Assessment of Corrective Measures
Landfill and Surface Impoundment

Lansing Generating Station
Lansing, Iowa

Prepared for:

Alliant Energy

SCS ENGINEERS

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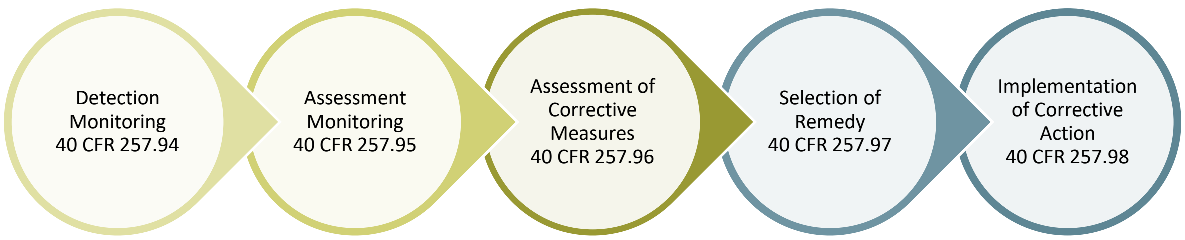
EXECUTIVE SUMMARY

Interstate Power and Light Company (IPL), an Alliant Energy company, operates a dry ash landfill and ash ponds at the Lansing Generating Station (LAN). The landfill and ponds are used to manage coal combustion residuals (CCR) and wastewater from the power plant, which burns coal to generate electricity.

IPL samples and tests the groundwater in the area of the landfill and pond to comply with U.S. Environmental Protection Agency (USEPA) standards for the Disposal of CCR from Electric Utilities, or the “CCR Rule” (Rule). Groundwater monitoring is also conducted under an Iowa Department of Natural Resources (IDNR) sanitary disposal project permit for the landfill.

Groundwater samples from one of the wells installed under the Rule to monitor the landfill and pond contain arsenic at levels higher than the Groundwater Protection Standards (GPS) defined in the Rule. Arsenic occurs naturally and can be present in coal and CCR.

IPL has prepared this Assessment of Corrective Measures (ACM) Report in response to the groundwater sampling results obtained to comply with the Rule at the LAN facility. The ACM process is one step in a series of steps defined in the Rule and shown below.



To prepare the ACM, IPL has worked to understand the following:

- Types of soil and rock deposits in the area of the LAN facility.
- Depth of groundwater.
- Direction that groundwater is moving.
- Potential sources of the arsenic in groundwater.
- The area where arsenic levels are higher than the USEPA standards.
- The people, plants, and animals that may be affected by levels of arsenic in groundwater that are above the GPS.

IPL has installed new wells to help identify where arsenic levels are higher than the USEPA standards. Because the time allowed by the Rule to prepare the ACM is limited, work to improve the understanding of the items listed above is still ongoing.

IPL has identified appropriate options, or Corrective Measures, to bring the levels of arsenic in groundwater below USEPA standards. In addition to stopping landfill disposal of CCR and the discharge of CCR and LAN wastewater to the pond, these corrective measures include:

- Cap CCR in Place with Monitored Natural Attenuation (MNA)
- Consolidate CCR and Cap with MNA

- Excavate and Dispose CCR on Site with MNA
- Excavate and Dispose CCR in Off-site Landfill with MNA

IPL has also included a “No Action” alternative for comparison purposes only.

The ACM includes a preliminary evaluation of all five options using factors identified in the Rule.

Based on what is currently known, the groundwater impacts at LAN are limited, but are not completely understood. IPL will continue to work on understanding groundwater impacts at LAN, and will use this information to select one of the Corrective Measures identified above.

IPL will provide semiannual updates on its progress in evaluating Corrective Measures to address the groundwater impacts at LAN.

Before a remedy is selected, IPL will hold a public meeting with interested and affected parties to discuss the ACM.

For more information on Alliant Energy, view our 2019 Corporate Sustainability Report at http://www.alliantenergy.com/sustainability.

1.0 INTRODUCTION AND PURPOSE

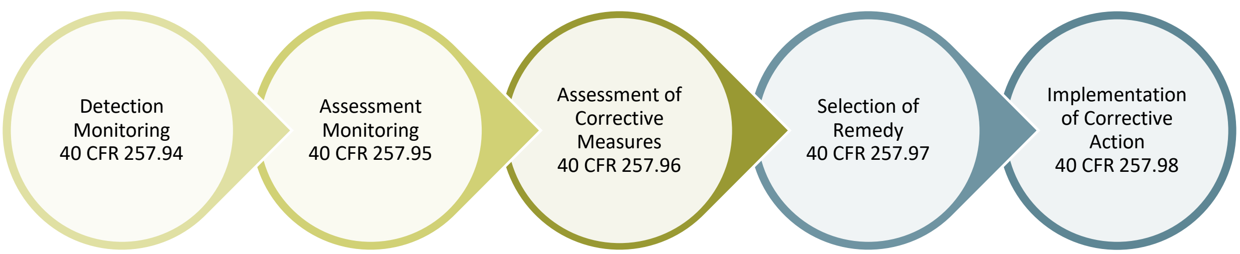
The Assessment of Corrective Measures (ACM) at the Interstate Power and Light Company (IPL) Lansing Generating Station (LAN) was prepared to comply with U.S. Environmental Protection Agency (USEPA) regulations regarding the Disposal of Coal Combustion Residuals from Electric Utilities [40 CFR 257.50-107], or the "CCR Rule" (Rule). Specifically, the ACM was initiated and this report was prepared to fulfill the requirements of 40 CFR 257.96, including:

- Prevention of further releases
- Remediation of release
- Restoration of affected areas

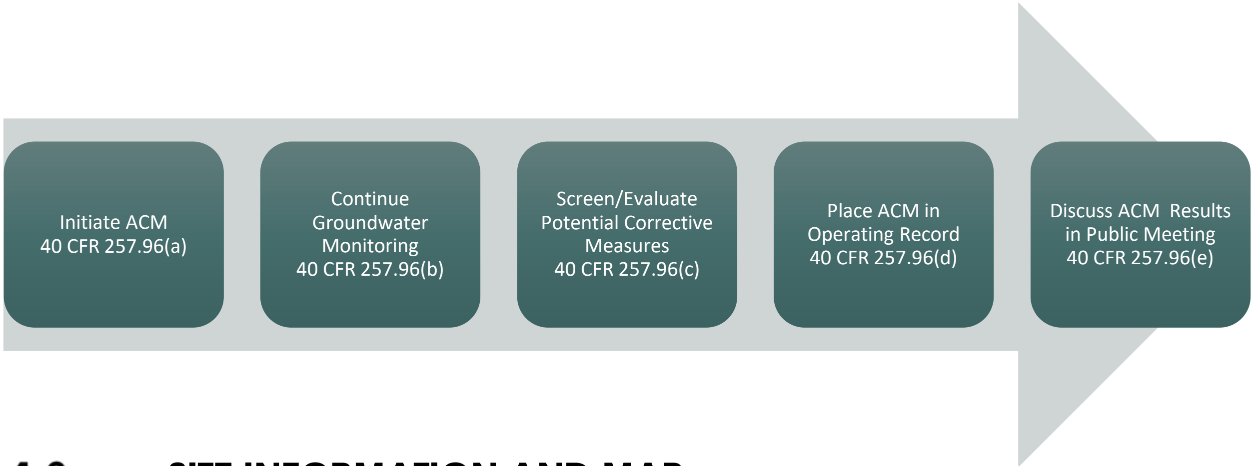
This ACM Report summarizes the remedial alternatives for addressing the Groundwater Protection Standard (GPS) exceedances observed in the 2018 sampling events and identified in the Notification of Groundwater Protection Standard Exceedance dated February 13, 2019.

1.1 ASSESSMENT OF CORRECTIVE MEASURES PROCESS

As discussed above, this ACM Report has been prepared in response to GPS exceedances observed in groundwater samples collected at the LAN facility. The ACM process is one step in a series of steps defined in the CCR Rule and depicted in the graphic below. To date, IPL has implemented a detection monitoring program per 40 CFR 257.94 and completed assessment monitoring at LAN per 40 CFR 257.95. An ACM is now required based on the groundwater monitoring results obtained through October 2018. With the ACM completed, IPL is required to select a corrective measure (remedy) according to 40 CFR 257.97. The remedy selection process must be completed as soon as feasible, and, once selected, IPL is required to start the corrective action process within 90 days.



The process for developing the ACM is defined in 40 CFR 257.96 and is shown in the graphic below. IPL is required to discuss the ACM results in a public meeting at least 30 days before selecting a remedy. To facilitate the selection of a remedy for the GPS exceedances at LAN, IPL continues to investigate and assess the nature and extent of the groundwater impacts. Information about the site, the groundwater monitoring completed, the groundwater impacts as they are currently understood, and the ongoing assessment activities are discussed in the sections that follow.



1.2 SITE INFORMATION AND MAP

LAN is located along the west bank of the Mississippi River, south of the City of Lansing, in Allamakee County, Iowa. The address of the plant is 2320 Power Plant Drive in Lansing, Iowa (**Figure 1**). The facility includes a coal-fired generating plant, a coal combustion residuals (CCR) landfill, and a CCR settling pond. The LAN was originally constructed in 1948, with additional units added in 1957 and 1976.

The groundwater monitoring system at LAN is a multi-unit system monitoring two existing CCR Units that are contiguous:

- LAN Landfill (existing landfill)
- LAN Upper Ash Pond (existing surface impoundment)

The LAN Landfill is operated under a sanitary disposal project permit (Permit #03-SDP-05-01P) administered by the Iowa Department of Natural Resources (IDNR). A separate groundwater monitoring system has been established to monitor the landfill for the state permit. The permitted landfill airspace may, at the earliest, be fully utilized by the end of 2021. Once fully utilized, the landfill will close by installing a state-permitted final cover design that meets the CCR Rule minimum design requirements in 40 CFR 257.102(d)(3).

The LAN Upper Ash Pond is operated with discharges regulated under individual National Pollutant Discharge Elimination System (NPDES) Permit Number IA0300100. The LAN Upper Ash Pond will close to comply with the requirements of 40 CFR 257.101(b)(1) and 103(a). The pond is expected to close by November 1, 2023.

A map showing the CCR Units and all background (or upgradient) and downgradient monitoring wells with identification numbers for the CCR groundwater monitoring program is provided as **Figure 2.** Monitoring wells installed for the state monitoring program for the CCR landfill are also shown on **Figure 2.**

2.0 BACKGROUND

2.1 REGIONAL GEOLOGIC INFORMATION

The uppermost geologic formation beneath LAN that meets the definition of the "uppermost aquifer," as defined under 40 CFR 257.53, is the shallow alluvial aquifer in combination with the hydraulically connected lower Cambrian-Ordovician sandstone unit (Jordan sandstone).

The uppermost bedrock unit in the site area is the Jordan aquifer, which is the lower Cambrian-Ordovician sandstone interbedded with dolostone. The thickness of the Jordan aquifer varies from 50 to more than 120 feet thick in most areas of Allamakee County. Underlying the Cambrian-Ordovician sandstone are the Cambrian confining beds comprised of dolostone, siltstone, and shale. The Cambrian confining beds overly the Dresbach Aquifer, comprised of shaly sandstone. A summary of the regional hydrogeologic stratigraphy is presented in **Appendix A**. A regional bedrock surface hydrogeologic map, hydrogeologic cross sections, and a contour map of the top of the Cambrian-Ordovician sandstone in northeastern Iowa are also included in **Appendix A**. The bedrock surface elevation is highly variable due to erosion.

The Mississippi River and associated alluvial aquifers are a major source of surface water and shallow groundwater in the area. The alluvial aquifer is up to 60 feet thick within the deeply incised valley where LAN is located, but is thin to absent on the surrounding bluffs and hilltops. The lower Cambrian-Ordovician sandstone unit (Jordan sandstone) is the shallowest regional bedrock aquifer. The October 1989 IDNR Water Atlas No. 8 states that the Jordan aquifer is commonly the source of municipal and industrial high-capacity wells in the region. A summary of the regional groundwater units is included in **Appendix A**.

A map showing the regional potentiometric surface in the Jordan sandstone is presented in **Appendix A**. This map shows the potentiometric surface near the site area as sloping to the east-northeast. The flow direction in the shallow unconsolidated aquifer at LAN is generally to the north-northwest (**Figure 3**). The flow in the Jordan sandstone immediately beneath the landfill and ponds is also likely to the north-northwest due to the influence of incoming groundwater from the bluffs flanking the valley with ultimate discharge to the Mississippi River.

2.2 SITE GEOLOGIC INFORMATION

Monitoring wells MW-301 through MW-306 were installed to intersect the surficial alluvium aquifer at the site. The unconsolidated material found at these well locations is generally sand and silt. The total boring depths were between 16 and 27 feet below ground surface (bgs) and bedrock was not encountered in these borings. Upgradient well MW-6 was previously installed for a state groundwater monitoring program, which is required as part of the solid waste permit for the CCR landfill. MW-6 was installed to a total depth of 93.5 feet bgs and intersects the water table, which is in the Jordan sandstone aquifer at this well location. Boring logs for MW-6 and MW-301 through MW-306 are included in **Appendix B**.

Shallow groundwater at the site generally flows to the north-northwest. The groundwater flow pattern based on water levels measured in April 2019 is shown on **Figure 3**. The groundwater elevation data for the CCR rule monitoring wells and the state program monitoring wells are provided in **Table 1**.

A geologic cross-section was prepared along a line through the CCR units and in alignment with the direction of groundwater flow. The cross-section location is provided on **Figure 2** and the geologic cross-section is provided on **Figure 4**. The cross-section line runs through the landfill, the Upper Ash Pond, and the coal pile, and also shows upgradient monitoring well MW-6, several borings or monitoring wells near the landfill and pond, and downgradient assessment monitoring well MW-306. Sandstone bedrock, unconsolidated geologic material, and estimated water table levels are identified on the cross section.

2.3 CCR RULE MONITORING SYSTEM

The original groundwater monitoring system established in accordance with the CCR Rule consists of one upgradient (background) monitoring well and three downgradient (compliance) monitoring wells. The background monitoring well is MW-6. The three initial downgradient monitoring wells are MW-301, MW-302, and MW-303, which were installed in November 2015. Three additional downgradient monitoring wells, MW-304, MW-305, and MW-306, were installed in May 2019 in accordance with the requirements of 40 CFR 257.95(g)(1). The CCR Rule wells were installed in the upper portion of the uppermost aquifer at LAN. Well depths range from approximately 14.5 to 91 feet bgs.

3.0 NATURE AND EXTENT OF GROUNDWATER IMPACTS

3.1 POTENTIAL SOURCES

The potential sources of groundwater impacts are currently under evaluation. Based on a review of existing site documents, potential sources of groundwater impacts from the monitored CCR units include the following:

CCR Unit	Potential Sources	Description	Quantity
Landfill	CCR	Bottom ash, economizer ash, fly ash, dry flue gas desulfurization (FGD) byproduct, and pyrites	485,000 CY (permitted maximum volume)
Upper Ash Pond	CCR	Bottom ash, economizer ash, and fly ash	357,000 CY
	Low volume waste waters from plant	Includes Unit 4 hydroveyor water, air heater washes, RO reject water, demineralizer regeneration wastewater, and Unit 4 boiler sump discharge	4.83 million gallons per day (MGD)
	Storm water	Annual precipitation, runoff from landfill and surrounding areas	99 AC-FT (Watershed of 87 acres)

Note: Storm water volume is calculated based on the watershed area for the pond (17 acres) and landfill and surrounding areas (70 acres), and the annual average precipitation for Lansing, Iowa, of 35 inches per year. Runoff from the landfill and surrounding areas (8.5 inches) is estimated using **Figure 1**. Average Annual Runoff, 1951-1980 from USGS publication Average Annual Runoff in the United States, 1951-1980 (Gebert 1987).

3.2 GROUNDWATER ASSESSMENT

3.2.1 Groundwater Depth and Flow Direction

Depth to groundwater as measured in the site monitoring wells varies from 8 to 75 feet bgs due to topographic variations across the facility. Groundwater flow at the site is generally to the north-northwest. The flow in the Jordan sandstone immediately beneath the landfill and ponds is also likely to the north-northwest due to the influence of incoming groundwater from the bluffs flanking the valley with ultimate discharge to the Mississippi River.

3.2.2 Groundwater Protection Standard Exceedances Identified

The ACM process was triggered by the detection of arsenic at statistically significant levels exceeding the GPS in samples from MW-302.

This statistical evaluation of the assessment monitoring results was based on the first three sampling events for the Appendix IV assessment monitoring parameters, including sampling events in April, August, and October 2018. The complete results for these sampling events are summarized in **Table 3.**

GPS exceedances were identified from the April 2019 sampling events for the following well and parameter:

Assessment Monitoring Appendix IV Parameters	Location of GPS Exceedance(s)	Historic Range of Detections at Wells Exceeding GPS	Groundwater Protection Standard (GPS)
Arsenic (µg/L)	MW-302	30.8 to 50.4	10

Note: Historic range includes results from assessment monitoring from April 2018 through April 2019.

3.2.3 Expanding the Groundwater Monitoring Network

Monitoring wells MW-304, MW-305, and MW-306 were installed in May 2019 downgradient of the CCR units to expand the groundwater monitoring network at LAN beyond the edge of the CCR unit boundaries and to fulfill the requirements of 40 CFR 257.95(g)(1), which requires additional characterization to support a complete and accurate assessment of corrective measures. Groundwater samples were collected following installation of the three new monitoring wells.

The initial sampling results from MW-304, MW-305, and MW-306, shown in **Table 3**, indicate that arsenic did not exceed the GPS in the samples from these wells. The extent of GPS exceedances may be limited to the immediate vicinity of the landfill and impoundment if future sampling results confirm there are no GPS exceedances in wells MW-304, MW-305, and MW-306.

3.2.4 State Monitoring Program Arsenic Results

Arsenic is included in the parameter list for the state monitoring program for the CCR landfill. Monitoring results from the state program, provided in **Table 4**, provide additional information on the nature and extent of arsenic concentrations at the site.

Arsenic GPS exceedances in the state program results are limited to two monitoring well locations (MW-11/11R and MW12). The arsenic levels at these two locations adjacent to the landfill are lower than the concentrations in downgradient CCR well MW-302. Per IDNR requirements, metals sampling was changed from filtered to unfiltered in 2016. Arsenic concentrations appear to be stable since that time. Metals like arsenic tend to adsorb to suspended solids that can be introduced into the sample during collection, which are not removed from unfiltered samples. Arsenic results from other wells in the vicinity of or downgradient from these two wells (including MW-12P, MW-14, TW-17, TW-18, TW-19, and MW-20) were below the GPS defining the horizontal and vertical extent of arsenic impacts in this area.

Groundwater assessments were performed in accordance with the state monitoring program during 2013 and 2014 to evaluate the elevated arsenic concentrations. The assessment reports concluded that elevated arsenic concentrations were due in part to localized geochemical conditions in the immediate vicinity of the landfill. IDNR required no further investigation of the arsenic concentrations.

3.3 CONCEPTUAL SITE MODEL

The following conceptual site model describes the arsenic levels above the GPS, discusses potential exposure pathways affecting human health and the environment, and presents a cursory review of the potential impacts. The conceptual site model for LAN has been prepared in general conformance with the Standard Guide for Developing Conceptual Site Models for Contaminated Sites (ASTM E1689-95). This conceptual site model is the basis for assessing the efficacy of likely corrective measures to address the source, release mechanisms, and exposure routes.

3.3.1 Nature of Constituent above GPS

To describe the nature of the constituents in groundwater at LAN, we have reviewed a number of sources for information regarding arsenic in groundwater, and how that groundwater may impact potential receptors through the exposure pathways discussed in **Section 3.3.2**.

Arsenic

Arsenic (As) is a metalloid that is naturally present in rocks, soil, and water. Arsenic is naturally present in coal and is present in CCR after the coal is combusted.

Arsenic has historically had numerous industrial and commercial uses, including as copper chromated arsenate (CCA), a wood preservative. Arsenic is also used in pesticides, semiconductors, and light-emitting diodes; and it is added to other metals to form alloys for industrial use, including in lead-acid batteries.

Primary food sources of arsenic include seafood; however, much of the arsenic in food sources is in the form of relatively nontoxic organic arsenic compounds. In some areas, drinking water also contains arsenic. Human intake varies depending on location and diet.

A summary of the properties, occurrences, and potential health effects of arsenic is provided in the Public Health Statement and ToxFAQs factsheet prepared by the Agency for Toxic Substances and Disease Registry (ATSDR), which is an agency of the U.S. Department of Health and Human Services. Copies of the ATSDR Public Health Statement and ToxFAQs factsheet are provided in **Appendix C.**

Arsenic Exposure

A summary of the potential exposures and health effects of arsenic is provided in the Public Health Statement and ToxFAQs factsheet prepared by ATSDR. Copies of the ATSDR Public Health Statement and ToxFAQs factsheet are provided in **Appendix C.**

For comparison, the concentrations of arsenic detected to date in groundwater samples from the CCR Rule monitoring system wells range from below the detection limit to 50.4 ug/L (Note: 1 ug/L in water is equivalent to 1 ppb). The GPS for arsenic is 10 ug/L. The GPS for arsenic is equivalent to the USEPA maximum contaminant level (MCL) for arsenic.

3.3.2 Potential Receptors and Pathways

As described in **Section 3.3**, ASTM E1689-95 provides a framework for identifying potential receptors (people or other organisms potentially affected by the groundwater impacts at LAN) and pathways (the ways groundwater impacts might reach receptors). In accordance with ASTM E1689-95, we have considered both potential human and ecological exposures to groundwater impacted by arsenic, as identified in **Section 3.2.2**.

Human Health

In general, human health exposure routes to contaminants in the environment include ingestion, inhalation, and dermal contact with the following environmental media:

- Groundwater
- Surface Water and Sediments
- Air
- Soil
- Biota/Food

If people might be exposed to the impacts described in **Section 3.0** via one of the environmental media listed above, a potential exposure route exists and is evaluated further. For the groundwater impacts at LAN, the following potential exposure pathways have been identified with respect to human health:

- **Groundwater – Ingestion and Dermal Contact.** The potential for ingestion of, or dermal contact with, impacted groundwater from LAN exists if water supply wells are present in the area of impacted groundwater and are used as a potable water supply. Based on a review of the IDNR GeoSam well database. and information provided by LAN:
  - No off-site water supply wells have been identified downgradient of the CCR Units.
  - A private supply well located across County Highway X52 from the landfill was sampled by Allamakee County in 2014 at the homeowner's request, and the sample was analyzed for arsenic. Arsenic was not detected in the sample. The Allamakee County Sanitarian stated that the well was 400 feet deep and under artesian pressure.
  - Two on-site water supply wells, Well #2 and Well #4, are currently used as sources of potable water.
    - Well #2 is 235 feet deep and is cased to 78 feet. Well #4 is 240 feet deep and is cased to 143 feet. Both wells are open to the sandstone aquifer.
    - The water supply operation permit for these wells (IDNR public water supply ID 0345181) requires sampling for inorganic constituents every 9 years. Arsenic was not detected in the most recent samples, collected on April 21, 2014.

- **Surface Water and Sediments – Ingestion and Dermal Contact.** The potential for ingestion of or dermal contact with impacted surface water and sediments exists if impacted groundwater from the LAN facility has interacted with adjacent surface water and sediments, to the extent that arsenic is present in these media at concentrations that represents a risk to human health. There is no current evidence indicating that impacted groundwater has interacted with adjacent surface water and created an exposure pathway, but the exposure pathway assessment is incomplete and ongoing.

- **Biota/Food – Ingestion.** The potential for ingestion of impacted food exists if impacted groundwater from the facility has interacted with elements of the human food chain. Based on discussions with facility staff, no hunting or farming occurs within the current area of known groundwater impacts. Elements of the food chain may also be exposed indirectly through groundwater-to-surface water interactions, which are subject to additional assessment.

Based on the lack of groundwater exposure, only the surface water, sediment, and biota/food exposure pathways were retained for further consideration. However, the implementation of potential corrective measures may introduce secondary exposure pathways that are discussed in **Section 6.0** and will be evaluated further as a corrective measure is selected for LAN.

Ecological Health

In addition to human exposures to impacted groundwater, potential ecological exposures are also considered. If ecological receptors might be exposed to impacted groundwater, the potential exposure routes are evaluated further. Ecological receptors include living organisms, other than humans, the habitat supporting those organisms, or natural resources potentially adversely affected by CCR impacts. This includes:

- Transfer from an environmental media to animal and plant life. This can occur by bioaccumulation, bioconcentration, and biomagnification:
  - Bioaccumulation is the general term describing a process by which chemicals are taken up by a plant or animal either directly from exposure to impacted media (soil, sediment, water) or by eating food containing the chemical.
  - Bioconcentration is a process in which chemicals are absorbed by an animal or plant to levels higher than the surrounding environment.
  - Biomagnification is a process in which chemical levels in plants or animals increase from transfer through the food web (e.g., predators have greater concentrations of a particular chemical than their prey).
- Benthic invertebrates within adjacent waters.

Based on the information presented in **Section 3.2.3** and the location of the Mississippi River downgradient from the current area of known groundwater impacts, both of these ecological exposure routes need to be evaluated further. Both potential ecological exposure pathways require groundwater-to-surface water interactions for the exposure pathway to be complete. The groundwater-to-surface water interactions at LAN are the subject of ongoing assessment.

The surface water/sediment, biota/food, and ecological exposure assessment is presently incomplete as the extent of groundwater impacts is still being evaluated. If groundwater impacts extend to the river, then these exposure pathways will be evaluated further. Evaluation of constituent concentrations in sediment and surface water may be estimated through calculations and/or additional sampling.

4.0 POTENTIAL CORRECTIVE MEASURES

In this section, we identify potential corrective measures to meet the ACM goals identified in 40 CFR 257.96(a), which are to:

- Prevent further releases
- Remediate releases
- Restore affected areas to original conditions

The development of corrective measure alternatives is described further in the following sections. Corrective measure alternatives developed to address the groundwater impacts at LAN are described in **Section 5.0**. The alternatives selected are qualitatively evaluated in **Section 6.0**.

As required under 40 CFR 257.96(c), the following sections provide an analysis of the effectiveness of potential corrective measures. This evaluation includes the requirements and objectives identified in 40 CFR 257.97, which includes:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to residual contamination;

- The time required to begin and complete the remedy; and

- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy.

4.1 IDENTIFICATION OF CORRECTIVE MEASURES

As described in the USEPA Solid Waste Disposal Facility Criteria Technical Manual (USEPA 1998), corrective measures generally include up to three components, including:

- Source Control
- Containment
- Restoration

Within each component, there are alternative measures that may be used to accomplish the component objectives. The measures from one or more components are then combined to form corrective measure alternatives (discussed in **Section 5.0**) intended to address the observed groundwater impacts. Potential corrective measures were identified based on site information available during development of the ACM for the purpose of meeting the goals described in **Section 4.0**.

Each component and associated corrective measures are further identified in subsequent paragraphs. The corrective measures are evaluated for feasibility and combined to create the corrective action alternatives identified in this section, and further evaluated in **Section 5.0**. We continue to evaluate site conditions and may identify additional corrective measures based on new information regarding the nature and extent of the impacts.

4.1.1 Source Control

The source control component of a corrective measure is intended to identify and locate the source of impacts and provide a mechanism to prevent further releases from the source. For this site, the sources to be controlled are the CCR materials in the landfill and impoundment, along with plant process water. Each of the source control measures below require closure of the landfill and impoundment, and for waste water to be re-directed from the CCR units to eliminate the flows that may mobilize constituents from the CCR and transport them to groundwater. We have identified the following potential source control measures:

- **Cap in place.** Cap the CCR in uncovered areas of the existing landfill and the CCR surface impoundment in place to reduce the infiltration of rain water into the impoundments, and prevent transport of CCR constituents from unsaturated CCR materials into the groundwater and reduce the potential for CCR to interface with groundwater. The landfill closure will be conducted according to the disposal permit issued by the IDNR.

- **Consolidate and cap.** Consolidate CCR from the surface impoundment into a smaller area adjacent to the landfill to reduce the potential source footprint. Install a cap over uncovered areas of the existing landfill, and the consolidated CCR from the surface impoundment to prevent transport of CCR constituents from unsaturated CCR materials into the groundwater and minimize the potential for CCR to interface with groundwater. The landfill closure will be conducted according to the disposal permit issued by the IDNR.

- **Excavate CCR and create on-site disposal area.** Excavate CCR from the landfill and surface impoundment and place CCR in a new lined disposal area on site to prevent further releases from the CCR and isolate the CCR from potential groundwater interactions. Cap the new disposal area with final cover to prevent the transport of CCR constituents from unsaturated CCR.

- **Excavate impounded CCR and dispose at a licensed off-site disposal area.** Remove all CCR from the site and haul to a licensed landfill to prevent further releases from the CCR areas.

Water movement through the CCR materials is the mechanism for CCR impacts to groundwater. Surface water can move vertically through the CCR materials via infiltration of rainwater and surface water runoff. Groundwater can move horizontally through the CCR material in areas where CCR material is at an elevation that is below the water table. The source control measures have been considered to prevent “vertical” migration of water through the CCR via cap and cover systems.

Based on the available information for this site, all the source control measures have potential to prevent further releases, thus are retained for incorporation into alternatives for further evaluation. However, IPL continues to investigate the source of groundwater impacts and, with new information, source control measures may be added or removed from consideration.

4.1.2 Containment

The objective of containment is to limit the spread of the groundwater impacts beyond the source. The need for containment depends on the nature and extent of impacts, exposure pathways, and risks to receptors. Containment may also be implemented in combination with restoration as described in **Section 4.1.3**. Containment may be a recommended element of a corrective measure if needed to:

- Prevent off-site migration of groundwater impacts
- Cease completion of an exposure pathway (e.g., water supply well).

Containment may also be used in lieu of active restoration if an active approach is needed but treatment is not warranted by the aquifer characteristics including:

- Water in the affected aquifer is naturally unsuited for human consumption
- Contaminants present in low concentration with low mobility
- Low potential for exposure to contaminants and low risk associated with exposure
- Low transmissivity and low future user demand

The following measures have potential to limit the spread of the existing groundwater impacts:

- **Gradient Control with Pumping.** Gradient control includes a measure to alter the groundwater velocity and direction to slow or isolate impacts. This can be accomplished with pumping wells and/or a trench/sump collection system. If groundwater pumping is considered for capturing an impacted groundwater plume, the impacted groundwater must be managed in conformance with all applicable Federal and State requirements.

- **Gradient Control with Phytotechnology.** Gradient control with phytotechnology relies on the ability of vegetation to evapotranspire sources of surface water and groundwater. Water interception capacity by the aboveground canopy and subsequent evapotranspiration through the root system can limit vertical migration of water from the surface downward. The horizontal migration of groundwater can be controlled or contained using deep-rooted species, such as prairie plants and trees, to intercept, take up, and transpire the water. Trees classified as phreatophytes are deep-rooted, high-transpiring, water-loving organisms that send their roots into regions of high moisture and can survive in conditions of temporary saturation.

- **Chemical Stabilization.** Stabilization refers to processes that involve chemical reactions that reduce the leachability of arsenic. Stabilization chemically immobilizes impacts or reduces their solubility through a chemical reaction. The desired results of stabilization methods include converting metals into a less soluble, mobile, or toxic form.

Based on the currently available information for this site, active containment (other than source control) is not currently required for this site and is not included in the proposed alternatives. IPL will continue to investigate the nature and extent of the groundwater impacts at LAN and may add containment measures as warranted by data.

4.1.3 Restoration

Restoration is the process through which groundwater quality is restored to meet GPSs. This can be accomplished by way of Monitored Natural Attention (MNA) or intensively addressed by groundwater treatment with or without extraction.

MNA can be a viable remedy or component of a remedial alternative for groundwater impacted with metals. MNA requires ongoing involvement and potentially intense characterization of the geochemical environment to understand the attenuation processes involved, and to justify reliance on them and regular, long-term monitoring to ensure the attenuation processes are meeting remedial goals.

MNA is not a “do-nothing” alternative; rather it is an effective knowledge-based remedy where a thorough engineering analysis provides the basis for understanding, monitoring, predicting, and documenting natural processes. To properly employ this remedy, there needs to be a strong scientific basis supported by appropriate research and site-specific monitoring implemented in accordance with quality controls. The compelling evidence needed to support proper evaluation of the remedy requires that the processes that lower metal concentrations in groundwater be well understood.

If active treatment is implemented, water may be treated in situ, on site, or off site. The need for active treatment depends on the nature and extent of impacts, potential exposure pathways, and current and anticipated future risks to receptors. If there are no receptors or if the risks are acceptably low, then MNA is an appropriate option. If existing or future risks require a more rapid restoration of groundwater quality, then active restoration may be needed.

Treated groundwater may be re-injected, sent to a local publicly owned treatment works (POTW), or discharged to a local body of surface water, depending on local, State, and Federal requirements. Typical on-site treatment practices for metals include coagulation and precipitation, ion exchange, or reverse osmosis. Off-site wastewater treatment may include sending the impacted groundwater that is extracted to a local POTW or to a facility designed to treat the contaminants of concern.

The removal rate of groundwater constituents such as arsenic will depend on the rate of groundwater extraction, the cation exchange capacity of the soil, and partition coefficients of the constituents sorbed to the soil. As the concentration of metals in groundwater is reduced, the rate at which constituents become partitioned from the soil to the aqueous phase may also be reduced. The amount of flushing of the aquifer material required to remove the metals and reduce their concentration in groundwater below the GPS will generally determine the time frame required for restoration. This time frame is site-specific.

In-situ methods may be appropriate, particularly where pump and treat technologies may present adverse effects. In-situ methods may include biological restoration requiring pH control, addition of specific micro-organisms, and/or addition of nutrients and substrate to augment and encourage degradation by indigenous microbial populations. Bioremediation requires laboratory treatability studies and pilot field studies to determine the feasibility and the reliability of full-scale treatment.

At this time, based on current information, Monitored Natural Attenuation is retained for incorporation into alternatives for further evaluation. Other restoration measures may be retained or additional ones added from the results of our continued investigation of the nature and extent of groundwater impacts.

5.0 CORRECTIVE MEASURE ALTERNATIVES

We have preliminarily identified the following corrective measure alternatives for the groundwater impacts at LAN:

- Alternative 1 – No Action
- Alternative 2 – Close and Cap in Place with MNA
- Alternative 3 – Consolidate and Cap with MNA
- Alternative 4 – Excavate CCR and Dispose On Site with MNA

- Alternative 5 – Excavate CCR and Dispose Off Site with MNA

These alternatives were developed by selecting components from the reasonable and appropriate corrective measures components discussed above. Capping areas of the landfill that are currently open is included with all potential source control measures. With the exception of the No Action alternative, each of the corrective measure alternatives meet the requirements in 40 CFR 257.97(b)(1) through (5) based on the information available at the current time. We may identify additional alternatives based on the continued evaluation of site conditions.

5.1 ALTERNATIVE 1 – NO ACTION

IPL is committed to implementing corrective measures as required under the Rule, and the No-Action alternative is only included as a baseline condition and a point of comparison for the other alternatives. The consideration of this alternative assumes the monitoring of groundwater continues under this action.

5.2 ALTERNATIVE 2 – CLOSE AND CAP IN PLACE WITH MNA

Alternative 2 includes closing the landfill in accordance with the CCR Rule and existing State of Iowa sanitary disposal project permit and closing the CCR impoundment with no further discharge. CCR materials will be capped and vegetation established on the final cover in accordance with the requirements for closure in place in 40 CFR 257.102(d). This measure is consistent with landfill cover systems to prevent infiltration of surface water into the CCR as described in **Section 4.1.1**. The capped areas will be subject to enhanced groundwater monitoring via MNA.

This alternative eliminates CCR sluicing/plant process water discharges and, with the installation of a cap, will reduce infiltration through the CCR. This is expected to address the major contributor to the observed GPS exceedances, which is exposure of CCR material to precipitation/surface water infiltration. Further leaching of metals and migration within groundwater will be reduced and may be eliminated over time. MNA is included with this alternative to monitor changes in groundwater impacts and the effectiveness of degradation mechanisms on groundwater concentrations over time.

5.3 ALTERNATIVE 3 – CONSOLIDATE AND CAP WITH MNA

Alternative 3 includes closing the landfill in accordance with the CCR Rule and existing State of Iowa sanitary disposal project permit, and closing the CCR impoundment (no further discharge). The impounded CCR will be closed by relocating a portion of the impounded CCR and consolidating it into a smaller footprint within the CCR surface impoundment and/or landfill. The impounded CCR materials and currently open areas of the landfill will be capped in accordance with the requirements for closure in place in 40 CFR 257.102(d). This measure is consistent with landfill cover systems to prevent infiltration of surface water into the CCR as described in **Section 4.1.1**. The capped areas will be subject to enhanced groundwater monitoring via MNA.

This alternative eliminates CCR sluicing/plant process water discharges and, with the consolidation of the CCR footprint and the installation of a cap, will reduce infiltration through the CCR. This is expected to address the major contributor to the observed GPS exceedances, which is exposure of CCR material to precipitation/surface water infiltration. Further leaching of metals and migration within groundwater will be reduced and may be eliminated over time. MNA is included with this alternative to monitor changes in groundwater impacts and the effectiveness of degradation mechanisms on groundwater concentrations over time.

5.4 ALTERNATIVE 4 – EXCAVATE CCR AND DISPOSE ON SITE WITH MNA

Alternative 4 includes closing the landfill and impoundment (no further disposal or discharge), excavation of CCR from the landfill and surface impoundment, and creation of a new on-site disposal area with a liner and cap system. This alternative will serve to entomb the CCR at the site and allow for the collection and management of liquids generated from the new disposal area. Further releases from the CCR will be prevented by the use of engineering controls constructed/installed to meet the design criteria for new CCR landfills required under 40 CFR 257.70. The capped areas will be subject to enhanced groundwater monitoring via MNA.

This alternative eliminates CCR sluicing/plant process water discharges and, with the consolidation of the CCR footprint and the installation of a new on-site disposal area liner and cap, will reduce infiltration through the CCR. This is expected to address the major contributor to the observed GPS exceedances, which is exposure of CCR material to precipitation/surface water infiltration. MNA is included with this alternative to monitor changes in groundwater impacts and the effectiveness of degradation mechanisms on groundwater concentrations over time.

If the ongoing assessment of potential sources discussed in **Section 3.1** eliminates either the landfill or surface impoundment as the source of the arsenic impacts, Alternative 4 may be refined to focus on the remaining source. For example, if the landfill can be eliminated as a source of arsenic in groundwater through further evaluation, the landfill may be closed according to the disposal permit issued by the IDNR as described under Alternatives 2 and 3.

5.5 ALTERNATIVE 5 – EXCAVATE CCR AND DISPOSE OFF SITE WITH MNA

Alternative 5 includes closing the landfill and impoundment (no further disposal or discharge), excavation of all CCR, and transport to an approved off-site landfill. Further on site releases from the CCR sources will be prevented by relocating the source material to another site, which eliminates the potential for ongoing leaching of constituents in impounded CCR into groundwater at LAN.

This alternative eliminates CCR sluicing/plant process water discharges and, with the removal of CCR from the site, will reduce infiltration through the CCR. This is expected to address the major contributor to the observed GPS exceedances, which is exposure of CCR material to precipitation/surface water infiltration. MNA is included with this alternative to monitor changes in groundwater impacts and the effectiveness of degradation mechanisms on groundwater concentrations over time.

If the ongoing assessment of potential sources discussed in **Section 3.1** eliminates either the landfill or surface impoundment as the source of the arsenic impacts, Alternative 5 may be refined to focus on the remaining source. For example, if the landfill can be eliminated as a source of arsenic in groundwater through further evaluation, the landfill may be closed according to the disposal permit issued by the IDNR as described under Alternatives 2 and 3.

6.0 EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

As required by 40 CFR 257.96(c), the following sections provide an evaluation of the effectiveness of corrective measure alternatives in meeting the requirements and objectives outlines in 40 CFR

257.97. The evaluation addresses the requirements and objectives identified in 40 CFR 257.96(c)(1) through (3), which include:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to residual contamination;
- The time required to begin and complete the remedy; and
- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy.

In addition to the discussion of the items listed above, **Table 5** provides a summary of the initial evaluation of the alternatives including each of the criteria listed in 40 CFR 257.97.

6.1 ALTERNATIVE 1 – NO ACTION

As described in **Section 5.1**, the No Action alternative is only included as a baseline condition and a point of comparison for the other alternatives. This alternative does not satisfy all five criteria in 40 CFR 257.97(b)(1) through (5), so it is not an acceptable corrective measure under the CCR Rule. For comparison only, Alternative 1 is evaluated with regard to the criteria in 40 FR 257.96(c) below:

- **Performance, Reliability, Implementation, and Impacts.**
  - Performance – The ability to attain the GPS for arsenic without any additional action is unlikely.
  - Reliability – Alternative 1 does not provide any reduction in existing risk.
  - Implementation – Nothing is required to implement Alternative 1.
  - Impacts – No additional safety or cross-media impacts are expected with Alternative 1. This alternative does not control current suspected routes of exposure to residual contamination.

- **Timing.** No time is required to begin. However, the time required to attain the GPS for arsenic under Alternative 1 is unknown.

- **Institutional Requirements.** No institutional requirements beyond maintaining current regulatory approvals exist for Alternative 1.

6.2 ALTERNATIVE 2 – CLOSE AND CAP IN PLACE WITH MNA

As described in **Section 5.2**, Alternative 2 includes closing the landfill in accordance with the CCR Rule and existing State of Iowa sanitary disposal project permit and closing the CCR impoundment with no further discharge. CCR materials will be capped and vegetation established on the final cover in accordance with the requirements for closure in place in 40 CFR 257.102(d).

- **Performance, Reliability, Implementation, and Impacts.**
  - Performance – Ceasing wastewater discharges and closing the landfill and impoundments by capping is expected to address infiltration, which is a key contributor to groundwater impacts. MNA monitoring will identify, if active, the natural attenuation processes that reduce mass, toxicity, mobility, volume, or concentrations of the constituents of concern in groundwater. Alternative 2 is capable of and expected to attain the GPS for arsenic.

- Reliability – The expected reliability of capping is good. Capping is a common practice and standard remedial method for closure in place in remediation and solid waste management. There is significant industry experience with the design and construction of this method.

- Implementation – The construction of Alternative 2 is moderately complex due to the thixotropic characteristics of the impounded CCR. Dewatering will be required to the extent a suitable subgrade is established in the impoundment for cap construction, which can likely be achieved through standard dewatering methods. Additional subgrade stabilization may be required to support the cap. The cap construction may put a high demand on the local supply of suitable cap materials. The local availability of cap materials will be evaluated further during remedy selection. The equipment and personnel required to implement Alternative 2 are not specialized and are generally readily available with the exception of potential stabilization of impounded CCR with thixotropic characteristics.

- Impacts – Safety impacts associated with the implementation of Alternative 2 are not significantly different than other heavy civil construction projects. Cross-media impacts are expected to be limited due to the small volume of CCR expected to be relocated on site, the short duration of cap construction, the effectiveness of standard engineering controls during construction (e.g., dust control), and the lack of off-site transportation of CCR. The potential for exposure to residual contamination is low since CCR will be capped.

- **Timing.** Closure of the landfill and impoundment can be completed within 1 to 2 years of remedy selection. At LAN, the closure of the landfill and impoundment is expected to be completed by the end of 2021. The time required to attain the GPS for arsenic will be evaluated further during the remedy selection process, but is expected to take between 2 and 10 years after closure construction is complete. Alternative 2 can provide full protection within the 30-year post-closure monitoring period.

- **Institutional Requirements.** The following permits and approvals are expected to be required to implement Alternative 2:
  - IDNR Closure Permit
  - State and local erosion control/construction stormwater management permits

6.3 ALTERNATIVE 3 – CONSOLIDATE ON-SITE AND CAP WITH MNA

As described in **Section 5.3**, Alternative 3 includes closing the landfill, closing the impoundment with no further discharge, relocating and consolidating impounded CCR into a smaller footprint within the CCR surface impoundment and/or landfill, covering the CCR materials with a cap, and establishing vegetation in accordance with the existing State of Iowa sanitary disposal project permit and requirements for closure in place in 40 CFR 257.102(d).

- **Performance, Reliability, Implementation, and Impacts.**
  - Performance – Ceasing wastewater discharges and closing the landfill and impoundment by capping is expected to address infiltration, which is a key contributor to groundwater impacts. The consolidation of impounded CCR into a smaller footprint may enhance the performance of the cap by further reducing the area exposed to limited post-construction infiltration through the cap. MNA monitoring will identify, if active, the natural attenuation processes that reduce mass,

toxicity, mobility, volume, or concentrations of the constituents of concern in groundwater. Alternative 3 is capable of and expected to attain the GPS for arsenic.

  - Reliability – The expected reliability of capping is good. Capping is a common practice and standard remedial method for closure in place in remediation and solid waste management. There is significant industry experience with the design and construction of this method. A consolidated cap footprint may enhance reliability by reducing the scale of post-closure maintenance.

  - Implementation – The construction of Alternative 3 is moderately complex due to the thixotropic characteristics of the impounded CCR. Dewatering will be required to the extent required to excavate and relocate CCR within the CCR impoundments and provide a suitable subgrade for cap construction. Additional subgrade stabilization may be required to support the cap. Conditioning (e.g., drying) of relocated CCR is expected during on-site re-disposal. Alternative 3 can likely be achieved through standard dewatering and conditioning methods. Although the cap footprint will be minimized, cap construction may put a high demand on the local supply of suitable cap materials. The local availability of cap materials will be evaluated further during remedy selection. The equipment and personnel required to implement Alternative 3 are not specialized and are generally readily available with the exception of potential stabilization of impounded CCR with thixotropic characteristics.

  - Impacts – Safety impacts associated with the implementation of Alternative 3 are not significantly different than other heavy civil construction projects. The level of disturbance required to consolidate CCR before capping may represent some increase in safety risk due to site conditions and on-site construction traffic. Cross-media impacts are expected to be limited due to the small volume of CCR expected to be relocated on site, the short duration of cap construction, the effectiveness of standard engineering controls during construction (e.g., dust control), and the lack of off-site transportation of CCR. The potential for exposure to residual contamination is low since CCR will be capped and the footprint of the cap minimized.

- **Timing.** Closure of the landfill and impoundment can be completed within 1 to 2 years of remedy selection. At LAN, the closure of the landfill and impoundment is expected to be completed by the end of 2021. The time required to attain the GPS for arsenic will be evaluated further during the remedy selection process, but is expected to take between 2 and 10 years after closure construction is complete. The level of source disturbance during construction may increase the time required to reach GPS. The consolidation of CCR into a smaller cap area may decrease the time to reach GPS. Alternative 3 can provide full protection within the 30-year post-closure monitoring period.

- **Institutional Requirements.** The following permits and approvals are expected to be required to implement Alternative 3:
  - IDNR Closure Permit
  - State and local erosion control/construction stormwater management permits

6.4 ALTERNATIVE 4 – EXCAVATE AND DISPOSE ON SITE WITH MNA

As described in **Section 5.4**, Alternative 4 includes closing the landfill and impoundment, excavation of impounded CCR from the source area, and creation of a new on-site disposal that meets the design criteria for new CCR landfills required under 40 CFR 257.70.

- **Performance, Reliability, Implementation, and Impacts.**
  - Performance – Ceasing wastewater discharges and closing the landfill and impoundment by removing and re-disposing CCR in a new lined/capped disposal area in combination with capping open areas of the landfill is expected to address infiltration, which is a key contributor to groundwater impacts. The consolidation of CCR into a smaller footprint may enhance the performance of the cap by further reducing the area exposed to limited post-construction infiltration through the cap. The separation from groundwater and other location criteria for the new on-site disposal facility may enhance the performance of this alternative. MNA monitoring will identify, if active, the natural attenuation processes that reduce mass, toxicity, mobility, volume, or concentrations of the constituents of concern in groundwater. Alternative 4 is capable of and expected to attain the GPS for arsenic.

  - Reliability – The expected reliability of on-site re-disposal with a composite liner and cap is good. Disposal facilities that meet the requirements in 40 CFR 257.70 or other similar requirements have been used for solid waste disposal including municipal and industrial waste for numerous years. There is significant industry experience with the design and construction of similar disposal facilities. The composite liner and cover combined with a consolidated disposal footprint may enhance reliability by reducing infiltration and the scale of post-closure maintenance. At the same time, post-closure maintenance is likely more complex due to maintenance of a leachate collection system and geosynthetic repairs requiring specialized personnel, material, and equipment.

  - Implementation – The complexity of constructing the new liner and cap is moderate due to the composite design and the management of CCR with thixotropic characteristics. The limited area available at the facility for developing an on-site disposal facility makes this alternative logistically complex. Significant volumes of CCR will be excavated and stored on site while the disposal facility is constructed. Significant dewatering will be required to excavate and relocate CCR to a temporary storage area. Conditioning (e.g., drying) of relocated CCR is expected to facilitate temporary storage and on-site re-disposal. Alternative 4 can likely be achieved through standard dewatering and conditioning methods, but may be impacted by the space available for these activities and the thixotropic character of some CCR. Although the post-closure CCR footprint will be minimized, composite liner and cap construction may put a high demand on the local supply of suitable cap materials. The local availability of liner and cap materials will be evaluated further during remedy selection. The equipment and personnel required to implement Alternative 4 are not specialized and are generally readily available with the exception of the resources needed to install the geosynthetic portions of the composite liner and cover, which are not locally available.

  - Impacts – Safety impacts associated with the implementation of Alternative 4 are not significantly different than other heavy civil construction projects. However, the level of disturbance required to excavate, store, and re-dispose CCR on site and the traffic required to import composite liner and cap material are not typical and likely represent an increase in safety risk due to site conditions, on-site construction traffic, and incoming/outgoing off-site construction traffic. A risk of cross-media impacts is possible due to the large volume of CCR to be excavated, stored, and relocated on site. The potential for exposure to residual contamination is low since CCR will be capped and the footprint of the cap minimized.

- **Timing.** Closure of the landfill and impoundment can be completed within 1 to 2 years of remedy selection. At LAN, the closure of the landfill and impoundment is expected to be completed by the end of 2021. However, the time required to permit and develop the on-site disposal facility may extend this schedule. The time required to attain the GPS for arsenic will be evaluated further during the remedy selection process, but is expected to take between 2 and 10 years after closure construction is complete. The level of source disturbance during construction may increase the time required to reach GPS. The consolidation of CCR into a new on-site disposal facility with a composite liner and cap may decrease the time to reach GPS. Alternative 4 can provide full protection within the 30-year post-closure monitoring period.

- **Institutional Requirements.** The following permits and approvals are expected to be required to implement Alternative 4:
  - IDNR Closure Permit
  - IDNR Disposal Facility (Landfill) Permit
  - State and local erosion control/construction stormwater management permits

6.5 ALTERNATIVE 5 – EXCAVATE AND DISPOSE OFF SITE WITH MNA

As described in **Section 5.5**, Alternative 5 includes closing the landfill and impoundment, excavation of CCR from the source area, and transporting the impounded CCR off site for disposal.

- **Performance, Reliability, Implementation, and Impacts.**
  - Performance – Ceasing wastewater discharges and closing the landfill and impoundment by removing and re-disposing CCR off site will eliminate the source material exposed to infiltration, which is a key contributor to groundwater impacts. The off-site disposal of CCR prevents further releases at LAN, but introduces the possibility of releases at the receiving facility. MNA monitoring will identify, if active, the natural attenuation processes that reduce mass, toxicity, mobility, volume, or concentrations of the constituents of concern in groundwater. Alternative 5 is capable of and expected to attain the GPS for arsenic.

  - Reliability – The expected reliability of excavation and off-site disposal of impounded CCR is good. Off-site disposal facilities are required to meet the requirements in 40 CFR 257.70 or other similar requirements, which have been used for solid waste disposal including municipal and industrial waste for numerous years. There is significant industry experience with the design and construction of these disposal facilities.

  - Implementation –The complexity of excavating CCR for off-site disposal is moderate due to the thixotropic characteristics of some of the CCR. The scale of CCR excavation (expected to exceed 840K cy), off-site transportation, and the permitting/development of off-site disposal facility airspace makes this alternative logistically complex. Significant dewatering will be required to excavate CCR. Conditioning (e.g., drying) of relocated CCR is expected to facilitate off site re-disposal. Alternative 5 can likely be achieved through standard dewatering and conditioning methods, but may be impacted by the space available for these activities and the thixotropic character of some CCR. Although the source area at LAN will be eliminated, the development of off-site disposal airspace will put a high demand on the receiving disposal facility, which may not have the current physical or logistical capacity to receive large volumes of CCR in a short period of time. The equipment and personnel required to implement on-site and off-site aspects of Alternative 5 are not specialized and are generally readily available with the exception of the resources needed to install the geosynthetic portions of the off-site composite liner and cover, which are not locally available.

- Impacts – Safety impacts associated with the implementation of Alternative 5 are not significantly different than other heavy civil construction projects. However, the level of disturbance required to excavate, transport, and re-dispose CCR and the traffic required to import composite liner and cap material at the receiving disposal facility are not typical and likely represent an increase in safety risk due to large volumes of incoming/outgoing off-site construction traffic at both sites. A risk of cross-media impacts is possible due to the large volume of CCR to be excavated and transported from the site. The potential for exposure to residual contamination on site is very low since CCR will be capped or removed; however, the off-site potential for exposure to CCR is increased due to the relocation of the source material.

- **Timing.** Closure of the landfill and impoundment can be completed within 1 to 2 years of remedy selection. At LAN, the closure of the landfill and impoundment is expected to be completed by the end of 2021. However, the time required to secure the off-site disposal airspace required to complete this alternative, including potential procurement, permitting, and construction, may extend this schedule significantly. The time required to attain the GPS for arsenic will be evaluated further during the remedy selection process, but is expected to take between 2 and 10 years after closure construction is complete. The level of source disturbance during construction may increase the time required to reach GPS. The removal of impounded CCR from LAN may decrease the time to reach GPS. Alternative 5 can provide full protection within the 30-year post-closure monitoring period.

- **Institutional Requirements.** The following permits and approvals are expected to be required to implement Alternative 5:
  - IDNR Closure Permit
  - Approval of off-site disposal facility owner or landfill permit for new off-site facility
  - State and local erosion control/construction stormwater management permits
  - Transportation agreements and permits (local roads and railroads)

  State solid waste comprehensive planning approvals may also be required.

7.0 SUMMARY OF ASSESSMENT

Each of the identified corrective measure alternatives exhibits both favorable and unfavorable outcomes with respect to the assessment factors that must be evaluated in accordance with 40 CFR 257.97(c). At the present time, limited impacts have been identified as described in **Section 3.0**. The nature and extent of those impacts are the subject of ongoing assessment and IPL continues to assess remedies to meet the requirements and objectives described in 40 CFR 257.97.

8.0 REFERENCES

W.A. Gebert, David J. Graczyk, and William R. Krug (1987), Average Annual Runoff in the United States, 1951-80, USGS Hydrologic Atlas 710.

U.S. EPA. (1998) "Solid Waste Disposal Facility Criteria Technical Manual (EPA530-R-93-017), Revised April 13, 1998." Solid Waste and Emergency Response.

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Tables

Table 1. Water Level Summary
Interstate Power & Light - Lansing, Iowa / SCS Engineers Project #25219070

Well Number	MW1 (4)	MW2	MW3 (3)	MW4	MW5	MW6	MW11	MW11R	MW12	MW12P	MW13	MW14	MW15	TW17	TW18	TW19	MW-16	MW-18	MW-19	MW-22	MW-22P	MW20	MW301	MW302	MW303	MW304	MW305	MW306
Top of Casing Elevation (feet amsl)	636.67	657.36	656.78	698.17	698.46	741.33	686.19	686.42	691.40	691.58	658.38	646.06	656.82	659.59	659.15	659.05	700.26	771.09	713.07	702.55	702.17	662.29	641.61	638.40	656.27	636.43	633.87	637.48
Screen Length (ft)	20	10	10	10	10	10	10	10	15	5	15	15	15	15	15	15	15	15	15	15	5	10	10	10	10	10	10	10
Top of Well Screen Elevation (ft)	626.50	620.50	600.00	650.00	630.00	656.00	657.96	646.94	657.70	627.98	649.48	636.96	640.82	649.39	650.55	648.95	662.18	669.23	651.69	665.27	625.14	648.79	624.01	626.90	637.97	630.43	627.87	621.48
December 10, 2015	NM	NM	NM	NM	NM	662.28	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NI	NI	NI	NI	NI	648.27	623.54	627.88	638.79	NI	NI	NI
April 28, 2016	627.50	620.26	620.83	651.55	652.79	662.80	AB	645.96	650.05	650.00	643.56	641.56	634.71	647.78	NM (5)	646.80	NI	NI	NI	NI	NI	648.61	623.45	627.24	638.15	NI	NI	NI
July 20, 2016	NM	NM	NM	NM	NM	663.21	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	649.86	624.76	628.60	639.33	NI	NI	NI
October 27, 2016	NM	NM	NM	NM	NM	670.82	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	651.32	624.97	628.35	638.65	NI	NI	NI
January 18, 2017	NM	NM	NM	NM	NM	666.28	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	650.18	624.09	627.32	638.10	NI	NI	NI
April 19-21, 2017	629.39	622.04	622.02	658.84	660.00	669.82	AB	648.24	653.68	653.40	647.61	643.01	634.50	649.87	649.03	649.01	660.45	669.88	649.12	668.38	667.45	651.71	624.70	628.98	639.20	NI	NI	NI
June 19-20, 2017	NM	NM	NM	NM	NM	670.65	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	650.22	624.89	627.75	638.77	NI	NI	NI
August 15, 2017	NM	NM	NM	NM	NM	670.61	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	649.58	624.09	627.28	637.86	NI	NI	NI
October 16, 2017	NM	NM	NM	NM	NM	669.58	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	650.81	625.70	628.75	638.79	NI	NI	NI
April 16-17, 2018	628.63	620.82	617.50	AB	AB	667.64	AB	647.07	652.25	651.90	646.36	642.61	634.07	648.77	648.49	648.23	NM	NM	NM	NM	NM	650.77	624.29	628.98	638.62	NI	NI	NI
April 26, 2018	628.67	620.86	617.63	AB	AB	667.96	AB	647.47	651.75	652.54	646.38	645.46	634.14	648.99	648.35	648.00	656.61	667.79	647.19	666.28	665.17	651.18	624.56	628.75	638.57	NI	NI	NI
June 4, 2018	NM	NM	NM	AB	AB	NM	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	624.62	628.27	638.81	NI	NI	NI
October 8, 2018	NM	NM	NM	AB	AB	664.71	AB	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	625.73	628.59	637.32	NI	NI	NI
April 15-16, 2019	630.95	632.16	628.40	AB	AB	672.78	AB	648.69	654.35	653.99	649.45	643.08	633.71	649.73	648.47	648.10	NM	672.64	651.55	671.05	669.22	652.57	629.19	629.99	638.22	NI	NI	NI
June 20, 2019	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	623.61	629.12	623.05
Bottom of Well Elevation (ft)	606.50	610.50	590.00	640.47	620.36	646.03	647.59	636.94	642.70	622.98	634.48	621.96	625.82	634.39	635.55	633.95	647.18	654.23	636.69	650.27	620.14	638.79	614.01	616.90	627.97	620.43	617.87	611.48

Notes: NM = not measured NI = not installed AB = abandoned

1. MW3 could not be located during this sampling event.
2. Repairs were completed at MW3 in July 2013. Elevations calculated for February, April, and July 2013 are estimates based on the old top of casing elevation (657.36 feet amsl). MW3 was re-surveyed on June 3, 2014.
3. MW1 was repaired in April 2013. Groundwater elevations measured before this date are calculated using the old top of casing elevation (637.60 ft amsl).
4. TW18 was damaged and could not be accessed for a water level measurement in April 2016. The well was repaired in July 2016.

Created by: MDB Date: 8/9/2013
Last revision by: JR Date: 6/28/2019
Checked by: ACW Date: 7/15/2019

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Table 2. CCR Rule Groundwater Samples Summary
Lansing Generating Station /SCS Engineers

Sample Dates	Downgradient Wells						Background Well
	MW-301	MW-302	MW-303	MW-304	MW-305	MW-306	MW-6
12/10/2015	B	B	B	--	--	--	B
4/29/2016	B	B	B	--	--	--	B
7/20/2016	B	B	B	--	--	--	B
10/26-27/2016	B	B	B	--	--	--	B
1/17-18/2017	B	B	B	--	--	--	B
4/19/2017	B	B	B	--	--	--	B
6/19-20/2017	B	B	B	--	--	--	B
8/15/2017	B	B	B	--	--	--	B
10/16/2017	D	D	D	--	--	--	D
4/16/2018	A	A	A	--	--	--	A
4/26/2018	--	--	--	--	--	--	A-R
6/4/2018	A-R	A-R	A-R	--	--	--	--
8/7/2018	A	A	A	--	--	--	A
10/8/2018	A	A	A	--	--	--	A
4/15/2019	A	A	A	--	--	--	A
6/20/2019	--	--	--	A	A	A	--

Abbreviations:
B = Background Sample Event
D = Detection Monitoring Program Event
-- = Not Applicable
A = Assessment Monitoring Sample Event
A-R = Assessment Monitoring Resample Event

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I:\25218201.00\Deliverables\LAN ACM\Tables\[2_GW_Samples_Summary_Table_LAN.xlsx]GW Summary

Table 3. Groundwater Analytical Results Summary - Assessment Monitoring
Lansing Generating Station / SCS Engineers Project #25218201.00

				Background Well					Compliance Wells																	
				MW-6					**MW-301**					**MW-302**					**MW-303**					**MW-304**	**MW-305**	**MW-306**
Parameter Name	**UPL Method**	**UPL**	**GPS**	10/16/2017	4/16/2018, 4/26/2018 ^	8/7/2018	10/8/2018	4/15/2019	10/16/2017	4/16/2018, 6/4/2018 ^	8/7/2018	10/8/2018	4/15/2019	10/16/2017	4/16/2018, 6/4/2018 ^	8/7/2018	10/8/2018	4/15/2019	10/16/2017	4/16/2018, 6/4/2018 ^	8/7/2018	10/8/2018	4/15/2019	6/20/2019	6/20/2019	6/20/2019
Appendix III																										
Boron, ug/L	P*	100		41.2 J	29.8 J	42.9 J	40.2 J	<110	436	198.0	279	357	250	708	489	648	694	690	592	144	675	474	150 J	<110	180 J	860
Calcium, mg/L	P	73.9		66.9	72.7	66.5	69.6	67	65.9	64.5	65.1	72.5	73	116	120	116	122	130	84.7	54.6	46.0	35.3	49	82	92	240
Chloride, mg/L	P	8.52		6.5	6.5	7.3	6.6	6.7	17.3	20.2	17.7	15.9	17	13.9	13.0	13.9	13.5	13	17.2	24.1	14.6	16.3	18	5.9	6.8	24
Fluoride, mg/L	P*	0.2		0.14 J	0.084 J	0.12 J	<0.19	0.63	0.24	0.24	0.23	0.27	0.9	0.28	0.24	0.23	0.27	0.79	0.25	0.32	0.47	0.72	1.0	<0.23	<0.23	<0.23
Field pH, Std. Units	P	7.9		7.03	7.34	7.18	7.06	7.59	7.66	8.4	8.08	8.16	8.47	7.1	7.26	6.92	6.93	7.66	7.20	8.00	7.66	7.91	7.95	7.01	7.19	6.87
Sulfate, mg/L	P	29.4		25.8	26.4	24.8	25.5	26	52.7	49.3	53.2	64.4	51	<0.5	<0.24	<0.24	<0.24	<1.8	69.9	43.5	52.5	29.1	35	20	24	280
Total Dissolved Solids, mg/L	P	386.7		318	343	351	319	340	289	300.0	326	320	350	507	543	562	518	450	379	296	262	181	280	350	440	1,200
Appendix IV		**UPL**	**GPS**																							
Antimony, ug/L	NP*	0.037	6	NA	<0.026	<0.15	<0.078	<0.53	NA	0.071 J	0.16 J	0.085 J	<0.53	NA	0.035 J	<0.15	<0.078	<0.53	NA	0.16 J	0.34 J	0.19 J	<0.53	<0.53	<0.53	<0.53
Arsenic, ug/L	P*	0.37	10	NA	0.23 J	0.26 J	0.24 J	<0.75	NA	3.9	4.4	5.4	5.4	NA	30.8	47.6	50.4	37	NA	1.2	2.3	2.3	1.4 J	<0.75	2.2	8.6
Barium, ug/L	P	48.5	2,000	NA	44.1	43.1	43	43	NA	163	156	155	160	NA	789	661	603	690	NA	173	194	121	160	54	170	280
Beryllium, ug/L	DQ	DQ	4	NA	<0.012	<0.12	<0.089	<0.27	NA	<0.012	<0.12	<0.089	<0.27	NA	<0.012	<0.12	<0.089	<0.27	NA	0.046 J	<0.12	<0.089	<0.27	<0.27	<0.27	<0.27
Cadmium, ug/L	DQ	DQ	5	NA	<0.018	NA	<0.033	<0.077	NA	<0.018	NA	<0.033	<0.077	NA	<0.018	NA	<0.033	<0.077	NA	<0.018	NA	<0.033	<0.077	<0.077	<0.077	<0.077
Chromium, ug/L	P	1.20	100	NA	0.66 J	0.97 J	0.73 J	<0.98	NA	1.1	<0.19	0.09 J	<0.98	NA	0.35 J	0.49 J	0.39 J	<0.98	NA	0.51 J	0.44 J	0.089 J	<0.98	1.6 J	<0.98	<0.98
Cobalt, ug/L	NP*	0.34	6	NA	<0.014	<0.15	<0.062	<0.091	NA	0.086 J	0.16 J	0.11 J	0.11 J	NA	1.1	1.1	1.1	1.5	NA	0.14 J	0.36 J	0.21 J	<0.091	1.1	0.52	1.0
Fluoride, mg/L	P*	0.2	4	NA	0.084 J	0.12 J	<0.19	0.63	NA	0.24	0.23	0.27	0.90	NA	0.24	0.23	0.27	0.79	NA	0.32	0.47	0.72	1.0	<0.23	<0.23	<0.23
Lead, ug/L	NP*	0.13	15	NA	<0.033	<0.12	<0.13	<0.27	NA	0.037 J	<0.12	<0.13	<0.27	NA	0.084 J	0.23 J	<0.13	<0.27	NA	<0.033	0.24 J	<0.13	<0.27	1.2	<0.27	0.52
Lithium, ug/L	NP*	3	40	NA	<4.6	NA	<4.6	<2.7	NA	<4.6	NA	9.1 J	8.7 J	NA	<4.6	NA	<4.6	<2.7	NA	<4.6	NA	8.1 J	3.3 J	<2.7	3.4 J	19
Mercury, ug/L	DQ	DQ	2	NA	<0.090	<0.090	<0.090	<0.10	NA	0.31	<0.090	<0.090	<0.10	NA	0.35	<0.090	<0.090	<0.10	NA	<0.090	<0.090	<0.090	<0.10	<0.10	<0.10	<0.10
Molybdenum, ug/L	P*	0.37	100	NA	0.26 J	0.28 J	<0.57	<1.1	NA	4.4	5.6	10.3	11	NA	0.91 J	1.2	1.5	<1.1	NA	7.3	21.6	12	6.2	<1.1	1.7 J	<1.1
Selenium, ug/L	P*	0.72	50	NA	0.47 J	0.5 J	0.46 J	<1.0	NA	<0.086	0.22 J	0.18 J	<1.0	NA	<0.086	0.3 J	0.26 J	<1.0	NA	3.3	0.38 J	0.39 J	<1.0	<1.0	<1.0	<1.0
Thallium, ug/L	NP*	0.29	2	NA	<0.036	NA	<0.099	<0.27	NA	<0.036	NA	<0.099	<0.27	NA	<0.036	NA	<0.099	<0.27	NA	<0.036	NA	<0.099	<0.27	<0.27	<0.27	<0.27
Radium 226/228 Combined, pCI/L	P	1.88	5	NA	1.35	0.974	1.37	0.255	NA	0.689	1.66	0.556	0.232	NA	1.96	2.09	3.52	0.146	NA	0.787	0.929	1.87	0.543	0.0356	0.553	0.897

4.4	Italics and blue shaded cell indicates the compliance well result exceeds the UPL (background) and the Limit of Quantitation (LOQ).
30.8	Bold and yellow highlighted cell indicates the compliance well result exceeds the GPS.

Abbreviations:

UPL = Upper Prediction Limit
NA = Not Analyzed
P = Parametric UPL with 1-of-2 retesting
U = Result is less than the sample detection limit.

GPS = Groundwater Protection Standard
J = Estimated concentration at or above the LOD and below the LOQ.
DQ = Double Quantification rule applies (not detected in background samples)

LOD = Limit of Detection
LOQ = Limit of Quantitation
NP = Nonparametric UPL (highest background value)

* = UPL is below the LOQ for background sampling. For compliance wells, only results confirmed above the LOQ are evaluated as potential SSIs above background.
^ = During the April 2018 sampling event, all non-radium sample containers for MW-6 were damaged during shipment. MW-6 was resampled for non-radium parameters on 4/26/2018. Total Dissolved Solids samples for MW-301, MW-302, and MW-303 were analyzed out of hold time. Those wells were resampled for TDS only on 6/5/2018.

Notes:

1. An individual result above the UPL or GPS does not constitute a statistically significant increase (SSI) above background or statistically significant increase above the GPS.
   See the accompanying letter text for identification of statistically significant results.
2. GPS is the United States Environmental Protection Agency (US EPA) Maximum Contamination Level (MCL), if established; otherwise, the value from 40 CFR 257.95(h)(2) is used.
3. Interwell UPLs calculated based on results from background well MW-6.

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Table 4. Historical Groundwater Arsenic Results for State Monitoring Wells
Alliant-Lansing CCR Landfill
(Results are in µg/L, unless otherwise noted)

Sample	Date	Arsenic (µg/L)
MW3	5/11/2001	<1.8
MW4	5/11/2001	<1.8
	3/8/2002	<0.88
	2/19/2004	<3.5
	5/26/2004	3.3
	8/23/2004	<0.79
	11/18/2004	<0.79
	5/5/2005	<0.79
	5/19/2006	2.9
	5/30/2007	<1
	4/16/2008	<0.43
	4/3/2009	0.27 J
	4/21/2010	<1.0
	5/4/2011	<1.0
	5/4/2011(Dup)	<2.0 RL
	4/25/2012	<1.0
	4/2/2013	<1.0
	7/2/2013	<1.0
	4/29/2014	0.62 J
	5/29/2014	<0.18
	4/21/2015	<0.25
	4/28/2016	0.30 J
	4/20/2017	0.33 J
MW5	3/8/2002	<0.88
	2/19/2004	<3.5
	5/26/2004	4.7
	8/23/2004	0.92
	11/18/2004	<0.79
	5/5/2005	<0.79
	5/19/2006	<0.79
	5/30/2007	<1
	4/16/2008	<0.43
	04/16/08 Dup	<0.43
	4/3/2009	0.22 J
	4/21/2010	<1.0
	4/21/2010 (Dup)	<1.0
	5/4/2011	<1.0
	4/25/2012	<1.0
	4/2/2013	<1.0
	7/2/2013	<1.0
	4/29/2014	0.65 J
	5/29/2014	1.3
	4/21/2015	<0.25
	4/28/2016	0.26 J
	4/20/2017	0.26 J

Table 4. Historical Groundwater Arsenic Results for State Monitoring Wells
Alliant-Lansing CCR Landfill
(Results are in µg/L, unless otherwise noted)

Sample	Date	Arsenic (µg/L)
MW6	5/11/2001	<1.8
	3/8/2002	<0.88
	2/19/2004	<3.5
	5/26/2004	3.9
	8/23/2004	<0.79
	11/18/2004	<0.79
	5/5/2005	<0.79
	5/19/2006	0.93 J
	5/30/2007	<1.0
	4/16/2008	<0.43
	4/3/2009 Dup	0.29 J
	4/3/2009	0.29 J
	4/21/2010	<1.0
	5/4/2011	<1.0
	4/25/2012	<1.0
	4/2/2013	<1.0
	7/2/2013	<1.0
	4/29/2014	0.55 J
	4/20/2015	<0.25
	4/29/2016	0.26 J
	4/19/2017	0.27 J
	4/16/2018	0.19 J
	4/15/2019	<0.75
MW11	3/8/2002	**23**
	5/26/2004	**16**
	8/23/2004	3.8
MW11R	4/21/2010	2.44
	5/4/2011	**11.6**
	4/25/2012	**13.6**
	4/25/2012 (Dup)	**15.7**
	4/2/2013	**25**
	7/2/2013	**23**
	4/30/2014	**27**
	5/29/2014	**27**
	4/21/2015	**23**
	4/28/2016	**33.4**
	4/20/2017	**30.4**
	4/17/2018	**28.5**
	4/16/2019	**28**
MW12	4/2/2013	**16**
	7/2/2013	**17**
	4/30/2014	**16**
	5/29/2014	**14**
	4/21/2015	**13**
	4/28/2016	**24.2**
	4/20/2017	**19.4**
	4/17/2018	**20.6**
	4/16/2019	**20**
MW12P	4/30/2014	1.0
	5/29/2014	0.45 J
	4/21/2015	0.34 J
	4/28/2016	0.44 J
	4/20/2017	0.88 J
	4/17/2018	0.51 J
	4/16/2019	<0.75

Table 4. Historical Groundwater Arsenic Results for State Monitoring Wells
Alliant-Lansing CCR Landfill
(Results are in µg/L, unless otherwise noted)

Sample	Date	Arsenic (µg/L)
MW13	4/2/2013	1.1
	7/2/2013	<1.0
	7/2/2013 Dup	<1.0
	4/30/2014	1.6
	5/29/2014	0.65 J
	4/20/2015	1.1
	4/28/2016	3.5
	4/20/2017	1.5
	4/17/2018	0.89 J
	4/16/2019	<0.75
MW14	4/2/2013	<1.0
	7/2/2013	<1.0
	4/30/2014	0.54 J
	5/29/2014	<0.18
	4/20/2015	<0.25
	4/29/2016	0.16 J
	4/20/2017	0.68 J
	4/17/2018	0.16 J
	4/15/2019	<0.75
MW15	4/30/2014	0.95 J
	5/29/2014	0.82 J
	4/20/2015	0.79 J
	4/29/2016	0.39 J
	4/20/2017	0.42 J
	4/17/2018	0.14 J
	4/16/2019	<0.75
TW17	4/30/2014	0.87 J
	5/29/2014	0.25 J
TW18	4/30/2014	1.40
	5/29/2014	<0.18
	4/20/2015	0.47 J
	4/20/2017	1.2
	4/17/2018	2.1
	4/16/2019	<0.75
TW19	4/30/2014	4.6
	5/29/2014	0.59 J
Groundwater Protection Standard (GPS)		10

Abbreviations:
µg/L = micrograms per liter

Notes:
Bold+underlined values meet or exceed GPS.

Laboratory Notes/Qualifiers:
J = Estimated value. Analyte detected at a level less than the reporting limit and greater than or equal to the Method Detection Limit. The user of this data should be aware that this data is of unknown quality.
RL = Reporting limit raised due to sample matrix effects.

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Table 5. Preliminary Evaluation of Corrective Measure Alternatives
Lansing Generating Station / SCS Engineers Project #25218201.00

	Alternative #1 No Action	Alternative #2 Close and Cap in place with MNA	Alternative #3 Consolidate and Cap with MNA	Alternative #4 Excavate CCR and Dispose On Site with MNA	Alternative #5 Excavate CCR and Dispose Off Site
CORRECTIVE ACTION ASSESSMENT - 40 CFR 257.97(b)					
257.97(b)(1) Is remedy protective of human health and the environment?	Potentially	Yes	Yes	Yes	Yes
257.97(b)(2) Can the remedy attain the groundwater protection standard?	Potentially	Yes	Yes	Yes	Yes
257.97(b)(3) Can the remedy control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment?	No	Yes	Yes	Yes	Yes
257.97(b)(4) Can the remedy remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible?	Not Applicable - No release of CCR	Not Applicable - No release of CCR	Not Applicable - No release of CCR	Not Applicable - No release of CCR	Not Applicable - No release of CCR
257.97(b)(5) Can the remedy comply with standards for management of wastes as specified in §257.98(d)?	Not Applicable	Yes	Yes	Yes	Yes
LONG- AND SHORT-TERM EFFECTIVENESS - 40 CFR 257.97(c)(1)					
257.97(c)(1)(i) Magnitude of reduction of existing risks	No reduction of existing risk	Existing risk reduced by achieving GPS	Same as Alternative #2	Same as Alternative #2	Same as Alternative #2
257.97(c)(1)(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy	No reduction of existing risk Residual risk is limited for all alternatives due to limited extent of impacts and lack of receptors	Magnitude of residual risk of further releases is lower than current conditions due to final cover eliminating infiltration through CCR Residual risk is limited for all alternatives due to limited extent of impacts and lack of receptors	Same as Alternative #2 with potential further reduction in release risk due to CCR material footprint However, limited to no additional overall risk reduction is provided due to lack of current/anticipated future receptors for groundwater impacts	Same as Alternative #3 with further reduction in release risk due to composite liner and cover However, limited to no additional overall risk reduction is provided due to lack of current/anticipated future receptors for groundwater impacts	Same as Alternative #3 with further reduction in release risk due to removal of CCR from site However, limited to no additional overall risk reduction is provided due to lack of current/anticipated future receptors for groundwater impacts
257.97(c)(1)(iii) The type and degree of long-term management required, including monitoring, operation, and maintenance	Not Applicable	30-year post-closure groundwater monitoring Groundwater monitoring network maintenance and as-needed repair/replacement Final cover maintenance (e.g., mowing and as-needed repair) Periodic final cover inspections Additional corrective action as required based on post-closure groundwater monitoring	Same as Alternative #2	Same as Alternative #2 with increased effort for new leachate collection and management systems	Limited on-site post-closure groundwater monitoring until GPSs are achieved for impoundment Receiving disposal facility for impounded CCR will have same/similar long-term monitoring, operation, and maintenance requirements as Alternative #2

Table 5. Preliminary Evaluation of Corrective Measure Alternatives
Lansing Generating Station / SCS Engineers Project #25218201.00

	Alternative #1 No Action	Alternative #2 Close and Cap in place with MNA	Alternative #3 Consolidate and Cap with MNA	Alternative #4 Excavate CCR and Dispose On Site with MNA	Alternative #5 Excavate CCR and Dispose Off Site
LONG- AND SHORT-TERM EFFECTIVENESS - 40 CFR 257.97(c)(1) (continued)					
257.97(c)(1)(iv) Short-term risks - Implementation					
Excavation	None	Limited risk to community and environment due to limited amount of excavation (likely <100K cy) required to establish final cover subgrades and no off-site excavation	Same as Alternative #2 with increased risk to environment due to increased excavation volumes required for consolidation (>100K cy but <357K cy = published maximum CCR inventory as of February 2018 per Written Closure Plan)	Same as Alternative #3 with increased risk to environment due to increased excavation volumes (>840K cy) and temporary CCR storage during disposal site construction required for removal and on-site re-disposal	Same as Alternative #4 with reduced risk to environment from excavation due to limited on-site storage
Transportation	None	No risk to community or environment from offsite CCR transportation; Typical risk due to construction traffic delivering final cover materials to site	Same as Alternative #2 with reduced risk from construction traffic due to reduced final cover material requirements (smaller cap footprint)	Same as Alternative #2 with increased risk from construction traffic due to increased material import requirements (liner and cap construction required)	Highest level of community and environmental risk due to CCR volume export (>840K cy)
Re-Disposal	None	Limited risk to community and environment due to limited volume of CCR re-disposal (likely <100K cy)	Same as Alternative #2 with increased risk to environment due to increased excavation volumes (likely >100K cy but <357K cy) required for consolidation	Same as Alternative #3 with increased risk to environment due to increased excavation volumes (~840K cy) and temporary CCR storage during disposal site construction required for removal and on-site re-disposal	Same as Alternative #4 with increased risk to community and environment due to re-disposal of large CCR volume (~840K cy) at another facility Re-disposal risks are managed by the receiving disposal facility
257.97(c)(1)(v) Time until full protection is achieved	Unknown	To be evaluated further during remedy selection Impoundment closure and capping anticipated by end of 2021 Landfill closure and capping anticipated by end of 2021 Groundwater protection timeframe to reach GPS potentially 2 to 10 years following closure construction, achievable within 30 year post-closure monitoring period	Similar to Alternative #2. Potential for increase in time to reach GPS due to significant source disturbance during construction. Potential for decrease in time to reach GPS due to consolidation of impounded CCR	Similar to Alternative #2 Potential for increase in time to reach GPS due to significant source disturbance during construction Potential decrease in time to reach GPS due to CCR source isolation within liner/cover system	Similar to Alternative #2 Potential for increase in time to reach GPS due to significant source disturbance during construction Potential decrease in time to reach GPS due to CCR source removal
257.97(c)(1)(vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment	No change in potential exposure	Potential for exposure is low Remaining waste is capped	Same as Alternative #2	Same as Alternative #2	No potential for on-site exposure to remaining waste since no waste remains on site Risk of potential exposure is transferred to receiving disposal facility and is likely similar to Alternative #2
257.97(c)(1)(vii) Long-term reliability of the engineering and institutional controls	Not Applicable	Long-term reliability of cap is good Significant industry experience with methods/controls Capping is common practice/industry standard for closure in place for remediation and solid waste management	Same as Alternative #2 with potentially increased reliability due to smaller footprint and reduced maintenance	Same as Alternative #3	Success of remedy at LAN does not rely on long-term reliability of engineering or institutional controls Overall success relies on reliability of the engineering and institutional controls at the receiving facility
257.97(c)(1)(viii) Potential need for replacement of the remedy	Not Applicable	Limited potential for remedy replacement if maintained Some potential for remedy enhancement due to residual groundwater impacts following source control	Same as Alternative #2 with reduced potential need for remedy enhancement with consolidated/smaller closure area footprint	Same as Alternative #2 with further reduction in potential need for remedy enhancement composite with liner	No potential for remedy replacement Limited potential for remedy enhancement due to residual groundwater impacts following source control
SOURCE CONTROL TO MITIGATE FUTURE RELEASES - 40 CFR 257.97(c)(2)					
257.97(c)(2)(i) The extent to which containment practices will reduce further releases	No reduction in further releases	Cap will reduce further releases by minimizing infiltration through CCR	Same as Alternative #2 with further reduction due to consolidated/smaller closure footprint	Same as Alternative #3 with further reduction due to composite liner and 5-foot groundwater separation required by CCR Rule	Removal of CCR prevents further releases at LAN Receiving disposal site risk similar to Alternative #3
257.97(c)(2)(ii) The extent to which treatment technologies may be used	Alternative does not rely on treatment technologies	Alternative does not rely on treatment technologies	Alternative does not rely on treatment technologies	Alternative does not rely on treatment technologies	Alternative does not rely on treatment technologies

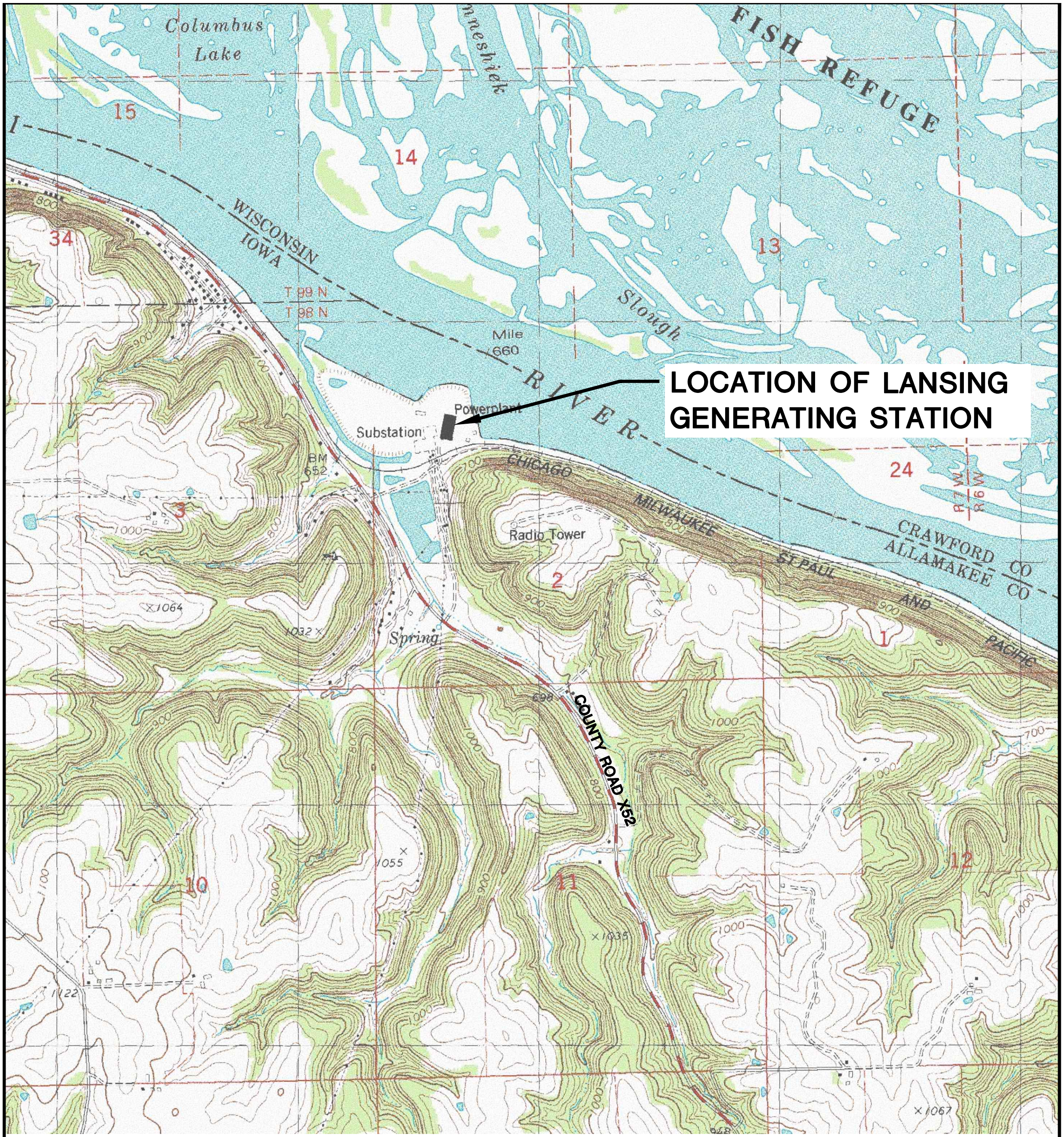
Table 5. Preliminary Evaluation of Corrective Measure Alternatives
Lansing Generating Station / SCS Engineers Project #25218201.00

	Alternative #1 No Action	Alternative #2 Close and Cap in place with MNA	Alternative #3 Consolidate and Cap with MNA	Alternative #4 Excavate CCR and Dispose On Site with MNA	Alternative #5 Excavate CCR and Dispose Off Site
IMPLEMENTATION - 40 CFR 257.97(c)(3)					
257.97(c)(3)(i) Degree of difficulty associated with constructing the technology	Not Applicable	Moderately complex construction due to impounded CCR thixotropic characteristics Potentially lowest level of dewatering effort - dewatering required for cap installation only	Moderately complex construction due to impounded CCR thixotropic characteristics Moderate degree of logistical complexity Moderate level of dewatering effort - dewatering required for material excavation/placement and capping	Moderately complex construction due to composite liner and cover High degree of logistical complexity due to excavation and on-site storage of ~840K cy of CCR while new lined disposal area is constructed High level of dewatering effort - dewatering required for excavation of full CCR volume	Moderately complex construction due to CCR thixotropic characteristics High degree of logistical complexity including the excavation and off-site transport of ~840K cy of CCR and permitting/development of off-site disposal facility airspace High level of dewatering effort - dewatering required for excavation of full CCR volume
257.97(c)(3)(ii) Expected operational reliability of the technologies	Not Applicable	High reliability based on historic use of capping as corrective measure	Same as Alternative #2	Same as Alternative #2	Success at LAN does not rely on operational reliability of technologies; Overall success relies on offsite disposal facility, which is likely same/similar to Alternative #2
IMPLEMENTATION - 40 CFR 257.97(c)(3) (continued)					
257.97(c)(3)(iii) Need to coordinate with and obtain necessary approvals and permits from other agencies	Not Applicable	Need is low in comparison to other alternatives State Closure Permit required	Same as Alternative #2	Need is high in comparison to other alternatives State Closure Permit required State Landfill Permit may be required	Need is highest in comparison to other alternatives State Closure Permit required Approval of off-site disposal site owner required May require State solid waste comprehensive planning approval Local road use permits likely required
257.97(c)(3)(iv) Availability of necessary equipment and specialists	Not Applicable	Necessary equipment and specialists are highly available Highest level of demand for cap construction material	Same as Alternative #2 Lowest level of demand for cap construction material	Same as Alternative #2; Moderate level of demand for liner and cap construction material	Availability of necessary equipment to develop necessary off-site disposal facility airspace and transport ~840K cy of CCR to new disposal facility will be a limiting factor in the schedule for executing this alternative No liner or cover material demands for on-site implementation of remedy
257.97(c)(3)(v) Available capacity and location of needed treatment, storage, and disposal services	Not Applicable	Capacity and location of treatment, storage, and disposal services is not a factor for this alternative	Capacity and location of treatment, storage, and disposal services is unlikely to be a factor for this alternative	Available temporary on-site storage capacity of staged re-disposal of ~840K cy of CCR while composite liner is constructed is significant limiting factor	Off-site disposal capacity, facility logistical capacity, or the time required to develop the necessary off-site disposal and logistical capacity is a significant limiting factor
COMMUNITY ACCEPTANCE - 40 CFR 257.97(c)(4)					
257.97(c)(4) The degree to which community concerns are addressed by a potential remedy (Anticipated)	To be determined based on input obtained through public meetings/outreach to be completed	To be determined based on input obtained through public meetings/outreach to be completed	To be determined based on input obtained through public meetings/outreach to be completed	To be determined based on input obtained through public meetings/outreach to be completed	To be determined based on input obtained through public meetings/outreach to be completed

Created by: LAB/SK Date: 6/20/2019
Last revision by: EJN Date: 9/10/2019
Checked by: TK Date: 9/12/2019

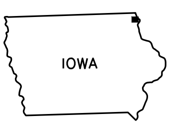
I:\25218201.00\Deliverables\LAN ACM\Tables\[5_Prelim Evaluation of Corrective Measures_LAN.xlsx]LAN_Evaluation Matrix

Figures



N

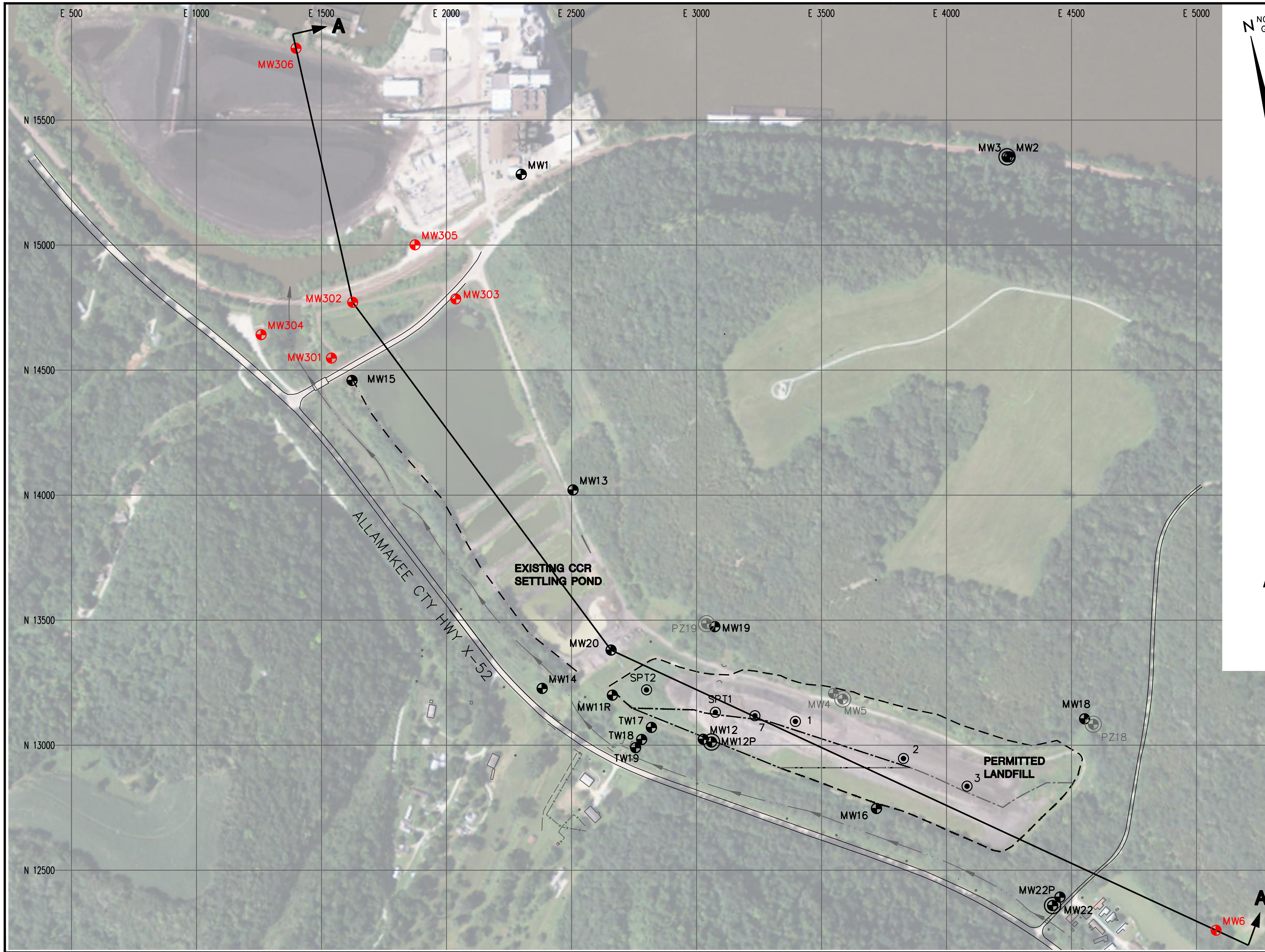
LANSING QUADRANGLE
IOWA–ALLAMAKEE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NW/4 LANSING 15' QUADRANGLE
1997
SCALE: 1" = 2,000'



CLIENT	SITE	
ALLIANT ENERGY. INTERSTATE POWER AND LIGHT 2320 POWER PLANT DRIVE LANSING, IA 52151-9733	INTERSTATE POWER AND LIGHT LANSING GENERATING STATION COAL COMBUSTION RESIDUE LANDFILL LANSING, IOWA	SITE LOCATION MAP

				ENGINEER	FIGURE
PROJECT NO.	25218201	DRAWN BY:	AHB	SCS ENGINEERS	
DRAWN:	08/09/12	CHECKED BY:	MDB	2830 DAIRY DRIVE MADISON, WI 53718-6751	1
REVISED:	08/27/19	APPROVED BY:	TJK 09/10/19	PHONE: (608) 224-2830	

I:\25218201.00\Drawings\Lansing\SITE LOC.dwg, 9/10/2019 1:16:53 PM



NORTH GRID

400 0 400

SCALE: 1" = 400'

LEGEND

— — — —	APPROVED LIMITS OF WASTE
—·—·—·—	LIMITS OF PHASE 1 FINAL COVER
—··—··—	LIMITS OF PHASE 2 FINAL COVER
MW17	EXISTING STATE PROGRAM MONITORING WELL
MW12P	EXISTING STATE PROGRAM PIEZOMETER
MW17	EXISTING CCR RULE MONITORING WELL
MW4	ABANDONED MONITORING WELL
MW5	ABANDONED PIEZOMETER
	SOIL BORING
	SLURRY WALL
	EXISTING STREAM
	CROSS SECTION LOCATION

NOTES:

1. MONITORING WELL LOCATIONS ARE APPROXIMATE.
2. ONLY BORINGS USED FOR GEOLOGIC CROSS SECTION A–A' ARE SHOWN.
3. MW6 IS SAMPLED UNDER BOTH TH STATE AND CCR RULE MONITORING PROGRAMS.

PROJECT NO.	25218201	DRAWN BY:	AHB/RJG
DRAWN:	07/03/19	CHECKED BY:	MDB
REVISED:	08/07/19	APPROVED BY:	TJK 09/10/19

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

CLIENT: ALLIANT ENERGY.
INTERSTATE POWER AND LIGHT
2320 POWER PLANT DRIVE
LANSING, IA 52151-9733

SITE: INTERSTATE POWER AND LIGHT
LANSING GENERATING STATION
COAL COMBUSTION RESIDUE LANDFILL
LANSING, IOWA

SITE PLAN AND MONITORING WELL LOCATION MAP

FIGURE 2

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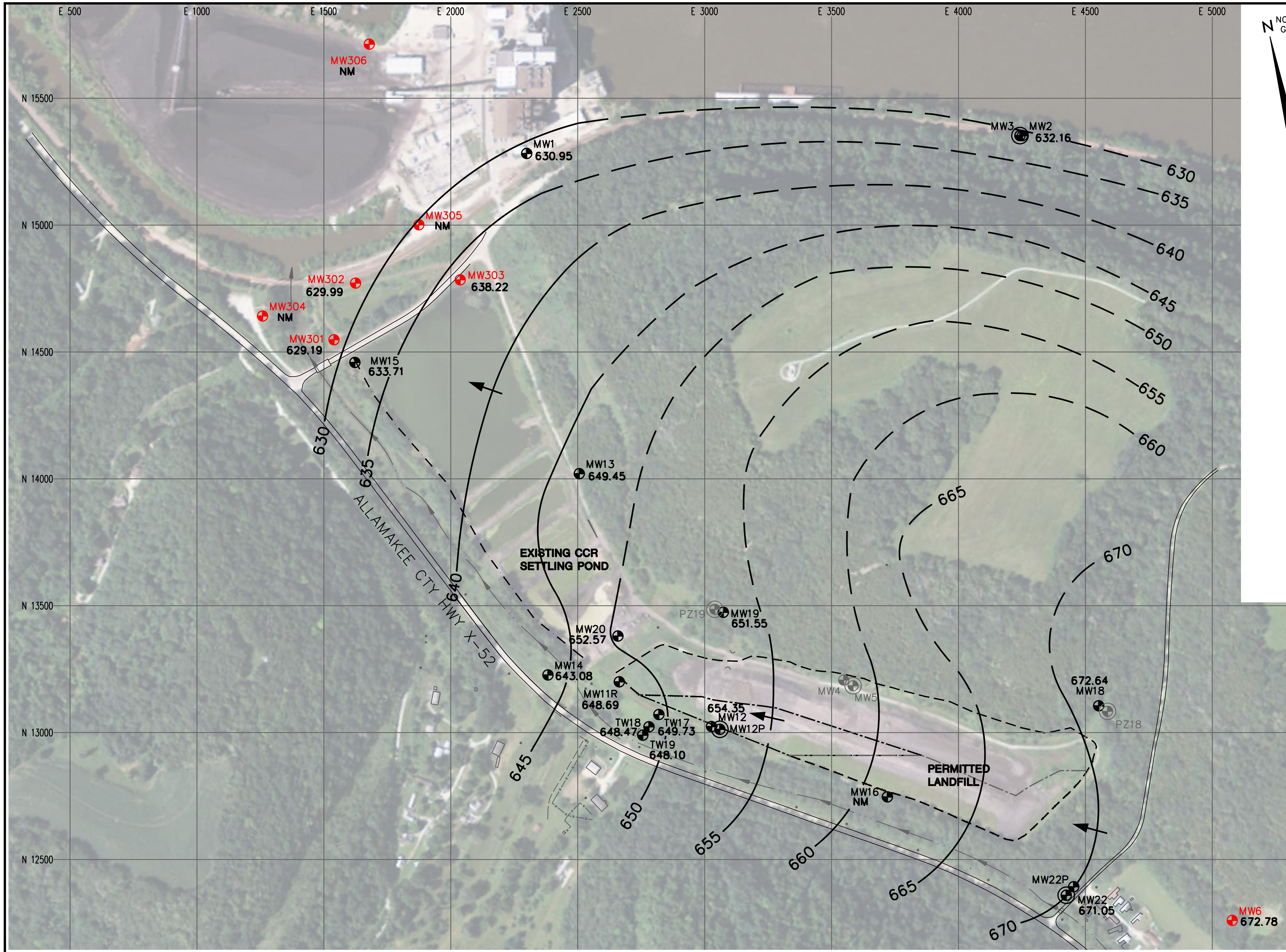

NORTH
GRID
N

400 0 400

SCALE: 1" = 400'

LEGEND

— — — —	APPROVED LIMITS OF WASTE
— · — · —	LIMITS OF PHASE 1 FINAL COVER
— · · — · · —	LIMITS OF PHASE 2 FINAL COVER
MW17	EXISTING MONITORING WELL
MW12P	EXISTING PIEZOMETER
MW17	EXISTING CCR MONITORING WELL
MW4	ABANDONED MONITORING WELL
MW5	ABANDONED PIEZOMETER
— · — · —	SLURRY WALL
··· ➝ ··· ➝	EXISTING STREAM
629.99	WATER TABLE ELEVATION
NM	NOT MEASURED
———	WATER TABLE CONTOUR (DASHED WHERE INFERRED)
➝	APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTES:

1. MONITORING WELL LOCATIONS ARE APPROXIMATE.
2. MONITORING WELLS MW304, MW305, AND MW306 WERE INSTALLED IN MAY 2019.

PROJECT NO.	25219070.00	DRAWN BY:	BSS
DRAWN:	07/03/19	CHECKED BY:	NK
REVISED:	07/08/19	APPROVED BY:	TJK 09/10/19

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

CLIENT: ALLIANT ENERGY
INTERSTATE POWER AND LIGHT
2320 POWER PLANT DRIVE
LANSING, IA 52151-9733

SITE: INTERSTATE POWER AND LIGHT
LANSING POWER STATION
COAL COMBUSTION RESIDUE LANDFILL
LANSING, IOWA

WATER TABLE MAP – APRIL 15-16, 2019

FIGURE 3

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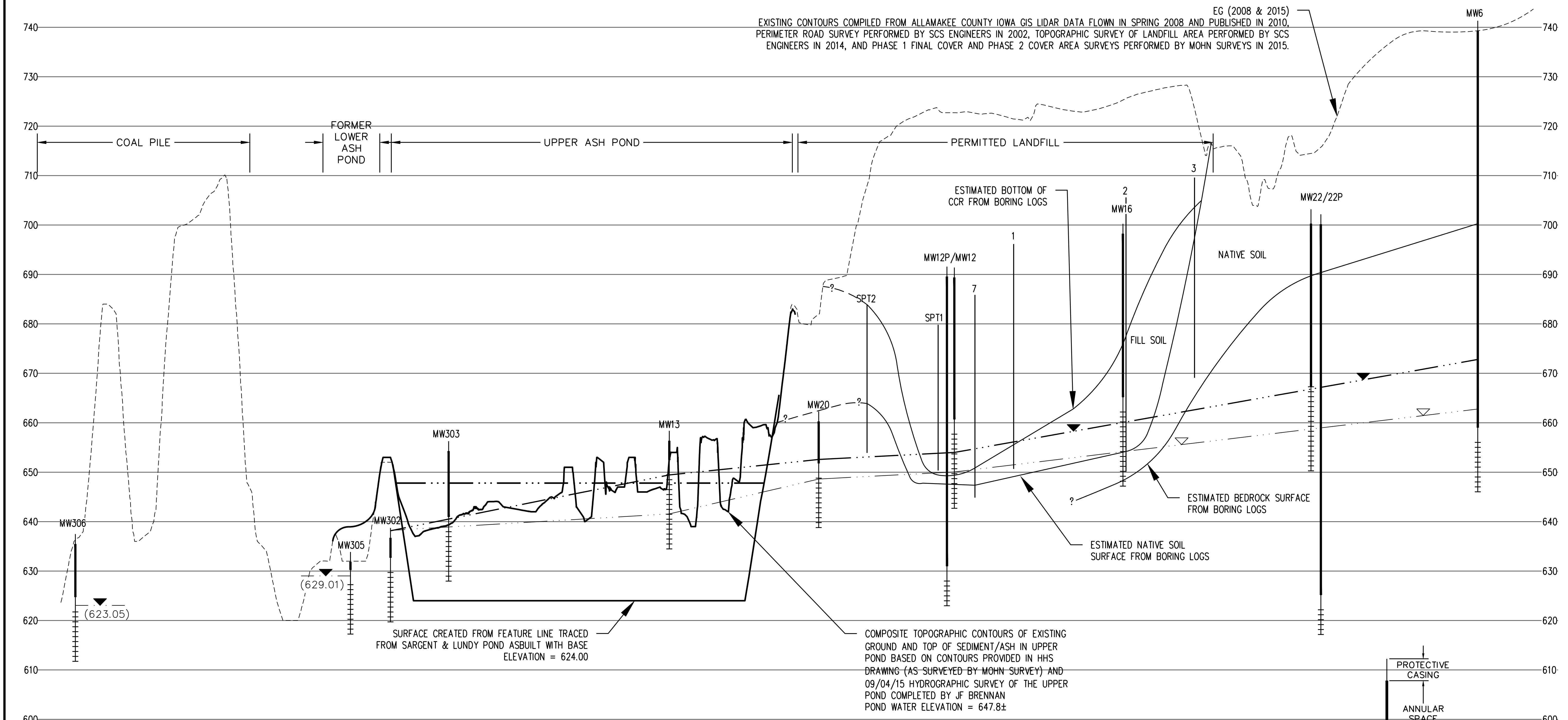


NOTES:

1. THE FOLLOWING MONITORING WELL AND BORING LOCATIONS ARE PROJECTED ALONG THE CROSS SECTION; MW22P/MW22, MW16, MW12/MW12P, MW13, MW303, MW305, 1, 2, 3, 7, SPT1, AND SPT2. SEE FIGURE 1 FOR CROSS SECTION LOCATION.

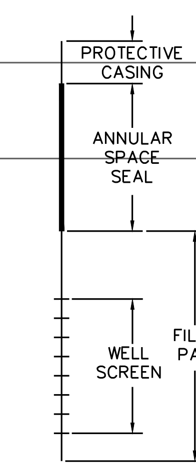
2. MONITORING WELLS MW305 AND MW306 WERE INSTALLED IN MAY 2019 AND FIRST SAMPLED ON JUNE 20, 2019. WATER TABLE ELEVATIONS FOR JUNE 20, 2019 ARE SHOWN AT THESE WELLS.

0 400

HORIZONTAL SCALE: 1" = 300'
VERTICAL SCALE: 1" = 20'
VERTICAL EXAGGERATION = 20X

LEGEND

- HIGH WATER TABLE MEASURED APRIL 15–16, 2019
- LOW WATER TABLE MEASURED APRIL 28, 2016
- (623.05) JUNE 20, 2019 WATER TABLE ELEVATION
- UPPER ASH POND SURFACE WATER ELEVATION



WELL DETAIL

PROJECT NO.	25219070.00	DRAWN BY:	AHB/RJG
DRAWN:	07/03/19	CHECKED BY:	MDB
REVISED:	08/07/19	APPROVED BY:	TJK 09/10/19

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

CLIENT: ALLIANT ENERGY.
INTERSTATE POWER AND LIGHT
2320 POWER PLANT DRIVE
LANSING, IA 52151-9733

SITE: INTERSTATE POWER AND LIGHT
LANSING POWER STATION
COAL COMBUSTION RESIDUE LANDFILL
LANSING, IOWA

CROSS SECTION A–A'

FIGURE 4

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Appendix A

Regional Geological and Hydrogeological Information

Table LAN-3 Regional Hydrogeologic Stratigraphy
Lansing Generating Station / SCS Engineers Project #25215053

Strategic Unit			Hydrogeologic Units	Type of Rock	Hydrologic Conditions	Thickness Range (ft)	Age of Rocks*
Quaternary		Recent and Pleistocene deposits	Surficial aquifers-Alluvium, Drift, Buried-channel	Sand and gravel interbedded with silt and clay	Mostly unconfined local aquifers, some artesian, small-to-large yields	0 – 305	0 – 2.8 million years (m.y.)
Devonian	Yellow Spring Group (Gp)	Lime Creek Formation (Fm)	Confining layers	Shale, some dolostone	Non-aquifer	0 – 50	365 – 405 m.y.
	Cedar Valley Gp	Lithograph City Fm Coralville Fm Little Cedar Fm	Silurian-Devonian aquifer	Limestone and dolostone, thin shales	Major aquifer, mostly artesian, moderate-to-large yields	0 – 400	
	Wapsipinicon Gp	Pinicon Ridge Fm Spillville Fm		Dolostone and limestone			
Silurian		Scotch Grove Fm Hopkinton Fm Blanding Fm Tete des Morts Fm		Dolostone, locally with much chert, local shale as cavern fillings			405 – 425 m.y.
Ordovician	Maquoketa Fm	Brainard Member Fort Atkinson Member Clermont Member Elgin Member	Maquoketa Fm, confining beds Fort Atkinson – Elgin aquifer	Shale and dolostone, some chert	Non-aquifer to local aquifer, small-to-moderate yields	0 – 300	425 – 455 m.y.
	Galena Gp	Dubuque Fm Wise Lake Fm Dunleith Fm Decorah Fm	Galena aquifer	Limestone and dolostone, minor chert, shale at base and locally in upper part	Local aquifer, confined and unconfined, small-to-moderate yields	0 – 240	455 – 460 m.y.
		Platteville Fm Glenwood Fm	Decorah-Platteville-Glenwood confining beds	Limestone and shale	Non-aquifer	0 – 50	
		St. Peter Sandstone	Cambrian-Ordovician aquifer	Sandstone	Major aquifer, mostly artesian, large yields	0 – 580	460 – 500 m.y.
		Prairie du Chien Gr		Dolostone, minor sandstone and chert			500 – 503 m.y.
Cambrian		Jordan Sandstone		Sandstone, dolomitic			
		St. Lawrence Fm	Cambrian confining beds	Dolostone, silty	Non-aquifer	0 – 400	503 – 508 m.y.
		Lone Rock (Franconia) Fm		Fine, sandstone, siltstone, shale, and minor dolostone			
		Wenowoc (incl Ironton-Galesville sandstone) Fm	Dresbach aquifer	Sandstone	Artesian aquifer, large yields	0 – 1,950	508 – 515 m.y.
		Eau Claire Fm		Fine sandstone, siltstone, and shale			
		Mt. Simon Sandstone		Sandstone			
Pre-C		Undifferentiated crystalline rocks	Unknown	Igneous and metamorphic rocks	Unknown	Unknown	570 m.y. – > 2 billion years

*Age determinations as used on COSUNA charts published by AAPG-USGS
Source: "Water Resources of Southeast Iowa," Iowa Geologic Survey Water Atlas No. 4.

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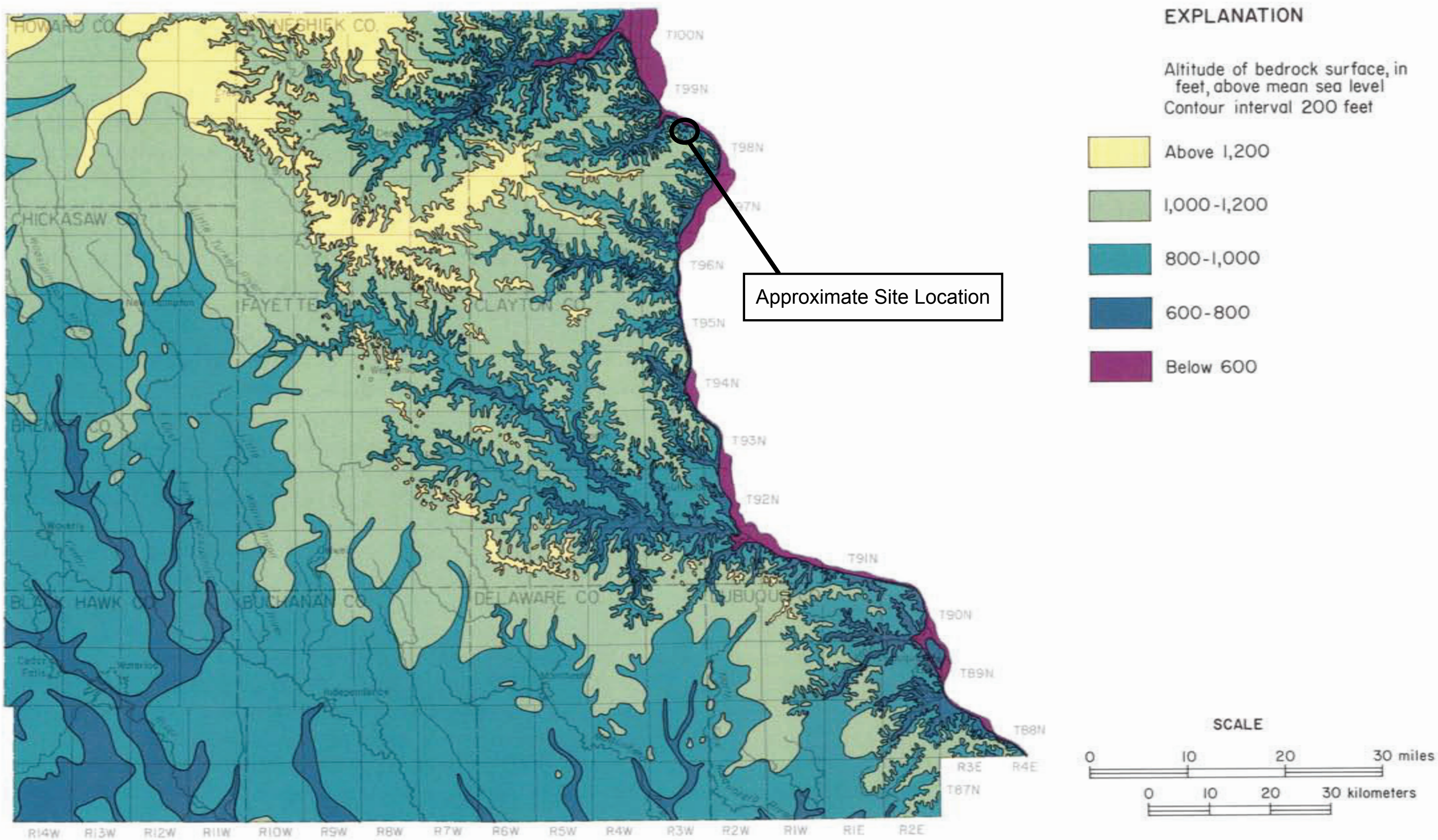

Figure 30. Altitude and configuration of the bedrock surface

Source: Horick, Paul J., Water Resources of Northeast Iowa, Iowa Department of Natural Resources Water Atlas Number 8, October

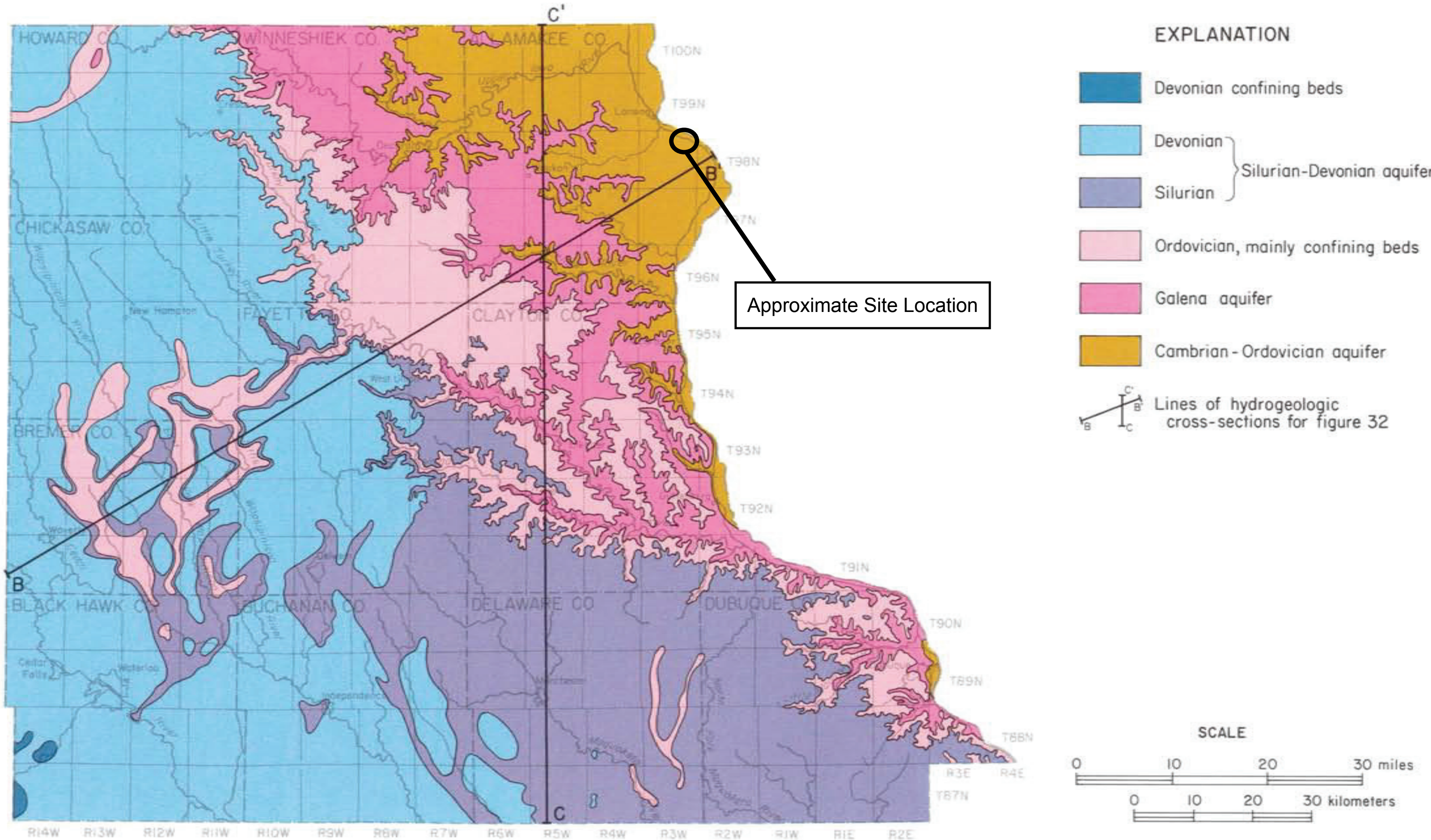

Figure 31. Bedrock hydrogeologic map

Source: Horick, Paul J., Water Resources of Northeast Iowa, Iowa Department of Natural Resources Water Atlas Number 8, October

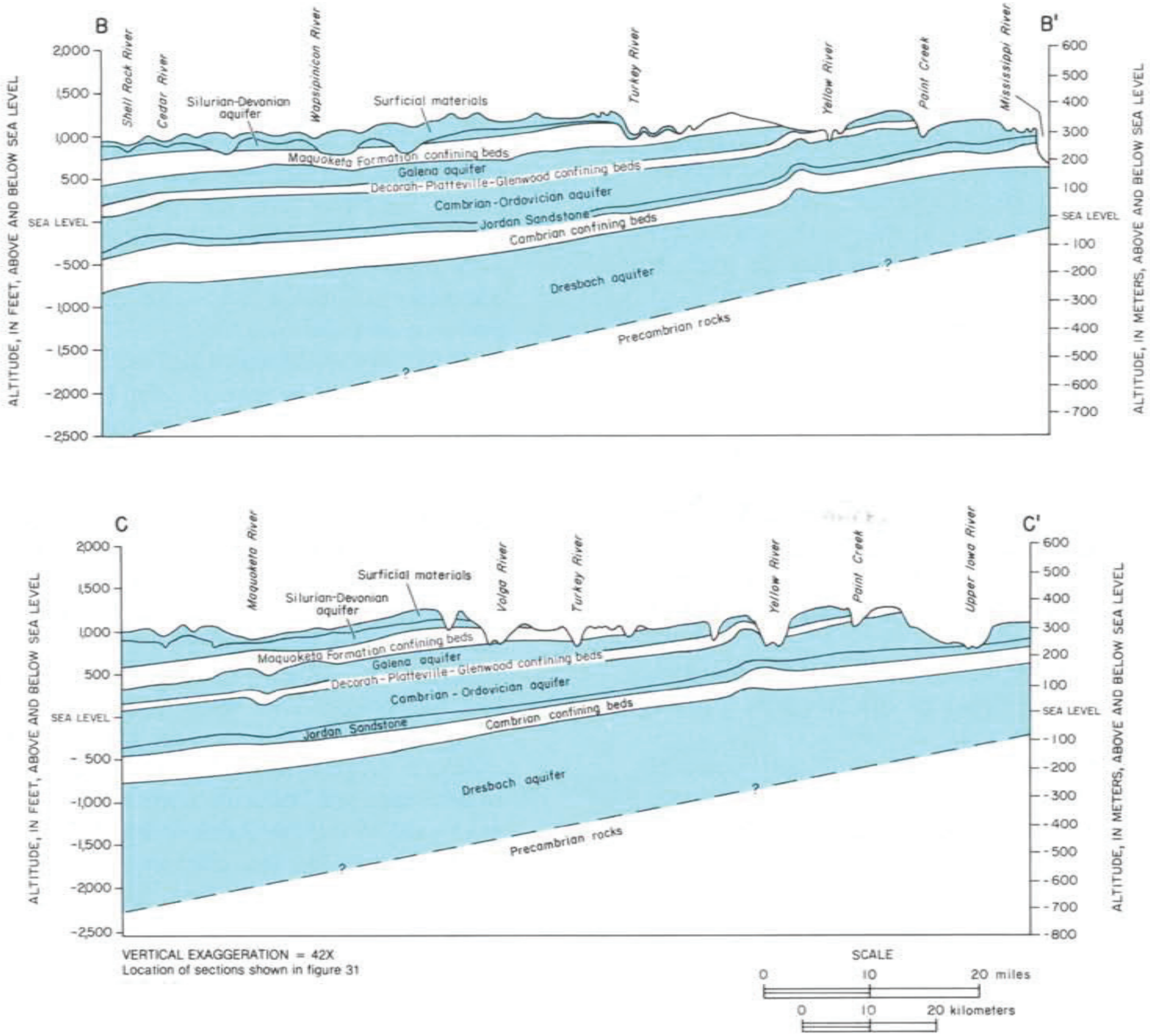

Figure 32. Hydrogeologic cross-sections

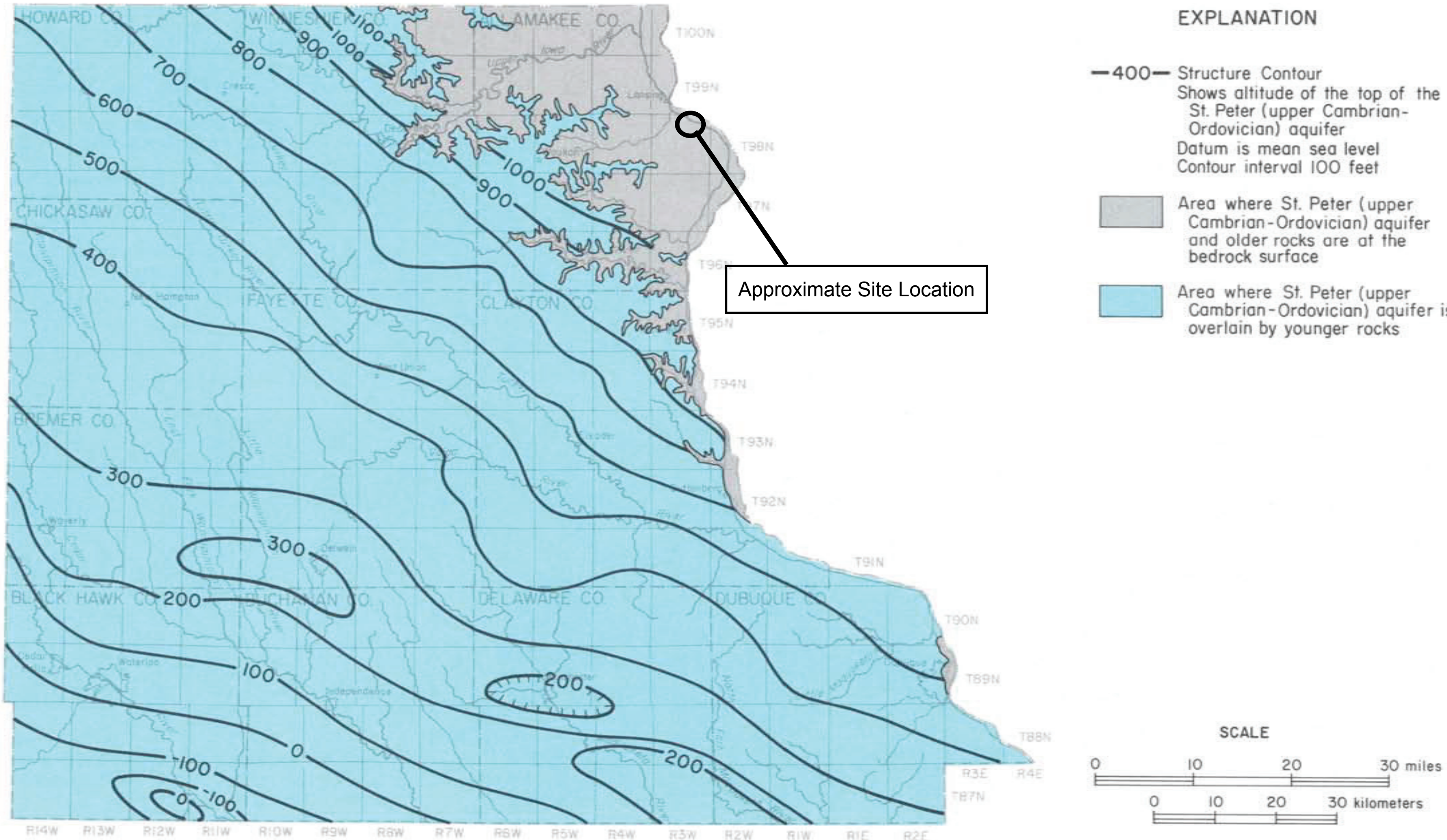

Figure 38. Altitude of the top of the St. Peter (upper Cambrian-Ordovician) aquifer

Source: Horick, Paul J., Water Resources of Northeast Iowa, Iowa Department of Natural Resources Water Atlas Number 8, October

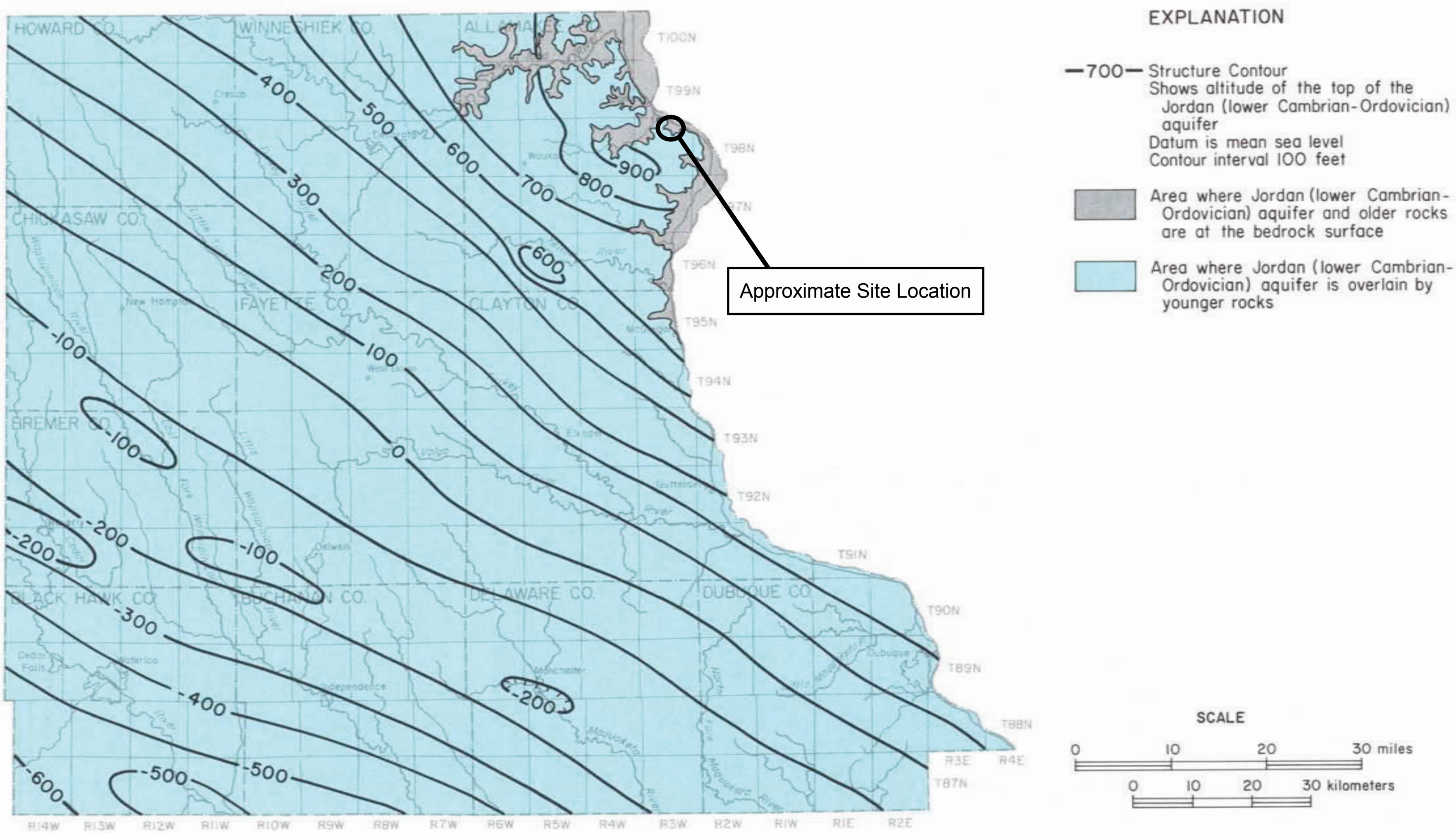

Figure 39. Altitude of the top of the Jordan (lower Cambrian-Ordovician) aquifer

Source: Horick, Paul J., Water Resources of Northeast Iowa, Iowa Department of Natural Resources Water Atlas Number 8, October

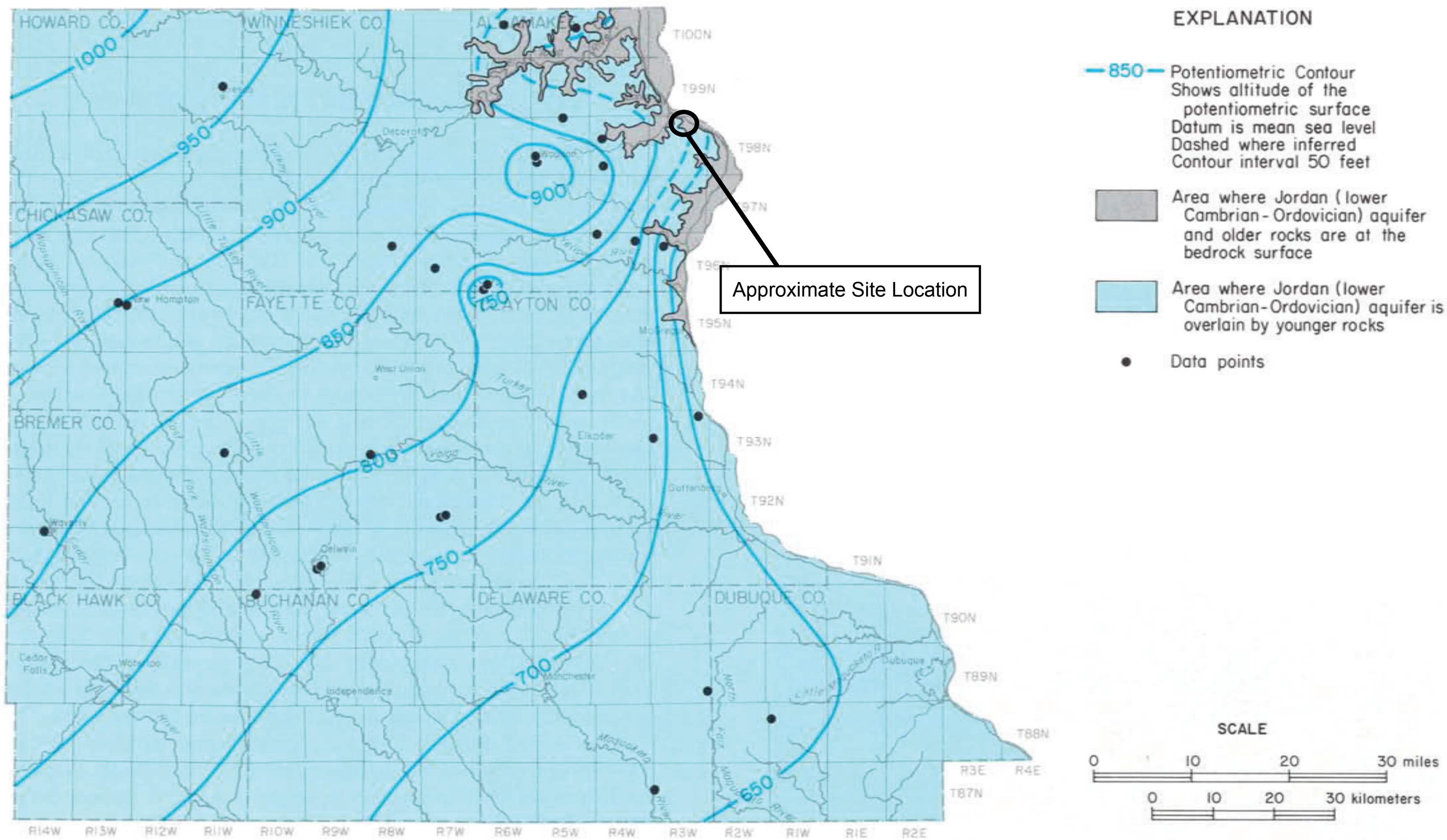

Figure 56. Potentiometric surface of the Jordan (lower Cambrian-Ordovician) aquifer

Source: Horick, Paul J., Water Resources of Northeast Iowa, Iowa Department of Natural Resources Water Atlas Number 8, October

Appendix B

Boring Logs

CaCO3	K (cm/sec)			MW-6	ELEVATION (ft, msl)	DEPTH (feet)	LITHOLOGY	MATERIALS DESCRIPTION
					734.0	5		0.0 to 6.0 SILT Topsoil developed in silt from 0.0 to 1.5. Topsoil is dark brown. Clayey silt, trace sand is loess or colluvium (slopewash) derived from loess. Medium brown, changing gradually to yellow brown below 5.0.
					729.0	10		6.0 to 37.0 TALUS Light brown sandy silt with dolomite chunks.
					724.0	15		
					719.0	20		
					714.0	25		
					709.0	30		
					704.0	35		
					699.0	40		37.0 to 93.5 INTERBEDDED SANDSTONE AND SILTSTONE Sandstone is fine-grained, with quartz silt matrix, glauconitic. Siltsone contains minor amount of very fine quartz sand and glauconite. Sandstone is laminated light greenish gray with creamy color. Siltstone is light greenish gray. Sandstone from 37.0 to 58.0.
					694.0	45		
					689.0	50		

Howard R Green Company
CONSULTING ENGINEERS

PROJECT Interstate Power Company

PROJECT NUMBER 717880-J

SURFACE ELEVATION 739.3 Feet MSL

TOTAL DEPTH OF HOLE 93.5 Feet

LOG OF MW-6

LOCATION Lansing, Iowa

GEOLOGIST Barbara Torney

CaCO3	K (cm/sec)			MW-6	ELEVATION (ft, msl)	DEPTH (feet)	LITHOLOGY	MATERIALS DESCRIPTION
					684.0	55		
								Siltstone from 58.0 to 68.0.
					679.0	60		
					674.0	65		
								Interbedded sandstone and siltstone from 68.0 to 78.0.
					669.0	70		
					664.0	75		
								Siltstone from 78.0 to 83.0
					659.0	80		
								No sample from 83.0 to 93.5. Likely interbedded sandstone and siltstone by comparison to same interval on log of MW-4 and MW-5. Lower few feet may be primarily siltstone.
					654.0	85		
					649.0	90		
					644.0	95		
					639.0	100		

Howard R. Green Company
CONSULTING ENGINEERS

PROJECT Interstate Power Company
PROJECT NUMBER 717680-J
SURFACE ELEVATION 739.3 Feet MSL
TOTAL DEPTH OF HOLE 93.5 Feet

LOG OF MW-6

LOCATION Lansing, Iowa
GEOLOGIST Barbara Torney

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
IPL- Lansing Generating Station SCS#: 25215135.70		B-301

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Mike Mueller Cascade Drilling	11/2/2015	11/2/2015	hollow stem auger

Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		MW-301	Feet	639.4 Feet	8.0 in

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 3,957,744 N, 5,541,108 E S/C/N
NW 1/4 of SW 1/4 of Section 2, T 98 N, R 3 W
Lat ° ' "
Long ° ' "
Local Grid Location ☐ N ☐ E Feet ☐ S Feet ☐ W

Facility ID	County	Civil Town/City/ or Village
	Allamakee	Lansing

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–4	POORLY GRADED SAND, medium grained, very dark gray brown (10YR 3/2).	SP									
S1	23	10 31 38 48	3							M				
S2	24	32 47 50	4.5–7	POORLY GRADED SAND WITH SILT, medium grained, dark yellowish brown (10YR 3/4).	SP-SM					M				
S3	22	18 33 47 43	7–9.5	POORLY GRADED SAND WITH SILT AND GRAVEL, medium grained sand, large grained gravel, dark yellowish brown (10YR 3/6).	SP-SM					M				
S4	24	36 46 50	9.5–	POORLY GRADED SAND WITH SILT, medium grained, dark yellowish brown (10YR 3/6).						S				Water @ 10 ft bgs
S5	22	13 9 7 10	13		SP-SM					S				

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm	
Kyle Mu[illegible]	SCS Engineers 2830 Dairy Drive Madison, WI 53718	Tel: 608-224-2830 Fax:

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number B-301

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
S6	20	3 2 4	16, 17	SILT, black (10YR 3/1).	ML					S				
S7	24	2 2 2 2	18, 19	SILT WITH SAND, black (10YR 3/1).	ML					S				
S8	24	2 2 4	20, 21, 22	POORLY GRADED SAND WITH SILT, black (10YR 3/1).	SP-SM					S				
S9	24	2 9 12 14	23, 24, 25	SILT, dark olive gray (5Y 3/2).	ML					S				
			26	End of Boring at 26 ft bgs.										

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
IPL- Lansing Generating Station SCS#: 25215135.70		B-302

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Mike Mueller Cascade Drilling	11/4/2015	11/4/2015	hollow stem auger

Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		MW-302	Feet	635.9 Feet	8.0 in

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 3,957,929 N, 5,541,179 E S/C/N
NW 1/4 of SW 1/4 of Section 2, T 98 N, R 3 W
Lat ° ' "
Long ° ' "
Local Grid Location
Feet ☐ N ☐ S
Feet ☐ E ☐ W

Facility ID	County	Civil Town/City/ or Village
	Allamakee	Lansing

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0	POORLY GRADED SAND, medium grained, dark grayish brown (10YR 4/2).	SP									
S1	24	6 14 17 19	3							M				
S2	24	26 45 50	5.5	SANDY SILT, trace small gravel, black (10YR 3/1).	ML					M				
S3	24	12 13 10 8	8							M				
S4	11	9 11 13 12	10.5	Large gravel						S				Saturation @ 11 ft bgs
S5	8	32 23 30 36	13	Large gravel						S				

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm	
	SCS Engineers 2830 Dairy Drive Madison, WI 53718	Tel: 608-224-2830 Fax:

Boring Number B-302

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
S6	24	5 5 6 8	16, 17	SANDY SILT, trace small gravel, black (10YR 3/1). *(continued)*	ML					S				
S7	18		18, 19, 20	Silt, Black (10YR 3/1).	ML					S				
				End of Boring at 20 ft bgs.										

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
IPL- Lansing Generating Station SCS#: 25215135.70		B-303

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Mike Mueller Cascade Drilling	11/2/2015	11/2/2015	hollow stem auger

Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		MW-303	Feet	653.9 Feet	8.0 in

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 3,957,857 N, 5,541,622 E S/C/N
NW 1/4 of SW 1/4 of Section 2, T 98 N, R 3 W

Lat ___° ___' ___"
Long ___° ___' ___"

Local Grid Location
Feet ☐ N ☐ S Feet ☐ E ☐ W

Facility ID	County	Civil Town/City/ or Village
	Allamakee	Lansing

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–2.5	SILTY SAND, very dark gray (5Y 3/1).	SM									
S1	24	5 16 17 24	2.5–7	POORLY GRADED SAND, medium grained, dark grayish brown (10 YR 4/2).	SP					M				
S2	24	11 8 10								M				
S3	24	11 38 50	7–15	POORLY GRADED SAND , medium grained, grayish brown (2.5Y 5/2).	SP					M				
S4	18	16 35 50								M				
S5	16	27 50 50								M				

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature]

Firm SCS Engineers
2830 Dairy Drive Madison, WI 53718
Tel: 608-224-2830
Fax:

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number B-303

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
S6	0	38 50	16	POORLY GRADED SAND , medium grained, grayish brown (2.5Y 5/2). *(continued)*	SP					M				Rock in Spoon
S7	18	17 25 40 47	17, 18, 19							S				Saturation @17 ft bgs.
S8	17	37 48 44	20, 21, 22	POORLY GRADED SAND, medium grained, very dark gray (5Y 3/1).	SP					S				
S9	18	11 24 26 27	23, 24							S				
S10	24	37 50	25, 26, 27							S				
				End of Boring at 27 ft bgs.										

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SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
IPL Lansing Generating Station SCS#: 25218221.00		MW304

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Eric Wetzel Roberts Environmental Drilling, Inc.	5/15/2019	5/15/2019	4.25" HSA

Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		MW304	623.61 Feet MSL	635.5 Feet MSL	8.5 in

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 3,957,893 N, 5,540,876 E S/C/N
SE 1/4 of NE 1/4 of Section 3, T 98 N, R 3 W
Lat ___° ___' ___"
Long ___° ___' ___"
Local Grid Location ☐ N ☐ S Feet; ☐ E ☐ W Feet

Facility ID	County	Civil Town/City/ or Village
	Allamakee	Lansing

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–3	SILT, mottled, (10YR 3/2), some black coal looking material.	ML									
	12	3 6 3 3	2							M				
			3–5	LEAN CLAY, (10YR 4/3), soft, some organic material.	CL									
	18	1 2 2 1	4							W				
			5–9	SILT, (10YR 2/2), uniform, trace fine sand and clay.	ML									
	12	2 2 3 2	6							M				
	18	1 1 3 2	8							W				
			9–15	POORLY GRADED SAND, fine to coarse, (10YR 3/4), (Alluvial).	SP									
	18	1 2 1 1	10							W				
	12	0 0 1 1	12							W				
	12	0 0 1 1	14							W				

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm	
for Zach Watson	SCS Engineers 2830 Dairy Drive, Madison, WI 53718	Tel: Fax:

Boring Number MW304

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
		0 0 1 1	16	POORLY GRADED SAND, fine to coarse, (10YR 3/4), (Alluvial). *(continued)*	SP					W				
		2 5 6 6	17, 18, 19	Same as above but more coarse, (2.5YR 5/4), trace silt.						W				
			20	End of Boring at 20 feet.										

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SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
IPL Lansing Generating Station SCS#: 25218221.00		MW305

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Eric Wetzel Roberts Environmental Drilling, Inc.	5/16/2019	5/16/2019	4.25" HSA

Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		MW305	629.12 Feet MSL	631.8 Feet MSL	8.5 in

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 3,958,109 N, 5,541,533 E S/C/N
SE 1/4 of NW 1/4 of Section 2, T 98 N, R 3 W
Lat ___° ___' ___"
Long ___° ___' ___"
Local Grid Location
Feet ☐ N ☐ S
Feet ☐ E ☐ W

Facility ID	County	Civil Town/City/ or Village
	Allamakee	Lansing

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–9.5	Hydrovaced to 9.5 feet.										
			9.5	FAT CLAY, dark greenish gray, (GLEY 13/10Y), soft, trace red sand, wood pieces and roots.	CH									
	24	1 1 1 1	10–12							W				
	24	0 0 0 2	12–14							W				
			13.5, 14.5	Sand seams at 13.5 and 14.5 feet.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: For Zach Watson
Firm: SCS Engineers
2830 Dairy Drive, Madison, WI 53718
Tel:
Fax:

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number MW305

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
			16	FAT CLAY, dark greenish gray, (GLEY 13/10Y), soft, trace red sand, wood pieces and roots. *(continued)*	CH					W				
				End of Boring at 16 feet.										

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SOIL BORING LOG INFORMATION

Route To: Watershed/Wastewater ☐ Waste Management ☐
Remediation/Redevelopment ☐ Other ☐

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
IPL Lansing Generating Station SCS#: 25218221.00		MW306

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Eric Wetzel Roberts Environmental Drilling, Inc.	5/16/2019	5/16/2019	4.25" HSA

Unique Well No.	DNR Well ID No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		MW306	623.05 Feet MSL	636.7 Feet MSL	8.5 in

Local Grid Origin ☐ (estimated: ☐) or Boring Location ☒
State Plane 3,958,977 N, 5,541,203 E S/C/N
NE 1/4 of NW 1/4 of Section 2, T 98 N, R 3 W
Lat ° ' "
Long ° ' "
Local Grid Location
Feet ☐ N ☐ S Feet ☐ E ☐ W

Facility ID	County	Civil Town/City/ or Village
	Allamakee	Lansing

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Sample: Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
			0–12	Hydrovaced to 12 feet.										
	12	1 2 4 3	12–15	POORLY GRADED SAND, medium to coarse, rusty in color, (10YR 4/6), trace fine silt.	SP					W				

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm	
[signature] for Zach Watson	SCS Engineers 2830 Dairy Drive, Madison, WI 53718	Tel: Fax:

SCS ENGINEERS
Environmental Consultants and Contractors

SOIL BORING LOG INFORMATION SUPPLEMENT
Form 4400-122A

Boring Number MW306

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID/FID	Soil Properties: Standard Penetration	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
	18	1 2 2 4		POORLY GRADED SAND, medium to coarse, rusty in color, (10YR 4/6), trace fine silt. *(continued)*						W				
			16	Same as above but gray, (10YR 4/2).										
	18	1 1 2 2	17							W				
			18											
	18		19							W				
			20		SP									
	18		21							W				
			22											
	18	3 1 2 2	23							W				
			24											
	18	2 1 3 2	25							W				
			26	End of Boring at 26 feet.										

Appendix C

Information on Arsenic

Arsenic - ToxFAQs™

CAS # 7440-38-2

This fact sheet answers the most frequently asked health questions (FAQs) about arsenic. For more information, call the CDC Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to higher than average levels of arsenic occur mostly in the workplace, near hazardous waste sites, or in areas with high natural levels. At high levels, inorganic arsenic can cause death. Exposure to lower levels for a long time can cause a discoloration of the skin and the appearance of small corns or warts. Arsenic has been found in at least 1,149 of the 1,684 National Priority List (NPL) sites identified by the Environmental Protection Agency (EPA).

What is arsenic?

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds.

Inorganic arsenic compounds are mainly used to preserve wood. Copper chromated arsenate (CCA) is used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards.

What happens to arsenic when it enters the environment?

- Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching.
- Arsenic cannot be destroyed in the environment. It can only change its form.
- Rain and snow remove arsenic dust particles from the air.
- Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment.
- Fish and shellfish can accumulate arsenic; most of this arsenic is in an organic form called arsenobetaine that is much less harmful.

How might I be exposed to arsenic?

- Ingesting small amounts present in your food and water or breathing air containing arsenic.
- Breathing sawdust or burning smoke from wood treated with arsenic.
- Living in areas with unusually high natural levels of arsenic in rock.
- Working in a job that involves arsenic production or use, such as copper or lead smelting, wood treating, or pesticide application.

How can arsenic affect my health?

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs.

Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet.

Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.

Skin contact with inorganic arsenic may cause redness and swelling.

Almost nothing is known regarding health effects of organic arsenic compounds in humans. Studies in animals show that some simple organic arsenic compounds are less toxic than inorganic forms. Ingestion of methyl and dimethyl compounds can cause diarrhea and damage to the kidneys.

How likely is arsenic to cause cancer?

Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer. The Department of Health and Human Services (DHHS) and the EPA have determined that inorganic arsenic is a known human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans.

How can arsenic affect children?

There is some evidence that long-term exposure to arsenic in children may result in lower IQ scores. There is also some evidence that exposure to arsenic in the womb and early childhood may increase mortality in young adults.

There is some evidence that inhaled or ingested arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of arsenic that cause illness in pregnant females, can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

How can families reduce the risks of exposure to arsenic?

- If you use arsenic-treated wood in home projects, you should wear dust masks, gloves, and protective clothing to decrease exposure to sawdust.
- If you live in an area with high levels of arsenic in water or soil, you should use cleaner sources of water and limit contact with soil.
- If you work in a job that may expose you to arsenic, be aware that you may carry arsenic home on your clothing, skin, hair, or tools. Be sure to shower and change clothes before going home.

Is there a medical test to determine whether I've been exposed to arsenic?

There are tests available to measure arsenic in your blood, urine, hair, and fingernails. The urine test is the most reliable test for arsenic exposure within the last few days. Tests on hair and fingernails can measure exposure to high levels of arsenic over the past 6-12 months. These tests can determine if you have been exposed to above-average levels of arsenic. They cannot predict whether the arsenic levels in your body will affect your health.

Has the federal government made recommendations to protect human health?

The EPA has set limits on the amount of arsenic that industrial sources can release to the environment and has restricted or cancelled many of the uses of arsenic in pesticides. EPA has set a limit of 0.01 parts per million (ppm) for arsenic in drinking water.

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit (PEL) of 10 micrograms of arsenic per cubic meter of workplace air (10 $\mu g/m^3$) for 8 hour shifts and 40 hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Arsenic (Update). Atlanta, GA: U.S. Department of Health and Human Services. Public Health Service.

Where can I get more information?

For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, 1600 Clifton Road NE, Mailstop F-57, Atlanta, GA 30329-4027.

Phone: 1-800-232-4636

ToxFAQs™ Internet address via WWW is http://www.atsdr.cdc.gov/toxfaqs/index.asp.

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

This Public Health Statement is the summary chapter from the Toxicological Profile for Arsenic. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-800-232-4636.

This public health statement tells you about arsenic and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Arsenic has been found in at least 1,149 of the 1,684 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the possibility exists that the number of sites at which arsenic is found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to this substance may harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to arsenic, many factors will determine whether you will be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS ARSENIC?

Arsenic is a naturally occurring element that is widely distributed in the Earth's crust. Arsenic is classified chemically as a metalloid, having both properties of a metal and a nonmetal; however, it is frequently referred to as a metal. Elemental arsenic (sometimes referred to as metallic arsenic) is a steel grey solid material. However, arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is called inorganic arsenic. Arsenic combined with carbon and hydrogen is referred to as organic arsenic.

Most inorganic and organic arsenic compounds are white or colorless powders that do not evaporate. They have no smell, and most have no special taste. Thus, you usually cannot tell if arsenic is present in your food, water, or air.

Inorganic arsenic occurs naturally in soil and in many kinds of rock, especially in minerals and ores that contain copper or lead. When these ores are heated in smelters, most of the arsenic goes up the stack and enters the air as a fine dust. Smelters may collect this dust and take out the arsenic as a compound called arsenic trioxide (As_2O_3).

However, arsenic is no longer produced in the United States; all of the arsenic used in the United States is imported.

Presently, about 90% of all arsenic produced is used as a preservative for wood to make it resistant to rotting and decay. The preservative is copper chromated arsenate (CCA) and the treated wood is referred to as "pressure-treated." In 2003, U.S. manufacturers of wood preservatives containing arsenic began a voluntary transition from CCA to other wood preservatives that do not contain arsenic in wood products for certain residential uses, such as play structures, picnic tables, decks, fencing, and boardwalks. This phase out was completed on December 31, 2003; however, wood treated prior to this date could still be used and existing structures made with CCA-treated wood would not be affected. CCA-treated wood products continue to be used in industrial applications. It is not known whether, or to what extent, CCA-treated wood products may contribute to exposure of people to arsenic.

In the past, inorganic arsenic compounds were predominantly used as pesticides, primarily on cotton fields and in orchards. Inorganic arsenic compounds can no longer be used in agriculture. However, organic arsenic compounds, namely cacodylic acid, disodium methylarsenate (DSMA), and monosodium methylarsenate (MSMA), are still used as pesticides, principally on cotton. Some organic arsenic compounds are used as additives in animal feed. Small quantities of elemental arsenic are added to other metals to form metal mixtures or alloys with improved properties. The greatest use of arsenic in alloys is in lead-acid batteries for automobiles. Another important use of arsenic compounds is in semiconductors and light-emitting diodes.

1.2 WHAT HAPPENS TO ARSENIC WHEN IT ENTERS THE ENVIRONMENT?

Arsenic occurs naturally in soil and minerals and it therefore may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching. Volcanic eruptions are another source of arsenic. Arsenic is associated with ores containing metals, such as copper and lead. Arsenic may enter the environment during the mining and smelting of these ores. Small amounts of arsenic also may be released into the atmosphere from coal-fired power plants and incinerators because coal and waste products often contain some arsenic.

Arsenic cannot be destroyed in the environment. It can only change its form, or become attached to or separated from particles. It may change its form by reacting with oxygen or other molecules present in air, water, or soil, or by the action of bacteria that live in soil or sediment. Arsenic released from power plants and other combustion processes is usually attached to very small particles. Arsenic contained in wind-borne soil is generally found in larger particles. These particles settle to the ground or are washed out of the air by rain. Arsenic that is attached to very small particles may stay in the air for many days and travel long distances. Many common arsenic compounds can dissolve in water. Thus, arsenic can get into lakes, rivers, or underground water by dissolving in rain or snow or through the discharge of industrial wastes. Some of the arsenic will stick to particles in the water or sediment on the bottom of lakes or rivers, and some will be carried along by the water. Ultimately, most arsenic ends up in the soil or sediment. Although some fish and shellfish take in arsenic, which may build up in tissues, most of this arsenic is in an organic form called arsenobetaine (commonly called "fish arsenic") that is much less harmful.

1.3 HOW MIGHT I BE EXPOSED TO ARSENIC?

Since arsenic is found naturally in the environment, you will be exposed to some arsenic by eating food, drinking water, or breathing air. Children may also be exposed to arsenic by eating soil. Analytical methods used by scientists to determine the levels of arsenic in the environment generally do not determine the specific form of arsenic present. Therefore, we do not always know the form of arsenic a person may be exposed to. Similarly, we often do not know what forms of arsenic are present at hazardous waste sites. Some forms of arsenic may be so tightly attached to particles or embedded in minerals that they are not taken up by plants and animals.

The concentration of arsenic in soil varies widely, generally ranging from about 1 to 40 parts of arsenic to a million parts of soil (ppm) with an average level of 3–4 ppm. However, soils in the vicinity of arsenic-rich geological deposits, some mining and smelting sites, or agricultural areas where arsenic pesticides had been applied in the past may contain much higher levels of arsenic. The concentration of arsenic in natural surface and groundwater is generally about 1 part in a billion parts of water (1 ppb), but may exceed 1,000 ppb in contaminated areas or where arsenic levels in soil are high. Groundwater is far more likely to contain high levels of arsenic than surface water. Surveys of U.S. drinking water indicate that about 80% of water supplies have less than 2 ppb of arsenic, but 2% of supplies exceed 20 ppb of arsenic. Levels of arsenic in food range from about 20 to 140 ppb. However, levels of inorganic arsenic, the form of most concern, are far lower. Levels of arsenic in the air generally range from less than 1 to about 2,000 nanograms (1 nanogram equals a billionth of a gram) of arsenic per cubic meter of air (less than 1–2,000 ng/m^3), depending on location, weather conditions, and the level of industrial activity in the area. However, urban areas generally have mean arsenic levels in air ranging from 20 to 30 ng/m^3.

You normally take in small amounts of arsenic in the air you breathe, the water you drink, and the food you eat. Of these, food is usually the largest source of arsenic. The predominant dietary source of arsenic is seafood, followed by rice/rice cereal, mushrooms, and poultry. While seafood contains the greatest amounts of arsenic, for fish and shellfish, this is mostly in an organic form of arsenic called arsenobetaine that is much less harmful. Some seaweeds may contain arsenic in inorganic forms that may be more harmful. Children are likely to eat small amounts of dust or soil each day, so this is another way they may be exposed to arsenic. The total amount of arsenic you take in from these sources is generally about 50 micrograms (1 microgram equals one-millionth of a gram) each day. The level of inorganic arsenic (the form of most concern) you take in from these sources is generally about 3.5 microgram/day. Children may be exposed to small amounts of arsenic from hand-to-mouth activities from playing on play structures or decks constructed out of CCA-treated wood. The potential exposure that children may receive from playing in play structures constructed from CCA-treated wood is generally smaller than that they would receive from food and water.

In addition to the normal levels of arsenic in air, water, soil, and food, you could be exposed to higher levels in several ways, such as the following:

- Some areas of the United States contain unusually high natural levels of arsenic in rock, and this can lead to unusually high levels of arsenic in soil or water. If you live in an area like this, you could take in elevated amounts of arsenic in drinking water. Children may be taking in higher amounts of arsenic because of hand-to-mouth contact or eating soil in areas with higher than usual arsenic concentrations.

- Some hazardous waste sites contain large quantities of arsenic. If the material is not properly disposed of, it can get into surrounding water, air, or soil. If you live near such a site, you could be exposed to elevated levels of arsenic from these media.

- If you work in an occupation that involves arsenic production or use (for example, copper or lead smelting, wood treating, or pesticide application), you could be exposed to elevated levels of arsenic during your work.

- If you saw or sand arsenic-treated wood, you could inhale some of the sawdust into your nose or throat. Similarly, if you burn arsenic-treated wood, you could inhale arsenic in the smoke.

- If you live in a former agricultural area where arsenic was used on crops, the soil could contain high levels of arsenic.

- In the past, several kinds of products used in the home (rat poison, ant poison, weed killer, some types of medicines) had arsenic in them. However, most of these uses of arsenic have ended, so you are not likely to be exposed from home products any longer.

1.4 HOW CAN ARSENIC ENTER AND LEAVE MY BODY?

If you swallow arsenic in water, soil, or food, most of the arsenic may quickly enter into your body. The amount that enters your body will depend on how much you swallow and the kind of arsenic that you swallow. This is the most likely way for you to be exposed near a waste site. If you breathe air that contains arsenic dusts, many of the dust particles settle onto the lining of the lungs. Most of the arsenic in these particles is then taken up from the lungs into the body. You might be exposed in this way near waste sites where arsenic-contaminated soils are allowed to blow into the air, or if you work with arsenic-containing soil or products. If you get arsenic-contaminated soil or water on your skin, only a small amount will go through your skin into your body, so this is usually not of concern.

Both inorganic and organic forms leave your body in your urine. Most of the inorganic arsenic will be gone within several days, although some will remain in your body for several months or even longer. If you are exposed to organic arsenic, most of it will leave your body within several days.

1.5 HOW CAN ARSENIC AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal care guidelines because laws today protect the welfare of research animals.

Inorganic arsenic has been recognized as a human poison since ancient times, and large oral doses (above 60,000 ppb in water which is 10,000 times higher than 80% of U.S. drinking water arsenic levels) can result in death. If you swallow lower levels of inorganic arsenic (ranging from about 300 to 30,000 ppb in water; 100–10,000 times higher than most U.S. drinking water levels), you may experience irritation of your stomach and intestines, with symptoms such as stomachache, nausea, vomiting, and diarrhea. Other effects you might experience from swallowing inorganic arsenic include decreased production of red and white blood cells, which may cause fatigue, abnormal heart rhythm, blood-vessel damage resulting in bruising, and impaired nerve function causing a "pins and needles" sensation in your hands and feet.

Perhaps the single-most characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. These include patches of darkened skin and the appearance of small "corns" or "warts" on the palms, soles, and torso, and are often associated with changes in the blood vessels of the skin. Skin cancer may also develop. Swallowing arsenic has also been reported to increase the risk of cancer in the liver, bladder, and lungs. The Department of Health and Human Services (DHHS) has determined that inorganic arsenic is known to be a human carcinogen (a chemical that causes cancer). The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans. EPA also has classified inorganic arsenic as a known human carcinogen.

If you breathe high levels of inorganic arsenic, then you are likely to experience a sore throat and irritated lungs. You may also develop some of the skin effects mentioned above. The exposure level that produces these effects is uncertain, but it is probably above 100 micrograms of arsenic per cubic meter ($\mu g/m^3$) for a brief exposure. Longer exposure at lower concentrations can lead to skin effects, and also to circulatory and peripheral nervous disorders. There are some data suggesting that inhalation of inorganic arsenic may also interfere with normal fetal development, although this is not certain. An important concern is the ability of inhaled inorganic arsenic to increase the risk of lung cancer. This has been seen mostly in workers exposed to arsenic at smelters, mines, and chemical factories, but also in residents living near smelters and arsenical chemical factories. People who live near waste sites with arsenic may have an increased risk of lung cancer as well.

If you have direct skin contact with high concentrations of inorganic arsenic compounds, your skin may become irritated, with some redness and swelling. However, it does not appear that skin contact is likely to lead to any serious internal effects.

Almost no information is available on the effects of organic arsenic compounds in humans. Studies in animals show that most simple organic arsenic compounds (such as methyl and dimethyl compounds) are less toxic than the inorganic forms. In animals, ingestion of methyl compounds can result in diarrhea, and lifetime exposure can damage the kidneys. Lifetime exposure to dimethyl compounds can damage the urinary bladder and the kidneys.

1.6 HOW CAN ARSENIC AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

Children are exposed to arsenic in many of the same ways that adults are. Since arsenic is found in the soil, water, food, and air, children may take in arsenic in the air they breathe, the water they drink, and the food they eat. Since children tend to eat or drink less of a variety of foods and beverages than do adults, ingestion of contaminated food or juice or infant formula made with arsenic-contaminated water may represent a significant source of exposure. In addition, since children often play in the soil and put their hands in their mouths and sometimes intentionally eat soil, ingestion of contaminated soil may be a more important source of arsenic exposure for children than for adults. In areas of the United States where natural levels of arsenic in the soil and water are high, or in areas in and around contaminated waste sites, exposure of children to arsenic through ingestion of soil and water may be significant. In addition, contact with adults who are wearing clothes contaminated with arsenic (e.g., with dust from copper- or lead-smelting factories, from wood-treating or pesticide application, or from arsenic-treated wood) could be a source of exposure. Because of the tendency of children to taste things that they find, accidental poisoning from ingestion of pesticides is also a possibility. Thus, although most of the exposure pathways for children are the same as those for adults, children may be at a higher risk of exposure because of normal hand-to-mouth activity.

Children who are exposed to inorganic arsenic may have many of the same effects as adults, including irritation of the stomach and intestines, blood vessel damage, skin changes, and reduced nerve function. Thus, all health effects observed in adults are of potential concern in children. There is also some evidence that suggests that long-term exposure to inorganic arsenic in children may result in lower IQ scores. We do not know if absorption of inorganic arsenic from the gut in children differs from adults.

There is some evidence that exposure to arsenic in early life (including gestation and early childhood) may increase mortality in young adults.

There is some evidence that inhaled or ingested inorganic arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of inorganic arsenic that cause illness in pregnant females can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

In animals, exposure to organic arsenic compounds can cause low birth weight, fetal malformations, and fetal deaths. The dose levels that cause these effects also result in effects in the mothers.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO ARSENIC?

If your doctor finds that you have been exposed to substantial amounts of arsenic, ask whether your children might also have been exposed. Your doctor might need to ask your state health department to investigate.

Many communities may have high levels of arsenic in their drinking water, particularly from private wells, because of contamination or as a result of the geology of the area. The north central region and the western region of the United States have the highest arsenic levels in surface water and groundwater sources, respectively. Wells used to provide water for drinking and cooking should be tested for arsenic. As of January 2006, EPA's Maximum Contaminant Level (MCL) for arsenic in drinking water is 10 ppb. If you have arsenic in your drinking water at levels higher that the EPA's MCL, an alternative source of water should be used for drinking and cooking should be considered.

If you use arsenic-treated wood in home projects, personal protection from exposure to arsenic-containing sawdust may be helpful in limiting exposure of family members. These measures may include dust masks, gloves, and protective clothing. Arsenic-treated wood should never be burned in open fires, or in stoves, residential boilers, or fire places, and should not be composted or used as mulch. EPA's Consumer Awareness Program (CAP) for CCA is a voluntary program established by the manufacturers of CCA products to inform consumers about the proper handling, use, and disposal of CCA-treated wood. You can find more information about this program in Section 6.5. Hand washing can reduce the potential exposure of children to arsenic after playing on play structures constructed with CCA-treated wood, since most of the arsenic on the children's hands was removed with water.

If you live in an area with a high level of arsenic in the water or soil, substituting cleaner sources of water and limiting contact with soil (for example, through use of a dense groundcover or thick lawn) would reduce family exposure to arsenic. By paying careful attention to dust and soil control in the home (air filters, frequent cleaning), you can reduce family exposure to contaminated soil. Some children eat a lot of soil. You should prevent your children from eating soil. You should discourage your children from putting objects in their mouths. Make sure they wash their hands frequently and before eating. Discourage your children from putting their hands in their mouths or engaging in other hand-to-mouth activities. Since arsenic may be found in the home as a pesticide, household chemicals containing arsenic should be stored out of reach of young children to prevent accidental poisonings. Always store household chemicals in their original labeled containers; never store household chemicals in containers that children would find attractive to eat or drink from, such as old soda bottles. Keep your Poison Control Center's number by the phone.

It is sometimes possible to carry arsenic from work on your clothing, skin, hair, tools, or other objects removed from the workplace. This is particularly likely if you work in the fertilizer, pesticide, glass, or copper/lead smelting industries. You may contaminate your car, home, or other locations outside work where children might be exposed to arsenic. You should know about this possibility if you work with arsenic.

Your occupational health and safety officer at work can and should tell you whether chemicals you work with are dangerous and likely to be carried home on your clothes, body, or tools and whether you should be showering and changing clothes before you leave work, storing your street clothes in a separate area of the workplace, or laundering your work clothes at home separately from other clothes. Material safety data sheets (MSDS) for many chemicals used should be found at your place of work, as required by the Occupational Safety and Health Administration (OSHA) in the U.S. Department of Labor. MSDS information should include chemical names and hazardous ingredients, and important properties, such as fire and explosion data, potential health effects, how you get the chemical(s) in your body, how to properly handle the materials, and what to do in the case of emergencies. Your employer is legally responsible for providing a safe workplace and should freely answer your questions about hazardous chemicals. Your state OSHA-approved occupational safety and health program or OSHA can answer any further questions and help your employer identify and correct problems with hazardous substances. Your state OSHA-approved occupational safety and health program or OSHA will listen to your formal complaints about workplace health hazards and inspect your workplace when necessary. Employees have a right to seek safety and health on the job without fear of punishment.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO ARSENIC?

Several sensitive and specific tests can measure arsenic in your blood, urine, hair, or fingernails, and these tests are often helpful in determining if you have been exposed to above-average levels of arsenic in the past. These tests are not usually performed in a doctor's office. They require sending the sample to a testing laboratory.

Measurement of arsenic in your urine is the most reliable means of detecting arsenic exposures that you experienced within the last several days. Most tests measure the total amount of arsenic present in your urine. This can sometimes be misleading, because the nonharmful forms of arsenic in fish and shellfish can give a high reading even if you have not been exposed to a toxic form of arsenic. For this reason, laboratories sometimes use a more complicated test to separate "fish arsenic" from other forms. Because most arsenic leaves your body within a few days, analysis of your urine cannot detect if you were exposed to arsenic in the past. Tests of your hair or fingernails can tell if you were exposed to high levels over the past 6–12 months, but these tests are not very useful in detecting low-level exposures. If high levels of arsenic are detected, this shows that you have been exposed, but unless more is known about when you were exposed and for how long, it is usually not possible to predict whether you will have any harmful health effects.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health, but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as "not-to-exceed" levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for ARSENIC include the following:

The federal government has taken several steps to protect humans from arsenic. First, EPA has set limits on the amount of arsenic that industrial sources can release into the environment. Second, EPA has restricted or canceled many of the uses of arsenic in pesticides and is considering further restrictions. Third, in January 2001, the EPA lowered the limit for arsenic in drinking water from 50 to 10 ppb. Finally, OSHA has established a permissible exposure limit (PEL), 8-hour time-weighted average, of 10 $\mu g/m^3$ for airborne arsenic in various workplaces that use inorganic arsenic.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below.

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses that result from exposure to hazardous substances.

Toxicological profiles are also available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information and technical assistance number at 1-800-CDCINFO (1-800-232-4636), by e-mail at cdcinfo@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Environmental Medicine
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

Organizations for-profit may request copies of final Toxicological Profiles from the following:

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: http://www.ntis.gov/