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WRITER'S DIRECT DIAL NO:
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March 25, 2025

Delivered Electronically

Mr. Clinton Woods, Commissioner
Indiana Department of Environmental Management
100 N. Senate Avenue
Mail Code 50-01
Indianapolis, IN 46204-2251

Dear Mr. Woods,

Re: Indiana-Kentucky Electric Corporation
Notification of CCR Rule Information Posting
Assessment of Corrective Measure Report
Clifty Creek Type I Landfill

As required by 40 CFR 257.106(h)(7), the Indiana-Kentucky Electric Corporation (IKEC) is providing notification to the Commissioner of the Indiana Department of Environmental Management that the Clifty Creek Type I Landfill Assessment of Corrective Measures (ACM) Report has been added to the company's publicly accessible internet site. The Clifty Creek Type I Landfill ACM Report will be used to support the ongoing evaluation of potential corrective measures for the Type I Landfill.

As required by 40 CFR 257.96(d), this report provides an update and details of the effectiveness of the potential corrective measures. The report was prepared by AGES, Inc., the site's hydrogeologist, using 40 CFR 257.24 as a basis for the selection of potential remedies. Per 40 CFR 257.106(h)(8), this letter provides notification that the report has been placed in the facility's operating record, as well as on the company's publicly accessible internet site and can be viewed at https://www.ovec.com/CCRCompliance.php . As required by 40 CFR 257.96(e), IKEC will discuss the results of the corrective measures at least 30 days prior to the selection of remedy in a public meeting with interested and affected parties.

If you have any questions, or require any additional information, please call me at (740) 289-7259.

Sincerely,

Jeremy Galloway
Environmental Specialist
JDG:zsh

AGES
Applied Geology And Environmental Science, Inc.

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COAL COMBUSTION RESIDUALS REGULATION ASSESSMENT OF CORRECTIVE MEASURES REPORT

TYPE I RESIDUAL WASTE LANDFILL
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA

MARCH 2025

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

Prepared by:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
TYPE I RESIDUAL WASTE LANDFILL
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CLIFTY CREEK STATION
MADISON, INDIANA

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Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

Prepared by:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

Travis Sitko
Scientist I

Robert W. King, P.G.
Chief Hydrogeologist

COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
TYPE I RESIDUAL WASTE LANDFILL
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CLIFTY CREEK STATION
MADISON, INDIANA

LIST OF ACRONYMS

ACM	Assessment of Corrective Measures
AGES	Applied Geology and Environmental Science, Inc.
ASD	Alternate Source Demonstration
bgs	Below Ground Surface
CCR	Coal Combustion Residuals
ft/day	Feet per Day
GMPP	Groundwater Monitoring Program Plan
GWPS	Groundwater Protection Standard
IDEM	Indiana Department of Environmental Management
IKEC	Indiana-Kentucky Electric Corporation
LRCP	Landfill Runoff Collection Pond
MNA	Monitored Natural Attenuation
MW	Megawatt
mV	Millivolts
NPDES	National Pollution Discharge Elimination System
O&M	Operations and Maintenance
ORP	Oxidation Reduction Potential
PRB	Permeable Reactive Barrier
RCRA	Resource Conservation and Recovery Act
SSL	Statistically Significant Level
SSI	Statistically Significant Increase
Stantec	Stantec Consulting Services, Inc.
StAP	Statistical Analysis Plan
SU	Standard Unit
Type I Landfill	Type I Residual Waste Landfill
U.S. EPA	United States Environmental Protection Agency
ug/L	Micrograms per Liter
WBSP	West Boiler Slag Pond

COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
TYPE I RESIDUAL WASTE LANDFILL
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA

1.0 INTRODUCTION

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final CCR regulation which regulates CCR as a non-hazardous waste under Subtitle D of the Resource Conservation and Recovery Act (RCRA) and became effective six (6) months from the date of its publication (April 17, 2015) in the Federal Register, referred to as the "CCR Rule." The rule applies to new and existing landfills, and surface impoundments used to dispose of or otherwise manage CCR generated by electric utilities and independent power producers. Because the rule was promulgated under Subtitle D of RCRA, it does not require regulated facilities to obtain permits, does not require state adoption, and cannot be enforced by the U.S. EPA.

The CCR Rule in 40 CFR § 257.96(a) requires that an owner or operator initiate an Assessment of Corrective Measures (ACM) to prevent further release, to remediate any releases, and to restore the affected area(s) to original conditions in the event that any Appendix IV constituent has been detected at a Statistically Significant Level (SSL) greater than a Groundwater Protection Standard (GWPS). The ACM must be completed within 90 days after initiation.

This ACM Report has been prepared to comply with 40 CFR § 257.90(c) of the CCR Rule and documents the results that are the basis for the evaluation of potential corrective measure remedial technologies. This report includes a summary of groundwater monitoring conducted to date, along with the results of site characterization activities. Finally, potential remedial technologies are identified in this report and evaluated against requirements, as specified in the CCR Rule.

2.0 SITE BACKGROUND

The Clifty Creek Station, located in Madison, Indiana, is a 1,304-megawatt (MW) coal-fired generating power plant operated by the Indiana-Kentucky Electric Corporation (IKEC), a subsidiary of the Ohio Valley Electric Corporation. The Clifty Creek Station has six (6) 217.26-MW generating units and has operated since 1955 (Figure 2-1). Beginning in 1955, coal combustion residual (CCR) products were sluiced to disposal ponds in the plant site.
There are three (3) CCR units at the Clifty Creek Station (Figure 2-1):

- Type I Residual Waste Landfill (Type I Landfill);

- Landfill Runoff Collection Pond (LRCP); and
- West Boiler Slag Pond (WBSP).

Under the CCR program, IKEC installed a groundwater monitoring network at each unit in accordance with the requirements of the CCR Rule. The Type I Landfill and LRCP are part of one (1) multi-unit monitoring system. From January 2016 through August 2017, nine (9) rounds of background groundwater monitoring were conducted at all of the CCR units. The first round of Detection Monitoring was performed in March 2018.

From March 2018 through March 2024, 13 rounds of Detection Monitoring were conducted at the Type I Landfill, and the statistical evaluations identified potential Statistically Significant Increase (SSIs) for Boron in wells CF-15-07 and/or CF-15-08, which were confirmed with resampling. After each event, an Alternative Source Demonstration (ASD) was conducted and certified to demonstrate that the Type I Landfill was not the source of Boron as historical data indicated the presence of Boron in groundwater prior to construction of the Type I Landfill. It was determined that the “foundation soils” that extend beneath the Type I Landfill and the hydraulically placed fly ash southwest of the Ohio River provide a direct hydraulic connection between the historic, hydraulically placed fly ash and were the source of Boron (AGES 2024a). From 2018 through 2023, the Type I Landfill remained in Detection Monitoring under the CCR program.

In March 2024, a potential SSI for Chloride (Appendix III constituent) was noted in well CF-15-08; the SSI was confirmed during a resampling event in June 2024. Results of the sampling are presented in the 2024 Annual Groundwater Monitoring and Corrective Action Report (AGES 2025). To evaluate whether an alternate source of Chloride was present, IKEC opted to pursue an ASD that included conducting a long-purge groundwater sampling event of well CF-15-08 for Chloride in late July 2024. As the SSI for Chloride was still present, the ASD was unsuccessful. In accordance with 40 CFR § 257.94(e), IKEC established an Assessment Monitoring Program meeting the requirements of 40 CFR § 257.95 and prepared a notification stating that an Assessment Monitoring Program had been established at the Type I Landfill.

Details regarding the initial round of assessment monitoring and further site characterization activities are presented below.

3.0 GEOLOGY AND HYDROGEOLOGY

3.1 Regional Setting

The site lies in the Central Lowland Physiographic Province along the western flanks of the Cincinnati Arch and within the Central Stable Region. The stratigraphic sequence in the regional area consists of widespread discontinuous layers of Quaternary deposits of alluvial and glacial origin overlying sedimentary rocks generally consisting of limestones, dolomites, and interbedded shale. The exposed sedimentary rocks range in age from Mississippian to Ordovician. The

Quaternary deposits are largely of glacial origin and consist of loess, till, and outwash. Glacial outwash is present in nearly all of the stream valleys north of and including the Ohio River valley. The outwash is covered, in some cases, by a veneer of recent alluvial deposits from active streams.

Unconsolidated alluvial sediments deposited along the Ohio River valley, near or adjacent to the river constitute the major aquifer of the region. These deposits are normally found only within the Ohio River valley and the tributary streams north and northeast of the river. Wells installed in this aquifer typically yield 100 to 1,000 gallons per minute (gpm) depending upon their location and construction. The Ohio River valley is incised into Ordovician bedrock. The low permeability bedrock forms the lateral and underlying confinement to the aquifer.

3.2 Unit-Specific Setting

Bedrock beneath the Type I Landfill consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 feet of clayey gravel with sand (AGES 2018a). The clayey gravel with sand is overlain by a lean clay with sand, which is overlain by a fine to medium sand with gravel, silt, and clay (Figure 3-1). The uppermost unit in the area is a surficial layer of silty clay. A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP (Figure 3-2). The Devil's Backbone acts as an impermeable barrier that forces groundwater passing beneath the Type I Landfill to flow either toward the northeast or toward the southwest (Figure 3-3).

Based on historic aquifer testing conducted at the site, the upper lean clay deposits exhibit low permeability, do not yield adequate quantities of water to wells, and are considered to be an aquitard. The underlying fine-medium sand with silt is considered to be an unconfined or possibly semi-confined aquifer and is therefore designated as the uppermost aquifer at the Type I Landfill.

4.0 SUMMARY OF GROUNDWATER MONITORING PROGRAM: TYPE I LANDFILL

In accordance with 40 CFR § 257.90 (e) of the CCR Rule, Annual Groundwater Monitoring and Corrective Action Reports have been prepared for the Clifty Creek Station for CCR program activities conducted from 2017 through 2024 (AGES 2018a, 2019a, 2020a, 2021, 2023, 2024b, and 2025). The reports documented the status of the groundwater monitoring and corrective action program for each CCR unit, summarized the key actions completed during these years, described any problems encountered, discussed actions to resolve the problems, and projected key activities for the upcoming year.

4.1 Groundwater Monitoring Network

As detailed in the Monitoring Well Installation Report (AGES 2018b) and the 2024 Annual Groundwater Monitoring and Corrective Action Report (AGES 2025), the CCR groundwater monitoring network for the Type I Landfill includes the following eight (8) wells:

- CF-15-04 (Background);
- CF-15-05 (Background);
- CF-15-06 (Background);
- CF-15-07 (Downgradient);
- CF-15-08 (Downgradient);
- CF-15-09 (Downgradient);
- WBSP-15-01 (Background); and
- WBSP-15-02 (Background).

The locations of the wells in the groundwater monitoring network are shown on Figure 4-1. As listed above and shown in Table 4-1, the CCR groundwater monitoring network for the Type I Landfill includes five (5) background and three (3) downgradient wells, which satisfies the requirements of the CCR Rule. Generalized groundwater flow maps (including the Ohio River) for March 2023, September 2023, and March 2024 are included in Appendix A.

4.2 Groundwater Sampling

In September 2024, groundwater samples were collected from all wells at the Type I Landfill in accordance with the Groundwater Monitoring Program Plan (GMPP) (AGES 2018c). As the Type I Landfill and LRCP are part of a multi-unit monitoring network, this event was considered the first round of Assessment Monitoring for the Type I Landfill and the thirteenth round of Assessment Monitoring for the LRCP. All samples were shipped to an off-site laboratory for analysis of Appendix III and Appendix IV constituents of the CCR Rule.

4.3 Analytical Results

Upon receipt, the September 2024 Assessment Monitoring data were statistically evaluated in accordance with 40 CFR § 257.93(f) of the CCR Rule and the Statistical Analysis Plan (StAP) (Stantec 2021) (Table 4-2). No SSIs for Appendix III constituents were identified in this round. However, as the unit was already in Assessment Monitoring, IKEC established a GWPS for each detected Appendix IV constituent per 40 CFR § 257.95(d) (Table 4-3). Appendix IV SSLs were noted for wells CF-15-07 (Arsenic) and CF-15-08 (Molybdenum) at concentrations exceeding their GWPS (10 micrograms per liter [ug/L] and 100 ug/L, respectively) (Table 4-4). Per the StAP, IKEC resampled the wells in December 2024; the SSLs in well CF-15-07 (Arsenic) and CF-15-08 (Molybdenum) were still confirmed (Table 4-5).

Based on these SSLs, IKEC proceeded to characterize the nature and extent of the release, completed required notifications, and initiated an ACM in accordance with 40 CFR § 257.95 (g). Results of these activities are presented in the following sections of this report.

5.0 CCR SITE CHARACTERIZATION ACTIVITIES

As specified in the CCR Rule in 40 CFR § 257.95(g)(1), further characterization of the nature and extent of the release to groundwater at the Type I Landfill was required. The objectives of the characterization were to:

- Install additional monitoring wells necessary to define the contaminant plume(s);
- Collect data on the nature of the material released including specific information on the constituents listed in Appendix IV and at the levels at which they are present in the material released;
- Install at least one (1) additional monitoring well at the facility boundary in the direction of contaminant migration and sample this well in accordance with § 257.95 (d)(1); and
- Sample all wells in accordance with § 257.95 (d)(1) to characterize the nature and extent of the release.

As an alternate source for Boron at the LRCP could not be established, the LRCP remained in Assessment Monitoring. Based on Molybdenum SSLs at the unit, an ACM was initiated in May 2019. As part of that ACM, IKEC installed two (2) boundary wells (CF-19-14 and CF-19-15) in the area downgradient of the LRCP, which includes the Type I Landfill. Routine sampling of all wells associated with the LRCP has been conducted since 2019 to characterize and monitor Molybdenum concentrations in groundwater downgradient of the LRCP and Type I Landfill. Based on the ongoing monitoring, Molybdenum concentrations in the uppermost aquifer exceeding the GWPS of 100 ug/L are confined to the site and are not reaching the Ohio River. Further action to characterize Molybdenum in groundwater downgradient of the Type I Landfill is, therefore, not required. The results of the ongoing sampling for Molybdenum are presented in the ACM Report for the LRCP (AGES 2019), the ACM Addendum Report for LRCP (AGES 2020), and the most recent Annual Groundwater Monitoring and Corrective Action Report for the site (AGES 2025).

5.1 Groundwater Flow

Groundwater elevation data from September 2024 was used to prepare a groundwater flow map for the area downgradient of the Type I Landfill (Table 5-1 and Figure 5-1). As shown, groundwater in the uppermost aquifer beneath the Type I Landfill flows to the south toward the Ohio River. Historic groundwater elevation data indicates that groundwater flow beneath the Type I Landfill is affected by the flow and water level in the Ohio River and evidence of several temporary flow reversals have been observed.

5.2 Groundwater Flow Velocity

Using groundwater flow data from September 2024 and hydraulic conductivity data from the recent slug tests (Tables 5-1 and 5-2), the average groundwater flow velocity for the uppermost aquifer beneath the Type I Landfill was estimated at 0.387 feet per day (ft/day) (Table 5-2). With this flow velocity and a distance between wells CF-15-08 and CF-19-15 (at the property boundary) of approximately 523 feet, the travel time for groundwater to flow between wells CF-15-08 and CF-19-15 is approximately four (4) years.

5.3 Groundwater Sampling: Arsenic at Property Boundary

To evaluate the extent of Arsenic in groundwater at the Type I Landfill, monitoring wells CF-19-14 and CF-19-15 were sampled for Arsenic in December 2024 in accordance with GMPP (AGES 2024). The monitoring wells were purged using a pump to remove stagnant water in the casing and to ensure that a representative groundwater sample was collected. Samples were collected in laboratory-provided, pre-preserved (if necessary) bottleware. All bottles were labeled with the unique sample number, time and date of sample collection, and the identity of the sampling fraction. Field parameters were measured and recorded on purging forms at the time of sample collection. Following sample collection, the samples were packed on ice in coolers insulated to four (4) degrees centigrade and shipped to Eurofins Environment Testing analytical laboratory in Buffalo, New York.

Arsenic was not detected above the GWPS of 10 ug/L in either property boundary well (0.55 ug/L [CF-19-14] and 0.56 ug/L [CF-19-15]) (Table 5-3 and Figure 5-2). Based on these results, Arsenic concentrations in the uppermost aquifer exceeding the GWPS of 10 ug/L are confined to the site and are not reaching the Ohio River. As of December 2024, boundary monitoring wells CF-19-14 and CF-19-15 were added to the Type I Landfill groundwater monitoring network.

6.0 ASSESSMENT OF CORRECTIVE MEASURES

Groundwater monitoring of the uppermost aquifer at the Type I Landfill has identified Arsenic and Molybdenum (Appendix IV constituents) at concentrations that exceed their GWPS defined under 40 CFR § 257.95(h); therefore, an ACM is necessary. The ACM requires the identification and evaluation of technologies and methods that may be used as elements of remedial actions to meet the requirements of the CCR Rule. These elements include potential source control methods and various groundwater remedial technologies that may be applicable to the Type I Landfill. Additional remedial technologies may also be evaluated at a later date, if determined to be applicable and appropriate.

6.1 Potential Source Control Measures

The objective of source control measures is to prevent further releases from the source (i.e., the Type I Landfill). According to 40 CFR § 257:

"Remedies must control the source of the contamination to reduce or eliminate further releases by identifying and locating the cause of the release. Source control measures may include the following: Modifying the operational procedures (e.g., banning waste disposal); undertaking more extensive and effective maintenance activities (e.g., excavate waste to repair a liner failure); or, in extreme cases, excavation of deposited wastes for treatment and/ or offsite disposal. Construction and operation requirements also should be evaluated."

The Type I Landfill is a properly constructed and double-lined disposal unit, consisting of approximately 109 acres, which has been approved by the Indiana Department of Environmental Management (IDEM) as a Type I Residual Waste Landfill; 34 additional acres of the Type I Landfill have been closed under the IDEM landfill permit requirements. Given the construction of the Type I Landfill, releases from the unit to groundwater are unlikely.

As noted above, the Type I Landfill and adjacent LRCP, the more likely source of releases, are part of the multi-unit groundwater monitoring network. In accordance with the CCR closure and post-closure requirements of 40 CFR § 257.102 and 40 CFR § 257.104, IKEC will close and maintain the LRCP in a manner consistent with recognized and generally accepted good engineering practices and in compliance within timeframes specified within the CCR Rule.

6.2 Objectives of Remedial Technology Evaluation

Per 40 CFR § 257.96(a), the objectives of the corrective measures evaluated in this ACM Report are "to prevent further releases, to remediate any releases, and to restore affected area to original conditions." As required in 40 CFR § 257.97(b), corrective measures, at minimum, must:

(1) Be protective of human health and the environment;

(2) Attain the groundwater protection standard as specified pursuant to § 257.95(h);

(3) 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;

(4) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;

(5) Comply with standards for management of wastes as specified in § 257.98(d).

6.3 Potential Remedial Technologies

The focus of corrective measures for the Type I Landfill is to address Arsenic and Molybdenum in groundwater that exceeded the GWPS. To accomplish this, the following three (3) types of technologies are presented below:

- In-Situ Groundwater Remedial Technologies;
- Ex-Situ Groundwater Remedial Technologies; and
- Treatment of Extracted Groundwater.

The detailed ACM evaluation is provided in Table 6-1 and summarized below. Additional remedial technologies may also be evaluated if determined to be applicable and appropriate.

6.3.1 In-Situ Groundwater Remedial Technologies

In-situ groundwater remediation approach involves treating the groundwater where it is presently situated, rather than removing and transferring it elsewhere for treatment and disposal. Long-term groundwater monitoring would be required to evaluate the effectiveness of any of these technologies. In-situ groundwater remediation technologies are discussed below.

6.3.1.1 Monitored Natural Attenuation (MNA)

MNA is a strategy and set of procedures used to demonstrate that physical, chemical and/or biological processes in an aquifer will reduce concentrations of constituents to levels below applicable standards. These processes attenuate the concentrations of inorganics in groundwater by physical and chemical means (e.g., dispersion, dilution, sorption, and/or precipitation). Dilution from recharge to shallow groundwater, mineral precipitation, and constituent adsorption will occur over time, which will further reduce constituent concentrations through attenuation. Regular monitoring of select groundwater monitoring wells is conducted to ensure constituent concentrations in groundwater are attenuating over time.

6.3.1.2 Groundwater Migration Barriers

Low permeability barriers can be installed below the ground surface to prevent groundwater flow from reaching locations that pose a threat to receptors. Barriers can be installed with continuous trenching techniques using bentonite or other slurries as a barrier material to prevent the migration of groundwater. Barriers of cement/concrete and sheet piling can also be used.

Barriers are most effective at preventing flow to relatively small areas or to protect specific receptors. Protecting larger areas is possible if the constituent of concern is not highly soluble and cannot follow a diverted groundwater flow pattern. The barrier will change the groundwater flow conditions, and at some point, the increased head (pressure) will cause a change in flow patterns.

This will generally be around the flanks or beneath the barrier. To ensure that groundwater will not flow beneath the barrier, it must be sealed at an underlying impermeable layer such as a clay layer.

Groundwater migration barriers are often used in conjunction with groundwater extraction systems. The barriers are used to restrict flow to allow extraction systems upgradient of the barrier to collect groundwater. However, the challenges discussed above for creating a competent seal with any underlying unit may still apply.

6.3.1.3 Permeable Reactive Barriers (PRBs)

PRBs can be an effective in-situ groundwater treatment technology. General design involves excavation of a narrow trench perpendicular to groundwater flow similar to migration barriers and then backfilling the trench with a reactive material that either removes or transforms the constituents as the groundwater passes through the PRB. Unlike simple barriers, the PRB can be designed to include impermeable sections to funnel the flow through a more narrow and permeable reactive zone. The ability to maintain adequate and reactive reagent concentrations at depth over an extended period of time is a significant operational and performance assurance challenge. As with other in-situ approaches, reconstruction or regeneration may be needed on a periodic basis.

6.3.1.4 In-Situ Chemical Stabilization

The placement of chemical reactants to immobilize dissolved phase constituents through precipitation or sorption can be an effective approach to reducing downgradient migration. Reagents such as ferrous sulfate, calcium polysulfide, zero-valent iron, organo-phosphorous mixtures, and sodium dithionate have been evaluated as potentially effective for coal ash related constituents.

Two (2) issues that must be considered with this technology are the permanence of the reaction product insolubility and the ability to inject the reactants sufficiently to ensure adequate contact with the constituents. Most stabilization reactions can be reversible depending on environmental conditions such as pH and oxidation state. Given the long periods of time for which the reaction products must remain insoluble, it may be difficult to predict future conditions sufficiently to ensure the permanence of this technology. Recurring treatment, based on routine testing, may be an option. Contact between reagents and the constituents must also be evaluated. This technology may need to be considered more as a source reduction technology than a capture or barrier technology, as the reactants may not be viable over an extended period of time.

6.3.1.5 Phytoremediation

Phytoremediation involves the planting of grasses, ferns, and/or trees that are capable of extracting metals and other pollutants from subsurface soils and groundwater. Contaminants are removed by plants without impacting the topsoil and may even improve the fertility and stability of the soils by providing organic matter. The various mechanisms of phytoremediation include:

- Phytoextraction;
- Phytofiltration;
- Phytostabilization;
- Phytovolatilization;
- Phytodegradation;
- Rhizodegradation; and
- Phytodesalination

All the mechanisms of phytoremediation handle the removal of contaminants in different ways, with phytoextraction likely being the most effective mechanism for the site. Phytoextraction occurs when plant roots take contaminants from soil or water and are converted into waste or energy.

Phytoremediation is typically more expensive and requires maintenance during the initial planting and growth stages, but long-term is cost-effective and low maintenance. Long-term groundwater monitoring would be required to evaluate the effectiveness of this technology.

6.3.2 Ex-Situ Groundwater Remedial Technologies

Ex-situ remedial technologies require groundwater extraction to remove constituent mass from the groundwater and can provide hydraulic control to reduce or prevent groundwater constituent migration. Groundwater can be removed from the aquifer through the use of conventional vertical extraction wells, horizontal wells, collection trenches and associated pumping systems. The type of well or trench system selected is based upon site-specific conditions. Long-term groundwater monitoring would be required to evaluate the effectiveness of any of these technologies. Ex-situ groundwater remediation technologies are discussed below.

6.3.2.1 Conventional Vertical Well System

Conventional vertical wells can usually be used in most cases unless accessibility is an issue. Well spacing and depths depend upon the aquifer characteristics. If flow production from the aquifer is extremely limited, conventional wells may not be feasible due to the extremely close spacing that would be required. Vertical wells may be used at any depth and can be screened in unconsolidated soils or completed as open-hole borings in bedrock.

6.3.2.2 Horizontal Well Systems

The use of horizontal recovery wells has increased due to development of more efficient horizontal drilling techniques. These systems can cover a significant horizontal cross-section and may be much more efficient than conventional vertical wells. They are not well suited to aquifers with wide variation in water levels, as the horizontal well may end up being dry.

6.3.2.3 Trenching Systems

Horizontal collection trenches function similarly to horizontal wells but are installed with excavation techniques. They can be more effective at shallow depths and with higher flow regimes. However, they may not be practical for deeper installations.

6.3.3 Treatment of Extracted Groundwater

Several technologies exist for the treatment of extracted groundwater to remove or immobilize constituents ex-situ. The following technologies would be considered if treatment of extracted groundwater became necessary prior to a permitted discharge. As presented in the following sections, there are five (5) primary treatment technologies that are applicable to Molybdenum and Arsenic:

- Filtration;
- Precipitation;
- Biological & Oxidation;
- Ion Exchange; and
- Other Adsorbents.

6.3.3.1 Filtration Technologies

There are a number of permeable membrane technologies that can be used to treat impacted groundwater for metals and other constituents. The most common is reverse osmosis, although microfiltration, ultrafiltration, and nanofiltration are also used. All of these technologies use pressure to force impacted water through a permeable membrane, which filters out the target constituents. The differences in the technologies are based on the filtration size and the corresponding pressure needed to operate the system. These membrane technologies can capture a number of target compounds simultaneously and can achieve low effluent concentrations, but they are also very sensitive to fouling and often require a pretreatment step. Membrane technologies can result in a relatively high volume of reject effluent, which may require additional treatment prior to disposal.

6.3.3.2 Precipitation

Treating impacted groundwater through the precipitation of metals is a well proven and often-used technology. In this process, soluble (dissolved) constituents are converted to insoluble particles that will precipitate such as hydroxides, carbonates, or sulfides. Insoluble particles are then removed by physical methods like clarification and/or filtration. The process typically involves pH adjustment, addition of a precipitant, and flocculation. The details of the process are driven by the solubility of the constituents and the effluent limit requirements. For many constituents, low effluent concentrations can be achieved; however, this technology has not been extensively used for all constituents related to coal ash sites.

6.3.3.3 Biological & Oxidation

Several biological treatment methods and other oxidation methods have been used to treat metals and other coal ash constituents. For Arsenic removal, biological systems can require a relatively long residence time (several hours) (Reinsel 2015). Other systems to remove Arsenic use biological formation of Bioscorodite (FeAsO4*2 H2O); in this process, bacteria oxidize Iron and available Arsenic to Ferric Iron and Arsenate. In general, biological systems are used to alter the oxidation state of the constituents so that it is less soluble and may be removed through adsorption or other means.

6.3.3.4 Exchange Technologies

Ion exchange is a well-proven technology for removing metals from groundwater. With some constituents, ion exchange can achieve very low effluent concentrations. Ion exchange is a physical process in which ions held electrostatically on the surface of a solid are exchanged for target ions of similar charge in a solution. The medium used for ion exchange is typically a resin made from synthetic organic materials, inorganic materials, or natural polymeric materials that contain ionic functional groups to which exchangeable ions are attached. The resin must be regenerated routinely, which involves treatment of the resin with a concentrated solution, often containing sodium or hydrogen ions (acid). There must be a feasible method to dispose of the regeneration effluent for this technology. Pretreatment may be required, based on site-specific conditions.

6.3.3.5 Adsorption Technologies

Groundwater containing dissolved constituents can be treated with adsorption media to reduce their concentration. However, the column must be regenerated or disposed of and replaced with new media on a routine basis. Common adsorbent media include activated alumina, copper-zinc granules, granular ferric hydroxide, ferric oxide-coated sand, greensand, zeolite, and other proprietary materials. This technology may also generate a significant regeneration waste stream.

6.4 Evaluation to Meet Requirements in 40 CFR § 257.96(c)

For this evaluation, each of the potential remedial technologies identified above will be screened against evaluation criteria requirements in 40 CFR § 257.96(c) listed below:

The assessment under paragraph (a) of this section must include an analysis of the effectiveness of potential corrective measures in meeting all of the requirements and objectives of the remedy as described under § 257.97 addressing at least the following:

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

(2) The time required to begin and complete the remedy;

(3) 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(s).

The ACM evaluation is provided in Table 6-1 and detailed below.

6.4.1 Performance

This criterion includes the ability of the technology to effectively achieve the specified goal of corrective measures to prevent further releases, to remediate any releases, and to restore the affected area to original conditions.

6.4.1.1 In-Situ Groundwater Remedial Technologies

MNA is a proven technology that can be implemented to reduce constituent concentrations over time through natural processes of geochemical and physical attenuation. Typical attenuation mechanisms that could affect Molybdenum and Arsenic would include adsorption, microbial activity, and dispersion. Molybdenum is highly sensitive to changes in oxidation-reduction conditions in groundwater. It is more mobile at higher Oxidation Reduction Potential (ORP) values; it is weakly absorbed with minimal mineral formation (precipitation) at pH values in the range of 6.5 to 7.5 Standard Units (SU) (Smedley and Kinniburgh 2002).

In the environment, Arsenic is more mobile at pH values greater than 8.5 SU, when it will desorb from mineral oxides (Smedley and Kinniburgh 2002). Highly reducing conditions at near neutral pH would also lead to the mobilization of Arsenic as it desorbs from oxides. In groundwater with high concentrations of Arsenic III and Iron II and low Sulfate concentrations, the reductive dissolution of Iron and Manganese Oxides can also release Arsenic to the environment.

Sorption to solid phases is a primary mechanism for removing Arsenic from groundwater. Hydroxides of Iron, Aluminum and Manganese, Sulfide Minerals, and organic matter are known to significantly adsorb Arsenic in groundwater (Wang and Mulligan 2006). The rate and amount of sorption is influenced by groundwater pH, redox potential, other ions, and the associated species of Arsenic (Ford, Wilkin, and Puls 2007). Microbial activity may also catalyze the transformation of Arsenic species, or impact redox reactions; this would also influence the mobility of Arsenic.

At the Type I Landfill, ORP values varied significantly in 2024 with ranges of -118 millivolts (mV) to 345 mV at CF-15-07; 308 mV to 405 mV at CF-15-08; 117 mV to 397 mV at CF-15-09; 414 mV to 420mV at CF-19-14; and 239 mV to 405mV at CF-19-15 (AGES 2025). The pH values at the Type I Landfill were also varied consistently ranging from 6.14 to 7.09 SU at all five (5) wells over the course of 2024. The wide range of ORP values are likely related to flood events when the groundwater flow direction reverses and water from the Ohio River recharges groundwater at the site. Within this range of values, the mobility of Molybdenum and Arsenic would vary (due to ORP variations) and there would be limited adsorption and precipitation (due to the pH range).

Dispersion, the mixing and spreading of constituents due to microscopic variations in velocity within and between interstitial voids in the aquifer, and dilution would reduce Molybdenum and Arsenic concentrations but would not destroy the Molybdenum and Arsenic. Given groundwater flow conditions, with periodic flood events and flow reversals, dispersion and dilution of Molybdenum and Arsenic would likely be a major factor in natural attenuation.

At the Type I Landfill, the existing well network would be used to monitor constituent trends over time. Given that Molybdenum and Arsenic concentrations are less than the GWPS at the property boundary, a long-term timeframe would likely be acceptable.

Although migration barriers, PRBs, and in-situ chemical stabilization are proven technologies, conditions at the Type I Landfill would limit the performance of each of these approaches. To be effective, a migration barrier would need to be tied into a lower competent unit at the Type I Landfill; either the lean clay layer at approximately 40 feet below ground surface (bgs) or bedrock at 80 to 90 feet bgs. Given that the Type I Landfill is located within an impermeable bedrock valley, these conditions would be conducive to this approach. Under these conditions, any altered flow paths due to the presence of the barrier could likely be managed. Note that periodic flooding of the area by the Ohio River would also impact the performance of these technologies.

Given site conditions, in-situ chemical stabilization reagents could be injected into the uppermost aquifer and distributed to where impacts occur. It would be critical to fully evaluate future groundwater conditions (i.e., pH, ORP, etc.) to maintain this approach. The effectiveness of this approach to treat Molybdenum and Arsenic is not well tested or established.

Phytoremediation is a relatively new remedial technology with sparse case studies with conditions similar those at the Type I Landfill. There are two (2) ways to utilize phytoremediation: plants or trees.

Plants such as grasses and ferns are typically utilized in phytoremediation due to their cost effectiveness and short implementation time. However, due to their shallow root systems, plants are typically utilized whenever contaminants are located primarily in subsurface soil. Additionally, due to the shallow root depths, these plants are vulnerable to flooding, and many of the plants generate hazardous waste, such as biomass, at the surface that would need to be disposed of properly. Given the vulnerability to flooding and excess hazardous waste that would be generated from these plants, this would not be a viable alternative for the site.

Trees are the most common form of phytoremediation for contaminants in groundwater due to their deep average root depth and minimal long-term maintenance needs. The trees utilize their roots to extract contaminants from the subsurface soil and groundwater and do not generate any hazardous waste in the process. The initial planting and growing stages are typically expensive and time-consuming as they would need to be regularly checked and treated with fertilizers and pesticides as needed. Additionally, trees typically take years to grow to their full height and may not be as effective during the early stage of remediation. There are three tree species that are typically utilized for phytoremediation: Poplar, Eastern Cottonwood, and Buttonwood trees. These tree species have deep root systems ranging from 10-75 ft bgs and range in vulnerability to flooding during growing seasons (Poplar) to very resilient (Buttonwood). Given the resilience to flooding and root depth, trees could be a viable alternative for the site.

6.4.1.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction is a proven technology that has been successfully implemented for decades at many sites. Conventional vertical wells are the most often used approach; although the use of horizontal wells has been increasing. At the Type I Landfill, a series of vertical recovery wells can likely be installed and operated to address impacted groundwater. Horizontal wells operate in a similar manner to vertical wells but are less effective in areas with significant water level fluctuations, like the Type I Landfill. The performance of both types of wells would be significantly impacted by the Iron content of groundwater, which can lead to clogging. Significant levels of operation and maintenance would likely be necessary.

Trenching systems are often used when groundwater impacts are encountered in a shallow unit. The depth to groundwater at the Type I Landfill is 15 to 20 feet bgs and the depth to the lean clay layer is 40 feet bgs. Although these depths are not ideal for a trench, they do not preclude the use of a trench at the Type I Landfill.

Note that periodic flooding of the area by the Ohio River would also impact the performance of these ex-situ technologies.

6.4.1.3 Treatment of Extracted Groundwater

Groundwater treatment is required as a supplemental technology to be used in conjunction with groundwater extraction. The need for treatment depends on permit requirements for discharge of the treated water via a National Pollution Discharge Elimination System (NPDES) permit. The concentrations of Molybdenum and Arsenic would need to be reduced to less than the required permit limits. Treatment for other constituents may also be required based on permit requirements.

Treatment of extracted groundwater can be performed, although Molybdenum is one of the more difficult constituents to remove from water. Molybdenum removal can be accomplished in both continuous and sequential batch processes. A typical batch operation would consist of chemical storage and dosing modules; a primary reactor and pretreatment holding tank; a solids dewatering device (if needed); and miscellaneous temperature and pH controls. Prior to design, bench scale testing should be conducted to fully evaluate site-specific conditions. Pilot testing would also likely be performed, if favorable results are obtained from the bench scale testing, prior to design and construction of a full-scale treatment system.

Several proven methods for Arsenic treatment exist. Precipitation is a frequently used and proven technology to treat Arsenic in water at various concentrations (U.S. EPA 2002). Precipitation systems require skilled operation and are more cost-effective at a large scale. The effectiveness of adsorption and ion exchange can be impacted by the presence of other constituents. However, at smaller scales these systems have lower operating and maintenance costs. Adsorption and ion exchange are often used when Arsenic is the only constituent requiring treatment. Filtration is used less frequently because it tends to have higher costs and produce a larger volume of residuals than other technologies that are available for the treatment of Arsenic. Several biological treatment methods and other oxidation methods have been used to treat Arsenic. However, most would not likely be practical at the scope of this project due to cost.

6.4.2 Reliability

This criterion includes the degree of certainty that the technology will consistently work toward and achieve the specified goal of corrective measures over time.

6.4.2.1 In-Situ Groundwater Remedial Technologies

As the process of MNA is based on natural processes, this approach would be considered to be reliable. However, as groundwater geochemistry can vary over time, routine monitoring is required to evaluate conditions and ensure the ongoing effectiveness of the MNA process. Geochemical changes in groundwater could significantly impact the effectiveness of MNA, which could lead to the need to implement other remedial measures at the Type I Landfill.

Migration barriers and PRBs are typically reliable technologies; the primary issue being the potential for altered groundwater flow directions and further migration of constituents. In addition, maintaining adequate and reactive reagent concentrations at depth over an extended period of time in a PRB can also be a significant operational and maintenance issue.

For in-situ chemical stabilization, reagents must be injected uniformly and consistently to adequately distribute them into the aquifer. The lack of a uniform and consistent approach could lead to reliability issues. Finally, changes in the geochemistry of the aquifer can lead to the need for adjustments in reagent type, concentrations, and injection approach.

Phytoremediation is typically a reliable technology. The primary concern is that any plants and/or trees utilized at the Type I Landfill would need to be resilient to flooding. There are few species of plants and trees that vary in resilience to flooding that would need to be considered prior to implementing this technology. Additionally, soil characterization would need to be completed to determine what species of plant and/or tree would be the most suited for the site.

6.4.2.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction solutions are generally considered reliable at controlling and removing constituents from the subsurface. At the Type I Landfill, conventional vertical wells would be the more reliable approach, as the large water level fluctuations at the unit would significantly impact the reliability of horizontal wells. There can be significant operation and maintenance issues associated with both conventional vertical or horizontal wells, but these issues are well understood and can be readily addressed. Once in place, trenching systems would also be reliable at the Type I Landfill although long-term Operations and Maintenance (O&M) would be required.

6.4.2.3 Treatment of Extracted Groundwater

Treatment of Molybdenum and Arsenic in extracted groundwater would be reliable as long as the treatment process are properly implemented.

6.4.3 Ease of Implementation

This criterion includes the ease with which the technologies can be implemented at the Type I Landfill.

6.4.3.1 In-Situ Groundwater Remedial Technologies

MNA is among the easiest of corrective measures to implement at a site. A sufficient number of monitoring wells already exist at the Type I Landfill, which could be used to monitor the effectiveness of MNA.

Due to the significant amount of time, effort, and disturbance required for implementation at the Type I Landfill, migration barriers, in-situ chemical stabilization and PRBs implementation would be difficult. Difficulties in construction would be related to the depth of installation and the need to install a barrier into the lean clay layer at the site at a depth of 40 feet bgs. Once constructed, the barrier technology would be passive and would operate immediately. The PRB would likely require periodic recharging with appropriate reagents. In-situ chemical stabilization may require less time and effort than with a migration barrier or PRB.

Phytoremediation ranges in difficulty of implementation. If using plants, less surface disturbance would be required, but most plants utilized for phytoremediation generate hazardous waste that would need to be disposed of properly. If using trees, more surface disturbance would be required to remove the existing trees. Additionally, the trees would need to be cared for during growth which could be time-consuming.

6.4.3.2 Ex-Situ Technologies for Groundwater Extraction

Implementation of both conventional vertical and horizontal wells at the Type I Landfill would require drilling and limited field construction; however, the conventional vertical wells would be more easily implemented. The orientation of the horizontal wells could present potential installation issues. Trenching systems would require significant construction and would be difficult to implement at the Type I Landfill.

6.4.3.3 Treatment of Extracted Groundwater

Treatment of Molybdenum and Arsenic in extracted groundwater can be implemented, as long as proper processes are used.

6.4.4 Potential Safety Impacts

This criterion includes potential safety impacts that may result from the implementation and use of the technology at the Type I Landfill.

6.4.4.1 In-Situ Groundwater Remedial Technologies

Potential safety impacts associated with MNA are very minimal; especially as no additional well installation is required. Minimal safety concerns are therefore associated with the ongoing groundwater monitoring program.

Migration barriers and PRBs require a significant construction effort and use of construction equipment, which would entail a relatively high risk of potential safety impacts. However, neither technology would have any potential significant safety impacts following construction. Potential safety concerns related to in-situ chemical stabilization are moderate. The potential for incidents during injection well construction or unintended worker contact with the chemicals used for treatment would be the primary safety concerns with this technology.

Potential safety concerns associated with phytoremediation are moderate given that existing vegetation may need to be removed, and additional soil characterization would be required prior to implementing the technology.

6.4.4.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction through use of wells (conventional vertical or horizontal) would involve drilling, construction, and installation of extraction wells, pumps, and associated control wiring and piping. Potential safety concerns exist with the activities associated with installation of these wells, as well as the ongoing O&M of the system, including inspection, maintenance, or replacement of the various system components.

Trenching systems would require use of significant construction equipment and present worker safety concerns, especially with the depth of the trench. Ongoing operation of the system would present minimal safety concerns.

6.4.4.3 Treatment of Extracted Groundwater

Treatment of extracted Molybdenum and Arsenic in groundwater would have minimal safety concerns.

6.4.5 Potential Cross-Media Impacts

This criterion includes the ability to control cross-media impacts during the implementation and use of the technology at the Type I Landfill.

6.4.5.1 In-Situ Groundwater Remedial Technologies

MNA poses no significant cross-media impact potential. Migration barriers and PRBs pose minimal risk of cross-media impacts, as they primarily involve an intended modification in groundwater flow. For a barrier technology, there could be some risk with the migration of impacted groundwater to other areas of the site; this concern is minimal. In the case of PRBs, constituents are removed from the groundwater through the use of reagents; this includes minimal potential for cross-media impacts.

Phytoremediation poses a moderate cross-media impact potential. This is only the case if plants are chosen as the remedial technology due to the hazardous waste that they generate at the surface. This waste would need to be properly characterized and disposed of regularly.

6.4.5.2 Ex-Situ Groundwater Remedial Technologies

Well and trench systems pose a moderate risk of cross-media impacts.

6.4.5.3 Treatment of Extracted Groundwater

Treatment of extracted groundwater would pose minimal risk of cross-media impacts.

6.4.6 Potential Impacts from Control of Exposure to Residual Constituents

This criterion includes the ability to control the exposure of humans and the environment to residual constituents through the implementation and use of the technology at the Type I Landfill.

6.4.6.1 In-Situ Groundwater Remedial Technologies

MNA and phytoremediation poses no significant potential for human or environmental exposure to impacted groundwater. Overall, in-situ technologies involve placement or injection of a structure or reagent to treat impacted groundwater in-place. Consequently, there is no increased risk of exposure of humans and the environment to residual contamination.

6.4.6.2 Ex-Situ Groundwater Remedial Technologies

Groundwater extraction involves bringing impacted groundwater from the subsurface to the surface for potential treatment and discharge. This would slightly increase the potential for exposure of humans or the environment to impacted groundwater. The groundwater would be conveyed through an engineered system designed to prevent the release of water into the environment and to limit the potential for human or environmental exposure to the impacted groundwater. The potential for exposure to residual contamination associated with this technology is therefore unlikely.

6.4.6.3 Treatment of Extracted Groundwater

Treatment of extracted groundwater would pose minimal risk of exposure to residual contamination.

6.4.7 Time Required to Begin Remedy

This criterion includes the time necessary for planning, pilot testing, design, permitting, procurement, installation, and startup of this technology at the Type I Landfill. Timeframes presented below and in Table 6-1 reflect the time required to implement the remedy after the closure of the unit.

6.4.7.1 In-Situ Groundwater Remedial Technologies

An MNA program could be implemented at the Type I Landfill within three (3) months, as a sufficient monitoring well network already exists at the site and a monitoring program is already established. This potential remedy would require the least amount of time to implement of the technologies considered.

Migration barriers, in-situ chemical stabilization, and PRBs could take a significant amount of time to design and install. Either technology would also involve a significant amount of regulatory permitting. The design and implementation time could take 1 to 1.5 years.

Phytoremediation could be implemented at the site within three (3) months to one (1) year depending on the remedial technology chosen. Plants would be the fastest to implement with trees taking the longest.

6.4.7.2 Ex-Situ Groundwater Remedial Technologies

Design and installation of groundwater extraction systems could be completed in six (6) months to one (1) year. This could vary depending on potential groundwater modeling efforts and regulatory approval and permitting.

6.4.7.3 Treatment of Extracted Groundwater

Design and installation of the system, including bench-scale and pilot testing, could be completed in six (6) months to one (1) year. This would depend on the regulatory approval and permitting process.

6.4.8 Time Required to Complete Remedy

This criterion includes the estimated time necessary to achieve the stated goals of corrective measures to prevent further releases from the Type I Landfill, to remediate any releases, and to restore the affected area to original conditions.

6.4.8.1 In-Situ Groundwater Remedial Technologies

As MNA does not require additional physical or chemical remedial treatment, the timeframe is the longest period to reach remedial goals. A groundwater model would be useful to more accurately predict the anticipated time required to complete the remediation.

A significant amount of time is expected to be required to meet remedial goals with migration barriers and PRB. However, as groundwater modeling has not been performed for the site, an accurate estimate cannot be developed at this time. If in-situ chemical stabilization option can effectively treat Arsenic at the unit boundary, this approach has the potential to treat groundwater more quickly than a barrier or PRB.

Phytoremediation does not have a specific time frame for completion. This is due to the fact that groundwater chemistry can change, and the performance of the technology chosen would need to be evaluated regularly.

6.4.8.2 Ex-Situ Groundwater Remedial Technologies

A significant amount of time is expected to be required to meet remedial goals with ex-situ technologies. However, as groundwater modeling has not been performed for the site, an accurate estimate cannot be developed at this time.

6.4.8.3 Treatment of Extracted Groundwater

The time required to meet remedial goals depends on the type of groundwater extraction system implemented. The time required for the treatment of extracted groundwater is insignificant.

6.4.9 State, Local, or Other Environmental Permit Requirements That May Impact Implementation

This criterion includes anticipation of any state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the technology at the Type I Landfill.

6.4.9.1 In-Situ Groundwater Remedial Technologies

A MNA or phytoremediation program would likely require coordination with IDEM but likely not formal approval. Therefore, it could be implemented in as little as (3) months, as a sufficient monitoring well network already exists at the site.

Migration barriers, in-situ chemical stabilization, and PRBs would require installation of barrier walls and associated components in the aquifer and/or chemical injections, which may require permitting through IDEM. This would require an anticipated minimum of 1 to 1.5 years of review and approval.

6.4.9.2 Ex-Situ Groundwater Remedial Technologies

A groundwater extraction system would require the installation of new wells and a treatment system at the Type I Landfill, which may require permitting through IDEM. This would require an anticipated minimum of 1 to 1.5 years of review and approval.

6.4.9.3 Treatment of Extracted Groundwater

The selection of a treatment system may require permitting through IDEM, especially if an NPDES permit is required. This would require an anticipated minimum of 1 to 1.5 years of review and approval.

6.5 Conclusions

For this evaluation, several in-situ and ex-situ remedial technologies to address Molybdenum and Arsenic in groundwater at the Type I Landfill were screened against evaluation criteria requirements in 40 CFR § 257.96(c). The screening of phytoremediation is applied to both Molybdenum and Arsenic. As presented in Table 6-1, during the screening, the technologies were ranked as High, Medium, or Low using professional judgement and past experience. Based on these rankings, the three (3) technologies that appear to be most likely for selection as a remedy were:

- MNA;
- Phytoremediation; and
- Conventional Vertical Well System (Groundwater Extraction) (Ex-Situ).

Groundwater treatment would be required as a supplemental technology in conjunction with a Conventional Vertical Well System. The selection of a treatment technology would be based on conditions at the time of selection of a final remedy.

The technologies that appear to be less likely for selection as a remedy were:

- Groundwater Migration Barriers (In-Situ);
- PRB (In-Situ);
- In-Situ Chemical Stabilization (In-Situ);
- Horizontal Well Systems (Ex-Situ); and
- Trenching Systems (Ex-Situ).

As groundwater quality downgradient of the Type I Landfill is anticipated to significantly improve over time as a result of planned closure activities for the adjacent LRCP, a flexible and adaptive approach to groundwater remediation that begins with post-closure groundwater monitoring at the unit is planned. During the post-closure monitoring period for the LRCP, the positive impacts of closure and the effects of natural attenuation on groundwater quality will be fully evaluated. The need for more active remedial measures will be determined after sufficient post-closure groundwater quality data has been collected and evaluated. The final selection of a remedy will be made based on the results of the post-closure groundwater monitoring program.

Additional remedial technologies may also be evaluated at a later date if determined to be applicable and appropriate.

7.0 SELECTION OF REMEDY PROCESS

The remedy selection begins following the completion of the ACM Report. Per 40 CFR § 257.97(a):

Based on the results of the corrective measures assessment conducted under § 257.96, the owner or operator must, as soon as feasible, select a remedy that, at a minimum, meets the standards listed in paragraph (b) of this section. This requirement applies to, not in place of, any applicable standards under the Occupational Safety and Health Act. The owner or operator must prepare a semiannual report describing the progress in selecting and designing the remedy. Upon selection of a remedy, the owner or operator must prepare a final report describing the selected remedy and how it meets the standards specified in paragraph (b) of this section. The owner or operator must obtain a certification from a qualified professional engineer that the remedy selected meets the requirements of this section. The report has been completed when it is placed in the operating record as required by § 257.105(h)(12).

This ACM Report provides a high-level assessment of groundwater remedial technologies that could potentially address Molybdenum and Arsenic concentrations in groundwater that exceed the GWPS at the Type I Landfill. With the submittal of this report, IKEC will begin the remedy selection process and ultimately select a remedy. The process and selected remedy will satisfy standards listed in 40 CFR § 257.97(b), with consideration to evaluation factors listed in 40 CFR § 257.97(c). The progress toward selecting a remedy will be documented in semi-annual reports.

7.1 Data Gaps

Based on a review of data to date, the following recommendations for additional data collection/evaluation have been identified:

- The development of a three-dimensional (3-D) groundwater model using Modflow or another commercially available software could be useful in supporting the evaluation of various potential remedial techniques at the Type I Landfill;

- As previously discussed, groundwater quality near the Type I Landfill is anticipated to significantly improve over time as a result of planned closure activities and natural attenuation. Ongoing sampling of monitoring wells prior to and after closure of the Type I Landfill should continue to evaluate whether Molybdenum and Arsenic concentrations in groundwater are increasing, decreasing, or asymptotic. This data will be useful in developing time-series evaluations that will support potential groundwater modeling efforts and the final selection of a remedy for the Type I Landfill;

- Given the dynamic nature of groundwater flow at the Type I Landfill, additional depth-to-groundwater data from wells in the area would be useful to support the potential groundwater modeling effort. This data can be most efficiently collected by installing downhole transducers in select wells near the Type I Landfill; and

- For phytoremediation, additional soil sampling may be necessary to determine general soil chemistry in the areas where the trees would be planted to ensure that the correct species is chosen.

7.2 Selection of Remedy

As noted above, IKEC will begin the process of selecting a remedy following the submittal of this ACM Report. Per 40 CFR § 257.97, the remedy will be selected and implemented as soon as feasible and progress toward selecting the remedy will be documented in semiannual reports. As part of the process, one (1) or more preferred remedial approaches will be developed based on technology effectiveness under site conditions, implementability, and other considerations. As discussed above, a flexible and adaptive approach to groundwater remediation that begins with post-closure monitoring is planned.

7.3 Public Meeting Requirement in 40 CFR § 257.96(e)

Per 40 CFR § 257.96(e), IKEC will hold a public meeting to discuss ACM results, the remedy selection process, and selection of one or more preferred remedial approaches. The public meeting will be conducted at least 30 days prior to selection of a final remedy, in accordance with the above-referenced rule. Prior to the meeting, citizen and governmental stakeholders will be formally notified as to the schedule for the public meeting.

7.4 Final Remedy Selection

After selection of a remedy, a report documenting the remedy selection process will be prepared. The report will demonstrate how the remedy selection process was performed and how the selected remedial approach satisfies 40 CFR § 257.97 requirements.

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TABLES

TABLE 4-1
GROUNDWATER MONITORING NETWORK
TYPE I LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Monitoring Well ID	Designation	Date of Installation	Coordinates		Ground Elevation (ft)²	Top of Casing Elevation (ft)²	Top of Screen Elevation (ft)	Base of Screen Elevation (ft)	Total Depth From Top of Casing (ft)
			Northing	Easting					
CF-15-04	Background	12/3/2015	451482.81	569307.19	465.55	468.03	439.55	429.55	38.48
CF-15-05	Background	12/1/2015	447491.91	565533.64	439.85	442.58	422.85	412.85	29.73
CF-15-06	Background	11/30/2015	447026.92	565190.31	437.49	440.40	431.49	421.49	18.91
CF-15-07	Downgradient	11/23/2015	443135.08	562259.25	438.61	441.11	432.61	422.61	18.50
CF-15-08	Downgradient	11/19/2015	443219.57	562537.29	460.33	462.79	430.33	420.33	42.46
CF-15-09	Downgradient	11/25/2015	443445.96	562871.69	456.73	459.45	447.73	442.73	16.72
WBSP-15-01	Background	11/30/2015	449072.27	566322.12	466.93	469.36	458.93	448.93	20.43
WBSP-15-02	Background	11/11/2015	449803.91	566987.30	473.83	476.76	457.83	452.83	23.93
CF-19-14	Downgradient/Boundary	3/8/2019	443401.75	562901.93	452.29	454.88	440.05	430.05	24.83
CF-19-15	Downgradient/Boundary	3/13/2019	442704.78	562483.02	441.10	443.61	415.19	405.19	38.42

Notes:
1. The Well locations are referenced to the North American Datum (NAD83), east zone coordinate system.
2. Elevations are referenced to the North American Vertical Datum (NAVD) 1988.
3. Boundary Monitoring Wells CF-19-14 and CF-19-15 were added to the Monitoring Network in December 2024

TABLE 4-2
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS - SEPTEMBER 2024
TYPE I LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Constituent	Units	CF-15-04	CF-15-05	CF-15-06	CF-15-07	CF-15-08	CF-15-09	WBSP-15-01	WBSP-15-02	CF-19-14	CF-19-15
Appendix III Constituents											
Boron, B	mg/L	0.06	0.12	NS	0.043	7.6	6	NS	NS	NA	NA
Calcium, Ca	mg/L	68	110	NS	160	320	190	NS	NS	NA	NA
Chloride, Cl	mg/L	34	43	NS	5.3	120	5.4	NS	NS	NA	NA
Fluoride, F	mg/L	0.13	0.63	NS	0.36	0.35	0.26	NS	NS	NA	NA
pH	s.u.	7.27	6.49	NS	6.41	6.52	7.03	NS	NS	NA	NA
Sulfate, SO4	mg/L	38	62	NS	3.7 J	910	10 U	NS	NS	NA	NA
Total Dissolved Solids (TDS)	mg/L	320	550	NS	650 B	1700 B	710	NS	NS	NA	NA
Appendix IV Constituents											
Antimony, Sb	ug/L	1 U	1 U	NS	1 U	1 U	1 U	NS	NS	NA	NA
Arsenic, As	ug/L	0.39 J	1.2	NS	12	0.43 J	3.6	NS	NS	NA	NA
Barium, Ba	ug/L	43	48	NS	89	57	44	NS	NS	NA	NA
Beryllium, Be	ug/L	0.70 U	0.70 U	NS	0.70 U	0.70 U	0.29 J	NS	NS	NA	NA
Cadmium, Cd	ug/L	0.50 U	0.50 U	NS	0.50 U	0.18 J B	0.080 J	NS	NS	NA	NA
Chromium, Cr	ug/L	1.2 J	2.9	NS	1.3 J	1.3 J	14	NS	NS	NA	NA
Cobalt, Co	ug/L	0.22 J	1.2	NS	2.8	0.56	4.9	NS	NS	NA	NA
Fluoride, F	mg/L	0.13	0.63	NS	0.36	0.35	0.26	NS	NS	NA	NA
Lead, Pb	ug/L	1 U	0.99 J	NS	0.22 J	1 U	4.3	NS	NS	NA	NA
Lithium, Li	mg/L	0.0014 J	0.019	NS	0.0019 J	0.027	0.02	NS	NS	NA	NA
Mercury, Hg	ug/L	0.20 U	0.20 U	NS	0.02 U	0.20 U	0.20 U	NS	NS	NA	NA
Molybdenum, Mo	ug/L	1.7	0.42 J	NS	5.3	280	85	NS	NS	52	0.47 J
Radium 226 & 228 (combined)	pCi/L	5 U	5 U	NS	5 U	5 U	2	NS	NS	NA	NA
Selenium, Se	ug/L	1 U	1 U	NS	1 U	0.65 J	1 U	NS	NS	NA	NA
Thallium, Tl	ug/L	0.20 U	0.20 U	NS	0.20 U	0.20 U	0.074 J	NS	NS	NA	NA

Notes:
NA: Sampling not required for this parameter
NS: Well not sampled
mg/L: Milligrams per liter
pCi/L: Picocuries per liter
s.u.: Standard units
ug/L: Micrograms per liter
Yellow Highlighted: Result exceeds the established Groundwater Protection Standard

TABLE 4-3
GROUNDWATER PROTECTION STANDARDS
TYPE I LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Appendix IV Constituents			
Constituent (Units)	**Background**	**MCL/SMCL**	**GWPS**
Antimony, Sb (µg/L)	2	6	6
Arsenic, As (µg/L)	5	10	10
Barium, Ba (µg/L)	99	2000	2000
Beryllium, Be (µg/L)	1.1	4	4
Cadmium, Cd (µg/L)	1	5	5
Chromium, Cr (µg/L)	3	100	100
Cobalt, Co (µg/L)	1.5	6*	6
Fluoride, F (mg/L)	0.56	4	4
Lead, Pb (µg/L)	1.1	15*	15
Lithium, Li (µg/L)	0.1	40*	40
Mercury, Hg (µg/L)	1.2	2	2
Molybdenum, Mo (µg/L)	6	100*	100
Radium 226 & 228 (combined) (pCi/L)	8	5	8
Selenium, Se (µg/L)	5	50	50
Thallium, Tl (µg/L)	1	2	2

Notes:
1. MCL: Maximum Contaminant Level.
2. SMCL: Secondary Maximum Contaminant Level.
3. *: Established by U.S. EPA as part of 2018 decision.
4. GWPS: Groundwater Protection Standard.
5. µg/L: Micrograms per liter.
6. mg/L: Milligrams per liter.
7. pCi/L: Picocuries per liter.

TABLE 4-4
SUMMARY OF GWPS EXCEEDANCES - SEPTEMBER 2024
TYPE I LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Potential Exceedance Parameter (Units)	1st Assessment Monitoring Sampling Event September 2024		1st Assessment Monitoring Resampling Event December 2024	
		Potential Exceedance Result	GWPS	Potential Exceedance Result	Confirmed Exceedance (Yes/No)
CF-15-07	Arsenic (ug/L)	12	10	44	**Yes**
CF-15-08	Molybdenum (ug/L)	280	100	230	**Yes**

Notes:
1. GWPS: Groundwater Protection Standard.
2. µg/L: Micrograms per liter.

TABLE 4-5
SUMMARY OF GROUNDWATER ANALYTICAL SSI RESAMPLING RESULTS - DECEMBER 2024
TYPE I LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Constituent	Units	CF-15-07	CF-15-08
Appendix IV Constituents			
Arsenic, As	ug/L	44	NA
Molybdenum, Mo	ug/L	NA	230

Notes:

NA: Sampling not required for this parameter

ug/L: Micrograms per liter

TABLE 5-1
SUMMARY OF GROUNDWATER ELEVATION DATA - SEPTEMBER 2024
TYPE I LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Sep-24
CF-15-04	454.12
CF-15-05	428.14
CF-15-06	DRY
CF-15-07	436.88
CF-15-08	447.22
CF-15-09	445.43
WBSP-15-01	DRY
WBSP-15-02	462.15
CF-19-14	441.94
CF-19-15	419.71

TABLE 5-2
SUMMARY OF GROUNDWATER VELOCITY CALCULATIONS
SEPTEMBER 2024
TYPE I LANDFILL
CLIFTY CREEK STATION
MADISON, INDIANA

Well Pair		h_1 (feet)	h_2 (feet)	d (feet)	K (feet/day)	n	i	V (feet/day)
Uppermost Aquifer								
CF-15-08 (h_1)	CF-19-15 (h_2)	447.22	419.71	523	1.47	0.2	0.0526	0.387

h_1 = Head elevation in well #1
h_2 = Head elevation in well #2
d = distance between wells
K = Hydraulic conductivity
n = effective porosity
i = Horizontal Hydraulic Gradient
V = Groundwater Velocity

Horizontal Hydraulic Gradient:

$$i = \frac{h_1 - h_2}{d}$$

Groundwater Velocity:

$$V = K\left(\frac{i}{n}\right)$$

TABLE 5-3
SUMMARY OF GROUNDWATER ANALYTICAL SITE CHARACTERIZATION RESULTS - DECEMBER 2024
TYPE I LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Constituent	Units	CF-19-14	CF-19-15
Appendix IV Constituents			
Arsenic, As	ug/L	0.55 J	0.56 J

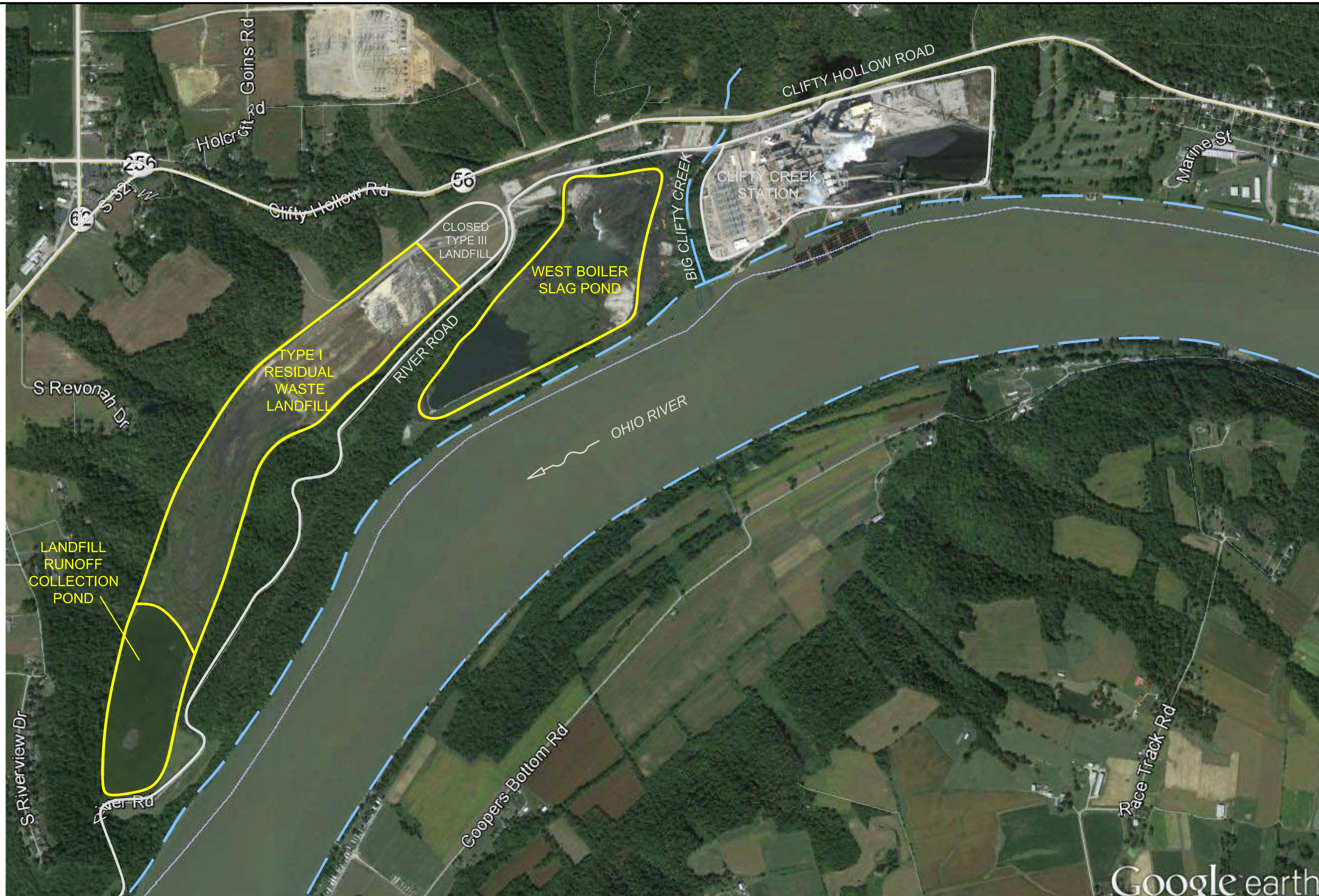
Notes:
ug/L: Micrograms per liter

TABLE 6-1
IN-SITU AND EX-SITU GROUNDWATER REMEDIAL TECHNOLOGIES SCREENING MATRIX - 40 CFR § 257.96(c) REQUIREMENTS
TYPE I LANDFILL
CLIFTY CREEK STATION
MADISON, INDIANA

	In-Situ Groundwater Remedial Technologies						Ex-Situ Groundwater Remedial Technologies		
	Monitored Natural Attenuation	Groundwater Migration Barriers	In-situ Chemical Stabilization	Permeable Reactive Barrier	Phytoremediation		Conventional Well System	Horizontal Well System	Trenching System
					Grasses and Ferns	Trees			
257.96(c)(1)									
Performance	Medium	Medium	Low	Low	Low	Medium	High	Low Significant Water Level Fluctuations Reduce Effectiveness of Horizontal Wells	High
Reliability	High	Medium	Medium	Medium	Medium	Medium	High Long Term O&M Required	Low Significant Issues with Water Level Fluctuations	High Long Term O&M Required
Ease of Implementation	High	Low	Low	Low	Medium	Medium	High Drilling and Limited Field Construction Required	Medium Drilling and Limited Field Construction Required	Low Trench Construction Required
Potential Safety Impacts	Low	Medium Field Construction Required	Medium Field Construction Required	Medium Field Construction Required	Low	Medium Initial Removal of Current Trees Required	Medium Drilling Required	Medium Drilling Required	Medium Trench Construction Required
Potential Cross-Media Impacts	Low	Low	Low	Low	High	Low	Medium	Medium	Medium
Potential Impacts from Control of Exposure to Residual Constituents	Low	Low	Low	Low	Low	Low	Medium	Medium	Medium
257.96(c)(2)									
Time To Begin Remedy	3 months	1 to 1.5 years	1 to 1.5 years	1 to 1.5 years	3 months	6 months	6 months to 1 year	6 months to 1 year	6 months to 1 year
Time To Complete Remedy	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required	Highly Variable Further Evaluation Required
257.96(c)(3)									
State, Local or other Environmental Permit Requirements that May Impact Implementation	Requires Coordination with IDEM	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM	No	No	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM
Additional Information	Groundwater F&T Modeling Required to Evaluate the Timing for This Approach for Molybdenum	Groundwater Flow Modeling Required to Fully Evaluate This Approach	Bench Scale Testing Required to Further Evaluate Applicability for Molybdenum	Bench Scale Testing Required to Further Evaluate Applicability for Molybdenum	Additional Soil Sampling required to Determine Plant Species	Additional Soil Sampling required to Determine Tree Species	Groundwater Flow Modeling Required to Fully Evaluate This Approach	Groundwater Flow Modeling Required to Fully Evaluate This Approach	Groundwater Flow Modeling Required to Fully Evaluate This Approach

Notes:
Relative assessments (low, medium, high) are based on experience and professional judgement

FIGURES



1200' 0' 1200' 2400'

SCALE: 1"= 1200'

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CHECKED BY	
JOB NO.	2019042-8-CLIFTY
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DRAWING SCALE	AS SHOWN

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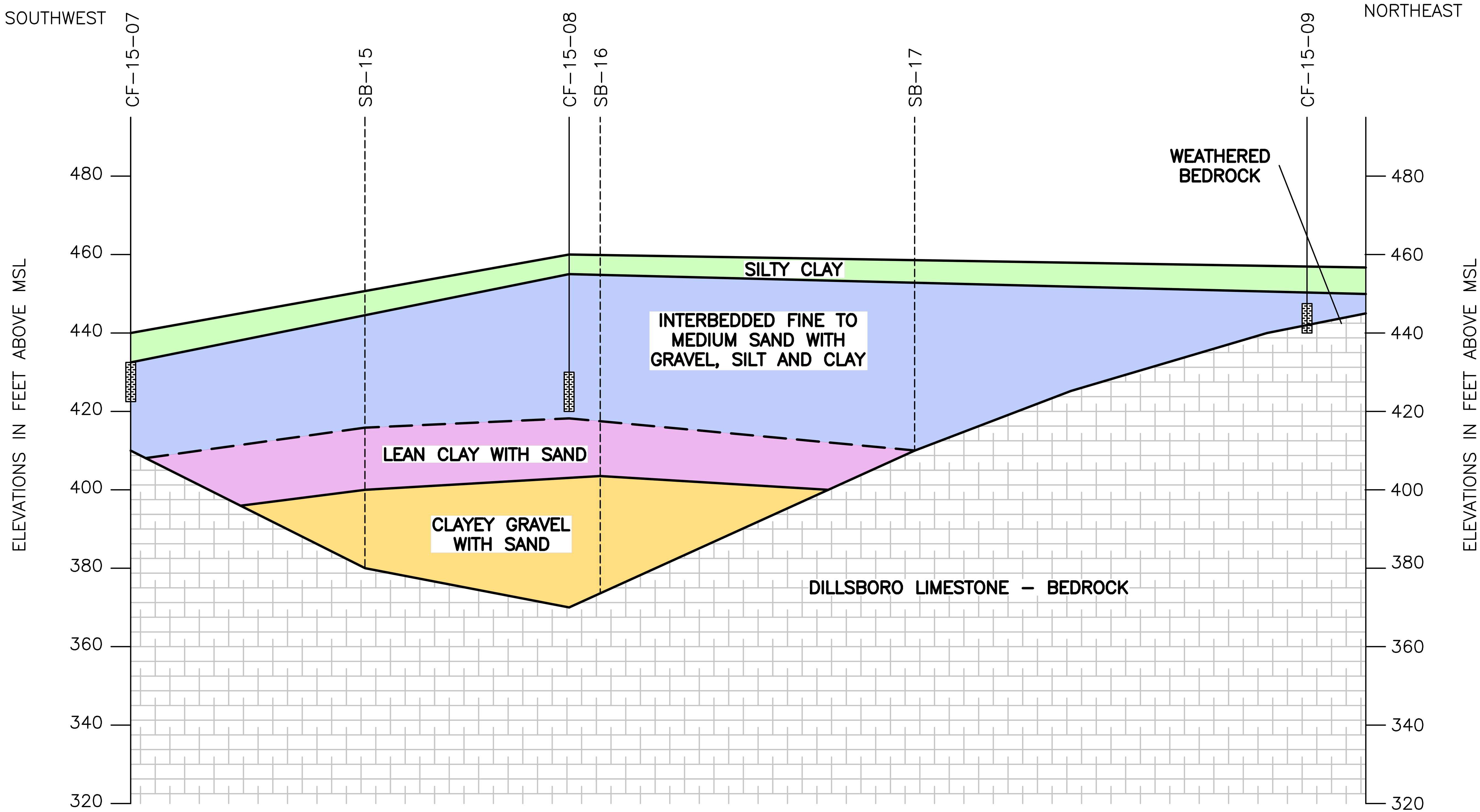
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
SITE LOCATION MAP

DRAWING NAME: FIGURE 2–1

REV. 0

PLOTTED: 3/10/2025 X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3-10-2025 TS\CAD\2019_IKEC_CLIFTY_ACM_FIG 2-1_LOCATION MAP.DWG



NOTES:

1) CROSS–SECTION COMPILED USING AGES BORING AND WELL LOGS, SOIL BORING INFORMATION FROM THE 2007 LITIGATION REPORT AND STANTEC DATA FROM THE LRCP STABILITY ASSESSMENT REPORT.

2) THE APPROXIMATE LOCATION OF THE CROSS–SECTION IS ILLUSTRATED ON FIGURE 3–2.

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DRAWING SCALE	NOT TO SCALE

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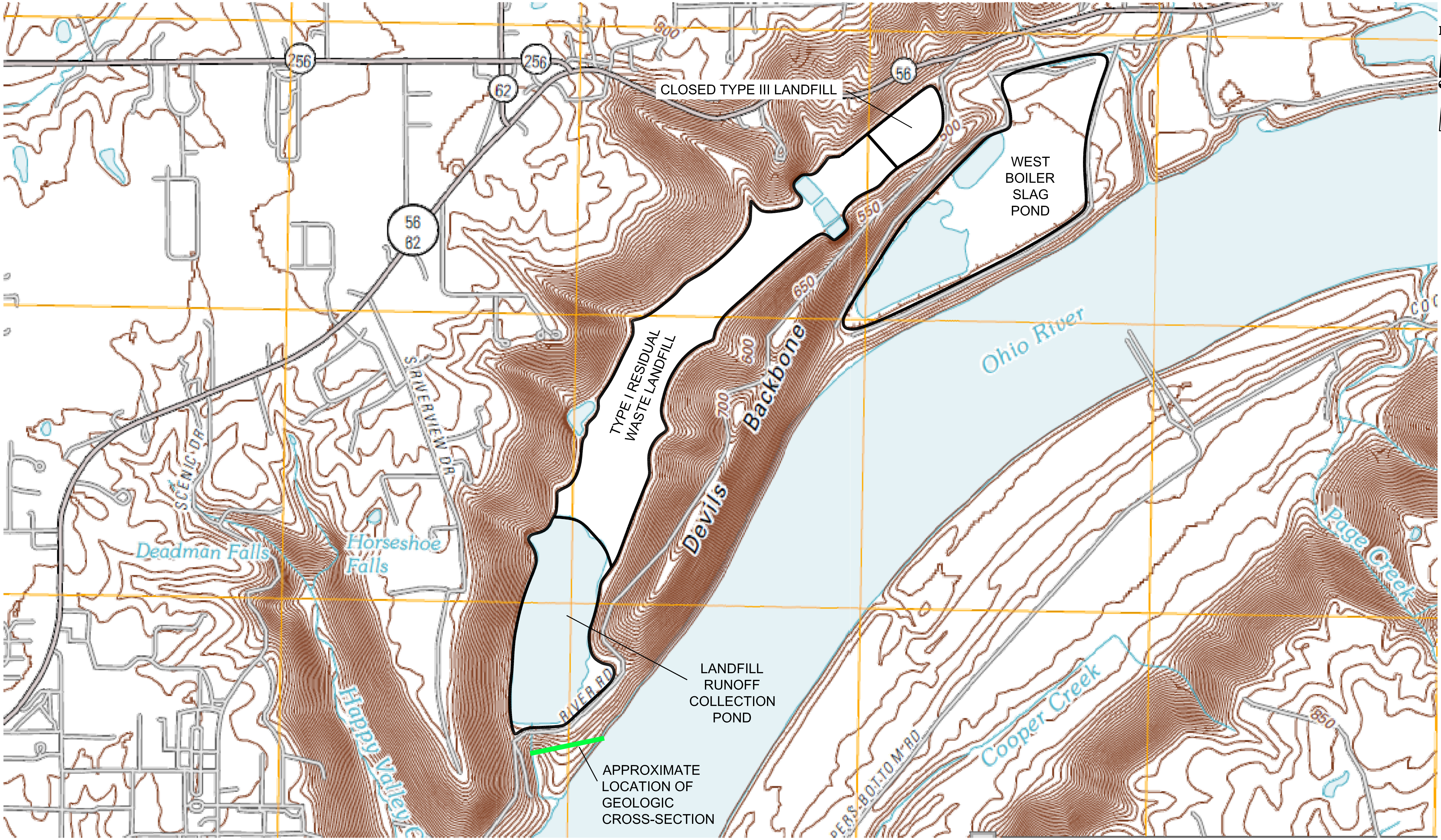
CLIFTY CREEK STATION
MADISON, INDIANA
GEOLOGIC CROSS–SECTION AT
TYPE I LANDFILL

DRAWING NAME: FIGURE 3–1

REV. 0



APPROXIMATE LOCATION OF THE GEOLOGIC CROSS–SECTION (FIGURE 3–1).

SOURCE: USGS MADISON WEST 7.5 MINUTE TOPOGRAHIC QUADRANGLE, 2010.

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042–8–CLIFTY
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DRAWING SCALE	NOT TO SCALE

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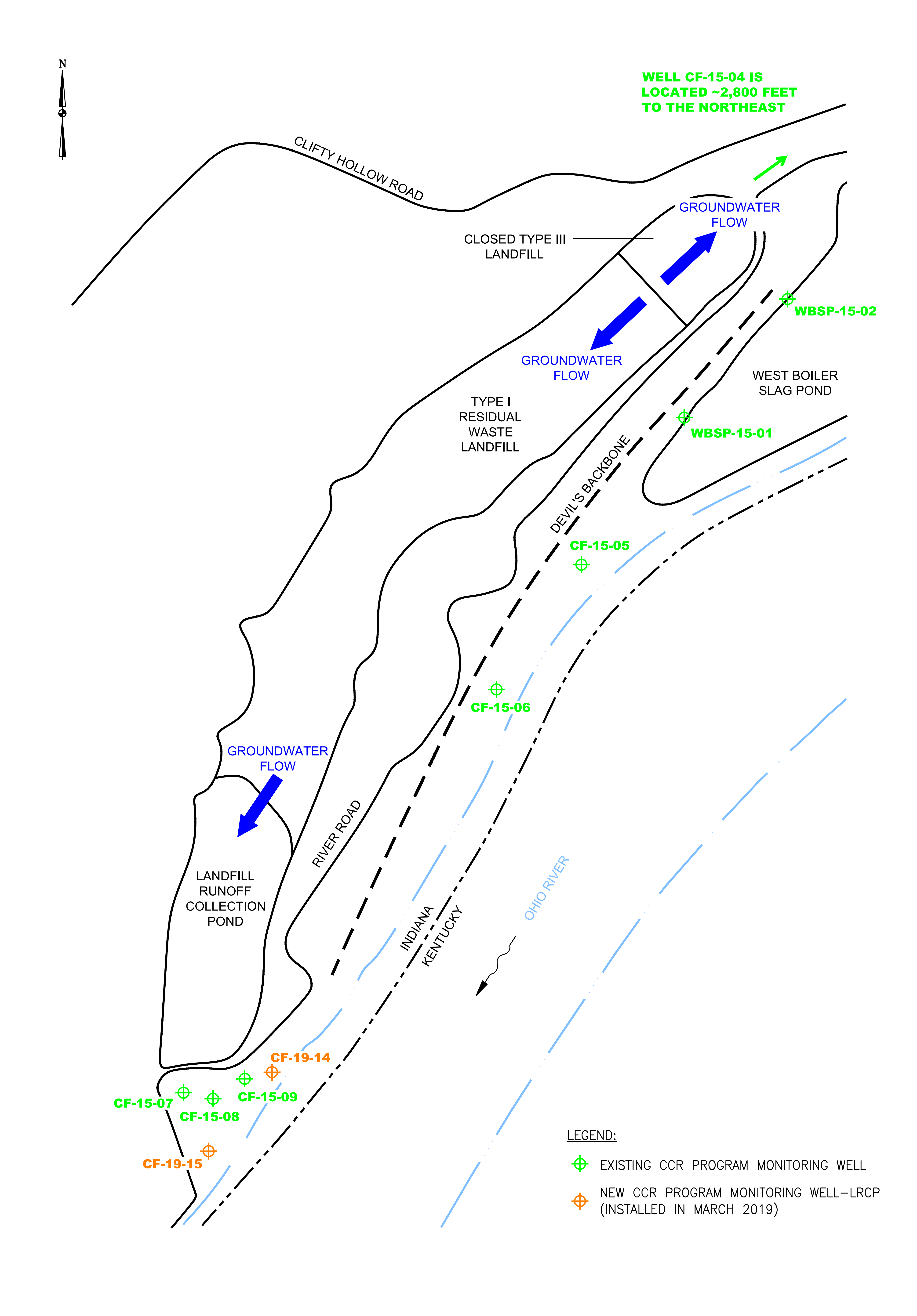
CLIFTY CREEK STATION
MADISON, INDIANA
TOPOGRAPHIC MAP

DRAWING NAME: FIGURE 3–2
REV. 0

Plot: 09/09/2019 14:51 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 3–2_USGS_topo_map.dwg



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DRAWING SCALE	AS SHOWN

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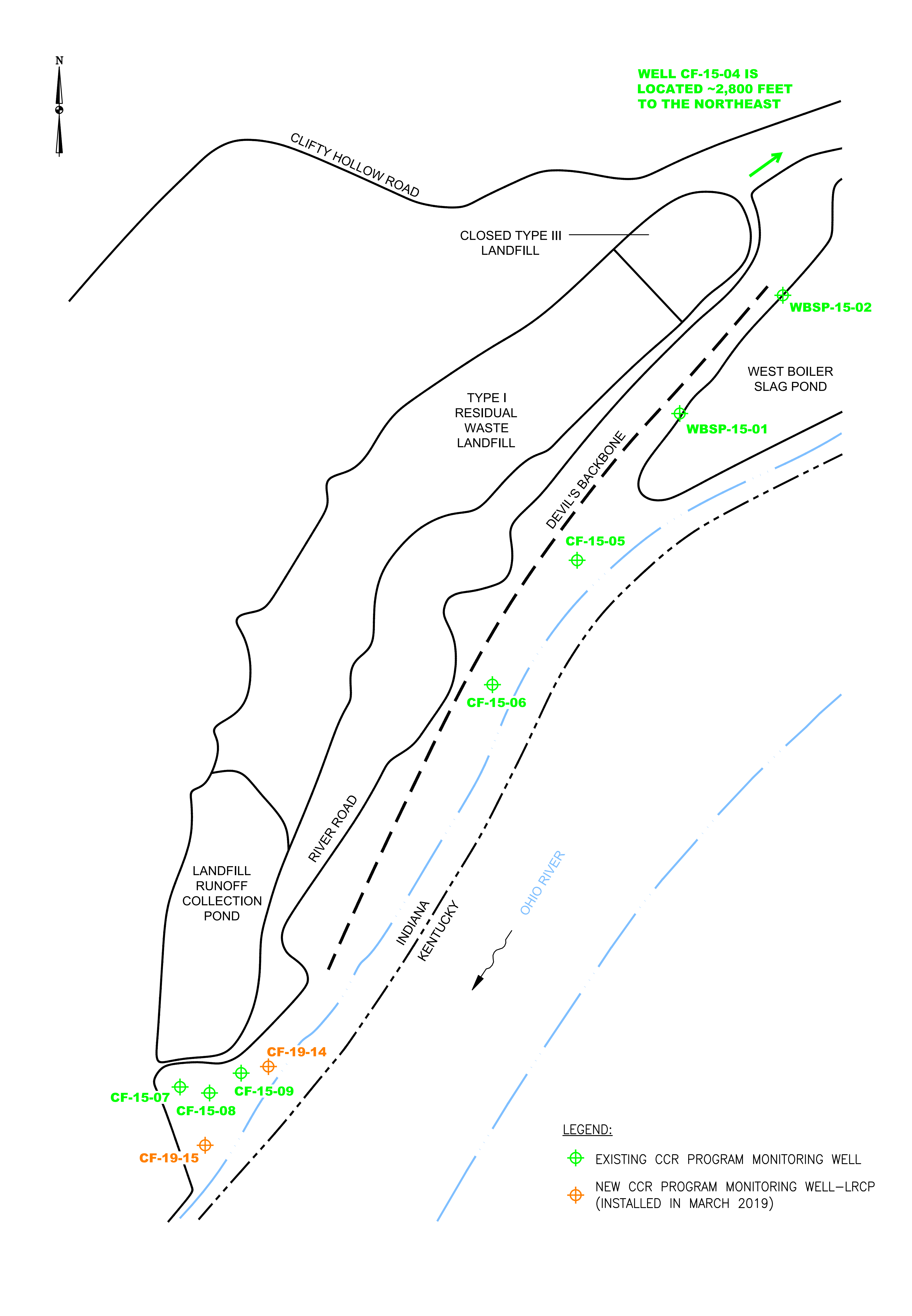
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I LANDFILL MONITORING WELL LOCATIONS AND
GENERALIZED FLOW MAP

DRAWING NAME: FIGURE 3–3
REV. 0

PLOTTED: 3/12/2025 X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3–12–2025\CAD\2024150–0–CLI__IKEC_CLIFTY_FIG 3–3_MOLYBDENUM AND ARSENIC CONCENTRATIONS.DWG



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DRAWING SCALE	AS SHOWN

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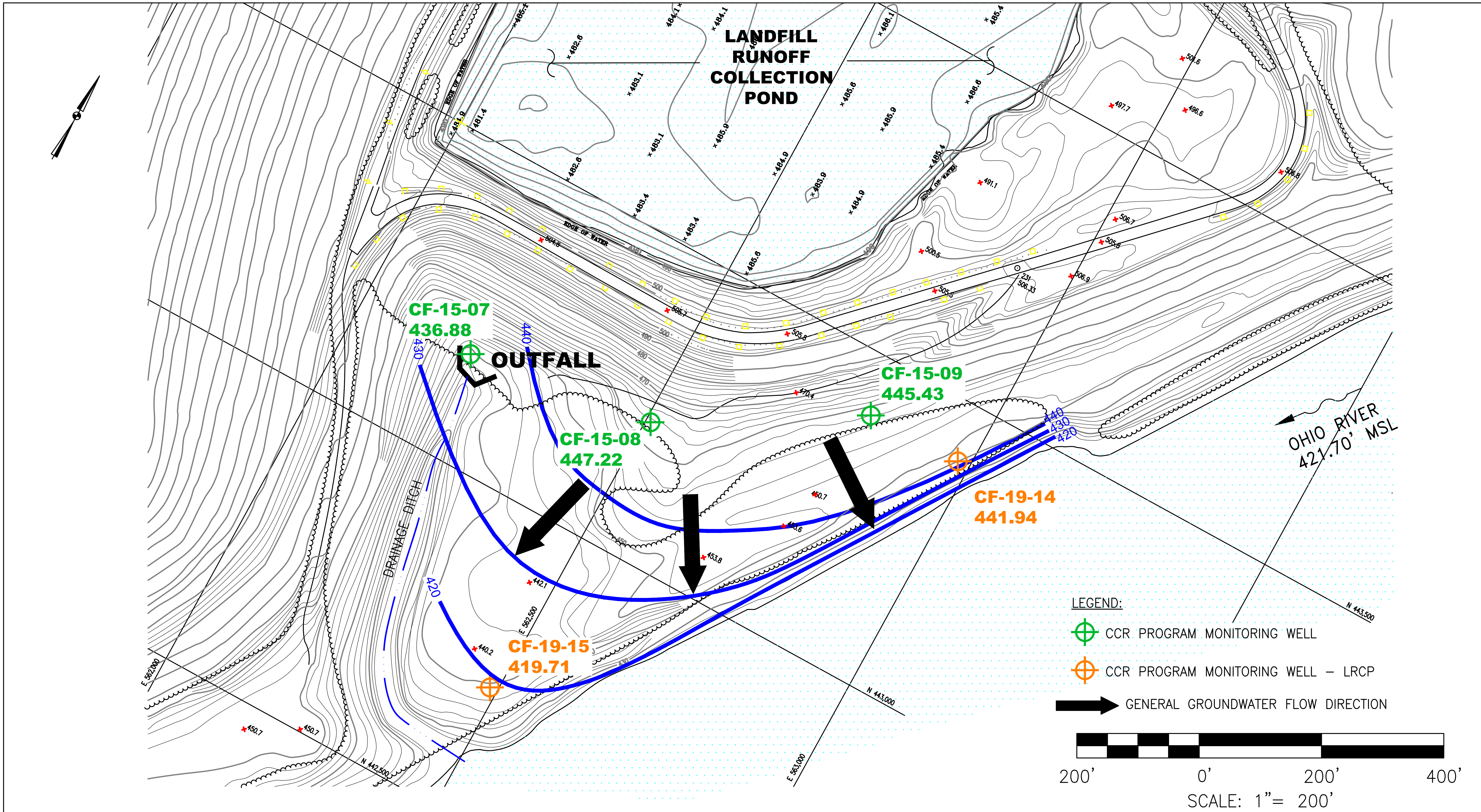
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I LANDFILL MONITORING WELL LOCATIONS

DRAWING NAME: FIGURE 4–1
REV. 0

PLOTTED: 3/12/2025 X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3-12-2025\CAD\2024150-0-CLI__IKEC_CLIFTY_FIG 4-1_MOLYBDENUM AND ARSENIC CONCENTRATIONS.DWG



NOTE:
WELLS CF–19–14 AND CF–19–15 WERE INSTALLED IN MARCH 2019 DURING THE CHARACTERIZATION OF THE LRCP.

DRAWN BY	GRM
DATE	1–29–2025
CHECKED BY	
JOB NO.	2024145–0–CLI
DWG FILE	2024145–0–CLI_IKEC_CLIFTY_ FIG 5–1.DWG
DRAWING SCALE	AS SHOWN

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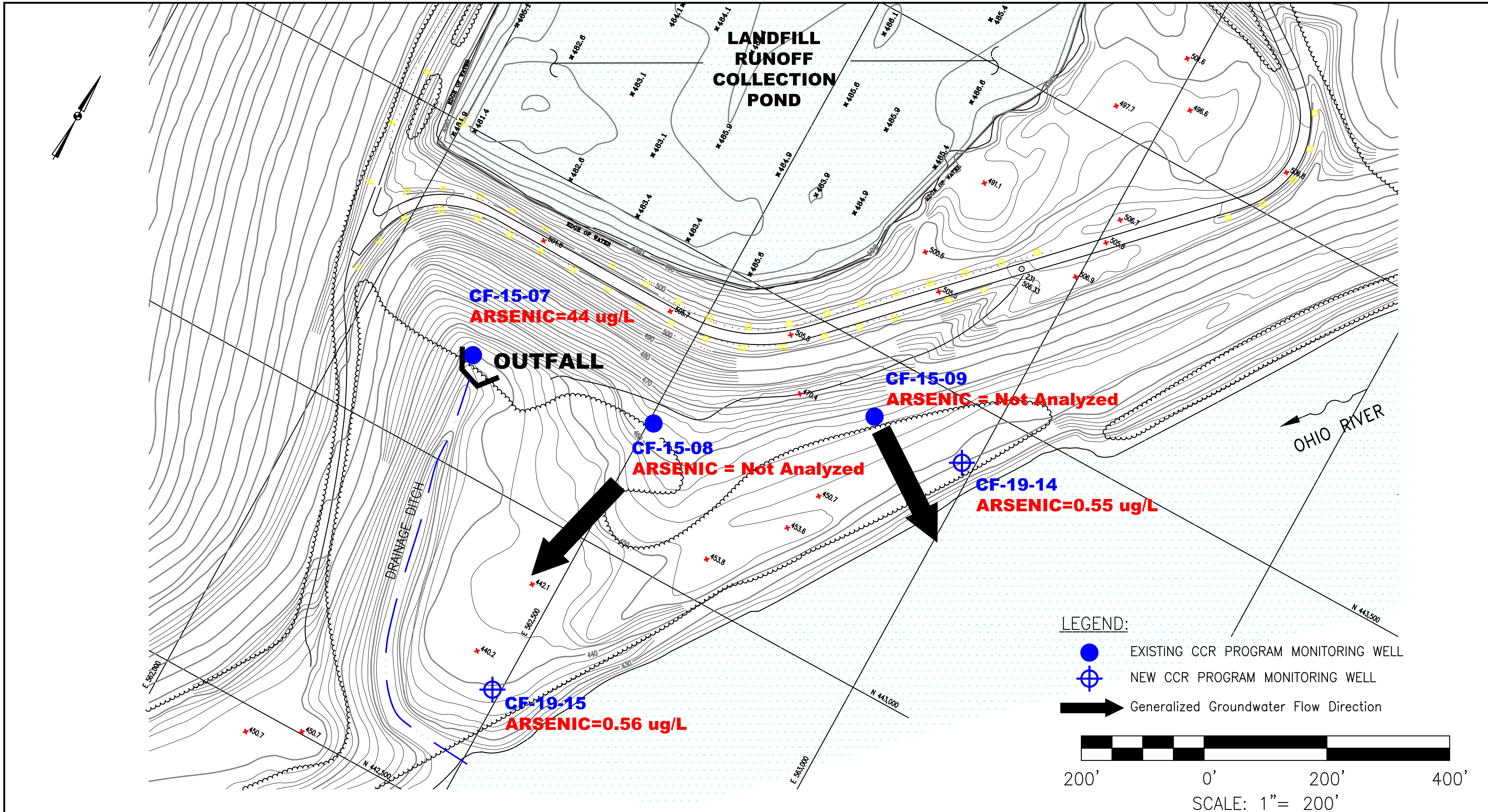
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND
GROUNDWATER FLOW – UPPERMOST AQUIFER
SEPTEMBER 2024

DRAWING NAME: FIGURE 5–1
REV. 0

PLOTTED: 3/10/2025 X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3–10–2025 TS\CAD\2024145–0–CLI_IKEC_CLIFTY_ FIG 5–1.DWG



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JOB NO.	2024145-0-CLI
DWG FILE	X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3-10-2025 TS\CAD\2024-145-0-CLI__IKEC_CLIFTY_FIG 5-2_ARSENIC CONCENTRATIONS.DWG
DRAWING SCALE	AS SHOWN

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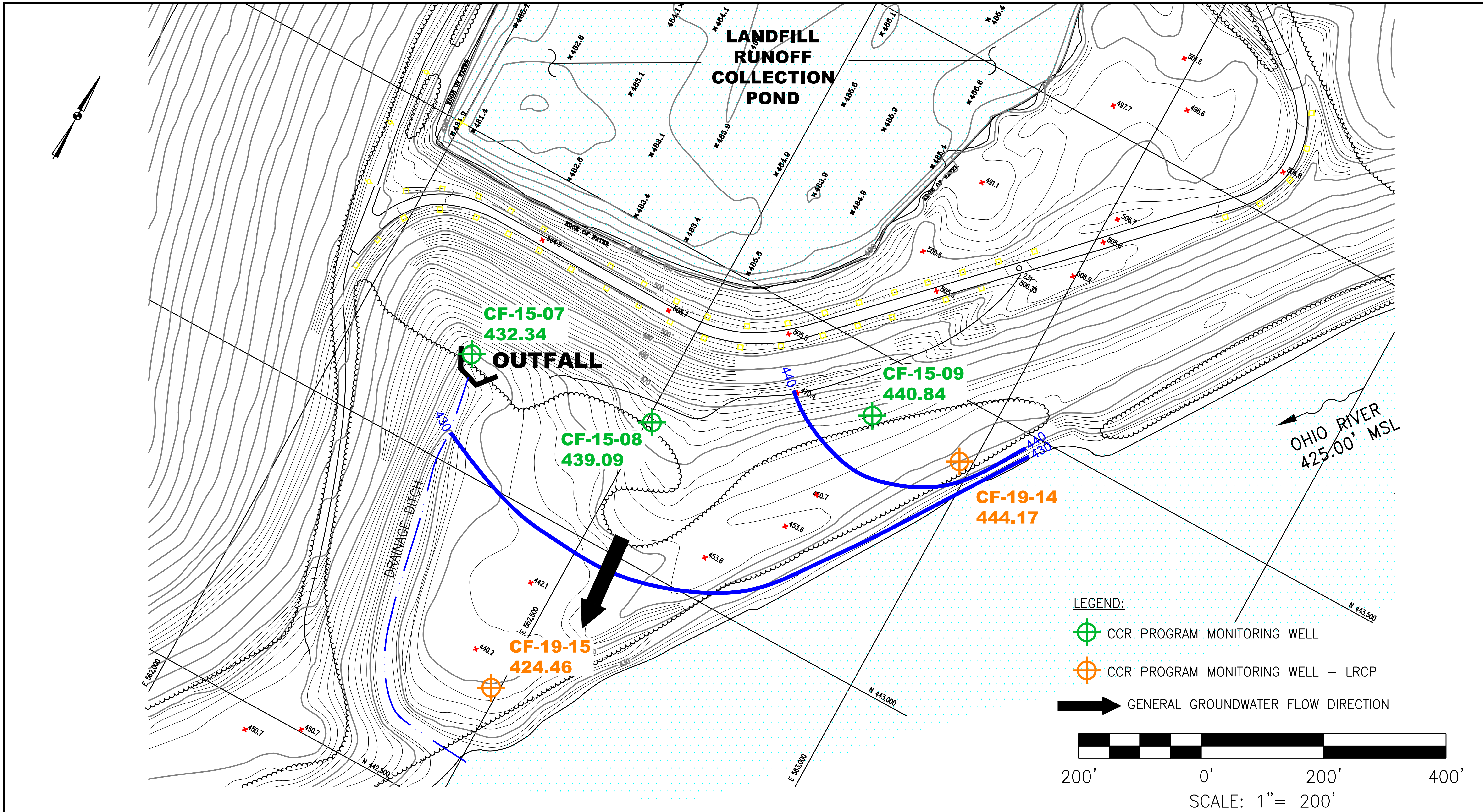
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
ARSENIC CONCENTRATIONS IN GROUNDWATER
DECEMBER 2024

DRAWING NAME: FIGURE 5-2
REV. 0

PLOTTED: 3/10/2025 X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3-10-2025 TS\CAD\2024-145-0-CLI__IKEC_CLIFTY_FIG 5-2_ARSENIC CONCENTRATIONS.DWG

APPENDIX A

GENERALIZED GROUNDWATER FLOW MAPS FOR MARCH 2023, SEPTEMBER 2023, AND MARCH 2024



NOTE:
WELLS CF–19–14 AND CF–19–15 WERE INSTALLED IN MARCH 2019 DURING THE CHARACTERIZATION OF THE LRCP.

DRAWN BY	GRM
DATE	1–29–2025
CHECKED BY	
JOB NO.	2024145–0–CLI
DWG FILE	
DRAWING SCALE	AS SHOWN

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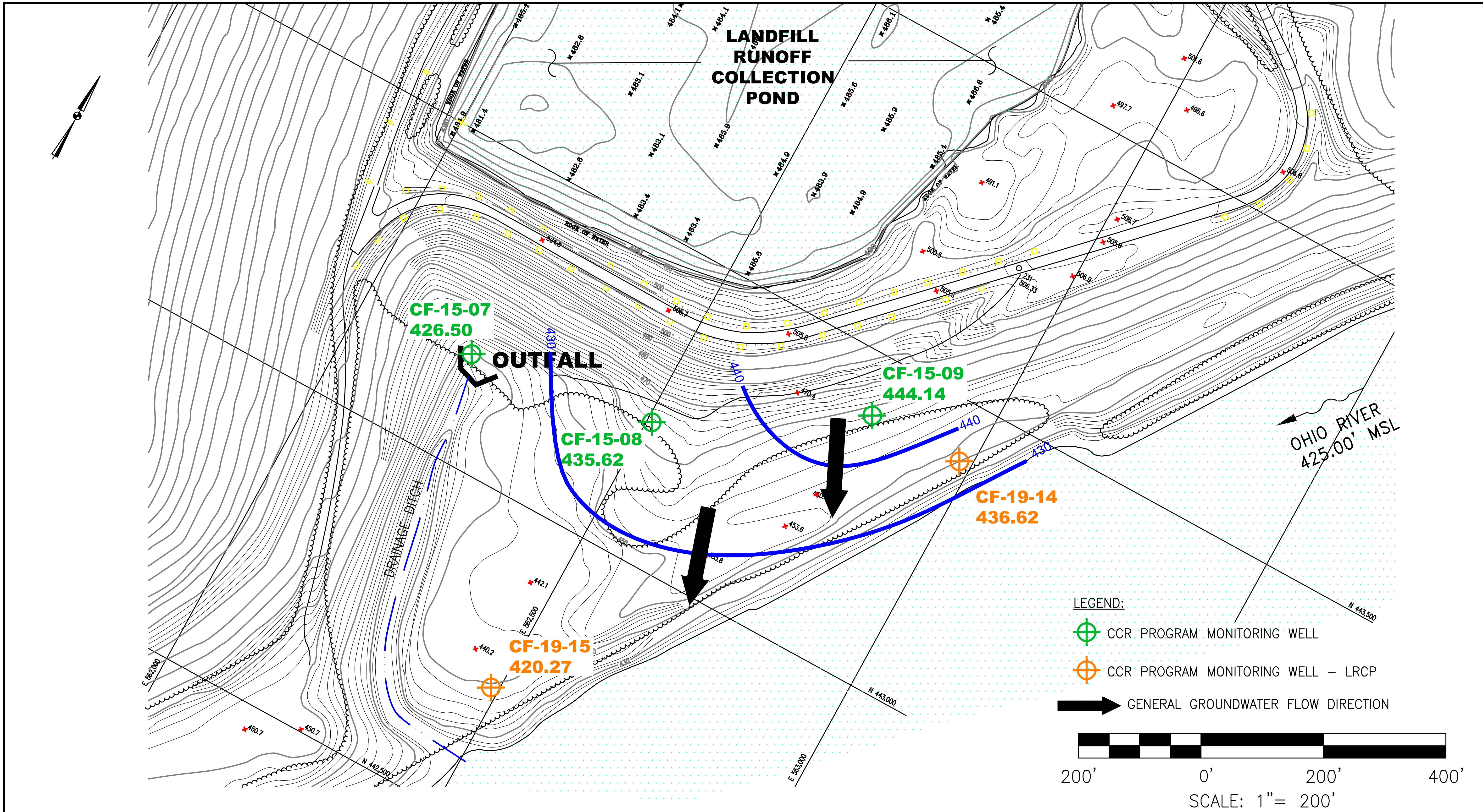
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
LANDFILL RUNOFF COLLECTION POND
GROUNDWATER FLOW – UPPERMOST AQUIFER
MARCH 2023

DRAWING NAME: FIGURE A–1

REV. 0

PLOTTED: 3/10/2025 X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3-10-2025 TS\CAD\2024145-0-CLI_IKEC_CLIFTY_ FIG A-1.DWG



NOTE:
WELLS CF–19–14 AND CF–19–15 WERE INSTALLED IN MARCH 2019 DURING THE CHARACTERIZATION OF THE LRCP.

DRAWN BY	GRM
DATE	1–29–2025
CHECKED BY	
JOB NO.	2024145–0–CLI
DWG FILE	2024145–0–CLI_IKEC_CLIFTY_ FIG A–2.DWG
DRAWING SCALE	AS SHOWN

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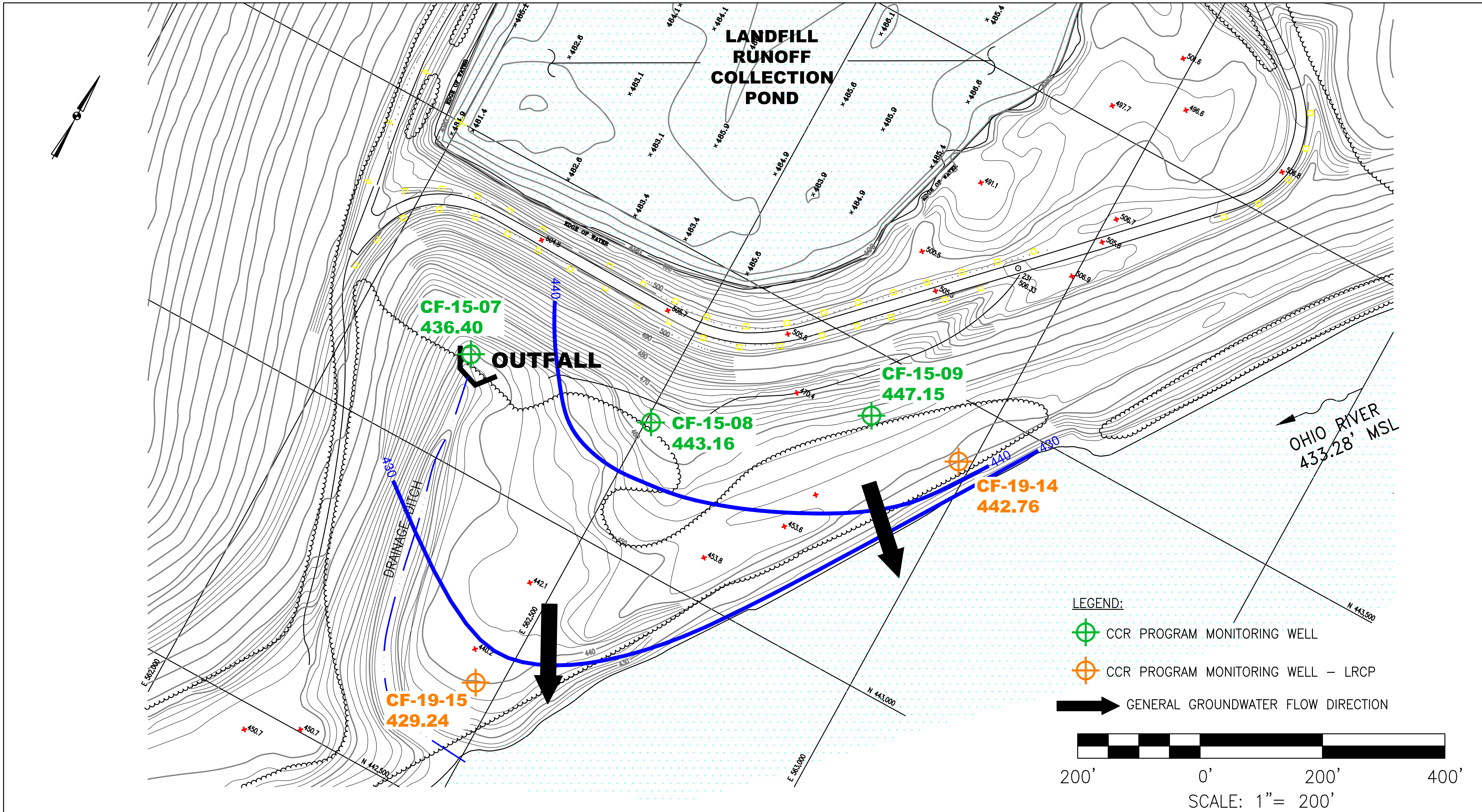
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
LANDFILL RUNOFF COLLECTION POND
GROUNDWATER FLOW – UPPERMOST AQUIFER
SEPTEMBER 2023

DRAWING NAME: FIGURE A–2

REV. 0



NOTE:
WELLS CF-19-14 AND CF-19-15 WERE INSTALLED IN MARCH 2019 DURING THE CHARACTERIZATION OF THE LRCP.

DRAWN BY	GRM
DATE	1-29-2025
CHECKED BY	
JOB NO.	2024145-0-CLI
DWG FILE	2024145-0-CLI_IKEC_CLIFTY_ FIG A-3.DWG
DRAWING SCALE	AS SHOWN

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INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
GROUNDWATER FLOW – UPPERMOST AQUIFER
MARCH 2024

DRAWING NAME: FIGURE A-3
REV. 0

PLOTTED: 3/10/2025 X:\SHARED\CLIENT_SHARE\GARYMALARKEY\2024 CLIFTY CREEK\CAD 3-10-2025 TS\CAD\2024145-0-CLI_IKEC_CLIFTY_ FIG A-3.DWG