S, S-LMW-4S, S-LMW-5S, S-LMW-6S, S-LMW-7S, S-LMW-8S, S-LMW-9S, **Background** -S-BMW-1D(*bg*),S-BMW-3D(*bg*), S-BMW-1S(bg), S-BMW-3S(bg)	S-TP-1D, S-TP-1S-TP-1S, S-TP-2D, S-TP-2M, S-TP-2S, S-TP-3D, S-TP-3M, S-TP-3S, S-TP-4D, S-TP-4M, S-TP-4S, S-TP-5D, S-TP-5M, S-TP-5S, S-TP-6D, S-TP-6M, S-TP-6S, S-TP-7D, S-TP-7M, S-TP-7S, S-TP-8D, S-TP-8M, S-TP-8S, AM-1S (UMW-7S), AM-1D (UMW-7D)	S-SCPA-2, S-SCPA-3S, S-SCPA-1D, S-SCPA-3D

Note: (bg) indicates background CCR rule monitoring well

The geochemical assessment of groundwater from the above identified locations included:

- Groundwater characterization to identify temporal and geographical trends, where present
- Geochemical modeling to identify the major chemical species and evaluation of saturation indices of minerals relevant to attenuation of molybdenum

Based on the results generated of this assessment, a screening-level attenuation evaluation was completed to determine the potential geochemical controls on molybdenum.

3.2.1 Geochemical Modeling

Geochemical modeling was conducted to evaluate general groundwater and pore-water quality, determine the potential for precipitation of sorbent media, evaluate the potential for mineral precipitation or adsorption in the aquifer, and determine the speciation of metals of interest. The geochemical computer code developed by the United States Geological Survey (USGS), PHREEQC, was used for these simulations (Parkhurst and Appelo 2013). PHREEQC version 3.4 is a general-purpose geochemical modeling code developed by the USGS and used to simulate reactions in water and between water and solid mineral phases (e.g., rocks and sediments). Reactions include aqueous equilibria, mineral dissolution and precipitation, ion exchange, surface complexation, solid solutions, gas-water equilibrium, and kinetic biogeochemical reactions. The widely-accepted thermodynamic database, Minteq.v4, 2017 edition, was used as a basis for the thermodynamic constants required for modeling.

The Geochemist's Workbench version 12 (Bethke 2015) was used to generate graphical representations of geochemical modeling outputs in the form of predominance, or Pourbaix diagrams (also known as Eh-pH diagrams) for the species of interest (i.e. cobalt, lithium, and molybdenum) and trilinear plots (also known as Piper plots) of the relative abundance of major ions. The Minteq.v4 database was also used as the basis for the Pourbaix diagrams.

The potential for mineral precipitation was assessed in PHREEQC using a saturation index (SI) calculated according to Equation 1.

$$SI = \log (IAP/Ksp) \qquad \text{(Equation 1)}$$

The saturation index is the ratio of the ion activity product (IAP) of a mineral to the solubility product (Ksp). An SI value greater than zero indicates that the water is supersaturated with respect to a particular mineral phase and, therefore, precipitation of the mineral may occur. An evaluation of precipitation kinetics is then required to determine whether the supersaturated mineral will indeed form. An SI value less than zero indicates the water is undersaturated with respect to a particular mineral phase. An SI value close to zero indicates equilibrium conditions exist between the mineral and the solution. SI values between -0.5 and 0.5 are referred to as 'at equilibrium' in this report.

3.2.2 Assumptions and Data Handling

Geochemical modeling assumptions and data handling included:

- **Groundwater continuity:** Groundwater quality data from a single sampling event conducted in November 2018 were evaluated. This sampling event was selected because the most wells were sampled and analyzed for the full suite of parameters. Temporal trend analysis for molybdenum, made use of available sampling events.
- **Pore-water chemistry:** Pore-water data was assumed to be representative of porewater found in ash impoundment based on the four porewater piezometer samples.
- **Redox values:** ORP values measured in the field were converted to reduction potential (Eh) by adding 200 millivolts (mV) to the field-measured values as per YSI (2015).
- **Non-detect values:** Constituents with concentrations not detected above the method detection limit were assumed to have a concentration equal to half the reporting limit in model simulations.
- **Charge balance:** Groundwater compositions with charge balance errors less than 10% were considered valid. Compositions with charge balance errors greater than 10% were not considered in the evaluation.

3.3 Groundwater characterization

Water quality monitoring data is summarized as follows:

- **Charge balance error:** There was one groundwater sample from November 2018 with a charge balance error of greater than 10% (S-UMW-3D). These results were retained and used during this evaluation, with the understanding that they may be somewhat less reliable.
- **pH:** Groundwater pH across the well network ranged from 6.1 to 8.9. The geometric mean pH across all wells was 7.0. Highest pH was measured in porewater at 8.9. The nature and extent wells ranged from 6.1 to 7.3.
- **ORP (Redox):** Field-measured redox, corrected to Eh (+200mV) values, ranged from +8 to +410 mV across the site. There was no apparent trend in redox conditions based on sample location or depth.
- **Total Dissolved Solids (TDS):** Groundwater TDS concentrations were variable. The lowest TDS concentrations (300 to 400 mg/L) occurred in groundwater in CCR rules wells, both in downgradient and background wells. The highest TDS concentration (2,200 to 2,900 mg/L) was measured in the porewater, shallow and deep wells of S-SPCA-3 (S/D). In general, all other wells (including pore-water in SPCA-1 and 2 wells) had TDS less than half of that measured in SPCA-3S/D.
- **Major ion chemistry:** A Piper plot was generated for all background, monitoring, and assessment wells to facilitate the identification of water types and changes in major ion chemistry over time (Figure 22a and 22b). In general, most of the shallow SCPB (LMW) and deeper SCPA (UMW) CCR groundwater monitoring wells can be identified to be a mix of background and pore-water from S-SCPA-1/2 (Figure 22a). S-UMW-2D and 3D show the most similarity to the porewater in SCPA-3S/D. However, nature and extent wells (Figure 22b) indicate they have dissimilar overall groundwater major ion chemistry than that of S-SPCA-3S/D.
- **Molybdenum:** Molybdenum concentrations in groundwater at monitoring wells (CCR rule and nature and extent) ranged from non-detect (<0.0005 mg/L) to 4.0 mg/L in November 2018. Six groundwater samples from CCR rule wells contained molybdenum greater than 100 µg/L (S-UMW-2D, 3D, 4D, 5D, and S-LMW-2S, 5S), the health-based standard. The molybdenum concentration in porewater has ranged from 0.03 to 56.6 mg/L (SPCA-1S; not included in geochemical modeling). Although the highest molybdenum in CCR rules wells exceeded the health-based standard, levels of molybdenum were an order of magnitude lower than the highest measured in porewater. Only two nature and extent wells exceeded the health-based standard (S-AM-1D (UMW-7D) and S-TP-5D). However, as shown in Figure 1, S-TP-5D is not located at the property boundary and AM-1D is located within 150 feet of the SCPA. The level of molybdenum in groundwater in CCR rule wells since March 2016 to November 2018 shows a general stable or downward trend since 2016 in all CCR Rule wells around the SCPA and SCPB, indicating a stable or decreasing plume (Figure 23a-c). Molybdenum is predominately present in the form of the divalent anion species molybdate (MoO_4^{-2}) based on field measured pH and redox conditions (Figure 22c).
- **Iron:** Total (un-filtered) iron concentrations were variable, ranging from non-detect (<0.012 mg/L) to 22 mg/L in November 2018. The highest concentration of 22 mg/L was detected in the groundwater sample collected from nature and extent well S-TP-1S. No geographical or depth trend is apparent; however, nature and extent wells generally tended to have higher total iron contents as a group. Ferric iron concentrations were higher than ferrous iron concentrations in all samples collected in November 2018.

In summary, the results of the groundwater quality evaluation indicate there are no initial indications or geochemical conditions that would be detrimental to attenuation of molybdenum at the Ameren SEC site. In addition, the positive redox across all wells at the site and the dominance of ferric iron over ferrous iron in groundwater are favorable indicators for the potential success of MNA.

3.4 Geochemical Modeling Results

The results of speciation modeling of groundwater at background, downgradient, and nature and extent wells are provided in Appendix C, including saturation indices for relevant minerals. Mineral saturation is important to identify when considering solid phases that may influence attenuation of metals, directly through precipitation, or indirectly by providing a sportive surface for metals to be removed from groundwater.

- **Iron-bearing minerals:** Ferrihydrite ($Fe(OH)_3$) was indicated to be at equilibrium with groundwater or oversaturated in all samples, indicating a strong potential for ongoing precipitation of solid phase iron oxides. Thus, throughout the Ameren SEC site, the prevalence of iron oxides is assumed.
- **Other minerals:** Nearly all groundwater samples were in equilibrium with respect to rhodochrosite ($MnCO_3$). Manganese presents an additional potential adsorption surface for attenuation. Calcite ($CaCO_3$) equilibrium was indicated in numerous wells as well. Calcite can provide a mechanism to maintain groundwater pH. Barite ($BaSO_4$) equilibrium was also indicated in numerous wells, and Gypsum ($CaSO_4{:}2H_2O$) equilibrium was present in two piezometers (S-SCPA-3S/D).

In summary, several mineral phases likely control groundwater composition at some or all wells: barite, calcite, ferrihydrite, gypsum, and rhodochrosite. In the case of ferrihydrite and rhodochrosite, the dissolved concentrations of constituents can be reduced through its ability to act as a substrate for adsorption (Dzombak and Morel 1990).

4.0 CONCLUSIONS

Based on both the groundwater flow model, the transport simulations and a geochemical analysis described in this report, the following conclusions can be made:

- Groundwater concentrations for Molybdenum are modeled to be slow moving, and concentrations above the GWPS stay within Ameren property boundaries to the west, south and east and in the leased area to the north.
- Molybdenum concentrations decrease by more than 75% in the 200-year post closure model estimation for monitoring wells with the highest current molybdenum concentrations.
- Based on data collected since 2016, the stable or decreasing trend in molybdenum concentrations in all CCR rule wells and lack of molybdenum above the health-based standard in monitoring wells on the western, southern and eastern portions of the property boundary indicate that plume from the ash impoundments are stable. The results of the groundwater quality evaluation indicate there are no indications or geochemical conditions that would be detrimental to natural attenuation of molybdenum at the Ameren SEC site.
- Based on geochemical modeling results, coupled with the site size, the apparent plume stability, and lack of molybdenum above the GWPS in all but one monitoring well to the north, attenuation of molybdenum is likely occurring, meeting the requirements of this initial modeling effort and MNA assessment.

5.0 LIMITATIONS

The modeling analyses presented in this report are a simplification of reality and the model-predicted results should be used with this understanding. The limitations associated with analyses such as these are detailed below.

Hydrogeologic investigations and groundwater modeling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time, and in the sense that the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that groundwater systems are complicated beyond human capability to evaluate them comprehensively in detail, and we invariably do not have sufficient data to do so. A groundwater model uses the laws of science and mathematics to draw together the available data into a mathematical or computer-based representation of the essential features of an existing hydrogeologic system. While the model itself obviously lacks the detailed reality of the existing hydrogeologic system, the behavior of a valid groundwater model reasonably approximates that of the real system. The validity and accuracy of the model depends on the amount of data available relative to the degree of complexity of the geologic formations, the site geochemistry, the fate and transport of the dissolved compounds, and on the quality and degree of accuracy of the data entered. Therefore, every groundwater model is a simplification of a reality and the model described in this report is not an exception.

The professional groundwater and geochemical modeling services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the quality and quality of available data, the time limits and financial and physical constraints applicable to the services. Unless otherwise specified, the results of previous or simultaneous work provided by sources other than Golder and quoted and/or used herein are considered as having been obtained according to recognized and accepted professional rules and practices, and therefore deemed valid. This model provides a predictive scientific tool to evaluate the impacts on a real groundwater system of specified hydrological stresses and/or to compare various scenarios in a decision-making process. However, and despite the professional care taken during the construction of the model and in conducting the simulations, its accuracy is bound to the normal uncertainty associated to groundwater modeling and no warranty, express or implied, is made.

Tables:

Table 1 – Model Input Data Ranges

Table 2 – Summary of Groundwater Flow Model Predictions for Future Scenarios

Table 3 - Model Estimates of Flow Around vs Into SCPA After Closure

Table 4 - Molybdenum Concentration Data Ranges

Table 5 - Monitoring Wells and Piezometers Included in the Geochemical Assessment

Figures:

Figure 23 – Molybdenum Trends

Appendices:

Appendix A – Model Predicted and Observed Transient Groundwater Level Elevations

Appendix B – Molybdenum Concentration Time Histories for Intermediate Alluvial Aquifer

Appendix C - Speciation Modeling

6.0 REFERENCES

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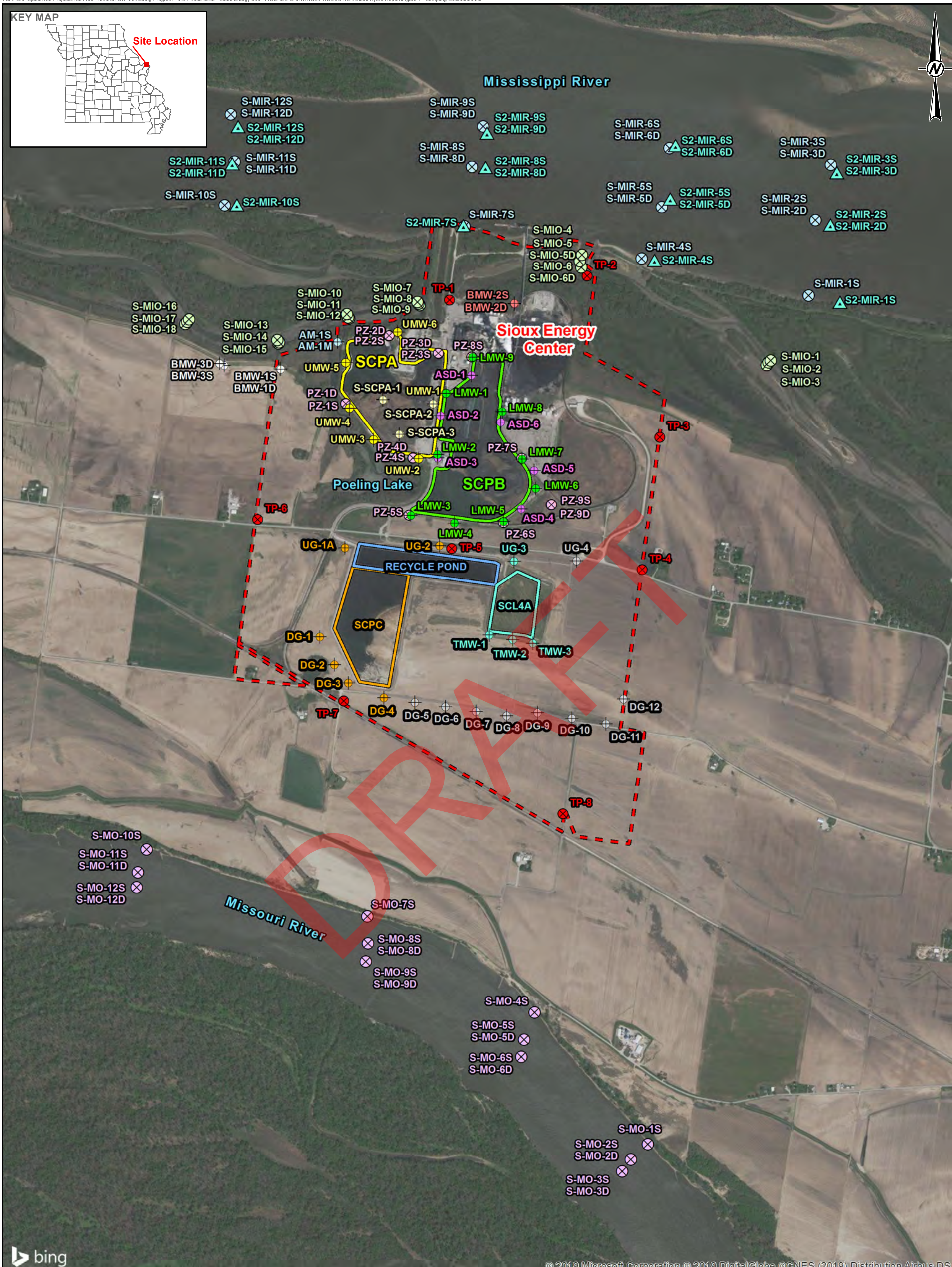
Figures

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Figure 1 - Sampling Locations.mxd



LEGEND

Sioux Energy Center Property Boundary

Surface Impoundments

- SCPB - Fly Ash Surface Impoundment
- SCPA - Bottom Ash Surface Impoundment

Utility Waste Landfill (UWL)

- Active Dry CCR Disposal Area
- Active WFGD Disposal
- Active Water Recycle Pond

Sampling Locations

- Assessment Monitoring Well
- National Pollutant Discharge Elimination System (NPDES) Piezometers
- Triple Nested Nature and Extent Monitoring Well
- September 2017 Missouri River Sample
- September 2017 Mississippi River Sample
- September 2017 Mississippi River chute Sample
- May 2018 Mississippi River Sample
- Background Monitoring Well
- SCPA - Bottom Ash Surface Impoundment Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- Existing Well Used as Piezometer
- Existing UWL Monitoring Well Not Currently Used for CCR Monitoring
- Temporary Monitoring Well Used for CCR Rule Monitoring
- Existing UWL Monitoring Well Currently Used for CCR Monitoring
- SCPA Pore-Water Piezometers
- Alternative Source Demonstration Alluvial Aquifer Piezometers

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. NPDES - NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM.
3. SURFACE WATER SAMPLE LOCATIONS BASED ON HANDHELD TRIMBLE GPS MEASUREMENTS. SAMPLE LOCATION REPRESENTS CENTERPOINT BETWEEN SAMPLE STARTING AND ENDING LOCATION.
4. THE ASD AND TP PIEZOMETERS ARE TRIPLE NESTED AND HAVE A SHALLOW, MIDDLE, AND DEEP PIEZOMETER.
5. SCPA-1 AND SCPA-3 HAVE DEEP AND SHALLOW PIEZOMETERS.
6. WFGD - WET FLUE GAS DESULFURIZATION

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.

0 1,000 2,000 3,000 4,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
SAMPLING LOCATION MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-07
PREPARED	RJF
DESIGN	JSI
REVIEW	EMS
APPROVED	MNH

PROJECT No.	PHASE	FIGURE
153-1406	0003	1

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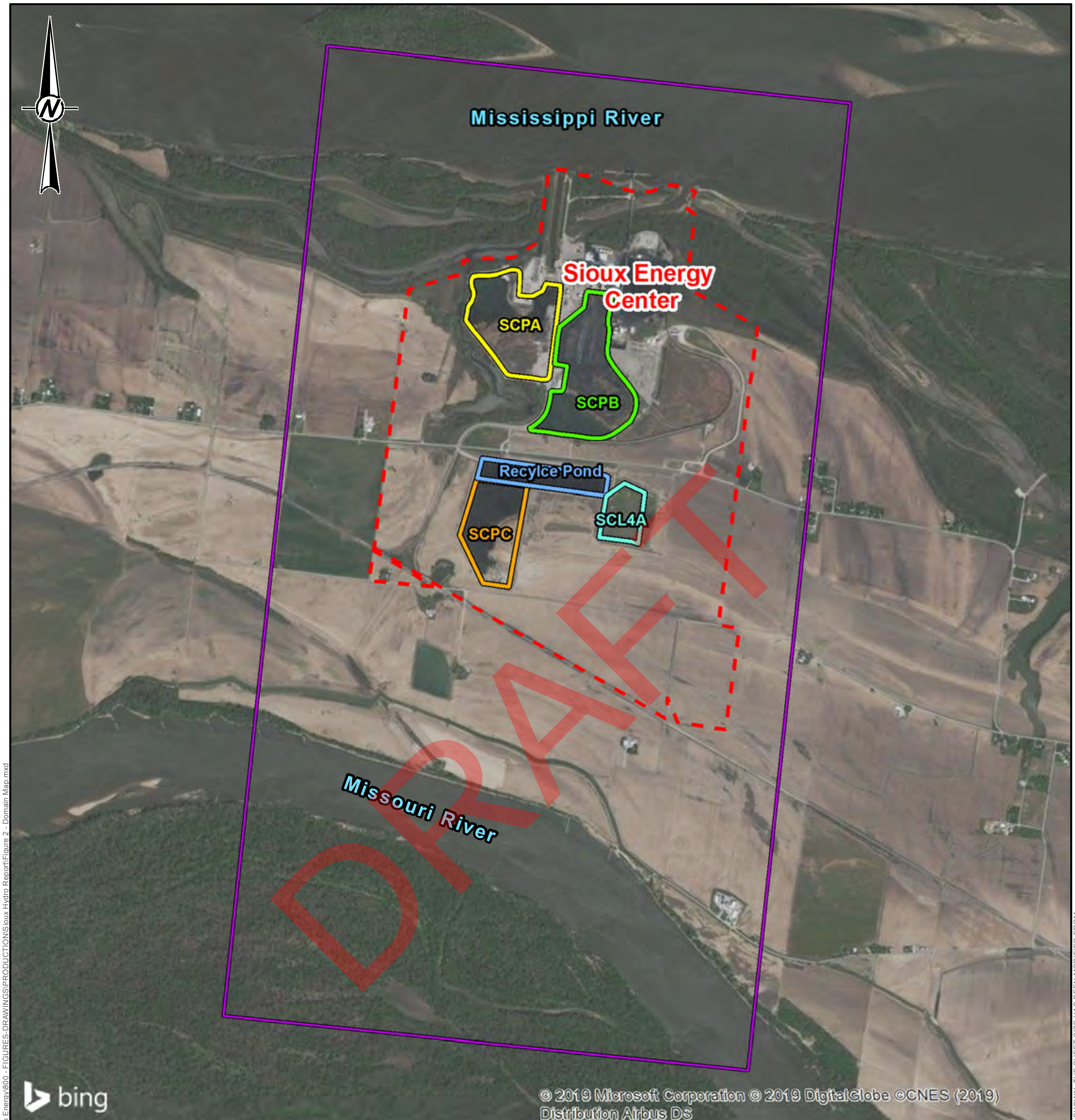

LEGEND

- Sioux Energy Center Property Boundary
- Groundwater Model Boundary
- SCPB - Lined Fly Ash Surface Impoundment
- SCPA - Unlined Bottom Ash Surface Impoundment
- Active Dry CCR Disposal Area
- Active WFGD Disposal Area
- Active Water Recycle Pond

0 2,000 4,000 6,000 Feet

NOTES

1. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.

CLIENT
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GROUNDWATER MODELING

CONSULTANT

GOLDER

YYYY-MM-DD	2018-03-07
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

TITLE
GROUNDWATER MODEL DOMAIN

Project	Rev.	FIGURE
153-1406	0.0	2

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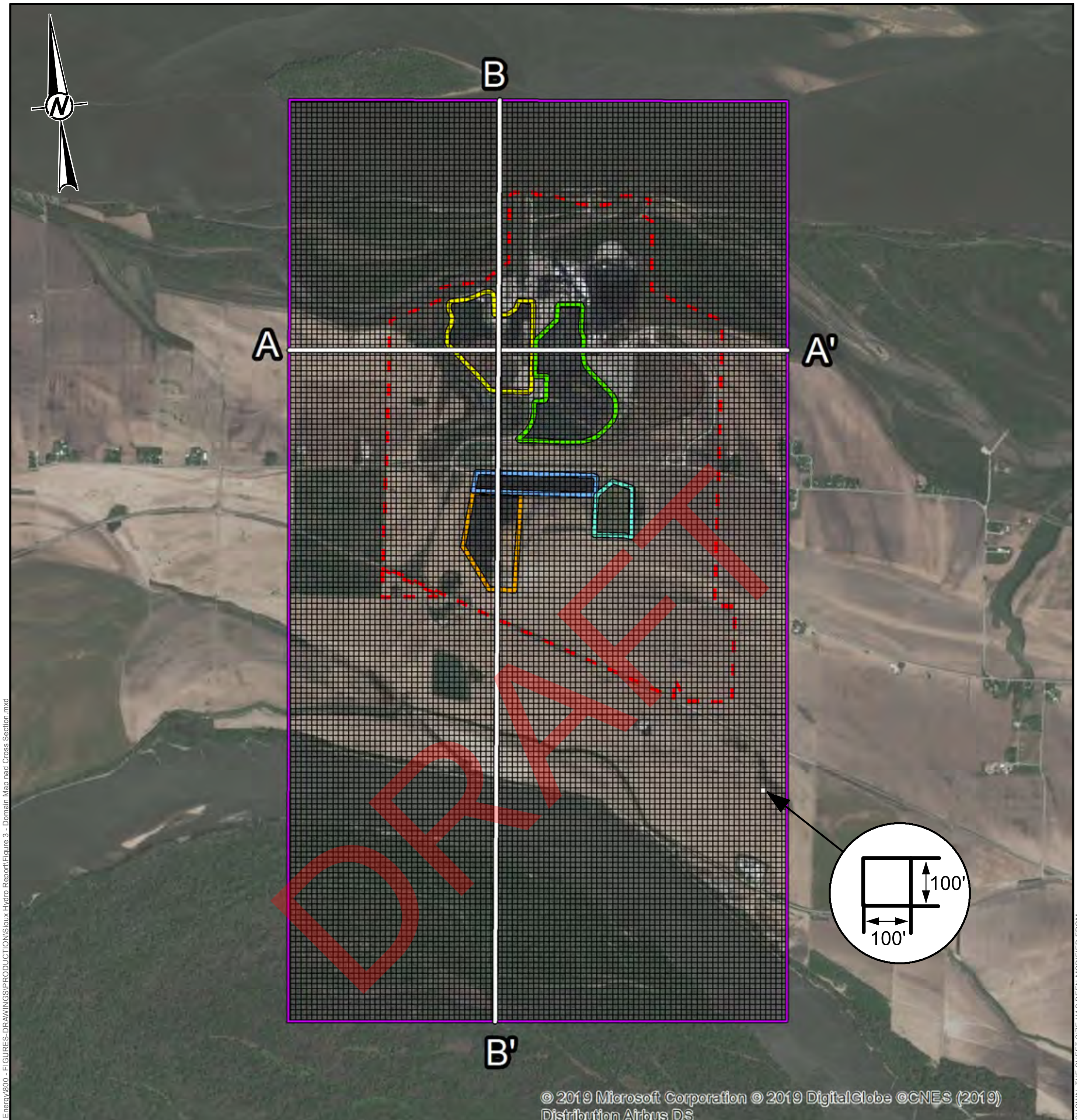

LEGEND

- Sioux Energy Center Property Boundary
- Groundwater Model Boundary
- SCPB - Lined Fly Ash Surface Impoundment
- SCPA - Unlined Bottom Ash Surface Impoundment
- Active Dry CCR Disposal Area
- Active WFGD Disposal Area
- Active Water Recycle Pond

0 2,000 4,000 6,000 8,000 Feet

NOTES

1. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.

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GOLDER

YYYY-MM-DD	2018-03-07
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

TITLE
GROUNDWATER MODEL GRID AND CROSS SECTION LOCATION MAP

Project	Rev.	FIGURE
153-1406	0.0	3

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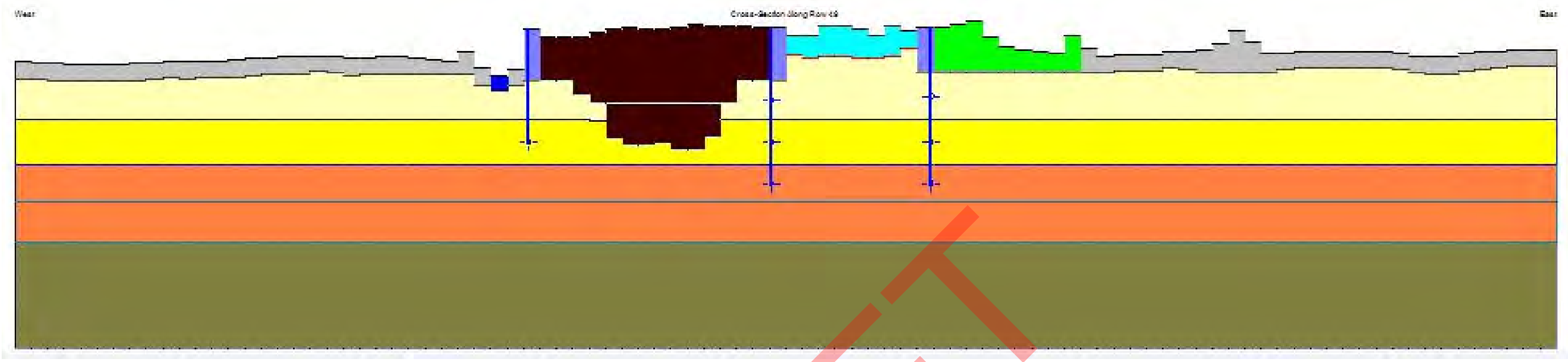
10X Vertical Exaggeration

A - West

A’ - East



Color	Layer	Kx, Ky		Kz	
		cm/sec	ft/day	cm/sec	ft/day
	Top Stratum (Silts/Clays)	9.9E-04	2.8	9.9E-04	2.8
	Shallow Alluvium (Sands and Silts)	2.6E-02	75	2.6E-03	7.5
	Intermediate Alluvium (Sands)	4.0E-02	113	4.0E-03	11.3
	Deep Alluvium (Sands and Gravels)	5.3E-02	150	5.3E-03	15
	SCPA - Fly Ash	1.8E-04	0.5	1.8E-05	0.05
	SCPA - Bottom Ash	1.8E-04	0.5	1.8E-05	0.05
	Embankments	2.7E-06	0.008	9.9E-09	2.80E-05
	Plant Areas (High Ground)	8.0E-04	2.3	8.1E-04	2.3
	Lined CCR Units	3.0E-03	8.5	3.0E-04	0.85
	Bedrock	9.9E-07	0.0028	9.9E-08	0.00028
	Surface Water	NA	NA	NA	NA
	No Flow				

DRAFT

NOTE(S)

1) Cross-section has a 10X vertical exaggeration.
2) Cm/sec = centimeters per second.
3) Ft/day = feet per day.
4) See Figure 3 for cross section location.

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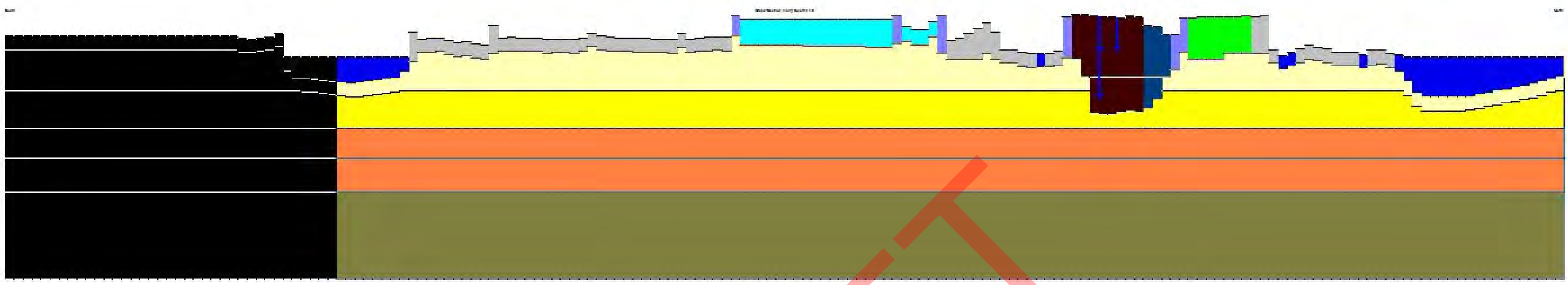
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

TITLE
A-A’ Cross-Section and Hydraulic Conductivities

PROJECT No.	REV.	FIGURE
153-1406	0.0	4

South - B

North – B’



15X Vertical Exaggeration

Color	Layer	Kx, Ky		Kz	
		cm/sec	ft/day	cm/sec	ft/day
	Top Stratum (Silts/Clays)	9.9E-04	2.8	9.9E-04	2.8
	Shallow Alluvium (Sands and Silts)	2.6E-02	75	2.6E-03	7.5
	Intermediate Alluvium (Sands)	4.0E-02	113	4.0E-03	11.3
	Deep Alluvium (Sands and Gravels)	5.3E-02	150	5.3E-03	15
	SCPA - Fly Ash	1.8E-04	0.5	1.8E-05	0.05
	SCPA - Bottom Ash	1.8E-04	0.5	1.8E-05	0.05
	Embankments	2.7E-06	0.008	9.9E-09	2.80E-05
	Plant Areas (High Ground)	8.0E-04	2.3	8.1E-04	2.3
	Lined CCR Units	3.0E-03	8.5	3.0E-04	0.85
	Bedrock	9.9E-07	0.0028	9.9E-08	0.00028
	Surface Water	NA	NA	NA	NA
	No Flow				

NOTE(S)

1) Cross-section has a 15X vertical exaggeration.
2) Cm/sec = centimeters per second.
3) Ft/day = feet per day.
4) See Figure 3 for cross section location.

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CONSULTANT

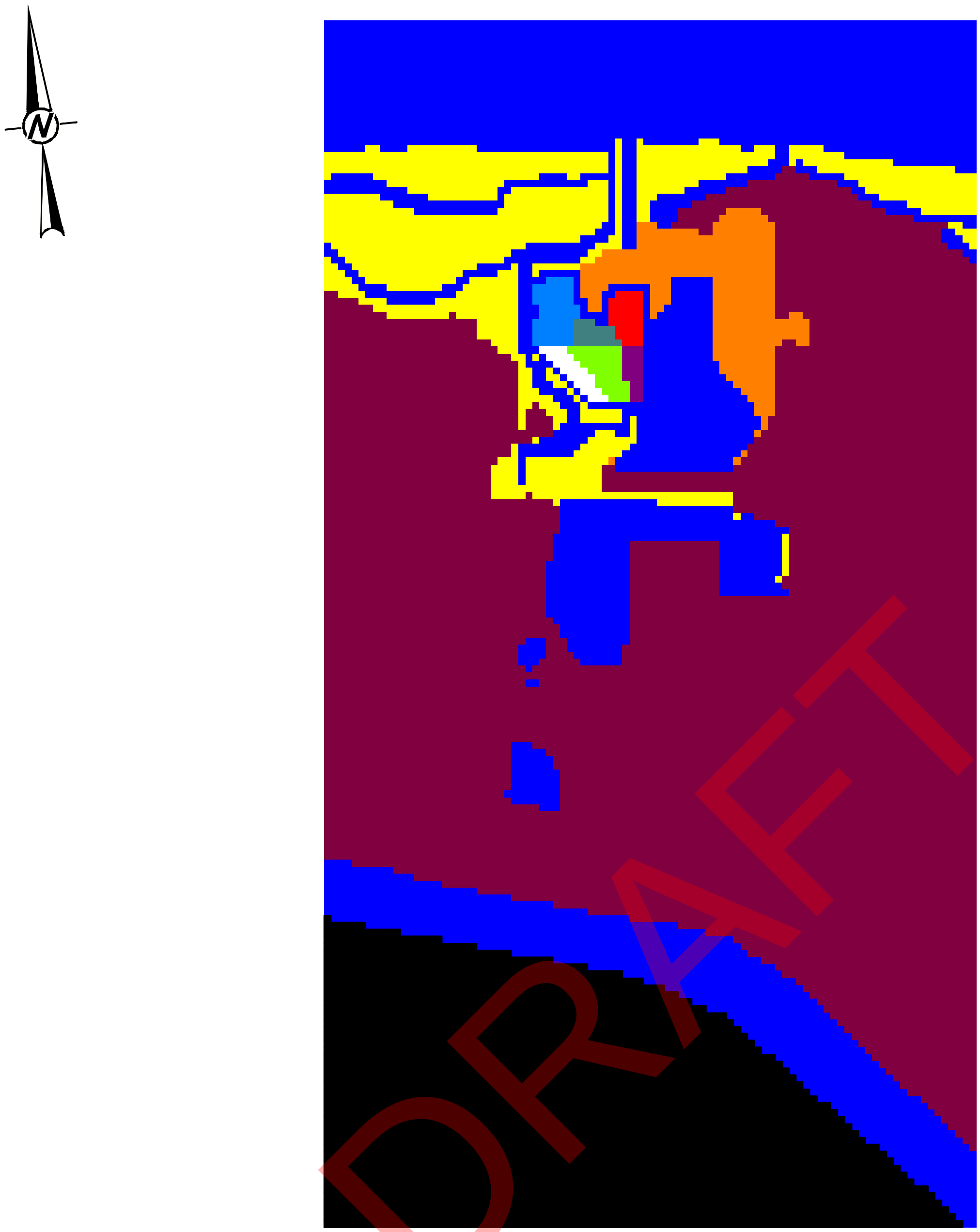
GOLDER

YYYY-MM-DD	2019-03-07
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
B-B’ Cross-Section and Hydraulic Conductivities

PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**5**



Color	Layer	Feet per day		Inches per year	
	Wooded Areas	0.00059		2.6	
	Built up Plant Areas	0.00059		2.6	
	Agricultural Areas	0.00059		2.6	
	Surface Water/ Line CCR Units	NA		NA	
	No Flow	NA		NA	
SCPA Conditions (Transient Conditons)					
		Active	Capped	Active	Capped
	Western Bottom Ash SCPA	0.015	0.00023	66	1.0
	Central Bottom Ash SCPA	0.02		88	
	Eastern Bottom Ash SCPA	0.03		131	
	Eastern Fly Ash SCPA	0.025		110	
	Central Fly As SCPA	0.02		88	
	Western Fly Ash SCPA	0.015		66	

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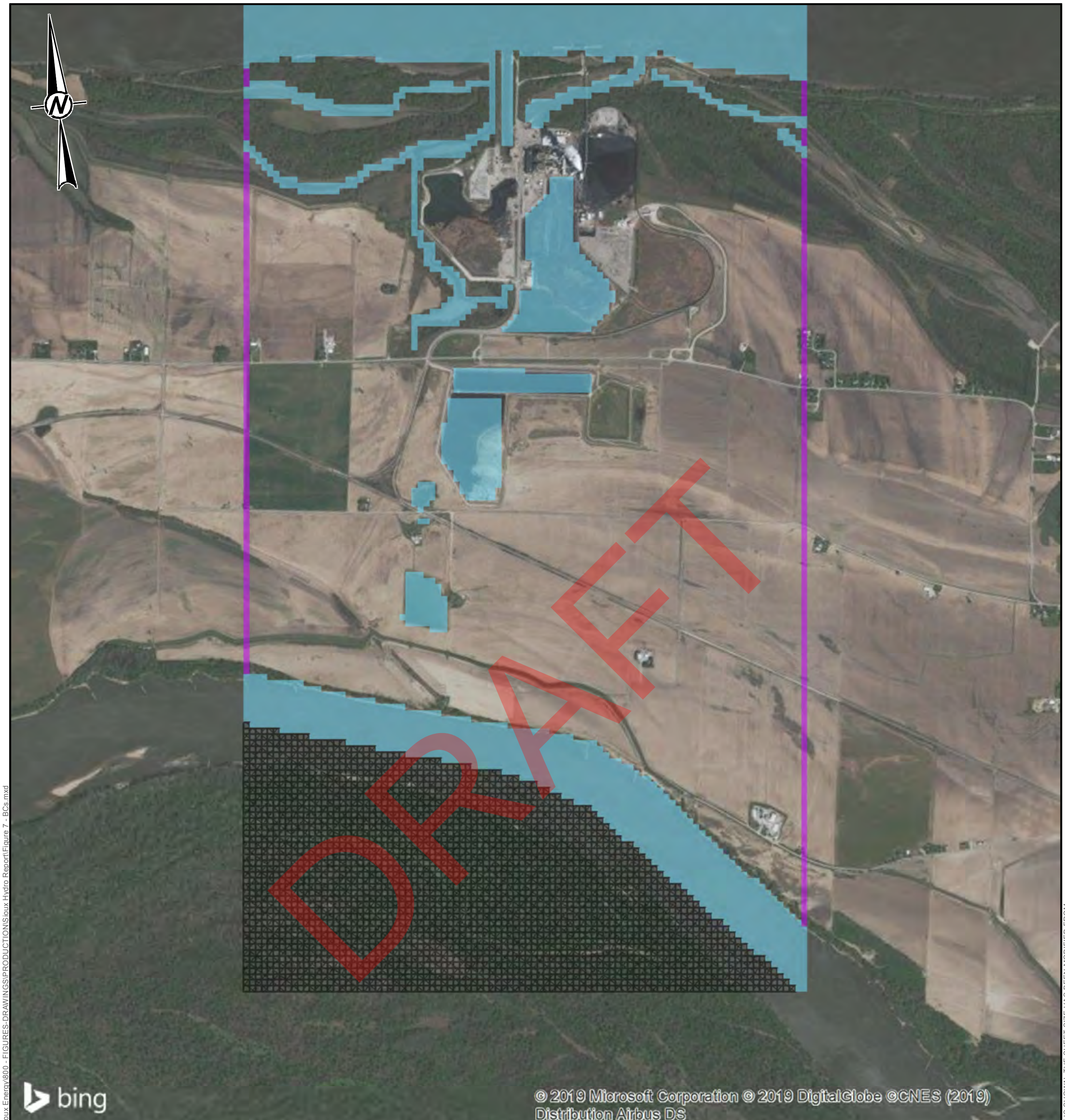
YYYY-MM-DD	2018-03-07
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
RECHARGE DISTRIBUTION

Project	Rev.	FIGURE
153-1406	0.0	6



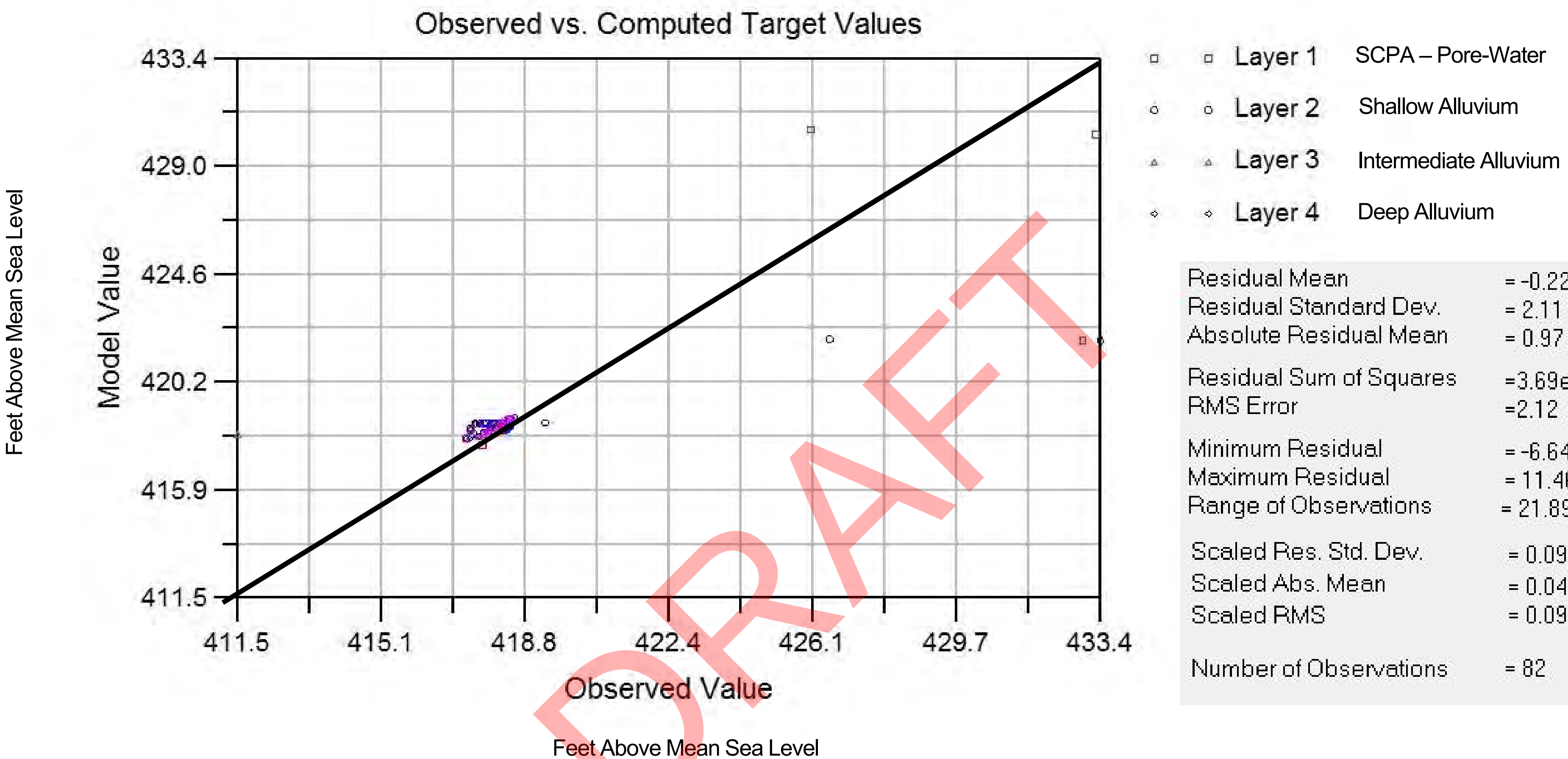
LEGEND

- General Head Boundary (GHB) - GHB is placed on the west and east sides of the model to allow west to east flow across the model.
- River - River boundary used to represent surface water including the Mississippi River, Missouri River, Poeling Lake, SCPB, SCPC and other surface water features.
- No Flow Boundary

CLIENT	AMEREN MISSOURI SIOUX ENERGY CENTER
CONSULTANT	GOLDER
YYYY-MM-DD	2018-03-07
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH
PROJECT	GROUNDWATER MODELING
TITLE	**OTHER MODEL BOUNDARY CONDITIONS**
Project	153-1406
Rev.	0.0
FIGURE	7

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Figure 7 - BCs.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0



Residual Mean	= -0.22
Residual Standard Dev.	= 2.11
Absolute Residual Mean	= 0.97
Residual Sum of Squares	=3.69e+002
RMS Error	=2.12
Minimum Residual	= -6.64
Maximum Residual	= 11.46
Range of Observations	= 21.89
Scaled Res. Std. Dev.	= 0.096
Scaled Abs. Mean	= 0.044
Scaled RMS	= 0.097
Number of Observations	= 82

NOTE(S)

1) Groundwater and surface water levels collected July 28, 2018, and Pore water levels collected March 9, 2018 (Pond level was the same both days) when the SCPA was in active conditions.
2) Mississippi River level was 417.70 and Missouri River level was 418.24 on July 28, 2018.

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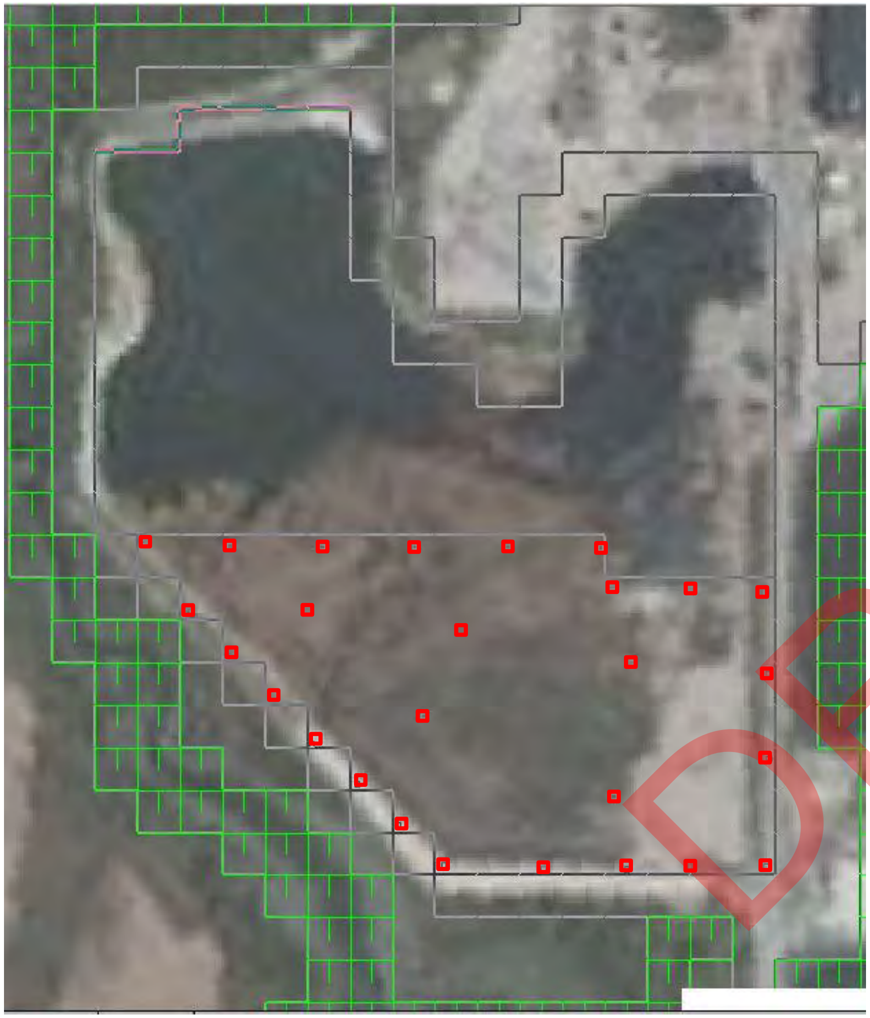
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
Scatter Diagram for Predicted and Observed Hydraulic Heads

PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**8**

LAYER 1 - SCPA



LAYER 2 - SCPA

RCPA Outline in each model layer

Starting Particle Location for Forward Particle Tracking

Model Boundary Condition Cells

River

NOTE(S)

Model Boundary Condition Cells

River

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APPROVED	MNH

PROJECT

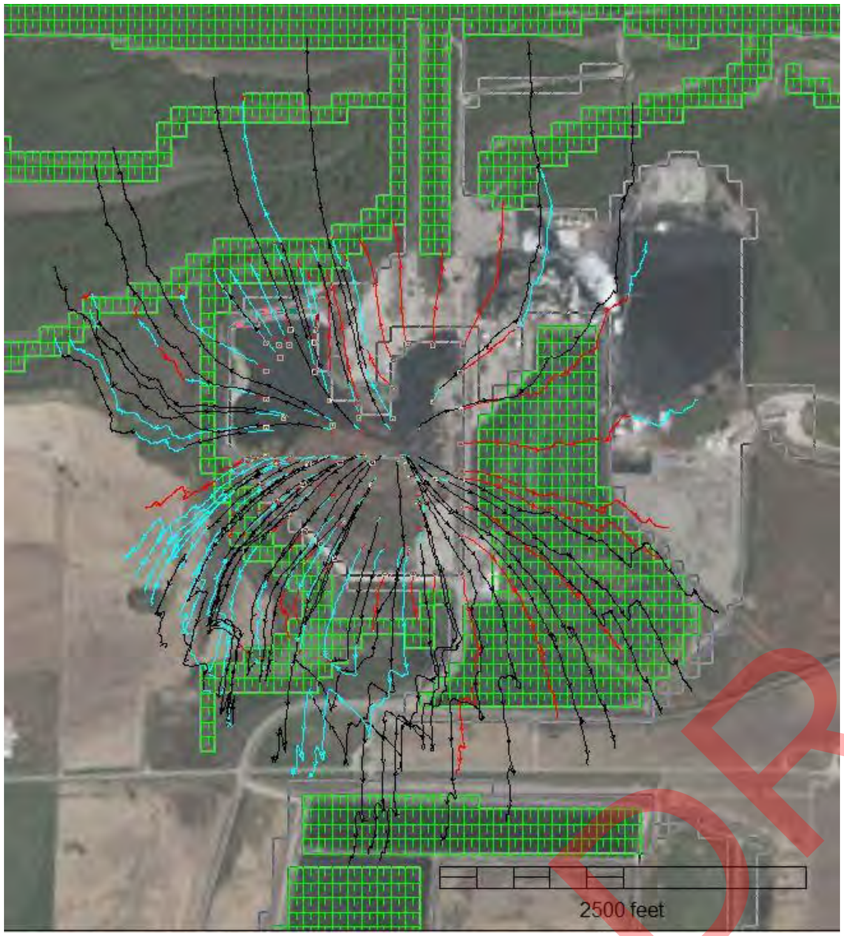
GROUNDWATER MONITORING PROGRAM

TITLE

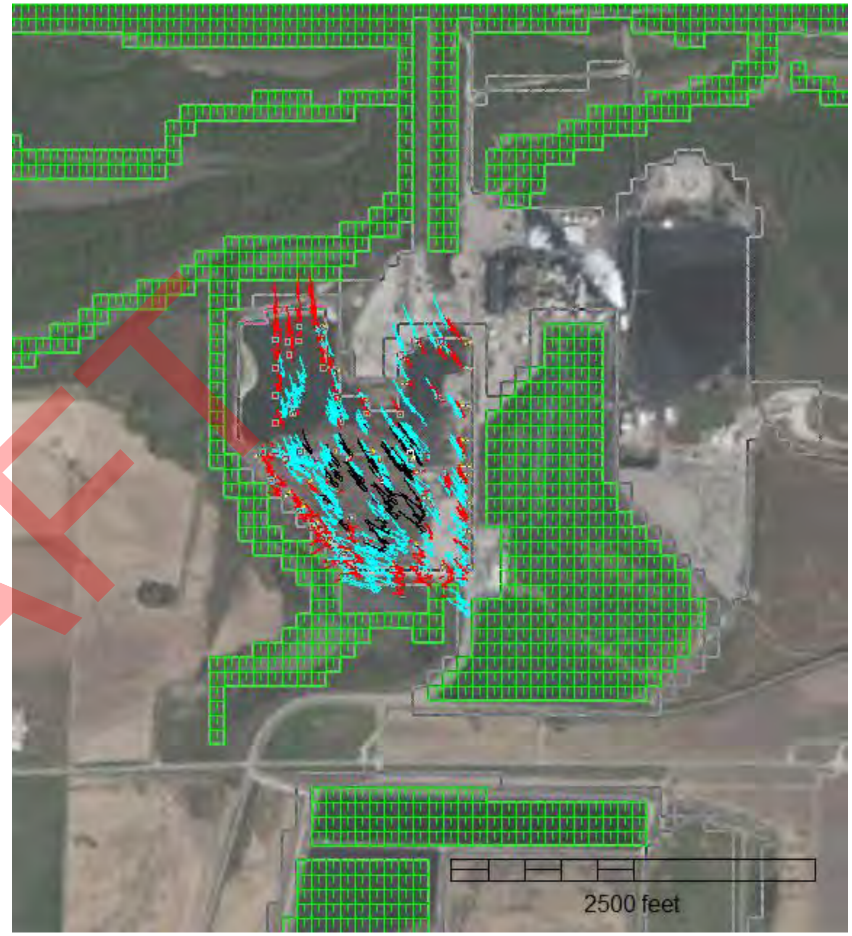
TRANSIENT GROUNDWATER MODEL STARTING PARTICLE LOCATIONS FOR FORWARD PARTICLE TRACKING

PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**9**

Predicted Historical Condition: No Cap (54 Years)



Predicted Future Condition: 1x10^-7 cm/s Cap (200 Years)



Particle Trace Colors

- SCPA or Top Stratum (Layer 1)
- SCPA or Shallow Alluvium (Layer 2)
- Intermediate Alluvium (Layer 3)
- Deep Alluvium (Layer 4 & 5)

Model Boundary Condition Cells

- River

RCPA Outline in each model layer

NOTE(S)

- Transient groundwater model predictions. Predicted Historical Condition runs 54 years (1967 through 2020). Predicted Future Condition runs 197 years (2024 through 2220).
- Particles are distributed around the outside edge and through the center between the historical fly ash and bottom ash managed portions of the SCPA in both layer 1 and layer 2.

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REVIEW	JM
APPROVED	MNH

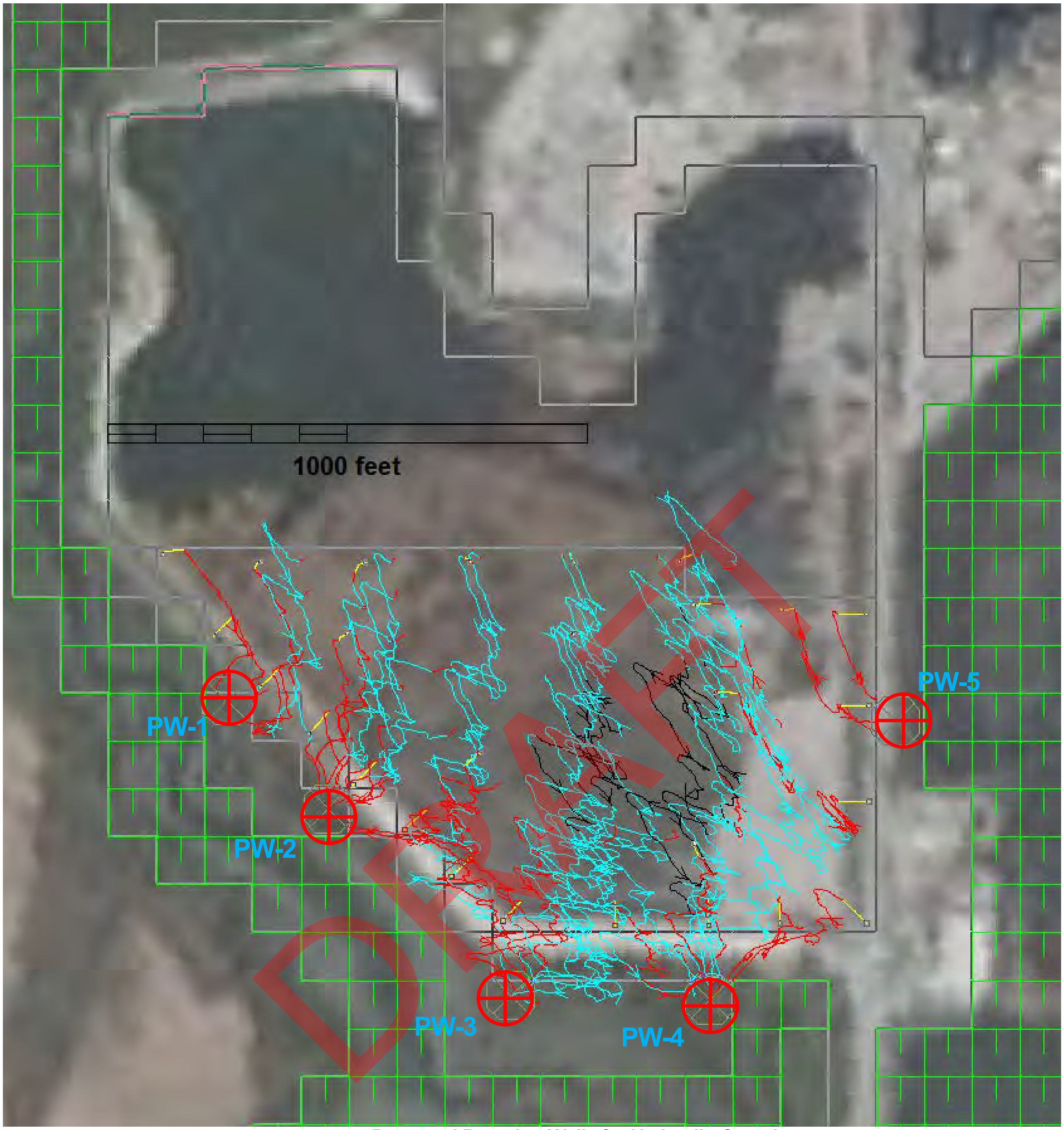
PROJECT

GROUNDWATER MONITORING PROGRAM

TITLE

TRANSIENT GROUNDWATER MODEL PREDICTIONS HISTORICAL (NO CAP) AND FUTURE (WITH CAP) CONDITIONS WITH FORWARD PARTICLE FLOW PATHS

PROJECT No.	REV.	FIGURE
153-1406	0.0	10



Particle Trace Colors

- SCPA or Top Stratum (Layer 1)
- SCPA or Shallow Alluvium (Layer 2)
- Intermediate Alluvium (Layer 3)
- Deep Alluvium (Layer 4)

Model Boundary Condition Cells

River

Proposed Pumping Wells for Hydraulic Containment of Particles Leaving Southern Portion of SCPA

PW-01 Proposed Pumping Well

-5 Proposed Pumping Wells at approximately 500 to 1000 foot spacing
-Screened from Very Shallow Alluvium to Deep Alluvium (Layers 1-4)
-Upward Vertical Hydraulic Gradient predicted in Deep Alluvium near each well
-Predicted hydraulic containment of southern SCPA particles maintained based on:
-Each Well Pumping Rate = **3 gpm** Total Pumping Rate = 1**5 gpm**

NOTE(S)
- Transient groundwater model predictions.
- Particles distributed along the outside edge of the SCPA in each model ash layer. See Figure 9 for details on starting particle locations.
- Cap model includes 1.0 inches/year recharge to the SCPA based model net infiltration prediction for 1 x 10^-7 cm/s soil cover.

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PROJECT
GROUNDWATER MONITORING PROGRAM

CONSULTANT
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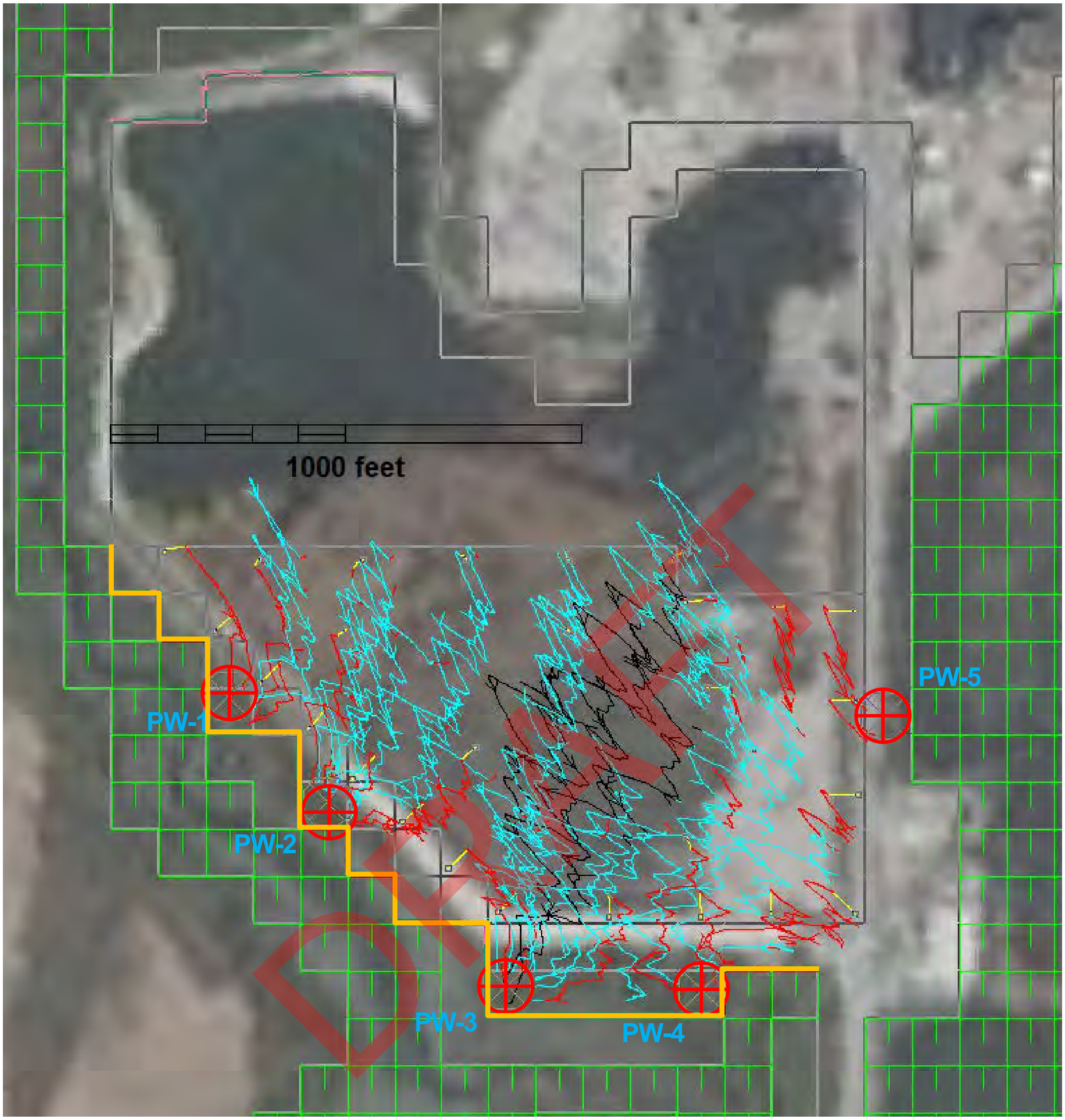
YYYY-MM-DD	2019-03-14
PREPARED	JSI
DESIGNED	JSI
REVIEWED	JM
APPROVED	MNH

TITLE
TRANSIENT GROUNDWATER MODEL PREDICTIONS WITH CLOSED (1x10^-7 CAP CM/SEC CAP) SCPA WITH FIVE PROPOSED PUMPING WELLS

PROJECT NO. **1531406** REV. **A** FIGURE **11**



Particle Trace Colors

- SCPA or Top Stratum (Layer 1)
- SCPA or Shallow Alluvium (Layer 2)
- Intermediate Alluvium (Layer 3)
- Deep Alluvium (Layer 4)

Model Boundary Condition Cells

River

Proposed Slurry Wall Constructed from Very Shallow Alluvium to Deep Alluvium/Top of Bedrock. The slurry wall was modeled as 2 feet thick and with a hydraulic conductivity of 1 x 10-6 cm/s.

Proposed Pumping Wells for Hydraulic Containment of Particles Leaving Southern Portion of SCPA

PW-01 Proposed Pumping Well

-5 Proposed Pumping Wells at approximately 500 to 1000 foot spacing
-Screened from Very Shallow Alluvium to Deep Alluvium (Layers 1-4)
-Upward Vertical Hydraulic Gradient predicted in Deep Alluvium near each well
-Predicted hydraulic containment of southern SCPA particles maintained based on:
-Each Well Pumping Rate = **1 gpm** Total Pumping Rate = **5 gpm**

NOTE(S)
- Transient groundwater model predictions.
- Particles distributed along the outside edge of the SCPA in each model ash layer. See Figure 9 for details on starting particle locations.
- Cap model includes 1.0 inches/year recharge to the SCPA based model net infiltration prediction for 1 x 10^-7 cm/s soil cover.

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PROJECT
GROUNDWATER MONITORING PROGRAM

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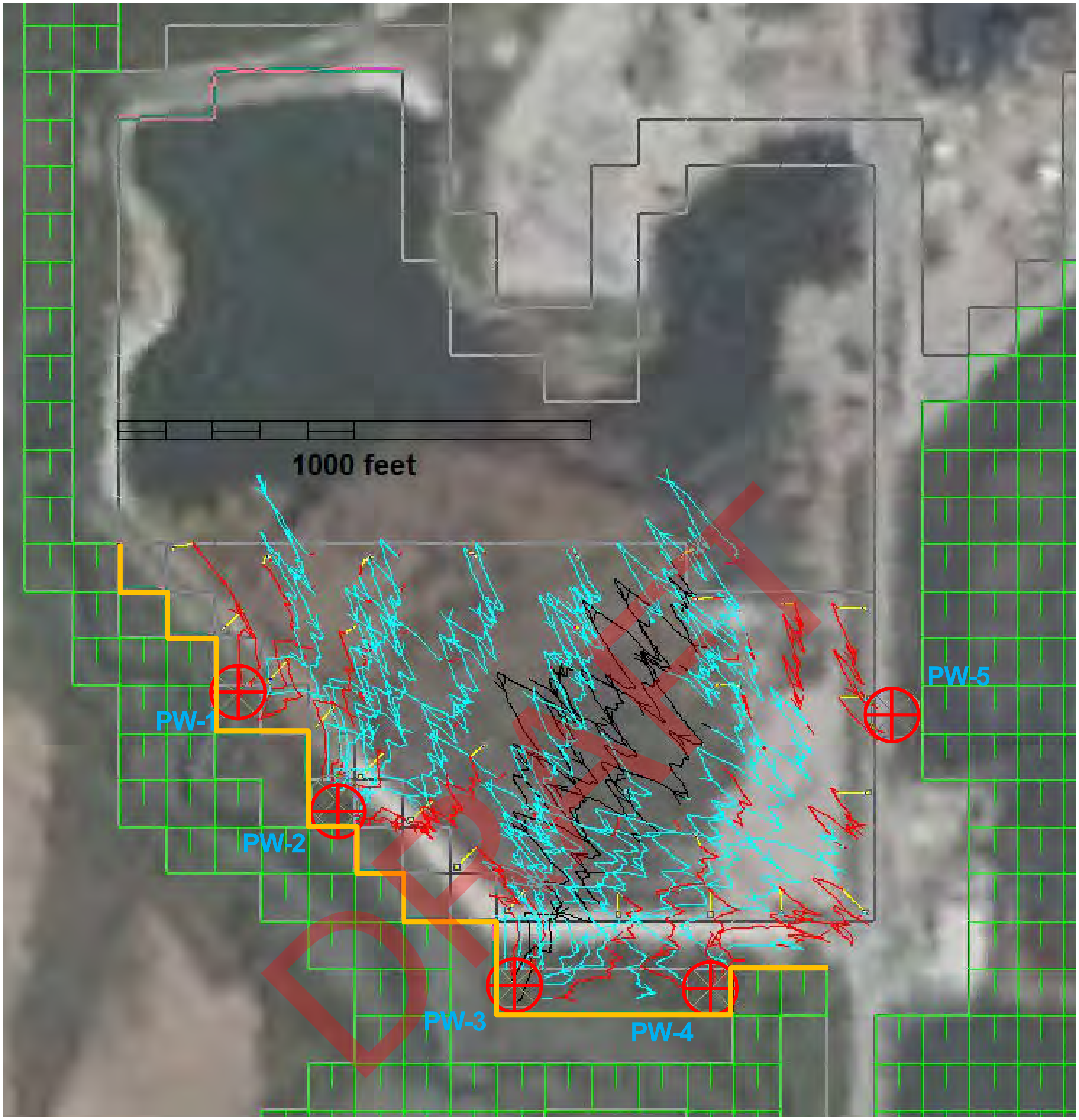
PREPARED	JSI
DESIGNED	JSI
REVIEWED	JM
APPROVED	MNH

TITLE
TRANSIENT GROUNDWATER MODEL PREDICTIONS WITH CLOSED (1x10^-7 CAP CM/SEC CAP) SCPA, SLURRY WALL (100 FT BGS), AND FIVE PROPOSED PUMPING WELLS

PROJECT NO.	REV.	FIGURE
1531406	A	12



Particle Trace Colors

- SCPA or Top Stratum (Layer 1)
- SCPA or Shallow Alluvium (Layer 2)
- Intermediate Alluvium (Layer 3)
- Deep Alluvium (Layer 4)

Model Boundary Condition Cells

- River
- Proposed Slurry Wall Constructed from Very Shallow Alluvium to Deep Alluvium/50 feet into Bedrock. The slurry wall was modeled as 2 feet thick and with a hydraulic conductivity of 1 x 10-6 cm/s.

Proposed Pumping Wells for Hydraulic Containment of Particles Leaving Southern Portion of SCPA

PW-01 Proposed Pumping Well

-5 Proposed Pumping Wells at approximately 500 to 1000 foot spacing
-Screened from Very Shallow Alluvium to Deep Alluvium (Layers 1-4)
-Upward Vertical Hydraulic Gradient predicted in Deep Alluvium near each well
-Predicted hydraulic containment of southern SCPA particles maintained based on:
-Each Well Pumping Rate = **1 gpm** Total Pumping Rate = **5 gpm**

NOTE(S)
- Transient groundwater model predictions.
- Particles distributed along the outside edge of the SCPA in each model ash layer. See Figure 9 for details on starting particle locations.
- Cap model includes 1.0 inches/year recharge to the SCPA based model net infiltration prediction for 1 x 10^-7 cm/s soil cover.

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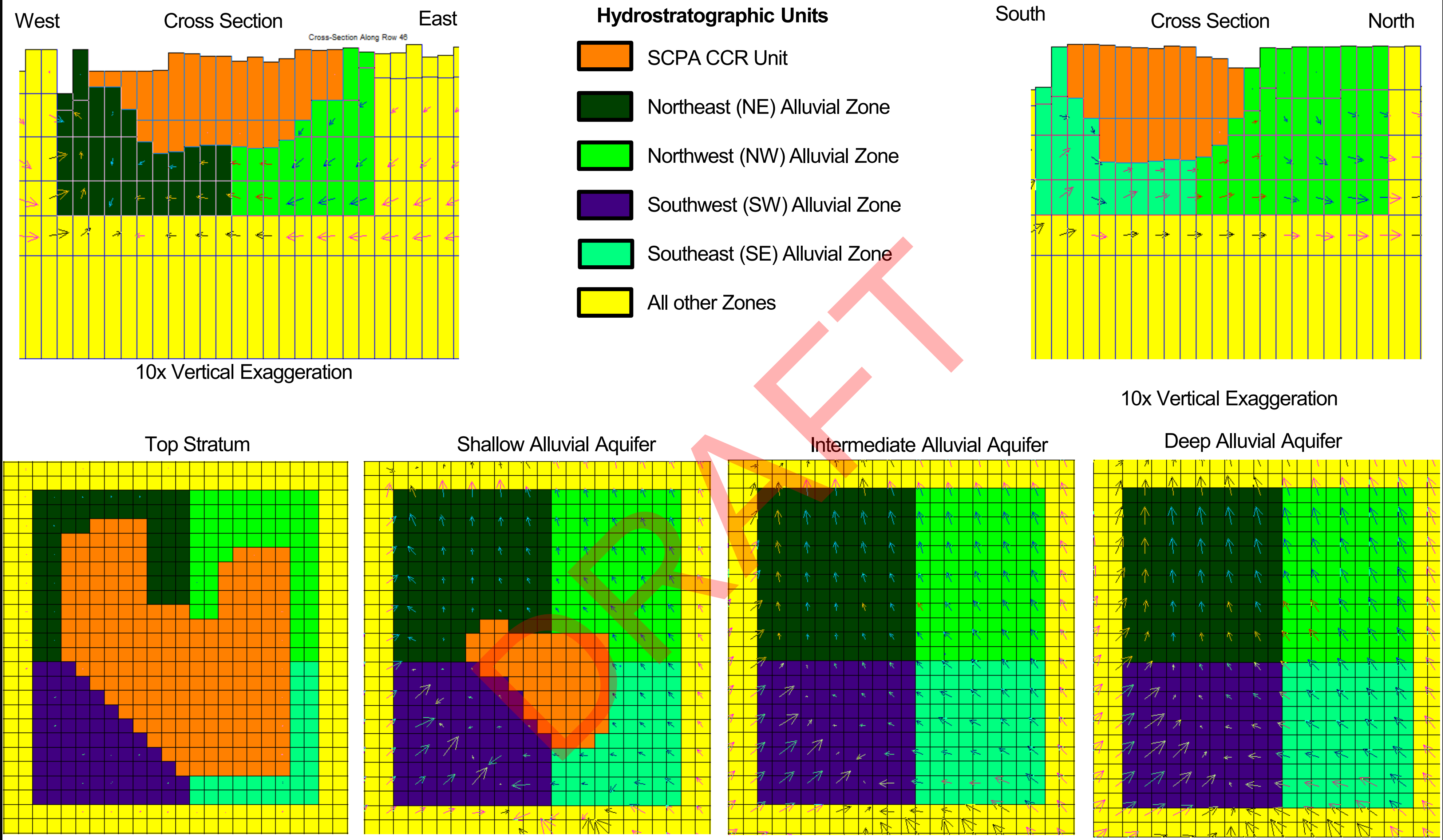
PROJECT	GROUNDWATER MONITORING PROGRAM
CONSULTANT	GOLDER
YYYY-MM-DD	2019-03-14
PREPARED	JSI
DESIGNED	JSI
REVIEWED	JM
APPROVED	MNH
TITLE	**TRANSIENT GROUNDWATER MODEL PREDICTIONS WITH CLOSED (1x10^-7 CAP CM/SEC CAP) SCPA, SLURRY WALL (150 FT BGS), AND FIVE PROPOSED PUMPING WELLS**
PROJECT NO.	**1531406**
REV.	**A**
FIGURE	**13**



NOTE(S)

1) Average flow is provided in Table 3
2) Vectors display direction and magnitude of groundwater flow
3) Images from Groundwater Vistas Software using Modflow.

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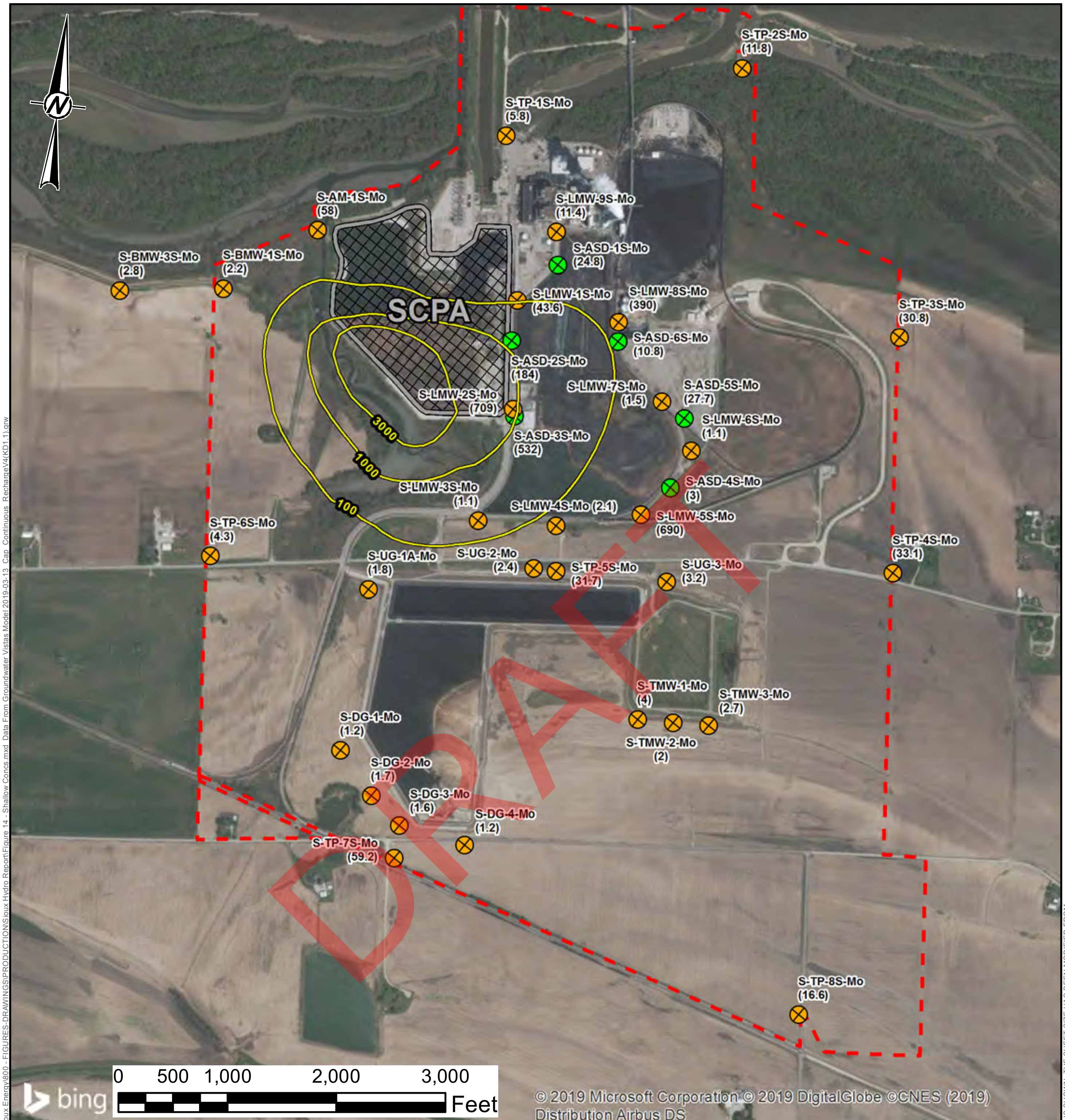
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
Model Estimates of Flow Around vs Into SCPA

PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**14**



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Model Estimated Molybdenum Concentrations (μg/L)
- Sampled in January 2018
- Sampled in November 2018

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 2 OF THE MODEL AT AN AVERAGE ELEVATION OF APPROXIMATELY 400 FEET ABOVE MEAN SEA LEVEL.
3. NON-DETECT VALUES ON FIGURES USE HALF OF THE METHOD DETECTION LIMIT FOR MODEL TARGET PURPOSES.
4. J-FLAGS NOT USED FOR MODEL TARGET PURPOSES.

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DESIGN	JSI
REVIEW	EMS
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

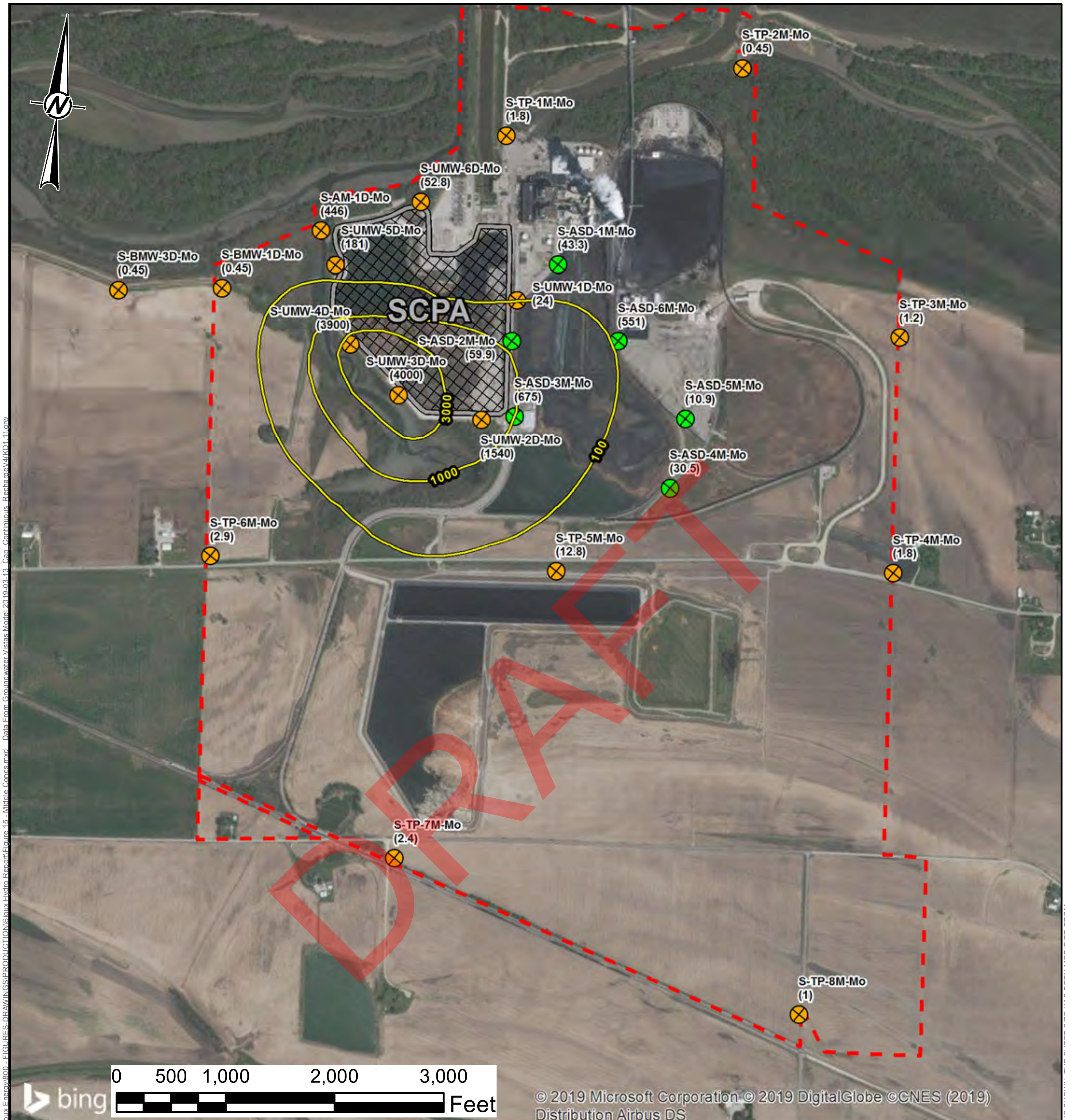
TITLE
2018 PREDICTED AND OBSERVED MOLYBDENUM CONCENTRATIONS – SHALLOW ALLUVIAL AQUIFER

Project	Rev.	FIGURE
153-1406	0.0	15

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Figure 14 - Shallow Concs.mxd Data From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

0 1 in



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Model Estimated Molybdenum Concentrations (µg/L)
- Sampled in January 2018
- Sampled in November 2018

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AN AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.
3. NON-DETECT VALUES ON FIGURES USE HALF OF THE METHOD DETECTION LIMIT FOR MODEL TARGET PURPOSES.
4. J-FLAGS NOT USED FOR MODEL TARGET PURPOSES.

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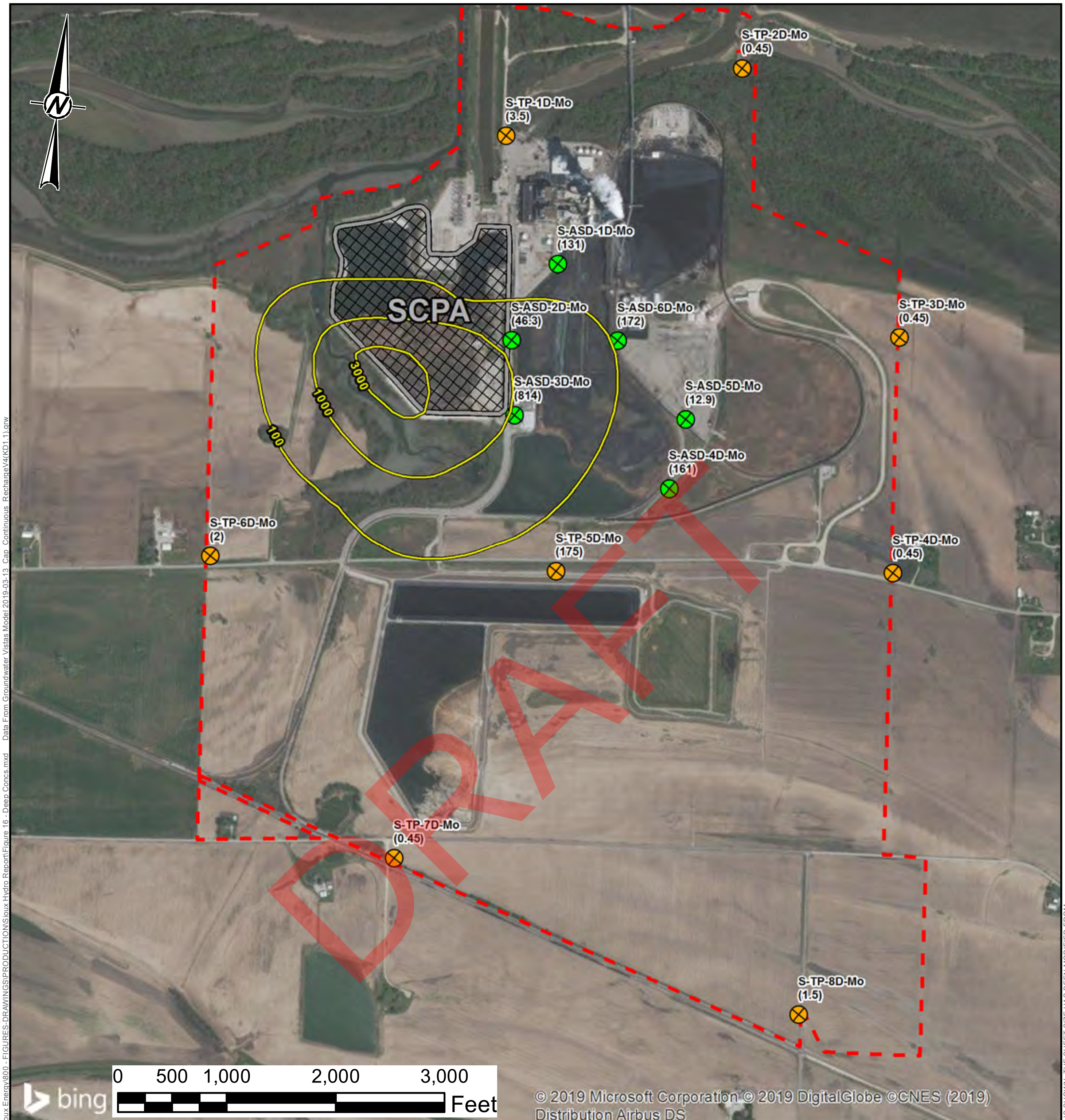
PREPARED	JSI
DESIGN	JSI
REVIEW	EMS
APPROVED	MNH

TITLE
2018 PREDICTED AND OBSERVED MOLYBDENUM CONCENTRATIONS – INTERMEDIATE ALLUVIAL AQUIFER

Project	Rev.	FIGURE
153-1406	0.0	16

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Model Estimated Molybdenum Concentrations (µg/L)
- Sampled in January 2018
- Sampled in November 2018

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 4 OF THE MODEL AT AN AVERAGE ELEVATION OF APPROXIMATELY 350 FEET ABOVE MEAN SEA LEVEL.
3. NON-DETECT VALUES ON FIGURES USE HALF OF THE METHOD DETECTION LIMIT FOR MODEL TARGET PURPOSES.
4. J-FLAGS NOT USED FOR MODEL TARGET PURPOSES.

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PREPARED	JSI
DESIGN	JSI
REVIEW	EMS
APPROVED	MNH

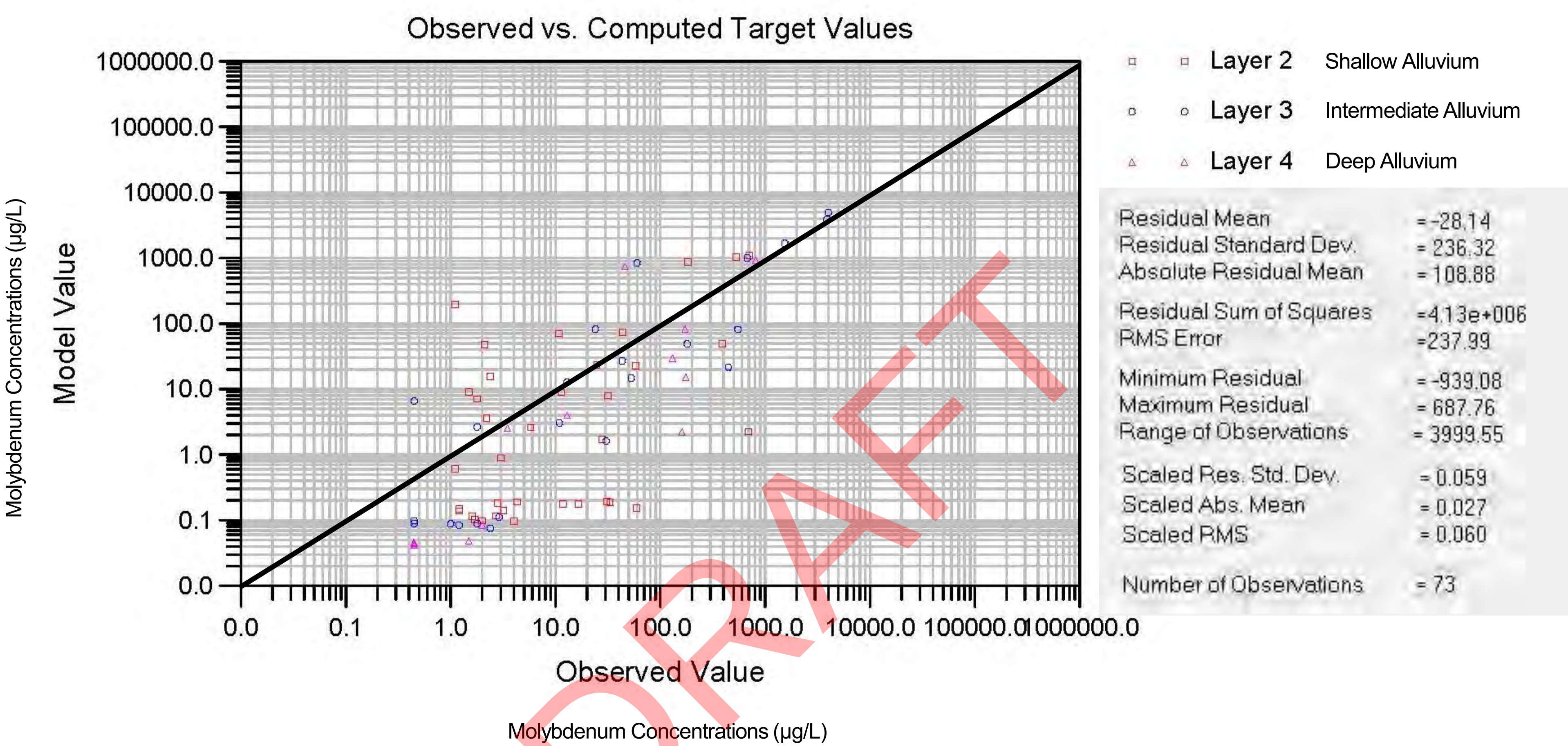
PROJECT
GROUNDWATER MODELING

TITLE
2018 PREDICTED AND OBSERVED MOLYBDENUM CONCENTRATIONS – DEEP ALLUVIAL AQUIFER

Project	Rev.	FIGURE
153-1406	0.0	17

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Figure 16 - Deep Concs.mxd Data From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in



NOTE(S)

1) Groundwater results collected from ASD and Pore-water samples in January-February 2018. Groundwater results from all other monitoring wells collected in November 2018. These samples were collected during active conditions of the SCPA.

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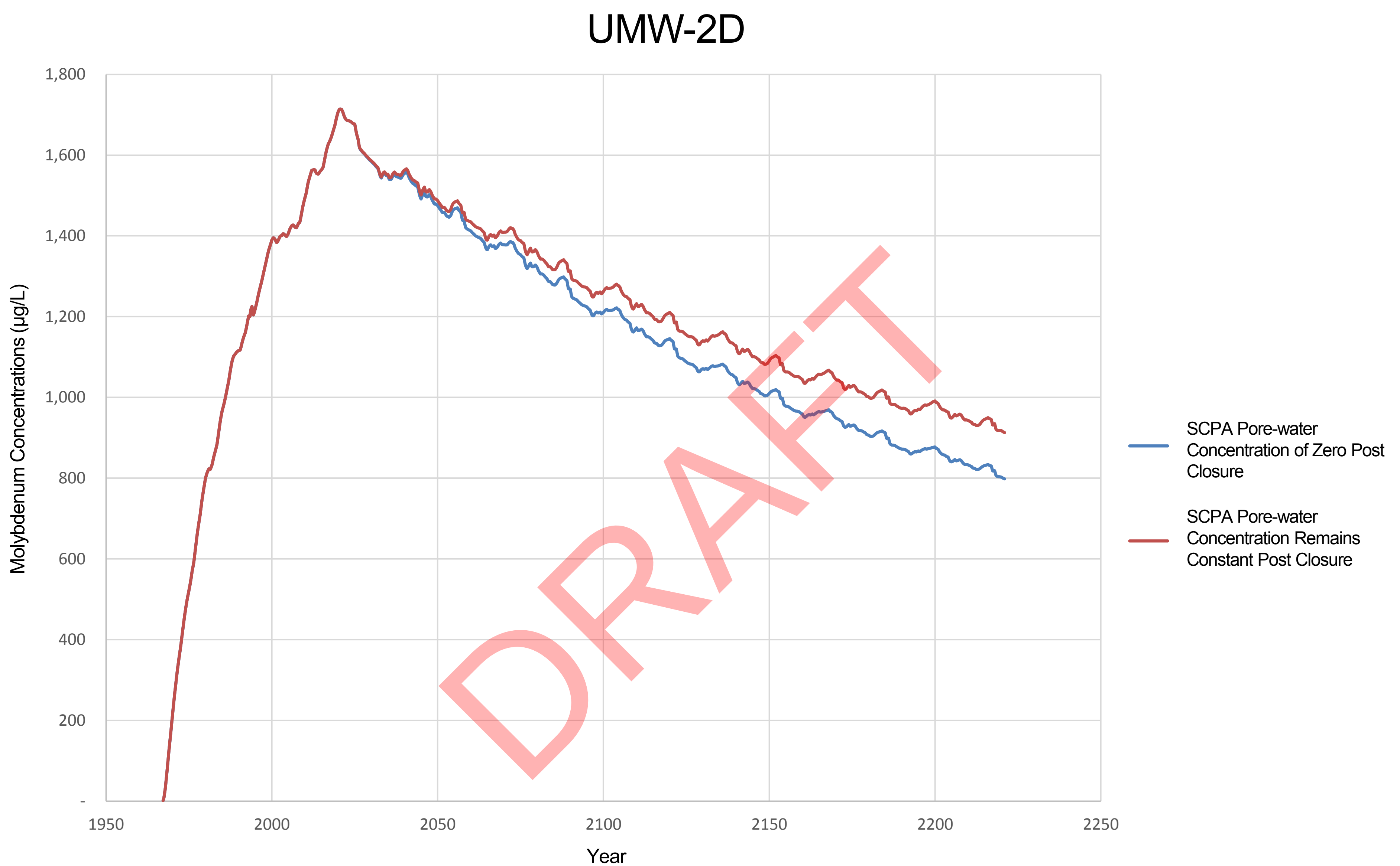
REVIEW	JM
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
Scatter Diagram for Predicted and Observed Molybdenum Concentrations

PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**18**



NOTE(S)

1) All model conditions are the same between the two scenarios except for SCPA Concentrations after closure

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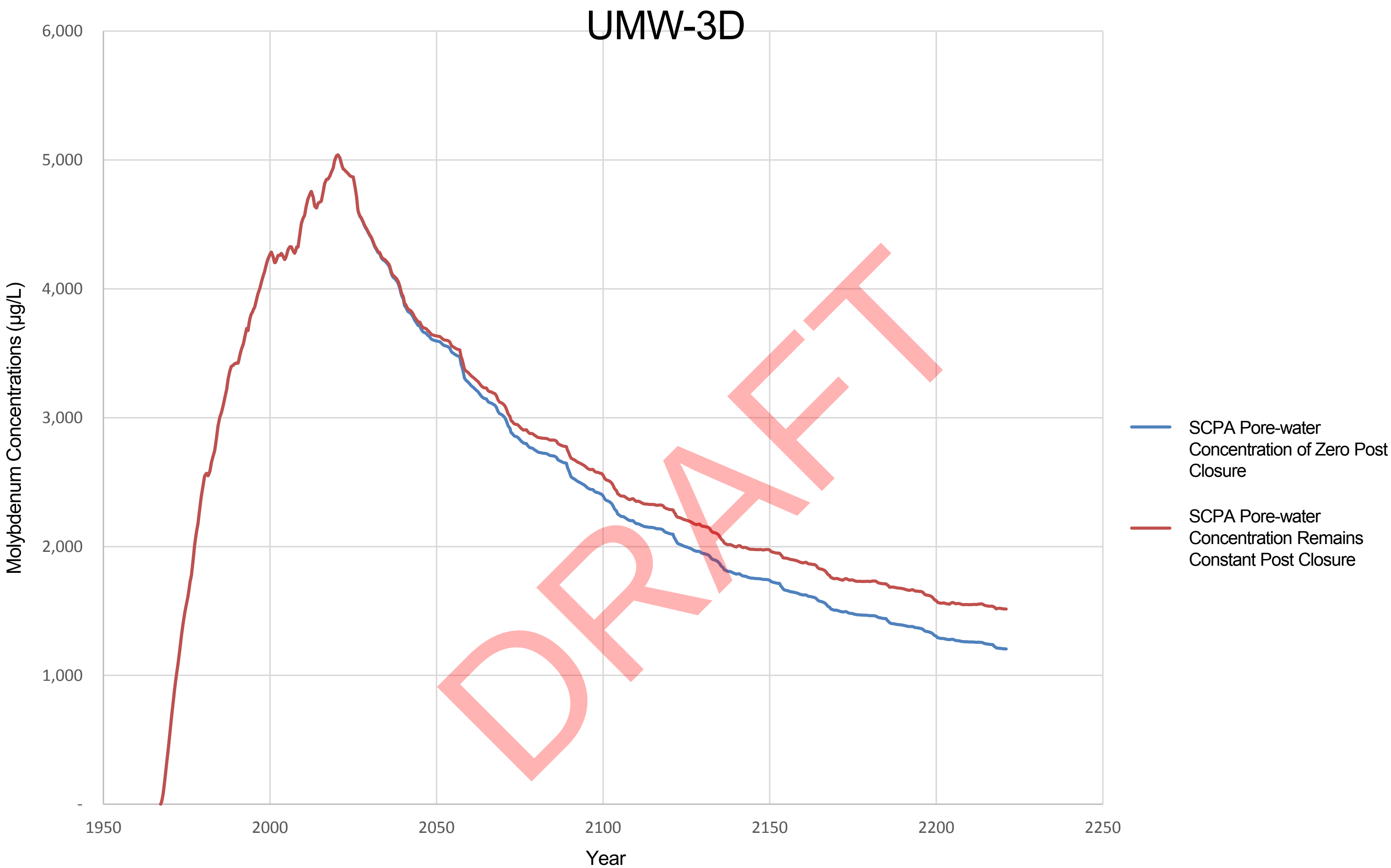
DESIGN	JSI`
REVIEW	JM
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
Predicted Molybdenum Concentrations at UMW-2D for Alternate Assumed Post Closure SCPA Porewater Concentrations

PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**19**

Models: 2019-03-12_Cap_Continuous_RechargeV4(KD1.1) & 2019-03-12_Cap_Zero_RechargeV4(KD1.1)



NOTE(S)

1) All model conditions are the same between the two scenarios except for SCPA Concentrations after closure

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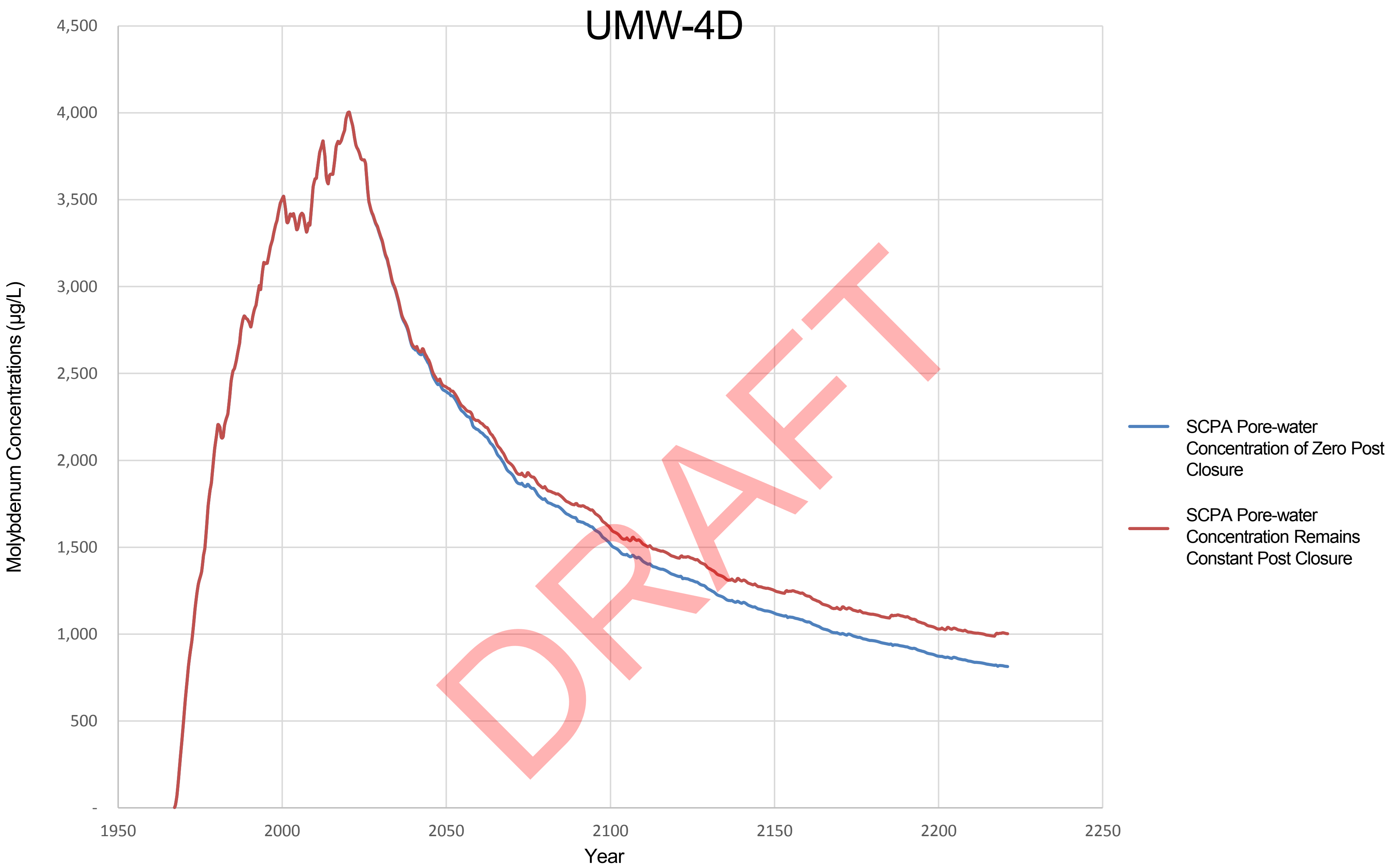
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
Predicted Molybdenum Concentrations at UMW-3D for Alternate Assumed Post Closure SCPA Porewater Concentrations

PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**20**

Models: 2019-03-12_Cap_Continuous_RechargeV4(KD1.1) & 2019-03-12_Cap_Zero_RechargeV4(KD1.1)



Models: 2019-03-12_Cap_Continuous_RechargeV4(KD1.1) & 2019-03-12_Cap_Zero_RechargeV4(KD1.1)

NOTE(S)

1) All model conditions are the same between the two scenarios except for SCPA Concentrations after closure

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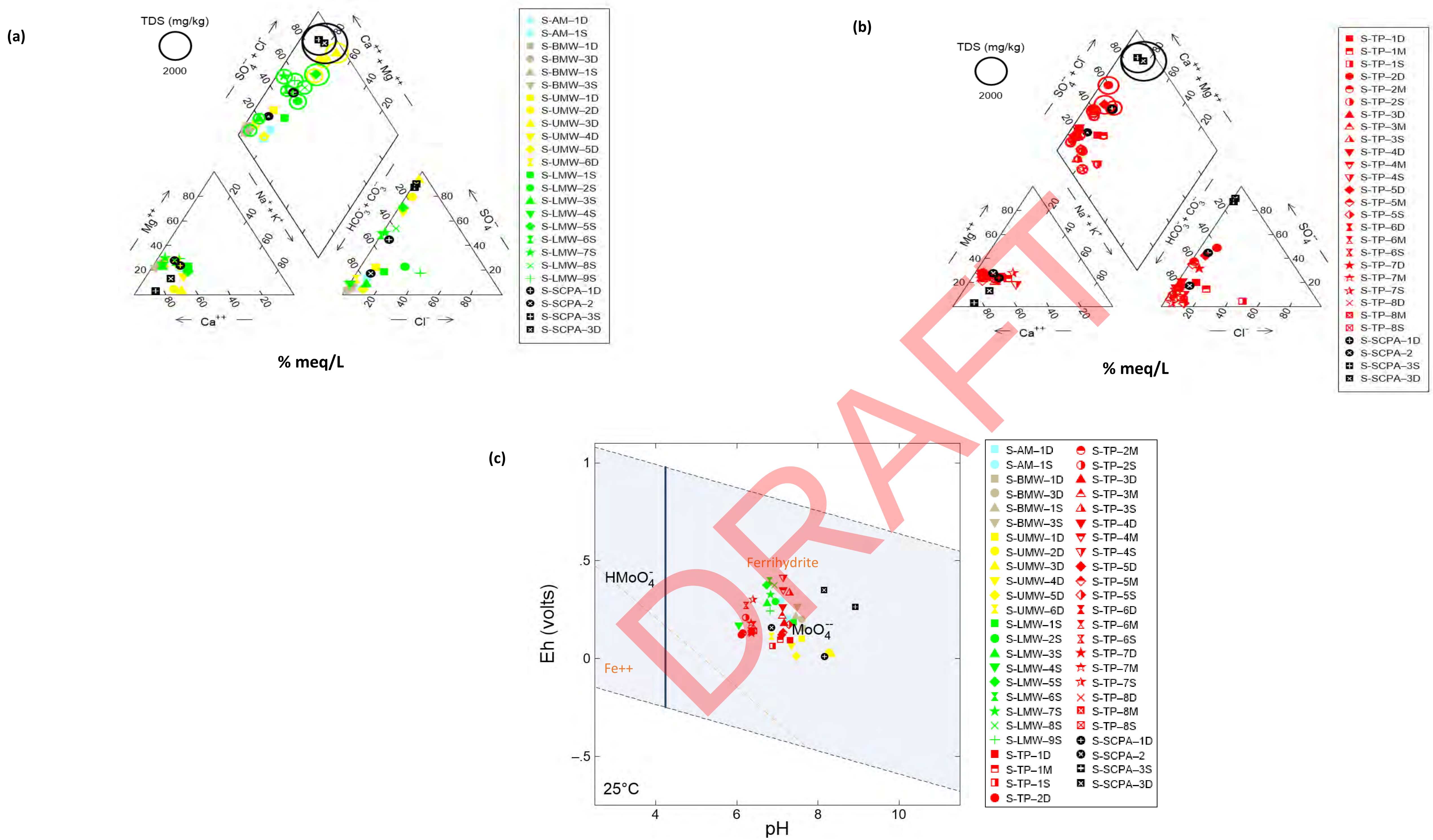
PREPARED	JSI
DESIGN	JSI
REVIEW	JM
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
Predicted Molybdenum Concentrations at UMW-4D for Alternate Assumed Post Closure SCPA Porewater Concentrations

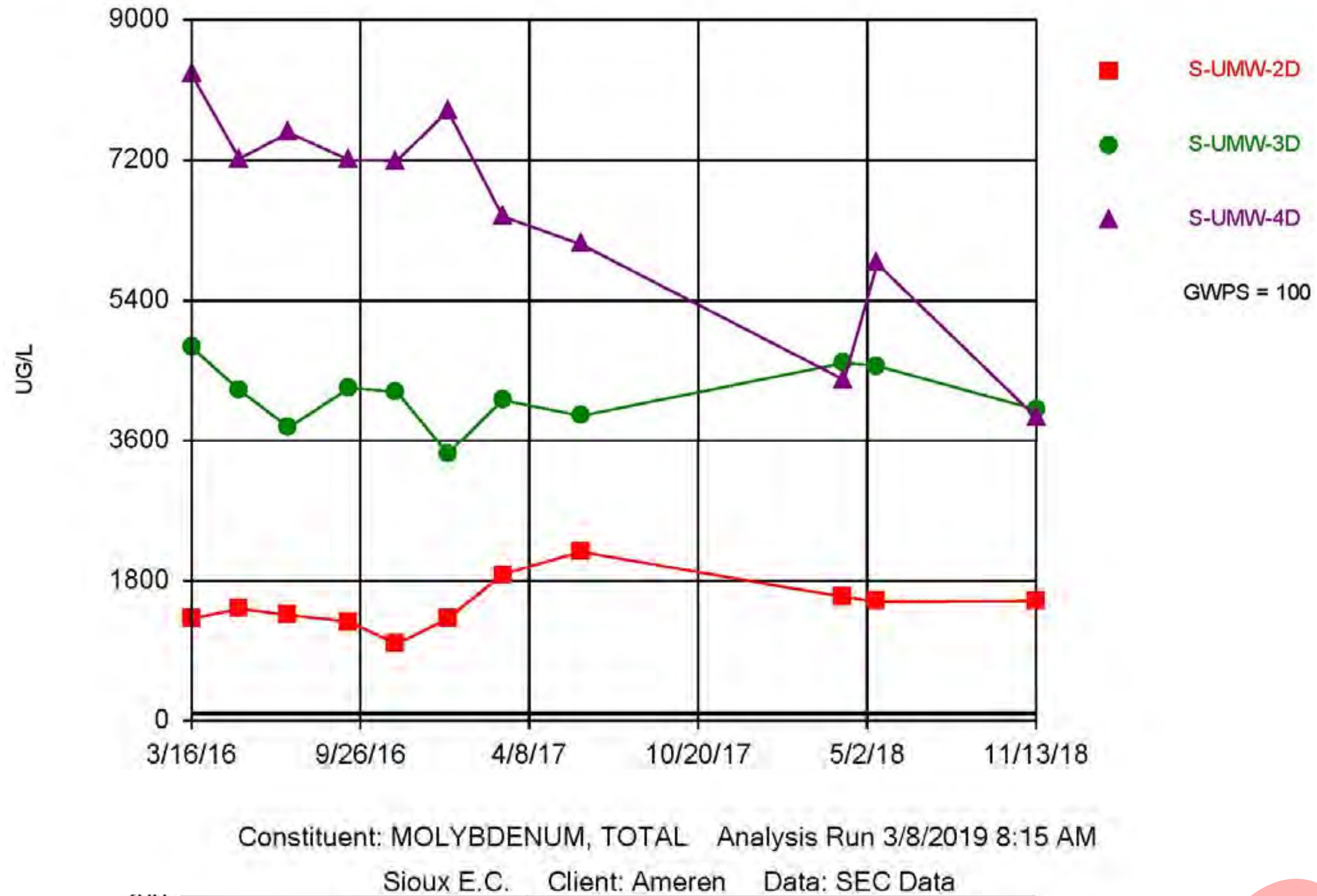
PROJECT No.	REV.	FIGURE
153-1406	**0.0**	**21**



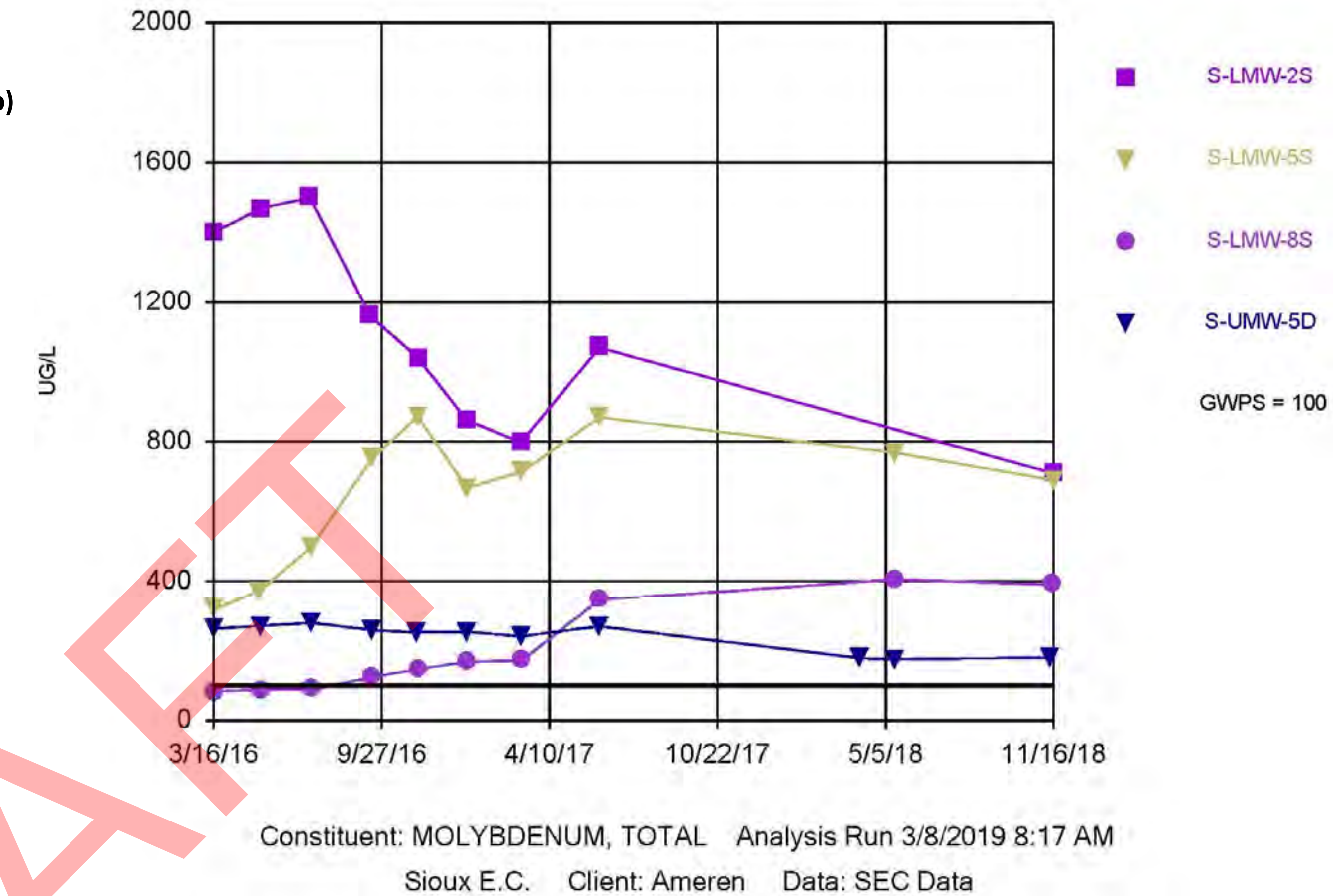
CLIENT	PROJECT
AMEREN MISSOURI SIOUX ENERGY CENTER	GROUNDWATER MONITORING PROGRAM
CONSULTANT GOLDER	TITLE **Major Ion Geochemistry**

PROJECT NO.	PHASE	REV.	FIGURE
1531406	0003		22

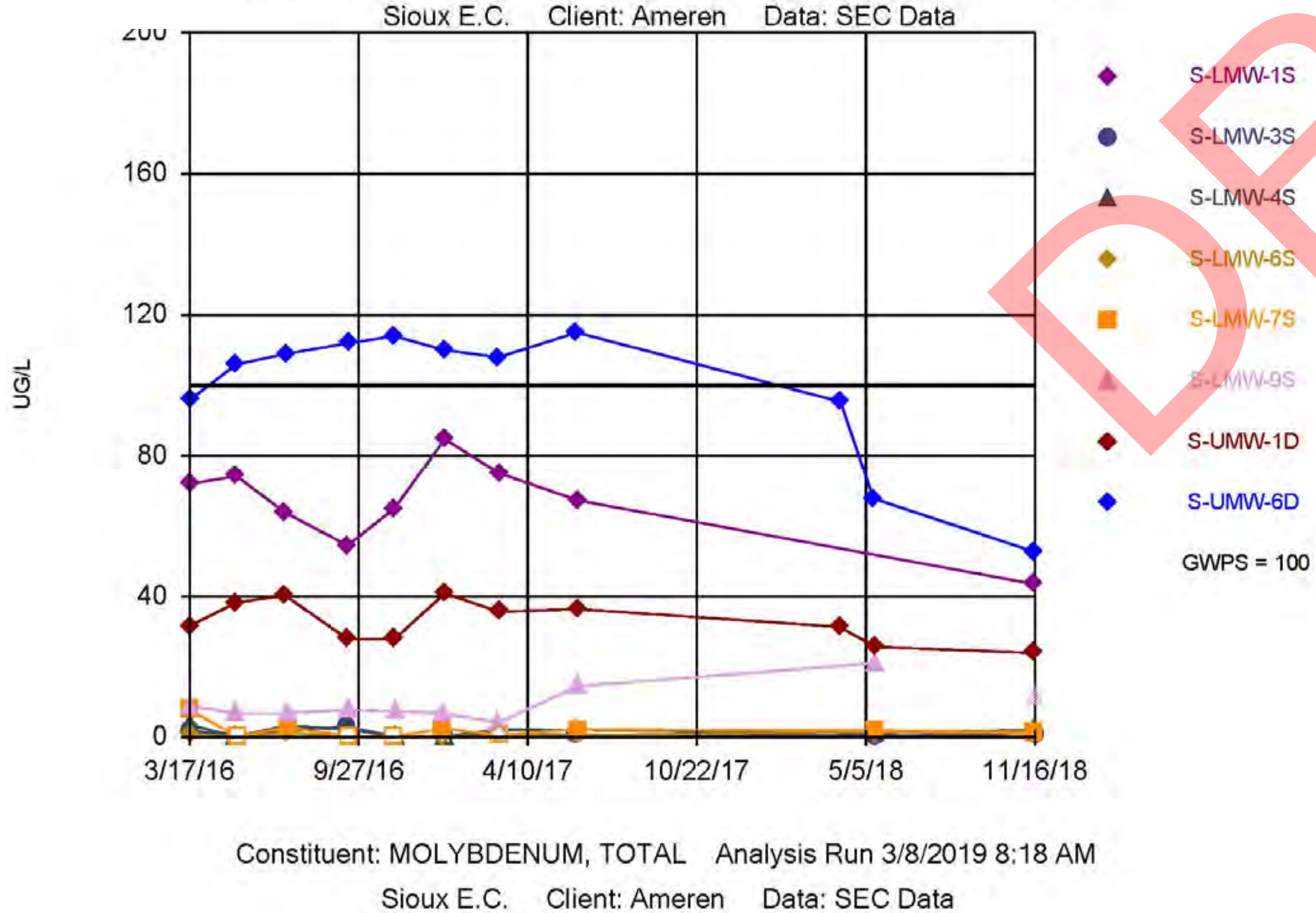
(a)



(b)



(c)



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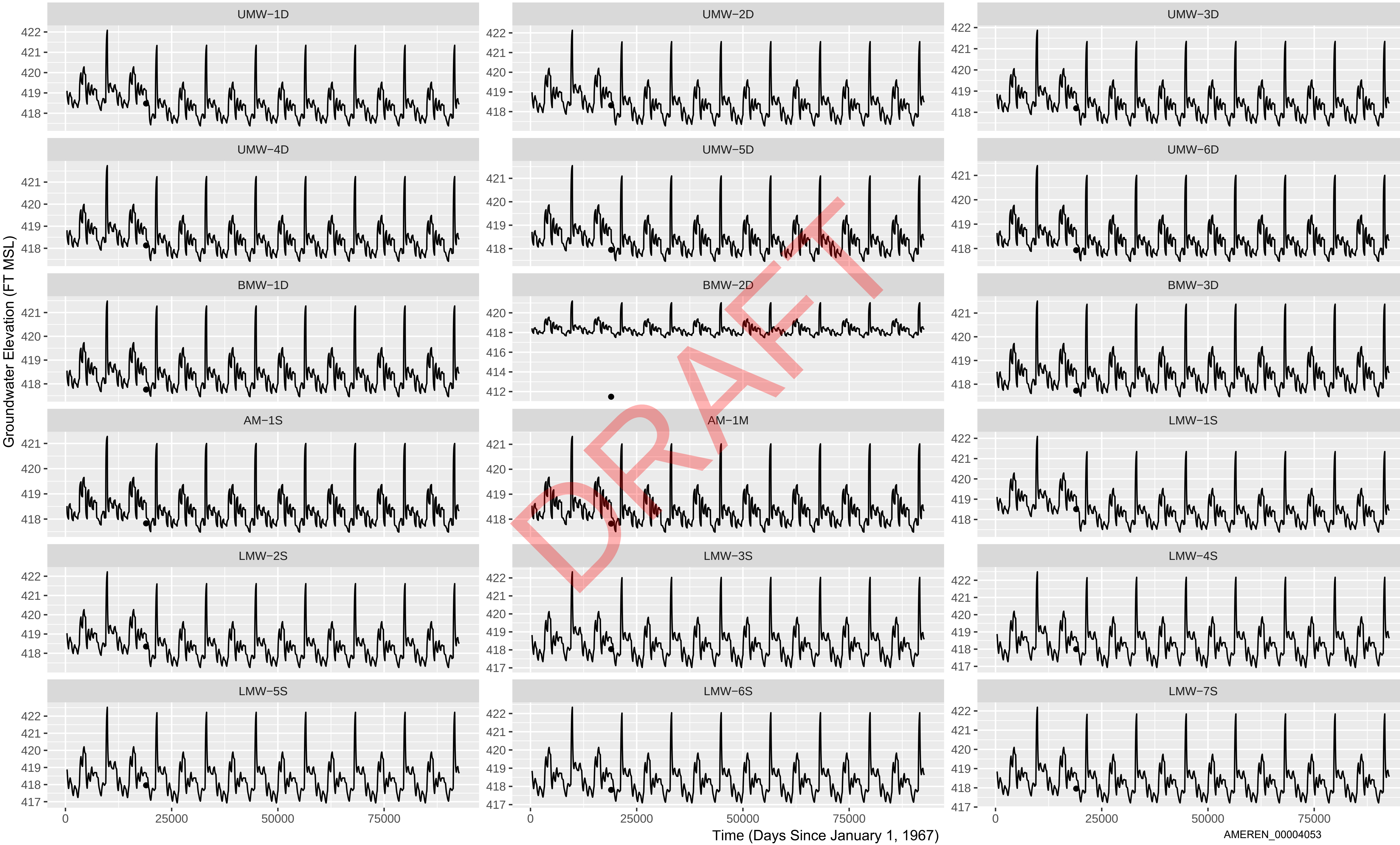
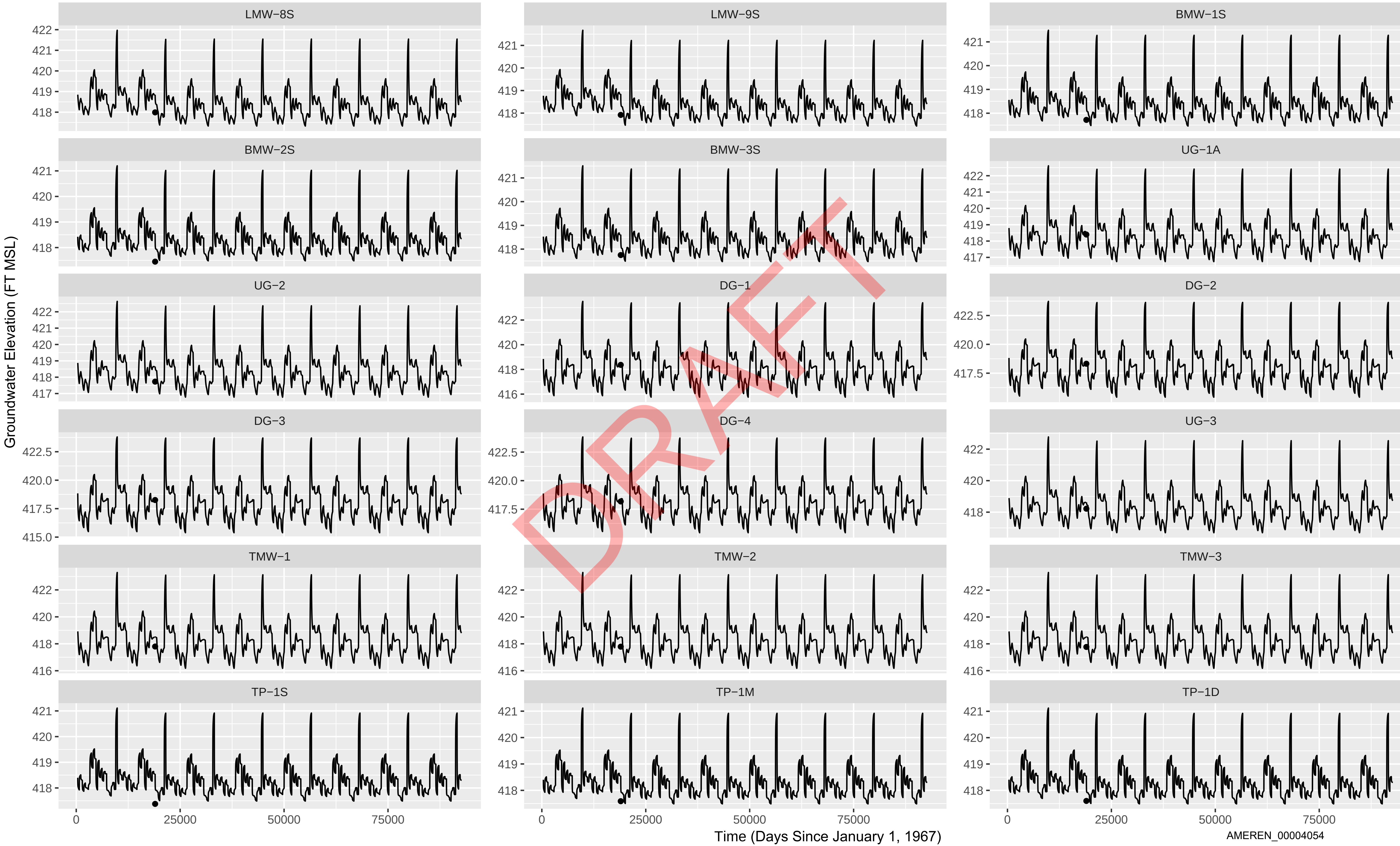
TITLE
Molybdenum Trends

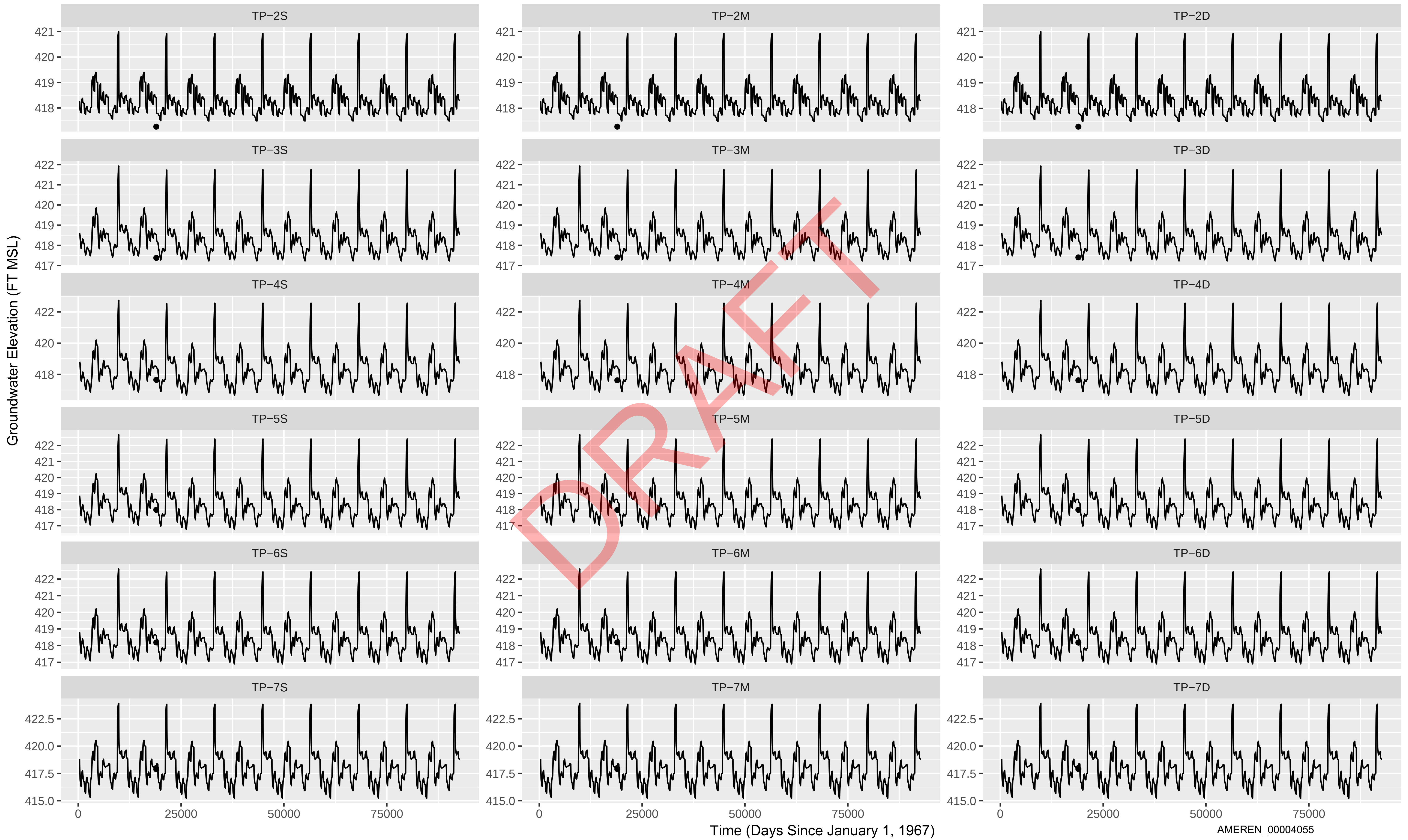
PROJECT NO.	PHASE	REV.	FIGURE
1531406	0003		23

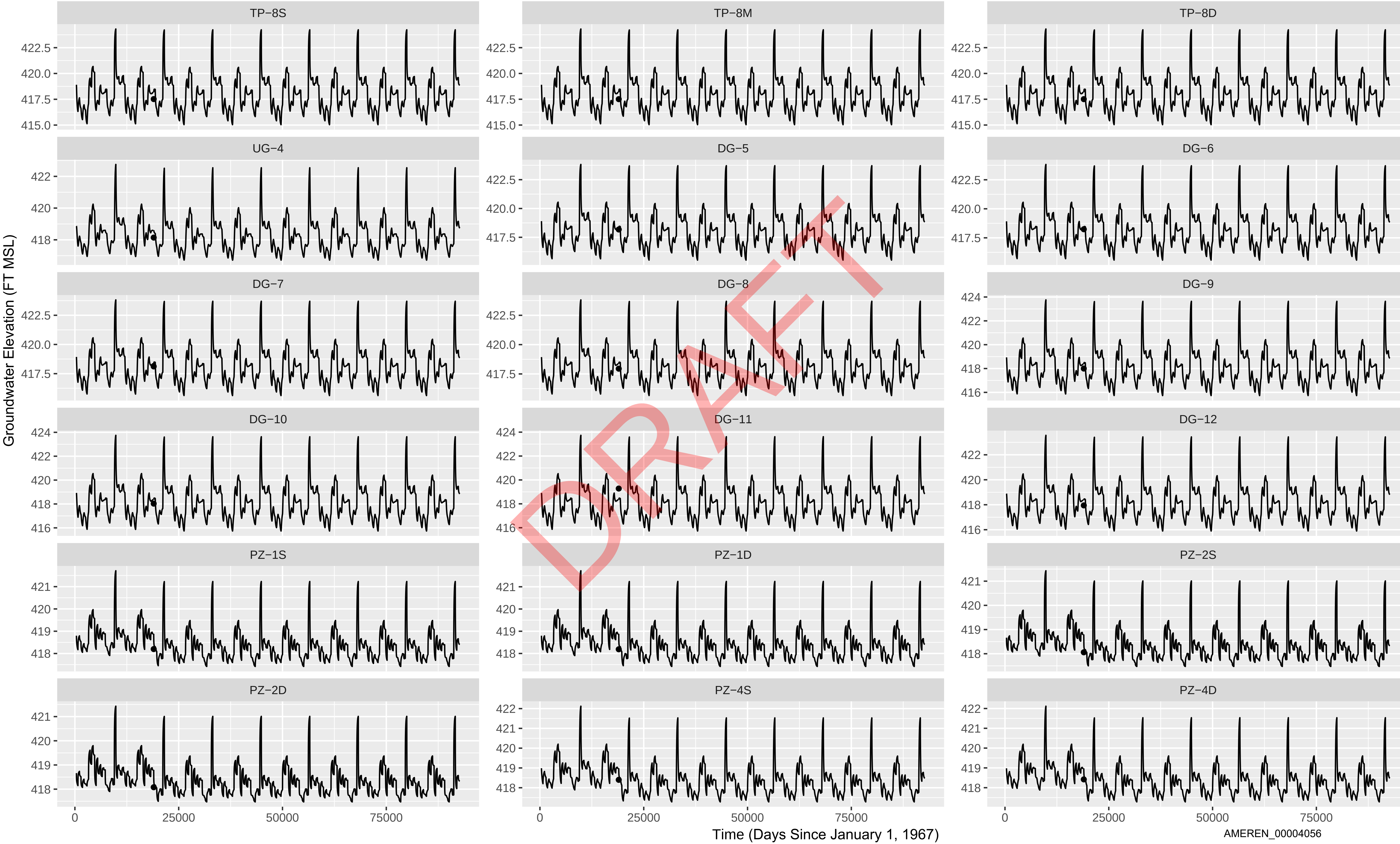
APPENDIX A

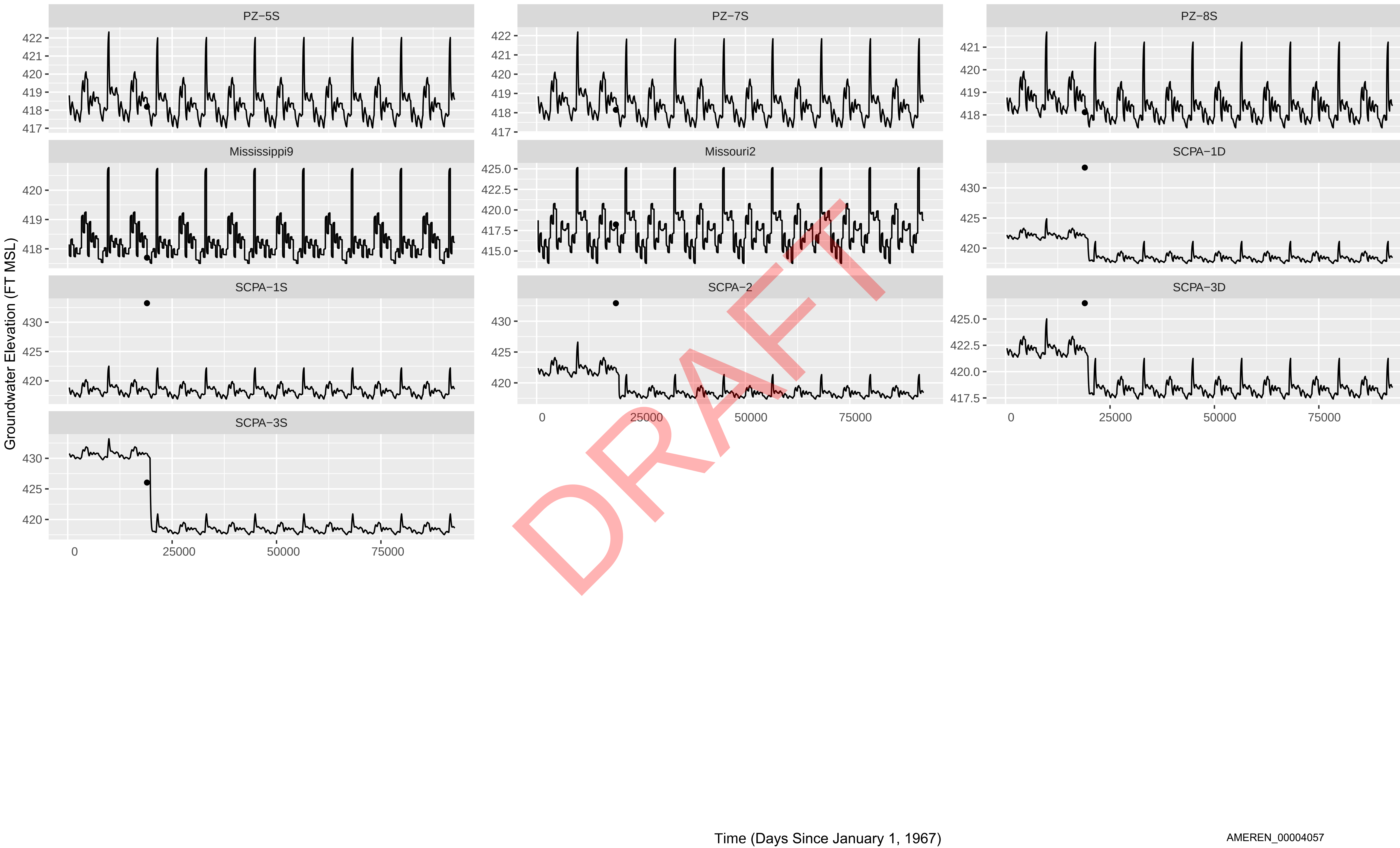
Model Predicted and Observed Transient Groundwater Level Elevations


UMW−1D
UMW−2D
UMW−3D
UMW−4D
UMW−5D
UMW−6D
BMW−1D
BMW−2D
BMW−3D
AM−1S
AM−1M
LMW−1S
LMW−2S
LMW−3S
LMW−4S
LMW−5S
LMW−6S
LMW−7S
Groundwater Elevation (FT MSL)
0
25000
50000
75000
Time (Days Since January 1, 1967)
DRAFT


LMW−8S
LMW−9S
BMW−1S
BMW−2S
BMW−3S
UG−1A
UG−2
DG−1
DG−2
DG−3
DG−4
UG−3
TMW−1
TMW−2
TMW−3
TP−1S
TP−1M
TP−1D
Groundwater Elevation (FT MSL)
Time (Days Since January 1, 1967)
0
25000
50000
75000
DRAFT


TP−2S
TP−2M
TP−2D
TP−3S
TP−3M
TP−3D
TP−4S
TP−4M
TP−4D
TP−5S
TP−5M
TP−5D
TP−6S
TP−6M
TP−6D
TP−7S
TP−7M
TP−7D
Groundwater Elevation (FT MSL)
Time (Days Since January 1, 1967)
0
25000
50000
75000
DRAFT

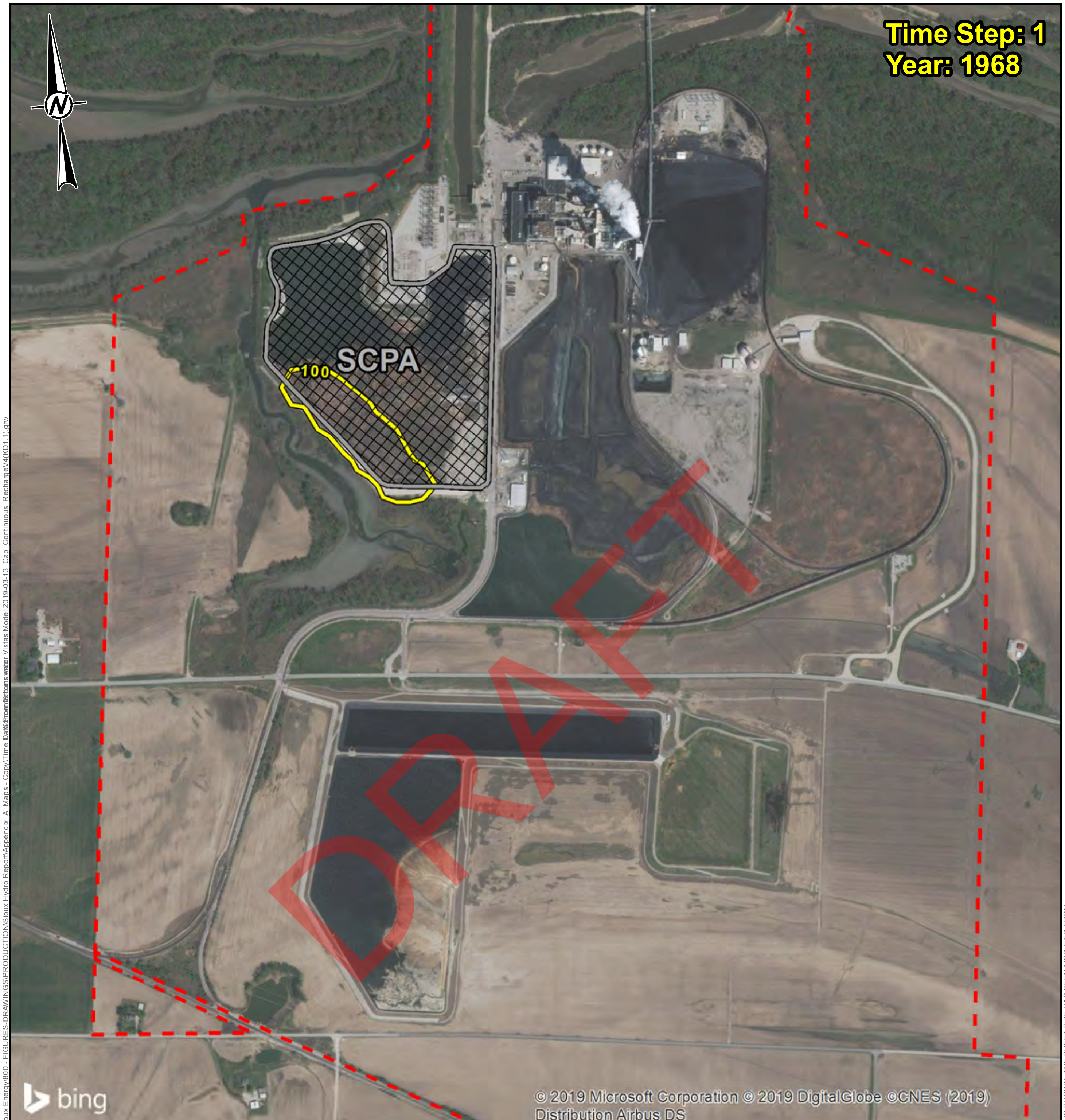

TP−8S
TP−8M
TP−8D
UG−4
DG−5
DG−6
DG−7
DG−8
DG−9
DG−10
DG−11
DG−12
PZ−1S
PZ−1D
PZ−2S
PZ−2D
PZ−4S
PZ−4D
Groundwater Elevation (FT MSL)
Time (Days Since January 1, 1967)
0
25000
50000
75000



PZ−5S
PZ−7S
PZ−8S
Mississippi9
Missouri2
SCPA−1D
SCPA−1S
SCPA−2
SCPA−3D
SCPA−3S
Groundwater Elevation (FT MSL)
0
25000
50000
75000
Time (Days Since January 1, 1967)
DRAFT

APPENDIX B

Molybdenum Concentration Time Histories for Intermediate Alluvial Aquifer



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

CONSULTANT

GOLDER

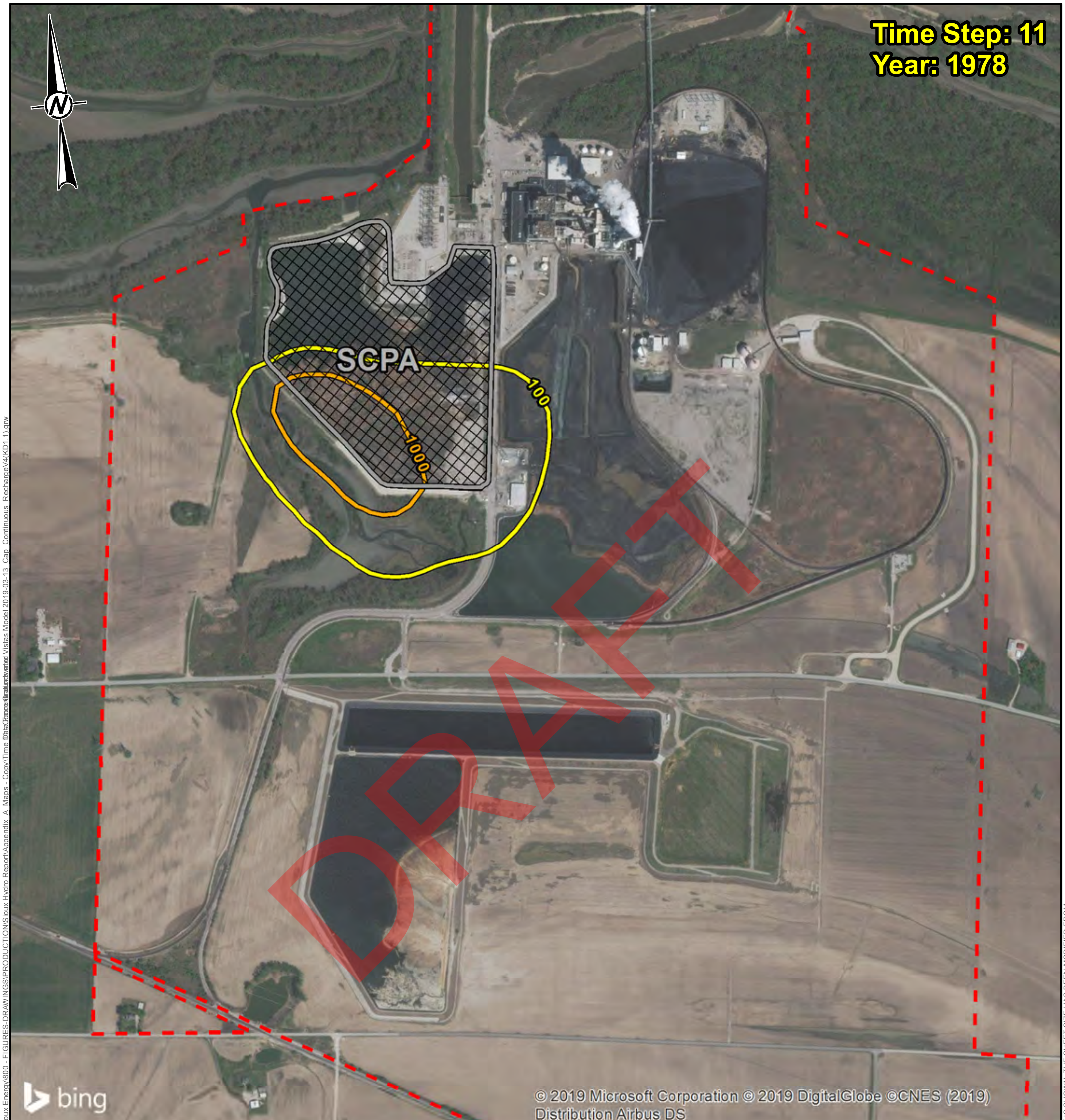
YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP
YEAR 1 (1968) - ACTIVE SCPA

Project	Rev.	FIGURE
153-1406	0.0	A1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
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SIOUX ENERGY CENTER

Ameren

PROJECT
GROUNDWATER MODELING

CONSULTANT

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PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

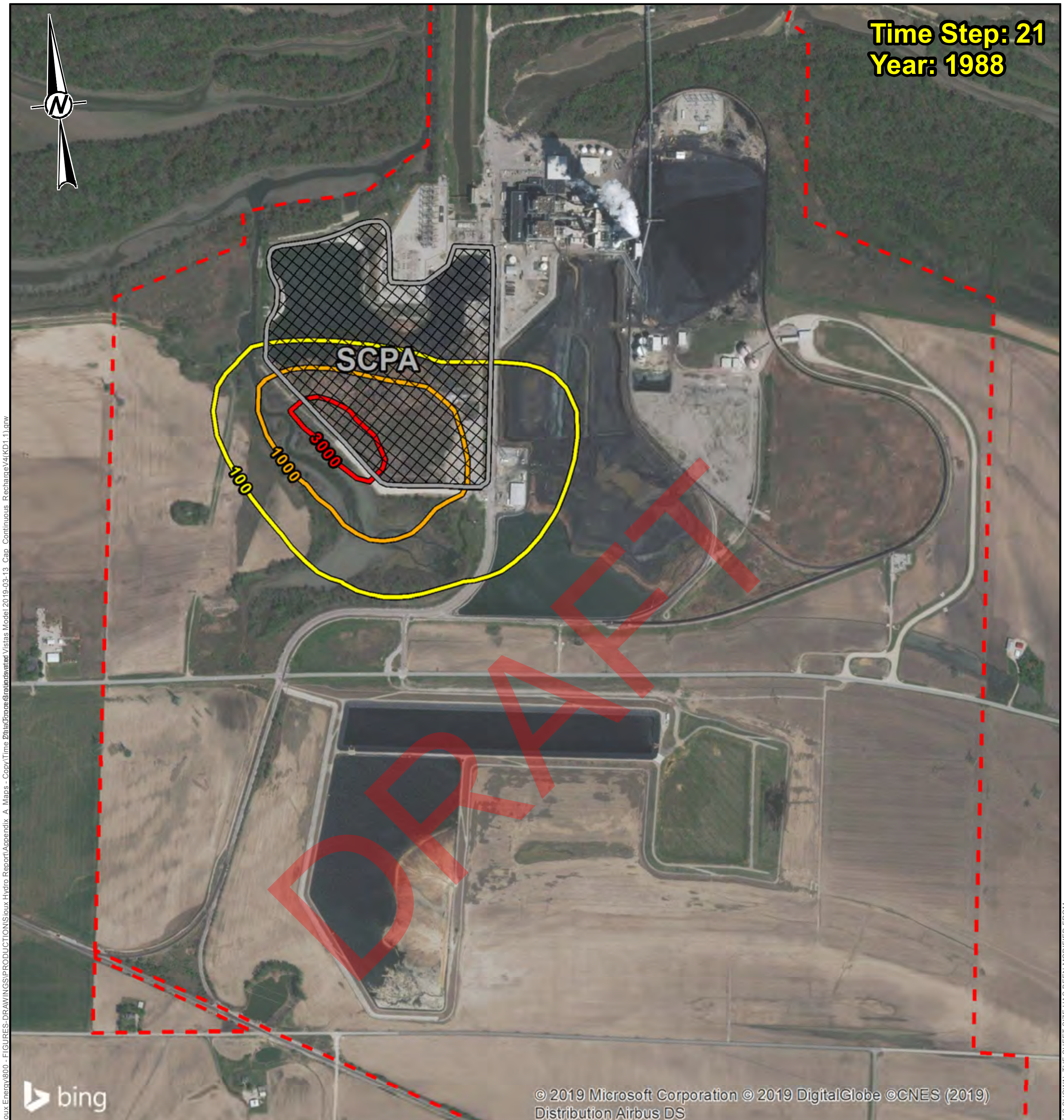
TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP
YEAR 11 (1978) - ACTIVE SCPA

Project	Rev.	FIGURE
153-1406	0.0	A2

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix A Maps - Copy\Time Data Groundwater Vistas Model 2019-03-13 Cap Continuous Recharge V4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

1 in
0



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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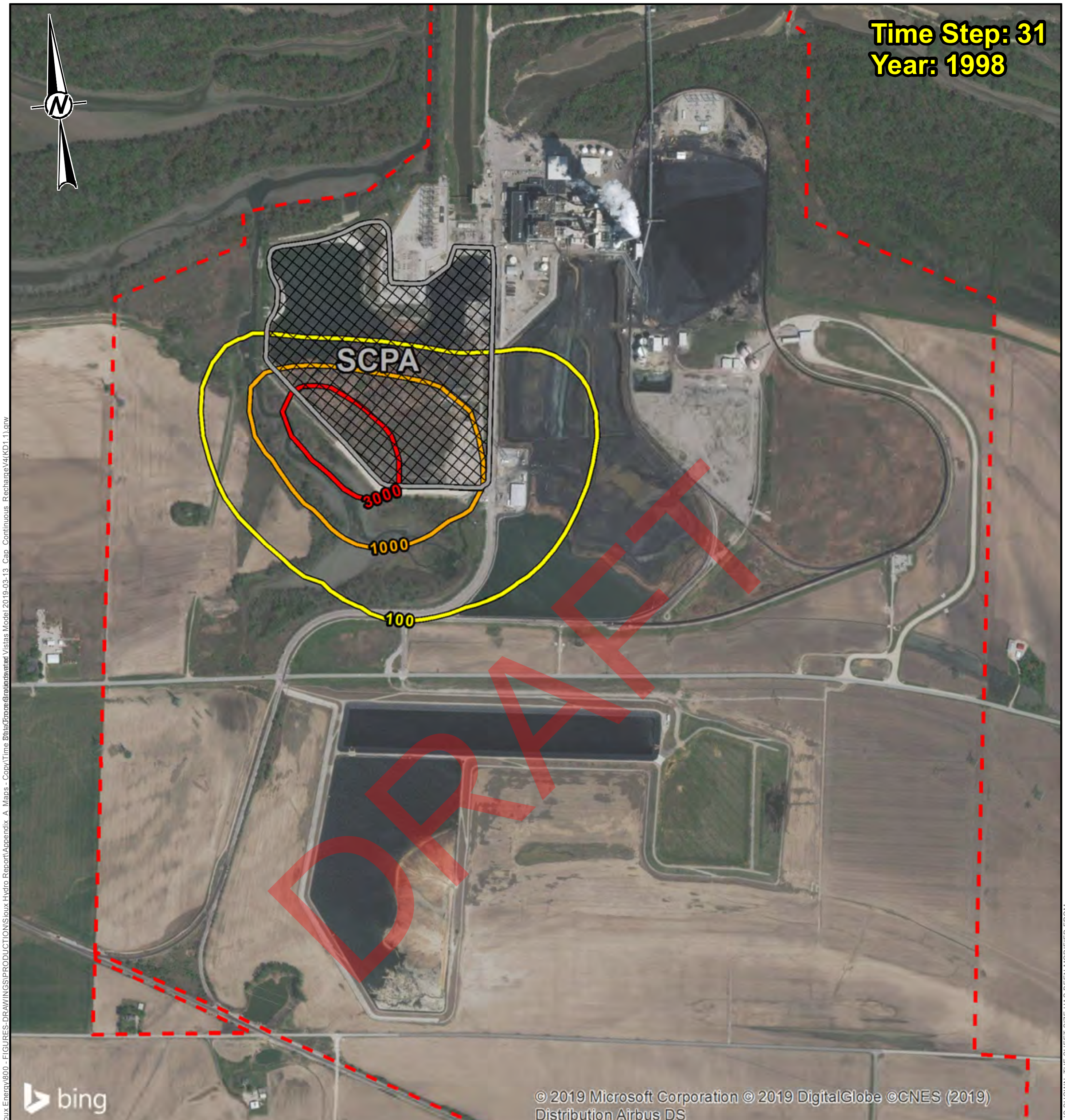
CONSULTANT	GOLDER
YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH
PROJECT	GROUNDWATER MODELING
TITLE	**MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 21 (1988) - ACTIVE SCPA**
Project	153-1406
Rev.	0.0
FIGURE	**A3**

AMEREN_00004061



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP
YEAR 31 (1998) - ACTIVE SCPA

Project	Rev.	FIGURE
153-1406	0.0	A4

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Series\Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

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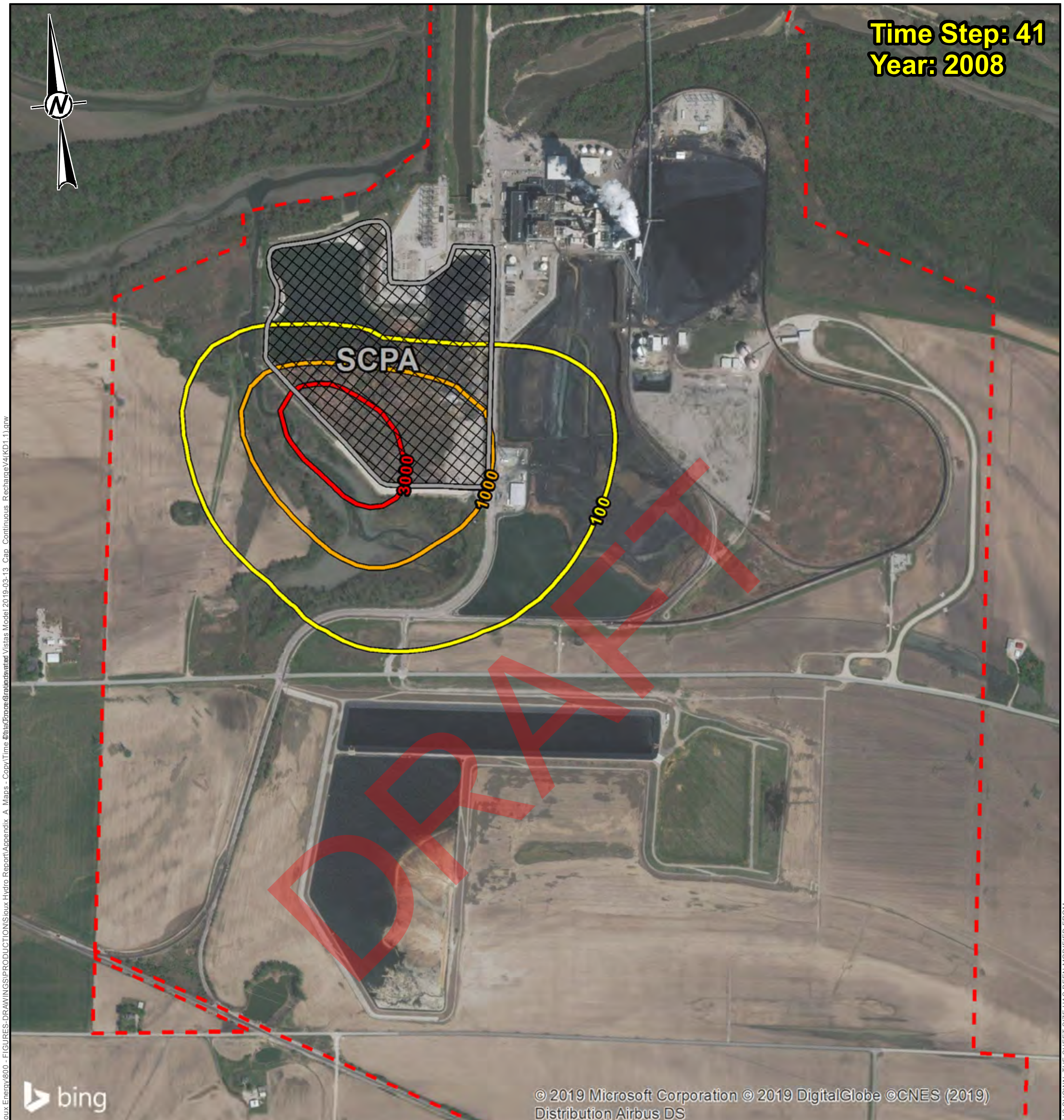

LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 41 (2008) - ACTIVE SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A5**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix A Maps - Copy\Time Series Groundwater Vistas Model 2019-03-13 Cap Continuous RechargeV4(KD1.1).grw

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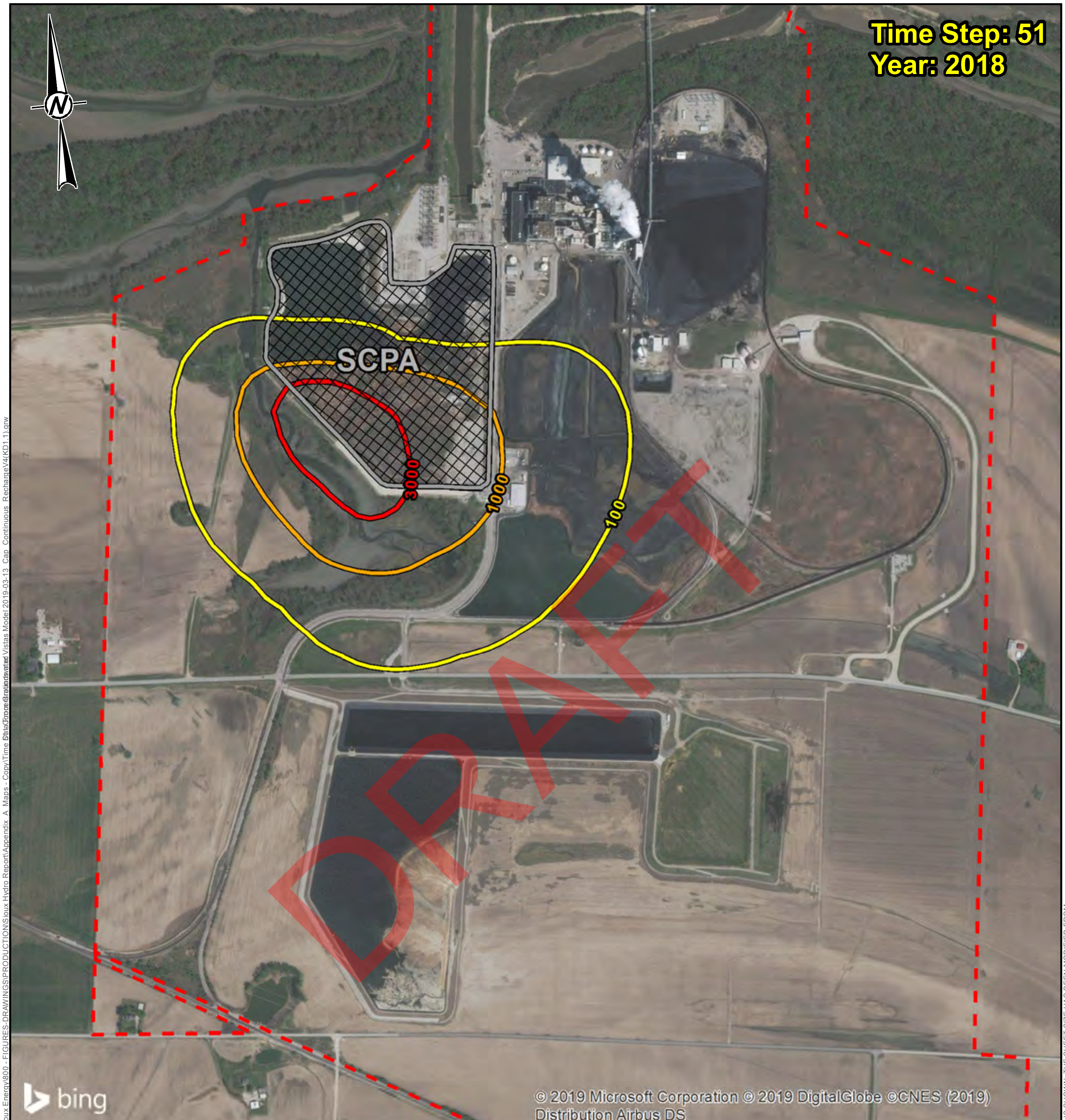

LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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SIOUX ENERGY CENTER

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DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

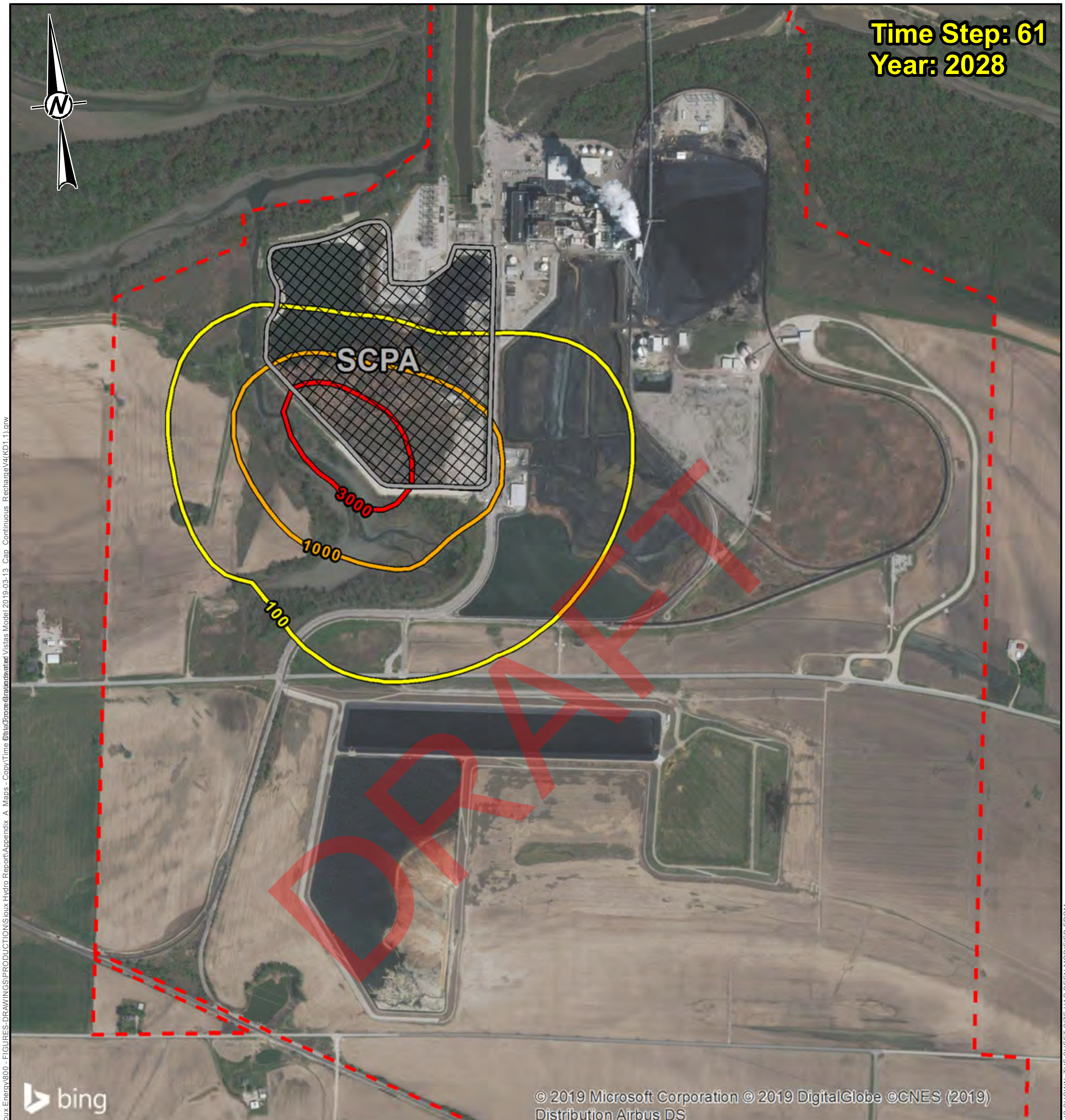
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 51 (2018) - ACTIVE SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Step Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

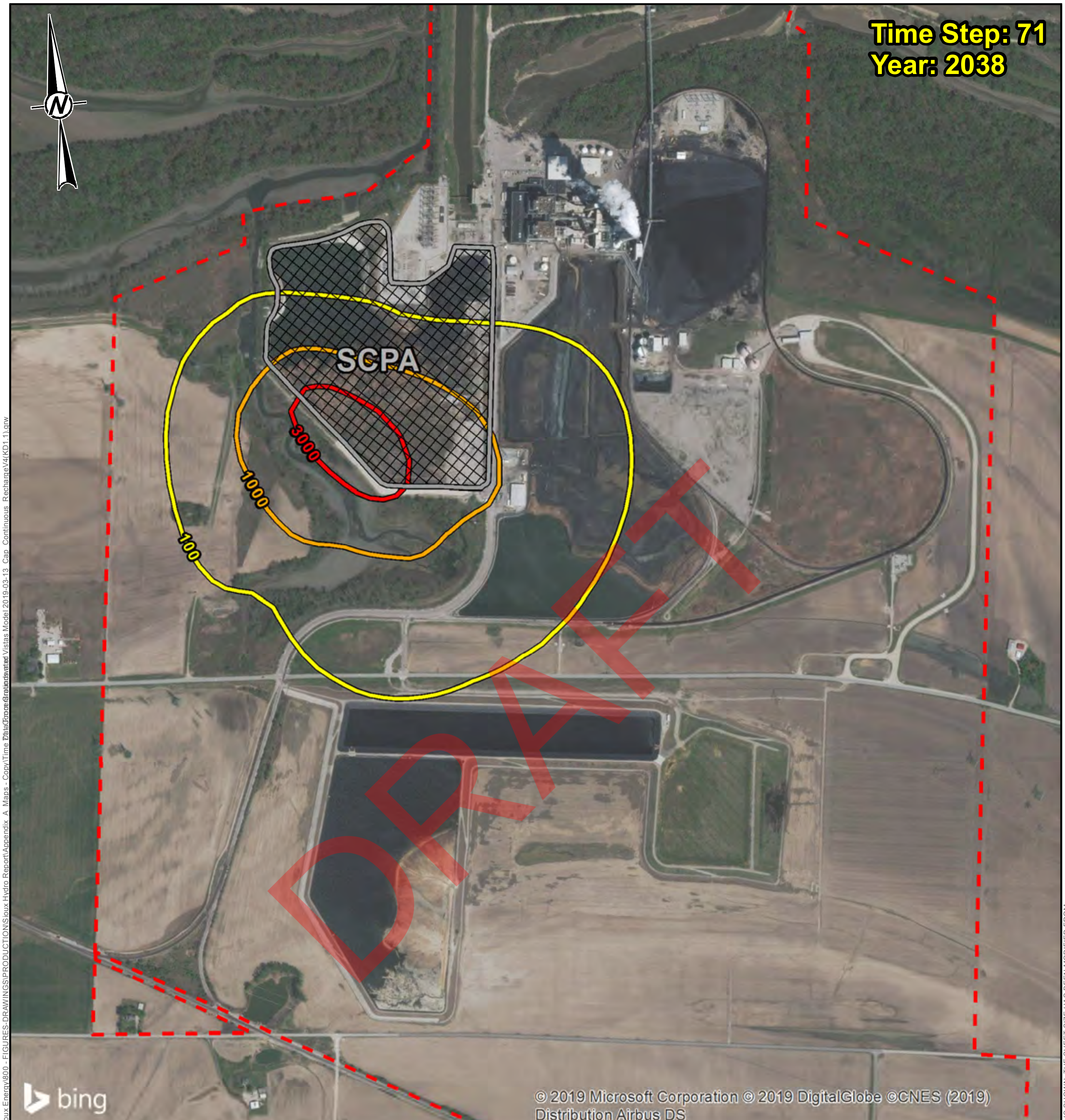
TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 61 (2028) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A7**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Series\Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

0 1 in



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 71 (2038) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A8**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data\Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

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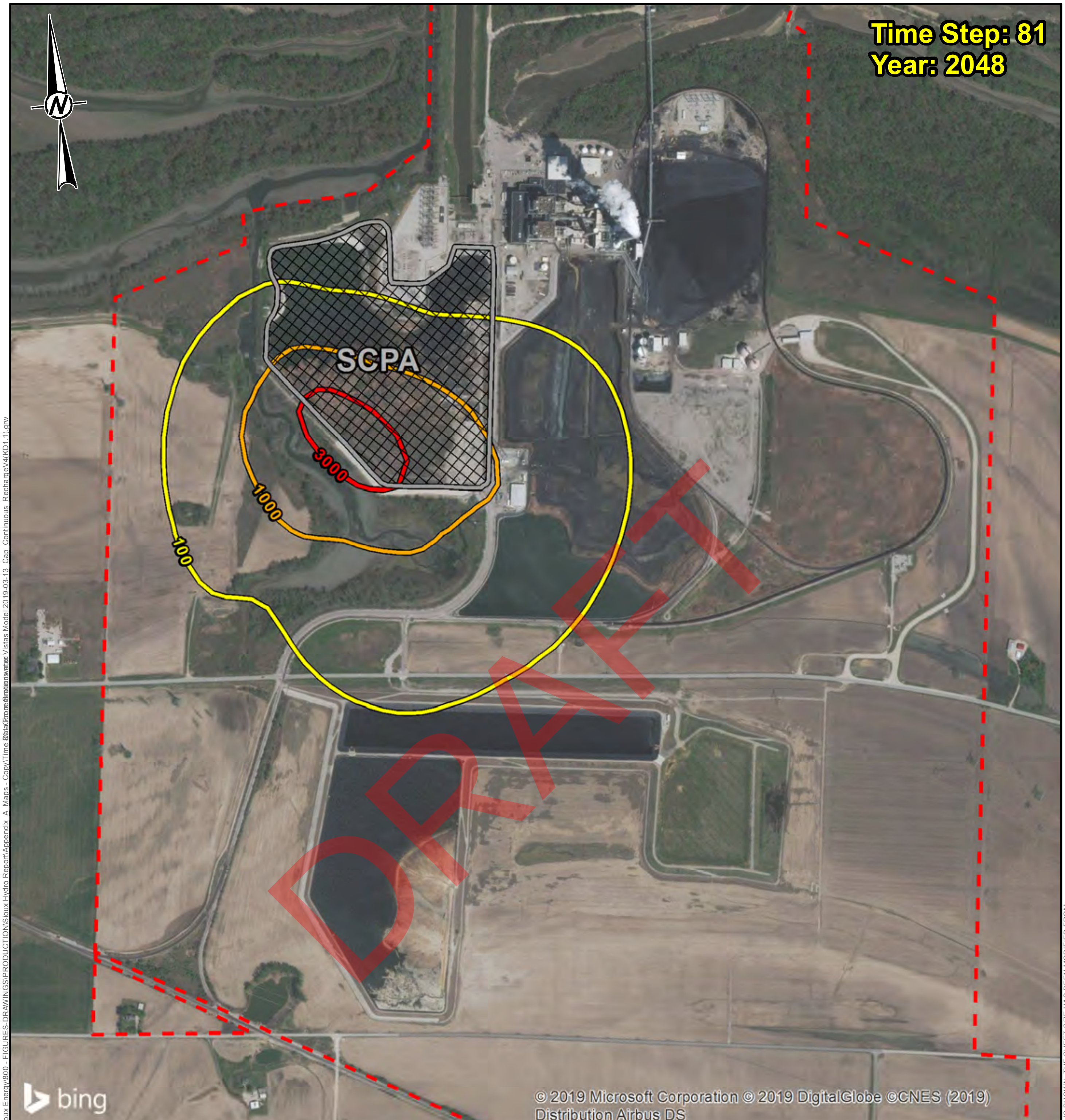

LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

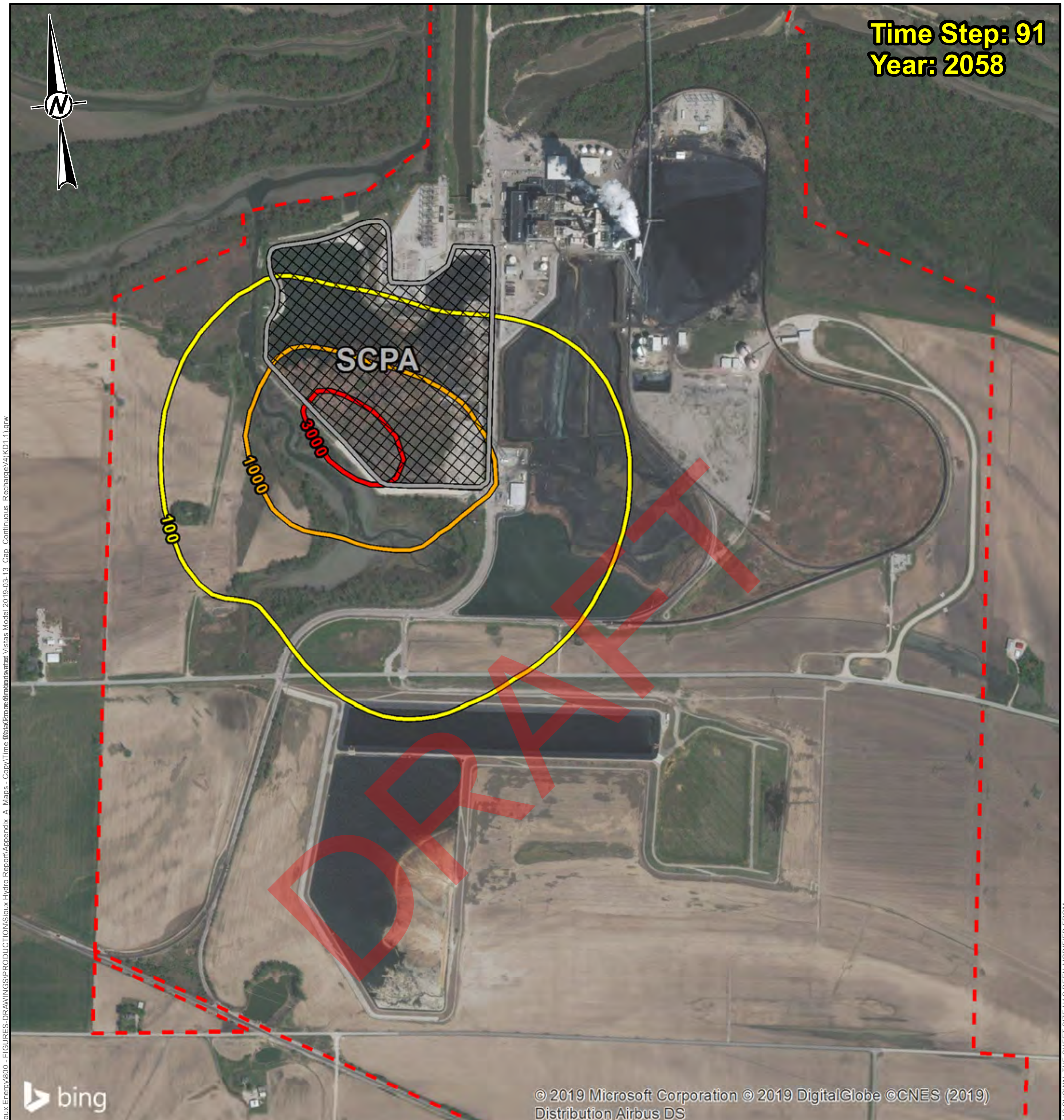
TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 81 (2048) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A9**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Series\Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

0 1 in



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

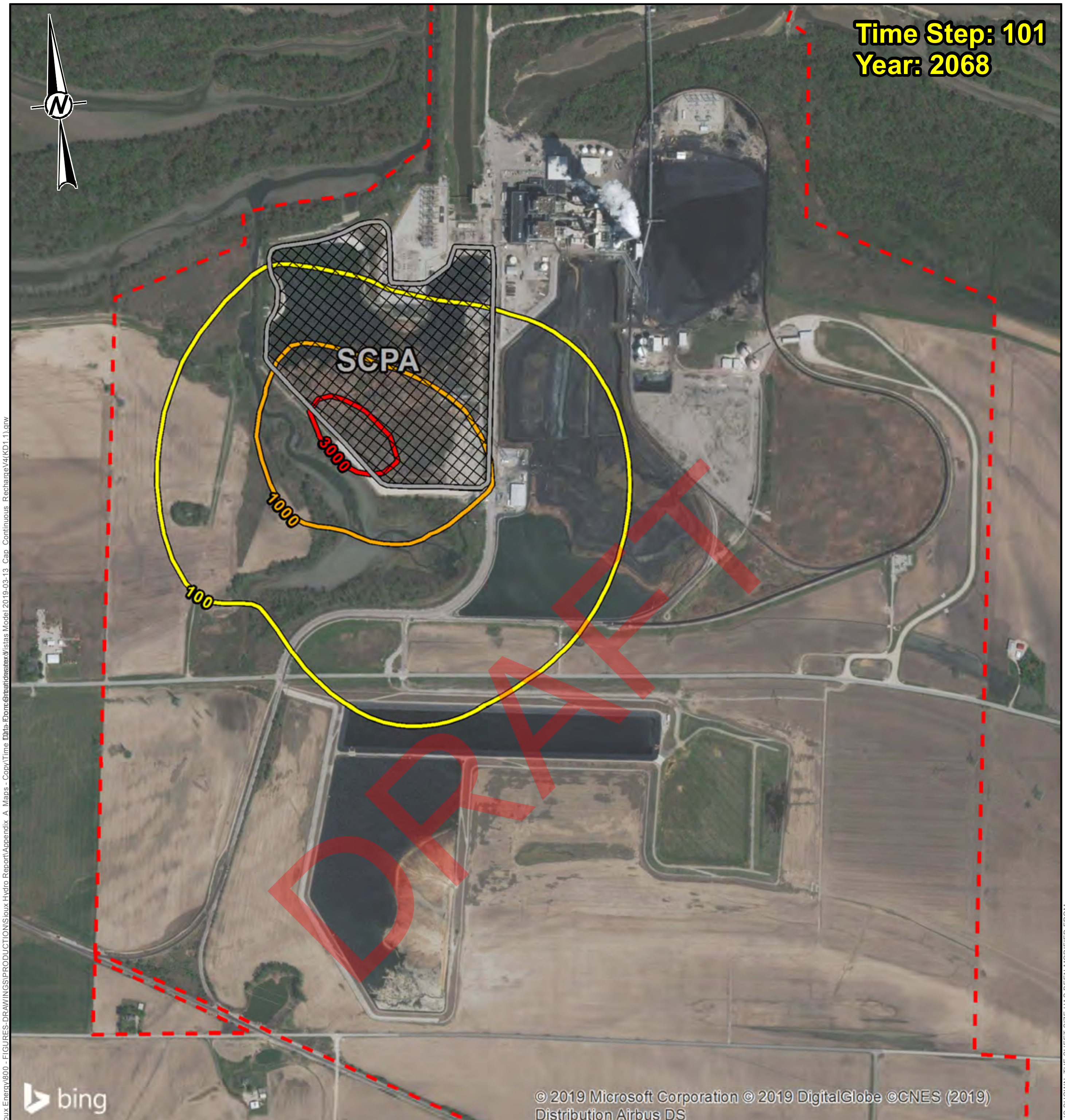
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 91 (2058) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A10**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix A Maps - Copy\Time Step Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 101 (2068) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A11**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

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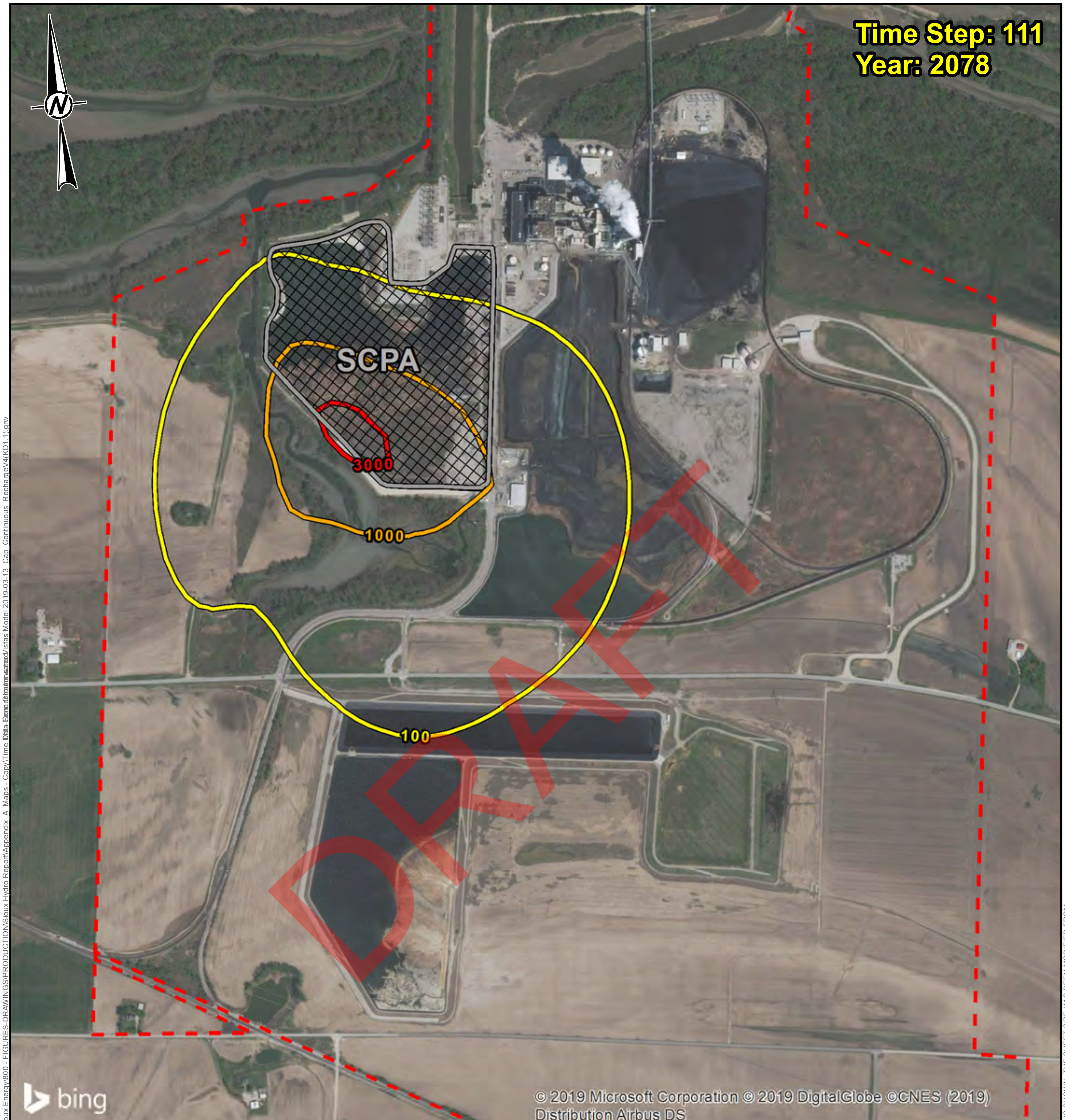

LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

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2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 111 (2078) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A12**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data Gen\Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

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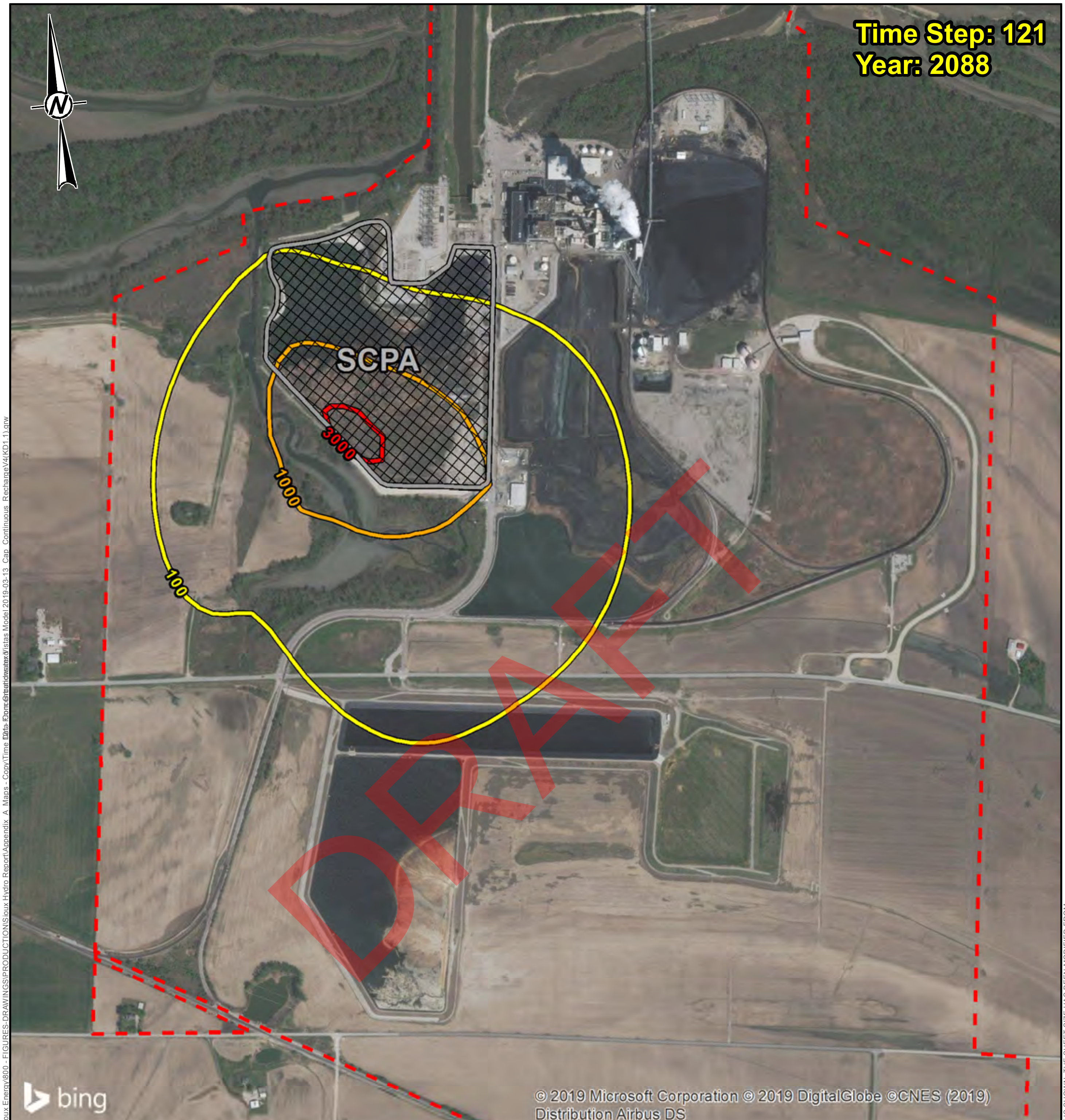

LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

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0 500 1,000 2,000 3,000 Feet

CLIENT
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YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

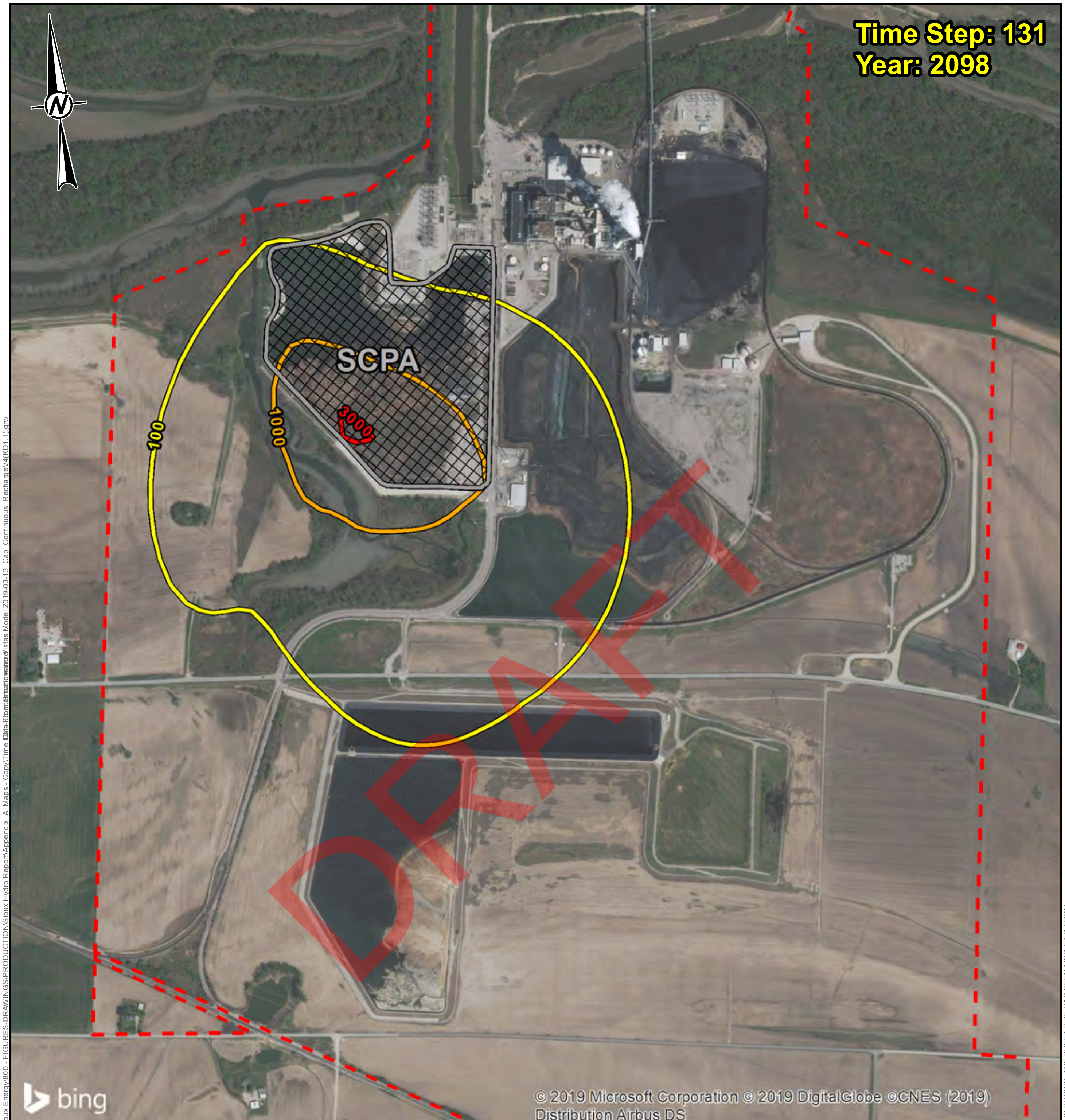
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 121 (2088) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A13**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data - From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

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YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 131 (2098) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A14**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data - From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

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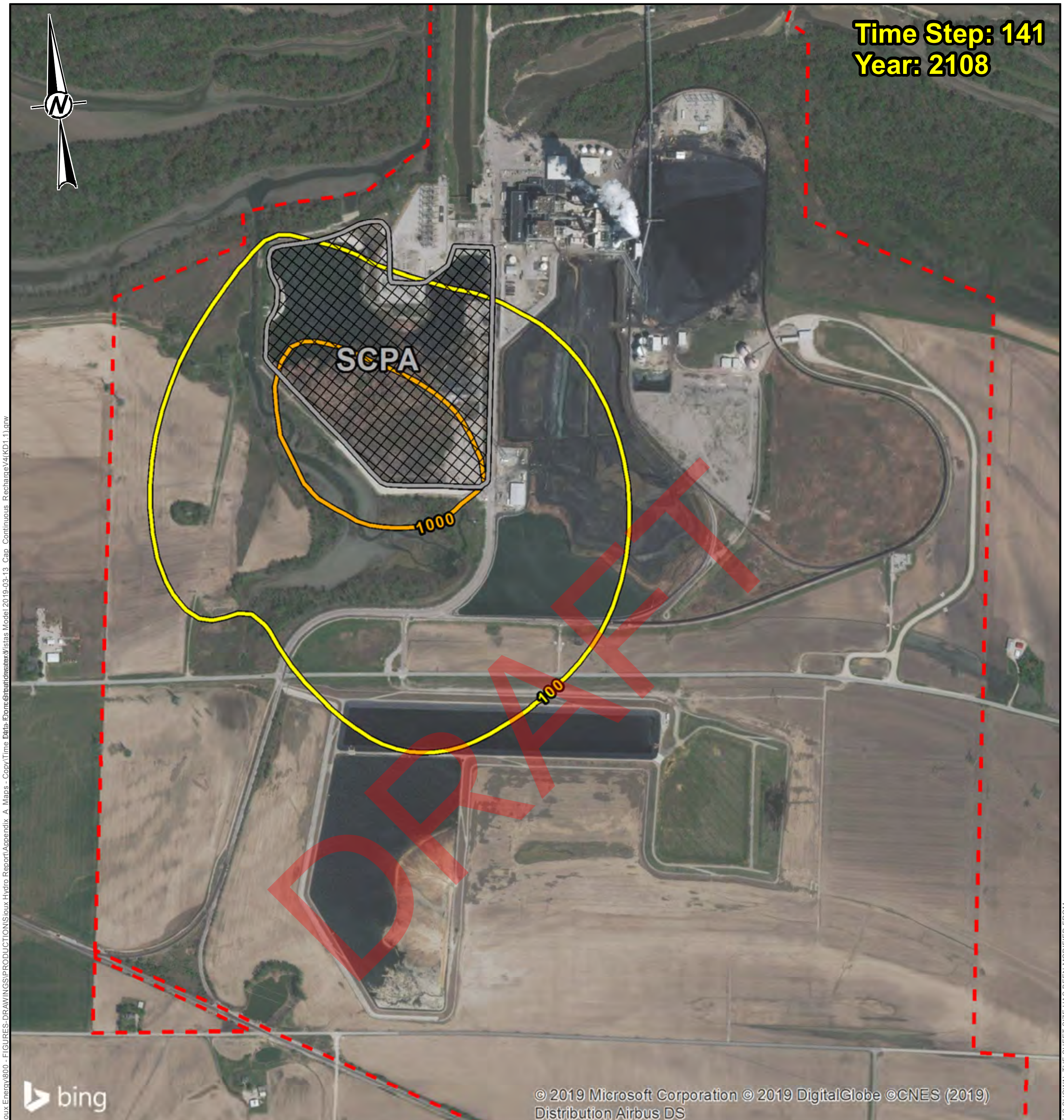


Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data - From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

CONSULTANT

GOLDER

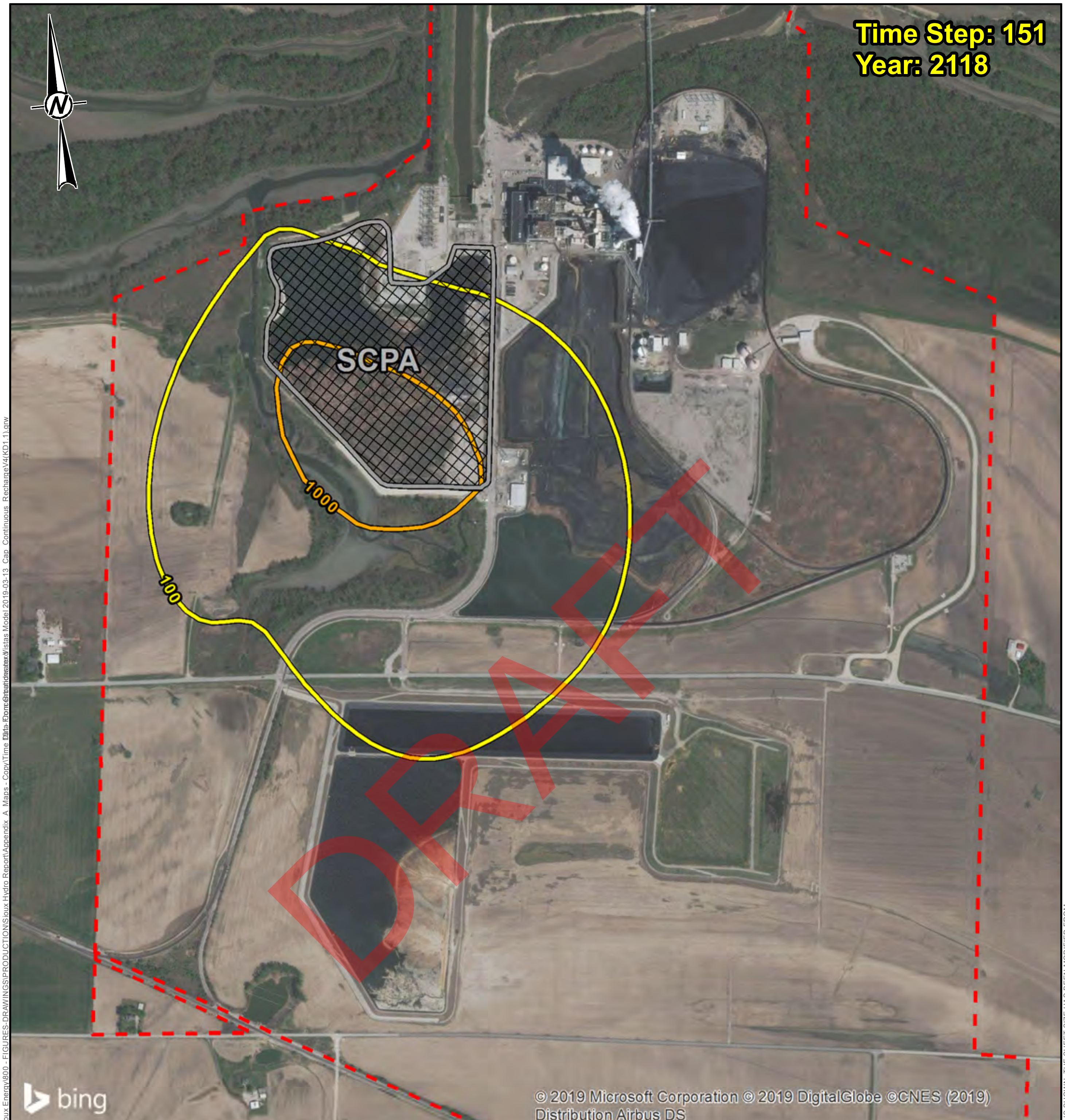
YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 141 (2108) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	A15

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
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Ameren

PROJECT
GROUNDWATER MODELING

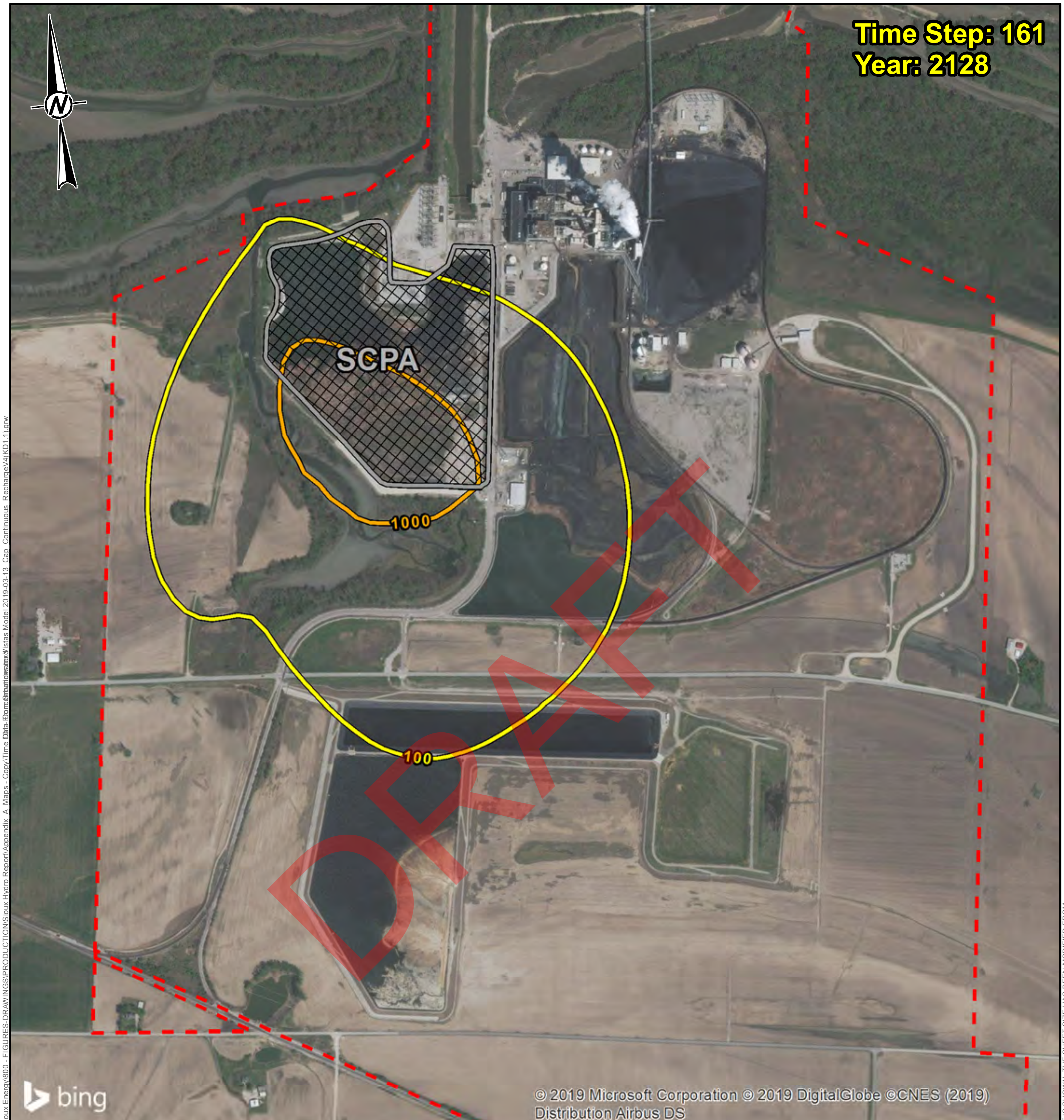
CONSULTANT

GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 151 (2118) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	A16



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
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YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

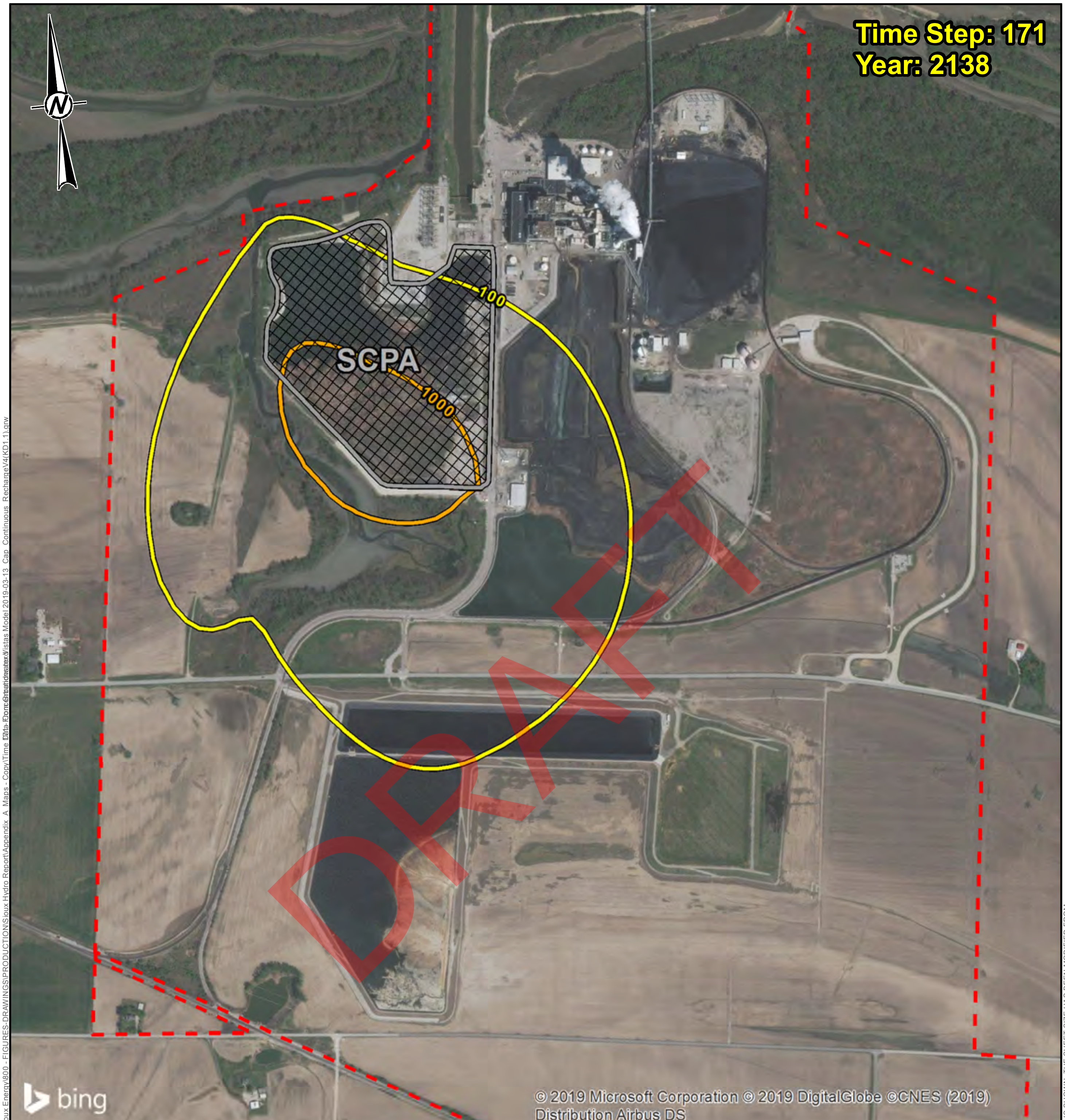
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 161 (2128) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A17**

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data - From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

CONSULTANT

GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

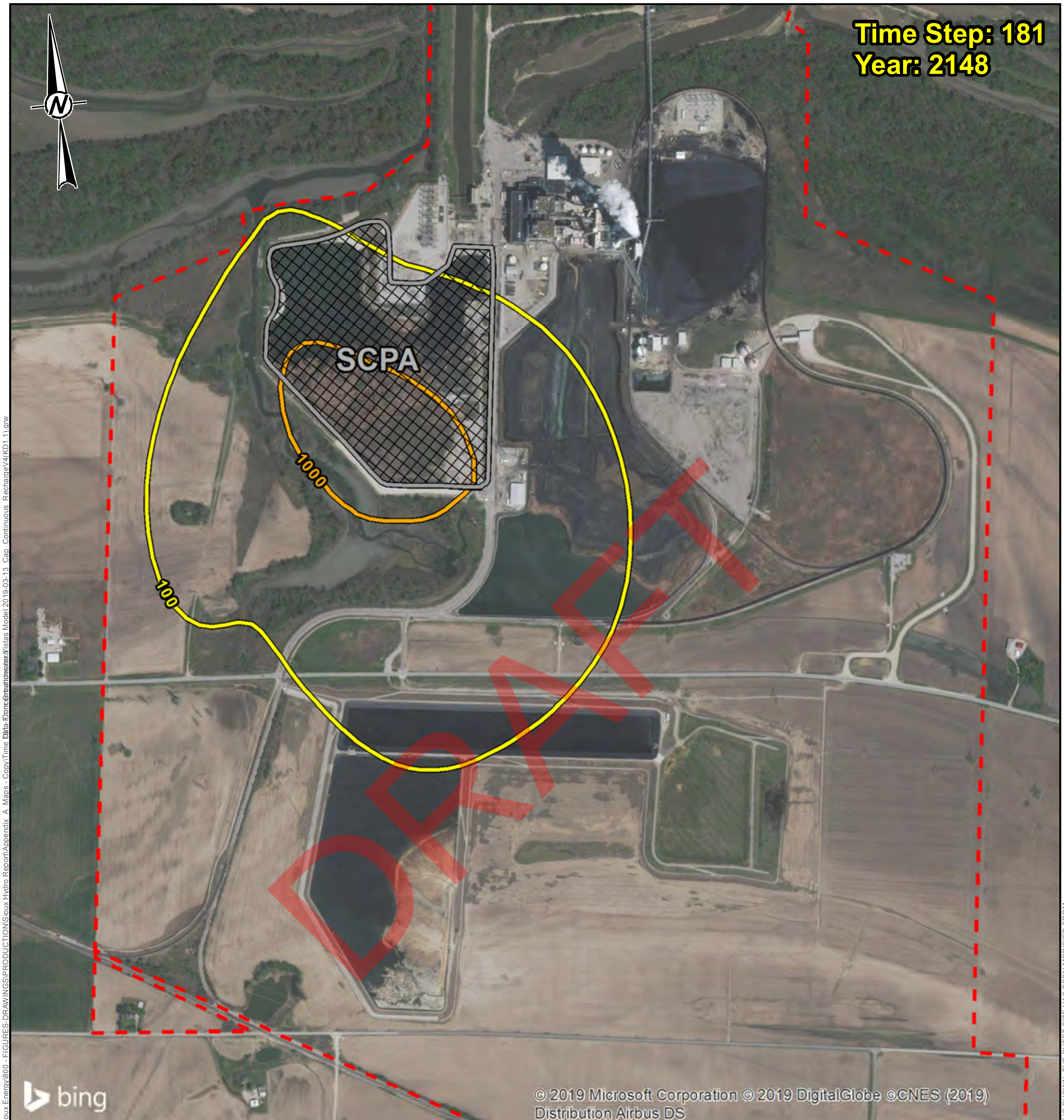
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 171 (2138) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A18**

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
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YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

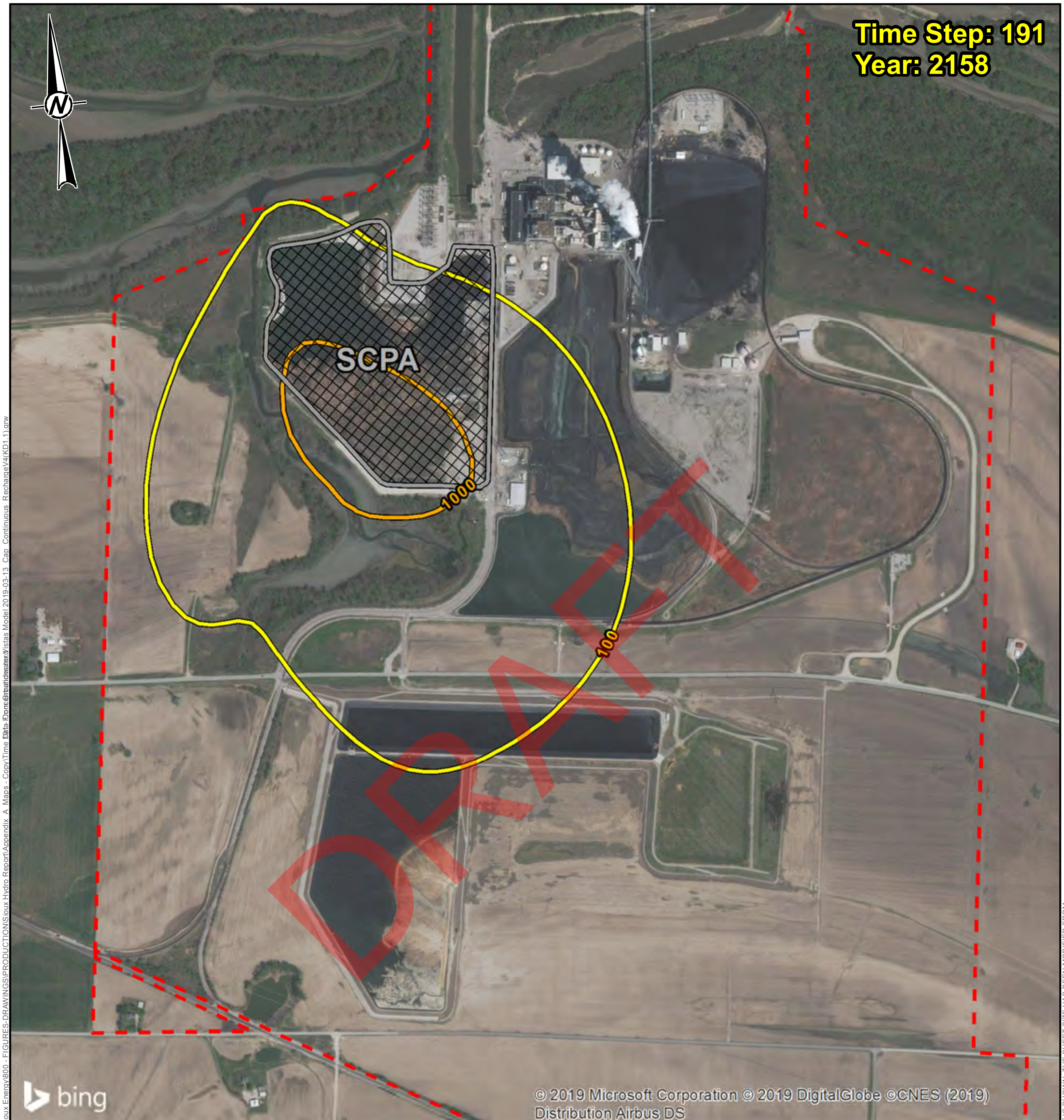
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 181 (2148) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	A19

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data - From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
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SIOUX ENERGY CENTER

Ameren

CONSULTANT

GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

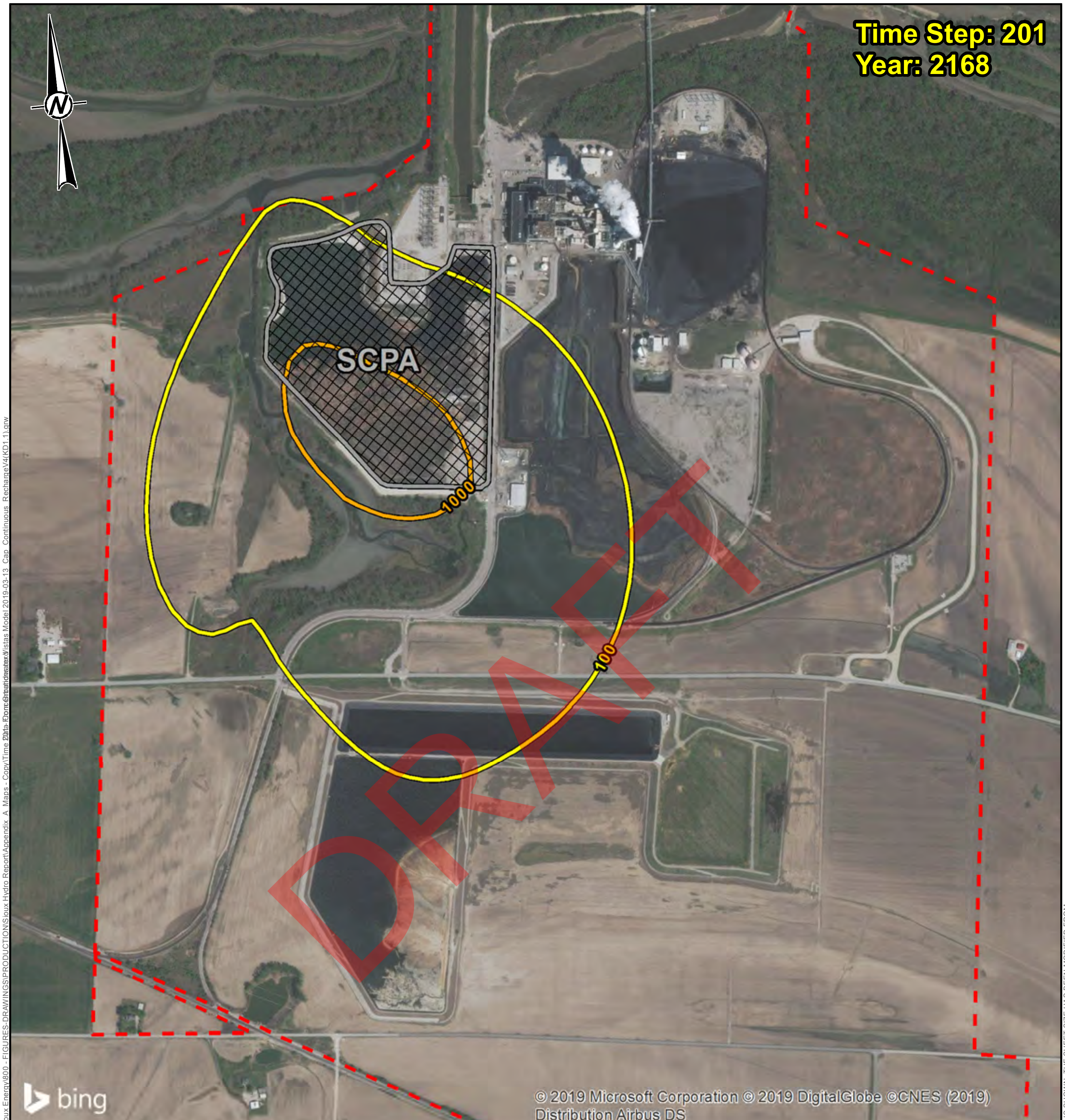
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP
YEAR 191 (2158) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	A20

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix A Maps - Copy\Time Data - From Groundwater Vistas Model 2019-03-13 Cap Continuous RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
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Ameren

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GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

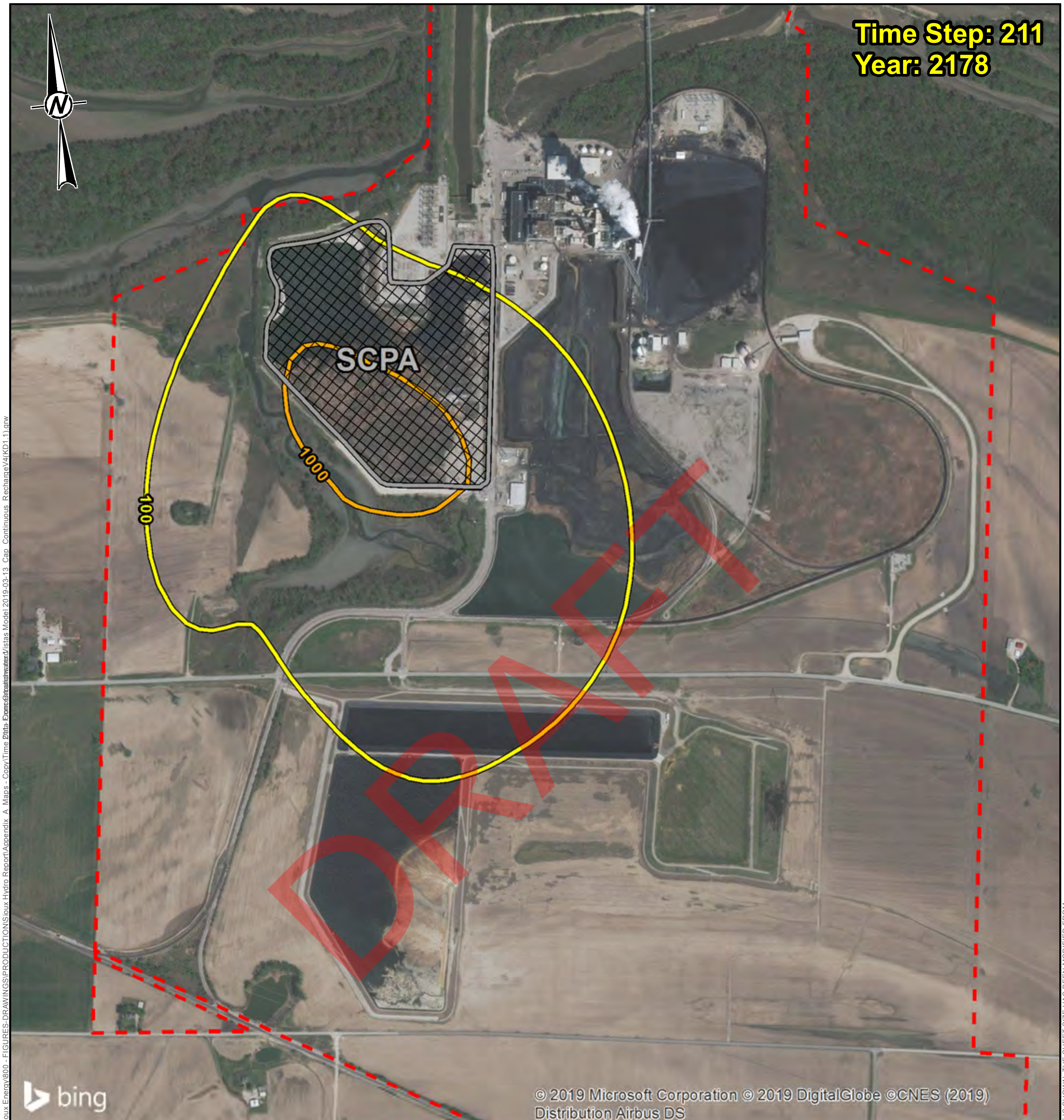
TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 201 (2168) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	A21

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Data - From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

AMEREN_00004079



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
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Ameren

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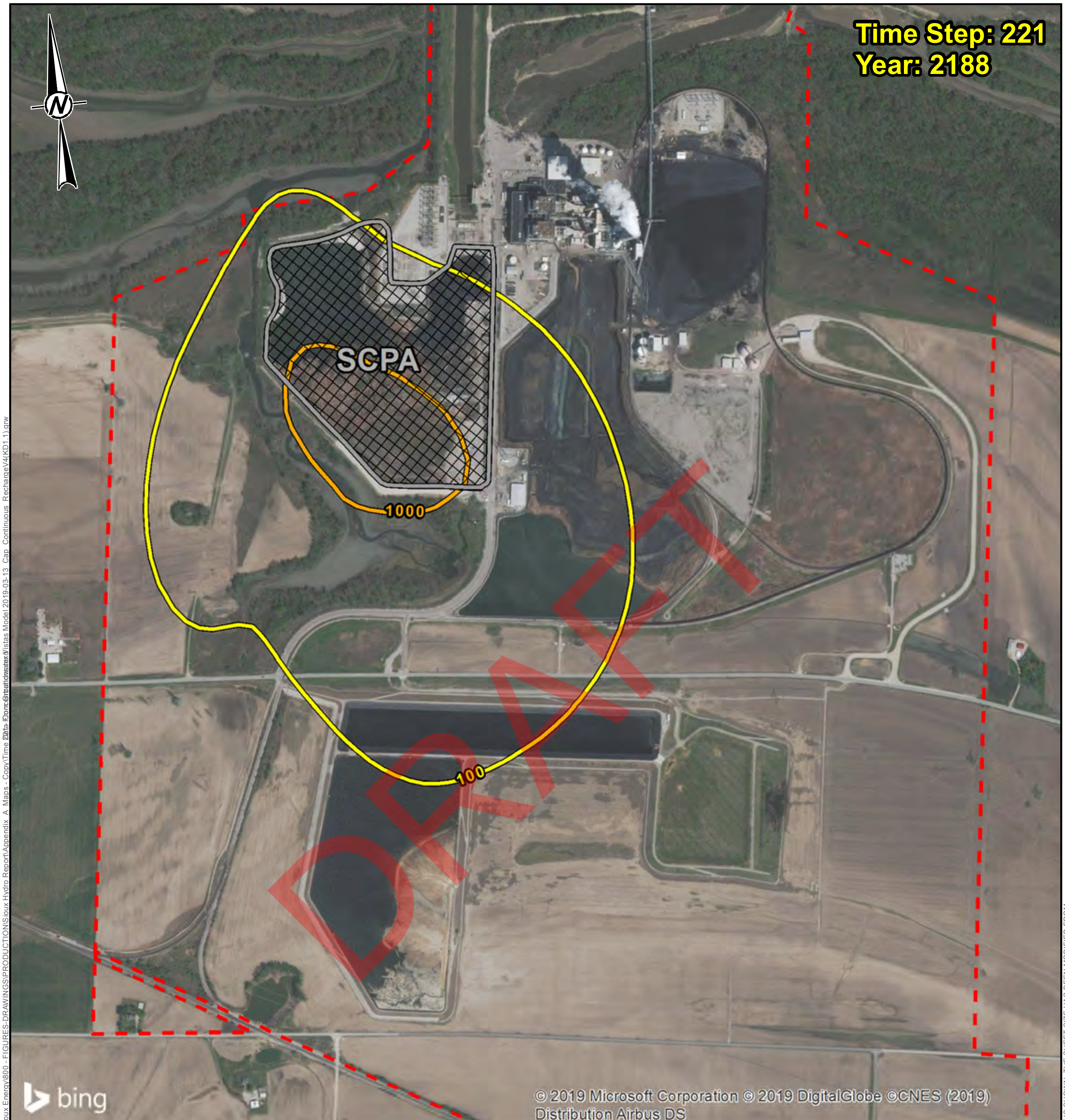
GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 211 (2178) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A22**



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

CONSULTANT

GOLDER

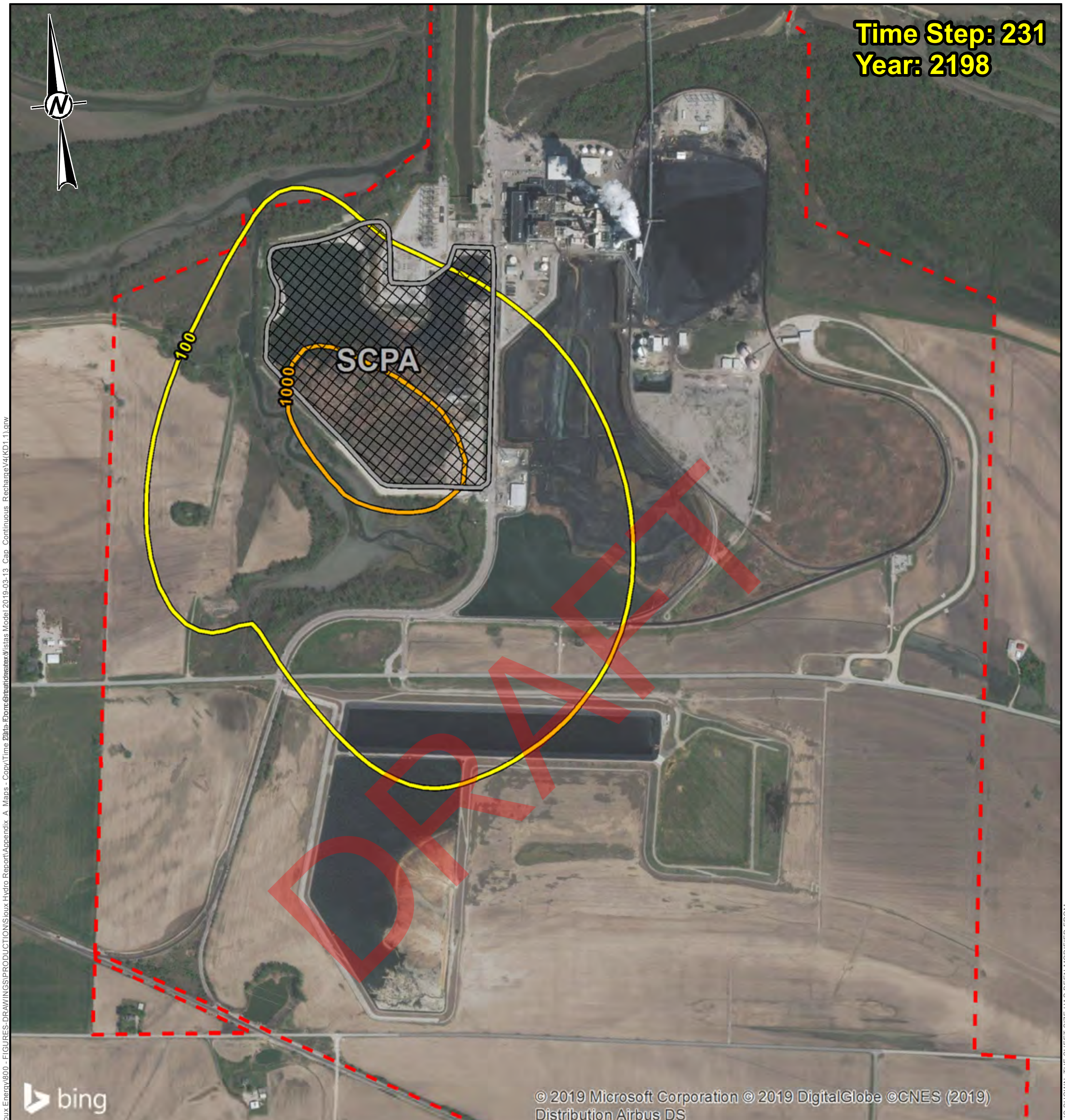
YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 221 (2188) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A23**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

CONSULTANT

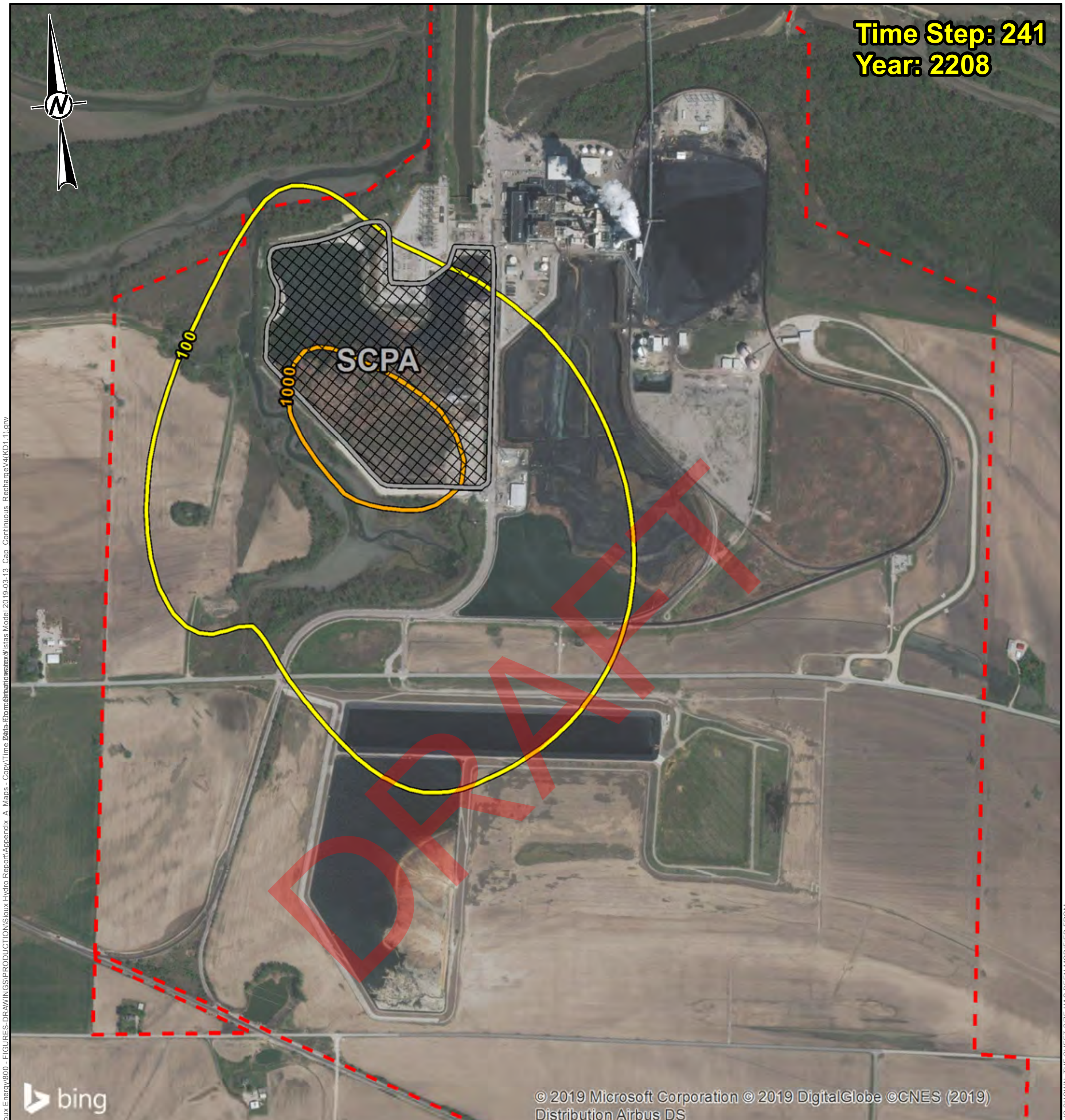
GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 231 (2198) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	**A24**



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
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GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

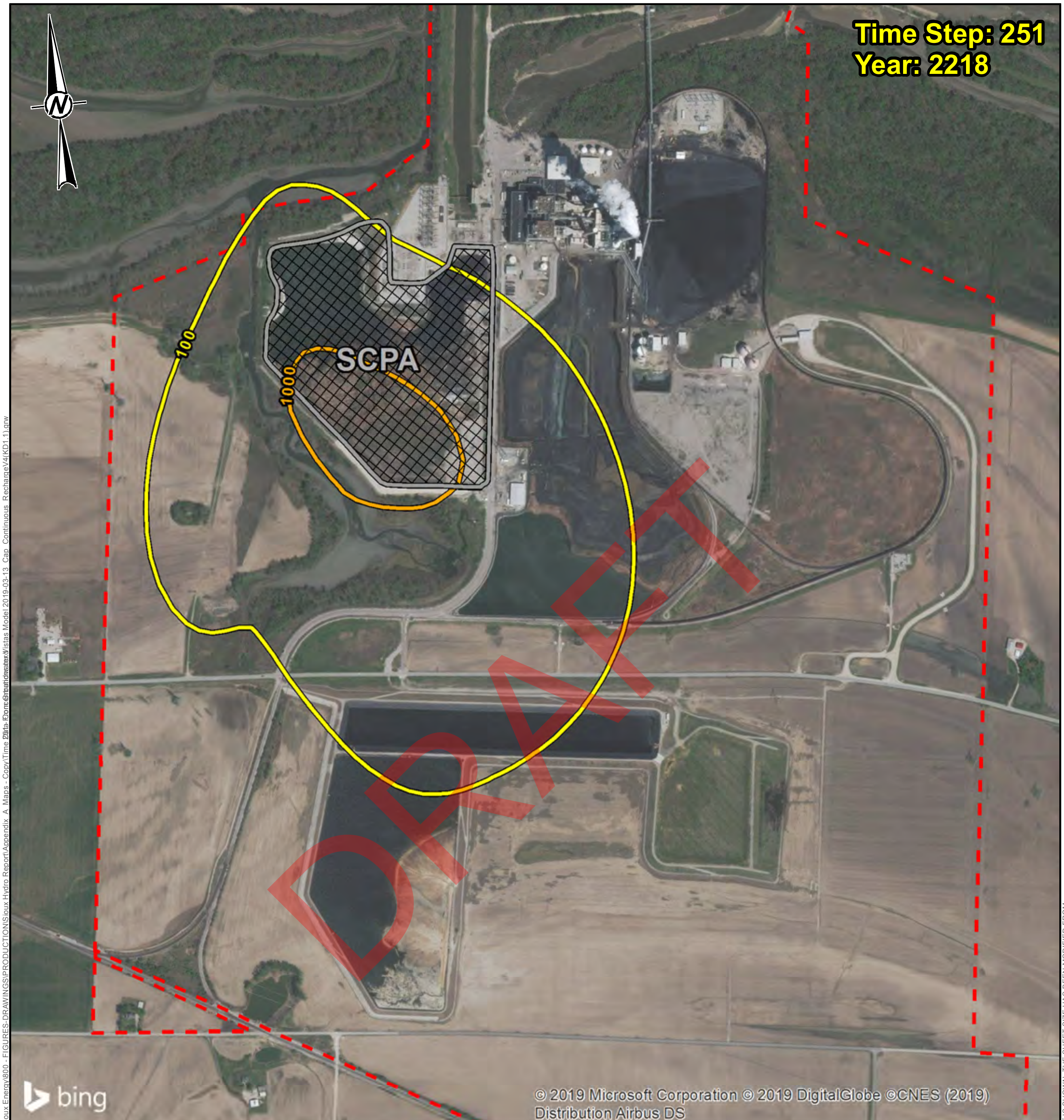
PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 241 (2208) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	A25

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 1 in

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Sioux Hydro Report\Appendix_A_Maps - Copy\Time Step_Data - From Groundwater Vistas Model 2019-03-13_Cap_Continuous_RechargeV4(KD1.1).grw



LEGEND

- Sioux Energy Center Property Boundary
- SCPA - Unlined Bottom Ash Surface Impoundment
- Molybdenum Concentrations Greater Than 100 (µg/L)
- Molybdenum Concentrations Greater Than 1000 (µg/L)
- Molybdenum Concentrations Greater Than 3000 (µg/L)

NOTES

1. PLUME CONCENTRATIONS CALCULATED USING GROUNDWATER VISTAS, MODFLOW, AND MT3DS.
2. PLUME REPRESENTS CONCENTRATIONS IN LAYER 3 OF THE MODEL AT AND AVERAGE ELEVATION OF APPROXIMATELY 375 FEET ABOVE MEAN SEA LEVEL.

0 500 1,000 2,000 3,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

CONSULTANT

GOLDER

YYYY-MM-DD	2019-03-12
PREPARED	EFT
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT
GROUNDWATER MODELING

TITLE
MODEL PREDICTED MOLYBDENUM CONCENTRATION MAP YEAR 251 (2218) - CAPPED AND CLOSED SCPA

Project	Rev.	FIGURE
153-1406	0.0	A26

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in

APPENDIX C

Speciation Modeling

Appendix C: Speciation Modeling

Parameter	Units	S-AM-1D	S-AM-1S	S-BMW-1D
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-1.2	-4.1	4.0
pH	s.u.	7.25	7.09	7.63
Eh	mV	201	296	154
Alkalinity	mg/L as $CaCO_3$	250	260	399
As	mg/L	0.000290	0.00130	0.000200
B	mg/L	11.7	0.432	0.140
Ba	mg/L	0.244	0.112	0.297
Ca	mg/L	75.0	67.5	128
Cd	mg/L	0.000120	0.000055	0.000016
Cl	mg/L	20.7	21.8	5.50
Co	mg/L	0.000435	0.00150	0.000435
Cr	mg/L	0.000039	0.000039	0.000039
F	mg/L	0.450	0.600	0.290
Fe	mg/L	3.34	1.71	9.75
K	mg/L	8.08	10.2	2.54
Li	mg/L	0.0326	0.0193	0.0162
Mg	mg/L	16.1	14.4	25.9
Mn	mg/L	0.389	0.576	1.09
Mo	mg/L	0.446	0.0580	0.000450
Na	mg/L	21.6	17.3	6.56
P	mg/L-P	0.0913	0.222	0.114
SO_4	mg/L	40.1	11.4	13.3
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**3.9**	**3.5**	**4.7**
Siderite	$FeCO_3$	-1.0	-1.4	-0.7
Melanterite	$FeSO_4$ $7H_2O$	-6.9	-7.7	-7.6
Rhodochrosite	$MnCO_3$	**-0.3**	**-0.3**	**0.6**
Birnessite	MnO_2	-13.6	-10.9	-13.4
Manganite	MnOOH	-5.6	-4.3	-4.8
Gypsum	$CaSO_4{:}2H_2O$	-1.9	-2.5	-2.3
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-2.9	-4.7	-3.3
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**3.9**	**2.0**	**3.5**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**0.8**	-1.2	**0.4**
Calcite	$CaCO_3$	**0.0**	**-0.2**	**0.7**
Magnesite	$MgCO_3$	-1.3	-1.5	-0.6
Barite	$BaSO_4$	**0.6**	**-0.3**	**0.1**
Witherite	$BaCO_3$	-2.9	-3.3	-2.2
Fluorite	CaF_2	-1.8	-1.5	-2.0
Carbon Dioxide	pCO_2(g) (b)	-1.8	-1.7	-2.1

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) pCO_2(g) values presented at 10^value atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-BMW-3D	S-UMW-1D	S-UMW-2D
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		0.4	2.7	-8.5
pH	s.u.	7.60	7.60	8.28
Eh	mV	201	101	29.6
Alkalinity	mg/L as $CaCO_3$	350	204	116
As	mg/L	0.0000325	0.00140	0.00280
B	mg/L	0.0473	0.163	18.4
Ba	mg/L	0.645	0.134	0.0657
Ca	mg/L	108	75.3	175
Cd	mg/L	0.000016	0.000016	0.000290
Cl	mg/L	8.40	21.8	20.0
Co	mg/L	0.000435	0.000435	0.000435
Cr	mg/L	0.000039	0.000039	0.000039
F	mg/L	0.300	0.190	0.460
Fe	mg/L	7.68	0.846	0.266
K	mg/L	3.64	5.49	23.9
Li	mg/L	0.0254	0.0157	0.0234
Mg	mg/L	23.6	21.3	5.71
Mn	mg/L	0.459	0.114	0.183
Mo	mg/L	0.000450	0.0240	1.54
Na	mg/L	6.50	15.2	50.0
P	mg/L-P	0.121	0.0587	0.0284
SO_4	mg/L	27.5	63.4	522
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**4.5**	**3.8**	**3.6**
Siderite	$FeCO_3$	-1.0	-2.2	-2.1
Melanterite	$FeSO_4$ $7H_2O$	-7.6	-8.4	-7.6
Rhodochrosite	$MnCO_3$	**0.2**	-0.6	**-0.2**
Birnessite	MnO_2	-12.3	-15.9	-15.8
Manganite	MnOOH	-4.5	-6.8	-5.8
Gypsum	$CaSO_4{:}2H_2O$	-2.0	-1.8	-0.7
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-2.9	-4.2	-5.8
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**4.1**	**2.5**	**2.4**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**0.8**	**-0.4**	-0.7
Calcite	$CaCO_3$	**0.6**	**0.3**	**0.8**
Magnesite	$MgCO_3$	-0.7	-1.0	-1.3
Barite	$BaSO_4$	**0.8**	**0.4**	**1.0**
Witherite	$BaCO_3$	-2.0	-2.8	-2.9
Fluorite	CaF_2	-2.0	-2.6	-1.5
Carbon Dioxide	pCO_2(g) (b)	-2.1	-2.3	-3.3

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) pCO_2(g) values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-UMW-3D	S-UMW-4D	S-UMW-5D
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		**-13.2**	-8.0	-1.0
pH	s.u.	8.34	7.35	7.47
Eh	mV	23.7	65.1	11.8
Alkalinity	mg/L as $CaCO_3$	56.7	201	264
As	mg/L	0.000820	0.000290	0.000400
B	mg/L	31.9	16.8	5.53
Ba	mg/L	0.0750	0.0569	0.265
Ca	mg/L	248	153	72.7
Cd	mg/L	0.001000	0.000940	0.000054
Cl	mg/L	12.8	23.8	24.9
Co	mg/L	0.000435	0.000435	0.000435
Cr	mg/L	0.000039	0.000039	0.000039
F	mg/L	0.960	0.490	0.490
Fe	mg/L	0.626	6.26	3.38
K	mg/L	20.4	13.1	9.26
Li	mg/L	0.0117	0.0383	0.0229
Mg	mg/L	7.21	21.6	16.7
Mn	mg/L	0.399	1.46	0.444
Mo	mg/L	4.00	3.90	0.181
Na	mg/L	106	59.9	18.7
P	mg/L-P	0.0303	0.0848	0.0783
SO_4	mg/L	994	459	12.0
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**4.0**	**4.3**	**4.1**
Siderite	$FeCO_3$	-2.6	-1.3	-0.6
Melanterite	$FeSO_4\ 7H_2O$	-7.5	-6.3	-7.3
Rhodochrosite	$MnCO_3$	**-0.3**	**0.1**	**0.0**
Birnessite	MnO_2	-15.5	-17.4	-19.1
Manganite	MnOOH	-5.5	-7.1	-8.0
Gypsum	$CaSO_4{:}2H_2O$	**-0.4**	-0.8	-2.5
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-4.5	**-0.2**	-4.2
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**3.8**	**6.9**	**2.9**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**1.0**	**4.0**	**-0.3**
Calcite	$CaCO_3$	**0.5**	**0.1**	**0.2**
Magnesite	$MgCO_3$	-1.7	-1.3	-1.0
Barite	$BaSO_4$	**1.2**	**0.8**	**0.1**
Witherite	$BaCO_3$	-3.3	-3.6	-2.6
Fluorite	CaF_2	-0.9	-1.6	-1.7
Carbon Dioxide	$pCO_2(g)$ (b)	-3.8	-2.1	-2.0

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) $pCO_2(g)$ values presented at 10^value atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-UMW-6D	S-BMW-1S	S-BMW-3S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		1.4	2.2	0.1
pH	s.u.	6.86	7.46	7.49
Eh	mV	112	213	266
Alkalinity	mg/L as $CaCO_3$	386	464	368
As	mg/L	0.000290	0.000950	0.000450
B	mg/L	0.589	0.0729	0.0615
Ba	mg/L	0.182	0.160	0.157
Ca	mg/L	123	157	124
Cd	mg/L	0.000016	-	-
Cl	mg/L	8.60	6.70	10.1
Co	mg/L	0.000435	-	-
Cr	mg/L	0.000039	-	-
F	mg/L	0.330	0.340	0.360
Fe	mg/L	8.84	0.0200	0.0630
K	mg/L	5.53	0.580	0.772
Li	mg/L	0.0203	0.00230	0.0121
Mg	mg/L	28.6	29.0	21.4
Mn	mg/L	0.716	0.607	0.400
Mo	mg/L	0.0528	0.00220	0.00280
Na	mg/L	11.8	5.60	5.07
P	mg/L-P	0.147	0.163	0.0750
SO_4	mg/L	53.4	28.8	25.6
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**4.0**	**1.7**	**2.4**
Siderite	$FeCO_3$	-1.4	-2.2	-2.2
Melanterite	$FeSO_4\ 7H_2O$	-7.1	-8.8	-8.8
Rhodochrosite	$MnCO_3$	**-0.3**	**0.3**	**0.0**
Birnessite	MnO_2	-17.9	-12.3	-10.6
Manganite	MnOOH	-8.0	-4.6	-3.8
Gypsum	$CaSO_4{:}2H_2O$	-1.7	-1.9	-2.0
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-0.9	-10.7	-9.0
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**5.3**	-4.8	-3.0
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**2.1**	-7.4	-5.6
Calcite	$CaCO_3$	**0.0**	**0.7**	**0.6**
Magnesite	$MgCO_3$	-1.3	-0.6	-0.8
Barite	$BaSO_4$	**0.4**	**0.1**	**0.1**
Witherite	$BaCO_3$	-3.2	-2.6	-2.7
Fluorite	CaF_2	-1.9	-1.8	-1.8
Carbon Dioxide	$pCO_2(g)$ (b)	-1.3	-1.8	-1.9

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) $pCO_2(g)$ values presented at 10^value atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-LMW-1S	S-LMW-2S	S-LMW-3S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		1.4	0.1	0.5
pH	s.u.	7.40	6.95	6.75
Eh	mV	184	290	284
Alkalinity	mg/L as $CaCO_3$	227	428	529
As	mg/L	0.00200	0.00100	0.000570
B	mg/L	0.539	8.53	0.298
Ba	mg/L	0.127	0.127	0.200
Ca	mg/L	79.4	197	188
Cd	mg/L	0.000049	0.000380	0.000110
Cl	mg/L	42.6	174	51.3
Co	mg/L	-	-	-
Cr	mg/L	0.000039	0.000039	0.000300
F	mg/L	0.370	0.320	0.260
Fe	mg/L	0.0230	0.166	0.0190
K	mg/L	6.80	6.72	5.12
Li	mg/L	0.0210	0.0416	0.0294
Mg	mg/L	20.1	41.7	36.9
Mn	mg/L	0.0594	0.545	0.00430
Mo	mg/L	0.0436	0.709	0.00110
Na	mg/L	33.4	91.7	16.9
P	mg/L-P	0.0848	0.00815	0.00815
SO_4	mg/L	62.2	188	54.3
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**1.9**	**2.4**	**1.0**
Siderite	$FeCO_3$	-2.4	-2.8	-2.8
Melanterite	$FeSO_4$ $7H_2O$	-8.4	-8.1	-8.6
Rhodochrosite	$MnCO_3$	-1.0	**-0.4**	-2.6
Birnessite	MnO_2	-14.2	-11.8	-14.9
Manganite	MnOOH	-6.2	-5.0	-7.7
Gypsum	$CaSO_4:2H_2O$	-1.8	-1.1	-1.6
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-9.1	-5.3	-9.5
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	-2.4	**1.1**	-3.4
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	-5.2	-1.3	-6.4
Calcite	$CaCO_3$	**0.1**	**0.2**	**0.1**
Magnesite	$MgCO_3$	-1.1	-1.1	-1.2
Barite	$BaSO_4$	**0.4**	**0.7**	**0.4**
Witherite	$BaCO_3$	-3.0	-3.3	-3.2
Fluorite	CaF_2	-2.0	-1.8	-2.0
Carbon Dioxide	$pCO_2(g)$ (b)	-2.0	-1.3	-1.0

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

[a] Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

[b] $pCO_2(g)$ values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-LMW-4S	S-LMW-5S	S-LMW-6S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		3.5	-5.8	-1.4
pH	s.u.	6.06	6.74	6.81
Eh	mV	166	373	397
Alkalinity	mg/L as $CaCO_3$	540	357	430
As	mg/L	0.000540	0.000730	0.000640
B	mg/L	1.02	13.4	10.4
Ba	mg/L	0.247	0.0735	0.0455
Ca	mg/L	179	280	199
Cd	mg/L	0.000170	0.00110	0.00150
Cl	mg/L	2.90	27.9	2.20
Co	mg/L	-	-	-
Cr	mg/L	0.000039	0.000220	0.000039
F	mg/L	0.350	0.340	0.320
Fe	mg/L	0.0280	0.266	0.0270
K	mg/L	5.05	4.56	4.65
Li	mg/L	0.0389	0.0521	0.0249
Mg	mg/L	36.9	54.2	52.5
Mn	mg/L	0.260	1.70	0.373
Mo	mg/L	0.00210	0.690	0.00110
Na	mg/L	14.3	136	44.1
P	mg/L-P	0.00815	0.00815	0.00815
SO_4	mg/L	50.0	912	385
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**0.6**	**2.3**	**1.3**
Siderite	$FeCO_3$	-3.5	-3.2	-3.0
Melanterite	$FeSO_4$ $7H_2O$	-8.6	-7.6	-7.8
Rhodochrosite	$MnCO_3$	-1.5	**-0.3**	-0.7
Birnessite	MnO_2	-19.9	-9.5	-9.0
Manganite	MnOOH	-10.0	-3.8	-3.8
Gypsum	$CaSO_4{:}2H_2O$	-1.7	**-0.4**	-0.8
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-8.2	-3.3	-7.4
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	-2.8	**2.7**	-1.3
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	-5.8	**0.7**	-3.8
Calcite	$CaCO_3$	-0.6	**-0.1**	**0.0**
Magnesite	$MgCO_3$	-1.9	-1.4	-1.2
Barite	$BaSO_4$	**0.5**	**1.1**	**0.6**
Witherite	$BaCO_3$	-3.8	-3.9	-3.9
Fluorite	CaF_2	-1.7	-1.8	-1.9
Carbon Dioxide	$pCO_2(g)$ (b)	**-0.3**	-1.2	-1.2

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

[a] Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

[b] $pCO_2(g)$ values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-LMW-7S	S-LMW-8S	S-LMW-9S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		1.5	0.1	-7.6
pH	s.u.	6.84	6.93	6.82
Eh	mV	326	373	243
Alkalinity	mg/L as $CaCO_3$	391	306	415
As	mg/L	0.000450	0.00110	0.000910
B	mg/L	2.74	8.50	1.76
Ba	mg/L	0.0910	0.105	0.0734
Ca	mg/L	221	177	194
Cd	mg/L	0.000260	0.000710	0.000260
Cl	mg/L	11.6	38.9	278
Co	mg/L	-	-	-
Cr	mg/L	0.000039	0.000039	0.000170
F	mg/L	0.340	0.870	0.560
Fe	mg/L	0.0210	0.0146	0.126
K	mg/L	3.99	4.88	4.72
Li	mg/L	0.0221	0.0231	0.0434
Mg	mg/L	60.2	41.0	60.6
Mn	mg/L	0.118	0.488	0.583
Mo	mg/L	0.00150	0.390	0.0114
Na	mg/L	16.9	77.8	49.9
P	mg/L-P	0.00815	0.0316	0.00815
SO_4	mg/L	396	405	163
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**1.2**	**1.1**	**2.2**
Siderite	$FeCO_3$	-3.0	-3.0	-2.9
Melanterite	$FeSO_4\ 7H_2O$	-7.8	-7.8	-8.2
Rhodochrosite	$MnCO_3$	-1.2	-0.6	-0.5
Birnessite	MnO_2	-11.8	-9.1	-13.8
Manganite	MnOOH	-5.4	-3.7	-6.1
Gypsum	$CaSO_4{:}2H_2O$	-0.8	-0.8	-1.2
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-7.8	-8.4	-5.5
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	-1.7	-2.2	**0.5**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	-4.6	-4.5	-2.0
Calcite	$CaCO_3$	**0.1**	**0.0**	**0.1**
Magnesite	$MgCO_3$	-1.1	-1.3	-1.1
Barite	$BaSO_4$	**0.9**	**1.0**	**0.4**
Witherite	$BaCO_3$	-3.6	-3.5	-3.7
Fluorite	CaF_2	-1.8	-1.0	-1.4
Carbon Dioxide	$pCO_2(g)$ (b)	-1.3	-1.5	-1.2

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

[a] Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

[b] $pCO_2(g)$ values presented at 10^value atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-1D	S-TP-1M	S-TP-1S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-6.7	-0.3	-0.4
pH	s.u.	7.31	7.07	6.88
Eh	mV	94.7	94.7	59.2
Alkalinity	mg/L as $CaCO_3$	187	241	438
As	mg/L	0.000160	0.000120	0.0253
B	mg/L	0.492	0.293	0.122
Ba	mg/L	0.0980	0.212	0.369
Ca	mg/L	54.4	78.4	204
Cd	mg/L	0.000016	0.000016	0.000016
Cl	mg/L	23.5	55.6	325
Co	mg/L	0.000435	0.000435	0.00270
Cr	mg/L	0.000110	0.000190	0.000240
F	mg/L	0.380	0.350	0.360
Fe	mg/L	2.86	6.70	22.6
K	mg/L	6.88	1.35	1.80
Li	mg/L	0.0164	0.0175	0.00650
Mg	mg/L	13.8	20.3	53.0
Mn	mg/L	0.329	0.398	11.6
Mo	mg/L	0.00350	0.00180	0.00580
Na	mg/L	17.1	38.0	71.6
P	mg/L-P	0.0913	0.218	0.652
SO_4	mg/L	51.6	50.4	34.8
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**3.9**	**4.0**	**4.4**
Siderite	$FeCO_3$	-1.6	-1.3	-1.1
Melanterite	$FeSO_4$ $7H_2O$	-7.3	-6.9	-7.1
Rhodochrosite	$MnCO_3$	**-0.5**	-0.5	**0.9**
Birnessite	MnO_2	-17.2	-18.0	-18.6
Manganite	MnOOH	-7.2	-7.9	-7.7
Gypsum	$CaSO_4{:}2H_2O$	-1.9	-1.9	-1.8
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-3.1	-1.6	**-0.4**
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**3.8**	**4.2**	**5.3**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**0.7**	**2.2**	**3.4**
Calcite	$CaCO_3$	**-0.2**	**-0.2**	**0.2**
Magnesite	$MgCO_3$	-1.4	-1.4	-1.0
Barite	$BaSO_4$	**0.3**	**0.6**	**0.4**
Witherite	$BaCO_3$	-3.3	-3.1	-2.9
Fluorite	CaF_2	-2.0	-2.0	-1.7
Carbon Dioxide	$pCO_2(g)$ (b)	-2.0	-1.7	-1.3

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) $pCO_2(g)$ values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-2D	S-TP-2M	S-TP-2S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-4.6	0.6	1.0
pH	s.u.	6.11	6.15	6.22
Eh	mV	118	130	207
Alkalinity	mg/L as $CaCO_3$	457	435	502
As	mg/L	0.000120	0.000190	0.0139
B	mg/L	0.0703	0.121	0.0805
Ba	mg/L	0.0872	0.178	0.283
Ca	mg/L	274	191	151
Cd	mg/L	0.000016	0.000016	0.000016
Cl	mg/L	86.6	11.4	11.5
Co	mg/L	0.000435	0.000435	0.00290
Cr	mg/L	0.000039	0.000039	0.000039
F	mg/L	0.0950	0.0950	0.0950
Fe	mg/L	17.4	16.9	12.6
K	mg/L	6.11	5.16	1.14
Li	mg/L	0.0471	0.0267	0.0132
Mg	mg/L	68.9	44.5	37.8
Mn	mg/L	1.16	0.862	4.86
Mo	mg/L	0.000450	0.000450	0.0118
Na	mg/L	20.7	18.1	12.9
P	mg/L-P	0.0913	0.0946	0.267
SO_4	mg/L	520	254	50.5
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**3.4**	**3.4**	**3.4**
Siderite	$FeCO_3$	-2.8	-2.7	-2.2
Melanterite	$FeSO_4\ 7H_2O$	-6.8	-7.0	-7.3
Rhodochrosite	$MnCO_3$	-1.0	-1.0	**-0.1**
Birnessite	MnO_2	-20.9	-20.4	-16.7
Manganite	MnOOH	-10.1	-9.8	-7.5
Gypsum	$CaSO_4{:}2H_2O$	-0.6	-1.0	-1.7
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	**1.9**	**1.4**	**-0.4**
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**7.6**	**7.1**	**4.7**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**4.6**	**4.1**	**2.2**
Calcite	$CaCO_3$	-0.6	-0.6	-0.5
Magnesite	$MgCO_3$	-1.8	-1.9	-1.7
Barite	$BaSO_4$	**1.0**	**1.1**	**0.6**
Witherite	$BaCO_3$	-4.3	-4.0	-3.6
Fluorite	CaF_2	-2.8	-2.9	-2.9
Carbon Dioxide	$pCO_2(g)$ (b)	**-0.5**	-0.5	-0.5

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

[a] Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

[b] $pCO_2(g)$ values presented at 10^[value] atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-3D	S-TP-3M	S-TP-3S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-1.7	0.0	0.2
pH	s.u.	7.17	7.12	7.30
Eh	mV	184	219	337
Alkalinity	mg/L as $CaCO_3$	355	335	410
As	mg/L	0.000170	0.000260	0.00420
B	mg/L	0.0520	0.0482	0.0713
Ba	mg/L	0.574	0.434	0.222
Ca	mg/L	119	109	113
Cd	mg/L	0.000016	0.000016	0.000033
Cl	mg/L	7.60	8.40	7.20
Co	mg/L	0.000435	0.000435	0.00110
Cr	mg/L	0.000160	0.000220	0.000180
F	mg/L	0.230	0.290	0.420
Fe	mg/L	8.08	9.71	3.41
K	mg/L	4.15	4.21	6.37
Li	mg/L	0.0321	0.0210	0.0119
Mg	mg/L	28.1	23.9	22.2
Mn	mg/L	0.603	0.600	1.81
Mo	mg/L	0.000450	0.00120	0.0308
Na	mg/L	7.44	12.0	30.2
P	mg/L-P	0.114	0.0880	0.00815
SO_4	mg/L	87.5	62.5	30.4
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**4.1**	**4.2**	**3.9**
Siderite	$FeCO_3$	-1.5	-1.4	-0.8
Melanterite	$FeSO_4\ 7H_2O$	-7.1	-7.1	-7.1
Rhodochrosite	$MnCO_3$	**-0.1**	**-0.2**	**0.5**
Birnessite	MnO_2	-14.6	-13.6	-8.3
Manganite	MnOOH	-6.0	-5.5	-2.5
Gypsum	$CaSO_4{:}2H_2O$	-1.5	-1.7	-2.0
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-1.4	-1.4	-3.5
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**5.2**	**5.2**	**3.3**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**1.9**	**2.1**	**0.5**
Calcite	$CaCO_3$	**0.2**	**0.1**	**0.4**
Magnesite	$MgCO_3$	-1.0	-1.2	-0.9
Barite	$BaSO_4$	**1.2**	**1.0**	**0.3**
Witherite	$BaCO_3$	-2.5	-2.7	-2.7
Fluorite	CaF_2	-2.2	-2.0	-1.7
Carbon Dioxide	pCO_2(g) (b)	-1.6	-1.6	-1.7

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) pCO_2(g) values presented at 10^value atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-4D	S-TP-4M	S-TP-4S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-1.1	1.0	-0.6
pH	s.u.	7.14	7.15	7.15
Eh	mV	260	349	414
Alkalinity	mg/L as $CaCO_3$	305	337	366
As	mg/L	0.000950	0.000330	0.00580
B	mg/L	0.0565	0.0730	0.112
Ba	mg/L	0.557	0.408	0.192
Ca	mg/L	104	112	90.7
Cd	mg/L	0.000016	0.000016	0.000016
Cl	mg/L	8.30	6.10	30.9
Co	mg/L	0.000435	0.000435	0.00140
Cr	mg/L	0.000160	0.000210	0.000039
F	mg/L	0.310	0.370	0.350
Fe	mg/L	6.56	7.15	1.91
K	mg/L	3.11	4.06	5.73
Li	mg/L	0.0296	0.0249	0.0148
Mg	mg/L	25.6	25.0	19.5
Mn	mg/L	0.438	0.605	2.18
Mo	mg/L	0.000450	0.00180	0.0331
Na	mg/L	6.62	9.80	59.7
P	mg/L-P	0.0978	0.0783	0.00815
SO_4	mg/L	78.4	60.4	43.0
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**4.1**	**4.1**	**3.6**
Siderite	$FeCO_3$	-0.9	-1.2	-2.5
Melanterite	$FeSO_4$ $7H_2O$	-6.5	-7.0	-8.5
Rhodochrosite	$MnCO_3$	**-0.3**	**-0.2**	**0.4**
Birnessite	MnO_2	-12.1	-8.9	-6.1
Manganite	MnOOH	-4.9	-3.2	-1.6
Gypsum	$CaSO_4:2H_2O$	-1.6	-1.7	-1.9
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-1.5	-1.6	-3.5
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**4.8**	**4.8**	**3.1**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**1.6**	**1.7**	**0.6**
Calcite	$CaCO_3$	**0.1**	**0.1**	**0.1**
Magnesite	$MgCO_3$	-1.2	-1.1	-1.2
Barite	$BaSO_4$	**1.2**	**0.9**	**0.4**
Witherite	$BaCO_3$	-2.5	-2.6	-2.9
Fluorite	CaF_2	-2.0	-1.8	-1.9
Carbon Dioxide	$pCO_2(g)$ (b)	-1.7	-1.6	-1.6

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) $pCO_2(g)$ values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-5D	S-TP-5M	S-TP-5S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		1.7	2.8	-0.9
pH	s.u.	7.11	7.15	7.29
Eh	mV	118	130	172
Alkalinity	mg/L as $CaCO_3$	275	318	430
As	mg/L	0.000300	0.00350	0.00370
B	mg/L	5.46	3.19	0.263
Ba	mg/L	0.183	0.252	0.440
Ca	mg/L	141	149	124
Cd	mg/L	0.000056	0.000016	0.000040
Cl	mg/L	26.8	8.90	47.7
Co	mg/L	0.000435	0.000435	0.000950
Cr	mg/L	0.000039	0.000039	0.000039
F	mg/L	0.340	0.300	0.280
Fe	mg/L	10.3	8.53	4.36
K	mg/L	5.16	5.62	5.23
Li	mg/L	0.0330	0.0310	0.00230
Mg	mg/L	32.4	26.5	27.4
Mn	mg/L	0.993	0.360	1.12
Mo	mg/L	0.175	0.0128	0.0317
Na	mg/L	24.8	17.2	30.0
P	mg/L-P	0.101	0.0652	0.0176
SO_4	mg/L	218	170	11.3
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**4.2**	**4.2**	**4.0**
Siderite	$FeCO_3$	-1.7	-2.0	-0.7
Melanterite	$FeSO_4\ 7H_2O$	-6.9	-7.4	-7.5
Rhodochrosite	$MnCO_3$	**-0.1**	**-0.5**	**0.3**
Birnessite	MnO_2	-16.8	-16.6	-14.1
Manganite	MnOOH	-7.1	-7.2	-5.5
Gypsum	$CaSO_4{:}2H_2O$	-1.1	-1.2	-2.4
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	**-0.1**	-0.6	-3.9
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**6.4**	**6.0**	**2.8**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**3.6**	**3.0**	**0.0**
Calcite	$CaCO_3$	**0.0**	**0.2**	**0.4**
Magnesite	$MgCO_3$	-1.2	-1.2	-0.9
Barite	$BaSO_4$	**1.1**	**1.1**	**0.2**
Witherite	$BaCO_3$	-3.1	-2.9	-2.4
Fluorite	CaF_2	-1.9	-1.9	-2.0
Carbon Dioxide	$pCO_2(g)$ (b)	-1.7	-1.7	-1.7

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) $pCO_2(g)$ values presented at 10^value atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-6D	S-TP-6M	S-TP-6S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-0.7	0.2	-1.3
pH	s.u.	6.34	6.42	6.23
Eh	mV	136	172	266
Alkalinity	mg/L as $CaCO_3$	353	386	376
As	mg/L	0.000170	0.000520	0.00200
B	mg/L	0.0704	0.0638	0.104
Ba	mg/L	0.391	0.454	0.224
Ca	mg/L	121	132	121
Cd	mg/L	0.000016	0.000034	0.000016
Cl	mg/L	13.3	14.3	6.70
Co	mg/L	0.000435	0.000435	0.00120
Cr	mg/L	0.000039	0.000039	0.000039
F	mg/L	0.0950	0.260	0.270
Fe	mg/L	9.09	10.2	1.02
K	mg/L	4.09	4.13	3.45
Li	mg/L	0.0280	0.0228	0.0337
Mg	mg/L	28.6	27.0	24.6
Mn	mg/L	0.472	0.452	0.615
Mo	mg/L	0.00200	0.00290	0.00430
Na	mg/L	6.23	16.3	7.87
P	mg/L-P	0.104	0.0391	0.0280
SO_4	mg/L	78.5	80.4	50.0
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**3.4**	**3.5**	**2.4**
Siderite	$FeCO_3$	-2.2	-2.1	-2.5
Melanterite	$FeSO_4$ $7H_2O$	-7.1	-7.1	-7.6
Rhodochrosite	$MnCO_3$	-1.1	-1.0	-1.0
Birnessite	MnO_2	-19.6	-18.1	-15.4
Manganite	MnOOH	-9.4	-8.5	-7.4
Gypsum	$CaSO_4{:}2H_2O$	-1.5	-1.5	-1.7
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	**-0.4**	**-0.3**	-3.4
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**5.3**	**5.5**	**2.1**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**2.0**	**2.6**	-1.1
Calcite	$CaCO_3$	-0.6	**-0.5**	-0.7
Magnesite	$MgCO_3$	-1.9	-1.8	-2.0
Barite	$BaSO_4$	**1.0**	**1.0**	**0.5**
Witherite	$BaCO_3$	-3.5	-3.3	-3.8
Fluorite	CaF_2	-3.0	-2.1	-2.1
Carbon Dioxide	pCO_2(g) (b)	-0.8	-0.9	-0.7

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) pCO_2(g) values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-7D	S-TP-7M	S-TP-7S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-1.6	-0.6	-0.8
pH	s.u.	6.37	6.36	6.40
Eh	mV	130	184	302
Alkalinity	mg/L as $CaCO_3$	335	415	605
As	mg/L	0.000230	0.000670	0.00840
B	mg/L	0.0854	0.0873	0.120
Ba	mg/L	0.410	0.382	0.443
Ca	mg/L	140	131	124
Cd	mg/L	0.000016	0.000016	0.000016
Cl	mg/L	32.7	16.6	26.1
Co	mg/L	0.000435	0.000435	0.001000
Cr	mg/L	0.000220	0.000840	0.000083
F	mg/L	0.260	0.330	0.380
Fe	mg/L	16.6	17.3	8.81
K	mg/L	5.33	5.99	9.78
Li	mg/L	0.0438	0.0402	0.0254
Mg	mg/L	35.6	30.8	43.1
Mn	mg/L	0.716	0.610	1.72
Mo	mg/L	0.000450	0.00240	0.0592
Na	mg/L	10.1	7.02	63.8
P	mg/L-P	0.137	0.134	0.0173
SO_4	mg/L	169	57.7	16.2
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**3.7**	**3.7**	**3.5**
Siderite	$FeCO_3$	-2.2	-2.1	-1.9
Melanterite	$FeSO_4$ $7H_2O$	-6.8	-7.3	-7.8
Rhodochrosite	$MnCO_3$	-0.9	-0.9	**-0.3**
Birnessite	MnO_2	-19.5	-17.8	-13.1
Manganite	MnOOH	-9.2	-8.4	-5.9
Gypsum	$CaSO_4{:}2H_2O$	-1.2	-1.7	-2.3
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	**1.0**	**0.2**	-1.8
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**6.9**	**6.1**	**4.3**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**3.6**	**2.6**	**1.6**
Calcite	$CaCO_3$	-0.6	-0.5	**-0.4**
Magnesite	$MgCO_3$	-1.8	-1.8	-1.4
Barite	$BaSO_4$	**1.3**	**0.8**	**0.3**
Witherite	$BaCO_3$	-3.5	-3.4	-3.1
Fluorite	CaF_2	-2.1	-1.9	-1.8
Carbon Dioxide	$pCO_2(g)$ (b)	-0.9	-0.8	-0.6

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

(b) $pCO_2(g)$ values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-TP-8D	S-TP-8M	S-TP-8S
Sampling Date		**Nov-18**	**Nov-18**	**Nov-18**
Charge Balance		-1.2	-0.7	1.4
pH	s.u.	6.34	6.37	6.43
Eh	mV	130	136	136
Alkalinity	mg/L as $CaCO_3$	334	356	374
As	mg/L	0.000880	0.000910	0.000430
B	mg/L	0.0659	0.0817	0.0845
Ba	mg/L	0.363	0.248	0.167
Ca	mg/L	110	114	112
Cd	mg/L	0.000016	0.000041	0.000085
Cl	mg/L	30.6	36.2	28.2
Co	mg/L	0.000435	0.000435	0.000435
Cr	mg/L	0.000360	0.000150	0.000079
F	mg/L	0.260	0.290	0.250
Fe	mg/L	6.67	8.81	0.0120
K	mg/L	3.68	3.81	9.76
Li	mg/L	0.0331	0.0276	0.0183
Mg	mg/L	23.7	25.1	24.4
Mn	mg/L	0.408	0.402	0.594
Mo	mg/L	0.00150	0.00100	0.0166
Na	mg/L	8.33	10.5	28.9
P	mg/L-P	0.127	0.0750	0.00815
SO_4	mg/L	32.7	22.0	28.9
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**3.3**	**3.4**	**0.4**
Siderite	$FeCO_3$	-1.9	-2.1	-3.2
Melanterite	$FeSO_4\ 7H_2O$	-7.2	-7.6	-8.7
Rhodochrosite	$MnCO_3$	-1.1	-1.1	-0.8
Birnessite	MnO_2	-19.8	-19.5	-19.0
Manganite	MnOOH	-9.5	-9.3	-9.0
Gypsum	$CaSO_4{:}2H_2O$	-1.9	-2.1	-2.0
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-1.5	-1.4	-10.6
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**4.2**	**4.2**	-4.5
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	**1.0**	**1.2**	-7.5
Calcite	$CaCO_3$	-0.7	-0.6	-0.5
Magnesite	$MgCO_3$	-2.0	-1.9	-1.8
Barite	$BaSO_4$	**0.6**	**0.2**	**0.2**
Witherite	$BaCO_3$	-3.5	-3.6	-3.7
Fluorite	CaF_2	-2.1	-2.0	-2.2
Carbon Dioxide	pCO_2(g) (b)	-0.8	-0.8	-0.9

Notes:
Non-detect values equal 1/2 analytical detection limit
Redox converted from field ORP to Eh by +200 mV
[a] Saturation indices between -0.5 and 0.5 identified by bold type and grey shading
[b] pCO_2(g) values presented at 10^{value} atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-SCPA-2	S-SCPA-3S	S-SCPA-1D
Sampling Date		**Jan-18**	**Jan-18**	**Jan-18**
Charge Balance		0.9	-4.0	-6.3
pH	s.u.	6.86	8.92	8.17
Eh	mV	154	260	5.92
Alkalinity	mg/L as $CaCO_3$	219	170	228
As	mg/L	0.00200	0.0720	0.0921
B	mg/L	0.348	67.8	7.68
Ba	mg/L	0.153	0.0329	0.0799
Ca	mg/L	73.4	501	101
Cd	mg/L	0.000240	0.00160	0.000440
Cl	mg/L	20.5	23.1	25.0
Co	mg/L	0.00180	0.000365	0.000365
Cr	mg/L	0.000420	0.000300	0.000190
F	mg/L	0.220	0.600	1.20
Fe	mg/L	1.35	0.0343	0.779
K	mg/L	4.35	40.1	11.8
Li	mg/L	0.0167	0.0434	0.0287
Mg	mg/L	20.0	9.60	23.9
Mn	mg/L	0.113	0.0179	0.0979
Mo	mg/L	0.0265	8.07	2.23
Na	mg/L	13.9	58.5	27.0
P	mg/L-P	-	-	-
SO_4	mg/L	48.5	1290	200
MINERAL PHASES - Saturation Indices (a)				
Ferrihydrite	$Fe(OH)_3$	**1.8**	**2.6**	**2.5**
Siderite	$FeCO_3$	-0.6	-6.2	**0.3**
Melanterite	$FeSO_4\ 7H_2O$	-6.1	-11.7	-5.8
Rhodochrosite	$MnCO_3$	-1.3	-1.2	**-0.1**
Birnessite	MnO_2	-17.0	-6.6	-17.3
Manganite	MnOOH	-8.1	-1.2	-6.8
Gypsum	$CaSO_4{:}2H_2O$	-1.9	**-0.1**	-1.2
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-7.6	-10.8	-9.6
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	-1.8	-1.8	-1.7
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	-4.7	-5.1	-4.8
Calcite	$CaCO_3$	**-0.4**	**1.3**	**0.9**
Magnesite	$MgCO_3$	-1.7	-1.0	**-0.3**
Barite	$BaSO_4$	**0.4**	**0.8**	**0.7**
Witherite	$BaCO_3$	-3.5	-3.1	-2.5
Fluorite	CaF_2	-2.4	-1.1	-0.9
Carbon Dioxide	$pCO_2(g)$ (b)	-1.5	-4.4	-2.8

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

[(a)] Saturation indices between -0.5 and 0.5 identified by bold type and grey shading

[(b)] $pCO_2(g)$ values presented at 10^value atmospheres

Appendix C: Speciation Modeling

Parameter	Units	S-SCPA-3D
Sampling Date		**Jan-18**
Charge Balance		-7.5
pH	s.u.	8.16
Eh	mV	349
Alkalinity	mg/L as $CaCO_3$	185
As	mg/L	0.0912
B	mg/L	79.5
Ba	mg/L	0.0777
Ca	mg/L	548
Cd	mg/L	0.00740
Cl	mg/L	27.1
Co	mg/L	0.000365
Cr	mg/L	0.000620
F	mg/L	2.90
Fe	mg/L	0.138
K	mg/L	60.3
Li	mg/L	0.170
Mg	mg/L	60.2
Mn	mg/L	0.202
Mo	mg/L	43.5
Na	mg/L	116
P	mg/L-P	-
SO_4	mg/L	1820
MINERAL PHASES - Saturation Indices (a)		
Ferrihydrite	$Fe(OH)_3$	**2.9**
Siderite	$FeCO_3$	-4.8
Melanterite	$FeSO_4$ $7H_2O$	-9.7
Rhodochrosite	$MnCO_3$	**-0.4**
Birnessite	MnO_2	-6.3
Manganite	MnOOH	-1.0
Gypsum	$CaSO_4{:}2H_2O$	**0.0**
Jarosite-H	$(H_3O)Fe_3(SO_4)_2(OH)_6$	-6.8
Jarosite-K	$KFe_3(SO_4)_2(OH)_6$	**2.3**
Jarosite-Na	$NaFe_3(SO_4)_2(OH)_6$	-1.0
Calcite	$CaCO_3$	**1.0**
Magnesite	$MgCO_3$	**-0.4**
Barite	$BaSO_4$	**1.4**
Witherite	$BaCO_3$	-3.0
Fluorite	CaF_2	**0.3**
Carbon Dioxide	$pCO_2(g)$ (b)	-3.1

Notes:

Non-detect values equal 1/2 analytical detection limit

Redox converted from field ORP to Eh by +200 mV

(a) Saturation indices between -0.5 and 0.5 identified by bold type a

(b) $pCO_2(g)$ values presented at 10^{value} atmospheres