INDIANA-KENTUCKY ELECTRIC CORPORATION
3932 U. S. Route 23
P. O. Box 468
Piketon, Ohio 45661
740-289-7200

WRITER'S DIRECT DIAL NO:
740-897-7768

February 28, 2020

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

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

Dear Mr. Pigott:

Re: Indiana-Kentucky Electric Corporation
2019 Annual Groundwater Monitoring and Corrective Actions Report

As required by 40 CFR 257.106(h)(1), the Indiana-Kentucky Electric Corporation (IKEC) is providing notification to the Commissioner (State Director) of the Indiana Department of Environmental Management that the third Annual CCR Groundwater Monitoring and Corrective Actions report has been completed in compliance with 40 CFR 257.90(e) for IKEC's Clifty Creek Station. The report has been placed in the facility's operating record in accordance with 40 CFR 257.105(h)(1), as well as, on the company's publically accessible internet site in accordance with 40 CFR 257.107(h)(1), which can be viewed at https://www.ovec.com/CCRCompliance.php .

If you have any questions, or require any additional information, please call me at (740) 897-7768.

Sincerely,

Tim Fulk

Tim Fulk
Engineer II

TLF:klr

Stantec Consulting Services Inc.
11687 Lebanon Road, Cincinnati OH 45241-2012

January 31, 2020

File: 175534018, 200.201

Ohio Valley Electric Corporation
Indiana-Kentucky Electric Corporation
Attention: Mr. Gabriel Coriell
3932 U.S. Route 23
P.O. Box 468
Piketon, Ohio 45661

Reference: 2019 Annual Groundwater Monitoring and Corrective Action Report
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Generating Station
Madison, Indiana

Dear Mr. Coriell,

The EPA Final CCR Rule requires owners or operators of existing CCR landfills and surface impoundments to prepare an annual groundwater monitoring and corrective action report no later than January 31 of the year following the calendar year a groundwater monitoring system has been established for such CCR unit as required by 40 CFR 257.90(e). For the Indiana-Kentucky Electric Corporation (IKEC), this applies to the Clifty Creek Station's West Boiler Slag Pond, Landfill Runoff Collection Pond, and CCR Landfill.

The annual report must document the status of the groundwater monitoring and corrective action program for the CCR unit, summarize key actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year. At a minimum, the annual groundwater monitoring and corrective action report must contain the following information, to the extent available:

1. A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit;
2. Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken;
3. In addition to all the monitoring data obtained under §§257.90 through 257.98, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs;
4. A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from detection monitoring to assessment monitoring in

**Reference: 2019 Annual Groundwater Monitoring and Corrective Action Report
EPA Final Coal Combustion Residuals (CCR) Rule
Clifty Creek Generating Station
Madison, Indiana**

addition to identifying the constituent(s) detected at a statistically significant increase over background level); and

5. Other information required to be included in the annual report as specified in §§257.90 through 257.98.

IKEC has retained Applied Geology and Environmental Science, Inc. of Clinton, Pennsylvania (AGES) to perform the Clifty Creek Station's groundwater monitoring and corrective action support under the EPA Final CCR Rule. The CCR Regulation 2019 Groundwater Monitoring and Corrective Action Report (GWCAR) was prepared by AGES to present the annual groundwater monitoring at the West Boiler Slag Pond, Landfill Runoff Collection Pond, and CCR Landfill of the Clifty Creek Station. Stantec Consulting Services Inc. (Stantec) has reviewed AGES (2019) and it meets the requirements specified in 40 CFR 257.90(e).

Please contact us with any questions or concerns. We appreciate the opportunity to continue to work with the Clifty Creek Generating Station and the Indiana-Kentucky Electric Corporation.

Regards,

Stantec Consulting Services Inc.

Jacqueline S. Harmon, P.E.
Senior Associate
Phone: (513) 842-8200 ext 8220
Fax: (513) 842-8250
Jacqueline.Harmon@stantec.com

Attachment: AGES (2020). Coal Combustion Residuals Regulation, 2019 Groundwater Monitoring and Corrective Action Report, Indiana-Kentucky Electric Corporation. Clifty Creek Station, Madison, Indiana, January.

c. Stan Harris, John Griggs

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AGES
Applied Geology And Environmental Science, Inc.

2402 Hookstown Grade Road, Suite 200
Clinton, PA 15026
www.appliedgeology.net
P 412. 264. 6453
F 412. 264. 6567

COAL COMBUSTION RESIDUALS REGULATION 2019 GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA

JANUARY 2020

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

COAL COMBUSTION RESIDUALS REGULATION
2019 GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA

JANUARY 2020

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

Prepared By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

Bethany Flaherty
Project Scientist

Robert W. King, P.G.
President/Chief Hydrogeologist

**COAL COMBUSTION RESIDUALS REGULATION
2019 GROUNDWATER MONITORING AND
CORRECTIVE ACTION REPORT
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA**

T A B L E O F C O N T E N T S

COAL COMBUSTION RESIDUALS REGULATION
2019 GROUNDWATER MONITORING AND
CORRECTIVE ACTION REPORT
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA

T A B L E O F C O N T E N T S
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LIST OF ACRONYMS

ACM	Assessment of Corrective Measures
AGES	Applied Geology and Environmental Science, Inc.
ASD	Alternate Source Demonstration
CCR	Coal Combustion Residuals
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
MCL	Maximum Contaminant Level
MW	Megawatt
OVEC	Ohio Valley Electric Corporation
RCRA	Resource Conservation and Recovery Act
StAP	Statistical Analysis Plan
SSI	Statistically Significant Increase
Stantec	Stantec Consulting Services, Inc.
Type I Landfill	Type I Residual Waste Landfill
S.U.	Standard Unit
ug/L	micrograms per liter
U.S. EPA	United States Environmental Protection Agency
WBSP	West Boiler Slag Pond

COAL COMBUSTION RESIDUALS REGULATION
2019 GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
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 Coal Combustion Residuals (CCR) regulation which regulates CCR as a non-hazardous waste under Subtitle D of 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 U.S. EPA.

This Groundwater Monitoring and Corrective Action Report has been prepared in accordance with §257.90 (e) of the CCR Rule and documents the status of the groundwater monitoring and corrective action program for each CCR unit, summarizes the key actions completed during 2019, describes any problems encountered, discusses actions to resolve the problems, and projects key activities for the upcoming year.

2.0 BACKGROUND

The Clifty Creek Station, located in Madison, Indiana, is a 1,304-megawatt (MW) coal-fired generating plant operated by the Indiana-Kentucky Electric Corporation (IKEC), a subsidiary of the Ohio Valley Electric Corporation (OVEC). The Clifty Creek Station has six (6) 217.26-MW generating units and has been in operation since 1955. Beginning in 1955, ash products were sluiced to disposal ponds located in the plant site. During the course of plant operations, CCRs have been managed and disposed of in various units at the station. There are three (3) CCR units at the Clifty Creek Station (Figure 1):

- Type I Residual Waste Landfill (Type I Landfill);
- Landfill Runoff Collection Pond (LRCP); and
- West Boiler Slag Pond (WBSP).

A discussion of the status of the groundwater monitoring program for each CCR unit is presented in the following sections of this report. Under the CCR program, IKEC installed a groundwater monitoring system at each unit in accordance with the requirements of the CCR Rule; the Type I

Landfill and LRCP are included in a multi-unit monitoring system. The units are discussed separately in this report.

3.0 TYPE I RESIDUAL WASTE LANDFILL

The Type I Landfill and LRCP occupy an approximately 200-acre area situated within an eroded bedrock channel (Figures 1 and 2). Beginning in 1955, ash products were sluiced to disposal ponds located in the plant site. To allow for more disposal capacity, an on-site fly ash pond was developed into a Type III Landfill in 1988. All required permits for the Type III Landfill were obtained from the Indiana Department of Environmental Management (IDEM) and the Type III Landfill went operational in 1991. In March 1994, IDEM approved a pH variance for the disposal of low-sulfur coal ash in the fly ash Type III Landfill. Emplacement of low-sulfur coal ash in the Type III Landfill began in January 1995. In April 2007, IKEC submitted a permit application to IDEM to upgrade the former landfill from a Type III landfill to a Type I landfill. In 2013, IDEM issued a renewed permit and approved IKEC's request to upgrade the landfill to a Type I landfill.

The Type I Landfill consists of approximately 109 acres and has been approved by IDEM as a Type I Residual Waste Landfill. The remaining 91 acres consist of the LRCP located at the southwest end of the Type I Landfill. The LRCP is discussed in Section 4.0.

3.1 Groundwater Monitoring Network

As detailed in the Monitoring Well Installation Report (Applied Geology and Environmental Science, Inc. [AGES] 2018a), the CCR groundwater monitoring network for the Type I Landfill consists of the following eight (8) monitoring 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 2. As listed above and shown on Table 3-1, the CCR groundwater monitoring network includes five (5) background and three (3) downgradient monitoring wells, which satisfies the requirements of the CCR Rule. Groundwater levels measured in 2019 are included in Table A-1 of Appendix A. Groundwater flow maps for the two (2) monitoring events completed in 2019 are included in Appendix B.

3.2 Groundwater Sampling

In accordance with §257.94 of the CCR Rule, the second round of Detection Monitoring was conducted in March 2019 and the third round of Detection Monitoring samples were collected in October 2019.

All groundwater samples were collected in accordance with the Groundwater Monitoring Program Plan (GMPP) (AGES 2018b). The Detection Monitoring samples were analyzed for all Appendix III constituents, which are listed in Appendix C. In accordance with §257.90(e)(3), Table 3-2 presents a sampling summary, including the number of groundwater samples collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the Detection or the Assessment Monitoring program. Table 3-3 summarizes the measurements of field parameters collected at the completion of purging, immediately prior to collection of each sample. All samples were shipped to an analytical laboratory to be analyzed.

3.3 Analytical Results

Upon receipt of the March 2019 analytical results, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Clifty Creek Station CCR Statistical Analysis Plan (StAP) (Stantec 2018). Appendix D summarizes the analytical results for groundwater samples collected in 2019. The statistical evaluation of the data identified potential Statistically Significant Increases (SSIs) for Boron in CF-15-08 and CF-15-09. In accordance with the StAP, the wells were resampled for Boron in June 2019. Based on the resampling results, both SSIs were confirmed for Boron in wells CF-15-08 and CF-15-09 (Table 3-4).

Upon receipt of the October 2019 analytical results, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Clifty Creek Station CCR StAP (Stantec 2018). The statistical evaluation of the identified a potential SSI for Boron in well CF-15-08. In accordance with the StAP, well CF-15-08 was resampled for Boron in November 2019 and the Boron SSI was confirmed (Table 3-4).

3.4 Alternate Source Demonstration

For both 2019 Detection Monitoring events, OVEC prepared an Alternate Source Demonstration (ASD) that indicated that the Boron detected in groundwater came from a source other than the Type I Landfill. Therefore, the Type I Landfill remains in Detection Monitoring. The ASDs for March 2019 and October 2019 are provided in Appendix E and Appendix F, respectively.

4.0 LANDFILL RUNOFF COLLECTION POND

The Type I Landfill and LRCP occupy an approximately 200-acre area situated within an eroded bedrock channel (Figures 1 and 2). The Type I Landfill, which is discussed above in Section 3.0, consists of approximately 109 acres, and the remaining 91 acres consist of the LRCP located at the southwest end of the Type I Landfill. The CCR activities for the LRCP during March and October 2019 are summarized in Sections 4.1 and 4.3 below.

4.1 Summary of CCR Activities for March 2019

4.1.1 Groundwater Monitoring Network

As detailed in the Monitoring Well Installation Report (AGES 2018a), the CCR groundwater monitoring network for the LRCP consisted of the following eight (8) monitoring wells for the March 2019 monitoring event activities:

- 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 2. As listed above and shown on Table 4-1, the CCR groundwater monitoring network includes five (5) background and three (3) downgradient monitoring wells, which satisfies the requirements of the CCR Rule. Groundwater levels measured in 2019 are included in Table A-2 of Appendix A. The groundwater flow map for the March 2019 Assessment Monitoring event is included in Appendix B.

4.1.2 Groundwater Sampling

In accordance with §257.94 of the CCR Rule, the second round of Assessment Monitoring was conducted in March 2019.

All groundwater samples were collected in accordance with the GMPP (AGES 2018b). The Assessment Monitoring samples were analyzed for Appendix III and Appendix IV constituents, which are listed in Appendix C. In accordance with §257.90(e)(3), Table 4-2 presents a sampling summary, including the number of groundwater samples collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the Detection or the Assessment Monitoring program. Table 4-3 summarizes the measurements of field parameters collected at the completion of purging, immediately prior to collection of each sample. All samples were shipped to an analytical laboratory to be analyzed.

4.1.3 Analytical Results-Appendix III

Upon receipt, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Clifty Creek Station CCR StAP (Stantec 2018). Appendix D summarizes the analytical results for groundwater samples collected in 2019. The statistical evaluation identified potential SSIs for Boron in wells CF-15-08 and CF-15-09 in March 2019. In accordance with the StAP, the wells were resampled for Boron in June 2019. Based on the resampling results, SSIs were confirmed for Boron in wells CF-15-08 and CF-15-09 (Table 4-4).

4.1.4 Analytical Results-Appendix IV

Based on previous detections of Appendix IV constituents in groundwater at the LRCP, IKEC established a Groundwater Protection Standard (GWPS) for each detected Appendix IV constituent in accordance with the §257.95(h)(1) through §257.95(h)(3) as follows:

(1) For constituents for which the U.S. EPA has established a Maximum Contaminant Level (MCL), the GWPS shall be the MCL for that constituent.

(2) On July 30, 2018, the U.S. EPA published alternate limits to be used for several constituents that did not have previously established MCLs to be used as the GWPS for those constituents.

(3) For constituents for which the background level is higher than the MCL or the alternate limit, the background concentration shall be the GWPS for that constituent.

Table 4-5 presents the list of GWPSs for the Assessment Monitoring program at the LRCP that were developed in accordance with the above requirements. Based on a comparison of the Appendix IV sampling results to the GWPSs, it was confirmed that Molybdenum in well CF-15-08 exceeded the GWPS of 100 micrograms per liter (ug/L) and that Molybdenum concentrations in CF-15-09 did not exceed the GWPS (Table 4-6).

4.2 Assessment of Corrective Measures

Based on the Molybdenum exceedances, OVEC conducted additional groundwater sampling to characterize the nature and extent of the release and an Assessment of Corrective Measures (ACM) in accordance with §257.95(g). As part of this assessment, in March 2019, two (2) additional wells (CF-19-14 and CF-19-15) were installed in the uppermost aquifer at the property boundary downgradient from the LRCP (Figure 2). These wells were developed, hydraulically tested and sampled for analysis of Appendix III and Appendix IV constituents. Details regarding the installation of these wells and potential corrective measures are included in the ACM Report for the LRCP (AGES 2019), which is included in Appendix G. In accordance with §257.96(e), in November 2019, a public meeting was held to discuss the results of the corrective measures.

4.3 Summary of CCR Activities for October 2019

4.3.1 Groundwater Monitoring Network

The two (2) monitoring wells that were installed as part of the additional assessment activities for the LRCP (AGES 2019) were added to the CCR groundwater monitoring network for the LRCP as follows:

- CF-19-14 (Downgradient); and
- CF-19-15 (Downgradient).

The locations of the wells in the groundwater monitoring network are shown on Figure 2. As listed above and shown on Table 4-1, these additional monitoring wells satisfy the requirements of the CCR Rule. Groundwater levels measured in 2019 are included in Table A-2 of Appendix A. The groundwater flow map for the October 2019 Assessment Monitoring event is included in Appendix B.

4.3.2 Groundwater Sampling

In accordance with §257.94 of the CCR Rule, the third round of Assessment Monitoring samples were collected in October 2019.

All groundwater samples were collected in accordance with the GMPP (AGES 2018b). The Assessment Monitoring samples were analyzed for Appendix III and Appendix IV constituents, which are listed in Appendix C. In accordance with §257.90(e)(3), Table 4-2 presents a sampling summary, including the number of groundwater samples collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the Detection or the Assessment Monitoring program. Table 4-3 summarizes the measurements of field parameters collected at the completion of purging, immediately prior to collection of each sample. All samples were shipped to an analytical laboratory to be analyzed.

4.3.3 Analytical Results-Appendix III

Upon receipt, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Clifty Creek Station CCR StAP (Stantec 2018). Appendix D summarizes the analytical results for groundwater samples collected in 2019. The statistical evaluation identified potential SSIs for Boron in wells CF-15-08 and CF-19-14 in October 2019. In accordance with the StAP, well CF-15-08 was resampled for Boron in November 2019. Based on the resampling, the SSI was confirmed for Boron in well CF-15-08 in October 2019 (Table 4-4). Well CF-19-14 was inadvertently not resampled and the SSI was assumed to be confirmed.

4.3.4 Analytical Results-Appendix IV

Table 4-5 presents the list of GWPSs for the Assessment Monitoring program at the LRCP that were developed in accordance with the CCR. All Appendix IV results were compared to the GWPSs. Molybdenum in well CF-15-08 was confirmed to exceed the GWPS of 100 ug/L during the October 2019 Assessment Monitoring event (Table 4-6).

5.0 WEST BOILER SLAG POND

The WBSP currently serves as a settling facility for sluiced boiler slag produced at the plant. The pond is formed by natural grade to the north, east and west and a southern dike that runs along the bank of the Ohio River. The Devil's Backbone borders the northern side of the WBSP (Figures 1 and 3).

5.1 Groundwater Monitoring Network

As detailed in the Monitoring Well Installation Report (AGES 2018a), the CCR groundwater monitoring network for the WBSP includes the following 13 wells:

- CF-15-04 (Background);
- CF-15-05 (Background);
- CF-15-06 (Background);
- WBSP-15-01 (Upgradient);
- WBSP-15-02 (Upgradient);
- WBSP-15-03 (Upgradient);
- WBSP-15-04 (Downgradient);
- WBSP-15-05 (Downgradient);
- WBSP-15-06 (Downgradient);
- WBSP-15-07 (Downgradient);
- WBSP-15-08 (Downgradient);
- WBSP-15-09 (Downgradient); and
- WBSP-15-10 (Downgradient).

The locations of the wells in the groundwater monitoring network are shown on Figure 3. As listed above and shown on Table 5-1, the CCR groundwater monitoring network for the WBSP includes six (6) background and upgradient wells and seven (7) downgradient wells, which satisfies the requirements of the CCR Rule.

Groundwater levels measured in 2019 are included in Table A-3 of Appendix A. Groundwater flow maps for the two (2) monitoring events completed in 2019 are included in Appendix B. As background wells WBSP-15-01, WBSP-15-02 and WBSP-15-03 are not screened in the uppermost aquifer at the unit, groundwater flow directions are based on the groundwater elevations in downgradient wells and the elevation of the nearby Ohio River.

5.2 Groundwater Sampling

In accordance with §257.94 of the CCR Rule, IKEC completed two (2) rounds of Detection Monitoring at the WBSP. Table 5-2 presents a sampling summary, which includes the number of groundwater samples collected for analysis for each upgradient, background and downgradient well, the dates the samples were collected, and whether the sample was required by the Detection Monitoring program. Table 5-3 summarizes the measurements of field parameters collected at the completion of purging, immediately prior to collection of each sample. All samples were collected in accordance with the GMPP (AGES 2018b) and shipped to an analytical laboratory to be analyzed for all of the parameters listed in Appendix III of the CCR Rule (Appendix C).

5.3 Analytical Results

Upon receipt of the March 2019 and October 2019 analytical results, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Clifty Creek Station CCR StAP (Stantec 2018). Appendix D summarizes the analytical results for groundwater samples collected in 2019. No potential SSIs were identified during either Detection Monitoring events. Therefore, the WBSP will remain in Detection Monitoring.

6.0 PROBLEMS ENCOUNTERED

There were no problems encountered during the 2019 groundwater morning program at Clifty Creek Station.

7.0 PROJECTED ACTIVITIES FOR 2020

The Type I Landfill will remain in Detection Monitoring and continue to be sampled on a semi-annual basis.

The LRCP will remain in Assessment Monitoring and continue to be sampled on a semi-annual basis. As described above, an ACM has been completed for this unit and the process of the selection of remedy for the LRCP will continue in 2020.

The WBSP will remain in Detection Monitoring and continue to be sampled on a semi-annual basis.

8.0 REFERENCES

Applied Geology and Environmental Science, Inc. (AGES) 2019. Coal Combustion Residuals Regulation Assessment of Corrective Measures Report Landfill Runoff Collection Pond, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. September 2019.

Applied Geology and Environmental Science, Inc. (AGES) 2018c. Coal Combustion Residuals Regulation Alternate Source Demonstration Report, February/March 2018 Detection Monitoring Event, Indiana Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Ohio. September 2018.

Applied Geology and Environmental Science, Inc. (AGES) 2018a. Coal Combustion Residuals Regulation Monitoring Well Installation Report, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. Revision 1.0. November 2018.

Applied Geology and Environmental Science, Inc. (AGES) 2018b. Coal Combustion Residuals Regulation Groundwater Monitoring Program Plan, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. Revision 1.0. November 2018.

Stantec Consulting Services, Inc. (Stantec) 2018. Coal Combustion Residuals Regulation Statistical Analysis Plan, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. January 2018.

TABLES

TABLE 3-1
GROUNDWATER MONITORING NETWORK
TYPE I RESIDUAL WASTE 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

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.

TABLE 3-2
SAMPLES COLLECTED DURING 2019
TYPE I RESIDUAL WASTE LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Designation	Mar-19	Jun-19	Oct-19	Nov-19
CF-15-04	Background	DM	NS	DM	NS
CF-15-05	Background	DM	NS	DM	NS
CF-15-06	Background	DM	NS	NS	NS
CF-15-07	Downgradient	DM	NS	DM	NS
CF-15-08	Downgradient	DM	DM	DM	DM
CF-15-09	Downgradient	DM	DM	DM	NS
WBSP-15-01	Background	DM	NS	NS	NS
WBSP-15-02	Background	DM	NS	NS	NS

Notes:
1. DM: Detection Monitoring.
2. NS: Not Sampled.

TABLE 3-3
SUMMARY OF MEASURED FIELD PARAMETERS DURING 2019
TYPE I RESIDUAL WASTE LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Sample ID	Date	Temperature (°C)	Conductivity (µohms/cm)	pH (S.U.)	Oxidation Reduction Potential (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTUs)
CF-15-04	Mar-19	9.97	581	6.65	171	4.19	3.84
CF-15-05	Mar-19	12.12	948	6.77	54	1.48	4.08
CF-15-06	Mar-19	10.28	946	6.99	265	2.72	2.86
CF-15-07	Mar-19	14.41	1090	7.05	-87.0	0.34	4.92
CF-15-08	Mar-19	15.89	1019	7.05	23.1	0.16	4.32
CF-15-09	Mar-19	8.77	1035	7.19	130	0.87	4.61
WBSP-15-01	Mar-19	9.11	1090	6.76	188	5.51	11.6
WBSP-15-02	Mar-19	11.47	1390	6.85	266	8.18	4.04
CF-15-08	Jun-19	26.07	856	7.1	91	0.31	3.61
CF-15-09	Jun-19	19.71	971	7.91	102	3.37	5.07
CF-15-04	Oct-19	24.16	589	7.23	105	1.83	3.48
CF-15-05	Oct-19	20.49	939	7.12	-89	1.95	4.01
CF-15-06	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
CF-15-07	Oct-19	20.03	1120	7.02	-127	1.78	4.08
CF-15-08	Oct-19	19.58	917	7.29	38	4.35	3.75
CF-15-09	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
WBSP-15-01	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
WBSP-15-02	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
CF-15-08	Nov-19	13.91	893	7.49	74	2.18	4.38

Notes:

1. °C: Degrees Celsius.
2. µohms/cm: Micro-ohms per centimeter.
3. S.U.: Standard Units.
4. mV: Millivolts.
5. mg/L: Milligrams per liter.
6. NTUs: Nephelometric Turbidity Units.

TABLE 3-4
SUMMARY OF POTENTIAL AND CONFIRMED APPENDIX III SSIs
TYPE I RESIDUAL WASTE LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Potential SSI Parameter (Units)	2nd Detection Monitoring Sampling Event March 2019		2nd Detection Monitoring Resampling Event June 2019		3rd Detection Monitoring Sampling Event October 2019		3rd Detection Monitoring Resampling Event November 2019	
		Potential SSI Result	UPL	Potential SSI Result	Confirmed SSI (Yes/No)	Potential SSI Result	UPL	Potential SSI Result	Confirmed SSI (Yes/No)
CF-15-08	Boron (mg/L)	9.8	5.566	8.5	**Yes**	11	5.566	9	**Yes**
CF-15-09	Boron (mg/L)	6.7	5.566	6.5	**Yes**	NA	NA	NA	NA

Notes:
1. SSI: Statistically Significant Increase.
2. UPL: Upper Prediction Limit (Maximum Interwell UPL).
3. mg/L: Milligrams per liter.
4. NA: Not Applicable—no SSI.

TABLE 4-1
GROUNDWATER MONITORING NETWORK
LANDFILL RUNOFF COLLECTION POND
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	3/8/2019	443401.75	562901.93	452.29	454.88	440.05	430.05	24.83
CF-19-15	Downgradient	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.

TABLE 4-2
SAMPLES COLLECTED DURING 2019
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Designation	Mar-19	Jun-19	Oct-19	Nov-19
CF-15-04	Background	AM	NS	AM	NS
CF-15-05	Background	AM	NS	AM	NS
CF-15-06	Background	AM	NS	NS	NS
CF-15-07	Downgradient	AM	NS	AM	NS
CF-15-08	Downgradient	AM	AM	AM	AM
CF-15-09	Downgradient	AM	AM	AM	NS
WBSP-15-01	Background	AM	NS	NS	NS
WBSP-15-02	Background	AM	NS	NS	NS
CF-19-14	Downgradient	NI	NI	AM	NS
CF-19-15	Downgradient	NI	NI	AM	NS

Notes:
1. AM: Assessment Monitoring.
2. NS: Not Sampled.
3. NI: Not Installed or Sampled—refer to Sections 4.2 and 4.3.

TABLE 4-3
SUMMARY OF MEASURED FIELD PARAMETERS DURING 2019
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Sample ID	Date	Temperature (°C)	Conductivity (µohms/cm)	pH (S.U.)	Oxidation Reduction Potential (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTUs)
CF-15-04	Mar-19	9.97	581	6.65	171	4.19	3.84
CF-15-05	Mar-19	12.12	948	6.77	54	1.48	4.08
CF-15-06	Mar-19	10.28	946	6.99	265	2.72	2.86
CF-15-07	Mar-19	14.41	1090	7.05	-87.0	0.34	4.92
CF-15-08	Mar-19	15.89	1019	7.05	23.1	0.16	4.32
CF-15-09	Mar-19	8.77	1035	7.19	130	0.87	4.61
WBSP-15-01	Mar-19	9.11	1090	6.76	188	5.51	11.6
WBSP-15-02	Mar-19	11.47	1390	6.85	266	8.18	4.04
CF-15-08	Jun-19	26.07	856	7.1	91	0.31	3.61
CF-15-09	Jun-19	19.71	971	7.91	102	3.37	5.07
CF-15-04	Oct-19	24.16	589	7.23	105	1.83	3.48
CF-15-05	Oct-19	20.49	939	7.12	-89	1.95	4.01
CF-15-06	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
CF-15-07	Oct-19	20.03	1120	7.02	-127	1.78	4.08
CF-15-08	Oct-19	19.58	917	7.29	38	4.35	3.75
CF-15-09	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
WBSP-15-01	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
WBSP-15-02	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
CF-19-14	Oct-19	26.92	839	7.02	-85	3.94	4.38
CF-19-15	Oct-19	19.24	1450	6.72	-3	3.92	3.98
CF-15-08	Nov-19	13.91	893	7.49	74	2.18	4.38

Notes:
1. °C: Degrees Celsius.
2. µohms/cm: Micro-ohms per centimeter.
3. S.U.: Standard Units.
4. mV: Millivolts.
5. mg/L: Milligrams per liter.
6. NTUs: Nephelometric Turbidity Units.

TABLE 4-4
SUMMARY OF POTENTIAL AND CONFIRMED APPENDIX III SSIs
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Potential SSI Parameter (Units)	2nd Assessment Monitoring Sampling Event March 2019		2nd Assessment Monitoring Resampling Event June 2019		3rd Assessment Monitoring Sampling Event October 2019		3rd Assessment Monitoring Resampling Event November 2019	
		Potential SSI Result	UTL	Potential SSI Result	Confirmed SSI (Yes/No)	Potential SSI Result	UTL	Potential SSI Result	Confirmed SSI (Yes/No)
CF-15-08	Boron (mg/L)	9.8	5.02	8.5	**Yes**	11	5.02	9	**Yes**
CF-15-09	Boron (mg/L)	6.7	5.02	6.5	**Yes**	NA	NA	NA	NA
CF-19-14	Boron (mg/L)	NI	NI	NI	NI	5.3	5.02	NS	**Yes**

Notes:
1. SSI: Statistically Significant Increase.
2. UTL: Upper Tolerance Limit (Pooled Interwell UTL).
3. mg/L: Milligrams per liter.
4. NA: Not Applicable—no SSI.
5. NI: Not Installed.
6. NS: Not Sampled—Well CF-19-14 was inadvertently not resampled in November 2019. SSI was therefore assumed to be confirmed.

TABLE 4-5
GROUNDWATER PROTECTION STANDARDS
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Appendix IV Constituents			
Constituent (Units)	**Background**	**MCL/SMCL**	**GWPS**
Antimony, Sb (µg/L)	0.2185	6	6
Arsenic, As (µg/L)	4.47	10	10
Barium, Ba (µg/L)	116.7	2000	2000
Beryllium, Be (µg/L)	0.176	4	4
Cadmium, Cd (µg/L)	0.08	5	5
Chromium, Cr (µg/L)	8.4	100	100
Cobalt, Co (µg/L)	2.578	6*	6
Fluoride, F (mg/L)	0.5532	4	4
Lithium, Li (µg/L)	0.103	40*	40
Lead, Pb (µg/L)	2.023	15*	15
Mercury, Hg (µg/L)	1.33	2	2
Molybdenum, Mo (µg/L)	62.4	100*	100
Radium 226 & 228 (combined) (pCi/L)	8.02	5	8.02
Selenium, Se (µg/L)	0.44	50	50
Thallium, Tl (µg/L)	0.1788	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 4-6
SUMMARY OF GWPS EXCEEDANCES
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Potential Exceedance Parameter (Units)	2nd Assessment Monitoring Sampling Event March 2019		2nd Assessment Monitoring Resampling Event June 2019		3rd Assessment Monitoring Sampling Event October 2019		3rd Assessment Monitoring Resampling Event November 2019	
		Potential Exceedance Result	GWPS	Potential Exceedance Result	Confirmed Exceedance (Yes/No)	Potential Exceedance Result	GWPS	Potential Exceedance Result	Confirmed Exceedance (Yes/No)
CF-15-08	Molybdenum (ug/L)	380	100	360	**Yes**	390	100	360	**Yes**
CF-15-09	Molybdenum (ug/L)	100	100	87.0	No	NA	NA	NA	NA

Notes:
1. GWPS: Groundwater Protection Standard.
2. µg/L: Micrograms per liter.
3. NA: Not Applicable—no potential exceedance.

TABLE 5-1
GROUNDWATER MONITORING NETWORK
WEST BOILER SLAG POND
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
WBSP-15-01	Upgradient	11/30/2015	449072.27	566322.12	466.93	469.36	458.93	448.93	20.43
WBSP-15-02	Upgradient	11/11/2015	449803.91	566987.30	473.83	476.76	457.83	452.83	23.93
WBSP-15-03	Upgradient	12/4/2015	451181.98	568093.60	484.91	488.03	476.91	471.91	16.12
WBSP-15-04	Downgradient	11/12/2015	450610.07	568637.65	471.17	473.71	416.17	406.17	67.54
WBSP-15-05	Downgradient	11/17/2015	450051.40	568495.72	471.90	474.42	410.90	400.90	73.52
WBSP-15-06	Downgradient	11/19/2015	449470.57	568402.50	471.28	473.51	395.78	385.78	87.73
WBSP-15-07	Downgradient	11/23/2015	448947.93	567946.39	468.82	471.31	426.82	416.82	54.49
WBSP-15-08	Downgradient	11/25/2015	448625.46	567343.24	468.56	471.06	415.76	405.76	65.30
WBSP-15-09	Downgradient	1/6/2016	448359.31	566711.13	471.21	470.69	421.21	410.21	59.48
WBSP-15-10	Downgradient	1/5/2016	448125.51	566225.21	471.21	470.69	425.21	435.21	55.48

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.

TABLE 5-2
SUMMARY OF SAMPLES COLLECTED DURING 2019
WEST BOILER SLAG POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Designation	Mar-19	Oct-19
CF-15-04	Background	DM	DM
CF-15-05	Background	DM	DM
CF-15-06	Background	DM	DM
WBSP-15-01	Upgradient	DM	DM
WBSP-15-02	Upgradient	DM	DM
WBSP-15-03	Upgradient	DM	DM
WBSP-15-04	Downgradient	DM	DM
WBSP-15-05	Downgradient	DM	DM
WBSP-15-06	Downgradient	DM	DM
WBSP-15-07	Downgradient	DM	DM
WBSP-15-08	Downgradient	DM	DM
WBSP-15-09	Downgradient	DM	DM
WBSP-15-10	Downgradient	DM	DM

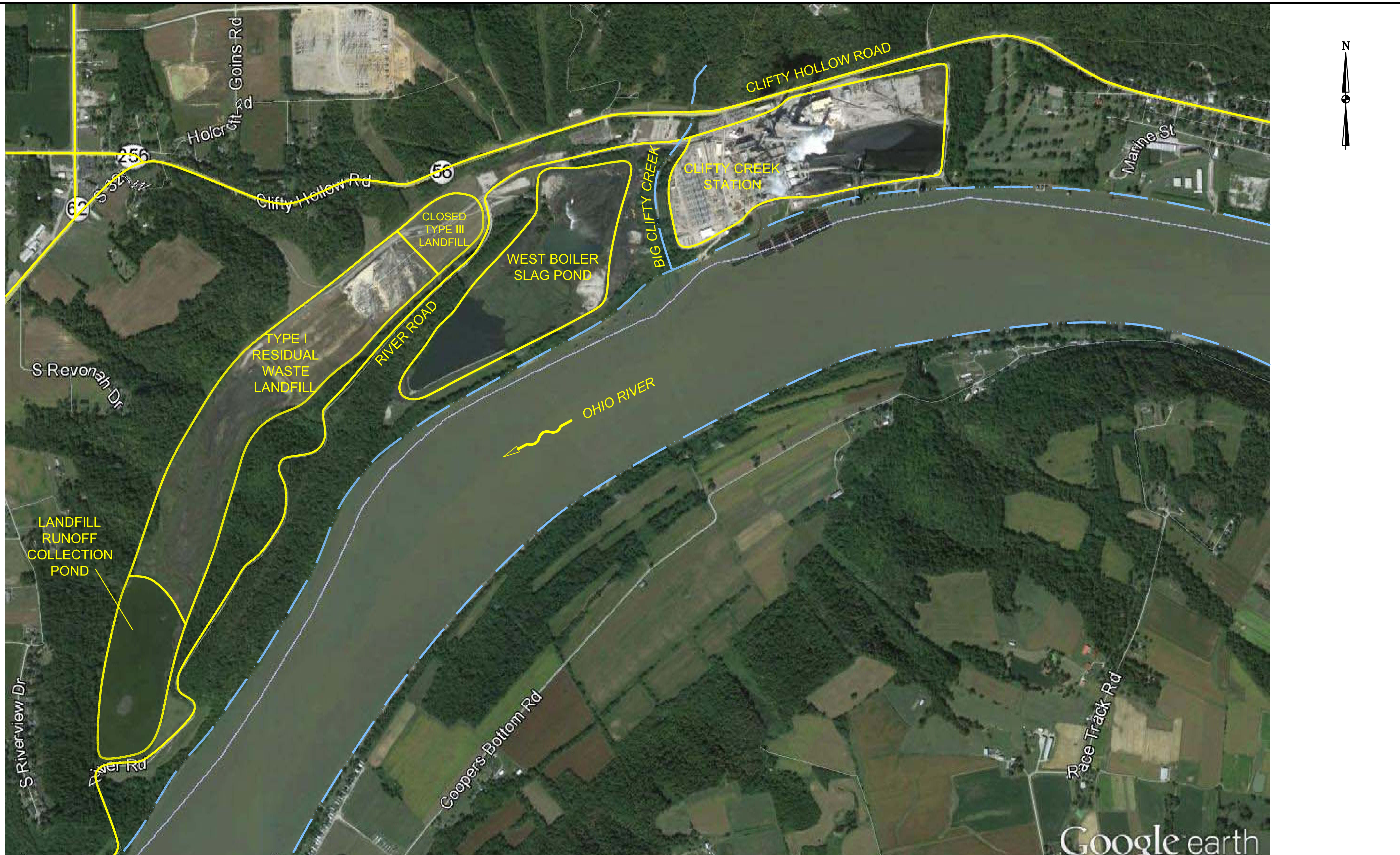
Notes:
1. DM: Detection Monitoring.

TABLE 5-3
SUMMARY OF MEASURED FIELD PARAMETERS DURING 2019
WEST BOILER SLAG POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Sample ID	Date	Temperature (°C)	Conductivity (µohms/cm)	pH (S.U.)	Oxidation Reduction Potential (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTUs)
CF-15-04	Mar-19	9.97	581	6.65	171	4.19	3.84
CF-15-05	Mar-19	12.12	948	6.77	54	1.48	4.08
CF-15-06	Mar-19	10.28	946	6.99	265	2.72	2.86
WBSP-15-01	Mar-19	9.11	1090	6.76	188	5.51	11.6
WBSP-15-02	Mar-19	11.47	1390	6.85	266	8.18	4.04
WBSP-15-03	Mar-19	9.1	9190	6.85	157	1.83	2.12
WBSP-15-04	Mar-19	15.48	9420	8.03	51	1.79	4.7
WBSP-15-05	Mar-19	14.32	8750	7.41	-86	1.79	5.47
WBSP-15-06	Mar-19	16.12	8990	7.34	-42	3.85	17.1
WBSP-15-07	Mar-19	14.73	1470	6.82	-168	0.32	4.95
WBSP-15-08	Mar-19	15.08	8780	6.42	-138	0.21	22.1
WBSP-15-09	Mar-19	18.64	4130	6.71	-24	3.88	4.47
WBSP-15-10	Mar-19	14.78	5090	6.98	149	8.61	28.6
CF-15-04	Oct-19	24.16	589	7.23	105	1.83	3.48
CF-15-05	Oct-19	20.49	939	7.12	-89	1.95	4.01
CF-15-06	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
WBSP-15-01	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
WBSP-15-02	Oct-19	DRY	DRY	DRY	DRY	DRY	DRY
WBSP-15-03	Oct-19	28.13	1400	7.08	24	2.87	2.91
WBSP-15-04	Oct-19	19.85	761	7.27	182	0.28	4.1
WBSP-15-05	Oct-19	23.37	856	7.75	-102	0.42	3.77
WBSP-15-06	Oct-19	20.13	897	7.73	-81	0.2	3.81
WBSP-15-07	Oct-19	2.76	1214	6.95	-75	0.34	4.1
WBSP-15-08	Oct-19	19.32	822	7.89	-71	0.93	3.85
WBSP-15-09	Oct-19	19.39	499	7.49	-102	0.71	4.11
WBSP-15-10	Oct-19	19.87	505	7.38	-39	2.05	33.5

Notes:
1. °C: Degrees Celsius.
2. µohms/cm: Micro-ohms per centimeter.
3. S.U.: Standard Units.
4. mV: Millivolts.
5. mg/L: Milligrams per liter.
6. NTUs: Nephelometric Turbidity Units.

FIGURES



1200' 0' 1200' 2400'
SCALE: 1"= 1200'

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DATE	
CHECKED BY	
JOB NO.	2019008–CLI
DWG FILE	2019_IKEC_Clifty_Corrective Action_Site Loc_FIG 1.dwg
DRAWING SCALE	AS SHOWN

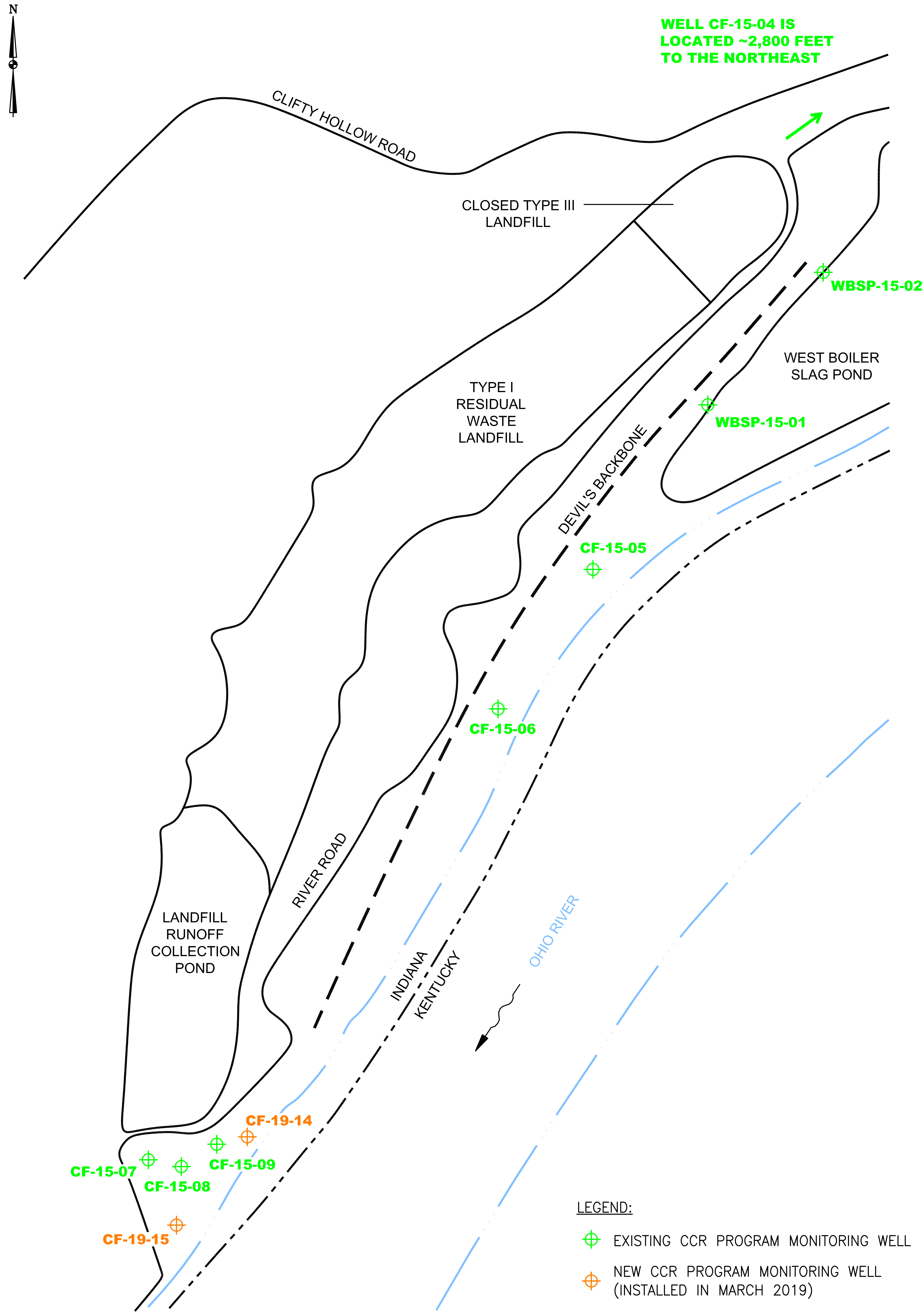
AGES
Applied Geology And Environmental Science, Inc.
2402 Hookstown Grade Road, Suite 200
Clinton, PA 15026
412.264.6453

INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
SITE LOCATION MAP

DRAWING NAME: FIGURE 1
REV. 0

Plot: 12/23/2019 14:40 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 GW Monitoring-Corrective Action Rpt\2019_IKEC_Clifty_Corrective Action_Site Loc_FIG 1.dwg



NOTE:
WELLS CF-19-14 AND CF-19-15 WERE INSTALLED IN MARCH 2019.

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DATE	
CHECKED BY	
JOB NO.	2019008-CLIFTY
DWG FILE	2019_IKEC_Clifty_GW MW LOCs_LANDFILL b01.dwg
DRAWING SCALE	NOT TO SCALE

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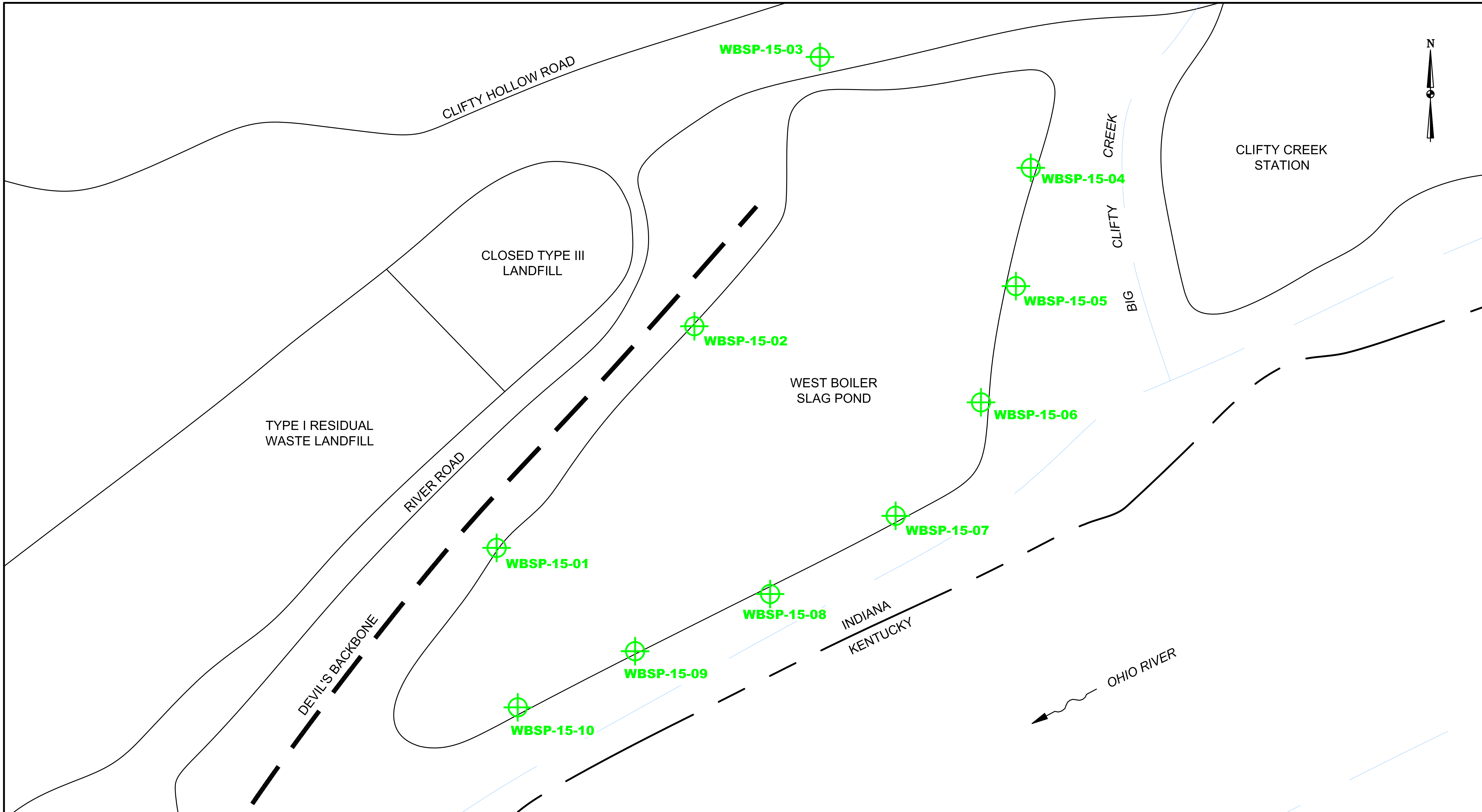
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
MONITORING WELL LOCATION MAP

DRAWING NAME: FIGURE 2
REV. 0

Plot: 01/28/2020 16:18 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 GW Monitoring-Corrective Action Rpt\2019_IKEC_Clifty GW MW LOCs_LANDFILL b01.dwg



LEGEND:

EXISTING CCR PROGRAM MONITORING WELL

400' 0' 400' 800'

SCALE: 1"= 400'

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008–CLI
DWG FILE	2019_IKEC_Clifty_Well Loc Map_WBSP_Annual GW Rpt.dwg
DRAWING SCALE	AS SHOWN

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INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
WEST BOILER SLAG POND
MONITORING WELL LOCATION MAP

DRAWING NAME: FIGURE 3

REV. 0

Plot: 01/14/2020 15:39 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\2019 GW Monitoring–Corrective Action Rpt\2019_IKEC_Clifty_Well Loc Map_WBSP_Annual GW Rpt\well loc

APPENDIX A

GROUNDWATER ELEVATIONS

TABLE A-1
SUMMARY OF GROUNDWATER ELEVATION DATA DURING 2019
TYPE I RESIDUAL WASTE LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Mar-19	Jun-19	Oct-19	Nov-19
	Groundwater Elevation (ft)	Groundwater Elevation (ft)	Groundwater Elevation (ft)	Groundwater Elevation (ft)
CF-15-04	438.40	444.24	439.51	NM
CF-15-05	438.40	439.22	429.17	NM
CF-15-06	429.85	431.93	422.15	NM
CF-15-07	438.08	435.33	433.65	432.71
CF-15-08	444.69	444.95	440.57	439.52
CF-15-09	449.67	449.81	444.28	444.22
WBSP-15-01	451.50	455.00	449.75	NM
WBSP-15-02	468.47	470.10	453.90	NM

Notes:
1. NM: Not Measured.

TABLE A-2
SUMMARY OF GROUNDWATER ELEVATION DATA DURING 2019
LANDFILL RUNOFF COLLECTION POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Mar-19 Groundwater Elevation (ft)	Jun-19 Groundwater Elevation (ft)	Oct-19 Groundwater Elevation (ft)	Nov-19 Groundwater Elevation (ft)
CF-15-04	438.40	444.24	439.51	NM
CF-15-05	438.40	439.22	429.17	NM
CF-15-06	429.85	431.93	422.15	NM
CF-15-07	438.08	435.33	433.65	432.71
CF-15-08	444.69	444.95	440.57	439.52
CF-15-09	449.67	449.81	444.28	444.22
WBSP-15-01	451.50	455.00	449.75	NM
WBSP-15-02	468.47	470.10	453.90	NM
CF-19-14	446.73	448.34	438.39	438.81
CF-19-15	433.74	435.69	419.91	420.85

Notes:
1. NM: Not Measured.

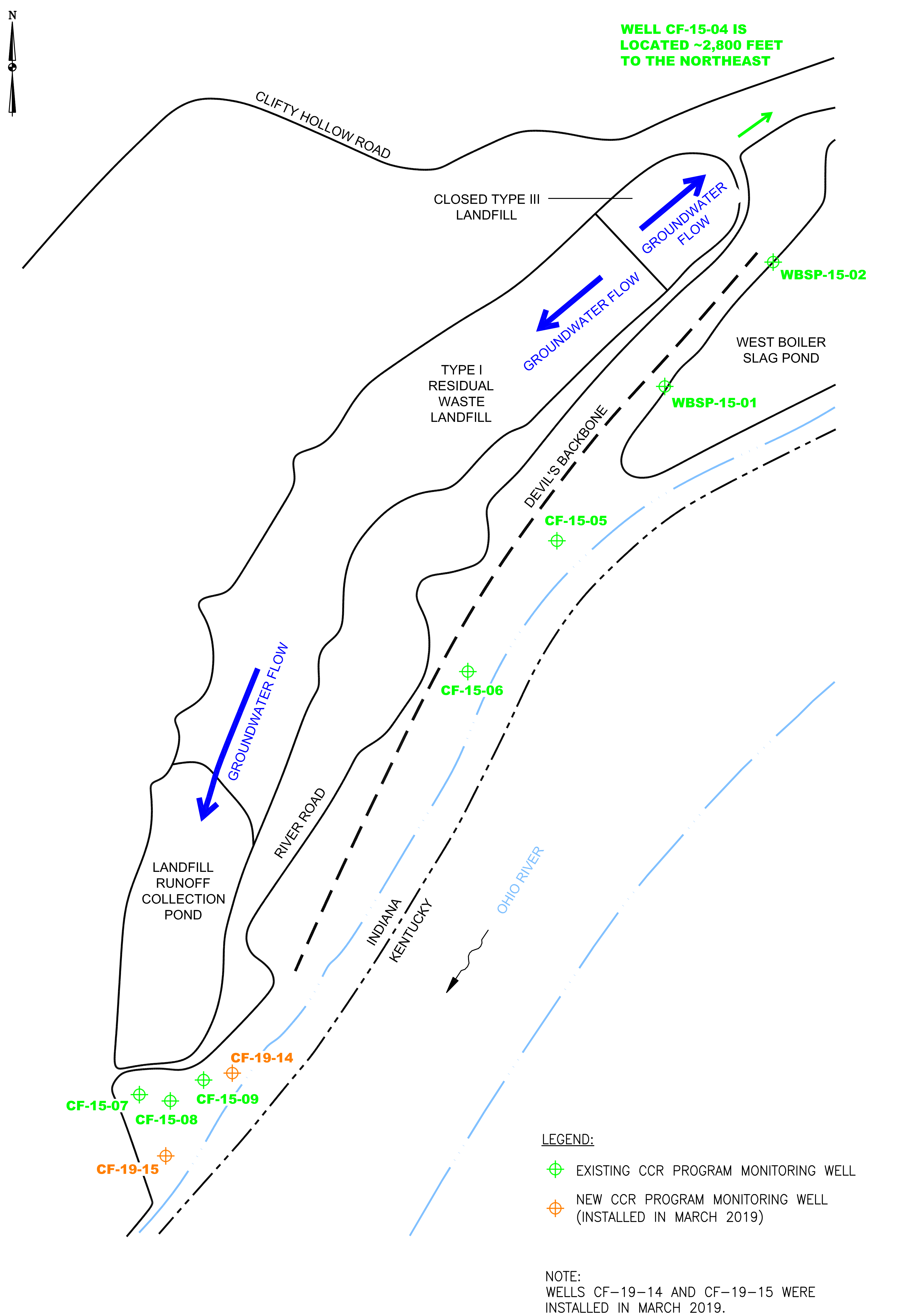
TABLE A-3
SUMMARY OF GROUNDWATER ELEVATION DATA DURING 2019
WEST BOILER SLAG POND
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Mar-19 Groundwater Elevation (ft)	Jun-19 Groundwater Elevation (ft)	Oct-19 Groundwater Elevation (ft)	Nov-19 Groundwater Elevation (ft)
CF-15-04	438.40	444.24	439.51	NM
CF-15-05	438.40	439.22	429.17	NM
CF-15-06	429.85	431.93	422.15	NM
WBSP-15-01	451.50	455.00	449.75	NM
WBSP-15-02	468.47	470.10	453.90	NM
WBSP-15-03	478.84	480.65	475.94	NM
WBSP-15-04	423.59	433.47	419.62	NM
WBSP-15-05	423.40	433.46	419.64	NM
WBSP-15-06	423.32	433.21	419.39	NM
WBSP-15-07	435.56	442.61	431.67	NM
WBSP-15-08	437.88	444.42	433.48	NM
WBSP-15-09	436.51	443.25	432.31	NM
WBSP-15-10	438.45	443.20	432.26	NM

Notes:
1. NM: Not Measured.

APPENDIX B

GROUNDWATER FLOW MAPS



NOTE:
WELLS CF-19-14 AND CF-19-15 WERE INSTALLED IN MARCH 2019.

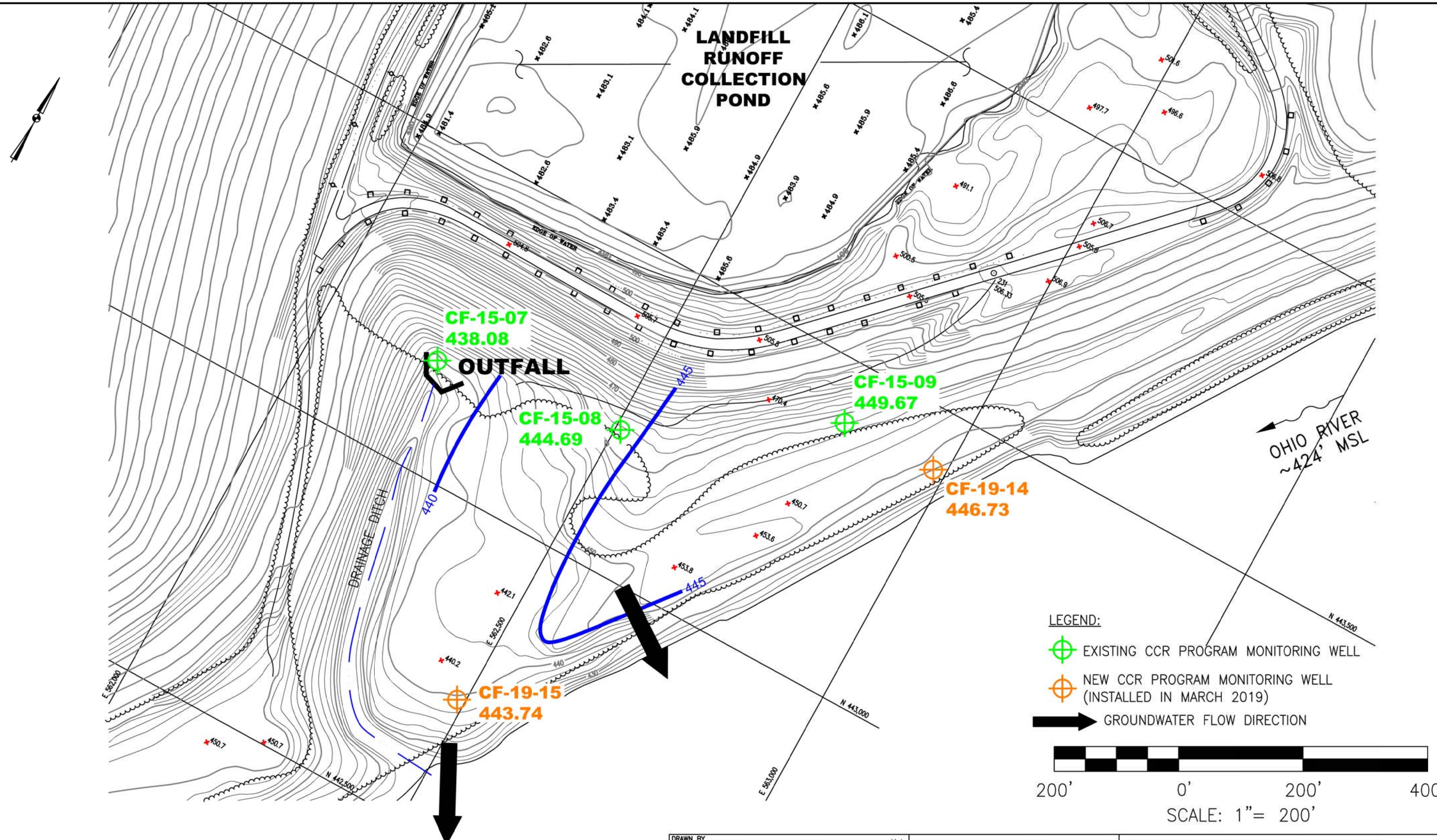
DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008-CLIFTY
DWG FILE	2019_IKEC_Clifty_GW Flow_Appx B_LANDFILL b01.dwg
DRAWING SCALE	NOT TO SCALE

AGES
Applied Geology And Environmental Science, Inc.
2402 Hookstown Grade Road, Suite 200
Clinton, PA 15026
412.264.6453

INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
GENERALIZED GROUNDWATER FLOW
UPPERMOST AQUIFER - MARCH 2019/OCTOBER 2019

DRAWING NAME: FIGURE B-1
REV. 0

Plot: 01/28/2020 16:14 \Clifty Creek-CCR Program\CAD\2019 GW Monitoring-Corrective Action Rpt\Appx B\2019_IKEC_Clifty GW Flow_Appx B_LANDFILL b01.dwg



NOTE:
WELLS CF-19-14 AND CF-19-15 WERE INSTALLED IN MARCH 2019.

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008-CLIFTY
DWG FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19.dwg
DRAWING SCALE	AS SHOWN

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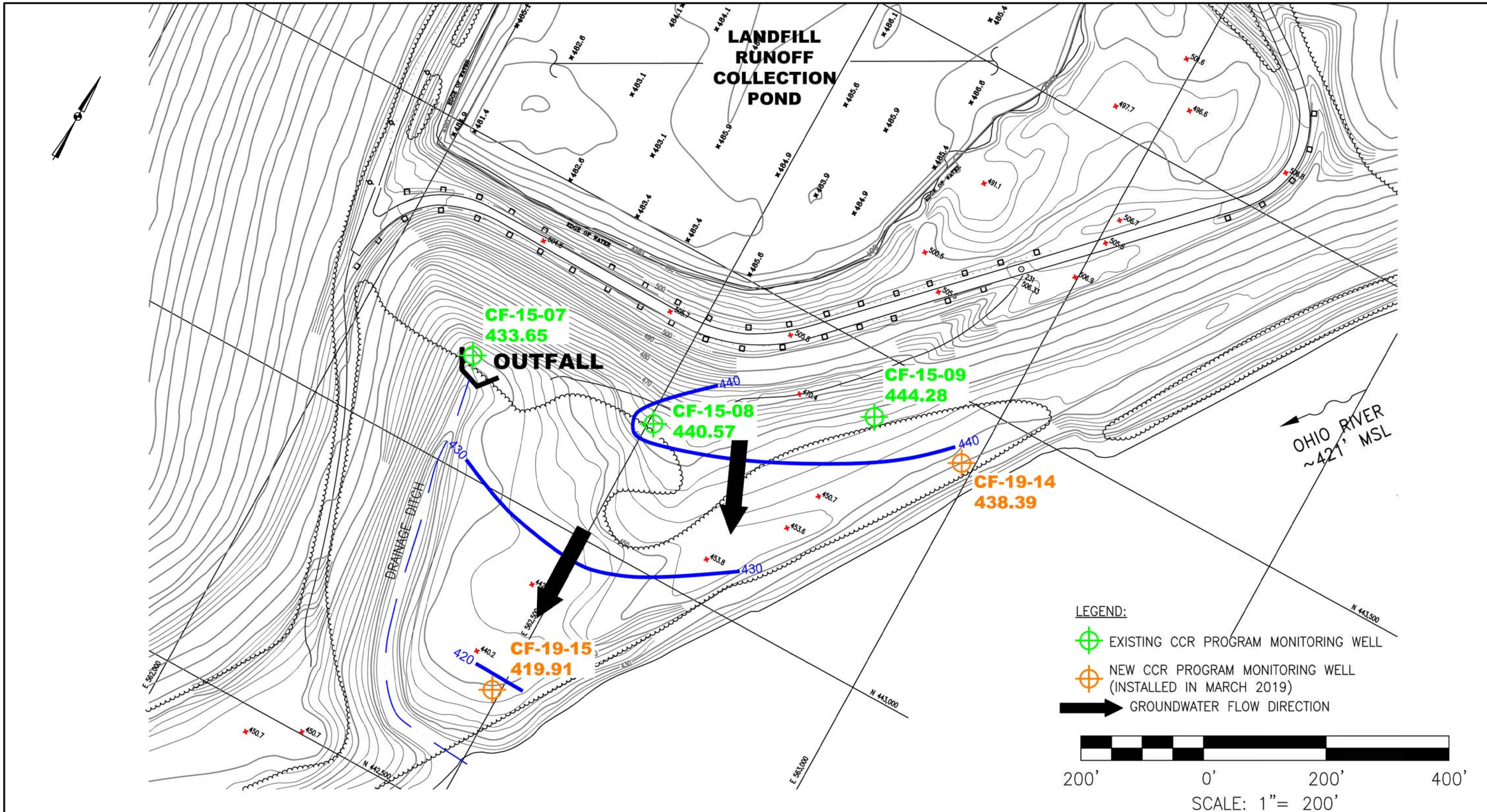
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
GROUNDWATER FLOW – UPPERMOST AQUIFER
MARCH 2019

DRAWING NAME: FIGURE B–2 REV. 0

Plot: 01/28/2020 15:38 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 GW Monitoring-Corrective Action Rpt\Appx B\2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19.dwg



NOTE:
WELLS CF-19-14 AND CF-19-15 WERE INSTALLED IN MARCH 2019.

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008-CLIFTY
DWG. FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_OCT19.dwg
DRAWING SCALE	AS SHOWN

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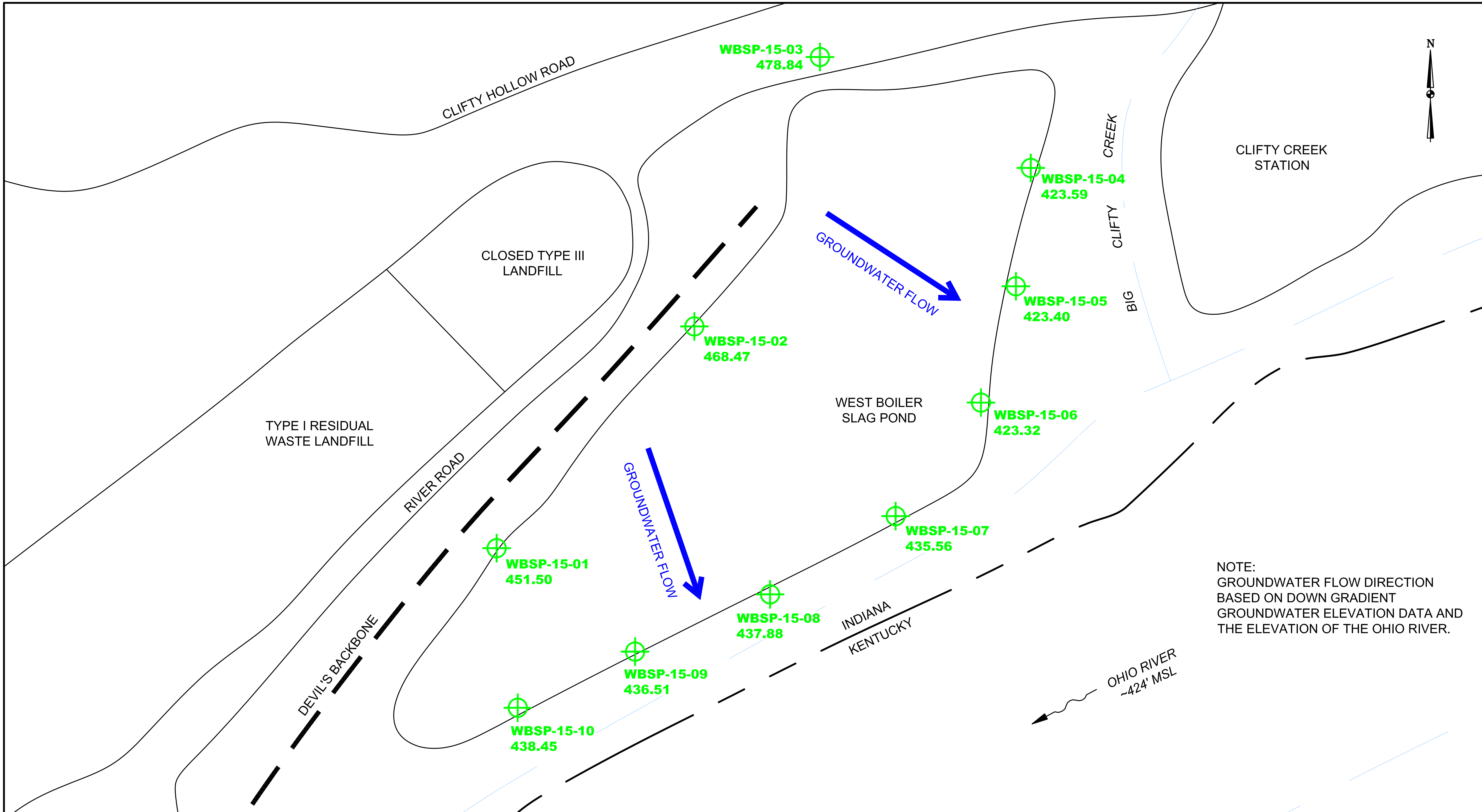
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
GROUNDWATER FLOW – UPPERMOST AQUIFER
OCTOBER 2019

DRAWING NAME: FIGURE B–3
REV. 0



LEGEND:

MONITORING WELL LOCATION

GROUNDWATER FLOW DIRECTION

400' 0' 400' 800'

SCALE: 1"= 400'

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008–CLI
DWG FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19_WBSP.dwg
DRAWING SCALE	AS SHOWN

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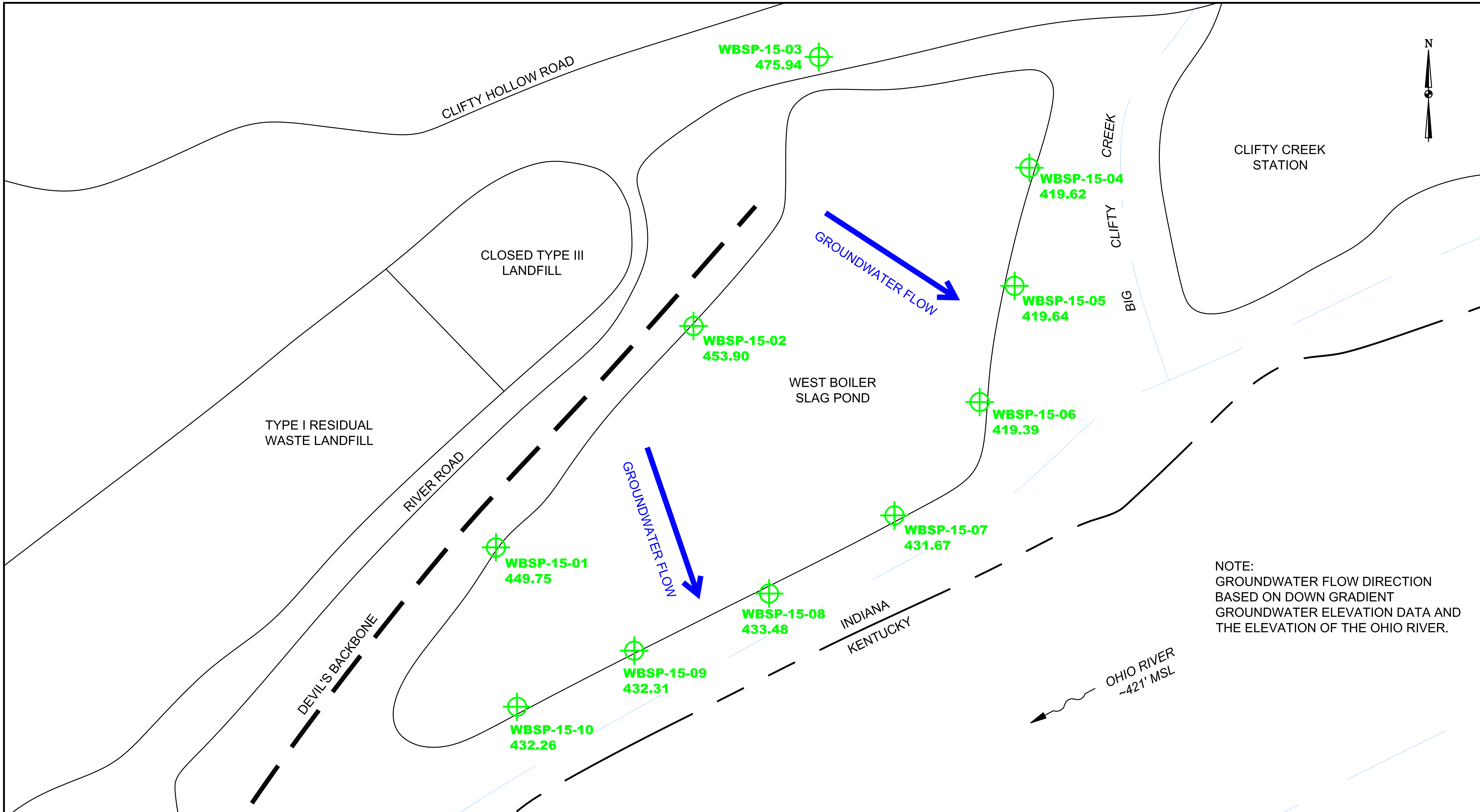
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
WEST BOILER SLAG POND
GROUNDWATER LEVELS AND FLOW DIRECTION
MARCH 2019

DRAWING NAME: FIGURE B–4

REV. 0

Plot: 01/28/2020 15:43 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\2019 GW Monitoring–Corrective Action Rpt\Appx B\2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19_WBSP.dwg\MAR19



LEGEND:

MONITORING WELL LOCATION

GROUNDWATER FLOW DIRECTION

400' 0' 400' 800'

SCALE: 1"= 400'

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008–CLI
DWG. FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_OCT19_WBSP.dwg
DRAWING SCALE	AS SHOWN

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INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
WEST BOILER SLAG POND
GROUNDWATER LEVELS AND FLOW DIRECTION
OCTOBER 2019

DRAWING NAME: FIGURE B–5

REV. 0

Plot: 01/28/2020 15:44 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\2019 GW Monitoring–Corrective Action Rpt\Appx B\2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_OCT19_WBSP.dwg\OCT19

APPENDIX C

APPENDIX III AND APPENDIX IV CONSTITUENTS

APPENDIX III AND APPENDIX IV CONSTITUENTS
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND AND WEST BOILER SLAG POND
CLIFTY CREEK STATION
MADISON, INDIANA

Appendix III Constituents (Detection Monitoring)
Constituent
Boron, B
Calcium, Ca
Chloride, Cl
Fluoride, F
pH (units=SU)
Sulfate, SO4
Total Dissolved Solids (TDS)
Appendix IV Constituents (Assessment Monitoring)
Constituent
Antimony, Sb
Arsenic, As
Barium, Ba
Beryllium, Be
Cadmium, Cd
Chromium, Cr
Cobalt, Co
Fluoride, F
Lithium, Li
Lead, Pb
Mercury, Hg
Molybdenum, Mo
Radium 226 & 228 (combined)(units=pCi/L)
Selenium, Se
Thallium, Tl

APPENDIX D

ANALYTICAL RESULTS

CF-15-04
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.045 J	0.058 J
Calcium, Ca	mg/L	85	74
Chloride, Cl	mg/L	11	37
Fluoride, F	mg/L	0.085	0.11
pH	s.u.	6.65	7.23
Sulfate, SO4	mg/L	28	37
Total Dissolved Solids (TDS)	mg/L	340	360
Appendix IV Constituents			
Antimony, Sb	ug/L	2 U	2 U
Arsenic, As	ug/L	5 U	5 U
Barium, Ba	ug/L	50	46
Beryllium, Be	ug/L	1 U	1 U
Cadmium, Cd	ug/L	1 U	1 U
Chromium, Cr	ug/L	2 U	2 U
Cobalt, Co	ug/L	1 U	1 U
Fluoride, F	mg/L	0.085	0.11
Lithium, Li	mg/L	1 U	1 U
Lead, Pb	ug/L	0.008 U	0.008 U
Mercury, Hg	ug/L	0.2 U	0.2 U
Molybdenum, Mo	ug/L	5 U	1.1 J
Radium 226 & 228 (combined)	pCi/L	5 U	0.519
Selenium, Se	ug/L	5 U	5 U
Thallium, Tl	ug/L	1 U	1 U

CF-15-05
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.14	0.13
Calcium, Ca	mg/L	120	110
Chloride, Cl	mg/L	31	33
Fluoride, F	mg/L	0.5	0.5
pH	s.u.	6.77	7.12
Sulfate, SO4	mg/L	49	51
Total Dissolved Solids (TDS)	mg/L	520	520
Appendix IV Constituents			
Antimony, Sb	ug/L	2 U	2 U
Arsenic, As	ug/L	0.77 J	0.92 J
Barium, Ba	ug/L	59	48
Beryllium, Be	ug/L	0.47 J	1 U
Cadmium, Cd	ug/L	1 U	1 U
Chromium, Cr	ug/L	2 U	2 U
Cobalt, Co	ug/L	0.49 J	0.46 J
Fluoride, F	mg/L	0.5	0.5
Lithium, Li	mg/L	1 U	1 U
Lead, Pb	ug/L	0.014	0.016
Mercury, Hg	ug/L	0.2 U	0.2 U
Molybdenum, Mo	ug/L	5 U	5 U
Radium 226 & 228 (combined)	pCi/L	5 U	0.46
Selenium, Se	ug/L	5 U	5 U
Thallium, Tl	ug/L	1 U	1 U

CF-15-06
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19
Appendix III Constituents		
Boron, B	mg/L	0.24
Calcium, Ca	mg/L	120
Chloride, Cl	mg/L	4.2
Fluoride, F	mg/L	0.2
pH	s.u.	6.99
Sulfate, SO4	mg/L	95
Total Dissolved Solids (TDS)	mg/L	560
Appendix IV Constituents		
Antimony, Sb	ug/L	2 U
Arsenic, As	ug/L	5 U
Barium, Ba	ug/L	30
Beryllium, Be	ug/L	1 U
Cadmium, Cd	ug/L	1 U
Chromium, Cr	ug/L	1.1 J
Cobalt, Co	ug/L	0.22 J
Fluoride, F	mg/L	0.2
Lithium, Li	mg/L	1 U
Lead, Pb	ug/L	0.015 B
Mercury, Hg	ug/L	0.2 U
Molybdenum, Mo	ug/L	5 U
Radium 226 & 228 (combined)	pCi/L	5 U
Selenium, Se	ug/L	5 U
Thallium, Tl	ug/L	1 U

CF-15-07
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.045 J	0.08 J
Calcium, Ca	mg/L	150	160
Chloride, Cl	mg/L	5.6	5
Fluoride, F	mg/L	0.21	0.26
pH	s.u.	7.04	7.02
Sulfate, SO4	mg/L	11	5.9
Total Dissolved Solids (TDS)	mg/L	620	600
Appendix IV Constituents			
Antimony, Sb	ug/L	2 U	2 U
Arsenic, As	ug/L	4.6 J	7.5
Barium, Ba	ug/L	81	80
Beryllium, Be	ug/L	1 U	1 U
Cadmium, Cd	ug/L	1 U	1 U
Chromium, Cr	ug/L	2 U	2 U
Cobalt, Co	ug/L	2.4	2.6
Fluoride, F	mg/L	0.21	0.26
Lithium, Li	mg/L	1 U	1 U
Lead, Pb	ug/L	0.0017 J	0.0031 J
Mercury, Hg	ug/L	0.2 U	0.2 U
Molybdenum, Mo	ug/L	4.9 J	9.5 B
Radium 226 & 228 (combined)	pCi/L	2.34	0.329 U
Selenium, Se	ug/L	5 U	5 U
Thallium, Tl	ug/L	1 U	1 U

CF-15-08
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Jun-19	Oct-19	Nov-19
Appendix III Constituents					
Boron, B	mg/L	9.8	8.5	11	9
Calcium, Ca	mg/L	140	NA	140	NA
Chloride, Cl	mg/L	14	NA	16	NA
Fluoride, F	mg/L	0.37	NA	0.4	NA
pH	s.u.	7.05	NA	7.29	NA
Sulfate, SO4	mg/L	240	NA	230	NA
Total Dissolved Solids (TDS)	mg/L	680	NA	650	NA
Appendix IV Constituents					
Antimony, Sb	ug/L	2 U	NA	2 U	NA
Arsenic, As	ug/L	5 U	NA	1.3 J	NA
Barium, Ba	ug/L	60	NA	59	NA
Beryllium, Be	ug/L	1 U	NA	0.76 J B	NA
Cadmium, Cd	ug/L	1 U	NA	0.24 J	NA
Chromium, Cr	ug/L	2 U	NA	2 U	NA
Cobalt, Co	ug/L	0.19 J	NA	0.48 J	NA
Fluoride, F	mg/L	0.37	NA	0.4	NA
Lithium, Li	mg/L	1 U	NA	0.5 J	NA
Lead, Pb	ug/L	0.017	NA	0.019	NA
Mercury, Hg	ug/L	0.2 U	NA	0.2 U	NA
Molybdenum, Mo	ug/L	380	360	390 B	360
Radium 226 & 228 (combined)	pCi/L	0.413	NA	0.329 U	NA
Selenium, Se	ug/L	5 U	NA	1 J	NA
Thallium, Tl	ug/L	1 U	NA	0.76 J B	NA

Notes:
NA: Sampling not required for this parameter.

CF-15-09
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Jun-19
Appendix III Constituents			
Boron, B	mg/L	6.7	6.5
Calcium, Ca	mg/L	160	NA
Chloride, Cl	mg/L	3	NA
Fluoride, F	mg/L	0.31	NA
pH	s.u.	7.19	NA
Sulfate, SO4	mg/L	260	NA
Total Dissolved Solids (TDS)	mg/L	620	NA
Appendix IV Constituents			
Antimony, Sb	ug/L	2 U	NA
Arsenic, As	ug/L	5 U	NA
Barium, Ba	ug/L	14	NA
Beryllium, Be	ug/L	1.5	NA
Cadmium, Cd	ug/L	0.23 J	NA
Chromium, Cr	ug/L	2 U	NA
Cobalt, Co	ug/L	0.38 J	NA
Fluoride, F	mg/L	0.31	NA
Lithium, Li	mg/L	1 U	NA
Lead, Pb	ug/L	0.0087	NA
Mercury, Hg	ug/L	0.2 U	NA
Molybdenum, Mo	ug/L	100	87
Radium 226 & 228 (combined)	pCi/L	5 U	NA
Selenium, Se	ug/L	1.2 J	NA
Thallium, Tl	ug/L	0.2 J	NA

Notes:
NA: Sampling not required for this parameter.

WBSP-15-01
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19
Appendix III Constituents		
Boron, B	mg/L	0.082 J
Calcium, Ca	mg/L	160
Chloride, Cl	mg/L	7.1
Fluoride, F	mg/L	0.24
pH	s.u.	6.76
Sulfate, SO4	mg/L	130
Total Dissolved Solids (TDS)	mg/L	670
Appendix IV Constituents		
Antimony, Sb	ug/L	2 U
Arsenic, As	ug/L	5 U
Barium, Ba	ug/L	13
Beryllium, Be	ug/L	1.1
Cadmium, Cd	ug/L	1 U
Chromium, Cr	ug/L	1.7 J
Cobalt, Co	ug/L	0.78 J
Fluoride, F	mg/L	0.24
Lithium, Li	mg/L	0.76 J
Lead, Pb	ug/L	0.021
Mercury, Hg	ug/L	0.2 U
Molybdenum, Mo	ug/L	5 U
Radium 226 & 228 (combined)	pCi/L	5 U
Selenium, Se	ug/L	5 U
Thallium, Tl	ug/L	1 U

WBSP-15-02
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19
Appendix III Constituents		
Boron, B	mg/L	3.3
Calcium, Ca	mg/L	250
Chloride, Cl	mg/L	6.5
Fluoride, F	mg/L	0.35
pH	s.u.	6.85
Sulfate, SO4	mg/L	500
Total Dissolved Solids (TDS)	mg/L	1100
Appendix IV Constituents		
Antimony, Sb	ug/L	2 U
Arsenic, As	ug/L	5 U
Barium, Ba	ug/L	19
Beryllium, Be	ug/L	1 U
Cadmium, Cd	ug/L	1 U
Chromium, Cr	ug/L	2 U
Cobalt, Co	ug/L	1 U
Fluoride, F	mg/L	0.35
Lithium, Li	mg/L	1 U
Lead, Pb	ug/L	0.071 B
Mercury, Hg	ug/L	0.2 U
Molybdenum, Mo	ug/L	2.3 J
Radium 226 & 228 (combined)	pCi/L	5 U
Selenium, Se	ug/L	5 U
Thallium, Tl	ug/L	1 U

WBSP-15-03
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.067 J	0.22
Calcium, Ca	mg/L	100	210
Chloride, Cl	mg/L	110	66
Fluoride, F	mg/L	0.21	0.3
pH	s.u.	6.85	7.08
Sulfate, SO4	mg/L	120	330
Total Dissolved Solids (TDS)	mg/L	540	970

WBSP-15-04
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	5.6	5.5
Calcium, Ca	mg/L	130	110
Chloride, Cl	mg/L	130	92
Fluoride, F	mg/L	0.17	0.18
pH	s.u.	8.03	7.27
Sulfate, SO4	mg/L	240	210
Total Dissolved Solids (TDS)	mg/L	600	550

WBSP-15-05
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	3.6	3
Calcium, Ca	mg/L	130	130
Chloride, Cl	mg/L	60	59
Fluoride, F	mg/L	0.15	0.16
pH	s.u.	7.41	7.75
Sulfate, SO4	mg/L	250	240
Total Dissolved Solids (TDS)	mg/L	600	600

WBSP-15-06
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	3.8	3.8
Calcium, Ca	mg/L	140	130
Chloride, Cl	mg/L	84	86
Fluoride, F	mg/L	0.16	0.19
pH	s.u.	7.34	7.73
Sulfate, SO4	mg/L	260	220
Total Dissolved Solids (TDS)	mg/L	630	620

WBSP-15-07
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.025 J	0.1 U
Calcium, Ca	mg/L	200	180
Chloride, Cl	mg/L	13	11
Fluoride, F	mg/L	0.33	0.27
pH	s.u.	6.82	6.95
Sulfate, SO4	mg/L	15	23
Total Dissolved Solids (TDS)	mg/L	840	760

WBSP-15-08
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.027 J	0.028 J
Calcium, Ca	mg/L	78	80
Chloride, Cl	mg/L	17	16
Fluoride, F	mg/L	0.16	0.19
pH	s.u.	6.42	7.89
Sulfate, SO4	mg/L	8.1	1.8
Total Dissolved Solids (TDS)	mg/L	350	340

WBSP-15-09
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.042 J	0.038 J
Calcium, Ca	mg/L	48	53
Chloride, Cl	mg/L	1.7	2.4
Fluoride, F	mg/L	0.32	0.47
pH	s.u.	6.71	7.49
Sulfate, SO4	mg/L	17	5.7
Total Dissolved Solids (TDS)	mg/L	210	240

WBSP-15-10
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Mar-19	Oct-19
Appendix III Constituents			
Boron, B	mg/L	0.037 J	0.03 J
Calcium, Ca	mg/L	71	67
Chloride, Cl	mg/L	22	21
Fluoride, F	mg/L	0.28	0.29
pH	s.u.	6.98	7.38
Sulfate, SO4	mg/L	44	38
Total Dissolved Solids (TDS)	mg/L	310	30

CF-19-14
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Oct-19
Appendix III Constituents		
Boron, B	mg/L	5.3
Calcium, Ca	mg/L	150
Chloride, Cl	mg/L	3.2
Fluoride, F	mg/L	0.23
pH	s.u.	7.02
Sulfate, SO4	mg/L	180
Total Dissolved Solids (TDS)	mg/L	600
Appendix IV Constituents		
Antimony, Sb	ug/L	2 U
Arsenic, As	ug/L	1.7 J
Barium, Ba	ug/L	50
Beryllium, Be	ug/L	1 U
Cadmium, Cd	ug/L	1 U
Chromium, Cr	ug/L	2 U
Cobalt, Co	ug/L	1.4
Fluoride, F	mg/L	0.23
Lithium, Li	mg/L	0.54 J
Lead, Pb	ug/L	0.0033 J
Mercury, Hg	ug/L	0.2 U
Molybdenum, Mo	ug/L	15
Radium 226 & 228 (combined)	pCi/L	0.527
Selenium, Se	ug/L	5 U
Thallium, Tl	ug/L	1 U

CF-19-15
SUMMARY OF 2019 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	Units	Oct-19
Appendix III Constituents		
Boron, B	mg/L	0.15
Calcium, Ca	mg/L	230
Chloride, Cl	mg/L	11
Fluoride, F	mg/L	0.17
pH	s.u.	6.72
Sulfate, SO4	mg/L	140
Total Dissolved Solids (TDS)	mg/L	910
Appendix IV Constituents		
Antimony, Sb	ug/L	2 U
Arsenic, As	ug/L	5 U
Barium, Ba	ug/L	120
Beryllium, Be	ug/L	1 U
Cadmium, Cd	ug/L	1 U
Chromium, Cr	ug/L	2 U
Cobalt, Co	ug/L	1.2
Fluoride, F	mg/L	0.17
Lithium, Li	mg/L	1 U
Lead, Pb	ug/L	0.0025 J
Mercury, Hg	ug/L	0.2 U
Molybdenum, Mo	ug/L	1.1 J
Radium 226 & 228 (combined)	pCi/L	0.635
Selenium, Se	ug/L	2.7 J
Thallium, Tl	ug/L	1 U

APPENDIX E

ALTERNATE SOURCE DEMONSTRATION MARCH 2019

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COAL COMBUSTION RESIDUALS REGULATION
ALTERNATE SOURCE DEMONSTRATION REPORT
MARCH 2019 DETECTION MONITORING EVENT

TYPE I RESIDUAL WASTE LANDFILL
INDIANIA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
MADISON, JEFFERSON COUNTY, INDIANA

August 2019

Prepared for:

INDIANA KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

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Applied Geology and Environmental Science, Inc.

Bethany Flaherty
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Robert W. King, P.G.
President/Chief Hydrogeologist

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T A B L E O F C O N T E N T S

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1.0 INTRODUCTION

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final Coal Combustion Residuals (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, 2015) in the Federal Register, referred to as the "CCR Rule."

The Indiana Kentucky Electric Corporation (IKEC) contracted with Applied Geology and Environmental Science, Inc. (AGES) to administer the CCR Rule groundwater monitoring program at the Clifty Creek Station located in Madison, Jefferson County, Indiana. There are three (3) CCR units at the Clifty Creek Station (Figure 1):

- Type I Residual Waste Landfill (Type I Landfill);
- Landfill Runoff Collection Pond (LRCP); and,
- West Boiler Slag Pond (WBSP).

Statistically Significant Increases (SSIs) were not identified at the WBSP during the March 2019 Detection Monitoring event. Therefore, the WBSP is not discussed further in this report.

During the March 2018 Detection Monitoring event, Boron SSIs were confirmed in two (2) wells located downgradient of the Type I Landfill and LRCP and these CCR units entered into Assessment Monitoring in September 2018. Based on a successful Alternate Source Demonstration (ASD) (AGES 2019), OVEC determined that the Type I Landfill was not the source of the Boron. Therefore, the Type I Landfill returned to Detection Monitoring in January 2019. As an alternate source for Boron at the LRCP could not be established, the LRCP remains in Assessment Monitoring.

During the March 2019 Detection Monitoring event, Boron SSIs were confirmed in two (2) wells located downgradient of the Type I Landfill. Therefore, OVEC has prepared this ASD to show that the Type I Landfill is not the source of the Boron. Details regarding this evaluation are presented in this report.

1.1 Background

In accordance with §257.91(d) of the CCR Rule, as detailed in the Well Installation Report (AGES 2018a), because the LRCP is directly adjacent to the southwest (downgradient) of the Type I Landfill, and because of the hydrogeologic conditions of the site, IKEC installed a multiunit groundwater monitoring system to monitor groundwater quality directly downgradient of the Type I Landfill & LRCP. Based on a successful ASD, the Type I Landfill returned to Detection Monitoring in January 2019 and the LRCP remained in Assessment Monitoring. In accordance with §257.94 of the CCR Rule, IKEC completed the groundwater monitoring requirements of the Detection Monitoring Program at the Type I Landfill as described below.

The second round of Detection Monitoring groundwater samples was collected from monitoring wells at the Type I Landfill at the Clifty Creek Station between March 25 and 28, 2019 in accordance with §257.94(a) of the CCR Rule (Figure 1). All samples were collected in accordance with the Groundwater Monitoring Program Plan (GMPP) (AGES 2018b) and analyzed for all Appendix III constituents.

Upon receipt, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Statistical Analysis Plan (StAP) (Stantec 2018) for the Clifty Creek Station CCR groundwater monitoring program. The initial statistical evaluation identified potential SSIs for Boron in monitoring wells CF-15-08 and CF-15-09 at the Type I Landfill. The results of the statistical evaluation are summarized in Table 1.

In accordance with the StAP, IKEC resampled the wells for Boron on June 26 and June 27, 2019. Based on the results of the resampling event, SSIs for Boron were confirmed in monitoring wells CF-15-08 and CF-15-09 (Table 1).

1.2 Purpose of This Report

The purpose of this report is to present an ASD and provide sufficient evidence that the SSIs identified for Boron in wells CF-15-08 and CF-15-09 resulted from a source other than the Type I Landfill.

The CCR Rule does not contain specific requirements for an ASD beyond what is stated, as follows, in §257.94(e)(2):

"The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer verifying the

accuracy of the information in the report. If a successful demonstration is completed within the 90-day period, the owner or operator of the CCR unit may continue with a detection monitoring program under this section. If a successful demonstration is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under § 257.95. The owner or operator must also include the demonstration in the annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer."

In addition to the above requirements of the CCR Rule, this ASD has been conducted and presented using guidance and documentation recommendations included in the U.S. EPA document Solid Waste Disposal Facility Criteria Technical Manual EPA 530-R-93-017 (U.S. EPA 1993).

A detailed discussion of the confirmed SSIs and a technical justification that the exceedances result from a source other than the Type I Landfill are presented in the following sections of this report.

2.0 DESCRIPTION OF THE TYPE I LANDFILL

2.1 Unit Description

The Type I Landfill and LRCP occupy an approximately 200-acre area situated within an eroded bedrock channel. The Type I Landfill consists of approximately 109 acres that were approved as a Type I residual waste landfill by the Indiana Department of Environmental Management (IDEM) in 2007. The remaining 91 acres consist of the LRCP located at the southwest end of the Type I Landfill (Figures 1 and 2).

Beginning in 1955, ash products were sluiced to disposal ponds located in the bedrock channel at the plant site. To allow for more disposal capacity, an on-site fly ash pond was developed into a Type III residual landfill in 1988. All required permits for the Type III Residual Waste Landfill (Type III Landfill) were obtained from IDEM. The Type III Landfill was permitted to be constructed, and to serve as closure for the historic fly ash ponds. The Type III Landfill is located at the northeast end of the bedrock channel and went operational in 1991.

After IDEM approval, IKEC upgraded the Type III Landfill to a Type I residual waste landfill (Type I Landfill). As a result, the Type III Landfill was closed and the Type I Landfill was designed and constructed to serve as the cap for the closed Type III Landfill. The Type I Landfill, which went operational in 2011, is completely separated from the closed Type III Landfill by a geosynthetic liner and a compacted clay liner.

2.2 Hydrogeology

Based on information in the Hydrogeologic Study Report (AGES 2007), bedrock beneath the Type I Landfill and the closed Type III Landfill consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 to 35 feet of gray clay. The gray clay is directly overlain by fly ash that had been historically hydraulically placed in the area. A generalized cross section showing the proposed final limits of the Type I Landfill & LRCP, the location and limits of the closed Type III Landfill, and the extent of the historic hydraulically place fly ash is presented in Figure 3. A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP and the closed Type III Landfill. The Devil's Backbone acts as an impermeable barrier that forces groundwater passing beneath both of the landfills to flow either toward the northeast or toward the southwest. A detailed hydrogeologic study determined that a groundwater flow divide is present near the northeast end of the bedrock channel and that all groundwater beneath the active Type I Landfill flows toward the southwest (AGES 2007) (Figure 4). As detailed in the Monitoring Well Installation Report (AGES 2018a), an aquifer does not exist beneath either of the landfills. Therefore, alluvial deposits located southwest of the LRCP are designated as the uppermost aquifer for the Type I Landfill & LRCP.

The Type I Landfill was constructed using a geosynthetic liner and a compacted clay liner to prevent water from the Type I Landfill from entering the underlying layers. Water in the Type I Landfill is collected by an underground leachate system and is currently discharged into the WBSP where it mixes with surface water runoff from the surrounding 510-acre drainage area.

In November and December 2015, six (6) monitoring wells were installed at the Type I Landfill & LRCP (Figure 1). Three (3) monitoring wells (CF-15-07, CF-15-08 and CF-15-09) were installed in the alluvial deposits (uppermost aquifer) located southwest of the LRCP (Figure 1). Based on exploratory soil borings and historical data, there were no suitable upgradient locations for the Type I Landfill. CF-15-04 was installed northeast of and outside the hydrologic influence of the Type I Landfill and the closed Type III Landfill to serve as the required background monitoring well. CF-15-06 was installed to serve as a second background monitoring well and CF-15-05 was installed as a background/intermediate monitoring well to ensure groundwater from the WBSP is not impacting groundwater at well CF-15-06. Wells WBSP-15-01 and WBSP-15-02 are located southeast of the impermeable devil's Backbone and are hydraulically separated from groundwater flowing beneath the Type I Landfill & LRCP. Because these wells are outside the hydraulic influence of the Type I Landfill & LRCP, these wells were designated as background wells. Table 2 presents construction details for the monitoring wells in the groundwater monitoring network for the Type I Landfill & LRCP.

Based on groundwater levels measured from each well in March 2019, groundwater beneath the Type I Landfill & LRCP flows to the southwest toward the Ohio River. Appendix A presents a groundwater contour map for March 2019.

3.0 ALTERNATE SOURCE DEMONSTRATION

As noted above, Boron was identified as a confirmed SSI in wells CF-15-08 and CF-15-09 downgradient of the Type I Landfill & LRCP. Based on a review of the current and historic data, AGES/IKEC have determined that the active Type I Landfill is not the source of the Boron SSIs reported in the CCR monitoring wells and that historic fly ash that had been sluiced into the valley beginning in 1955 is the alternate source for the Boron SSIs. As discussed in detail below, this conclusion is based on the following lines of evidence:

- Ash that was historically sluiced into the bedrock valley in the 1950s is a known source of Boron and is hydraulically connected to groundwater downgradient of the Type I Landfill & LRCP;

- Boron has been detected in groundwater downgradient from the hydraulically-placed ash (and the Type I Landfill & LRCP) in IDEM program wells CF-9405, CF-9406 and CF-9407 (located near wells CF-15-08 and CF-15-09) since 1994, which is 17 years prior to operation of the Type I Landfill; and

- Given the extremely low groundwater flow velocity at the landfill, the travel time for a release of Boron from the Type I Landfill to reach wells CF-15-08 and CF-15-09 is estimated at 120 years. As the Type I Landfill has only been in operation for seven (7) years, the landfill cannot be the source of the Boron.

Details to support these conclusions are presented below.

3.1 Alternate Source Demonstration Method

The evaluation of the alternate source for Boron in wells CF-15-08 and CF-15-09 was assessed in general accordance with guidelines presented in the Solid Waste Disposal Facility Criteria Technical Manual (U.S. EPA 1993) using the following methods:

- Identify a potential alternate source;
- Establish that a hydraulic connection exists between the alternate source and the wells with the confirmed SSIs;
- Establish that constituents of concern are present at the alternate source; and
- Establish that the concentrations observed in the compliance wells could not have resulted from the CCR unit given the hydrogeologic conditions at the site.

3.2 Alternate Source Identification

The initial groundwater investigation conducted for the former Type III Landfill (beginning in 1994) focused on the fly ash that had been hydraulically placed in the bedrock channel beginning in 1955. The Type III Landfill was permitted to serve as the closure for the hydraulically placed fly ash.

After IDEM approval, IKEC upgraded the Type III Landfill to a Type I Landfill and the Type I Landfill was permitted as the closure for the Type III Landfill. The active Type I Landfill was constructed with a geosynthetic liner, and an engineered clay liner on top of the Type III Landfill to serve as a cap. The two (2) liners prevent migration of groundwater from the active Type I Landfill to the closed Type III Landfill. The closed Type III Landfill is not a CCR unit and is not subject to regulation under the CCR Rule.

Both landfills were constructed on top of the historic hydraulically placed fly ash, which extends the length of the bedrock channel (Figure 3) beneath the LRCP to the embankment at the southwestern end of the LRCP (Figure 5). Although the base of the LRCP contains historic hydraulically placed fly ash, the LRCP does not receive CCR and the existing historic CCR is not actively managed. Therefore, the LRCP is considered an inactive CCR unit.

Due to the age and extent of the historic, hydraulically placed ash, this material was identified as the alternate source for the Boron detected in wells CF-15-08 and CF-15-09.

3.3 Establish a Hydraulic Connection

A review of the permit drawings, construction drawings, and a figure from the Initial Structural Stability Assessment, Landfill Runoff Collection Pond Report (Stantec 2016) (Appendix C), indicated that material from the closed Type III Landfill and the historic hydraulically placed fly ash are located entirely beneath the active Type I Landfill & LRCP (Figure 3). The base of the layer of "hydraulically placed fly ash" is located between elevations 445 ft mean sea level (msl) and 500 ft msl.

When the fly ash was originally emplaced in the bedrock channel, there were no impermeable liners constructed to separate the fly ash from the underlying "foundation soils." The CCR and IDEM groundwater monitoring wells are screened in these "foundation soils," which consist of alluvial deposits of silt, sand and gravel. These alluvial deposits extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River and provide a direct hydraulic connection between the historic hydraulically placed fly ash and the groundwater monitoring wells (Figure 5).

3.4 Constituents Are Present at the Alternate Source

Both the closed Type III Landfill and the Type I Landfill are currently being monitored under an IDEM groundwater monitoring program. In 1994, three (3) monitoring wells (CF-9405, CF-9406 and CF-9407) were installed south of the LRCP as a condition of a pH Variance for the former Type III Landfill granted by IDEM. Since 1994, routine semi-annual and quarterly monitoring of these wells has been conducted. In 2009, three (3) additional wells (CF-07-06D, CF-07-08 and CF-07-09) were installed per IDEM to monitor groundwater quality during the year prior to the start of operations of the Type I Landfill in 2011. Wells in the IDEM groundwater monitoring network are located south of the LRCP and screened in the same "foundation soils" as the wells in the CCR monitoring network (Figure 6).

As shown on Table 3 and Figure 7, Boron was detected in wells CF-9406 (9.0 milligrams per liter [mg/L] to 17.1 mg/L) and CF-9407 (1.19 mg/L to 7.7 mg/L) from 1995 through 2011 (Table 3 and Figure 7). This demonstrates that Boron was present in groundwater downgradient of the eventual location of the Type I Landfill 17 years prior to its operation. Boron concentrations in downgradient CCR wells have ranged from 7.62 mg/L to 11.9 mg/L in well CF-15-08, and from 5.78 mg/L to 7.59 mg/L in CF-15-09 (Table 3 and Figure 7). These concentrations are similar to historic Boron concentrations observed in wells CF-9506 and CF-9407 from 1994 through 2011.

Because Boron concentrations similar to those observed in CCR wells CF-15-08 and CF-15-09 were detected in IDEM wells CF-9406 and CF-9407 prior to construction of the Type I Landfill, the historic hydraulically placed ash is the source of the detected Boron.

3.5 Hydrogeologic Conditions and Groundwater Flow Velocity

As presented in the Evaluation of Potential Risk to Supply Well Fields Report (AGES 2006), a groundwater flow velocity of 45 feet per year (ft/yr) was calculated for alluvial deposits, which are designated as the uppermost aquifer for these CCR units. Based on the most recent topographical survey conducted of the Type I Landfill (Appendix B), the current limit of waste for the active Type I Landfill is located approximately 5,400 feet (more than one (1) mile) northeast of the three (3) CCR groundwater monitoring wells (CF-15-07, CF-15-08 and CF-15-09) (Figure 8). Based on this data, it was calculated that it will take 120 years for groundwater to flow from the current limit of waste in the Type I Landfill to the CCR monitoring wells. Waste placement in the Type I Landfill began in early 2011. Given the two (2) constructed liners, the distance and the flow rate, water from the Type I Landfill is not able to enter the groundwater, and groundwater has not had enough time to reach the CCR monitoring wells.

Based on the calculations presented above, the active Type I Landfill cannot be the source of Boron detected in the CCR monitoring wells.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The ASD has been completed in general accordance with guidelines presented in the Solid Waste Disposal Facility Criteria Technical Manual (U.S. EPA 1993).

Based on a review of the current and historic data, AGES/IKEC have determined that the Type I Landfill is not the source of Boron detected in the CCR monitoring wells. This conclusion is supported by the following evidence:

- "Foundation soils" that extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River provide a direct hydraulic connection between the historic hydraulically placed fly ash and the CCR groundwater monitoring wells CF-15-08 and CF-15-09.

- Historic data from the IDEM groundwater monitoring program indicate that Boron concentrations similar to those observed in CCR wells CF-15-08 and CF-15-09 were detected in IDEM wells CF-9406 and CF-9407 for 17 years prior to operation of the Type I Landfill, indicating that the Boron is associated with the historic hydraulically placed fly ash.

- Using the previously calculated groundwater flow velocity of 45 ft/yr, it is estimated that it would take 120 years for groundwater flowing beneath the Type I Landfill to reach the CCR monitoring wells.

Based on the demonstration presented above, the Type I Landfill is not the source of the Boron detected in CCR monitoring wells. Therefore, it is recommended that the Type I Landfill remain in Detection Monitoring.

5.0 REFERENCES

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TABLES

TABLE 1
SUMMARY OF POTENTIAL AND CONFIRMED SSIs
TYPE I RESIDUAL WASTE LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Potential SSI Parameter (Units)	2nd Detection Monitoring Sampling Event March 2019		2nd Detection Monitoring Resampling Event June 2019	
		Potential SSI Result	UPL	Potential SSI Result	Confirmed SSI (Yes/No)
CF-15-08	Boron (mg/L)	9.8	5.566	8.5	**Yes**
CF-15-09	Boron (mg/L)	6.7	5.566	6.5	**Yes**

Notes:
1. SSI = Statistically Significant Increase.
2. UPL = Upper Prediction Limit (Maximum Interwell UPL).
3. mg/L = Milligrams per liter.

TABLE 2
GROUNDWATER MONITORING NETWORK
TYPE I RESIDUAL WASTE 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

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.

TABLE 3
HISTORIC BORON CONCENTRATIONS IDEM WELLS CF-9406 & CF-9407 AND CCR WELLS CF-15-08 & CF-15-09
CLIFTY CREEK STATION
MADISON, INDIANA

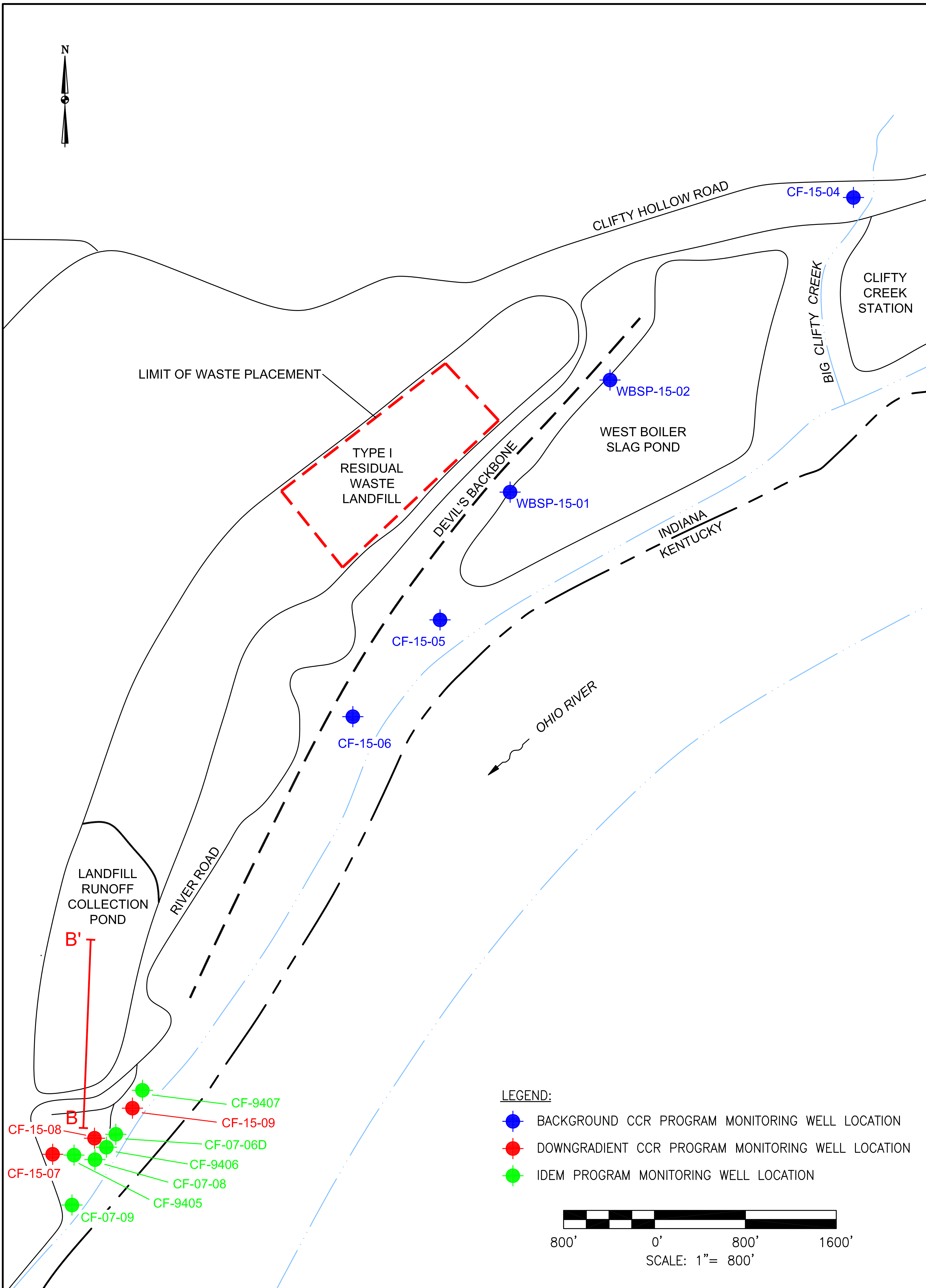
Boron Concentrations in IDEM Wells (1994 through 2015)					
Date	**CF-9406**	**CF-9407**	**Date**	**CF-9406**	**CF-9407**
6/8/1994	10	2.9	**11/19/2002**	16.2	5.92
6/22/1994	9.8	4.7	**5/14/2003**	13.7	3.83
7/6/1994	11	6.3	**11/12/2003**	14.7	5.4
7/20/1994	12	8.4	**5/11/2004**	14.2	3.86
8/3/1994	10	6.3	**11/9/2004**	**17.1**	5.28
8/17/1994	**9**	6.4	**5/9/2005**	15.2	7.16
8/31/1994	12	**7.7**	**11/8/2005**	14.3	DRY
9/14/1994	9.8	6.9	**5/17/2006**	12.8	7.4
9/28/1994	9.7	5.9	**11/15/2006**	15	5.69
10/12/1994	12	7.3	**5/9/2007**	13.7	4.71
10/26/1994	12	6.8	**11/14/2007**	14.6	DRY
11/9/1994	11	6.7	**5/13/2008**	15	3.21
11/30/1994	11	5	**11/12/2008**	15.6	DRY
12/7/1994	10	3.6	**5/19/2009**	14.7	4.75
12/21/1994	11	2.5	**11/16/2009**	14.7	7.23
1/18/1995	11	3	**12/16/2009**	NM	NM
2/22/1995	13	3.6	**01/14/2010**	NM	NM
6/14/1995	13	4.5	**02/23/2010**	NM	NM
12/21/1995	14	4.7	**03/16/2010**	NM	NM
6/26/1996	14	3.3	**04/15/2010**	NM	NM
12/23/1996	12	5.3	**5/19/2010**	14.1	6.77
4/30/1997	9.9	6.9	**06/23/2010**	NM	NM
6/30/1997	12	5.9	**07/15/2010**	NM	NM
10/7/1997	15	DRY	**08/24/2010**	NM	NM
12/16/1997	14	7.5	**09/14/2010**	NM	NM
4/16/1998	14	6.5	**10/19/2010**	NM	NM
6/24/1998	13	6.5	**11/3/2010**	16.9	DRY
9/23/1998	14	DRY	**Type I Landfill Operational**		
1/21/1999	13	5.1	**5/17/2011**	12.3	4.21
3/31/1999	12	4.3	**11/28/2011**	16.2	**1.19**
6/30/1999	13	7.5	**5/7/2012**	14.5	5.09
10/7/1999	DRY	DRY	**11/13/2012**	15.9	DRY
1/6/2000	15	4.4	**3/30/2013**	15	5.25
6/6/2000	15	7.2	**9/23/2013**	14.2	DRY
1/10/2001	16	7.4	**5/21/2014**	12.63	5.646
5/15/2001	15	6.6	**11/11/2014**	14.58	DRY
11/26/2001	18	7.3	**5/9/2015**	15.47	DRY
5/15/2002	13.5	5.1	**11/3/2015**	13.8	DRY

TABLE 3
HISTORIC BORON CONCENTRATIONS IDEM WELLS CF-9406 & CF-9407 AND CCR WELLS CF-15-08 & CF-15-09
CLIFTY CREEK STATION
MADISON, INDIANA

Boron Concentrations in IDEM and CCR Wells (January 2016 through March 2019)				
Date	**CF-9406**	**CF-9407**	**CF-15-08**	**CF-15-09**
1/11/2016	NM	NM	8.64	6.86
3/7/2016	NM	NM	8.24	**5.78**
5/11/2016	10.6	2.48	NM	NM
5/16/2016	NM	NM	9.34	6.58
7/25/2016	NM	NM	9.65	7.01
8/29/2016	NM	NM	9.63	DR
11/9/2016	15.3	DRY	NM	NM
11/28/2016	NM	NM	10.9	DRY
2/27/2017	NM	NM	9.29	6.78
5/8/2017	7.46	5.4	NM	NM
6/12/2017	NM	NM	**7.62**	6.3
8/28/2017	NM	NM	9.04	6.81
11/14/2017	11.7	7.58	NM	NM
3/1/2018	NM	NM	8.5	5.86
5/7/2018	13.8	7.25	8.6	6.1
9/2018	14.7	3.27	**11.9**	**7.59**
3/2019	13.9	6.56	9.8	6.7

Notes:
1. All concentrations are mg/L.
2. NM =Well was not monitored on this date.
3. DRY = Well was dry and not able to be sampled.
4. Maximum and minimum Boron results for each well are shown in **Bold.**

FIGURES



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017114–CLI
DWG FILE	IKEC_Clifty_ASD_MW Locs_b03.dwg
DRAWING SCALE	NOT TO SCALE

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412.264.6453

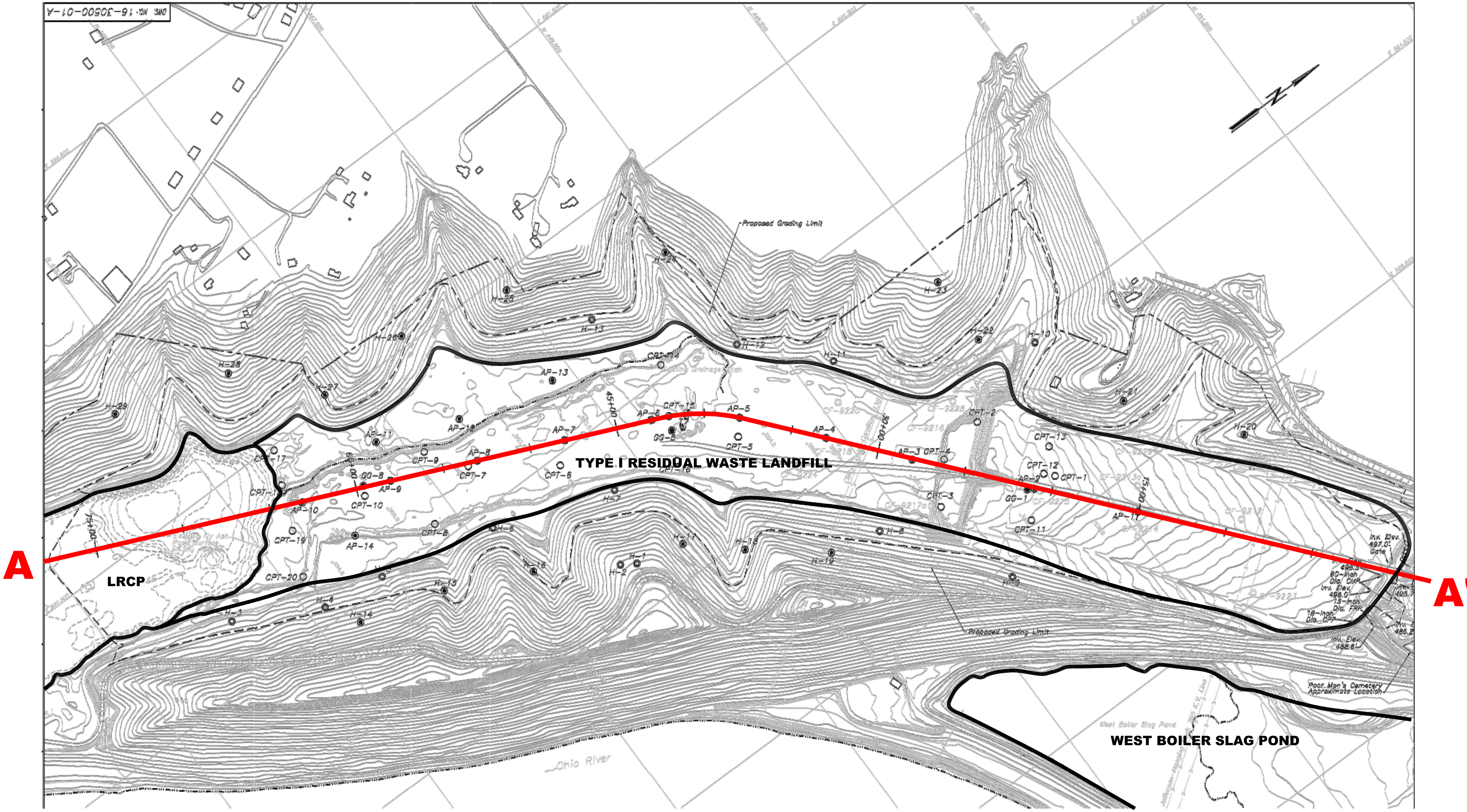
INDIANA–KENTUCKY ELECTRIC CORPORATION

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

DRAWING NAME: FIGURE 1

REV.: 0

Plot: 01/10/2019 13:32 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\ASD GW Sampling\IKEC_Clifty_ASD_MW Locs_b03.dwg\FIG 1



LEGEND:

A-A' CROSS SECTION TRANSECT

SOURCE: CLIFTY CREEK PERMIT DRAWINGS (FMSM, NOVEMBER 2006)

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116-CLI
DWG FILE	Clifty_ASD_Boring Plan b04.dwg
DRAWING SCALE	NOT TO SCALE

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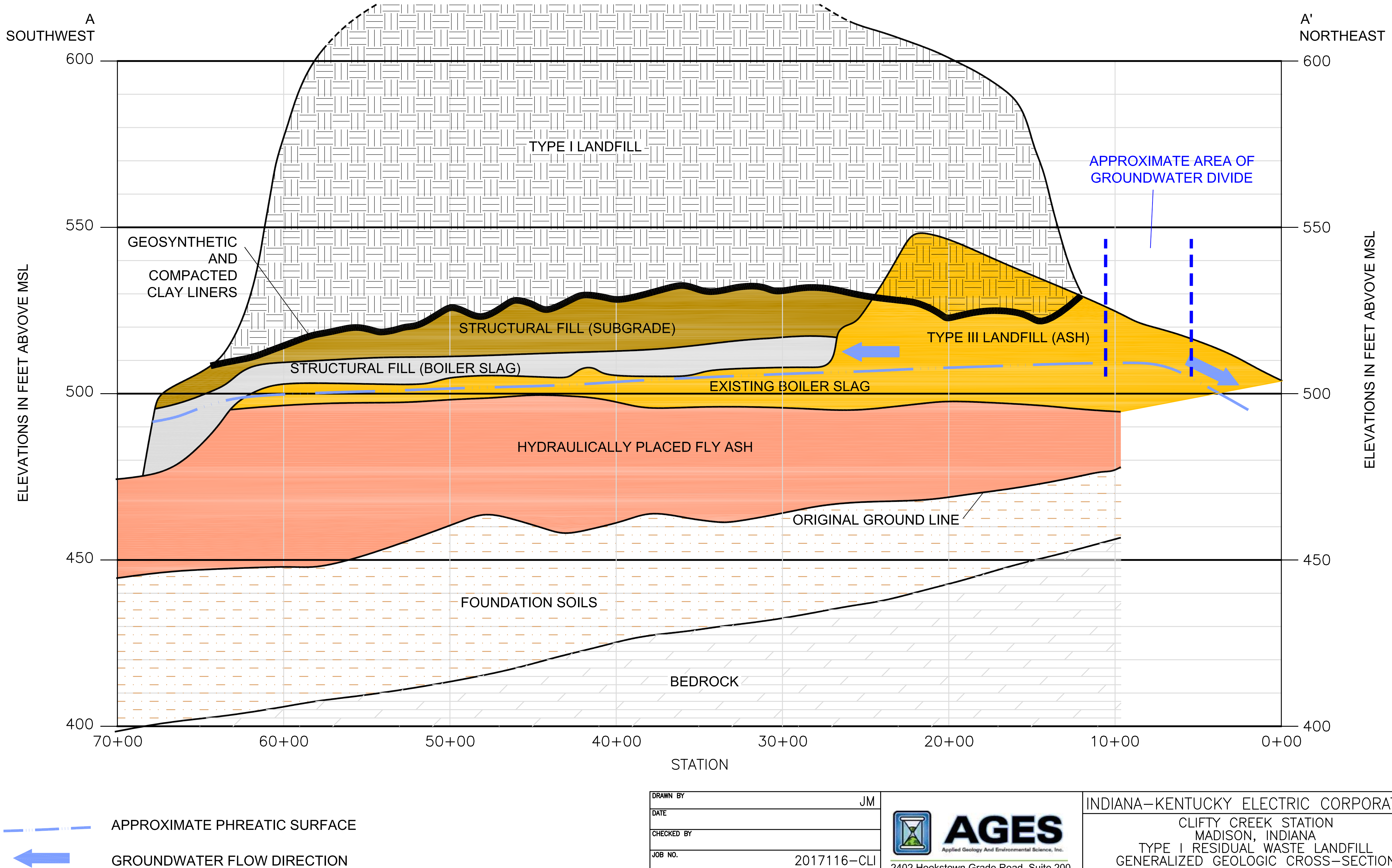
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
OVERVIEW OF TYPE I LANDFILL AND LRCP

DRAWING NAME: FIGURE 2
REV. 0

Plot: 12/12/2018 10:47 _PROGRAM-IKEC\Clifty Creek-CCR Program\CAD\ASD GW Sampling\Clifty_ASD_Boring Plan b04.dwg



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116–CLI
DWG FILE	Clifty_ASD_Cross Sec b02.dwg
DRAWING SCALE	NOT TO SCALE

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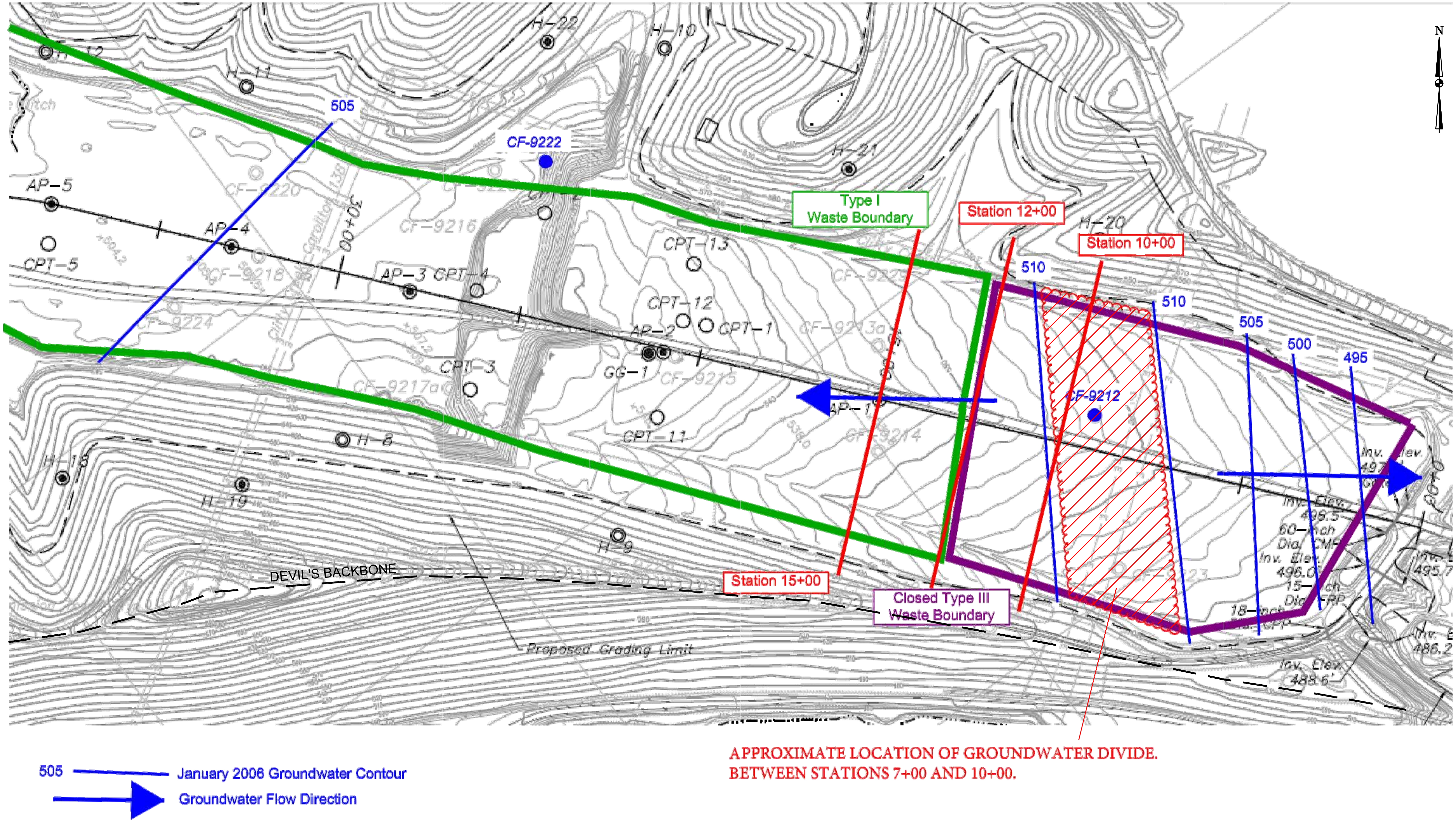
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL
GENERALIZED GEOLOGIC CROSS–SECTION
A–A' (SOUTHWEST–NORTHEAST)

DRAWING NAME: FIGURE 3
REV. 0

Plot: 12/12/2018 11:18 _PROGRAM–IKEC\Clifty Creek–CCR Program\CAD\ASD GW Sampling\Clifty_ASD_Cross Sec b02.dwg



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116-CLI
DWG FILE	Clifty_GW Divide b01.dwg
DRAWING SCALE	NOT TO SCALE

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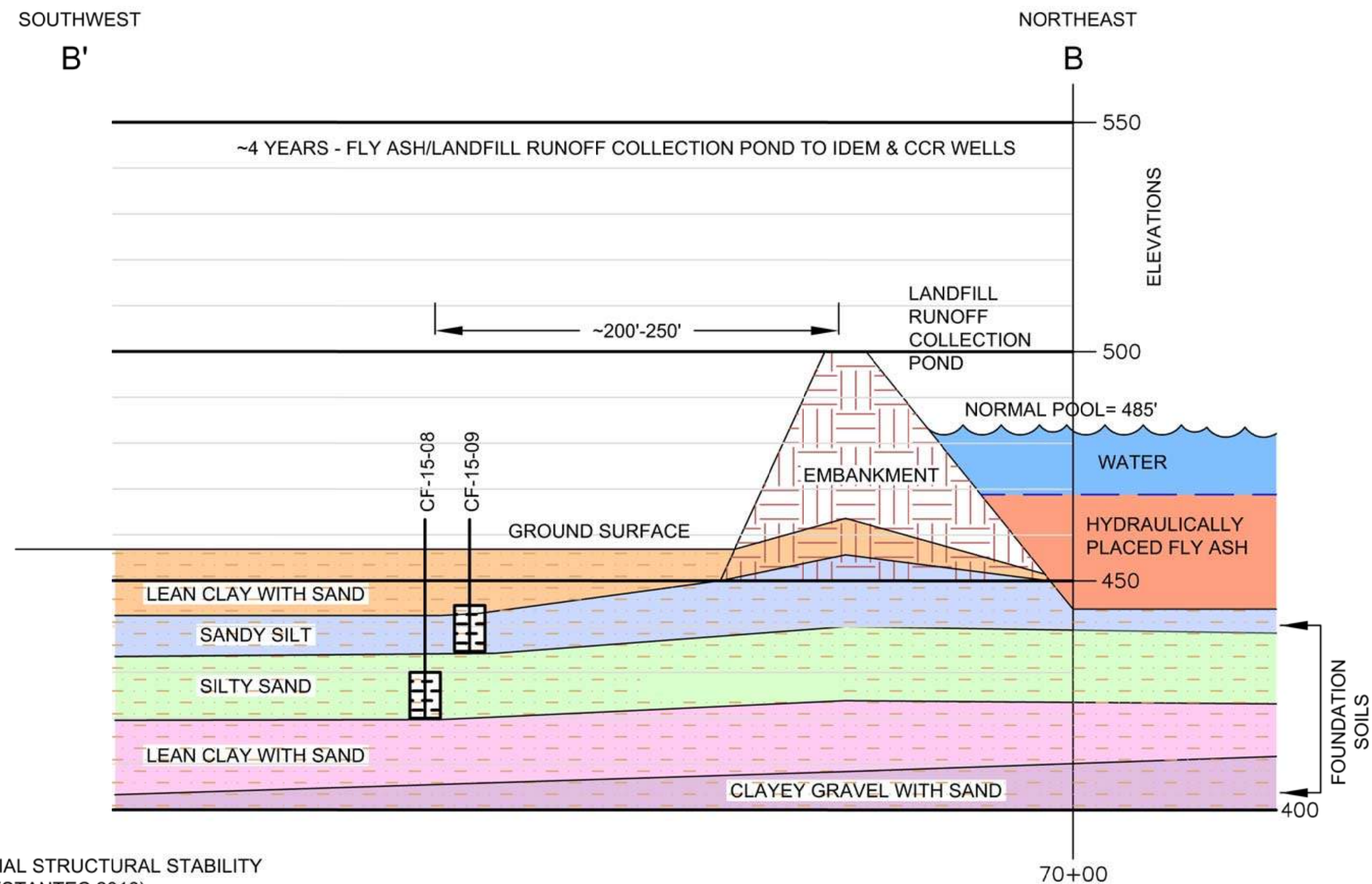
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
GROUNDWATER FLOW AT
NORTHEAST END OF BEDROCK CHANNEL

DRAWING NAME: FIGURE 4

REV. 0

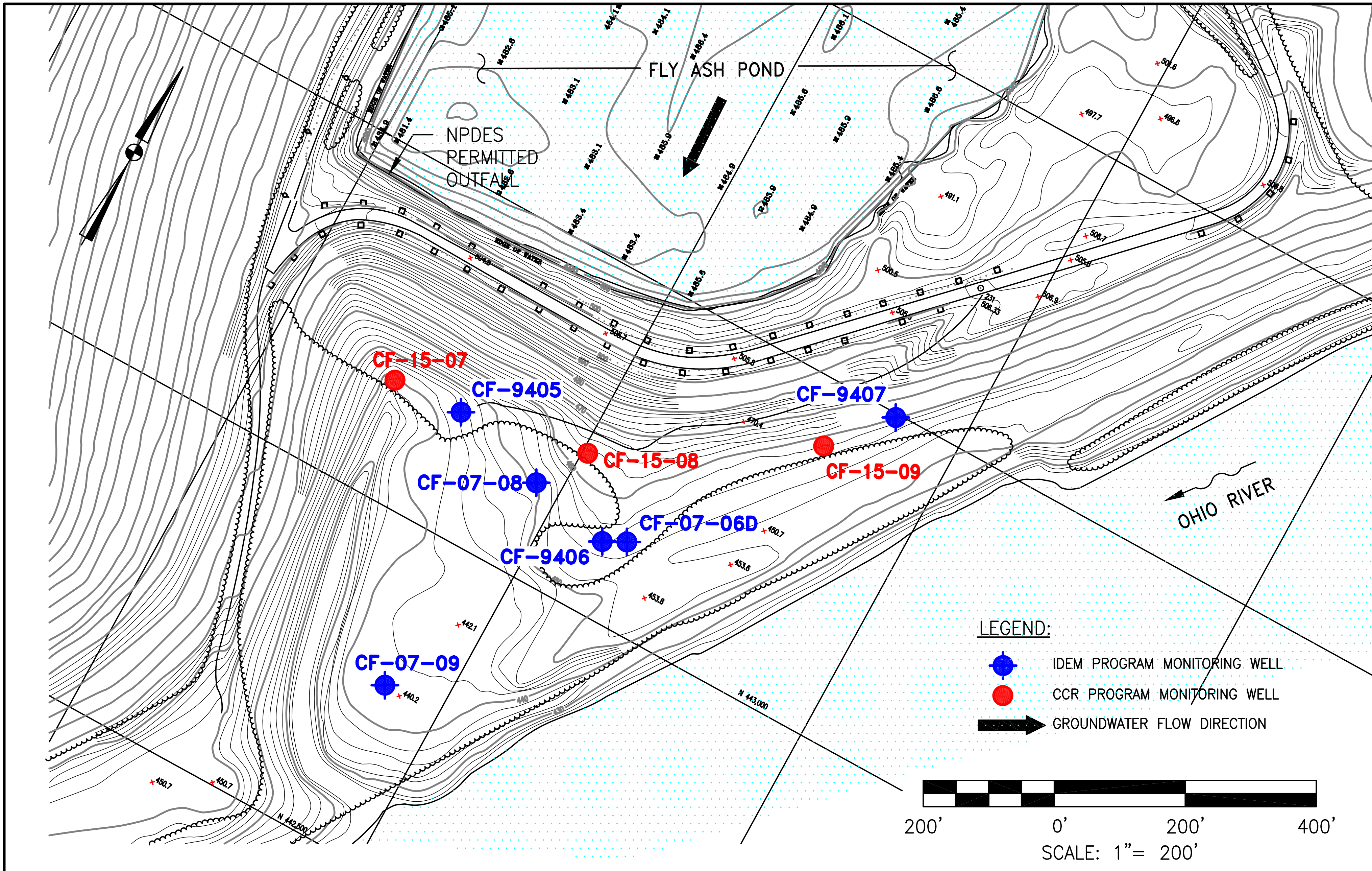
Plot: 12/12/2018 11:46 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\ASD GW Sampling\Clifty_GW Divide b01.dwg



NOTES:
BASED ON INITIAL STRUCTURAL STABILITY ASSESSMENT (STANTEC 2016).

DRAWN BY: JM	AGES — Applied Geology And Environmental Science, Inc. 2402 Hookstown Grade Road, Suite 200, Clinton, PA 15026, 412.264.6453	INDIANA–KENTUCKY ELECTRIC CORPORATION	
DATE:		CLIFTY CREEK STATION MADISON, INDIANA GENERALIZED CROSS–SECTION LANDFILL RUNOFF COLLECTION POND TO CCR MONITORING WELLS	
CHECKED BY:			
JOB NO.: 2017114–CLI			
DWG FILE: Clifty_ASD_X–Sec Pond–Wells a06.dwg		DRAWING NAME: FIGURE 5	REV. 0
DRAWING SCALE: NOT TO SCALE			

Plot: 01/10/2019 13:45 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\ASD GW Sampling\Clifty_ASD_X–Sec Pond–Wells a06.dwg



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116-CLI
DWG FILE	CLIFTY Well Locations a03 R2.dwg
DRAWING SCALE	AS SHOWN

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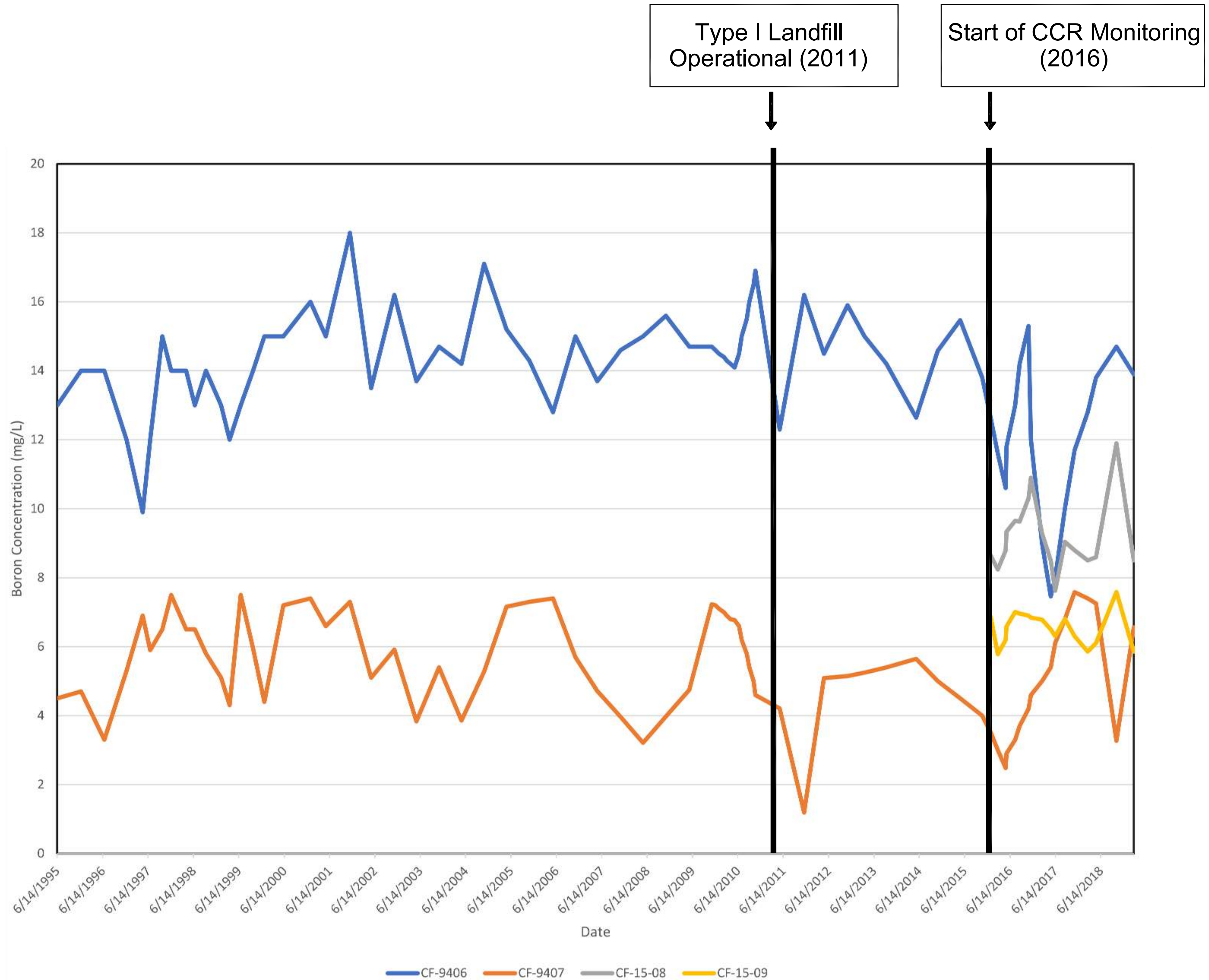
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK PLANT
MADISON, INDIANA
CCR PROGRAM AND IDEM PROGRAM
MONITORING WELL LOCATION MAP

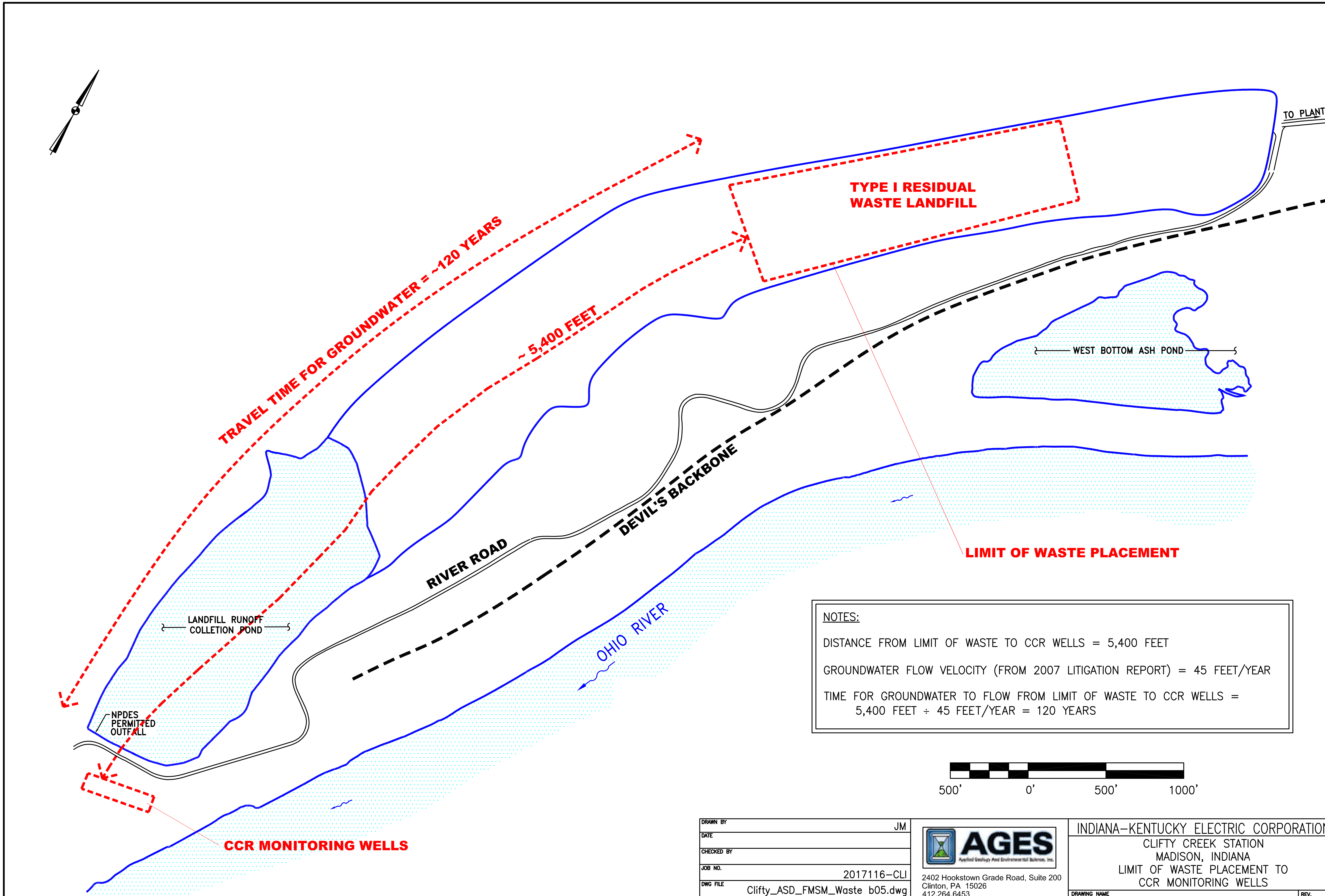
DRAWING NAME: FIGURE 6
REV. 0

Plot: 12/12/2018 12:18 _PROGRAM-IKEC\Clifty Creek-CCR Program\CAD\ASD GW Sampling\CLIFTY Well Locations a03 R2.dwg



DRAWN BY	JM	AGES Applied Geology And Environmental Science, Inc. 2402 Hookstown Grade Road, Suite 200 Clinton, PA 15026 412.264.6453	INDIANA–KENTUCKY ELECTRIC CORPORATION
DATE			CLIFTY CREEK STATION MADISON, INDIANA TIME SERIES DATA FOR BORON (mg/L) CF–9406, CF–9407, CF–15–08 AND CF–15–09 MARCH 2019
CHECKED BY			
JOB NO.	2019008–CLIFTY		
DWG FILE	Clifty_ASD_Boron–Time Graph_MAR2019.dwg		DRAWING NAME: FIGURE 7
DRAWING SCALE	NOT TO SCALE		REV. 0

Plot: 01/17/2020 15:03 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\ASD 2_MAR 2019\Clifty_ASD_Boron–Time Graph_MAR2019.dwg



NOTES:

DISTANCE FROM LIMIT OF WASTE TO CCR WELLS = 5,400 FEET

GROUNDWATER FLOW VELOCITY (FROM 2007 LITIGATION REPORT) = 45 FEET/YEAR

TIME FOR GROUNDWATER TO FLOW FROM LIMIT OF WASTE TO CCR WELLS =
5,400 FEET ÷ 45 FEET/YEAR = 120 YEARS

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116–CLI
DWG FILE	Clifty_ASD_FMSM_Waste b05.dwg
DRAWING SCALE	1" = 555'

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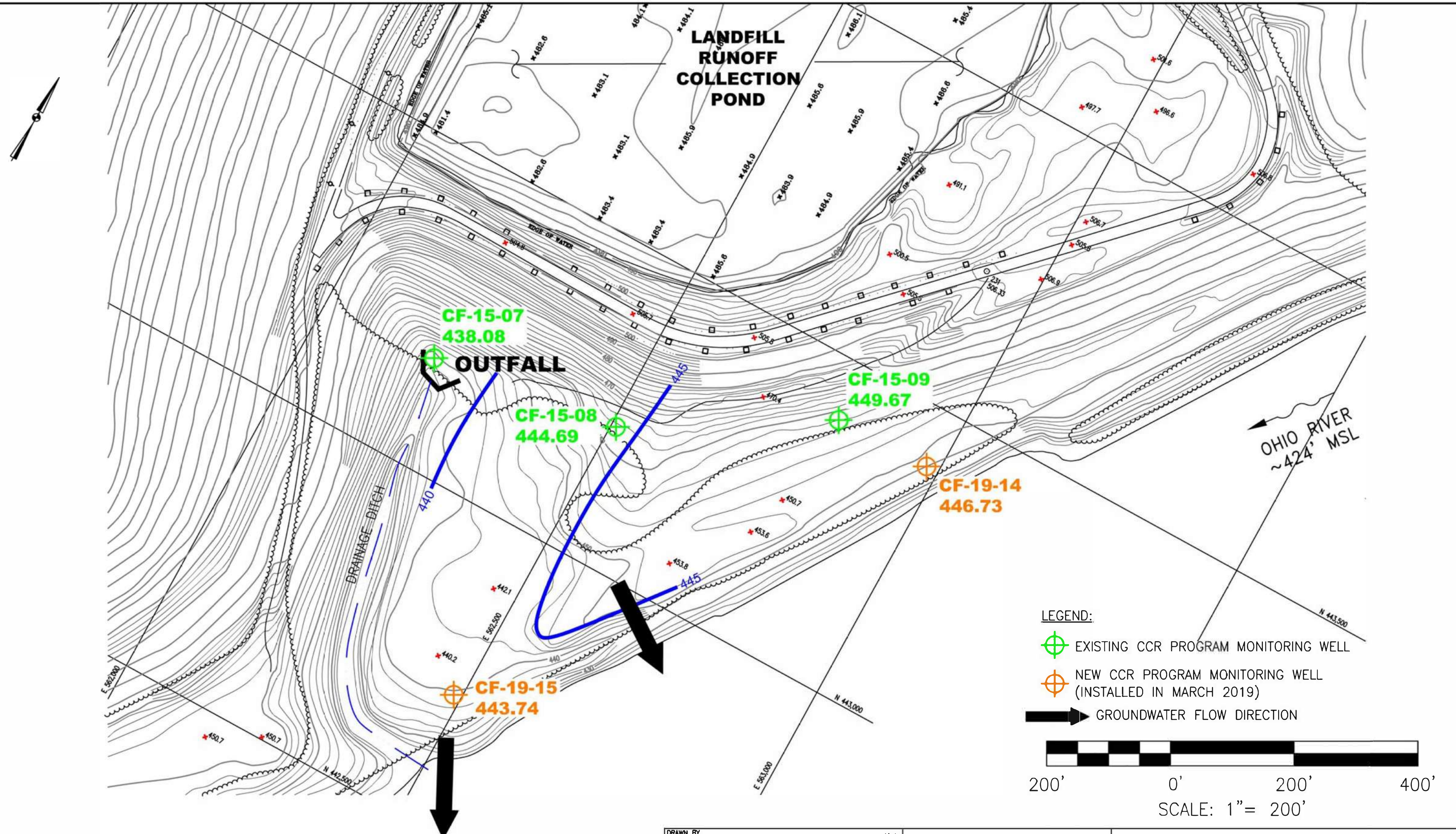
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
LIMIT OF WASTE PLACEMENT TO
CCR MONITORING WELLS

DRAWING NAME: FIGURE 8
REV. 0

Plot: 12/12/2018 12:40 _PROGRAM–IKEC\Clifty Creek–CCR Program\CAD\ASD GW Sampling\Clifty_ASD_FMSM_Waste b05.dwg

APPENDIX A

Groundwater Flow Map
March 2019



NOTE:
WELLS CF–19–14 AND CF–19–15 WERE INSTALLED IN MARCH 2019.

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008–CLIFTY
DWG FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19.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 2019

DRAWING NAME: FIGURE A–1
REV. 0

Plot: 01/28/2020 15:38 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 GW Monitoring-Corrective Action Rpt\Appx B\2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_MAR19.dwg

APPENDIX B

PHASE I EXISTING CONDITIONS TOPOGRAPHIC MAP (Stantec 2018)

Stantec
11687 Lebanon Road
Cincinnati, Ohio 45241-2012
www.stantec.com

Client/Project
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK COAL ASH LANDFILL MODIFICATION
JEFFERSON COUNTY, MADISON TOWNSHIP, INDIANA

Title
PHASE 1 EXISTING CONDITIONS (JUNE 2018)

Permit-Seal

Project Number: 175538039

Drawing No. 1
Revision -
Sheet 1 of 8

APPENDIX C

FIGURE FROM STABILITY ASSESSMENT REPORT
(Stantec 2016)

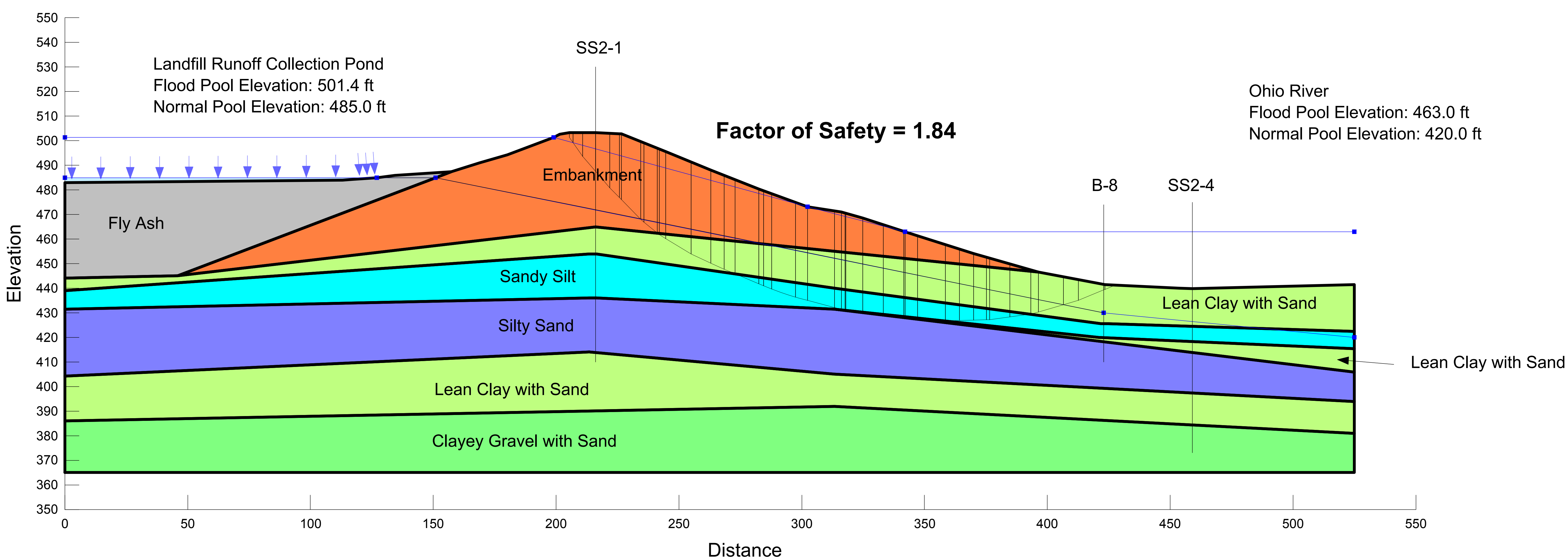
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Landfill Runoff Collection Pond Dam
Madison, Indiana
Section D-D'

Sudden Drawdown

Material Type	Unit Weight	Effective - c'	Effective - phi	Total - c	Total - phi
Embankment (SDD)	129 pcf	198 psf	27.5 °	1400 psf	21 °
Lean Clay with Sand (SDD)	127 pcf	206 psf	28 °	1200 psf	17 °
Sandy Silt (SDD)	125 pcf	0 psf	30 °	0 psf	30 °
Silty Sand (SDD)	94 pcf	0 psf	30 °	0 psf	30 °
Clayey Gravel with Sand (SDD)	130 pcf	0 psf	35 °	0 psf	35 °
Fly Ash (SDD)	115 pcf	0 psf	25 °	0 psf	25 °

Existing Geometry
Sudden Drawdown
Undrained, Sudden Drawdown Strengths

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



APPENDIX F

ALTERNATE SOURCE DEMONSTRATION OCTOBER 2019

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COAL COMBUSTION RESIDUALS REGULATION
ALTERNATE SOURCE DEMONSTRATION REPORT
OCTOBER 2019 DETECTION MONITORING EVENT

TYPE I RESIDUAL WASTE LANDFILL
INDIANIA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
MADISON, JEFFERSON COUNTY, INDIANA

January 2020

Prepared for:

INDIANA KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

COAL COMBUSTION RESIDUALS REGULATION
ALTERNATE SOURCE DEMONSTRATION REPORT
OCTOBER 2019 DETECTION MONITORING EVENT
TYPE I RESIDUAL WASTE LANDFILL
INDIANIA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
MADISON, JEFFERSON COUNTY, INDIANA

January 2020

Prepared for:

INDIANA KENTUCKY ELECTRIC CORPORATION (IKEC)

Prepared By:

Applied Geology and Environmental Science, Inc.

Bethany Flaherty

Bethany Flaherty
Project Scientist

Robert W. King

Robert W. King, P.G.
President/Chief Hydrogeologist

COAL COMBUSTION RESIDUALS REGULATION
ALTERNATE SOURCE DEMONSTRATION REPORT
OCTOBER 2019 DETECTION MONITORING EVENT
TYPE I RESIDUAL WASTE LANDFILL
INDIANA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
MADISON, JEFFERSON COUNTY, INDIANA

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CLIFTY CREEK PLANT
MADISON, JEFFERSON COUNTY, INDIANA

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**COAL COMBUSTION RESIDUALS REGULATION
ALTERNATE SOURCE DEMONSTRATION REPORT
OCTOBER 2019 DETECTION MONITORING EVENT
TYPE I RESIDUAL WASTE LANDFILL
INDIANIA KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK PLANT
MADISON, JEFFERSON COUNTY, INDIANA**

1.0 INTRODUCTION

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final Coal Combustion Residuals (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, 2015) in the Federal Register, referred to as the "CCR Rule."

The Indiana Kentucky Electric Corporation (IKEC) contracted with Applied Geology and Environmental Science, Inc. (AGES) to administer the CCR Rule groundwater monitoring program at the Clifty Creek Station located in Madison, Jefferson County, Indiana. There are three (3) CCR units at the Clifty Creek Station (Figure 1):

- Type I Residual Waste Landfill (Type I Landfill);
- Landfill Runoff Collection Pond (LRCP); and,
- West Boiler Slag Pond (WBSP).

Statistically Significant Increases (SSIs) were not identified at the WBSP during the October 2019 Detection Monitoring event. Therefore, the WBSP is not discussed further in this report.

During the March 2018 Detection Monitoring event, Boron SSIs were confirmed in two (2) wells located downgradient of the Type I Landfill and LRCP and these CCR units entered into Assessment Monitoring in September 2018. Based on a successful Alternate Source Demonstration (ASD) (AGES 2019), OVEC determined that the Type I Landfill was not the source of the Boron. Therefore, the Type I Landfill returned to Detection Monitoring in January 2019. As an alternate source for Boron at the LRCP could not be established, the LRCP remains in Assessment Monitoring.

During the October 2019 Detection Monitoring event, a Boron SSI was confirmed in one (1) well located downgradient of the Type I Landfill. Therefore, OVEC has prepared this ASD to show that the Type I Landfill is not the source of the Boron. Details regarding this evaluation are presented in this report.

1.1 Background

In accordance with §257.91(d) of the CCR Rule, as detailed in the Well Installation Report (AGES 2018a), because the LRCP is directly adjacent to the southwest (downgradient) of the Type I Landfill, and because of the hydrogeologic conditions of the site, IKEC installed a multiunit groundwater monitoring system to monitor groundwater quality directly downgradient of the Type I Landfill & LRCP. Based on a successful ASD, the Type I Landfill returned to Detection Monitoring in January 2019 and the LRCP remained in Assessment Monitoring. In accordance with §257.94 of the CCR Rule, IKEC completed the groundwater monitoring requirements of the Detection Monitoring Program at the Type I Landfill as described below.

The third round of Detection Monitoring groundwater samples was collected from monitoring wells at the Type I Landfill at the Clifty Creek Station between October 1 and 4, 2019 in accordance with §257.94(a) of the CCR Rule (Figure 1). All samples were collected in accordance with the Groundwater Monitoring Program Plan (GMPP) (AGES 2018b) and analyzed for all Appendix III constituents.

Upon receipt, the groundwater monitoring data were statistically evaluated in accordance with §257.93(f) of the CCR Rule and the Statistical Analysis Plan (StAP) (Stantec 2018) for the Clifty Creek Station CCR groundwater monitoring program. The initial statistical evaluation identified a potential SSI for Boron in monitoring well CF-15-08 at the Type I Landfill. The results of the statistical evaluation are summarized in Table 1.

In accordance with the StAP, IKEC resampled the well for Boron on November 25, 2019. Based on the result of the resampling event, the SSI for Boron was confirmed in monitoring well CF-15-08 (Table 1).

1.2 Purpose of This Report

The purpose of this report is to present an ASD and provide sufficient evidence that the SSI identified for Boron in well CF-15-08 resulted from a source other than the Type I Landfill.

The CCR Rule does not contain specific requirements for an ASD beyond what is stated, as follows, in §257.94(e)(2):

"The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report. If a successful demonstration is completed within the

90-day period, the owner or operator of the CCR unit may continue with a detection monitoring program under this section. If a successful demonstration is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under § 257.95. The owner or operator must also include the demonstration in the annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer."

In addition to the above requirements of the CCR Rule, this ASD has been conducted and presented using guidance and documentation recommendations included in the U.S. EPA document Solid Waste Disposal Facility Criteria Technical Manual EPA 530-R-93-017 (U.S. EPA 1993).

A detailed discussion of the confirmed SSIs and a technical justification that the exceedances result from a source other than the Type I Landfill are presented in the following sections of this report.

2.0 DESCRIPTION OF THE TYPE I LANDFILL

2.1 Unit Description

The Type I Landfill and LRCP occupy an approximately 200-acre area situated within an eroded bedrock channel. The Type I Landfill consists of approximately 109 acres that were approved as a Type I residual waste landfill by the Indiana Department of Environmental Management (IDEM) in 2007. The remaining 91 acres consist of the LRCP located at the southwest end of the Type I Landfill (Figures 1 and 2).

Beginning in 1955, ash products were sluiced to disposal ponds located in the bedrock channel at the plant site. To allow for more disposal capacity, an on-site fly ash pond was developed into a Type III residual landfill in 1988. All required permits for the Type III Residual Waste Landfill (Type III Landfill) were obtained from IDEM. The Type III Landfill was permitted to be constructed, and to serve as closure for the historic fly ash ponds. The Type III Landfill is located at the northeast end of the bedrock channel and went operational in 1991.

After IDEM approval, IKEC upgraded the Type III Landfill to a Type I residual waste landfill (Type I Landfill). As a result, the Type III Landfill was closed and the Type I Landfill was designed and constructed to serve as the cap for the closed Type III Landfill. The Type I Landfill, which went operational in 2011, is completely separated from the closed Type III Landfill by a geosynthetic liner and a compacted clay liner.

2.2 Hydrogeology

Based on information in the Hydrogeologic Study Report (AGES 2007), bedrock beneath the Type I Landfill and the closed Type III Landfill consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 to 35 feet of gray clay. The gray clay is directly overlain by fly ash that had been historically hydraulically placed in the area. A generalized cross section showing the proposed final limits of the Type I Landfill & LRCP, the location and limits of the closed Type III Landfill, and the extent of the historic hydraulically place fly ash is presented in Figure 3. A limestone ridge known as the Devil's Backbone runs northeast to southwest along the length of the Type I Landfill & LRCP and the closed Type III Landfill. The Devil's Backbone acts as an impermeable barrier that forces groundwater passing beneath both of the landfills to flow either toward the northeast or toward the southwest. A detailed hydrogeologic study determined that a groundwater flow divide is present near the northeast end of the bedrock channel and that all groundwater beneath the active Type I Landfill flows toward the southwest (AGES 2007) (Figure 4). As detailed in the Monitoring Well Installation Report (AGES 2018a), an aquifer does not exist beneath either of the landfills. Therefore, alluvial deposits located southwest of the LRCP are designated as the uppermost aquifer for the Type I Landfill & LRCP.

The Type I Landfill was constructed using a geosynthetic liner and a compacted clay liner to prevent water from the Type I Landfill from entering the underlying layers. Water in the Type I Landfill is collected by an underground leachate system and is currently discharged into the WBSP where it mixes with surface water runoff from the surrounding 510-acre drainage area.

In November and December 2015, six (6) monitoring wells were installed at the Type I Landfill & LRCP (Figure 1). Three (3) monitoring wells (CF-15-07, CF-15-08 and CF-15-09) were installed in the alluvial deposits (uppermost aquifer) located southwest of the LRCP (Figure 1). Based on exploratory soil borings and historical data, there were no suitable upgradient locations for the Type I Landfill. CF-15-04 was installed northeast of and outside the hydrologic influence of the Type I Landfill and the closed Type III Landfill to serve as the required background monitoring well. CF-15-06 was installed to serve as a second background monitoring well and CF-15-05 was installed as a background/intermediate monitoring well to ensure groundwater from the WBSP is not impacting groundwater at well CF-15-06. Wells WBSP-15-01 and WBSP-15-02 are located southeast of the impermeable devil's Backbone and are hydraulically separated from groundwater flowing beneath the Type I Landfill & LRCP. Because these wells are outside the hydraulic influence of the Type I Landfill & LRCP, these wells were designated as background wells. Table 2 presents construction details for the monitoring wells in the groundwater monitoring network for the Type I Landfill & LRCP.

Based on groundwater levels measured from each well in October 2019, groundwater beneath the Type I Landfill & LRCP flows to the southwest toward the Ohio River. Appendix A presents a groundwater contour map for October 2019.

3.0 ALTERNATE SOURCE DEMONSTRATION

As noted above, Boron was identified as a confirmed SSI in well CF-15-08 downgradient of the Type I Landfill & LRCP. Based on a review of the current and historic data, AGES/IKEC have determined that the active Type I Landfill is not the source of the Boron SSIs reported in the CCR monitoring wells and that historic fly ash that had been sluiced into the valley beginning in 1955 is the alternate source for the Boron SSIs. As discussed in detail below, this conclusion is based on the following lines of evidence:

- Ash that was historically sluiced into the bedrock valley in the 1950s is a known source of Boron and is hydraulically connected to groundwater downgradient of the Type I Landfill & LRCP;

- Boron has been detected in groundwater downgradient from the hydraulically-placed ash (and the Type I Landfill & LRCP) in IDEM program wells CF-9405, CF-9406 and CF-9407 (located near wells CF-15-08 and CF-15-09) since 1994, which is 17 years prior to operation of the Type I Landfill; and

- Given the extremely low groundwater flow velocity at the landfill, the travel time for a release of Boron from the Type I Landfill to reach well CF-15-08 is estimated at 120 years. As the Type I Landfill has only been in operation for seven (7) years, the landfill cannot be the source of the Boron.

Details to support these conclusions are presented below.

3.1 Alternate Source Demonstration Method

The evaluation of the alternate source for Boron in well CF-15-08 was assessed in general accordance with guidelines presented in the Solid Waste Disposal Facility Criteria Technical Manual (U.S. EPA 1993) using the following methods:

- Identify a potential alternate source;
- Establish that a hydraulic connection exists between the alternate source and the wells with the confirmed SSIs;
- Establish that constituents of concern are present at the alternate source; and
- Establish that the concentrations observed in the compliance wells could not have resulted from the CCR unit given the hydrogeologic conditions at the site.

3.2 Alternate Source Identification

The initial groundwater investigation conducted for the former Type III Landfill (beginning in 1994) focused on the fly ash that had been hydraulically placed in the bedrock channel beginning in 1955. The Type III Landfill was permitted to serve as the closure for the hydraulically placed fly ash.

After IDEM approval, IKEC upgraded the Type III Landfill to a Type I Landfill and the Type I Landfill was permitted as the closure for the Type III Landfill. The active Type I Landfill was constructed with a geosynthetic liner, and an engineered clay liner on top of the Type III Landfill to serve as a cap. The two (2) liners prevent migration of groundwater from the active Type I Landfill to the closed Type III Landfill. The closed Type III Landfill is not a CCR unit and is not subject to regulation under the CCR Rule.

Both landfills were constructed on top of the historic hydraulically placed fly ash, which extends the length of the bedrock channel (Figure 3) beneath the LRCP to the embankment at the southwestern end of the LRCP (Figure 5). Although the base of the LRCP contains historic hydraulically placed fly ash, the LRCP does not receive CCR and the existing historic CCR is not actively managed. Therefore, the LRCP is considered an inactive CCR unit.

Due to the age and extent of the historic, hydraulically placed ash, this material was identified as the alternate source for the Boron detected in well CF-15-08.

3.3 Establish a Hydraulic Connection

A review of the permit drawings, construction drawings, and a figure from the Initial Structural Stability Assessment, Landfill Runoff Collection Pond Report (Stantec 2016) (Appendix C), indicated that material from the closed Type III Landfill and the historic hydraulically placed fly ash are located entirely beneath the active Type I Landfill & LRCP (Figure 3). The base of the layer of "hydraulically placed fly ash" is located between elevations 445 ft mean sea level (msl) and 500 ft msl.

When the fly ash was originally emplaced in the bedrock channel, there were no impermeable liners constructed to separate the fly ash from the underlying "foundation soils." The CCR and IDEM groundwater monitoring wells are screened in these "foundation soils," which consist of alluvial deposits of silt, sand and gravel. These alluvial deposits extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River and provide a direct hydraulic connection between the historic hydraulically placed fly ash and the groundwater monitoring wells (Figure 5).

3.4 Constituents Are Present at the Alternate Source

Both the closed Type III Landfill and the Type I Landfill are currently being monitored under an IDEM groundwater monitoring program. In 1994, three (3) monitoring wells (CF-9405, CF-9406 and CF-9407) were installed south of the LRCP as a condition of a pH Variance for the former Type III Landfill granted by IDEM. Since 1994, routine semi-annual and quarterly monitoring of these wells has been conducted. In 2009, three (3) additional wells (CF-07-06D, CF-07-08 and CF-07-09) were installed per IDEM to monitor groundwater quality during the year prior to the start of operations of the Type I Landfill in 2011. Wells in the IDEM groundwater monitoring network are located south of the LRCP and screened in the same "foundation soils" as the wells in the CCR monitoring network (Figure 6).

As shown on Table 3 and Figure 7, Boron was detected in wells CF-9406 (9.0 milligrams per liter [mg/L] to 17.1 mg/L) and CF-9407 (1.19 mg/L to 7.7 mg/L) from 1995 through 2011 (Table 3 and Figure 7). This demonstrates that Boron was present in groundwater downgradient of the eventual location of the Type I Landfill 17 years prior to its operation. Boron concentrations in downgradient CCR wells have ranged from 7.62 mg/L to 11.9 mg/L in well CF-15-08, and from 5.78 mg/L to 7.59 mg/L in CF-15-09 (Table 3 and Figure 7). These concentrations are similar to historic Boron concentrations observed in wells CF-9506 and CF-9407 from 1994 through 2011.

Because Boron concentrations similar to those observed in CCR well CF-15-08 were detected in IDEM wells CF-9406 and CF-9407 prior to construction of the Type I Landfill, the historic hydraulically placed ash is the source of the detected Boron.

3.5 Hydrogeologic Conditions and Groundwater Flow Velocity

As presented in the Evaluation of Potential Risk to Supply Well Fields Report (AGES 2006), a groundwater flow velocity of 45 feet per year (ft/yr) was calculated for alluvial deposits, which are designated as the uppermost aquifer for these CCR units. Based on the most recent topographical survey conducted of the Type I Landfill (Appendix B), the current limit of waste for the active Type I Landfill is located approximately 5,400 feet (more than one (1) mile) northeast of the three (3) CCR groundwater monitoring wells (CF-15-07, CF-15-08 and CF-15-09) (Figure 8). Based on this data, it was calculated that it will take 120 years for groundwater to flow from the current limit of waste in the Type I Landfill to the CCR monitoring wells. Waste placement in the Type I Landfill began in early 2011. Given the two (2) constructed liners, the distance and the flow rate, water from the Type I Landfill is not able to enter the groundwater, and groundwater has not had enough time to reach the CCR monitoring wells.

Based on the calculations presented above, the active Type I Landfill cannot be the source of Boron detected in the CCR monitoring wells.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The ASD has been completed in general accordance with guidelines presented in the Solid Waste Disposal Facility Criteria Technical Manual (U.S. EPA 1993).

Based on a review of the current and historic data, AGES/IKEC have determined that the Type I Landfill is not the source of Boron detected in the CCR monitoring wells. This conclusion is supported by the following evidence:

- “Foundation soils” that extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River provide a direct hydraulic connection between the historic hydraulically placed fly ash and the CCR groundwater monitoring well CF-15-08.

- Historic data from the IDEM groundwater monitoring program indicate that Boron concentrations similar to those observed in CCR well CF-15-08 were detected in IDEM wells CF-9406 and CF-9407 for 17 years prior to operation of the Type I Landfill, indicating that the Boron is associated with the historic hydraulically placed fly ash.

- Using the previously calculated groundwater flow velocity of 45 ft/yr, it is estimated that it would take 120 years for groundwater flowing beneath the Type I Landfill to reach the CCR monitoring wells.

Based on the demonstration presented above, the Type I Landfill is not the source of the Boron detected in CCR monitoring wells. Therefore, it is recommended that the Type I Landfill remain in Detection Monitoring.

5.0 REFERENCES

Applied Geology and Environmental Science, Inc. (AGES), 2019. Coal Combustion Residuals Regulation Alternate Source Demonstration Report March 2018 Detection Monitoring Event, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. June 2019.

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Stantec Consulting Services, Inc. (Stantec), 2016. Coal Combustion Residuals Regulation Initial Structural Stability Assessment, Landfill Runoff Collection Pond, Indiana-Kentucky Electric Corporation, Clifty Creek Station, Madison, Jefferson County, Indiana. October 2016.

United States Environmental Protection Agency (U.S. EPA) 1993. Solid Waste Disposal Criteria Technical Manual, EPA 530-R-93-017. November 1993.

TABLES

TABLE 1
SUMMARY OF POTENTIAL AND CONFIRMED SSIs
TYPE I RESIDUAL WASTE LANDFILL
CCR GROUNDWATER MONITORING PROGRAM
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Potential SSI Parameter (Units)	3rd Detection Monitoring Sampling Event October 2019		3rd Detection Monitoring Resampling Event November 2019	
		Potential SSI Result	UPL	Potential SSI Result	Confirmed SSI (Yes/No)
CF-15-08	Boron (mg/L)	11	5.566	9	**Yes**

Notes:

1. SSI = Statistically Significant Increase.
2. UPL = Upper Prediction Limit (Maximum Interwell UPL).
3. mg/L = Milligrams per liter.

TABLE 2
GROUNDWATER MONITORING NETWORK
TYPE I RESIDUAL WASTE 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

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.

TABLE 3
HISTORIC BORON CONCENTRATIONS IDEM WELLS CF-9406 & CF-9407 AND CCR WELLS CF-15-08 & CF-15-09
CLIFTY CREEK STATION
MADISON, INDIANA

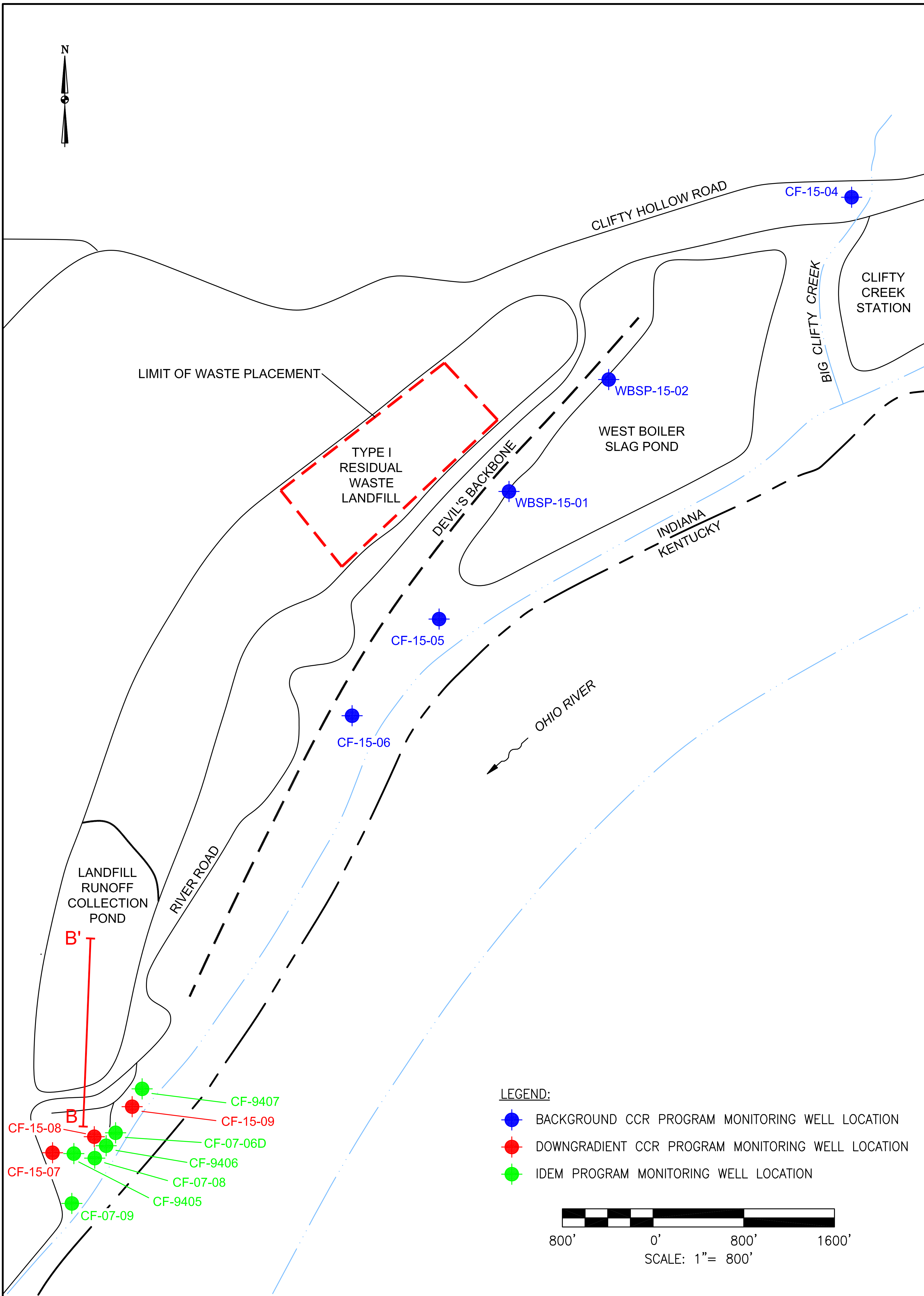
Boron Concentrations in IDEM Wells (1994 through 2015)						
Date	**CF-9406**	**CF-9407**		**Date**	**CF-9406**	**CF-9407**
6/8/1994	10	2.9		**11/19/2002**	16.2	5.92
6/22/1994	9.8	4.7		**5/14/2003**	13.7	3.83
7/6/1994	11	6.3		**11/12/2003**	14.7	5.4
7/20/1994	12	8.4		**5/11/2004**	14.2	3.86
8/3/1994	10	6.3		**11/9/2004**	**17.1**	5.28
8/17/1994	**9**	6.4		**5/9/2005**	15.2	7.16
8/31/1994	12	**7.7**		**11/8/2005**	14.3	DRY
9/14/1994	9.8	6.9		**5/17/2006**	12.8	7.4
9/28/1994	9.7	5.9		**11/15/2006**	15	5.69
10/12/1994	12	7.3		**5/9/2007**	13.7	4.71
10/26/1994	12	6.8		**11/14/2007**	14.6	DRY
11/9/1994	11	6.7		**5/13/2008**	15	3.21
11/30/1994	11	5		**11/12/2008**	15.6	DRY
12/7/1994	10	3.6		**5/19/2009**	14.7	4.75
12/21/1994	11	2.5		**11/16/2009**	14.7	7.23
1/18/1995	11	3		**12/16/2009**	NM	NM
2/22/1995	13	3.6		**01/14/2010**	NM	NM
6/14/1995	13	4.5		**02/23/2010**	NM	NM
12/21/1995	14	4.7		**03/16/2010**	NM	NM
6/26/1996	14	3.3		**04/15/2010**	NM	NM
12/23/1996	12	5.3		**5/19/2010**	14.1	6.77
4/30/1997	9.9	6.9		**06/23/2010**	NM	NM
6/30/1997	12	5.9		**07/15/2010**	NM	NM
10/7/1997	15	DRY		**08/24/2010**	NM	NM
12/16/1997	14	7.5		**09/14/2010**	NM	NM
4/16/1998	14	6.5		**10/19/2010**	NM	NM
6/24/1998	13	6.5		**11/3/2010**	16.9	DRY
9/23/1998	14	DRY		**Type I Landfill Operational**		
1/21/1999	13	5.1		**5/17/2011**	12.3	4.21
3/31/1999	12	4.3		**11/28/2011**	16.2	**1.19**
6/30/1999	13	7.5		**5/7/2012**	14.5	5.09
10/7/1999	DRY	DRY		**11/13/2012**	15.9	DRY
1/6/2000	15	4.4		**3/30/2013**	15	5.25
6/6/2000	15	7.2		**9/23/2013**	14.2	DRY
1/10/2001	16	7.4		**5/21/2014**	12.63	5.646
5/15/2001	15	6.6		**11/11/2014**	14.58	DRY
11/26/2001	18	7.3		**5/9/2015**	15.47	DRY
5/15/2002	13.5	5.1		**11/3/2015**	13.8	DRY

TABLE 3
HISTORIC BORON CONCENTRATIONS IDEM WELLS CF-9406 & CF-9407 AND CCR WELLS CF-15-08 & CF-15-09
CLIFTY CREEK STATION
MADISON, INDIANA

Boron Concentrations in IDEM and CCR Wells (January 2016 through October 2019)				
Date	**CF-9406**	**CF-9407**	**CF-15-08**	**CF-15-09**
1/11/2016	NM	NM	8.64	6.86
3/7/2016	NM	NM	8.24	**5.78**
5/11/2016	10.6	2.48	NM	NM
5/16/2016	NM	NM	9.34	6.58
7/25/2016	NM	NM	9.65	7.01
8/29/2016	NM	NM	9.63	DR
11/9/2016	15.3	DRY	NM	NM
11/28/2016	NM	NM	10.9	DRY
2/27/2017	NM	NM	9.29	6.78
5/8/2017	7.46	5.4	NM	NM
6/12/2017	NM	NM	**7.62**	6.3
8/28/2017	NM	NM	9.04	6.81
11/14/2017	11.7	7.58	NM	NM
3/1/2018	NM	NM	8.5	5.86
5/7/2018	13.8	7.25	8.6	6.1
9/2018	14.7	3.27	**11.9**	**7.59**
3/2019	13.9	6.56	9.8	6.7
10/2019	17	NM	11.0	DRY

Notes:
1. All concentrations are mg/L.
2. NM =Well was not monitored on this date.
3. DRY = Well was dry and not able to be sampled.
4. Maximum and minimum Boron results for each well are shown in **Bold.**

FIGURES



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CHECKED BY	
JOB NO.	2017114-CLI
DWG FILE	IKEC_Clifty_ASD_MW Locs_b03.dwg
DRAWING SCALE	NOT TO SCALE

AGES
Applied Geology And Environmental Science, Inc.
2402 Hookstown Grade Road, Suite 200
Clinton, PA 15026
412.264.6453

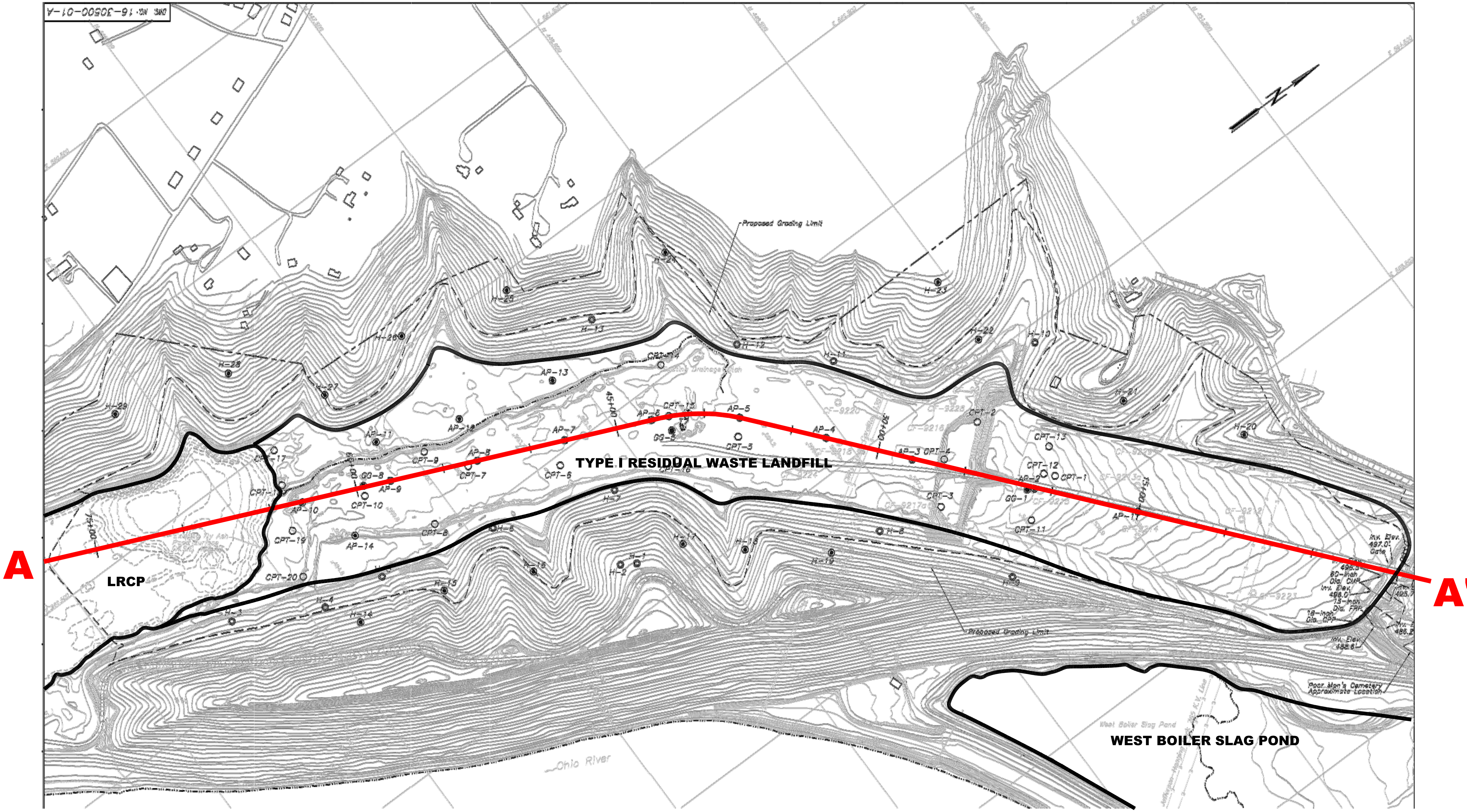
INDIANA–KENTUCKY ELECTRIC CORPORATION

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

DRAWING NAME: FIGURE 1

REV. 0

Plot: 01/10/2019 13:32 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\ASD GW Sampling\IKEC_Clifty_ASD_MW Locs_b03.dwg\FIG 1



LEGEND:

A-A' CROSS SECTION TRANSECT

SOURCE: CLIFTY CREEK PERMIT DRAWINGS (FMSM, NOVEMBER 2006)

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CHECKED BY	
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DRAWING SCALE	NOT TO SCALE

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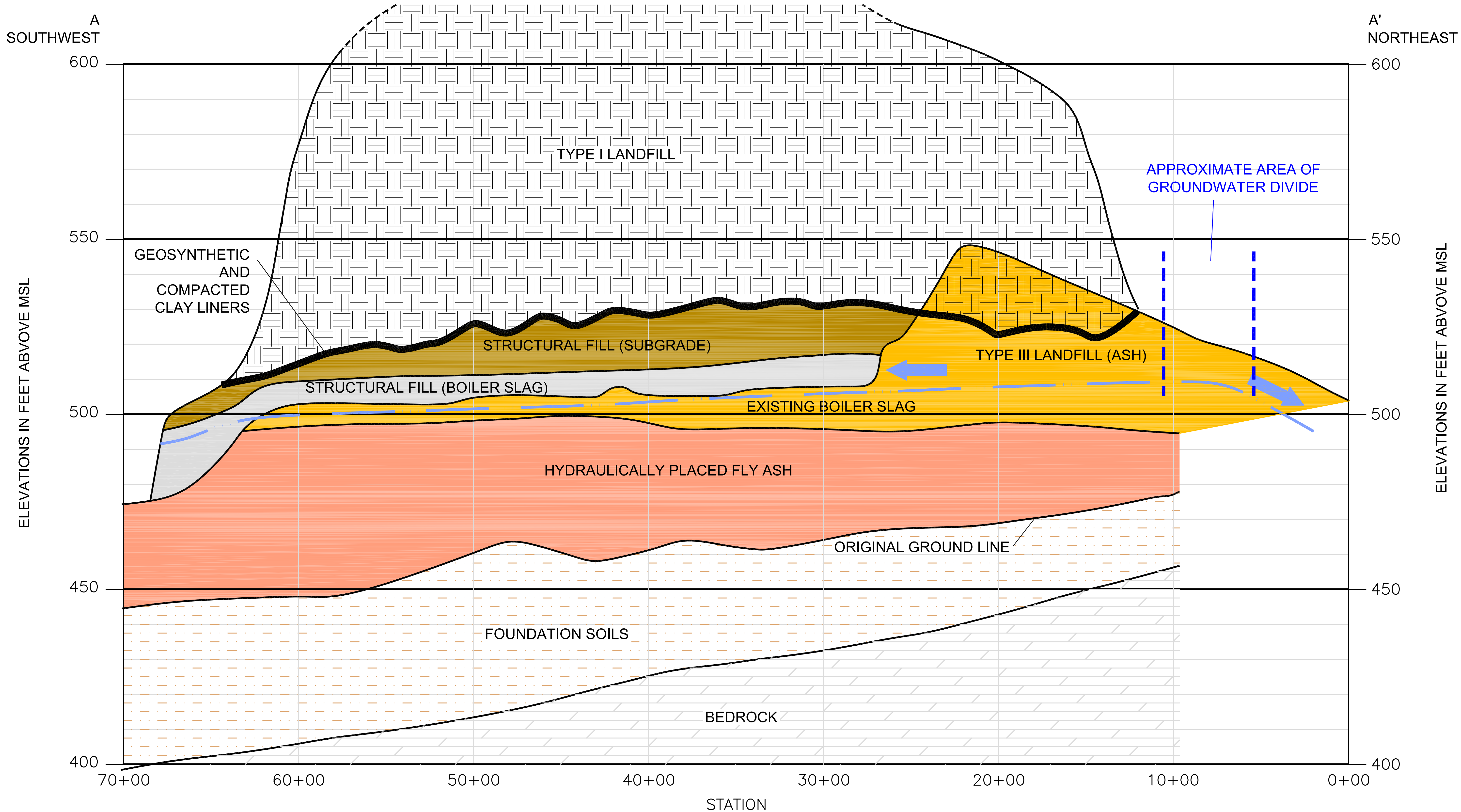
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
OVERVIEW OF TYPE I LANDFILL AND LRCP

DRAWING NAME: FIGURE 2

REV. 0

Plot: 12/12/2018 10:47 _PROGRAM–IKEC\Clifty Creek–CCR Program\CAD\ASD GW Sampling\Clifty_ASD_Boring Plan b04.dwg



APPROXIMATE PHREATIC SURFACE

GROUNDWATER FLOW DIRECTION

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CHECKED BY	
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DRAWING SCALE	NOT TO SCALE

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CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL
GENERALIZED GEOLOGIC CROSS–SECTION
A–A' (SOUTHWEST–NORTHEAST)

DRAWING NAME: FIGURE 3 — REV. 0

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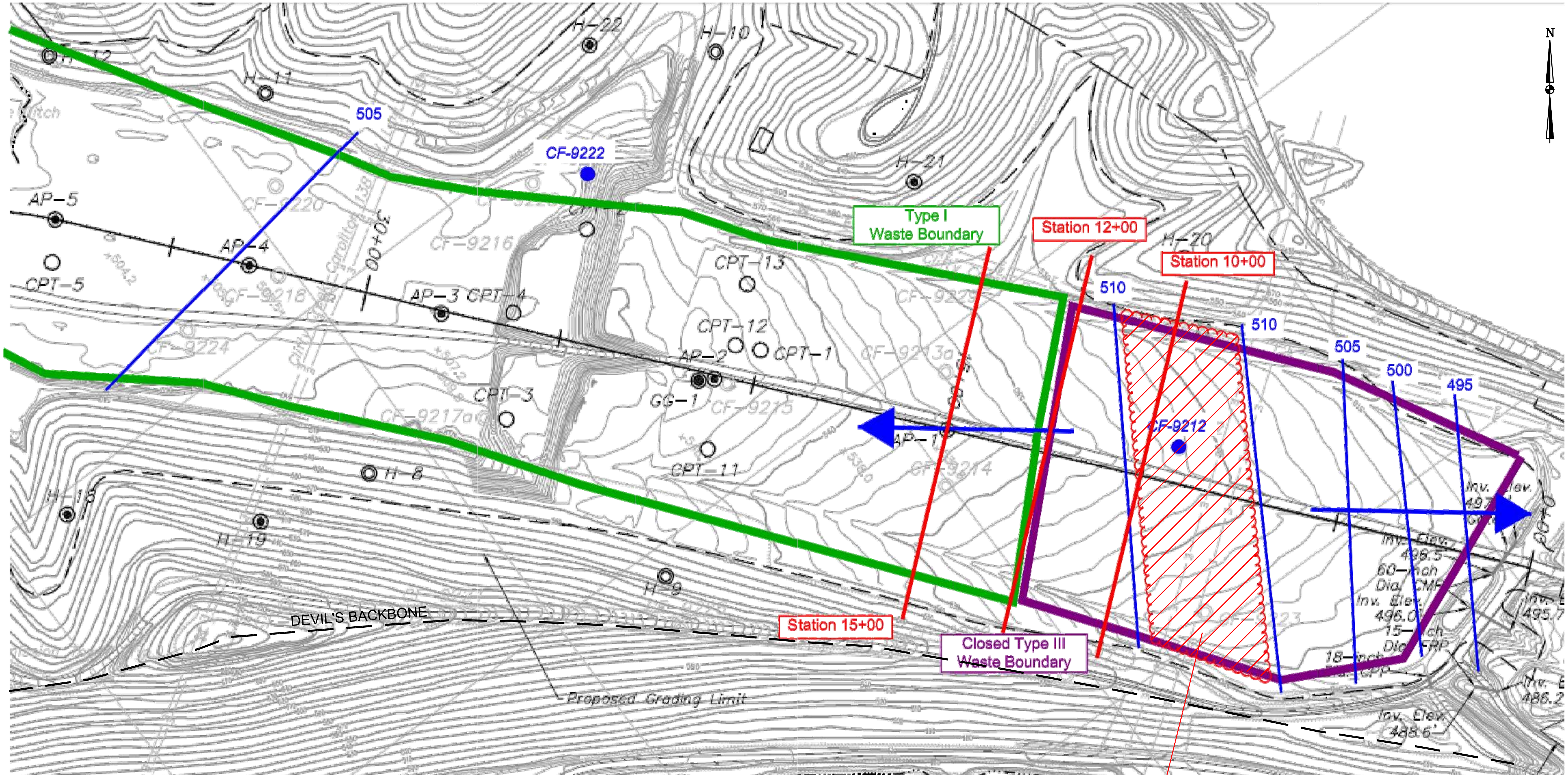

APPROXIMATE LOCATION OF GROUNDWATER DIVIDE.
BETWEEN STATIONS 7+00 AND 10+00.

505 — January 2006 Groundwater Contour

→ Groundwater Flow Direction

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116-CLI
DWG FILE	Clifty_GW Divide b01.dwg
DRAWING SCALE	NOT TO SCALE

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INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
GROUNDWATER FLOW AT
NORTHEAST END OF BEDROCK CHANNEL

DRAWING NAME: FIGURE 4

REV. 0

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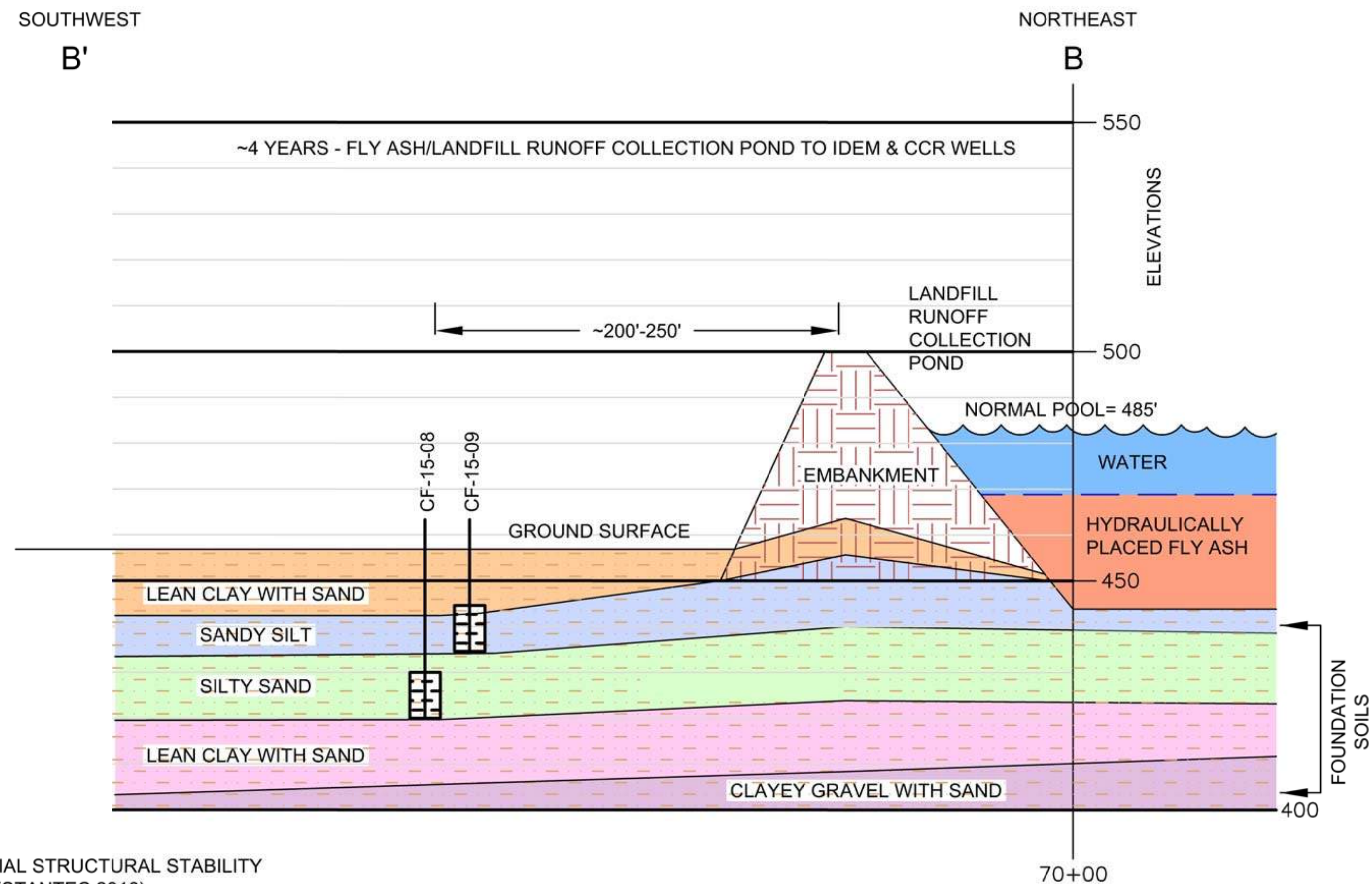

NOTES:
BASED ON INITIAL STRUCTURAL STABILITY ASSESSMENT (STANTEC 2016).

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DATE	
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CLIFTY CREEK STATION
MADISON, INDIANA
GENERALIZED CROSS–SECTION
LANDFILL RUNOFF COLLECTION POND TO
CCR MONITORING WELLS

DRAWING NAME: FIGURE 5
REV. 0

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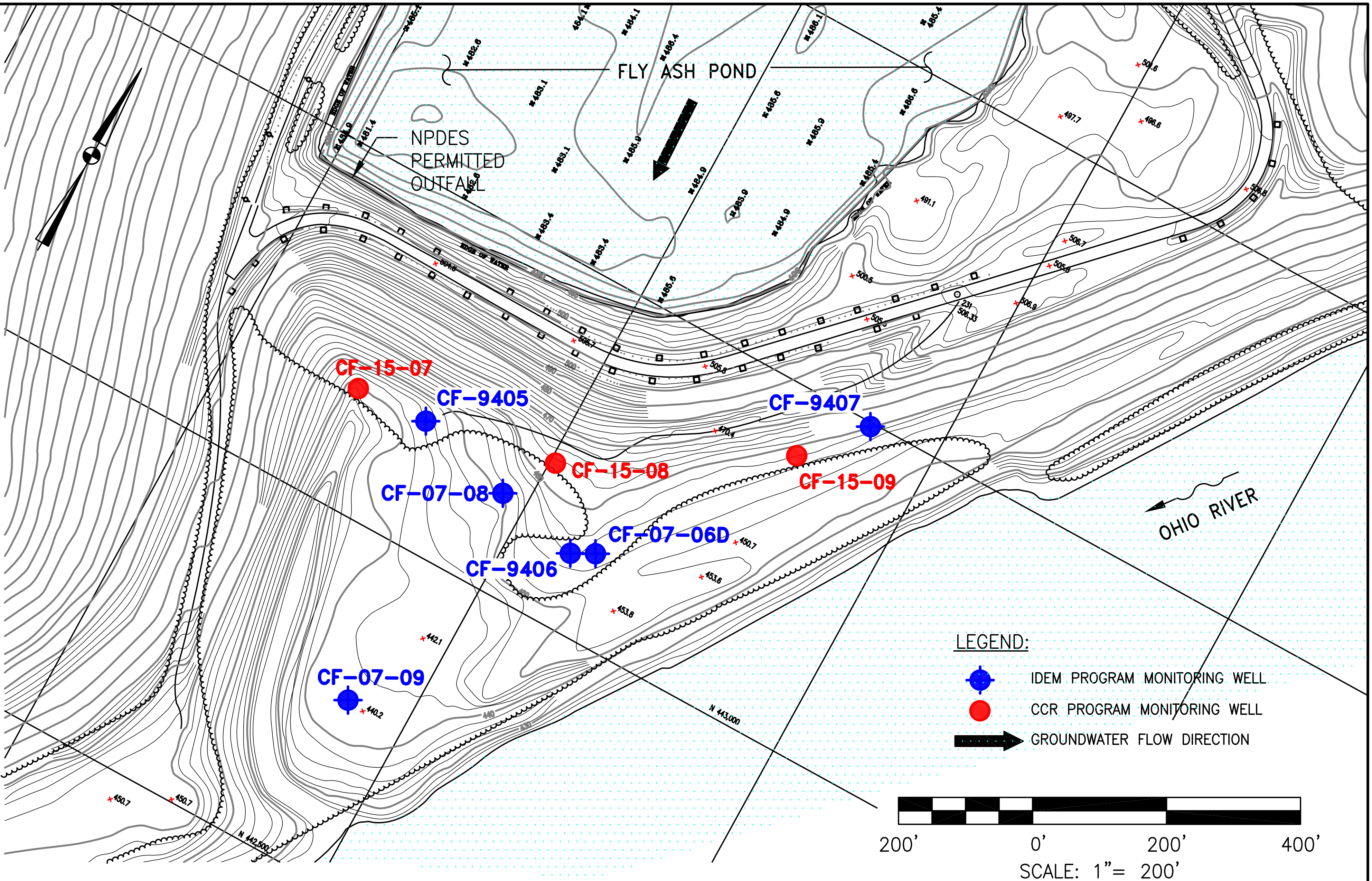

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JOB NO.	2017116-CLI
DWG FILE	CLIFTY Well Locations a03 R2.dwg
DRAWING SCALE	AS SHOWN

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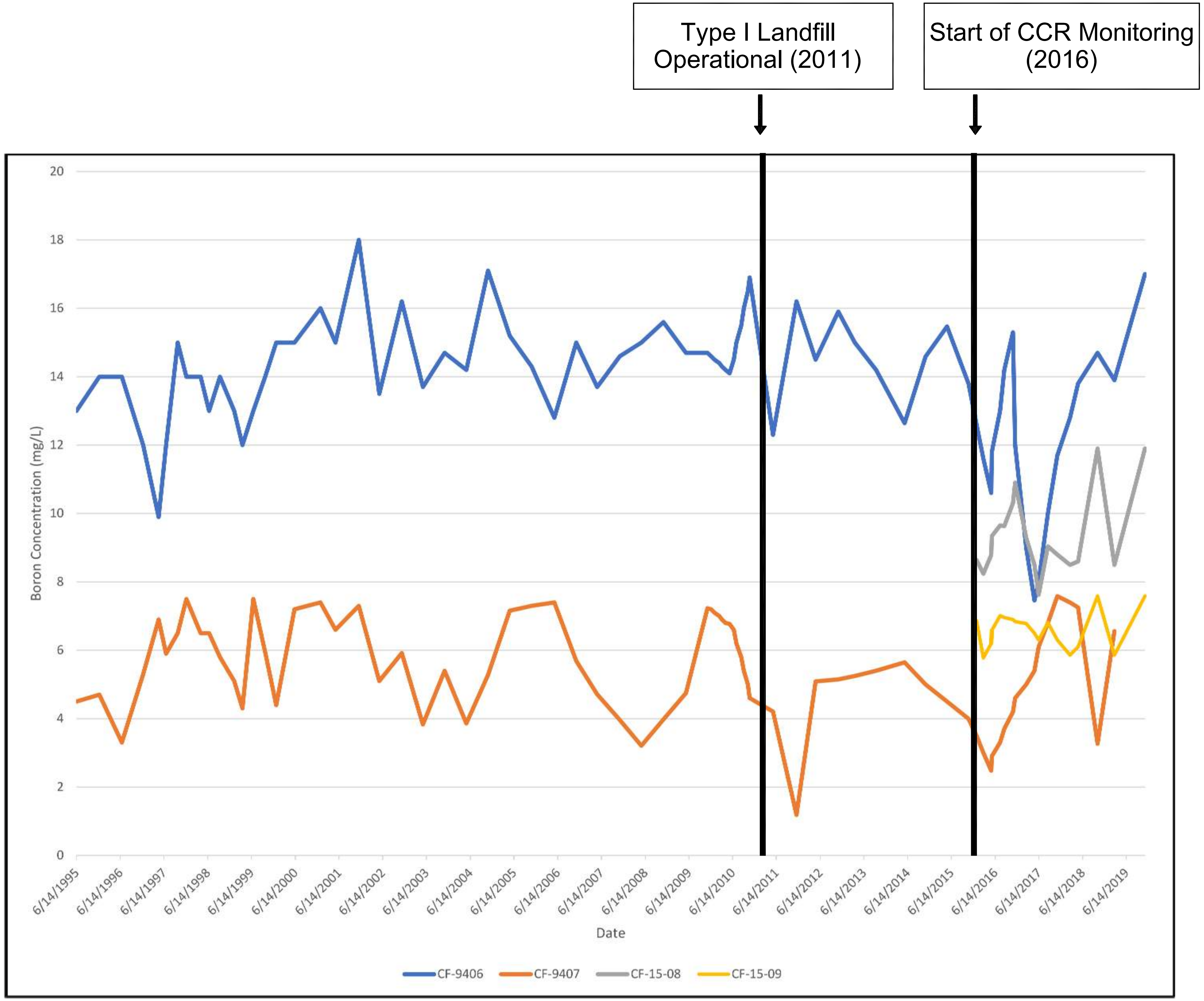
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK PLANT
MADISON, INDIANA
CCR PROGRAM AND IDEM PROGRAM
MONITORING WELL LOCATION MAP

DRAWING NAME: FIGURE 6 | REV. 0

Plot: 12/12/2018 12:18 _PROGRAM-IKEC\Clifty Creek-CCR Program\CAD\ASD GW Sampling\CLIFTY Well Locations a03 R2.dwg



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008–CLIFTY
DWG FILE	Clifty_ASD_Boron–Time Graph_OCT2019.dwg
DRAWING SCALE	NOT TO SCALE

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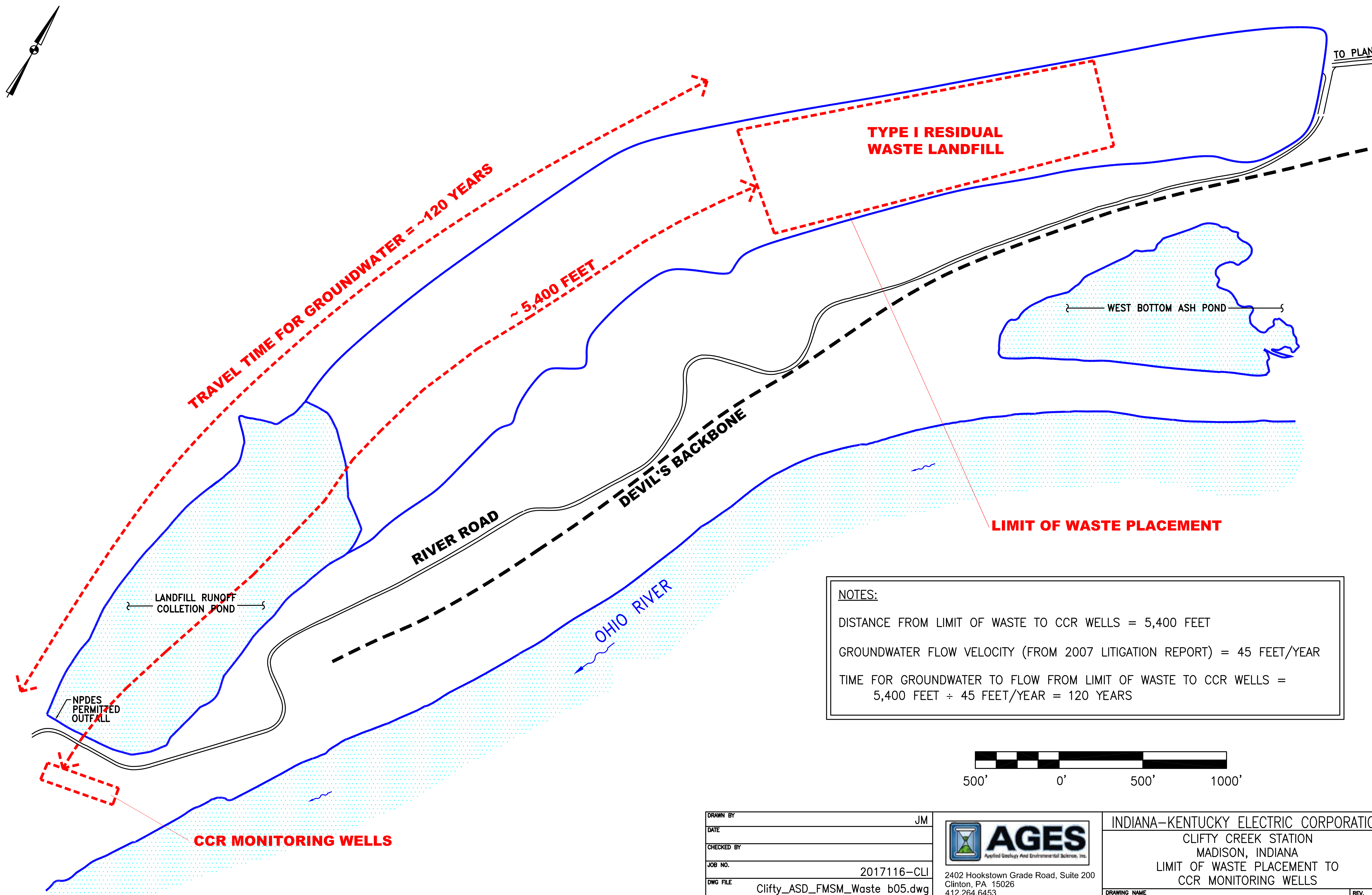
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
TIME SERIES DATA FOR BORON (mg/L)
CF–9406, CF–9407, CF–15–08 AND CF–15–09
OCTOBER 2019

DRAWING NAME: FIGURE 7

REV. 0



NOTES:

DISTANCE FROM LIMIT OF WASTE TO CCR WELLS = 5,400 FEET

GROUNDWATER FLOW VELOCITY (FROM 2007 LITIGATION REPORT) = 45 FEET/YEAR

TIME FOR GROUNDWATER TO FLOW FROM LIMIT OF WASTE TO CCR WELLS =
5,400 FEET ÷ 45 FEET/YEAR = 120 YEARS

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2017116–CLI
DWG FILE	Clifty_ASD_FMSM_Waste b05.dwg
DRAWING SCALE	1" = 555'

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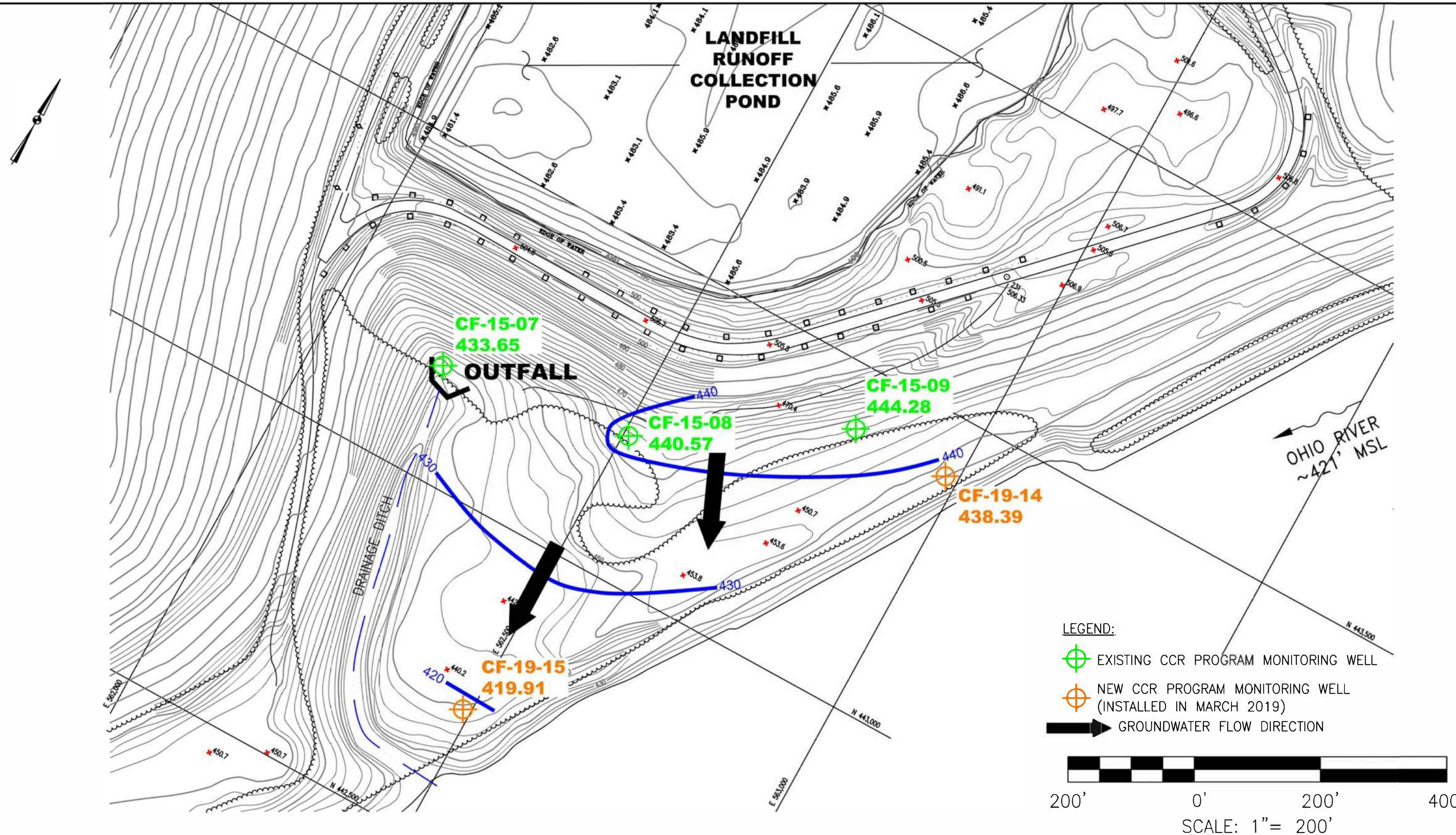
CLIFTY CREEK STATION
MADISON, INDIANA
LIMIT OF WASTE PLACEMENT TO
CCR MONITORING WELLS

DRAWING NAME: FIGURE 8
REV. 0

Plot: 12/12/2018 12:40 _PROGRAM–IKEC\Clifty Creek–CCR Program\CAD\ASD GW Sampling\Clifty_ASD_FMSM_Waste b05.dwg

APPENDIX A

Groundwater Flow Map
October 2019



NOTE:
WELLS CF-19-14 AND CF-19-15 WERE INSTALLED IN MARCH 2019.

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019008-CLIFTY
DWG. FILE	2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_OCT19.dwg
DRAWING SCALE	AS SHOWN

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INDIANA–KENTUCKY ELECTRIC CORPORATION

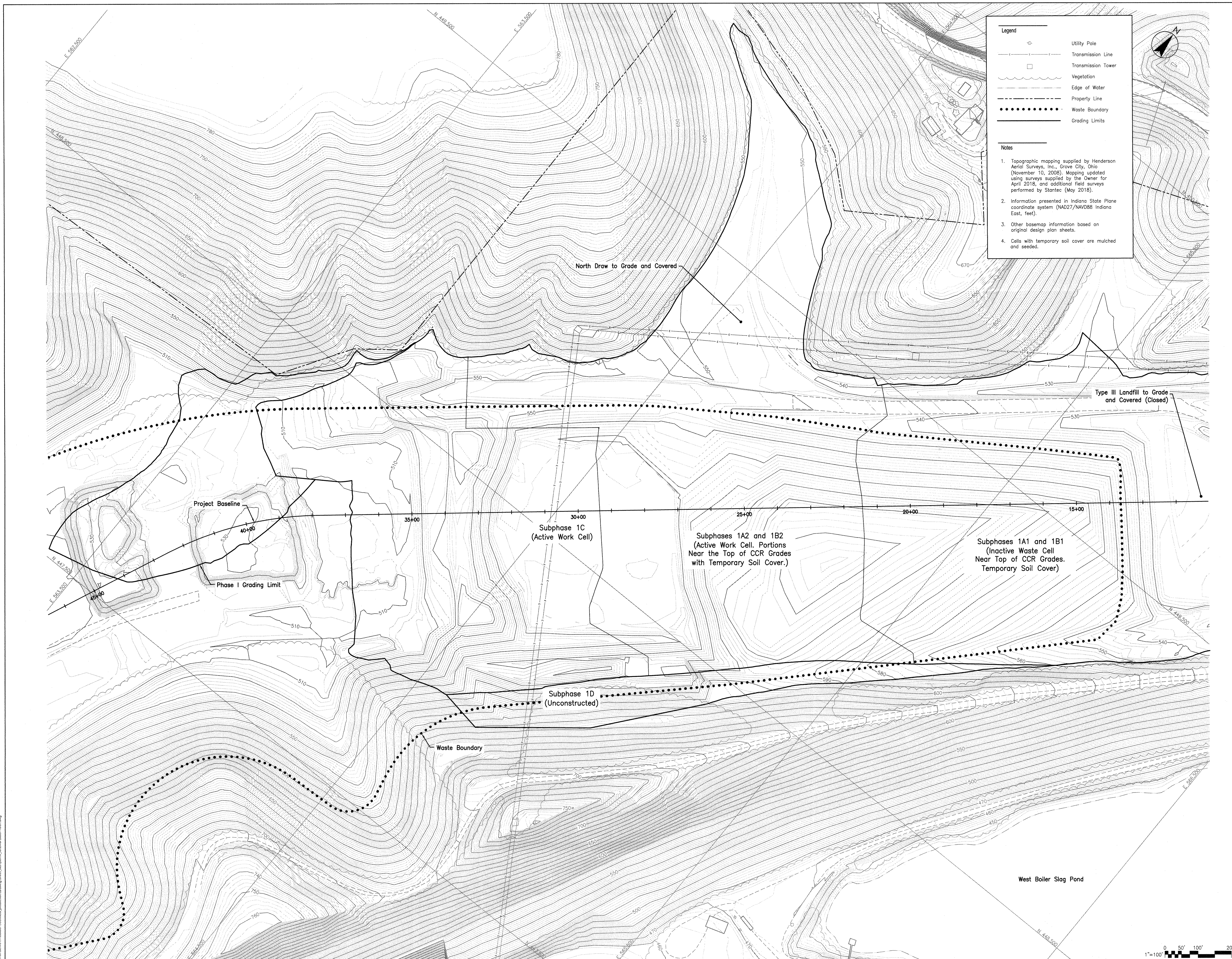
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
GROUNDWATER FLOW – UPPERMOST AQUIFER
OCTOBER 2019

DRAWING NAME	REV.
FIGURE A-1	0

Plot: 01/28/2020 15:41 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 GW Monitoring-Corrective Action Rpt\Appx B\2019_IKEC_Clifty_GW Flow_Appx B_Annual GW Rpt_OCT19.dwg

APPENDIX B

PHASE I EXISTING CONDITIONS TOPOGRAPHIC MAP (Stantec 2018)



Stantec

11687 Lebanon Road
Cincinnati, Ohio 45241-2012
www.stantec.com

Client/Project
INDIANA-KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK COAL ASH LANDFILL MODIFICATION
JEEFERSON COUNTY, MADISON TOWNSHIP, INDIANA

Title
PHASE 1 EXISTING CONDITIONS (JUNE 2018)

Permit-Seal
JACQUELINE S. HARMON REGISTERED No. 10911138 STATE OF INDIANA PROFESSIONAL ENGINEER
7/13/2018

Project Number: 175538039

File Name: 38039-18-01.dwg | MJ Dwn. | JSH Chkd. | JSH Dsgn. | 18.07.16 YY.MM.DD

Drawing No. 1

Revision	Sheet
-	1 of 8

APPENDIX C

FIGURE FROM STABILITY ASSESSMENT REPORT
(Stantec 2016)

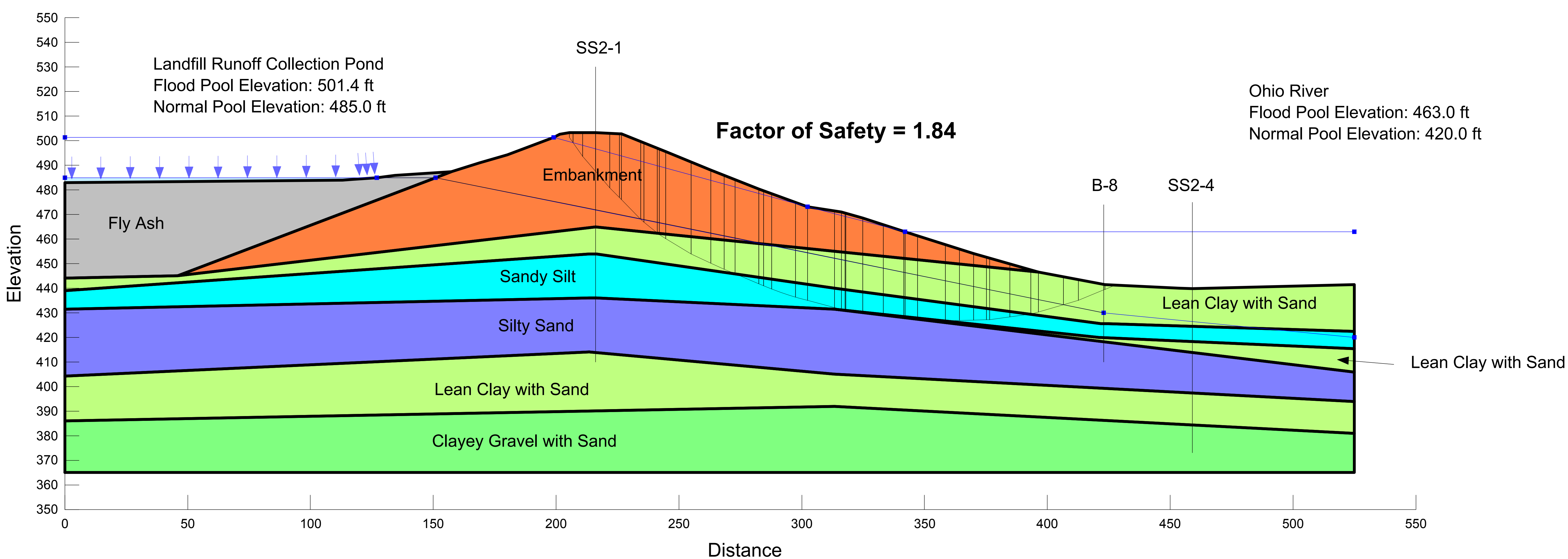
Sudden Drawdown

Indiana-Kentucky Electric Corporation
Clifty Creek Station
Landfill Runoff Collection Pond Dam
Madison, Indiana
Section D-D'

Existing Geometry
Sudden Drawdown
Undrained, Sudden Drawdown Strengths

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Material Type	Unit Weight	Effective - c'	Effective - phi	Total - c	Total - phi
Embankment (SDD)	129 pcf	198 psf	27.5 °	1400 psf	21 °
Lean Clay with Sand (SDD)	127 pcf	206 psf	28 °	1200 psf	17 °
Sandy Silt (SDD)	125 pcf	0 psf	30 °	0 psf	30 °
Silty Sand (SDD)	94 pcf	0 psf	30 °	0 psf	30 °
Clayey Gravel with Sand (SDD)	130 pcf	0 psf	35 °	0 psf	35 °
Fly Ash (SDD)	115 pcf	0 psf	25 °	0 psf	25 °



APPENDIX G

ASSESSMENT OF CORRECTIVE MEASURES SEPTEMBER 2019

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2402 Hookstown Grade Road, Suite 200
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COAL COMBUSTION RESIDUALS REGULATION ASSESSMENT OF CORRECTIVE MEASURES REPORT

LANDFILL RUNOFF COLLECTION POND (LRCP)
INDIANA-KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA

SEPTEMBER 2019

Prepared for:

INDIANA-KENTUCKY ELECTRIC CORPORATION (IKEC)

By:

APPLIED GEOLOGY AND ENVIRONMENTAL SCIENCE, INC.

COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
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CLIFTY CREEK STATION
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SEPTEMBER 2019

Prepared for:

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COAL COMBUSTION RESIDUALS REGULATION
ASSESSMENT OF CORRECTIVE MEASURES REPORT
LANDFILL RUNOFF COLLECTION POND (LRCP)
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LIST OF ACRONYMS

°C	Degrees Celsius
ACM	Assessment of Corrective Measures
AGES	Applied Geology and Environmental Science, Inc.
ASD	Alternate Source Demonstration
ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
CCR	Coal Combustion Residuals
ft/day	Feet per Day
ft/sec	Feet per Second
ft/yr	Feet per Year
GMPP	Groundwater Monitoring Program Plan
gpm	Gallons per minute
GWPS	Groundwater Protection Standard
IDEM	Indiana Department of Environmental Management
IKEC	Indiana-Kentucky Electric Corporation
K	Hydraulic Conductivity
LRCP	Landfill Runoff Collection Pond
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
mm	Millimeter
MNA	Monitored Natural Attenuation
MW	Megawatt
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit
O&M	Operations and Maintenance
ORP	Oxidation Reduction Potential
OVEC	Ohio Valley Electric Corporation
PRB	Permeable Reactive Barrier
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
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
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MADISON, INDIANA

1.0 INTRODUCTION

On December 19, 2014, the United States Environmental Protection Agency (U.S. EPA) issued their final Coal Combustion Residuals (CCR) regulation which regulates CCR as a non-hazardous waste under Subtitle D of 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 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 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. The CCR Rule allows up to an additional 60 days to complete the ACM if a demonstration shows that more time is needed because of site-specific conditions or circumstances. A certification from a qualified professional engineer attesting that the demonstration is accurate is required. As required by 40 CFR § 257.90(e), the demonstration showing that more time was needed will be included in the 2019 Groundwater Monitoring and Corrective Action Report.

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 plant operated by the Indiana-Kentucky Electric Corporation (IKEC), a subsidiary of the Ohio Valley Electric Corporation (OVEC). The Clifty Creek Station has six (6) 217.26-MW generating units and has been in operation since 1955. Beginning in 1955, ash products were sluiced to disposal ponds located in the plant site. During the course of plant operations, CCRs have been managed and disposed of in various units at the station.

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 system at each unit in accordance with the requirements of the CCR Rule; the Type I Landfill and LRCP are included in a 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. Based on groundwater monitoring conducted to date, no Statistically Significant Increases (SSIs) have been identified for Appendix III constituents at the WBSP. Therefore, this unit has remained in Detection Monitoring under the CCR program.

During the March 2018 Detection Monitoring event, SSIs were identified for the Type I Landfill and LRCP and both entered into Assessment Monitoring in September 2018. Further action was therefore required for both units under the CCR program. Details regarding these efforts are presented in the following sections of this report.

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 and LRCP consists of impermeable limestone and shale of the Ordovician Dillsboro formation, which is overlain by approximately 20 feet of clayey gravel with sand (Applied Geology and Environmental Science, Inc. [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 LRCP.

4.0 SUMMARY OF GROUNDWATER MONITORING PROGRAM: TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND

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 in 2017 (AGES 2018a) and 2018 (AGES 2019a). The reports documented the status of the groundwater monitoring and corrective action program for each CCR unit, summarized the key actions completed during 2017 and 2018, described any problems encountered, discussed actions to resolve the problems, and projected key activities for the upcoming year. Applicable details of the reports are presented below in Sections 4.1, 4.2, and 4.3.

4.1 Groundwater Monitoring Network

As detailed in the Monitoring Well Installation Report (AGES 2018b), the CCR groundwater monitoring network for the Type I Landfill and LRCP consists of the following eight (8) monitoring 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 all the wells in the groundwater monitoring network are shown on Figure 4-1. As listed above and shown on Table 4-1, the CCR groundwater monitoring network includes five (5) background and three (3) downgradient monitoring wells, which satisfies the requirements of the CCR Rule. Generalized groundwater flow maps (including the Ohio River) for March and October 2018 are included in Appendix A.

4.2 Groundwater Sampling

In accordance with 40 CFR § 257.94 of the CCR Rule, the first round of Detection Monitoring was conducted in March 2018. Based on the results of the statistical evaluation of the Detection Monitoring data, the Type I Landfill and LRCP entered into Assessment Monitoring in September 2018 and the first round of Assessment Monitoring samples was collected in October 2018.

All groundwater samples were collected in accordance with the Groundwater Monitoring Program Plan (GMPP) (AGES 2018c). The Detection Monitoring samples were analyzed for all Appendix III constituents, and the Assessment Monitoring samples were analyzed for all Appendix III and Appendix IV constituents. All samples were shipped to an analytical laboratory to be analyzed for all of the parameters listed in Appendix III and/or Appendix IV of the CCR Rule.

4.3 Analytical Results

The analytical results for groundwater samples collected in 2018 are summarized in Appendix B. Upon receipt, the March 2018 Detection Monitoring data were statistically evaluated in accordance with 40 CFR § 257.93(f) of the CCR Rule and the Statistical Analysis Plan (StAP) (Stantec Consulting Services, Inc. [Stantec] 2018) for the CCR program. This initial statistical evaluation of the Detection Monitoring data identified potential SSIs for pH and Boron (Appendix III constituents) in three (3) wells (CF-15-07, CF-15-08 and CF-15-09). As discussed in the 2018 Groundwater Monitoring and Corrective Action Report, a faulty pH meter was suspected of causing the SSIs for pH. In accordance with the StAP, the wells were re-sampled for pH and Boron in May 2018. Based on the results of the re-sampling, the SSIs were only confirmed for Boron in wells CF-15-08 and CF-15-09 (Table 4-2).

Upon receipt, the October 2018 Assessment Monitoring results were statistically evaluated in accordance with 40 CFR § 257.93(f) of the CCR Rule and the StAP (Stantec 2018). The initial statistical evaluation identified potential SSIs for Boron (Appendix III constituent) in wells CF-15-08 and CF-15-09. In accordance with the StAP, the wells were re-sampled for those constituents in December 2018. Based on the results of the re-sampling, the SSIs for Boron

(Appendix III) were confirmed at CF-15-08 and CF-15-09 (Table 4-2). As Appendix IV constituents were also detected in all three (3) downgradient wells, IKEC began the process of establishing a GWPS for any detected Appendix IV constituent.

4.4 Alternate Source Demonstration for Type I Landfill

Based on a review of current and historic data, the Type I Landfill was not believed to be the source of Boron in groundwater in the area. An ASD was therefore completed in general accordance with guidelines presented in the *Solid Waste Disposal Facility Criteria Technical Manual* (U.S. EPA 1993). Based on the ASD, it was concluded that the Type I Landfill was not the source of Boron detected in the area. This conclusion was supported by the following evidence:

- "Foundation soils" that extend from beneath the LRCP and the hydraulically placed fly ash southwest to the Ohio River provide a direct hydraulic connection between the historic hydraulically placed fly ash and the CCR groundwater monitoring wells CF-15-08 and CF-15-09.

- Historic data from the Indiana Department of Environmental Management (IDEM) groundwater monitoring program indicate that Boron concentrations similar to those observed in CCR wells CF-15-08 and CF-15-09 were detected in IDEM wells CF-9406 and CF-9407 for 17 years prior to operation of the Type I Landfill, indicating that the Boron is associated with the historic hydraulically placed fly ash.

- Using the previously calculated groundwater flow velocity of 45 feet per year (ft/yr), it is estimated that it would take 120 years for groundwater flowing beneath the Type I Landfill to reach the CCR monitoring wells.

The ASD Report for the March 2018 Detection Monitoring Event (AGES 2019b) was completed in June 2019 and was certified on July 3, 2019. Based on the successful ASD, an ACM was not required at the Type I Landfill. By definition of the CCR Rule, the LRCP is unlined and the historic hydraulically placed fly ash extends beneath the LCRP to the embankment; therefore, an ACM was conducted at the LRCP.

4.5 Groundwater Protection Standards-LRCP

In accordance with 40 CFR § 257.95(h)(1) through 40 CFR § 257.95(h)(3), IKEC established a GWPS for each Appendix IV constituent that was detected in groundwater (Table 4-3). Results for all Appendix IV constituents were less than the applicable GWPSs, except for Molybdenum in CF-15-08 in October 2018 (524 micrograms per liter [ug/L]) and December 2018 (429 ug/L) (Appendix B). Both results exceeded the GWPS for Molybdenum of 100 ug/L. Molybdenum in CF-15-09 in October 2018 (85.9 ug/L) and December 2018 (87.1 ug/L) did not exceed the GWPS. Molybdenum in CF-15-07 in October 2018 (12.8 ug/L) also did not exceed the GWPS.

Based on these results, 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 LRCP 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 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.

This section details the work conducted in between February and May 2019 to collect additional data to aid in characterization of the release and assessment of corrective measures. To evaluate the extent of Molybdenum impacts, two (2) additional wells (CF-19-14 and CF-19-15) were installed in the uppermost aquifer at the property boundary downgradient from the LRCP (Figure 5-1). To confirm that Molybdenum had not migrated into the deep aquifer, two (2) other wells (CF-19-08D and CF-18-15D) were also installed in the deep aquifer (clayey gravel with sand) (Figure 5-1). All of these wells were developed, hydraulically tested and sampled for analysis of Appendix III and Appendix IV constituents.

Details regarding this work are presented in the following sections of this report.

5.1 Grain Size Analysis and Monitoring Well Design

The CCR Rule requires that unfiltered groundwater samples be submitted for laboratory analysis of Appendix III and IV constituents. According to the preamble to the CCR Rule, the unfiltered sample requirement assumes that groundwater samples with a turbidity of less than 5 nephelometric turbidity units (NTUs) can be obtained from a properly designed monitoring well. The proper design of the sand pack and well screen in each unconsolidated CCR well is therefore critical to obtaining representative samples.

The four (4) new monitoring wells were designed and installed using the same methods and materials used during the installation of the other wells in the CCR groundwater monitoring network and in accordance with the GMPP (AGES 2018c). During installation, representative samples of the aquifer material from both the uppermost and deep aquifers were collected from well borings CF-19-08D and CF-19-15D. These soil samples were submitted to a geotechnical laboratory for grain-size analysis per American Society for Testing and Materials (ASTM) Methods D421 and D422. The results of the grain size analyses were used to confirm that the design of the well screens and filter packs was appropriate for the CCR monitoring program. In accordance with U.S. EPA monitoring well design guidelines (U.S. EPA 1991), the grain size of the filter pack was chosen by multiplying the 70% retention (or 30% passing) size of the formation, as determined by the grain size analysis, by a factor of 3 (for fine uniform formations) to 6 (for coarse, non-uniform formations). Table 5-1 summarizes the results of the grain-size analysis and the 70% retention size for each of the samples collected from each boring. The laboratory reports are included in Appendix C.

Two (2)-inch diameter 0.01" slotted Schedule 40 polyvinyl chloride (PVC) pre-packed screens designed specifically for sampling metals in groundwater were selected for use in the wells at the LRCP to reduce turbidity. The pre-packed well screens were constructed using an inner filter pack consisting of 0.40 millimeter (mm) clean quartz filter sand between two layers of food-grade plastic mesh to reduce sample turbidity by filtering out smaller particles than is possible with standard filter packed wells and prepack screens. No metal components were used in the construction of the pre-packed well screens, thus eliminating potential interference with metals analysis.

5.2 Monitoring Well Installation, Development, Sampling, and Testing

5.2.1 Monitoring Well Installation

From March 4 through 21, 2019, a total of four (4) additional monitoring wells were installed at the LRCP using hollow stem auger drilling methods. During drilling, the drill bit was simultaneously pushed down and rotated. Continuous split-spoon samples were logged by the AGES geologist. The augers were used to advance each boring to the desired depth and were kept in place to keep the borehole open during well installation. The augers were then removed as the well installation progressed.

Once each borehole was advanced to the desired depth, a 5-foot or 10-foot pre-packed well screen was set into the borehole. An outer filter pack consisting of 0.40 mm clean quartz sand was installed directly around the pre-packed well screen. The sand was placed as the augers were pulled back in one (1)- to two (2)- foot increments to reduce caving effects and ensure proper placement of the filter pack. The filter pack extended one (1)-foot above the top of the screen.

A two (2)-foot thick annular bentonite seal was installed above the filter pack in each well. Once in place, the bentonite seal was allowed to hydrate before the remainder of the annular space around each monitoring well was backfilled using a grout consisting of Portland cement and bentonite. Each monitoring well was completed with an above-ground protective steel casing and a locking well cap. Following installation, each monitoring well was surveyed for elevation and location by IKEC personnel.

Well construction details for the four (4) new wells installed at the LRCP are presented in Table 5-2. All well boring and construction logs are included in Appendix D.

5.2.2 Monitoring Well Development

Well development was initiated at least 48 hours after installation of each of the monitoring wells. Development consisted of alternating surging and pumping with a submersible pump. During development of the monitoring wells, field parameters including temperature, specific conductance, pH, and turbidity were recorded at regular intervals. Development continued until each parameter stabilized and turbidity was less than 5 NTUs. Well development data for each well is summarized on Table 5-3.

5.2.3 Groundwater Sampling

On March 26 and March 28, 2019, the four (4) new monitoring wells were sampled in accordance with the Clifty Creek GMPP (AGES 2018c) for all Appendix III and Appendix IV constituents. 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 in ice in coolers insulated to four degrees centigrade (4°C) and shipped to the TestAmerica analytical laboratory located in Canton, Ohio.

5.2.4 Aquifer Testing

In April 2019, slug tests were conducted on all of the new wells (CF-19-08D, CF-19-14, CF-19-15 and CF-19-15D) to obtain data to calculate the saturated hydraulic conductivity (K) for the shallow and deep aquifers beneath the LRCP. Both rising and falling head slug tests were performed on each well. The falling head tests were performed by lowering a pre-fabricated solid slug with a known volume, into the water column of the well and recording the drop in head over time. The rising head tests were performed by removing the solid slug and recording the rise in head over time. The change of head over time was recorded using a data logger and pressure transducer. Dedicated rope was used for each well and the slug was decontaminated using the procedures specified in the GMPP for the Clifty Creek Station (AGES 2018c).

The slug test data were evaluated using AQTESOLV, a commercially available software package. Data from each monitoring well were analyzed using both the Bouwer-Rice and Hvorslev slug test solutions (with automatic curve matching) which are straight-line analytical techniques commonly used to analyze rising and falling head slug test data. The AQTESOLV data for each well are presented in Appendix E.

5.3 Results of Site Characterization

5.3.1 Site Geology Updates

Based on the results of the site characterization, an update to the understanding of the geology at the unit is not necessary. The boring logs maintained during monitoring well installation confirmed that a fine-medium sand is the uppermost aquifer and confirmed the presence of a clay layer at a depth of 35 to 40 feet below ground surface (bgs) that separates the uppermost aquifer from the deep aquifer. The unconsolidated deposits overlay limestone bedrock of the Dillsboro Formation at depths ranging from 15 to 90 feet bgs.

5.3.2 Groundwater Flow

A complete round of groundwater level data was collected in March 2019 from the wells south of the LRCP (Table 5-4). A groundwater flow map generated using these data indicates that groundwater in the uppermost aquifer beneath the LRCP flows to the south toward the Ohio River (Figure 5-2). Groundwater in the deep aquifer also flows from the north (CF-19-08; groundwater elevation of 442.16 ft msl) to south (CF-19-15D; groundwater elevation of 428.77 ft msl) toward the Ohio River. Historic groundwater elevation data indicates that groundwater flow beneath the LRCP is affected by the flow and water level in the Ohio River and evidence of several flow reversals have been observed in the historic data (AGES 2018a).

5.3.3 Slug Testing

Slug test results from testing completed in May 2016 and April 2019 are summarized on Table 5-5. The revised mean K for the uppermost aquifer beneath the LRCP is 8.23×10^{-4} feet per second (ft/sec). The mean K for the deep aquifer is 1.31×10^{-5} ft/sec. Published literature indicates that these are reasonable K values for these type of unconsolidated deposits (Fetter 1980).

5.3.4 Groundwater Flow Velocity

Using water level data collected in March 2019 and hydraulic conductivity data from the recent slug tests (Tables 5-4 and 5-5), the average groundwater velocity for the uppermost and deep aquifers beneath the LRCP was estimated. The calculated average groundwater velocity for the shallow aquifer is 7.43 feet per day (ft/day) (Table 5-6). 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 CF-15-08 and CF-19-15 is approximately 70 days.

The calculated average groundwater velocity for the deep aquifer is 0.1446 ft/day (Table 5-6). With this flow velocity and a distance between wells CF-15-08D and CF-19-15D (at the property boundary) of approximately 523 feet, the travel time for groundwater to flow between CF-15-08 and CF-19-15 is approximately 3,617 days.

5.3.5 Groundwater Sampling Results

Analytical results for Appendix III and Appendix IV constituents in the four (4) new wells are presented on Table 5-7.

In the uppermost aquifer, Molybdenum concentrations south of the LRCP ranged from 4.9 ug/L in CF-15-07 to 380 ug/L in CF-15-08 (Figure 5-3). Molybdenum concentrations in the two (2) new shallow wells at the property boundary were 1.1 ug/L in CF-19-15 and 12 ug/L in CF-19-14. Based on these results, 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. However, to address Molybdenum concentrations in the uppermost aquifer an ACM is required.

In the deep aquifer, Molybdenum concentrations were 31 ug/L in CF-19-08D and 49 ug/L in CF-19-15D (Figure 5-3). Based on these results, Molybdenum impacts are confined to the uppermost aquifer as these concentrations are less than the GWPS of 100 ug/L. Further evaluation of Molybdenum in the deep aquifer is therefore not required.

6.0 ASSESSMENT OF CORRECTIVE MEASURES

Groundwater monitoring of the uppermost aquifer at the LRCP has identified Molybdenum (an Appendix IV constituent) at concentrations that exceed the GWPS defined under 40 CFR § 257.95(h); therefore, an ACM is necessary. The ACM will require 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 LRCP. Additional remedial technologies may also be evaluated at a later date, if determined to be applicable and appropriate.

Presented below is a discussion of the objectives of the ACM, the potential source control measures, a list of remedial technologies, a summary of the assessment process, and the detailed ACM evaluation.

6.1 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).

6.2 Potential Source Control Measures

The objective of source control measures is to prevent further releases from the source (i.e., the LRCP). 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 detailed evaluation of source control measures at the LRCP is provided in Table 6-1. Three (3) technologies are included in this evaluation:

- Dewatering of Pond Water;
- Engineered Cover System; and
- Excavation of Ash.

Per state and federal regulatory requirements and timelines, IKEC tentatively plans to close the LRCP. The method and timing of closure of the unit will depend on receipt of approval from the IDEM. Source control through closure will likely initially include the cessation of ongoing wastewater and storm water discharge into the LRCP, a combination of passive and active decanting of ponded water within the unit, and interstitial dewatering of ash pore-water within the unit.

Groundwater quality near the LRCP is anticipated to significantly improve over time as a result of the above-referenced closure activities. Terminating wastewater and storm water discharge to the LRCP, coupled with decanting of ponded water, will significantly decrease the hydraulic head in the LRCP and thereby significantly reduce infiltration of water from the unit to the underlying groundwater. Dewatering of the ash will also reduce the contact-time for Molybdenum with the ash pore-water, which should reduce the mobility of the Molybdenum. Groundwater monitoring over time is necessary to fully evaluate the positive impact that closure of the LRCP will have on groundwater quality.

6.3 Potential Remedial Technologies

The focus of corrective measures for the LRCP is to address Molybdenum in groundwater that exceeded the GWPS. To accomplish this, the following three (3) types of technologies will be presented in Sections 6.3.1 through 6.3.3:

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

As described in Section 6.2, groundwater quality near the LRCP is anticipated to significantly improve over time as a result of planned closure activities. Therefore, 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, 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 (as discussed below) 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.

The detailed ACM evaluation is provided in Table 6-2 and summarized below in Section 6.4. 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 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)

Permeable reactive barriers (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 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 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.

6.3.2 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 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 three (3) primary treatment technologies that are applicable to Molybdenum:

- Filtration;
- 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 reject effluent, which may require additional treatment prior to disposal.

6.3.3.2 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.

6.3.3.3 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 6-2 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 would include adsorption, precipitation, 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 adsorbed with minimal mineral formation (precipitation) at pH values in the range of 6.5 to 7.5 (Smedley and Kinniburgh 2017). At the LRCP, ORP values varied significantly in 2018 with ranges of -50 millivolts (mV) to 34.7 mV at CF-15-07; -47.7 mV to 335 mV at CF-15-08; and -50.4 mV to 325.1 mV at CF-15-09 (AGES 2019a). The pH values at the LRCP were more consistent ranging from 7.05 to 7.61 Standard Units (SU) at all three (3) wells over the course of 2018. 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 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 concentrations but would not destroy the Molybdenum. Given groundwater flow conditions, with periodic flood events and flow reversals, dispersion and dilution of Molybdenum would likely be a major factor in natural attenuation.

At the LRCP, the existing well network would be used to monitor constituent trends over time. Given that Molybdenum 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 LRCP 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 LRCP; either the lean clay layer at approximately 40 feet bgs or bedrock at 80 to 90 feet bgs. Given that the LRCP 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.

A groundwater extraction system may also be coupled with this technology to increase its long-term effectiveness. Similar to the migration barrier, a PRB could also be installed at the LRCP. However, maintaining adequate reagent concentrations at depth over time is a significant issue. In addition, the effectiveness of this approach to treat Molybdenum is not well tested or established.

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 is not well tested or established.

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 LRCP, 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 LRCP. 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 LRCP 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 LRCP.

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 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.

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 LRCP.

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. 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.

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 LRCP, 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 the place, trenching systems would also be reliable at the LRCP although long term Operations and Maintenance (O&M) would be required.

6.4.2.3 Treatment of Extracted Groundwater

Treatment of Molybdenum in extracted groundwater would be reliable as long as the bench-scale/pilot-test process outlined above is properly implemented.

6.4.3 Ease of Implementation

This criterion includes the ease with which the technologies can be implemented at the LRCP.

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 LRCP, 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 LRCP, 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.

6.4.3.2 Ex-Situ Technologies for Groundwater Extraction

Implementation of both conventional vertical and horizontal wells at the LCRP would require drilling and limited field construction; however, the conventional vertical wells would be the 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 LRCP.

6.4.3.3 Treatment of Extracted Groundwater

Treatment of Molybdenum in extracted groundwater can be implemented but would require the bench-scale/pilot-test process outlined above.

6.4.4 <u>Potential Safety Impacts</u>

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

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.

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 operations and maintenance 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 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 implementation and use of the technology at the LRCP.

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 use of reagents; this includes minimal potential for cross-media impacts.

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 <u>Potential Impacts from Control of Exposure to Residual Constituents</u>

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

6.4.6.1 In-Situ Groundwater Remedial Technologies

MNA 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 <u>Time Required to Begin Remedy</u>

This criterion includes the time necessary for planning, pilot testing, design, permitting, procurement, installation, and startup of this technology at the LRCP. Timeframes presented below and in Table 6-2 reflect the time required to implement the remedy after closure of the unit.

6.4.7.1 In-Situ Groundwater Remedial Technologies

A MNA program could be implemented at the LRCP 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.

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 LRCP, 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 Molybdenum at the unit boundary, this approach has the potential to treat groundwater more quickly than a barrier or PRB.

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 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 LRCP.

6.4.9.1 In-Situ Groundwater Remedial Technologies

A MNA 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 LRCP, 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 a 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 in groundwater at the LRCP were screened against evaluation criteria requirements in 40 CFR § 257.96(c). As presented in Table 6-2, during the screening, the technologies were ranked as High, Medium or Low using professional judgement and past experience. Based on these rankings, the two (2) technologies that appear to be most likely for selection as a remedy were:

- MNA; 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 near the LRCP is anticipated to significantly improve over time as a result of planned closure activities, 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, 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 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 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 concentrations in groundwater that exceed the GWPS at the LRCP. With the submittal of this report, IKEC will begin the remedy selection process and ultimately select a remedy. The remedy selection 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 semiannual 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 would be useful in supporting the evaluation of various potential remedial techniques at the LRCP.

- As previously discussed, groundwater quality near the LRCP 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 LRCP should continue to evaluate whether Molybdenum concentrations in groundwater are increasing, decreasing or are 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 LRCP.

- Additional hydraulic testing near the LRCP would provide more accurate data regarding the hydraulic conductivity and storage coefficient of the uppermost aquifer. This data will be useful in supporting the potential groundwater modeling effort.

- Given the dynamic nature of groundwater flow at the LRCP, 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 LRCP.

7.2 Selection of Remedy

As noted above, IKEC will begin the process of selecting a remedy following 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 or more preferred remedial approaches will be developed based upon 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.

8.0 REFERENCES

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TABLES

TABLE 4-1
GROUNDWATER MONITORING NETWORK
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND
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

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

TABLE 4-2
SUMMARY OF POTENTIAL AND CONFIRMED APPENDIX III SSIs
TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Well Id	Parameter	1st Detection Monitoring Event	1st Detection Monitoring Resampling May 2018	1st Assessment Monitoring Event	1st Assessment Monitoring Resampling December 2018
		Potential SSI	Confirmed SSI (Yes/No)	Potential SSI	Confirmed SSI (Yes/No)
Type I Residual Waste Landfill & Landfill Runoff Collection Pond					
CF-15-07	pH	**Yes**	**No**	**No**	**--**
CF-15-08	Boron	**Yes**	**Yes**	**Yes**	**Yes**
	pH	**Yes**	**No**	**No**	**--**
CF-15-09	Boron	**Yes**	**Yes**	**Yes**	**Yes**
	pH	**Yes**	**No**	**No**	**--**

SSI: Statistically Significant Increase
mg/L: Milligrams per liter
-- : Not evaluated

TABLE 4-3
GROUNDWATER PROTECTION STANDARDS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Appendix IV Constituents			
Constituent	**Background**	**MCL/SMCL**	**Groundwater Protection Standard**
Antimony, Sb	0.2185 (μg/L)	6 (μg/L)	6 (μg/L)
Arsenic, As	4.47 (μg/L)	10 (μg/L)	10 (μg/L)
Barium, Ba	116.7 (μg/L)	2000 (μg/L)	2000 (μg/L)
Beryllium, Be	0.176 (μg/L)	4 (μg/L)	4 (μg/L)
Cadmium, Cd	0.08 (μg/L)	5 (μg/L)	5 (μg/L)
Chromium, Cr	8.4 (μg/L)	100 (μg/L)	100 (μg/L)
Cobalt, Co	2.578 (μg/L)	6 (μg/L)*	6 (μg/L)
Fluoride, F	0.5532 (mg/L)	4 (mg/L)	4 (mg/L)
Lithium, Li	0.103 (μg/L)	40 (μg/L)*	40 (μg/L)
Lead, Pb	2.023 (μg/L)	15 (μg/L)*	15 (μg/L)
Mercury, Hg	1.33 (μg/L)	2 (μg/L)	2 (μg/L)
Molybdenum, Mo	62.4 (μg/L)	100 (μg/L)*	100 (μg/L)
Radium 226 & 228 (combined)	8.02 (pCi/L)	5 (pCi/L)	8.02 (pCi/L)
Selenium, Se	0.44 (μg/L)	50 (μg/L)	50 (μg/L)
Thallium, Tl	0.1788 (μg/L)	2 (μg/L)	2 (μg/L)

* Established by EPA as part of 2018 decision.

TABLE 5-1
GRAIN SIZE ANALYSIS RESULTS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Boring No.	Sample Depth (feet)	70% Retention (30% Passing) Size (mm)	Filter Pack Size (mm)	Screen Mesh (inches)	Unified Soil Classification Symbol & Description	
CF-19-08D	30 - 40	0.0095	0.40	0.01	SM	Silty Sand
CF-19-08D	84 - 89	0.14	0.40	0.01	GC	Clayey Gravel with Sand
CF-19-15D	22 - 33	0.006	0.40	0.01	CL	Lean Clay with Sand
CF-19-15D	64 - 70	0.011	0.40	0.01	CL	Sandy Lean Clay with Gravel

Notes:
mm: Millimeters

TABLE 5-2
NEW MONITORING WELL CONSTRUCTION DETAILS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Monitoring Well ID	Designation	Date of Installation	Coordinates (1)		Ground Elevation^{2} (feet)	Top of Casing Elevation^{2} (feet)	Top of Screen BGS (feet)	Base of Screen BGS (feet)	Total Depth BGS (feet)
			Northing	Easting					
CF-19-08D	Downgradient	3/5-8/2019	443224.617	562551.003	460.68	463.49	84.00	89.00	89.00
CF-19-14	Downgradient	3/7-8/2019	443401.75	562901.929	452.29	454.88	10.00	20.00	20.00
CF-19-15	Downgradient	3/13/2019	442704.784	562483.023	441.10	443.61	23.00	33.00	33.00
CF-19-15D	Downgradient	3/11-12/2019	442713.897	562487.596	441.78	444.34	65.00	70.00	70.00

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

bgs: Below Ground Surface

TABLE 5-3
SUMMARY OF WELL DEVELOPMENT DATA
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Well/Piezometer	Dates	Method	Volume (gallons)	Final Turbidity (NTU)
CF-19-08D	3/14-20/2019	Pump	52	4.75
CF-19-14	3/14-20/2019	Pump	16.5	3.84
CF-19-15	3/14-21/2019	Pump	24	4.35
CF-19-15D	3/14-21/2019	Pump	48	4.53

Notes:
NTU: Nephelometric Turbidity Unit

TABLE 5-4
SUMMARY OF GROUNDWATER ELEVATION DATA
MARCH 2019
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Monitoring Well Designation	Top of Casing Elevation (feet)	Depth to Groundwater (feet)	Groundwater Elevation (feet)
CF-15-07	441.11	3.03	438.08
CF-15-08	462.79	18.10	444.69
CF-15-09	459.45	9.78	449.67
CF-19-14	454.88	8.15	446.73
CF-19-15	443.61	9.87	433.74
CF-19-8D	463.49	21.33	442.16
CF-19-15D	444.34	15.57	428.77

TABLE 5-5
SUMMARY OF SLUG TEST RESULTS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Well ID	Test	Analytical Method	K (ft/sec)	Mean K
Uppermost Aquifer				
Slug test performed May 2016				
CF-15-08	Falling Head #1	Bouwer-Rice	2.24E-03	2.44E-03
		Hvorslev	2.70E-03	
	Rising Head #1	Bouwer-Rice	2.52E-03	
		Hvorslev	3.04E-03	
	Falling Head #2	Bouwer-Rice	2.18E-03	
		Hvorslev	2.62E-03	
	Rising Head #2	Bouwer-Rice	1.90E-03	
		Hvorslev	2.29E-03	
Slug test performed April 2019				
CF-19-14	Falling Head #1	Bouwer-Rice	4.10E-06	3.80E-06
		Hvorslev	5.35E-06	
	Rising Head #2	Bouwer-Rice	2.50E-06	
		Hvorslev	3.26E-06	
CF-19-15	Falling Head #1	Bouwer-Rice	2.89E-05	3.02E-05
		Hvorslev	3.36E-05	
	Rising Head #1	Bouwer-Rice	2.67E-05	
		Hvorslev	3.25E-05	
	Falling Head #2	Bouwer-Rice	2.75E-05	
		Hvorslev	3.36E-05	
	Rising Head #2	Bouwer-Rice	2.64E-05	
		Hvorslev	3.22E-05	
			Mean K (ft/sec)	**8.23E-04**
Deep Aquifer				
CF-19-15D	Falling Head #1	Bouwer-Rice	4.73E-05	1.72E-05
		Hvorslev	5.16E-05	
	Rising Head #1	Bouwer-Rice	1.30E-06	
		Hvorslev	1.42E-06	
	Falling Head #2	Bouwer-Rice	1.54E-05	
		Hvorslev	1.67E-05	
	Rising Head #2	Bouwer-Rice	1.98E-06	
		Hvorslev	2.16E-06	
CF-19-08D	Falling Head #1	Bouwer-Rice	1.36E-05	8.96E-06
		Hvorslev	1.43E-05	
	Rising Head #1	Bouwer-Rice	4.00E-06	
		Hvorslev	4.20E-06	
	Falling Head #2	Bouwer-Rice	1.15E-05	
		Hvorslev	1.21E-05	
	Rising Head #2	Bouwer-Rice	5.82E-06	
		Hvorslev	6.12E-06	
			Mean K (ft/sec)	**1.31E-05**

TABLE 5-6
SUMMARY OF GROUNDWATER VELOCITY CALCULATIONS
MARCH 2019
LANDFILL RUNOFF COLLECTION POND
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)	444.69	433.74	523	71.11	0.2	0.0209	7.43
Deep Aquifer								
CF-19-08D (h_1)	CF-19-15D (h_2)	442.16	428.77	523	1.13	0.2	0.0256	0.1446

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 5-7
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
MARCH 2019
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

Parameter	Units	GWPS	CF-15-07	CF-15-08	CF-15-09	CF-19-08D	CF-19-14	CF-19-15	CF-19-15D
Appendix III Constituents									
Boron, B	mg/L	--	0.045 J	9.8	6.7	0.099 J	6.3	0.15	0.078 J
Calcium, Ca	mg/L	--	150	140	160	44	170	240	47
Chloride, Cl	mg/L	--	5.6	14	3	6.6	5.0	13	7.4
Fluoride, F	mg/L	--	0.21	0.37	0.31	0.52	0.22	0.15	0.32
pH	s.u.	--	7.04	7.05	7.19	7.8	7.2	6.8	7.7
Sulfate, SO4	mg/L	--	11	240	260	9.1	230	150	16
Total Dissolved Solids (TDS)	mg/L	--	620	680	620	270	610	950	350
Appendix IV Constituents									
Antimony, Sb	ug/L	6	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Arsenic, As	ug/L	10	4.6 J	<5.0	<5.0	4.1 J	<5.0	<5.0	53
Barium, Ba	ug/L	2000	81	60	14	91	53	110	150
Beryllium, Be	ug/L	4	<1.0	<1.0	1.5	0.66 J	<1.0	<1.0	<1.0
Cadmium, Cd	ug/L	5	<1.0	<1.0	0.23 J	<1.0	<1.0	<1.0	<1.0
Chromium, Cr	ug/L	100	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Cobalt, Co	ug/L	9.745	2.4	0.19 J	0.38 J	0.39 J	3.4	1.9	0.97 J
Fluoride, F	mg/L	4	0.21	0.37	0.31	0.52	0.22	0.15	0.32
Lithium, Li	mg/L	0.04	<1.0	<1.0	<1.0	0.0035 J	<0.008	0.0029 J	0.004 J
Lead, Pb	ug/L	15	0.0017 J	0.017	0.0087	<1.0	<1.0	<1.0	<1.0
Mercury, Hg	ug/L	2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Molybdenum, Mo	ug/L	100	4.9 J	380	100	31	12	1.1 J	49
Radium 226 & 228 (combined)	pCi/L	5	2.34	0.413	<5.0	<0.238	<0.305	<0.193	0.332
Selenium, Se	ug/L	50	<5.0	<5.0	1.2 J	<5.0	<5.0	1.8 J	<5.0
Thallium, Tl	ug/L	2	<1.0	<1.0	0.2 J	<1.0	<1.0	<1.0	<1.0

Notes:
mg/L: Milligrams per liter
s.u.: Standard Units
ug/L: Micrograms per liter
pCi/L: Picocuries per liter

TABLE 6-1
SOURCE CONTROL TECHNOLOGIES SCREENING MATRIX - 40 CFR § 257.96(c) REQUIREMENTS
LANDFILL RUNOFF COLLECTION POND
CLIFTY CREEK STATION
MADISON, INDIANA

	Source Control Technologies		
	Dewatering of Pond Water	**Engineered Cover System**	**Excavation of Ash**
257.96(c)(1)			
Performance	Low	Medium	High
Reliability	Low	Medium	High
Ease of Implementation	Low Water Removal, Treatment & Discharge Required	Medium Field Construction Required	High Field Construction Required
Potential Safety Impacts	Low Field Construction Required	Medium Field Construction Required	High Field Construction Required
Potential Cross-Media Impacts	Medium	Low	Medium
Potential Impacts from Control of Exposure to Residual Constituents	Low	Low	Low
257.96(c)(2)			
Time To Begin Remedy	6 months to 1 year	1 to 1.5 years	1 to 1.5 years
Time To Complete Remedy	2 to 3 years	2 to 3 years	5 to 7 years
257.96(c)(3)			
State, Local or other Environmental Permit Requirements that May Impact Implementation	Requires Approval from IDEM	Requires Approval from IDEM	Requires Approval from IDEM
Additional Information	Required for In-Place Closure or Closure by Removal	Ash Remains in Place as Long-Term Source for Groundwater	Groundwater Issues Need to be Addressed

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

TABLE 6-2
IN-SITU AND EX-SITU GROUNDWATER REMEDIAL TECHNOLOGIES SCREENING MATRIX - 40 CFR § 257.96(c) REQUIREMENTS
LANDFILL RUNOFF COLLECTION POND
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**	**Conventional Well System**	**Horizontal Well System**	**Trenching System**
257.96(c)(1)							
Performance	High	Low	Low	Low	High	Low Significant Water Level Fluctuations Reduce Effectiveness of Horizontal Wells	High
Reliability	High	Low	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	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	Medium Drilling Required	Medium Drilling Required	Medium Trench Construction Required
Potential Cross-Media Impacts	Low	Medium	Low	Low	Medium	Medium	Medium
Potential Impacts from Control of Exposure to Residual Constituents	Low	Low	Low	Low	Low	Low	Low
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	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
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	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	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
*The time to begin the remedy is based on the time after closure of the unit.

FIGURES

1200'   0'   1200'   2400'

SCALE: 1"= 1200'

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DATE	
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JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 2-1_location map.dwg
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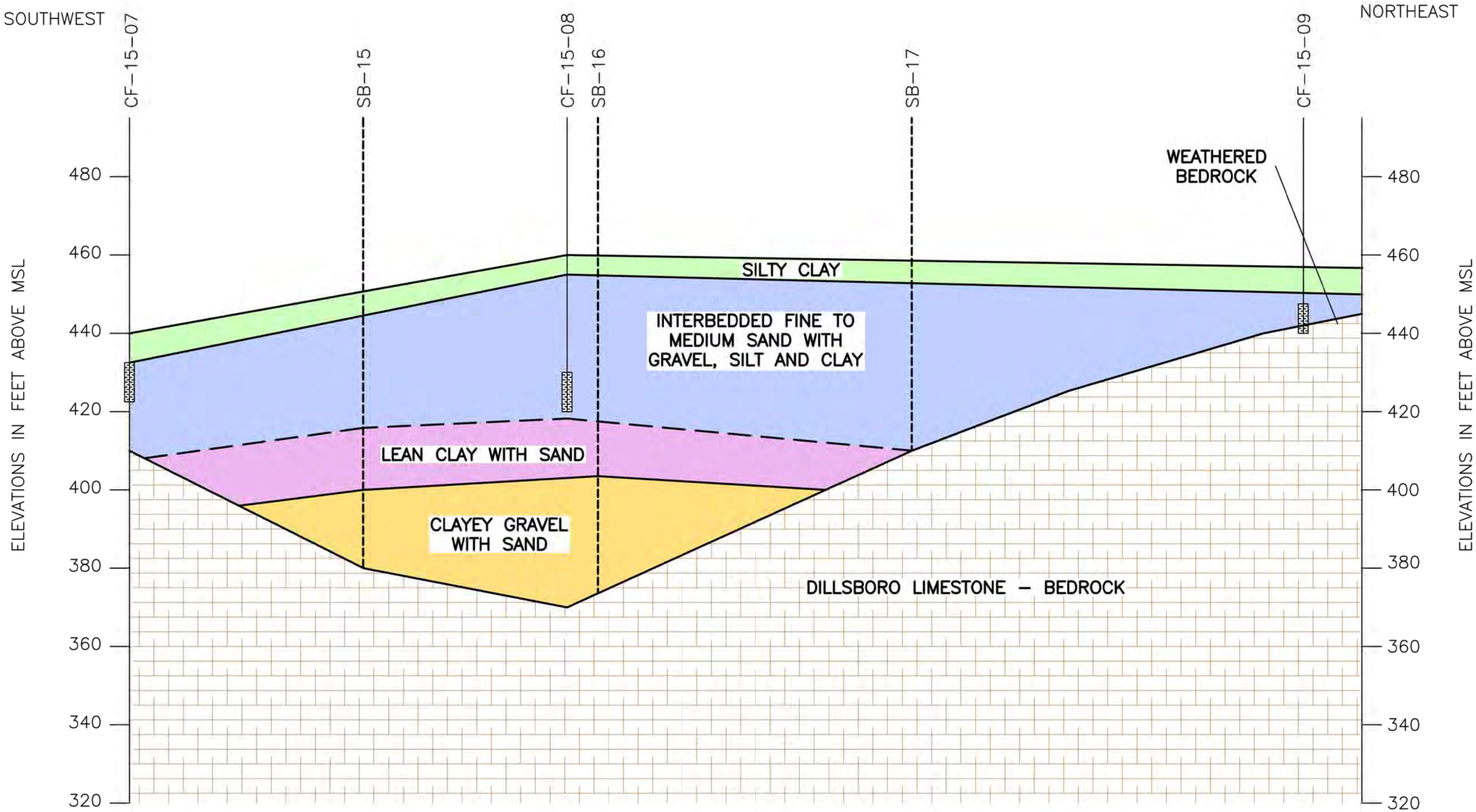
CLIFTY CREEK STATION
MADISON, INDIANA
SITE LOCATION MAP

DRAWING NAME: FIGURE 2–1

REV. 0

Plot: 08/09/2019 10:24 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\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.

DRAWN BY	JM
DATE	
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JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Fig 3-1_X-Section_LRCP.dwg
DRAWING SCALE	NOT TO SCALE

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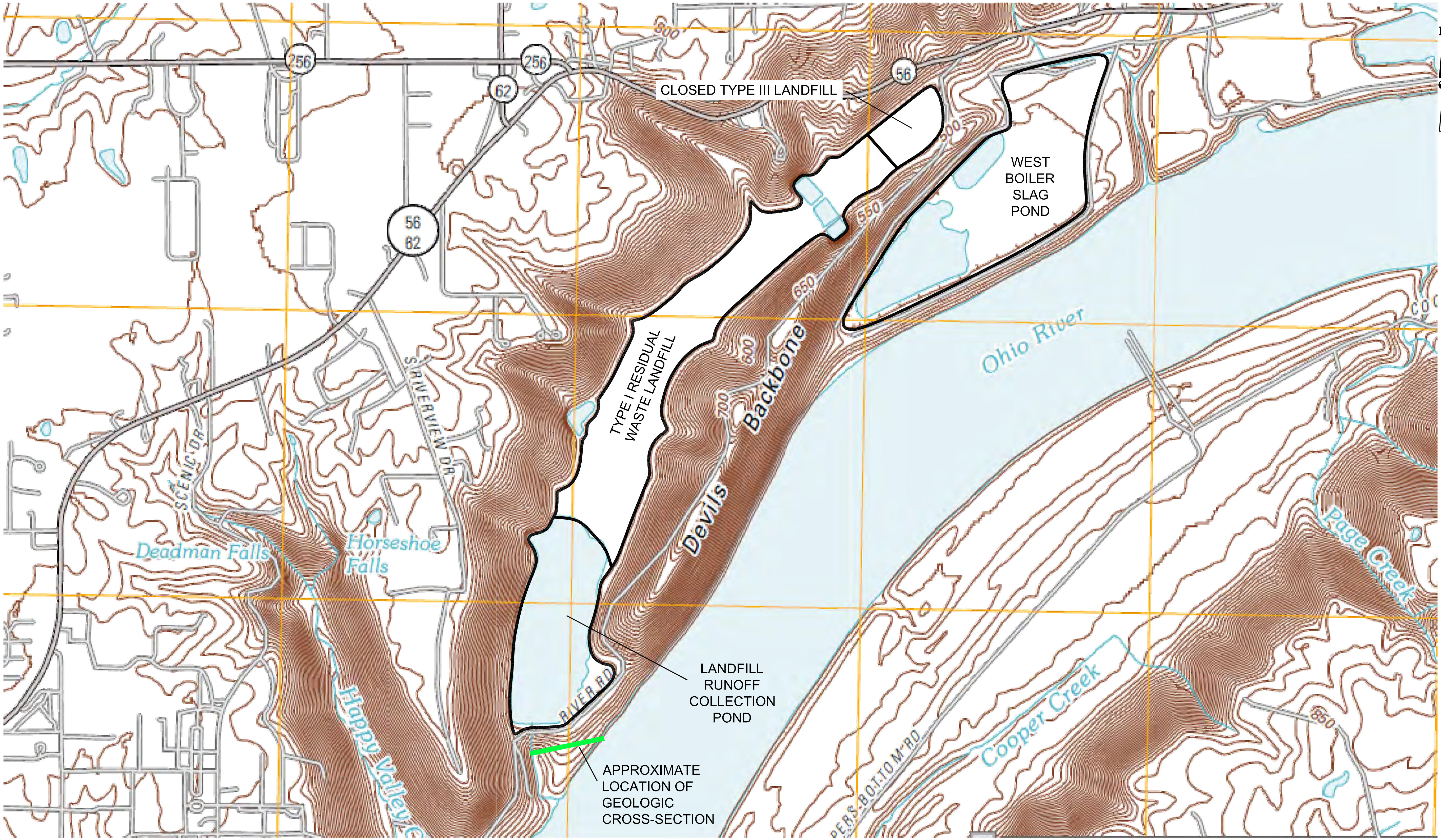
CLIFTY CREEK STATION
MADISON, INDIANA
GEOLOGIC CROSS-SECTION AT
LANDFILL RUNOFF COLLECTION POND

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.

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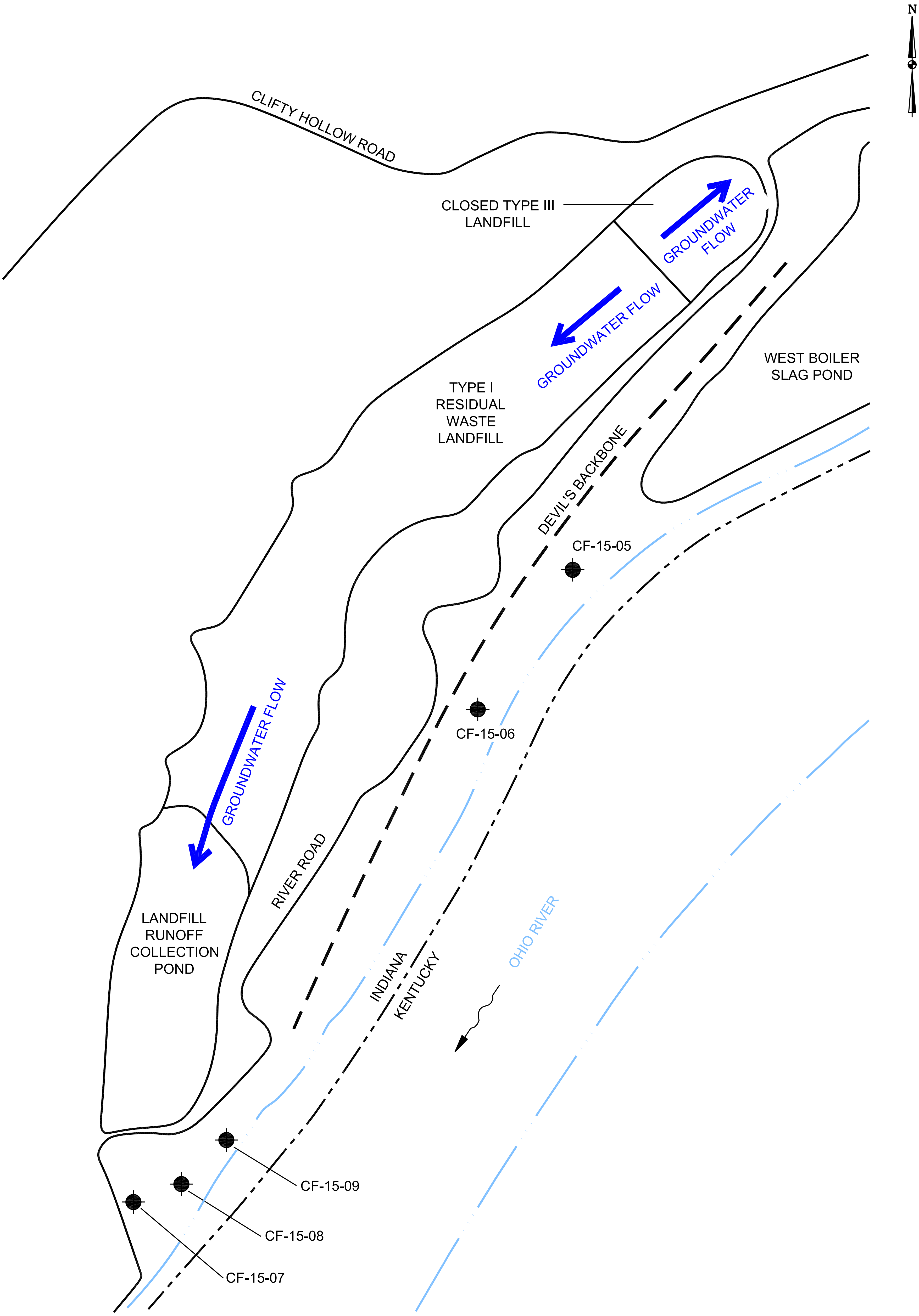
CLIFTY CREEK STATION
MADISON, INDIANA
TOPOGRAPHIC MAP

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



LEGEND:

MONITORING WELL LOCATION

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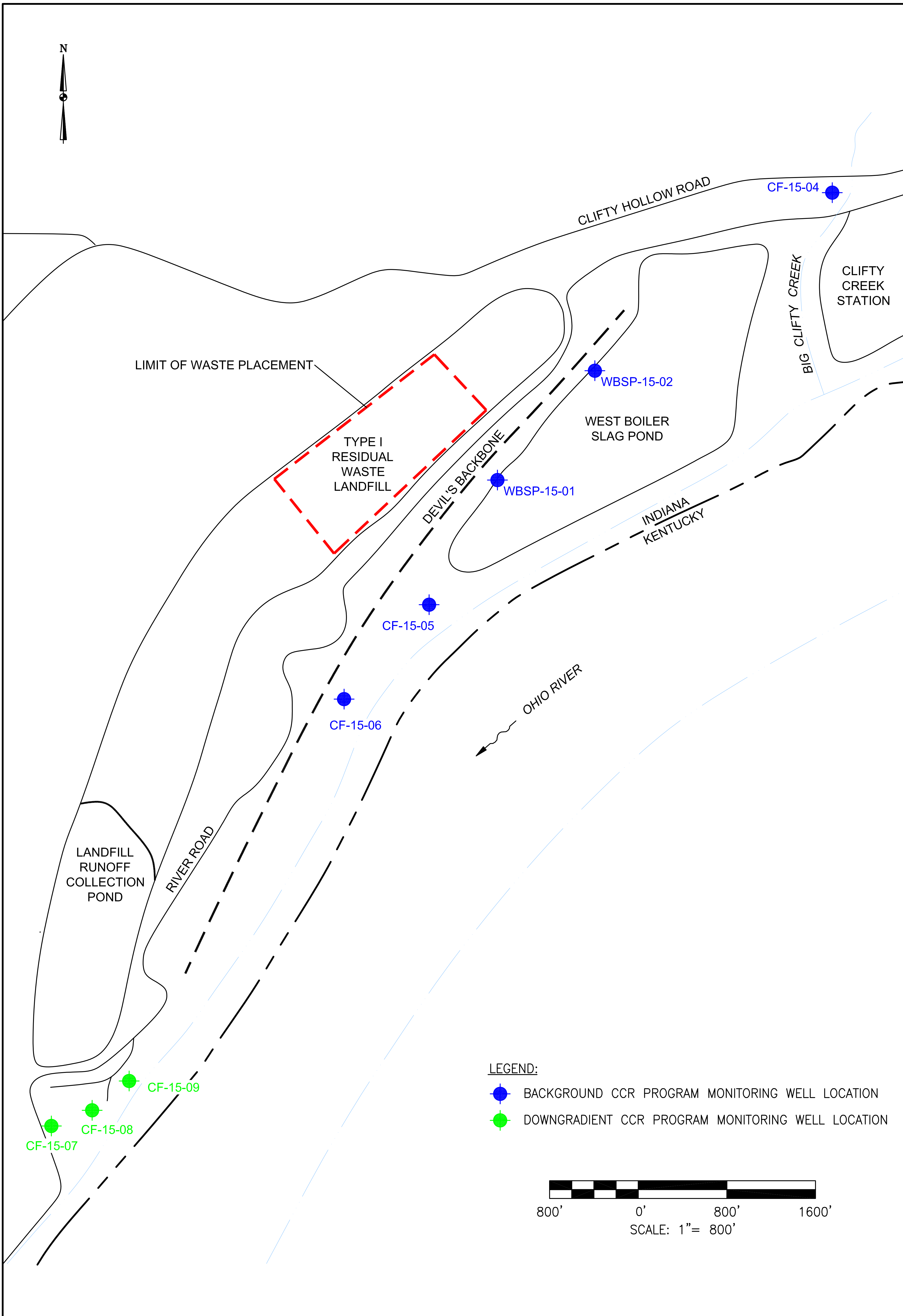
CLIFTY CREEK STATION
MADISON, INDIANA
TYPE I RESIDUAL WASTE LANDFILL AND
LANDFILL RUNOFF COLLECTION POND
EXISTING MONITORING WELL LOCATIONS AND
GENERALIZED GROUNDWATER FLOW MAP

DRAWING NAME: FIGURE 3-3

REV. 0

Plot: 08/09/2019 10:41 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 3-3_Gen_GW Flow Map.dwg



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DATE		CLIFTY CREEK STATION MADISON, INDIANA TYPE I RESIDUAL WASTE LANDFILL AND LANDFILL RUNOFF COLLECTION POND EXISTING MONITORING WELL LOCATIONS	
CHECKED BY			
JOB NO. 2019042–8–CLIFTY			
DWG FILE 2019_IKEC_Clifty_ACM_Fig 4–1_MW Locs.dwg		DRAWING NAME FIGURE 4–1	REV. 0
DRAWING SCALE NOT TO SCALE			

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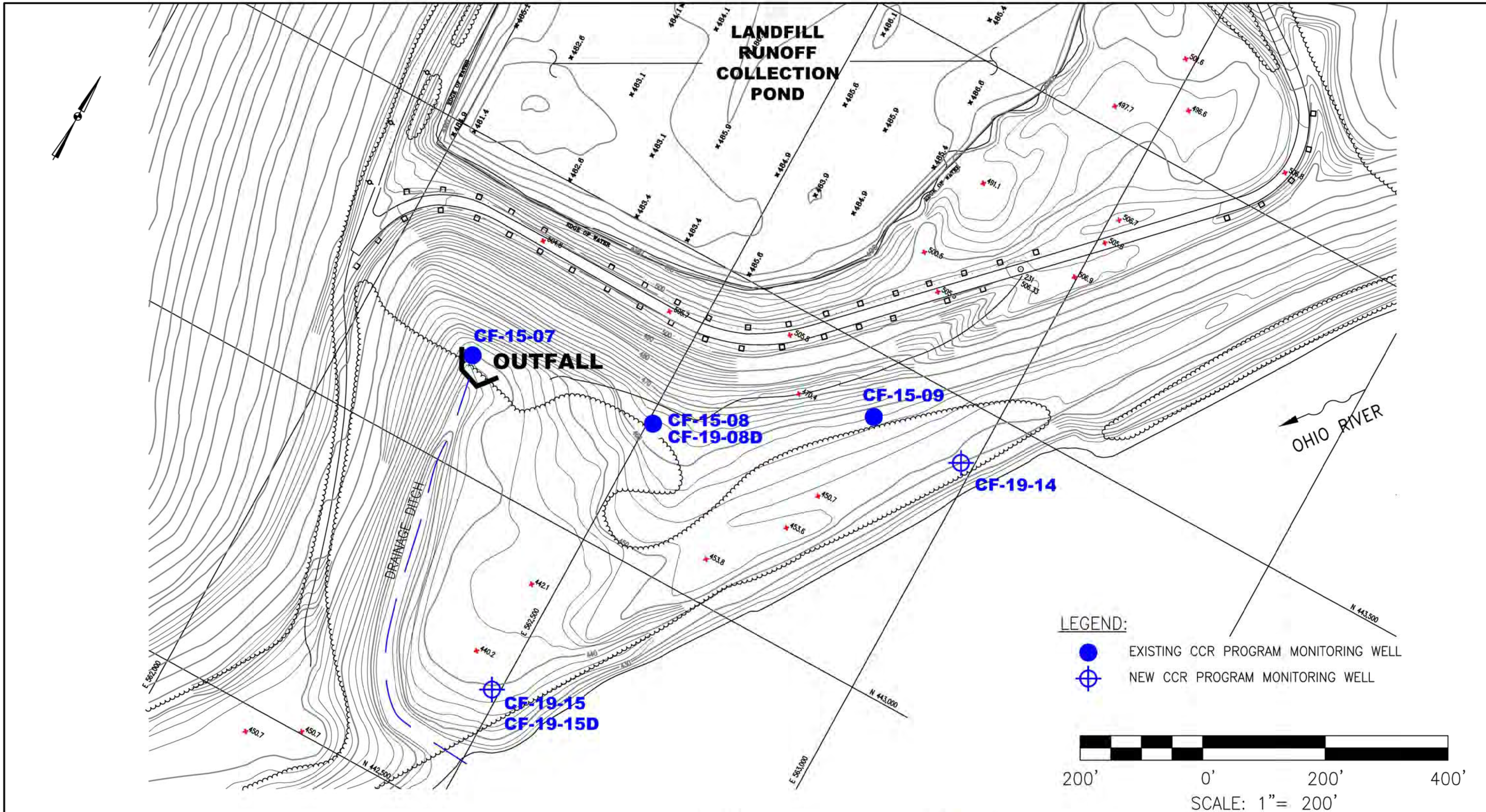

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JOB NO.: 2019042–8–CLIFTY	412.264.6453	CCR PROGRAM	
DWG FILE: 2019_IKEC_Clifty_ACM_Fig 5–1_MW locs.dwg		EXISTING AND NEW MONITORING WELL LOCATIONS	
DRAWING SCALE: AS SHOWN		DRAWING NAME: FIGURE 5–1	REV. 0

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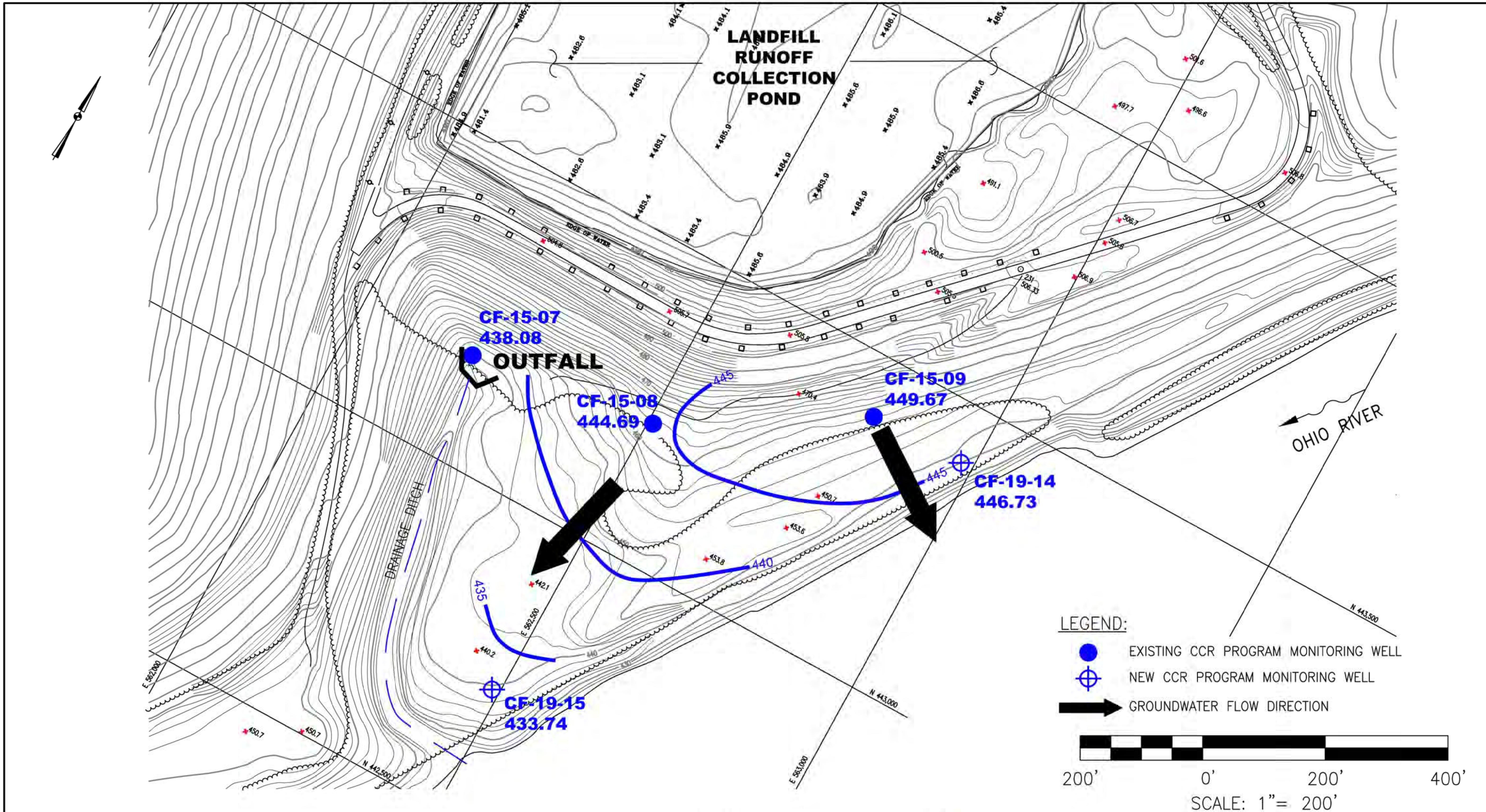

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JOB NO.	2019108-CLIFTY
DWG. FILE	2019_IKEC_Clifty_ACM_Fig 5-2_GW Flow-Upper Aquifer.dwg
DRAWING SCALE	AS SHOWN

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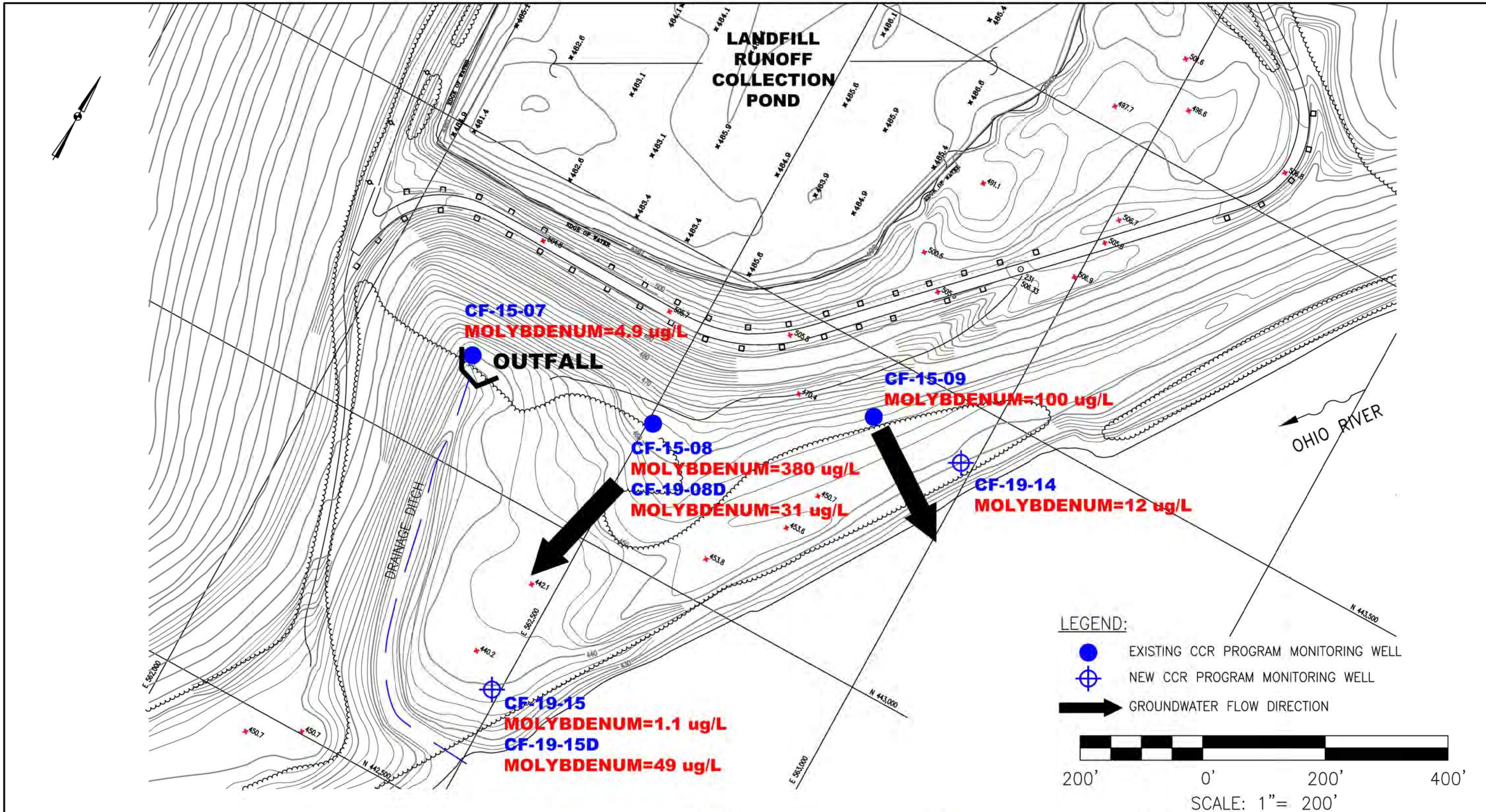
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
GROUNDWATER FLOW – UPPERMOST AQUIFER
MARCH 2019

DRAWING NAME: FIGURE 5–2
REV. 0

Plot: 09/09/2019 14:59 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 5-2_GW Flow-Upper Aquifer.dwg



DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019108–CLIFTY
DWG. FILE	2019_IKEC_Clifty_ACM_Fig 5-3_Molybdenum GW_Mar19.dwg
DRAWING SCALE	AS SHOWN

Applied Geology and Environmental Science, Inc.
2402 Hookstown Grade Road, Suite 200
Clinton, PA 15026
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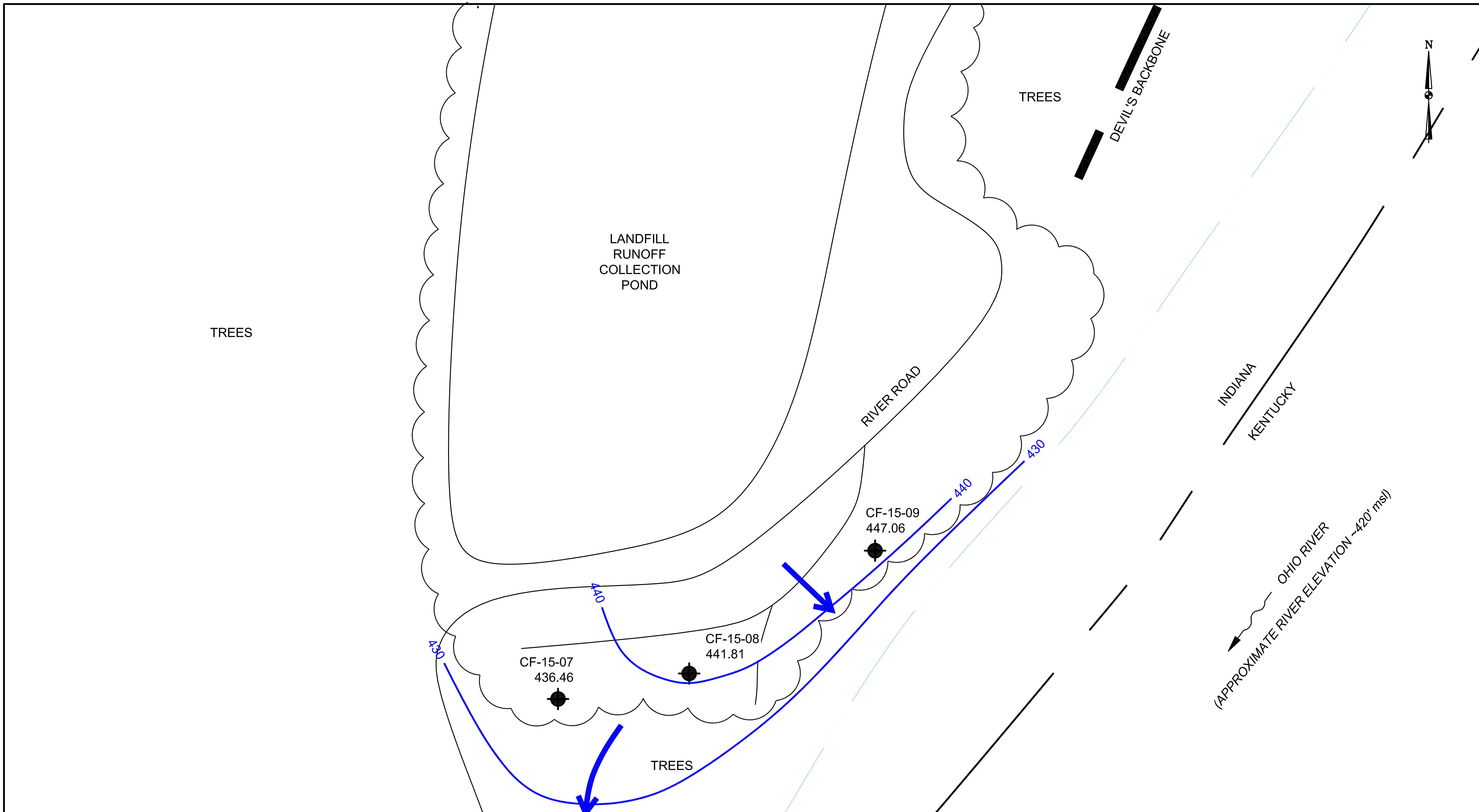
INDIANA–KENTUCKY ELECTRIC CORPORATION
CLIFTY CREEK STATION
MADISON, INDIANA
CCR PROGRAM
MOLYBDENUM CONCENTRATIONS IN GROUNDWATER
MARCH 2019

DRAWING NAME: FIGURE 5–3
REV. 0

Plot: 09/09/2019 15:03 _PROGRAMS-IKEC\Clifty Creek-CCR Program\CAD\2019 Assessment of Corrective Measures\2019_IKEC_Clifty_ACM_Fig 5-3_Molybdenum GW_Mar19.dwg

APPENDIX A

GENERALIZED GROUNDWATER FLOW MAPS FOR 2018



LEGEND:

MONITORING WELL LOCATION

GROUNDWATER FLOW DIRECTION

200' 0' 200' 400'

SCALE: 1"= 200'

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Appx A_MAR18.dwg
DRAWING SCALE	AS SHOWN

AGES
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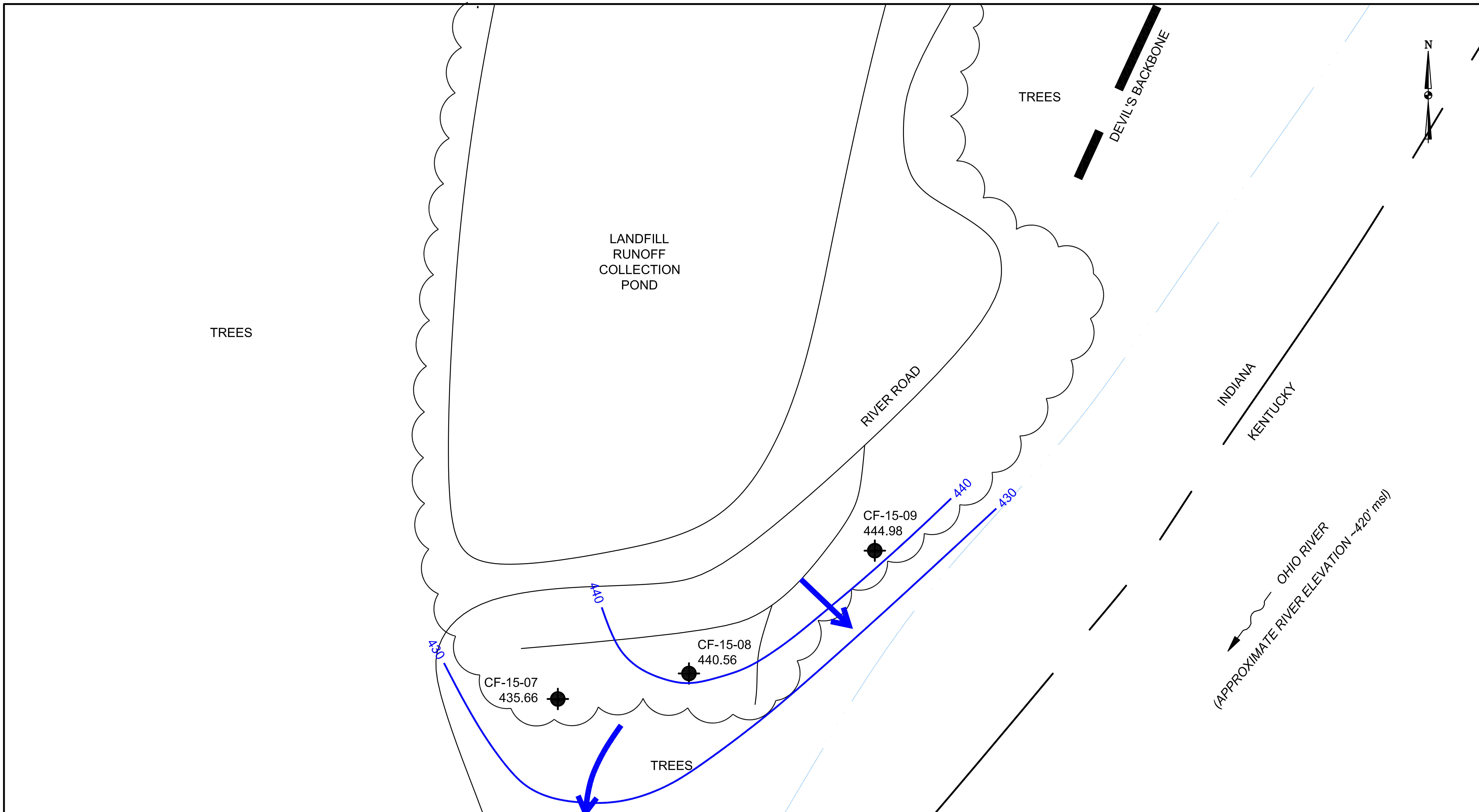
INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
LANDFILL RUNOFF COLLECTION POND
GENERALIZED GROUNDWATER FLOW MAP
MARCH 2018

DRAWING NAME: FIGURE A–1

REV. 0

Plot: 08/09/2019 13:20 _PROGRAMS–IKEC\Clifty Creek–CCR Program\CAD\2019 Assessment of Corrective Measures\Appx A\2019_IKEC_Clifty_ACM_Appx A_MAR18.dwg\A–1



LEGEND:

- MONITORING WELL LOCATION
- GROUNDWATER FLOW DIRECTION

200' 0' 200' 400'

SCALE: 1"= 200'

DRAWN BY	JM
DATE	
CHECKED BY	
JOB NO.	2019042-8-CLIFTY
DWG FILE	2019_IKEC_Clifty_ACM_Appx A_OCT18.dwg
DRAWING SCALE	AS SHOWN

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INDIANA–KENTUCKY ELECTRIC CORPORATION

CLIFTY CREEK STATION
MADISON, INDIANA
LANDFILL RUNOFF COLLECTION POND
GENERALIZED GROUNDWATER FLOW MAP
OCTOBER 2018

DRAWING NAME: FIGURE A–2

REV. 0

APPENDIX B

ANALYTICAL RESULTS FOR 2018 GROUNDWATER MONITORING

CF-15-04
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.043	0.09 J
Calcium, Ca (mg/L)	314.4	--	106	74.2
Chloride, Cl (mg/L)	282	--	282	50.2
Fluoride, F (mg/L)	0.5477	--	0.09	0.12
pH (s.u.)	5.57 - 10.36	--	10.06	7.76
Sulfate, SO4 (mg/L)	634	--	35.2	34.4
Total Dissolved Solids (TDS) (mg/L)	1290	--	788	377
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.1 J
Arsenic, As (ug/L)	4.47	10	NA	0.38
Barium, Ba (ug/L)	129.1	2000	NA	57.5
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U
Cadmium, Cd (ug/L)	0.3	5	NA	0.05 U
Chromium, Cr (ug/L)	8.4	100	NA	0.2 J
Cobalt, Co (ug/L)	4.01	6	NA	0.114
Fluoride, F (ug/L)	0.5477	4	0.09	0.12
Lithium, Li (ug/L)	0.2443	40	NA	0.009 J
Lead, Pb (ug/L)	3.703	15	NA	0.141
Mercury, Hg (ug/L)	1.16	2	NA	0.003 J
Molybdenum, Mo (ug/L)	62.4	100	NA	2.54
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.62
Selenium, Se (ug/L)	1.9	50	NA	0.2 J
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

CF-15-05
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.209	0.174
Calcium, Ca (mg/L)	314.4	--	103	113
Chloride, Cl (mg/L)	282	--	31.5	30.2
Fluoride, F (mg/L)	0.5477	--	0.47	0.48
pH (s.u.)	5.57 - 10.36	--	9.56	7.18
Sulfate, SO4 (mg/L)	634	--	44.3	40.9
Total Dissolved Solids (TDS) (mg/L)	1290	--	528	502
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.02 J
Arsenic, As (ug/L)	4.47	10	NA	0.91
Barium, Ba (ug/L)	129.1	2000	NA	58.8
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U
Cadmium, Cd (ug/L)	0.3	5	NA	0.04 J
Chromium, Cr (ug/L)	8.4	100	NA	0.228
Cobalt, Co (ug/L)	4.01	6	NA	0.463
Fluoride, F (ug/L)	0.5477	4	0.47	0.48
Lithium, Li (ug/L)	0.2443	40	NA	0.01 J
Lead, Pb (ug/L)	3.703	15	NA	0.21
Mercury, Hg (ug/L)	1.16	2	NA	0.003 J
Molybdenum, Mo (ug/L)	62.4	100	NA	2.94
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.484
Selenium, Se (ug/L)	1.9	50	NA	0.06 J
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

CF-15-06
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.16	0.05 J
Calcium, Ca (mg/L)	314.4	--	125	184
Chloride, Cl (mg/L)	282	--	7.76	8.21
Fluoride, F (mg/L)	0.5477	--	0.2	0.21
pH (s.u.)	5.57 - 10.36	--	10.36	7.89
Sulfate, SO4 (mg/L)	634	--	112	102
Total Dissolved Solids (TDS) (mg/L)	1290	--	630	696
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.07 J
Arsenic, As (ug/L)	4.47	10	NA	1.21
Barium, Ba (ug/L)	129.1	2000	NA	149
Beryllium, Be (ug/L)	0.934	4	NA	0.934
Cadmium, Cd (ug/L)	0.3	5	NA	0.3
Chromium, Cr (ug/L)	8.4	100	NA	6.81
Cobalt, Co (ug/L)	4.01	6	NA	8.27
Fluoride, F (ug/L)	0.5477	4	0.2	0.21
Lithium, Li (ug/L)	0.2443	40	NA	0.02 J
Lead, Pb (ug/L)	3.703	15	NA	15.7
Mercury, Hg (ug/L)	1.16	2	NA	0.006
Molybdenum, Mo (ug/L)	62.4	100	NA	3.02
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA
Selenium, Se (ug/L)	1.9	50	NA	1.9
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

CF-15-07
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18	Dec-18
Appendix III Constituents					
Boron, B (mg/L)	5.02	--	0.204	0.112	NA
Calcium, Ca (mg/L)	314.4	--	123	168	NA
Chloride, Cl (mg/L)	282	--	10.6	5.34	NA
Fluoride, F (mg/L)	0.5477	--	0.2	0.24	NA
pH (s.u.)	5.57 - 10.36	--	10.12	7.29	NA
Sulfate, SO4 (mg/L)	634	--	32.7	2.7	NA
Total Dissolved Solids (TDS) (mg/L)	1290	--	548	1240	NA
Appendix IV Constituents					
Antimony, Sb (ug/L)	0.2556	6	NA	0.06 J	NA
Arsenic, As (ug/L)	4.47	10	NA	6.81	2.49
Barium, Ba (ug/L)	129.1	2000	NA	92.4	NA
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U	NA
Cadmium, Cd (ug/L)	0.3	5	NA	0.07	NA
Chromium, Cr (ug/L)	8.4	100	NA	0.36	NA
Cobalt, Co (ug/L)	4.01	6	NA	2.41	NA
Fluoride, F (ug/L)	0.5477	4	0.2	0.24	NA
Lithium, Li (ug/L)	0.2443	40	NA	0.03 U	NA
Lead, Pb (ug/L)	3.703	15	NA	0.336	NA
Mercury, Hg (ug/L)	1.16	2	NA	0.004 J	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	12.8	NA
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.387	NA
Selenium, Se (ug/L)	1.9	50	NA	0.2 J	NA
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U	NA

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

CF-15-08
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	May-18	Oct-18	Dec-18
Appendix III Constituents						
Boron, B (mg/L)	5.02	--	8.5	8.6	11.9	11.9
Calcium, Ca (mg/L)	314.4	--	123	NA	145	NA
Chloride, Cl (mg/L)	282	--	14.7	NA	17.4	NA
Fluoride, F (mg/L)	0.5477	--	0.41	NA	0.41	NA
pH (s.u.)	5.57 - 10.36	--	10.21	7.45	7.53	NA
Sulfate, SO4 (mg/L)	634	--	203	NA	257	NA
Total Dissolved Solids (TDS) (mg/L)	1290	--	588	NA	636	NA
Appendix IV Constituents						
Antimony, Sb (ug/L)	0.2556	6	NA	NA	0.07 J	NA
Arsenic, As (ug/L)	4.47	10	NA	NA	0.94	NA
Barium, Ba (ug/L)	129.1	2000	NA	NA	51.4	NA
Beryllium, Be (ug/L)	0.934	4	NA	NA	0.1 U	NA
Cadmium, Cd (ug/L)	0.3	5	NA	NA	0.02 J	NA
Chromium, Cr (ug/L)	8.4	100	NA	NA	0.385	NA
Cobalt, Co (ug/L)	4.01	6	NA	NA	0.547	NA
Fluoride, F (ug/L)	0.5477	4	0.41	NA	0.41	NA
Lithium, Li (ug/L)	0.2443	40	NA	NA	0.02 J	NA
Lead, Pb (ug/L)	3.703	15	NA	NA	0.457	NA
Mercury, Hg (ug/L)	1.16	2	NA	NA	0.004 J	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	NA	524	429
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA	0.437	NA
Selenium, Se (ug/L)	1.9	50	NA	NA	0.07 J	NA
Thallium, Tl (ug/L)	0.25	2	NA	NA	0.5 U	NA

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

CF-15-09
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	May-18	Oct-18	Dec-18
Appendix III Constituents						
Boron, B (mg/L)	5.02	--	5.86	6.1	7.59	7.41
Calcium, Ca (mg/L)	314.4	--	184	NA	250	NA
Chloride, Cl (mg/L)	282	--	3.52	NA	3.47	NA
Fluoride, F (mg/L)	0.5477	--	0.3	NA	0.32	NA
pH (s.u.)	5.57 - 10.36	--	10.85	7.09	7.05	NA
Sulfate, SO4 (mg/L)	634	--	287	NA	274	NA
Total Dissolved Solids (TDS) (mg/L)	1290	--	710	NA	790	NA
Appendix IV Constituents						
Antimony, Sb (ug/L)	0.2556	6	NA	NA	0.16	NA
Arsenic, As (ug/L)	4.47	10	NA	NA	4.67	0.26
Barium, Ba (ug/L)	129.1	2000	NA	NA	38.2	NA
Beryllium, Be (ug/L)	0.934	4	NA	NA	0.261	<0.02
Cadmium, Cd (ug/L)	0.3	5	NA	NA	0.05 J	NA
Chromium, Cr (ug/L)	8.4	100	NA	NA	14.9	0.419
Cobalt, Co (ug/L)	4.01	6	NA	NA	7.45	0.04
Fluoride, F (ug/L)	0.5477	4	0.3	NA	0.32	NA
Lithium, Li (ug/L)	0.2443	40	NA	NA	0.02 J	NA
Lead, Pb (ug/L)	3.703	15	NA	NA	6.25	0.03
Mercury, Hg (ug/L)	1.16	2	NA	NA	0.007	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	NA	85.9	87.1
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA	NA	NA
Selenium, Se (ug/L)	1.9	50	NA	NA	1.3	0.1
Thallium, Tl (ug/L)	0.25	2	NA	NA	0.5 U	NA

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

WBSP-15-01
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	0.1	0.134
Calcium, Ca (mg/L)	314.4	--	157	164
Chloride, Cl (mg/L)	282	--	9.45	25.3
Fluoride, F (mg/L)	0.5477	--	0.27	0.31
pH (s.u.)	5.57 - 10.36	--	6.65	6.37
Sulfate, SO4 (mg/L)	634	--	139	146
Total Dissolved Solids (TDS) (mg/L)	1290	--	685	711
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.09 J
Arsenic, As (ug/L)	4.47	10	NA	1.52
Barium, Ba (ug/L)	129.1	2000	NA	25.3
Beryllium, Be (ug/L)	0.934	4	NA	0.144
Cadmium, Cd (ug/L)	0.3	5	NA	0.03 J
Chromium, Cr (ug/L)	8.4	100	NA	4.76
Cobalt, Co (ug/L)	4.01	6	NA	2.91
Fluoride, F (ug/L)	0.5477	4	0.27	0.31
Lithium, Li (ug/L)	0.2443	40	NA	0.034
Lead, Pb (ug/L)	3.703	15	NA	2.63
Mercury, Hg (ug/L)	1.16	2	NA	NA
Molybdenum, Mo (ug/L)	62.4	100	NA	0.7 J
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	NA
Selenium, Se (ug/L)	1.9	50	NA	0.6
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

WBSP-15-02
SUMMARY OF 2018 ANALYTICAL RESULTS
Indiana-Kentucky Electric Corporation
Clifty Creek Station
Madison, Indiana

Parameter	UTL	GWPS	Mar-18	Oct-18
Appendix III Constituents				
Boron, B (mg/L)	5.02	--	3.98	4.36
Calcium, Ca (mg/L)	314.4	--	231	277
Chloride, Cl (mg/L)	282	--	12.1	11.3
Fluoride, F (mg/L)	0.5477	--	0.37	0.36
pH (s.u.)	5.57 - 10.36	--	7.34	6.64
Sulfate, SO4 (mg/L)	634	--	607	515
Total Dissolved Solids (TDS) (mg/L)	1290	--	1200	1190
Appendix IV Constituents				
Antimony, Sb (ug/L)	0.2556	6	NA	0.14
Arsenic, As (ug/L)	4.47	10	NA	0.44
Barium, Ba (ug/L)	129.1	2000	NA	22.6
Beryllium, Be (ug/L)	0.934	4	NA	0.1 U
Cadmium, Cd (ug/L)	0.3	5	NA	0.03 J
Chromium, Cr (ug/L)	8.4	100	NA	0.788
Cobalt, Co (ug/L)	4.01	6	NA	0.081
Fluoride, F (ug/L)	0.5477	4	0.37	0.36
Lithium, Li (ug/L)	0.2443	40	NA	0.088
Lead, Pb (ug/L)	3.703	15	NA	0.09 J
Mercury, Hg (ug/L)	1.16	2	NA	0.002 J
Molybdenum, Mo (ug/L)	62.4	100	NA	2.45
Radium 226 & 228 (combined) (pCi/L)	5.523	8.02	NA	0.3588
Selenium, Se (ug/L)	1.9	50	NA	0.06 J
Thallium, Tl (ug/L)	0.25	2	NA	0.5 U

Notes:
NA = Sample not analyzed for the parameter
UTL: Upper Threshold Limit
GWPS: Groundwater Protection Standard

APPENDIX C

GRAIN SIZE ANALYSIS LAB REPORTS

Stantec

Summary of Soil Tests

Project Name: IKEC Clifty Creek
Project Number: 175534018
Source: CF-19-150-22-33
Lab ID: 5

Sample Type: SPT
Date Received: 3-18-19
Date Reported: 3-28-19

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 26.4

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	98.6
3/8"	9.5	98.3
No. 4	4.75	97.6
No. 10	2	95.3
No. 40	0.425	93.4
No. 200	0.075	80.6
	0.02	50.6
	0.005	27.9
	0.002	19.5
estimated	0.001	14.9

Plus 3 in. material, not included: 0 (%)

	ASTM	AASHTO
Range	(%)	(%)
Gravel	2.4	4.7
Coarse Sand	2.3	1.9
Medium Sand	1.9	---
Fine Sand	12.8	12.8
Silt	52.7	61.1
Clay	27.9	19.5

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: 35
Plastic Limit: 20
Plasticity Index: 15
Activity Index: 0.8

Moisture-Density Relationship

Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Estimated
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CL
Group Name: Lean clay with sand
AASHTO Classification: A-6 (11)

Comments:

Reviewed By JS

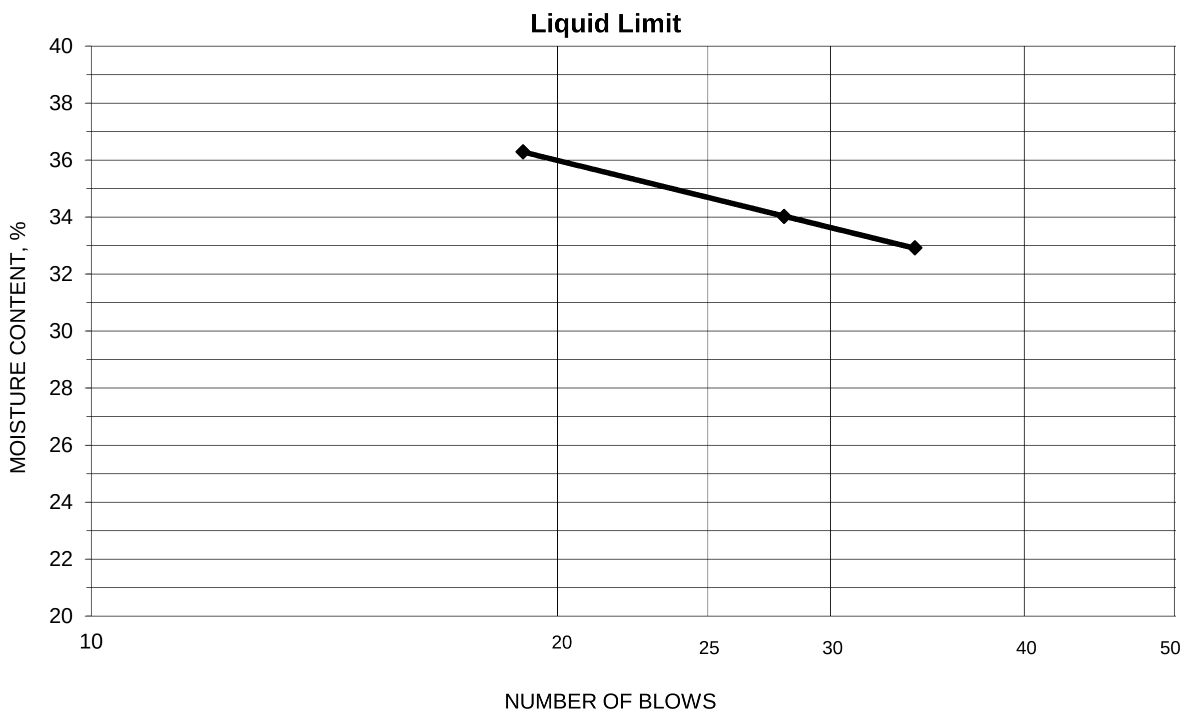
Template: tmp_sum_input.xlsm
Version: 20170217
Approved By: RJ

Stantec

ATTERBERG LIMITS

Project	IKEC Clifty Creek	Project No.	175534018
Source	CF-19-150-22-33	Lab ID	5
		% + No. 40	7
Tested By	MP	Test Method	ASTM D 4318 Method A
Date Received	03-18-2019		
Test Date	03-19-2019	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.87	20.70	11.07	34	32.9	
22.90	19.76	10.53	28	34.0	
22.84	19.69	11.01	19	36.3	35



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
18.25	16.96	10.67	20.5	20	15
18.05	16.90	11.09	19.8		

Remarks: ______________________

Reviewed By JS

Template: tmp_sum_input.xlsm
Version: 20170217
Approved By: RJ

Stantec Consulting Services Inc.

Particle-Size Analysis of Soils
ASTM D 422

Project Name: IKEC Clifty Creek
Project Number: 175534018
Source: CF-19-150-22-33
Lab ID: 5

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: MP
Test Date: 03-18-2019
Date Received: 03-18-2019

Maximum Particle size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	98.6
3/8"	98.3
No. 4	97.6
No. 10	95.3

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

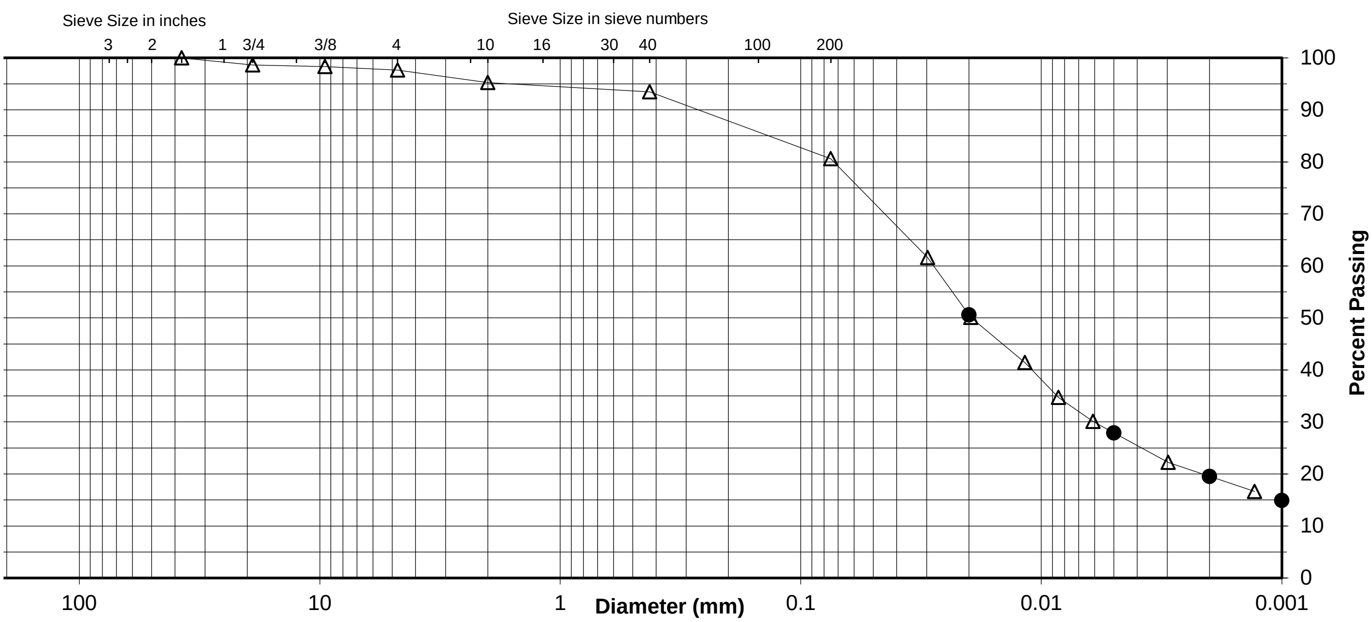
Dispersed using Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
No. 40	93.4
No. 200	80.6
0.02 mm	50.6
0.005 mm	27.9
0.002 mm	19.5
0.001 mm	14.9

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	1.4	1.0	2.3	1.9	12.8	52.7	27.9

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	4.7	1.9	12.8	61.1	19.5



Comments ______

Reviewed By JS

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Stantec

Summary of Soil Tests

Project Name: IKEC Clifty Creek
Project Number: 175534018
Source: CF-19-150-64-70
Lab ID: 6

Sample Type: SPT
Date Received: 3-18-19
Date Reported: 3-28-19

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 17.7

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	92.8
3/8"	9.5	84.2
No. 4	4.75	77.2
No. 10	2	69.1
No. 40	0.425	62.1
No. 200	0.075	53.5
	0.02	39.6
	0.005	22.5
	0.002	16.1
estimated	0.001	12.6

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	22.8	30.9
Coarse Sand	8.1	7.0
Medium Sand	7.0	---
Fine Sand	8.6	8.6
Silt	31.0	37.4
Clay	22.5	16.1

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: 34
Plastic Limit: 20
Plasticity Index: 14
Activity Index: 0.9

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CL
Group Name: Sandy lean clay with gravel

AASHTO Classification: A-6 (5)

Comments:

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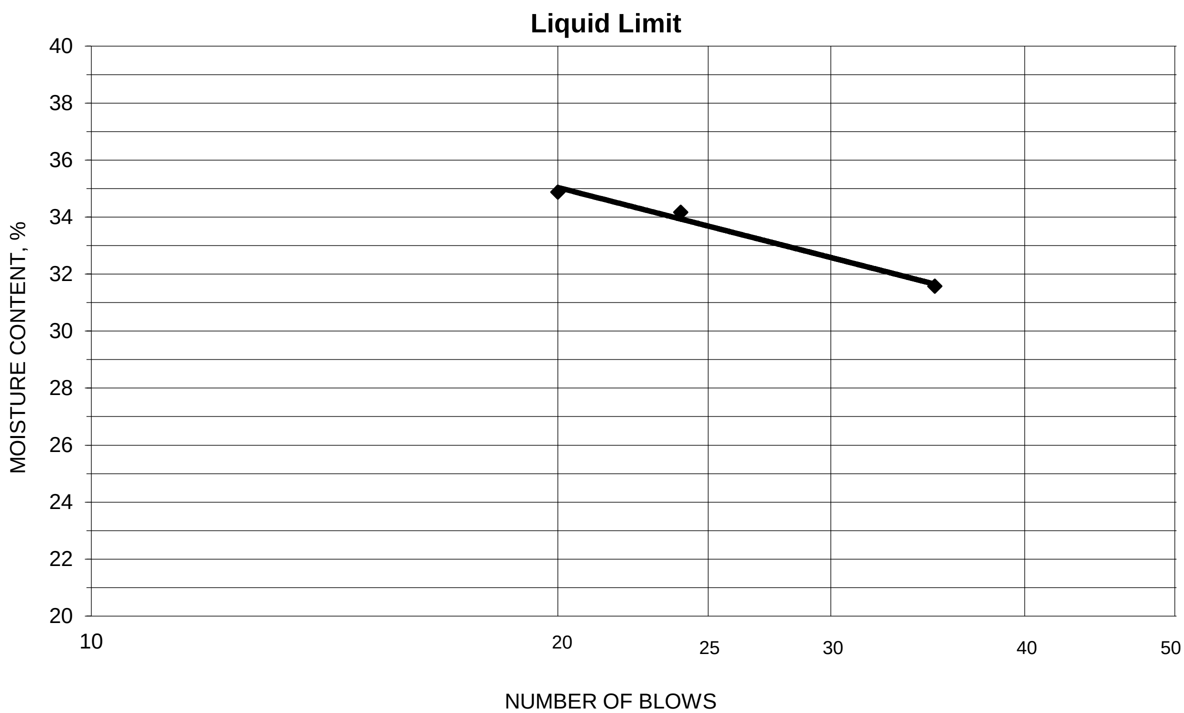
ATTERBERG LIMITS

Stantec

Project	IKEC Clifty Creek	Project No.	175534018
Source	CF-19-150-64-70	Lab ID	6
		% + No. 40	38
Tested By	MP	Test Method	ASTM D 4318 Method A
Date Received	03-18-2019		
Test Date	03-19-2019	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
27.17	23.17	10.50	35	31.6	
24.96	21.30	10.59	24	34.2	
24.74	21.20	11.05	20	34.9	34



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
18.45	17.25	11.05	19.4	20	14
18.47	17.25	11.07	19.7		

Remarks: ______

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Particle-Size Analysis of Soils
ASTM D 422

Project Name: IKEC Clifty Creek
Source: CF-19-150-64-70

Project Number: 175534018
Lab ID: 6

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: GW
Test Date: 03-18-2019
Date Received: 03-18-2019

Maximum Particle size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	92.8
3/8"	84.2
No. 4	77.2
No. 10	69.1

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

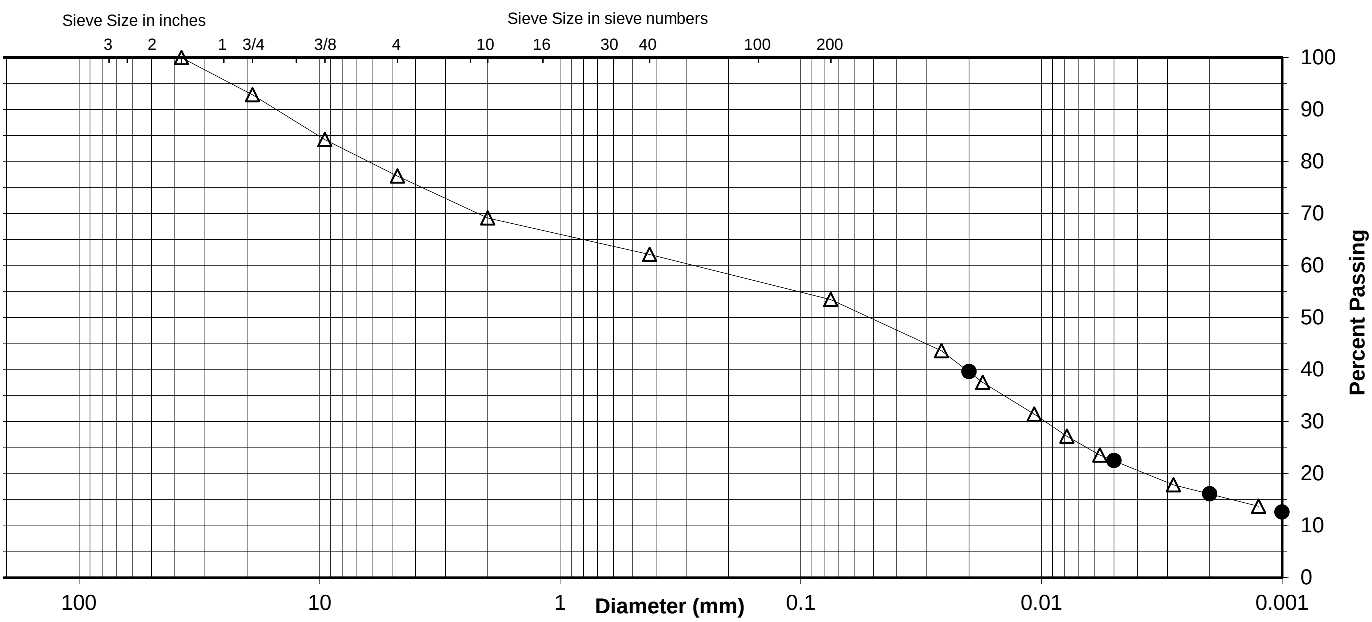
Dispersed using Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
No. 40	62.1
No. 200	53.5
0.02 mm	39.6
0.005 mm	22.5
0.002 mm	16.1
0.001 mm	12.6

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	7.2	15.6	8.1	7.0	8.6	31.0	22.5

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	30.9	7.0	8.6	37.4	16.1



Comments ______

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Approved By: RJ

Stantec

Summary of Soil Tests

Project Name: IKEC Clifty Creek
Project Number: 175534018
Source: CF-19-80-30-40
Lab ID: 7
Sample Type: SPT
Date Received: 3-18-19
Date Reported: 3-28-19

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 18.2

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: NP
Plastic Limit: NP
Plasticity Index: NP
Activity Index: N/A

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
3/8"	9.5	100.0
No. 4	4.75	99.6
No. 10	2	97.7
No. 40	0.425	88.4
No. 200	0.075	21.0
	0.02	8.6
	0.005	3.4
	0.002	2.0
estimated	0.001	1.1

Plus 3 in. material, not included: 0 (%)

	ASTM	AASHTO
Range	(%)	(%)
Gravel	0.4	2.3
Coarse Sand	1.9	9.3
Medium Sand	9.3	---
Fine Sand	67.4	67.4
Silt	17.6	19.0
Clay	3.4	2.0

Moisture-Density Relationship

Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Estimated
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: SM
Group Name: Silty sand
AASHTO Classification: A-2-4 (0)

Comments:

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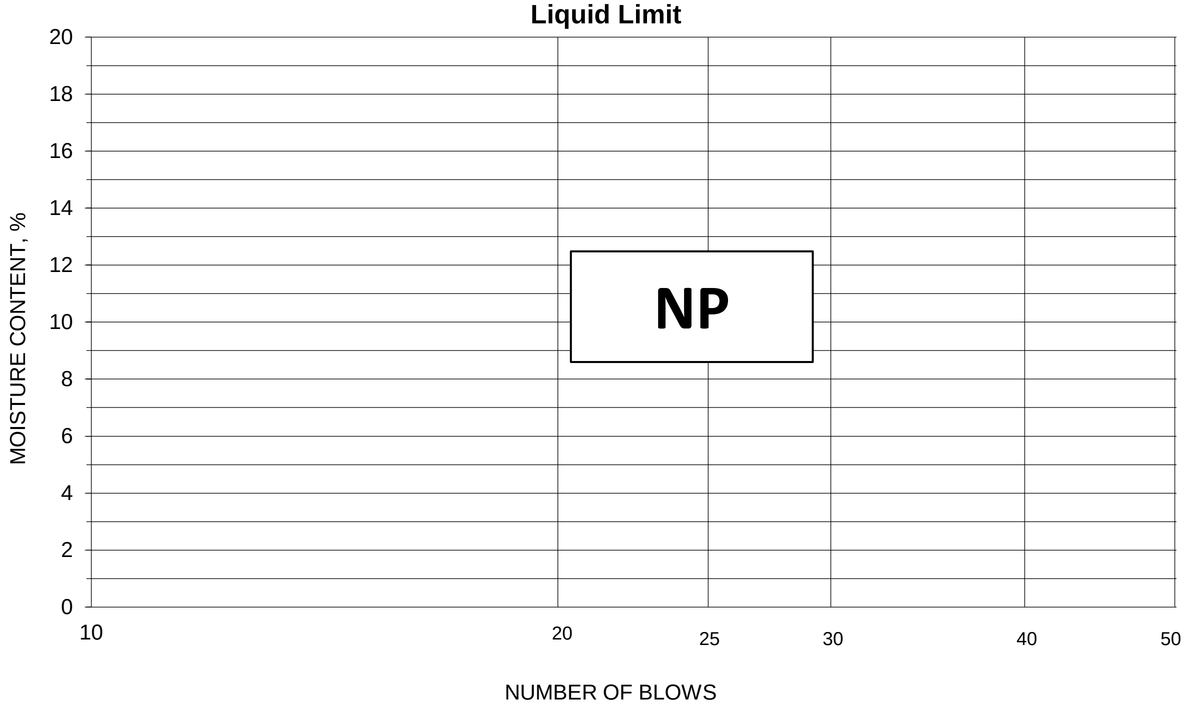
ATTERBERG LIMITS

Project	IKEC Clifty Creek	Project No.	175534018
Source	CF-19-80-30-40	Lab ID	7
		% + No. 40	12

Tested By	MP	Test Method	ASTM D 4318 Method A	Date Received	03-18-2019
Test Date	03-19-2019	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit

Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks:

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Approved By: RJ

Stantec Consulting Services Inc.

Particle-Size Analysis of Soils
ASTM D 422

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-80-30-40	Lab ID	7

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: GW
Test Date: 03-18-2019
Date Received: 03-18-2019

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3/8"	100.0
No. 4	99.6
No. 10	97.7

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

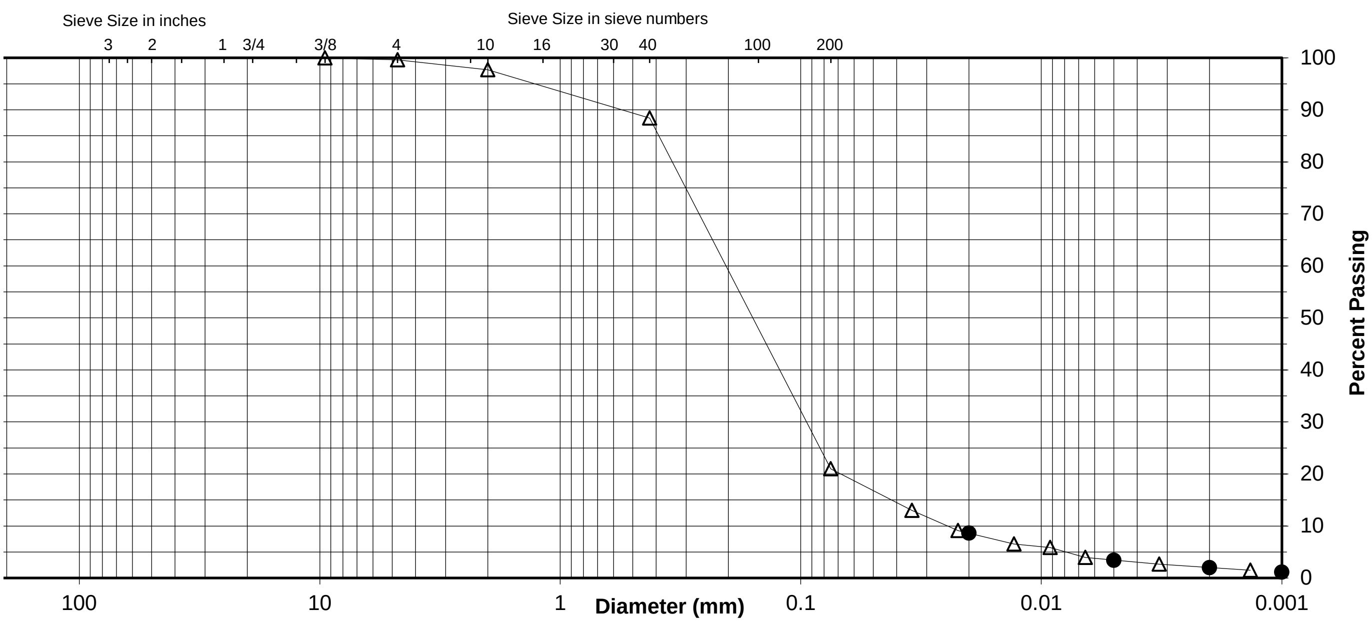
Dispersed using Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
No. 40	88.4
No. 200	21.0
0.02 mm	8.6
0.005 mm	3.4
0.002 mm	2.0
0.001 mm	1.1

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.4	1.9	9.3	67.4	17.6	3.4

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	2.3	9.3	67.4	19.0	2.0



Comments ______

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Stantec Consulting Services Inc.

Stantec

Summary of Soil Tests

Project Name: IKEC Clifty Creek
Project Number: 175534018
Source: CF-19-80-84-89
Lab ID: 8

Sample Type: SPT
Date Received: 3-18-19
Date Reported: 3-28-19

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 10.5

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	78.9
3/8"	9.5	61.7
No. 4	4.75	50.7
No. 10	2	41.1
No. 40	0.425	34.5
No. 200	0.075	28.0
	0.02	18.8
	0.005	9.4
	0.002	6.4
estimated	0.001	4.8

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	49.3	58.9
Coarse Sand	9.6	6.6
Medium Sand	6.6	---
Fine Sand	6.5	6.5
Silt	18.6	21.6
Clay	9.4	6.4

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: 27
Plastic Limit: 16
Plasticity Index: 11
Activity Index: 1.7

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: GC
Group Name: Clayey gravel with sand

AASHTO Classification: A-2-6 (0)

Comments:

Reviewed By JS

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Version: 20170217
Approved By: RJ

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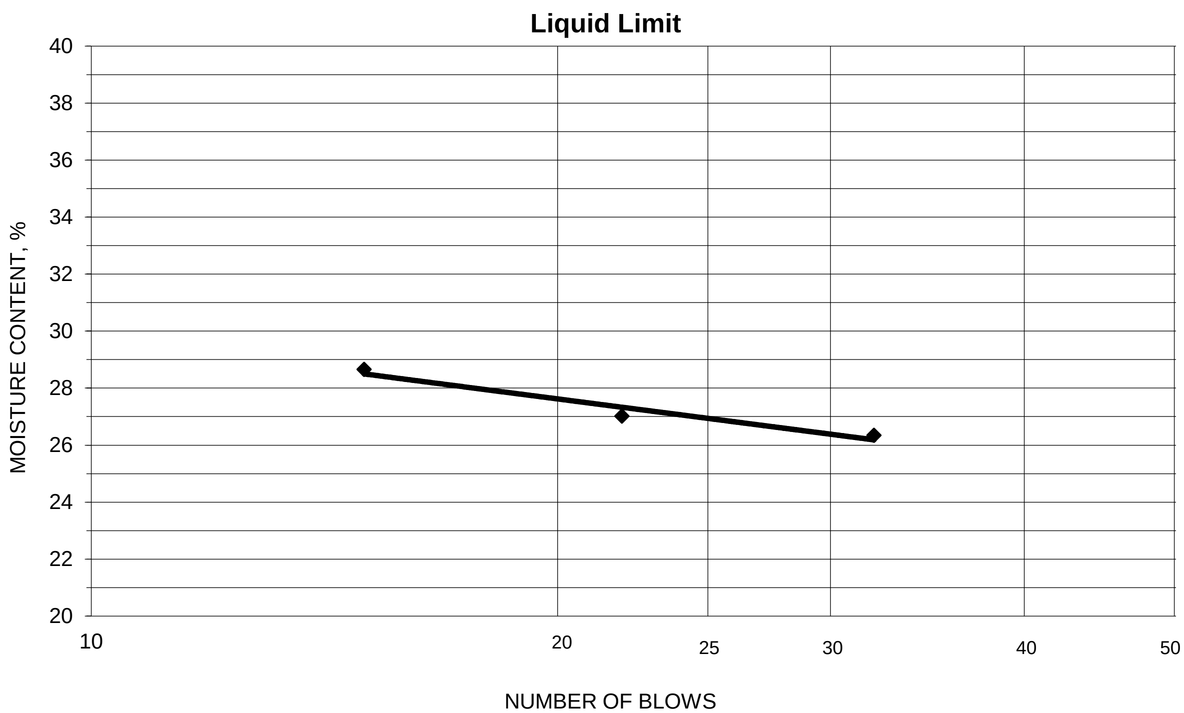
ATTERBERG LIMITS

Project	IKEC Clifty Creek	Project No.	175534018
Source	CF-19-80-84-89	Lab ID	8
		% + No. 40	65
Tested By	MP	Test Method	ASTM D 4318 Method A
Date Received	03-18-2019		
Test Date	03-19-2019	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
22.33	19.98	11.06	32	26.3	
22.20	19.82	11.01	22	27.0	
21.89	19.46	10.98	15	28.7	27



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
17.57	16.65	11.10	16.6	16	11
17.04	16.20	11.02	16.2		

Remarks:

Reviewed By JS

Particle-Size Analysis of Soils
ASTM D 422

Project Name	IKEC Clifty Creek	Project Number	175534018
Source	CF-19-80-84-89	Lab ID	8

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: GW
Test Date: 03-18-2019
Date Received: 03-18-2019

Maximum Particle size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	78.9
3/8"	61.7
No. 4	50.7
No. 10	41.1

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

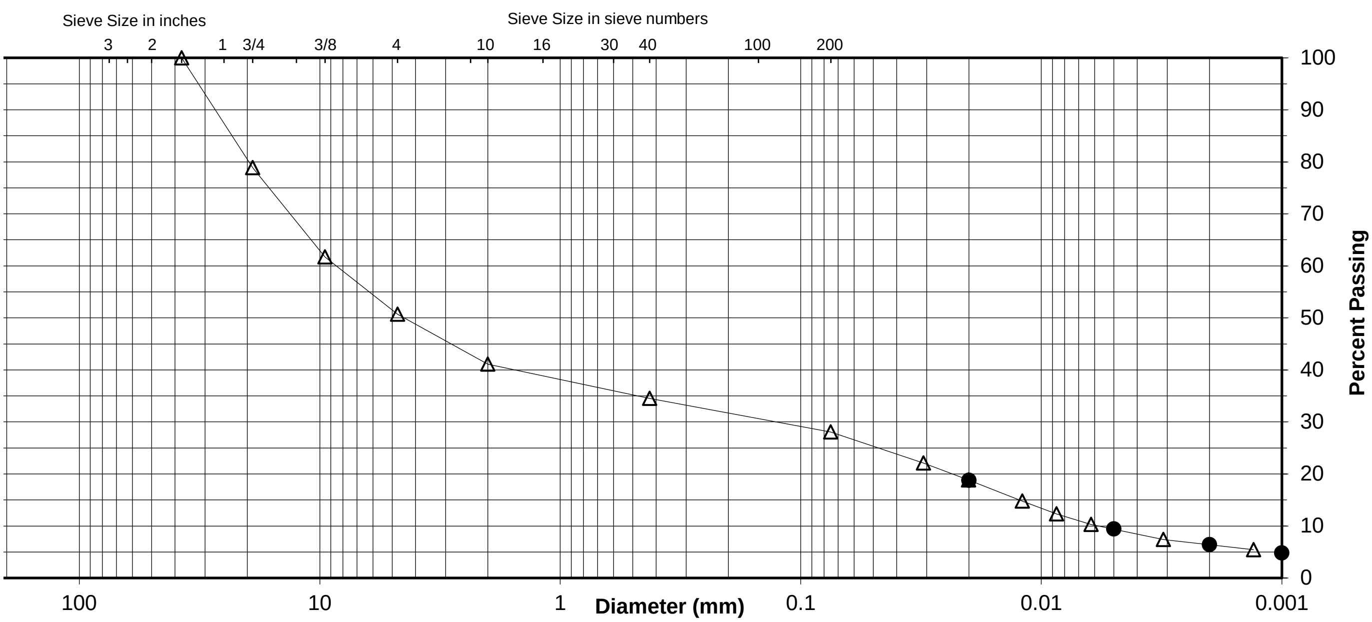
Dispersed using Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
No. 40	34.5
No. 200	28.0
0.02 mm	18.8
0.005 mm	9.4
0.002 mm	6.4
0.001 mm	4.8

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	21.1	28.2	9.6	6.6	6.5	18.6	9.4

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	58.9	6.6	6.5	21.6	6.4



Comments ______

Reviewed By JS

APPENDIX D

WELL BORING AND CONSTRUCTION LOGS

BORING NO. _____CF-19-08D _
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 2
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):	3/5/2019-3/6/2019	Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt.	160lb and Drop 2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water
Sampling Interval:	2’	Borehole Depth:	89’	Surface Elevation:	460.68’ MSL

NOTES/COMMENTS:

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.5	3-2-2-3	Orange brown sandy clay, moist	N/A
2-4	1.5	2-3-2-2	Orange brown sandy clay, moist	N/A
4-6	2	2-2-3-3	Orange brown sandy clay, moist	N/A
6-8	1.5	2-3-3-4	Orange brown sandy clay, moist	N/A
8-10	2	5-4-4-4	Orange brown sandy clay, moist	N/A
10-12	2	4-5-5-6	Orange brown sandy clay, moist	N/A
12-14	2	5-5-6-8	Orange brown sandy clay, moist	N/A
14-16	1.5	6-7-6-8	Orange brown sandy clay, wet; water at14 feet	N/A
16-18	1.5	4-4-8-8	Orange brown sandy clay, wet	N/A
18-20	1.5	6-6-7-8	Orange brown sandy clay, wet	N/A
20-22	2	5-5-5-7	Orange brown silty clay, fine sand, wet	N/A
22-24	2	3-2-3-4	Orange brown silty clay, fine sand, wet	N/A
24-26	2	2-4-6-7	Orange brown silty clay, fine sand, wet	N/A
26-28	2	6-7-7-18	26-27 orange brown silty clay, fine sand, wet; 27-28 orange brown till clay, very stiff, plastic, moist	N/A
28-30	2	3-3-8-8	Orange brown silty clay, fine sand, wet	N/A
30-32	2	7-8-11-16	Orange brown fine sand, some silt, wet	N/A
32-34	2	6-7-11-13	Orange brown fine sand, some silt, wet	N/A
34-36	2	6-6-8-10	Orange brown fine sand, some silt, wet	N/A

CONTINUED SAMPLE/CORE LOG
BORING CF-19-08D

Project No: 2019042 Geologist: Michael Gelles

36-38	2	6-8-6-10	Orange brown fine sand, some silt, wet	N/A
38-40	2	14-11-6-18	Orange brown fine sand, some silt, wet	N/A
40-42	2	6-8-9-11	Orange brown fine sand, some silt, wet	N/A
42-44	2	4-3-3-5	Orange brown fine sand, some silt, wet	N/A
44-46	1	2-3-4-7	Gray clay, lean, moist	N/A
46-48	1	6-7-8-4	Gray clay, lean, moist	N/A
48-50	0.6	4-5-6-4	Gray clay, lean, moist	N/A
50-52	1	3-4-5-6	Gray clay, lean, moist	N/A
52-54	1	2-3-4-3	Gray clay, lean, moist	N/A
54-56	1.5	3-3-3-3	Gray clay, lean, moist	N/A
56-58	2	2-4-6-6	Gray clay, lean, moist	N/A
58-60	2	3-5-8-8	Gray clay, lean, moist	N/A
60-62	2	5-6-7-8	Gray clay, lean, moist	N/A
62-64	1	1-1-1-1	Gray clay, lean, moist	N/A
64-66	1	1-1-1-2	Gray clay, lean, moist	N/A
66-68	2	4-6-7-6	Gray clay, lean, moist	N/A
68-70	2	5-4-5-9	Gray clay, lean, moist	N/A
70-72	2	5-7-9-9	Gray clay, lean, some silt and sand, moist	N/A
72-74	2	4-5-8-9	Gray clay, lean, some silt and sand, moist	N/A
74-76	2	7-6-7-8	Gray clay, lean, some silt and sand, moist	N/A
76-78	2	5-6-8-9	Gray clay, lean, some silt and sand, moist	N/A
78-80	2	8-4-8-6	Gray clay, lean, some silt and sand, trace gravel, moist	N/A
80-82	1.5	7-8-9-5	Gray clay, lean, some silt and sand, trace gravel, moist	N/A
82-84	2	3-4-4-4	Gray clay, lean, some silt, trace sand, moist	N/A
84-86	0.8	13-15-15-22	Orange brown silty clay, gravel, wet	N/A
86-88	1.2	10-12-15-20	Orange brown silty clay, gravel, wet	N/A
88-89	0.75	8-100/2	88-88.5 orange brown silty clay, gravel, wet; 88.5-88.75 refusal gray limestone	N/A

WELL CONSTRUCTION LOG
WELL NO. CF-19-08D

Project Number: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/5/2019-3/8/2019

Drilling Method: Hollow Stem Auger

Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/20/2019

Development Method: Submersible Pump and Bladder Pump

Field parameters stabilized.

Volume Purged: 52 gallons

Static Water-Level*: 20.71’

Top of Well Casing Elevation: 463.49’

Well Purpose:
Groundwater Monitoring

Northing (Y): 443224.617

Easting (X): 562551.033

Comments/Notes:
2 inch PVC riser and screen

5 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.

Inspector: Michael Gelles

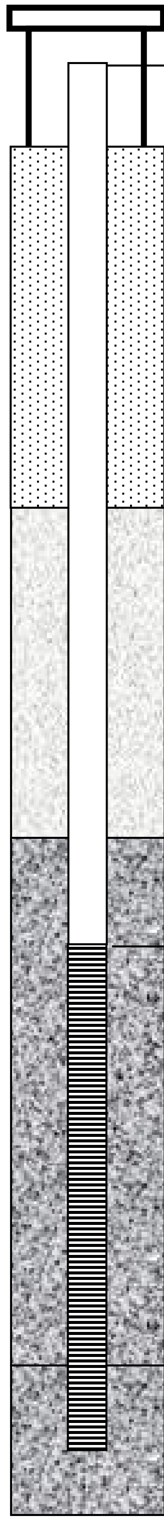
CONSTRUCTION MATERIALS USED:

3.5 Bags of Sand

1 Bags/Buckets Bentonite Pellets

10 Bags Portland for Grout

____ Bags Concrete/Sakrete



Protective Casing with Locking Cap

Top of Casing Elevation: 463.49 ft.

Stick-up: 2.81 ft.

Land Surface Elevation: 460.68 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch

Casing Material: PVC

Top of Seal: 81 ft*

Seal Type: Bentonite Pellets/Chips

Top of Sand/Gravel Pack: 83 ft*

Top of Well Screen 84 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch

Screen Slot-Size: 0.010 Inch

Screen Material: PVC

Bottom of Well Screen 89 ft.*

Base of Borehole: 89 ft.*

Total Depth of Well Below Top of Casing: 91.81 ft.

*Indicates Depth Below Land Surface

BORING NO. _____CF-19-14 _
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 1
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):	3/7/2019	Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt.	160lb and Drop 2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water
Sampling Interval:	2’	Borehole Depth:	20’	Surface Elevation:	452.29’ msl

NOTES/COMMENTS:

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.5	1-2-2-2	Brown silty clay, moist	N/A
2-4	1.5	3-3-6-7	Brown silty clay, moist	N/A
4-6	2	3-4-6-7	Brown silty clay, moist	N/A
6-8	2	7-8-6-7	Orange brown silty clay, moist	N/A
8-10	2	4-6-5-6	Orange brown silty clay, moist	N/A
10-12	2	2-3-4-3	Orange brown silty clay, moist	N/A
12-14	1.5	2-2-3-4	Orange brown silty clay, moist	N/A
14-16	2	3-2-2-3	Orange brown silty clay, wet, water at 14 feet	N/A
16-18	2	3-2-2-3	Orange brown silty clay, wet	N/A
18-20	1.5	6-1-3-100/4	Orange brown silty clay, wet; refusal gray limestone	N/A

WELL CONSTRUCTION LOG
WELL NO. CF-19-14

Project Number: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/7/2019-3/8/2019

Drilling Method: Hollow Stem Auger

Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/20/2019

Development Method: Submersible Pump and Bladder Pump

Field parameters stabilized.

Volume Purged: 16.5 gallons

Static Water-Level*: 7.09’

Top of Well Casing Elevation: 454.88’

Well Purpose:
Groundwater Monitoring

Northing (Y): 443401.75

Easting (X): 562901.929

Comments/Notes:
2 inch PVC riser and screen

10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.

Inspector: Michael Gelles

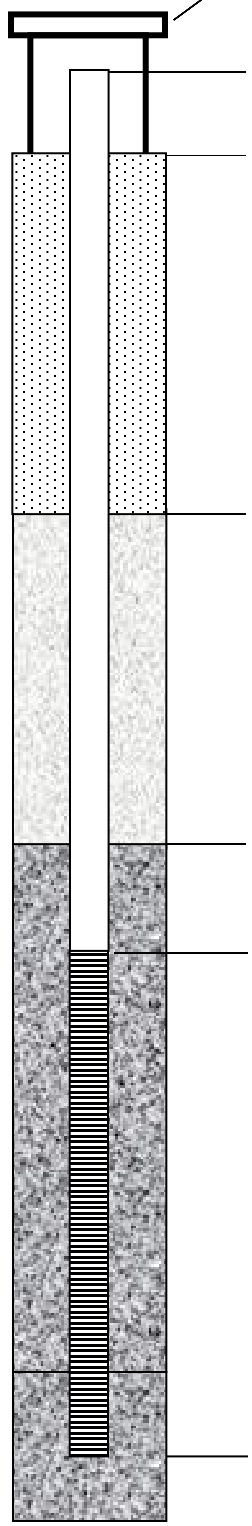
CONSTRUCTION MATERIALS USED:

6.5 Bags of Sand

1 Bags/Buckets Bentonite Pellets

2 Bags Portland for Grout

____ Bags Concrete/Sakrete



Protective Casing with Locking Cap

Top of Casing Elevation: 454.88 ft.

Stick-up: 2.59 ft.

Land Surface Elevation: 452.29 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch

Casing Material: PVC

Top of Seal: 7 ft*

Seal Type: Bentonite Pellets/Chips

Top of Sand/Gravel Pack: 9 ft*

Top of Well Screen 10 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch

Screen Slot-Size: 0.010 Inch

Screen Material: PVC

Bottom of Well Screen 20 ft.*

Base of Borehole: 20 ft.*

Total Depth of Well Below Top of Casing: 22.59 ft.

*Indicates Depth Below Land Surface

BORING NO. _____CF-19-15 _
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 1
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):		Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt.	160lb	and Drop	2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water		
Sampling Interval:	2’	Borehole Depth:	33’	Surface Elevation:	441.10’ msl		

NOTES/COMMENTS:

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-33	NA	NA	Advanced augers – no samples (see CF-19-15D log)	N/A

WELL CONSTRUCTION LOG
WELL NO. CF-19-15

Project Number: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/13/2019

Drilling Method: Hollow Stem Auger

Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/21/2019

Development Method: Submersible Pump and Bladder Pump

Field parameters stabilized.

Volume Purged: 24 gallons

Static Water-Level* 9.90’

Top of Well Casing Elevation: 443.61’

Well Purpose:
Groundwater Monitoring

Northing (Y): 442704.784

Easting (X): 562483.023

Comments/Notes:
2 inch PVC riser and screen

10 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.

Inspector: Michael Gelles

CONSTRUCTION MATERIALS USED:

6 Bags of Sand

1 Bags/Buckets Bentonite Pellets

3 Bags Portland for Grout

____ Bags Concrete/Sakrete

Protective Casing with Locking Cap

Top of Casing Elevation: 443.61 ft.

Stick-up: 2.51 ft.

Land Surface Elevation: 441.10 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch

Casing Material: PVC

Top of Seal: 20 ft*

Seal Type: Bentonite Pellets

Top of Sand/Gravel Pack: 22 ft*

Top of Well Screen 23 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch

Screen Slot-Size: 0.010 Inch

Screen Material: PVC

Bottom of Well Screen 33 ft.*

Base of Borehole: 33 ft.*

Total Depth of Well Below Top of Casing: 35.51 ft.

*Indicates Depth Below Land Surface

BORING NO. CF-19-15D
SAMPLE/CORE LOG

Project Number:	2019042	Log Page	1 of 2
Project Location:	Clifty Creek Plant LRCP	Drilling Contractor:	Bowser Morner
Drilling Date(s):	3/11/2019-3/12/2019	Geologist:	Michael Gelles

Drilling Method:	Hollow Stem Auger	Coring Device Size:	NA	Hammer Wt.	160lb and Drop 2ft
Sampling Method:	Split Spoon	Borehole Diameter:	6”	Drilling Fluid Used:	Water
Sampling Interval:	2’	Borehole Depth:	72’	Surface Elevation:	441.78’ MSL

NOTES/COMMENTS:

Depth Interval (feet)	Sample Recovery (feet)	Penetration (Hyd. Pres. or Blow Counts)	Sample/Core Description	PID (PPM)
0-2	1.5	1-1-3-3	Brown silty clay, sand, moist	N/A
2-4	1.5	2-2-3-3	Brown silty clay, sand, moist	N/A
4-6	1.5	1-2-4-5	Brown silty clay, sand, moist	N/A
6-8	1.5	1-3-4-5	Brown silty clay, sand, moist	N/A
8-10	2	4-4-6-8	Brown silty clay, sand, moist	N/A
10-12	2	4-3-5-7	Brown silty clay, sand, moist	N/A
12-14	2	2-3-5-7	Orange brown silty clay, sand, moist	N/A
14-16	2	3-4-5-5	Orange brown silty clay, sand, moist	N/A
16-18	2	4-5-5-6	Orange brown silty clay, sand, moist	N/A
18-20	2	2-4-5-6	Orange brown silty clay, sand, moist	N/A
20-22	2	2-3-3-5	Orange brown silty clay, sand, moist	N/A
22-24	2	2-3-4-5	Gray silty clay, sand, moist	N/A
24-26	2	2-2-3-4	Gray silty clay, sand, moist	N/A
26-28	2	2-3-3-4	Orange brown silty clay, sand, gravel, wet	N/A
28-30	2	1-2-3-5	Orange brown silty clay, sand, gravel, wet	N/A
30-32	2	3-4-7-8	Orange brown silty clay, sand, gravel, wet	N/A
32-34	2	3-2-6-4	32-33 orange brown silty clay, sand, gravel, wet; 33-34 gray clay, lean, moist	N/A
34-36	2	4-4-4-5	Gray clay, lean, moist	N/A

CONTINUED SAMPLE/CORE LOG
BORING CF-19-15D

Project No: 2019042 Geologist: Michael Gelles

36-38	2	4-5-4-5	Gray clay, lean, moist	N/A
38-40	0.5	4-4-4-5	Gray clay, lean, moist	N/A
40-42	2	3-4-6-7	Gray clay, lean, moist	N/A
42-44	2	3-4-6-8	Gray clay, lean, moist	N/A
44-46	2	3-3-5-6	Gray clay, lean, moist	N/A
46-48	2	6-6-7-8	Gray clay, lean, moist	N/A
48-50	2	6-5-7-8	Gray clay, lean, moist	N/A
50-52	2	3-4-4-5	Gray clay, lean, moist	N/A
52-54	2	8-7-5-5	Gray clay, lean, moist	N/A
54-56	2	2-2-2-4	Gray clay, lean, moist	N/A
56-58	2	3-3-4-5	Gray clay, lean, moist	N/A
58-60	2	4-6-7-8	Gray clay, lean, moist	N/A
60-62	1.5	8-7-7-7	Gray clay, lean, moist	N/A
62-64	2	7-5-7-9	Gray clay, lean, moist	N/A
64-66	2	9-7-8-7	Gray silty clay, gravel, sand, wet; water at 64 feet	N/A
66-68	2	9-10-8-15	Gray silty clay, gravel, sand, wet	N/A
68-70	1	12-15-18-50	Gray silty clay, gravel, sand, wet	N/A
70-72	0.1	100/2	Refusal gray limestone	N/A

WELL CONSTRUCTION LOG
WELL NO. CF-19-15D

Project Number: 2019042

Project Location: Clifty Creek Plant – LRCP

Installation Date(s): 3/11/2019-3/12/2019

Drilling Method: Hollow Stem Auger

Drilling Contractor: Bowser Morner

Development Date(s): 3/14/2019-3/21/2019

Development Method: Submersible Pump and Bladder Pump

Field parameters stabilized.

Volume Purged: 48 gallons

Static Water-Level*: 15.51’

Top of Well Casing Elevation: 444.34’

Well Purpose:
Groundwater Monitoring

Northing (Y): 442713.897

Easting (X): 562487.596

Comments/Notes:
2 inch PVC riser and screen

5 ft of 0.010 pre-packed well screen with an inner filter pack of 0.40 mm clean quartz sand and an outer layer of food-grade nylon mesh.

Inspector: Michael Gelles

CONSTRUCTION MATERIALS USED:

3.5 Bags of Sand

1 Bags/Buckets Bentonite Pellets

6 Bags Portland for Grout

____ Bags Concrete/Sakrete

Protective Casing with Locking Cap

Top of Casing Elevation: 444.34 ft.

Stick-up: 2.56 ft.

Land Surface Elevation: 441.78 ft.

Grout; Type: Portland cement/ Grout

Borehole Diameter: 6 inch

Casing Diameter: 2 Inch

Casing Material: PVC

Top of Seal: 62 ft*

Seal Type: Bentonite Pellets

Top of Sand/Gravel Pack: 64 ft*

Top of Well Screen 65 ft*

Sand/Gravel Pack; Type: Global #5

Screen Diameter: 2 Inch

Screen Slot-Size: 0.010 Inch

Screen Material: PVC

Bottom of Well Screen 70 ft.*

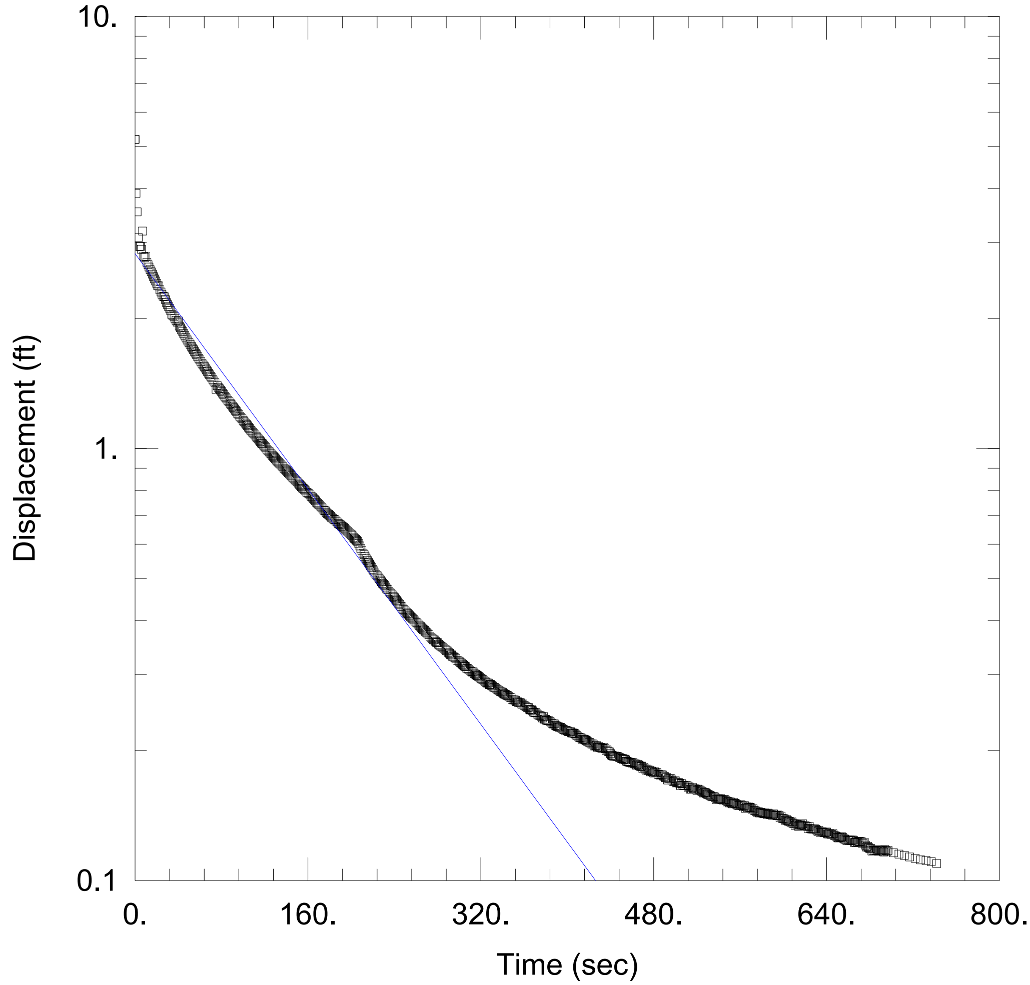
Base of Borehole: 70 ft.*

Total Depth of Well Below Top of Casing: 72.56 ft.

*Indicates Depth Below Land Surface

APPENDIX E

SLUG TEST RESULTS



CF-19-08D-IN1

Data Set: \...\CF-19-08D-IN1.aqt
Date: 05/31/19 Time: 14:23:10

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 1.

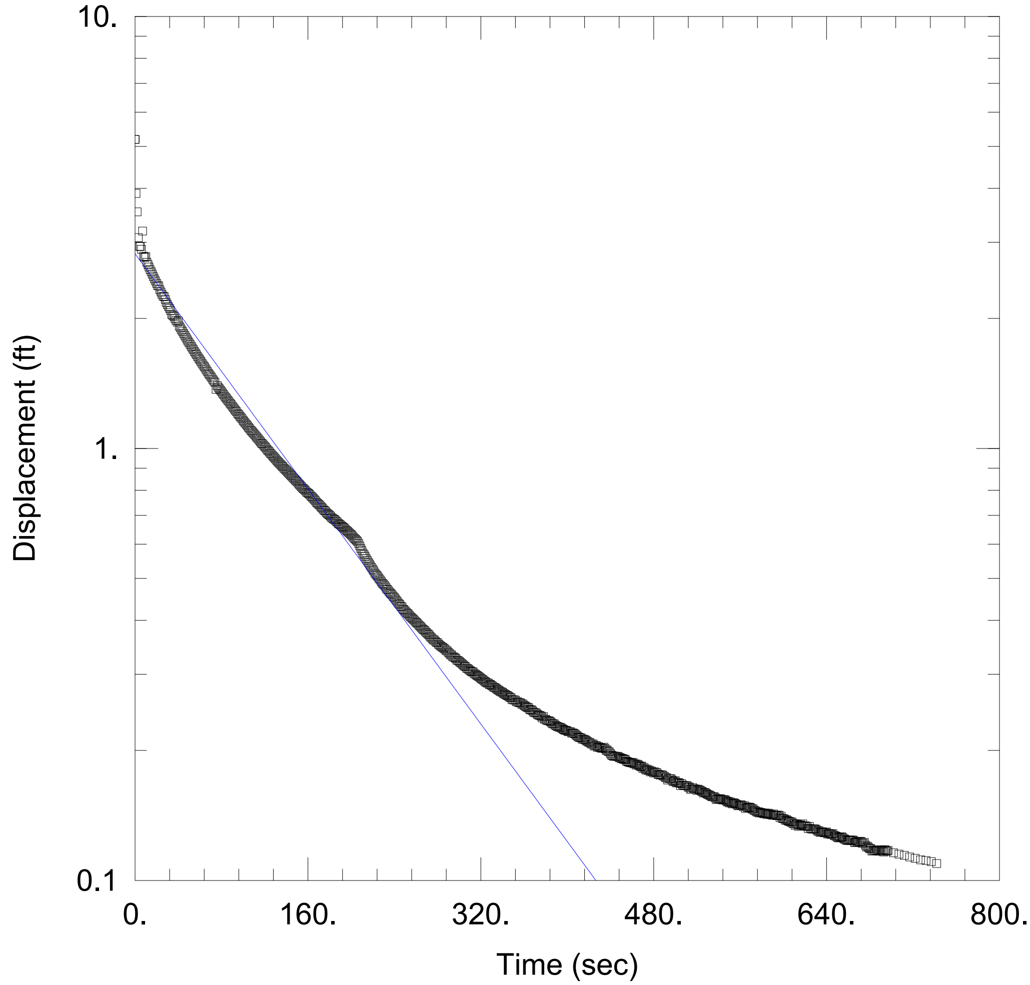
WELL DATA (CF-19-08D)

Initial Displacement: 5.191 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft
Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.361E-5 ft/sec y0 = 2.823 ft



CF-19-08D-IN1

Data Set: \...\CF-19-08D-IN1.aqt
Date: 05/31/19 Time: 14:23:38

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 1.

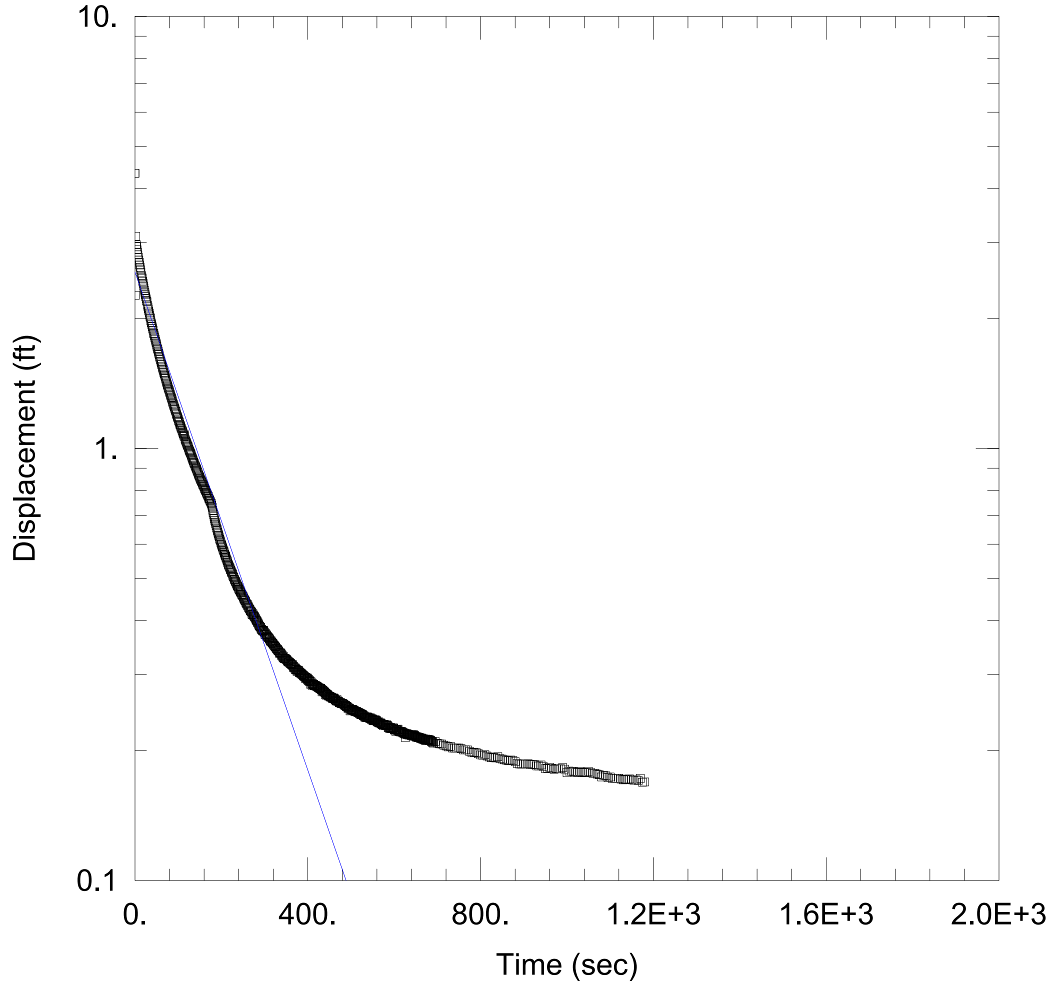
WELL DATA (CF-19-08D)

Initial Displacement: 5.191 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft
Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.429E-5 ft/sec y0 = 2.822 ft



CF-19-08D-IN2

Data Set: \...\CF-19-08D-IN2.aqt
Date: 05/31/19
Time: 14:27:00

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 1.

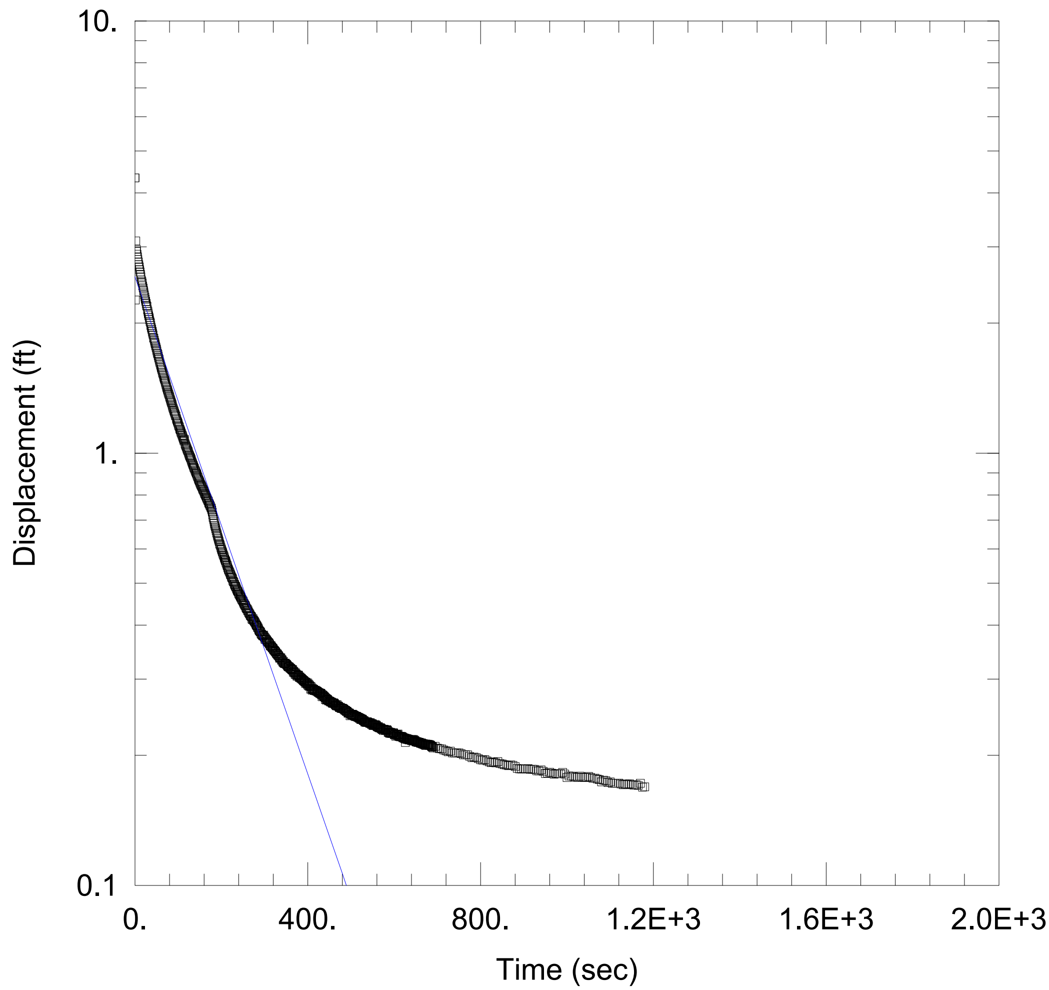
WELL DATA (CF-19-08D)

Initial Displacement: 4.335 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft
Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.152E-5 ft/sec
y0 = 2.561 ft



CF-19-08D-IN2

Data Set: \...\CF-19-08D-IN2.aqt
Date: 05/31/19 Time: 14:27:28

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft Anisotropy Ratio (Kz/Kr): 1.

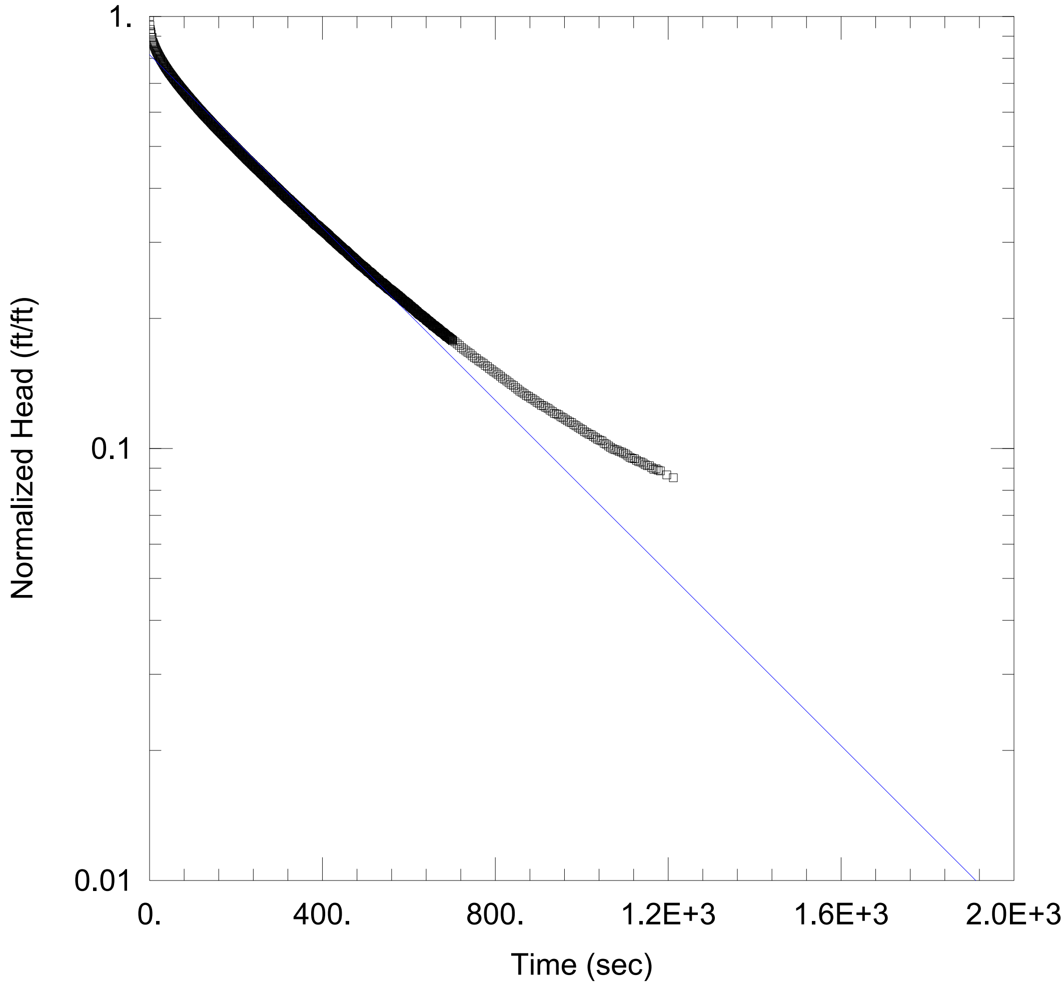
WELL DATA (CF-19-08D)

Initial Displacement: 4.335 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft
Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.209E-5 ft/sec y0 = 2.559 ft



CF-19-08D-OUT1

Data Set: \...\CF-19-08D-OUT1.aqt
Date: 05/31/19 Time: 14:18:00

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 1.

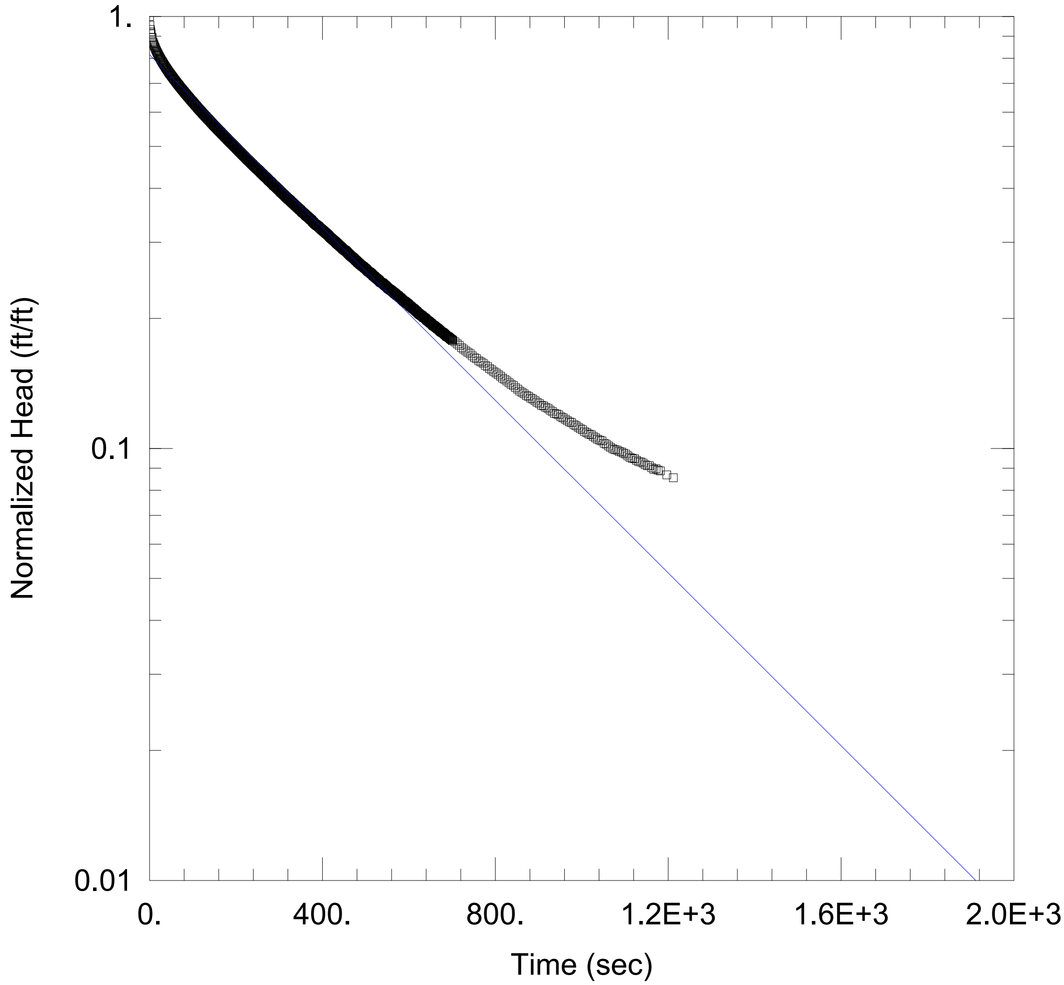
WELL DATA (CF-19-08D)

Initial Displacement: -3.113 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft
Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.995E-6 ft/sec
y0 = -2.537 ft



CF-19-08D-OUT1

Data Set: \...\CF-19-08D-OUT1.aqt
Date: 05/31/19 Time: 14:19:05

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 1.

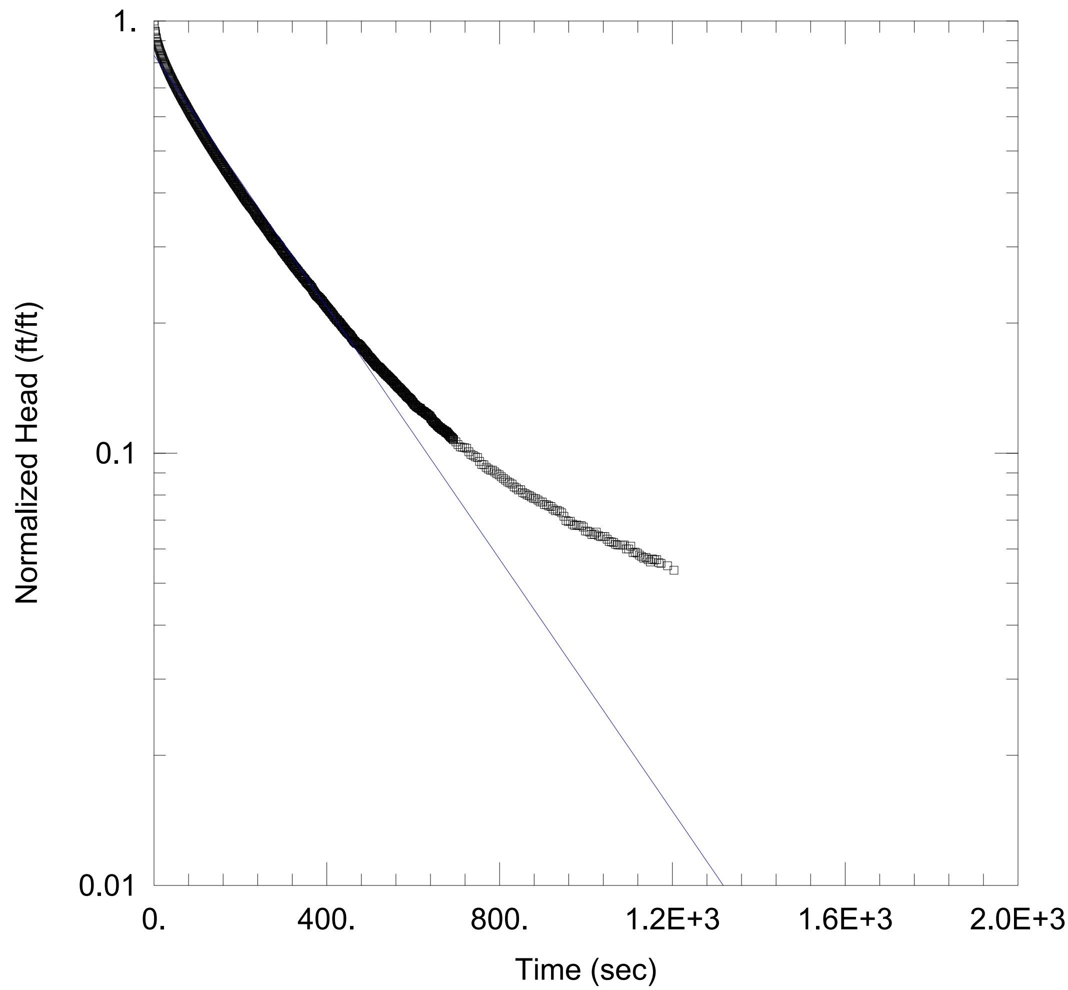
WELL DATA (CF-19-08D)

Initial Displacement: -3.113 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft
Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.201E-6 ft/sec
y0 = -2.537 ft



CF-19-08D-OUT2

Data Set: \...\CF-19-08D-OUT2.aqt
Date: 05/31/19 Time: 14:34:49

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 1.

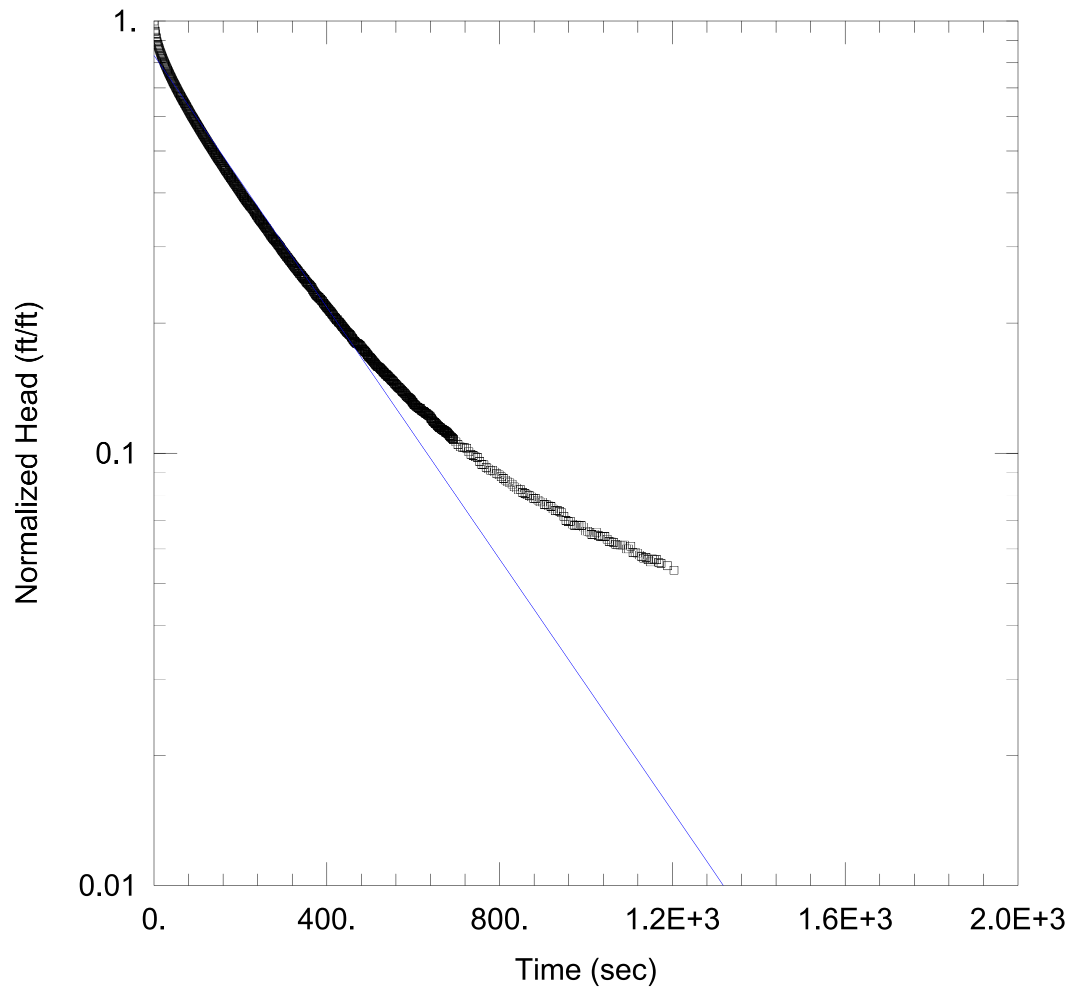
WELL DATA (CF-19-08D)

Initial Displacement: -2.969 ft
Total Well Penetration Depth: 89.9 ft
Casing Radius: 0.083 ft
Static Water Column Height: 65.31 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 5.823E-6 ft/sec
y0 = -2.472 ft



CF-19-08D-OUT2

Data Set: \...\CF-19-08D-OUT2.aqt
Date: 05/31/19 Time: 14:35:28

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-08D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 1.

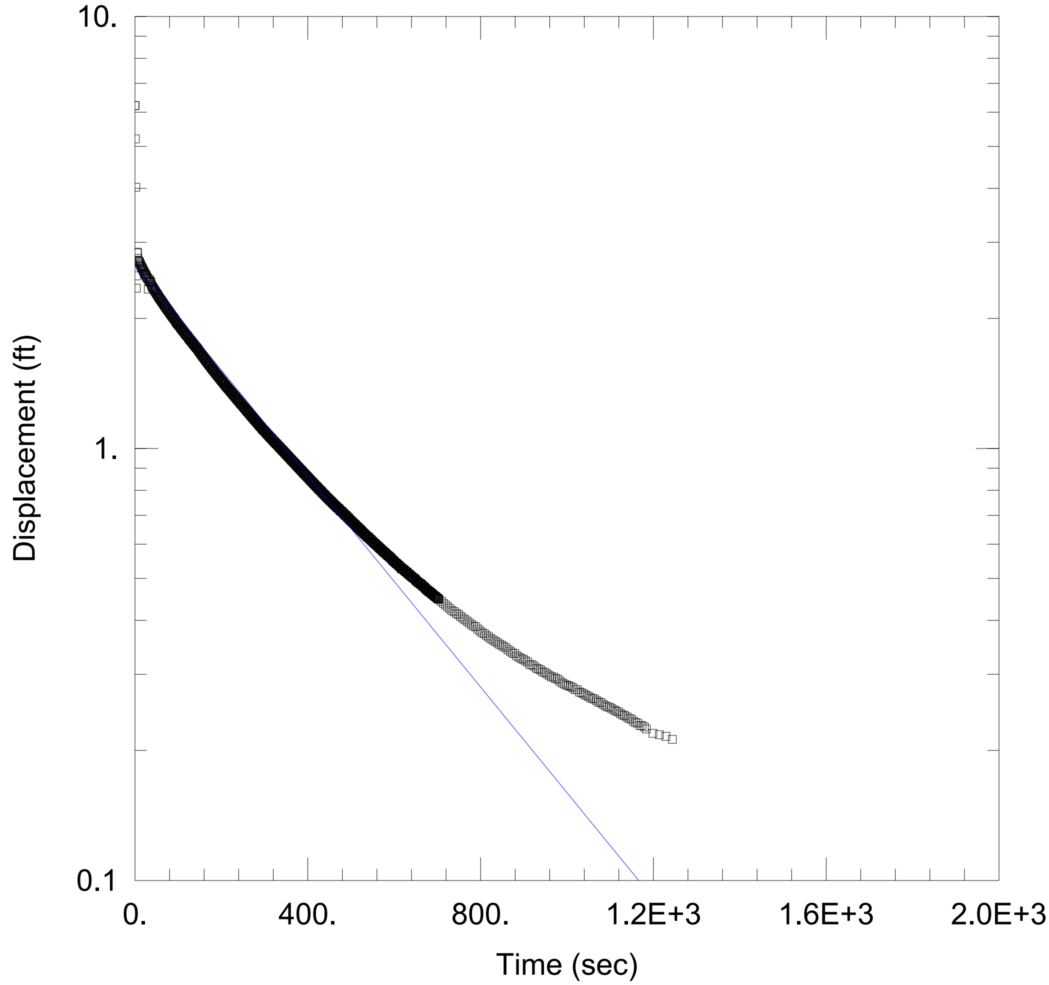
WELL DATA (CF-19-08D)

Initial Displacement: -2.969 ft
Static Water Column Height: 65.31 ft
Total Well Penetration Depth: 89.9 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 6.122E-6 ft/sec
y0 = -2.471 ft



CF-19-14-IN1

Data Set: \...\cf-19-14-in1.aqt
Date: 05/30/19 Time: 14:52:50

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-14
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-14)

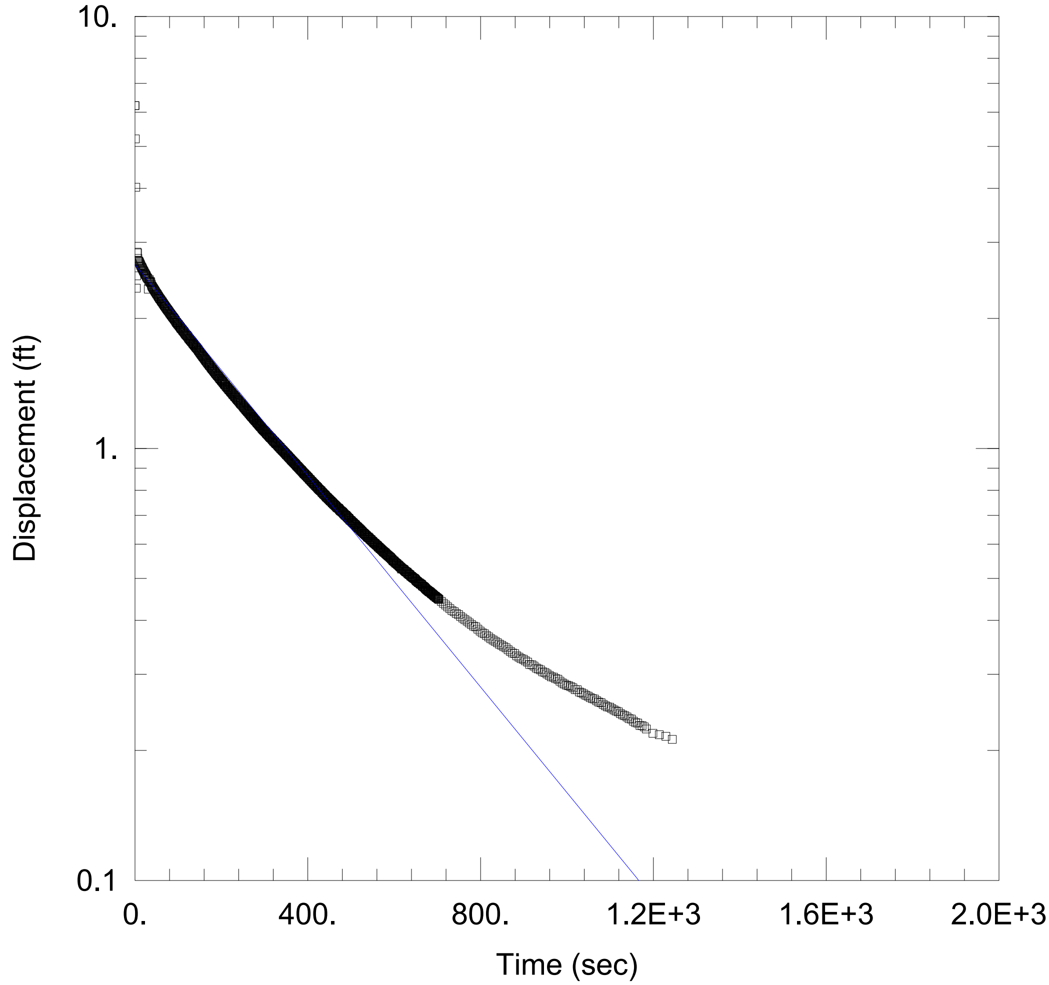
Initial Displacement: 6.214 ft
Total Well Penetration Depth: 22. ft
Casing Radius: 0.0833 ft

Static Water Column Height: 14.05 ft
Screen Length: 10. ft
Well Radius: 0.0833 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 4.099E-6 ft/sec y0 = 2.666 ft



CF-19-14-IN1

Data Set: \...\cf-19-14-in1.aqt
Date: 05/30/19 Time: 14:53:35

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-14
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft
Anisotropy Ratio (Kz/Kr): 1.

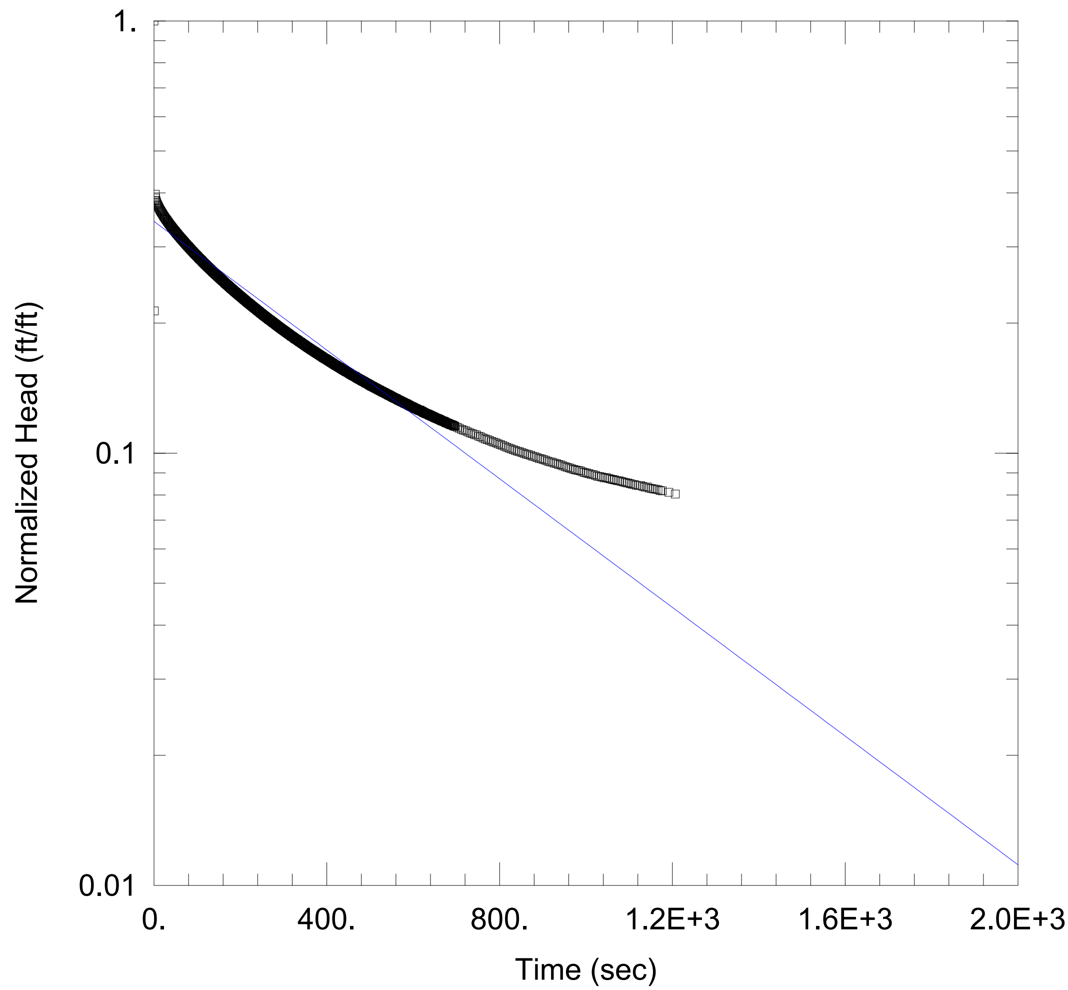
WELL DATA (CF-19-14)

Initial Displacement: 6.214 ft
Total Well Penetration Depth: 22. ft
Casing Radius: 0.0833 ft
Static Water Column Height: 14.05 ft
Screen Length: 10. ft
Well Radius: 0.0833 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.354E-6 ft/sec
y0 = 2.666 ft



CF-19-14-OUT2

Data Set: \...\CF-19-14-OUT2.aqt
Date: 05/30/19 Time: 14:57:13

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-14
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-14)

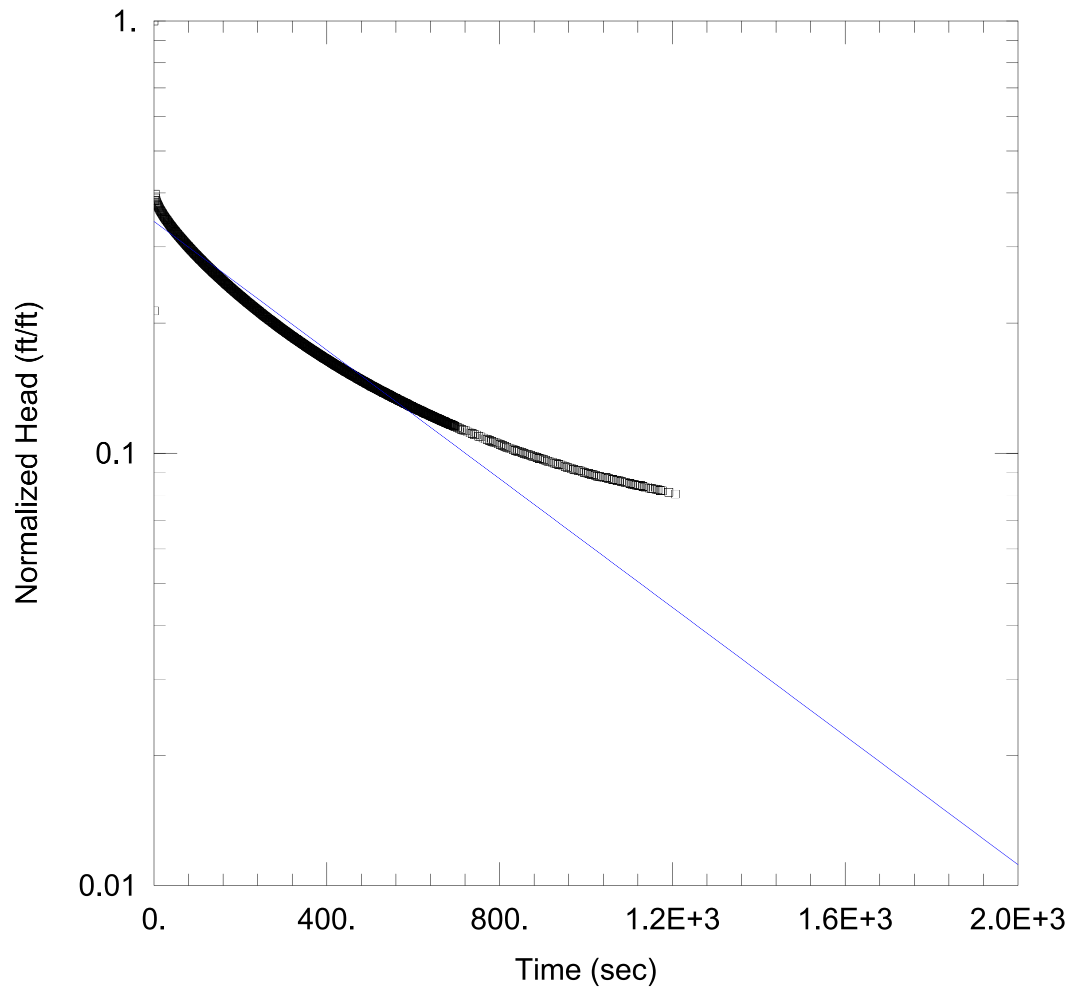
Initial Displacement: -7.572 ft
Total Well Penetration Depth: 22.24 ft
Casing Radius: 0.0833 ft

Static Water Column Height: 14.05 ft
Screen Length: 10. ft
Well Radius: 0.0833 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.498E-6 ft/sec y0 = -2.602 ft



CF-19-14-OUT2

Data Set: \...\CF-19-14-OUT2.aqt
Date: 05/30/19 Time: 14:58:10

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-14
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 14.05 ft
Anisotropy Ratio (Kz/Kr): 1.

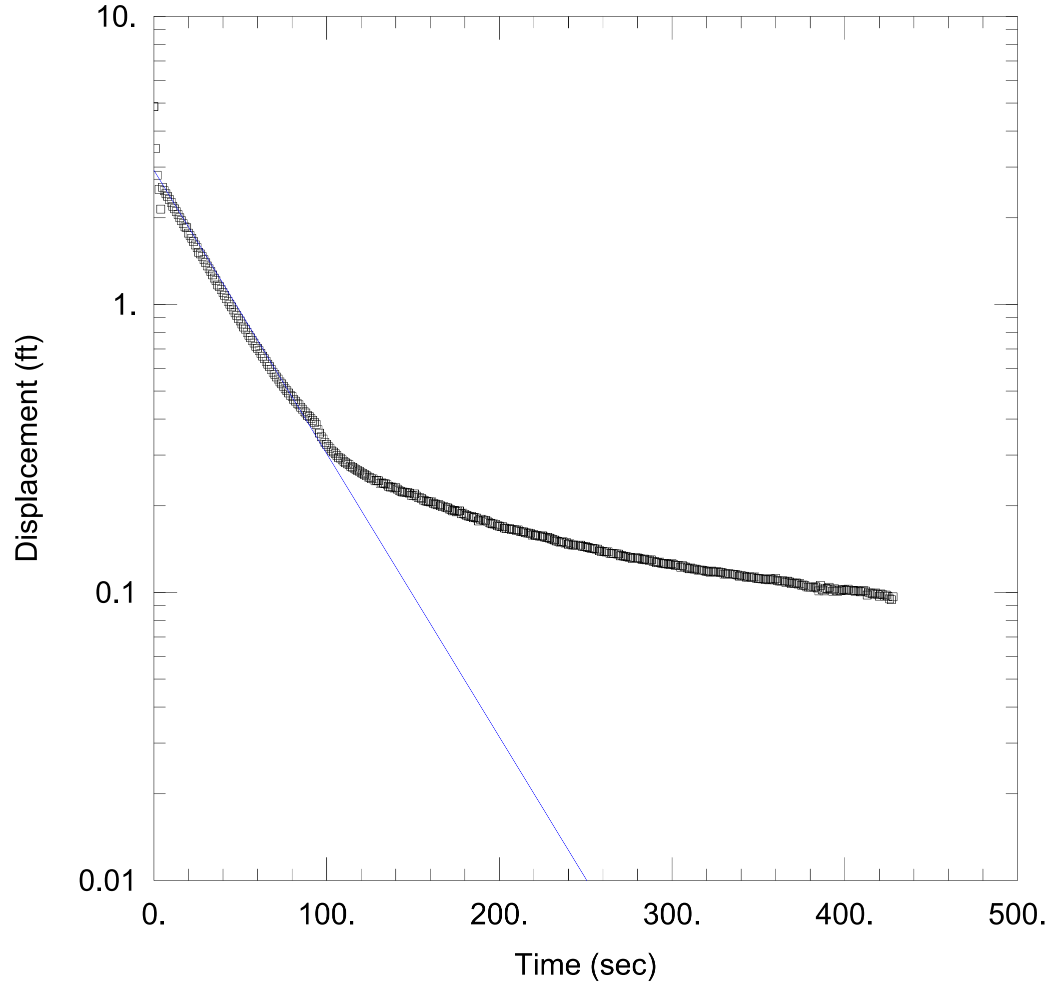
WELL DATA (CF-19-14)

Initial Displacement: -7.572 ft
Total Well Penetration Depth: 22.24 ft
Casing Radius: 0.0833 ft
Static Water Column Height: 14.05 ft
Screen Length: 10. ft
Well Radius: 0.0833 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.258E-6 ft/sec
y0 = -2.602 ft



CF-19-15D-IN1

Data Set: \...\CF-19-15DIN1.aqt
Date: 05/31/19 Time: 13:51:42

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

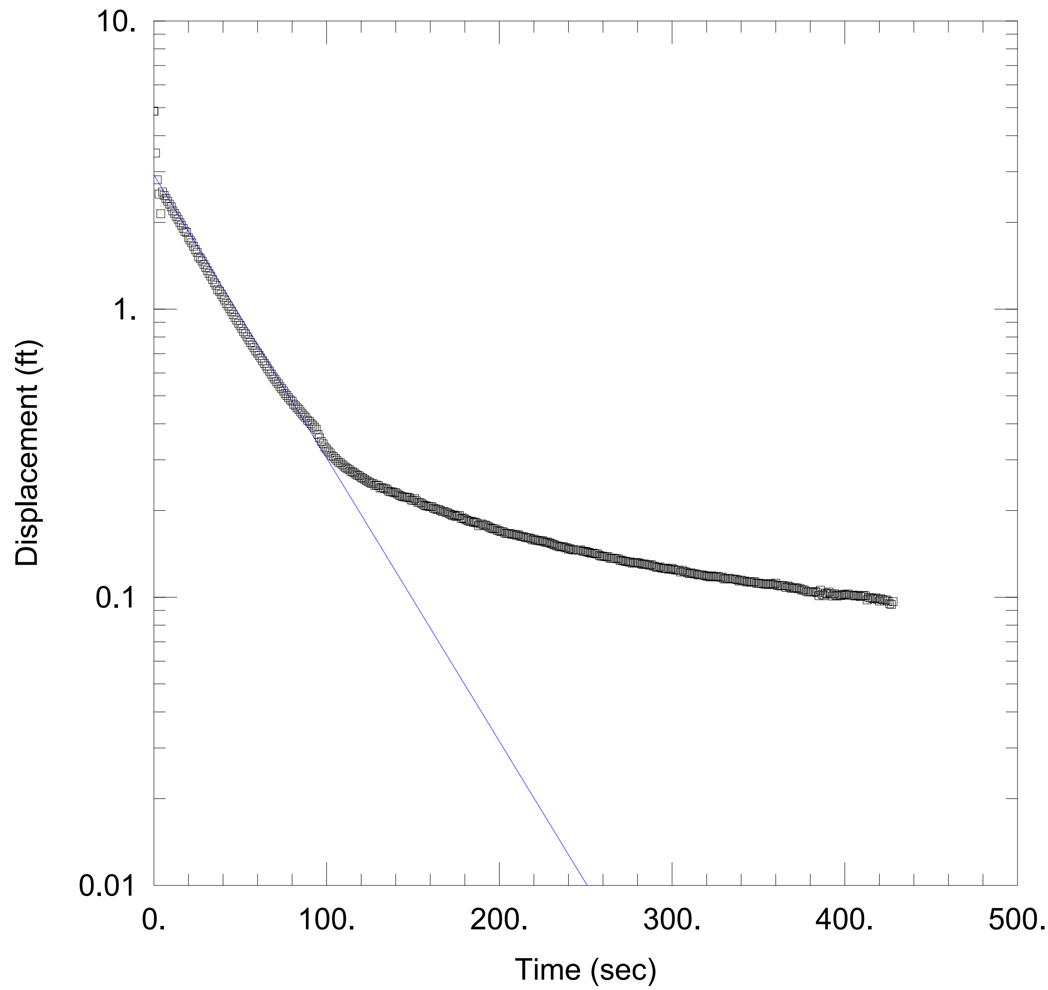
Initial Displacement: 4.865 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 4.728E-5 ft/sec y0 = 2.923 ft



CF-19-15D-IN1

Data Set: \...\CF-19-15DIN1.aqt
Date: 05/31/19 Time: 13:52:37

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft Anisotropy Ratio (Kz/Kr): 1.

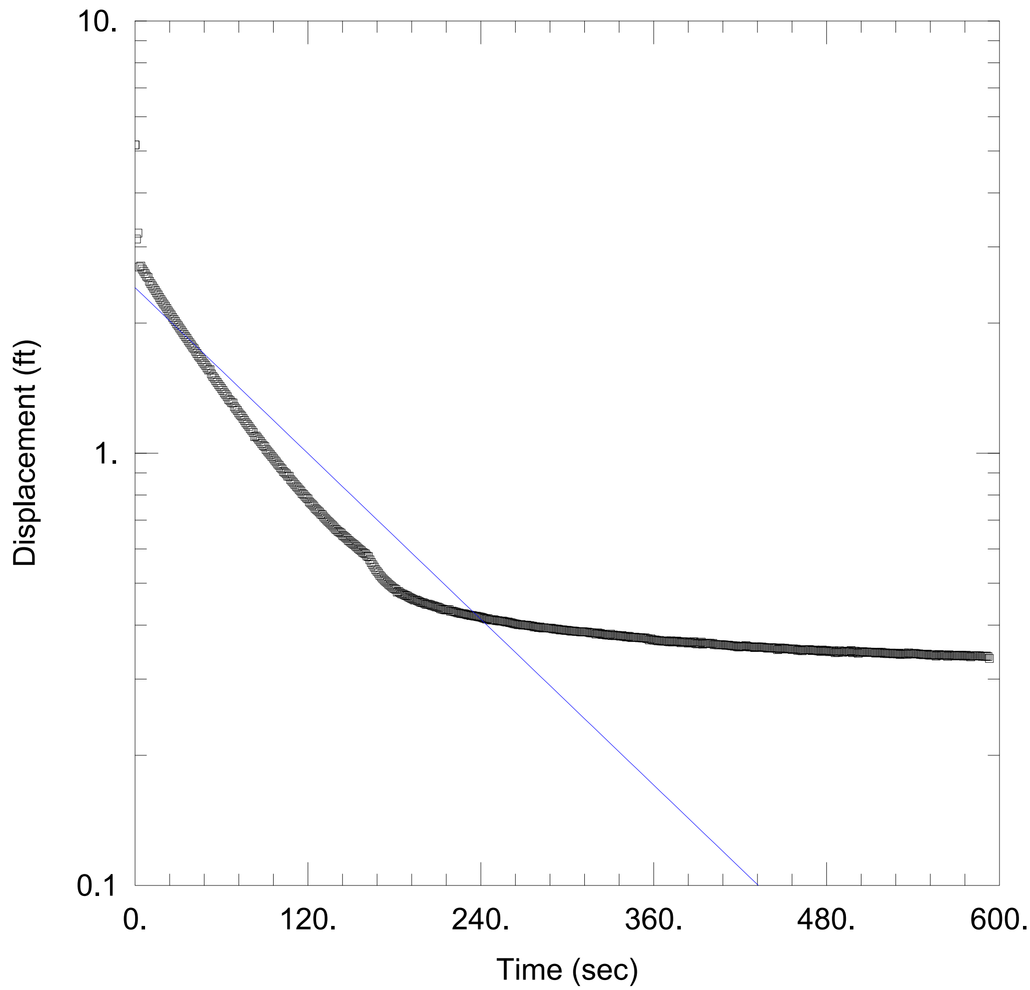
WELL DATA (CF-19-15D)

Initial Displacement: 4.865 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft
Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 5.163E-5 ft/sec y0 = 2.922 ft



CF-19-15D-IN2

Data Set: \...\CF-19-15D-IN2.aqt
Date: 05/31/19 Time: 13:55:33

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15D)

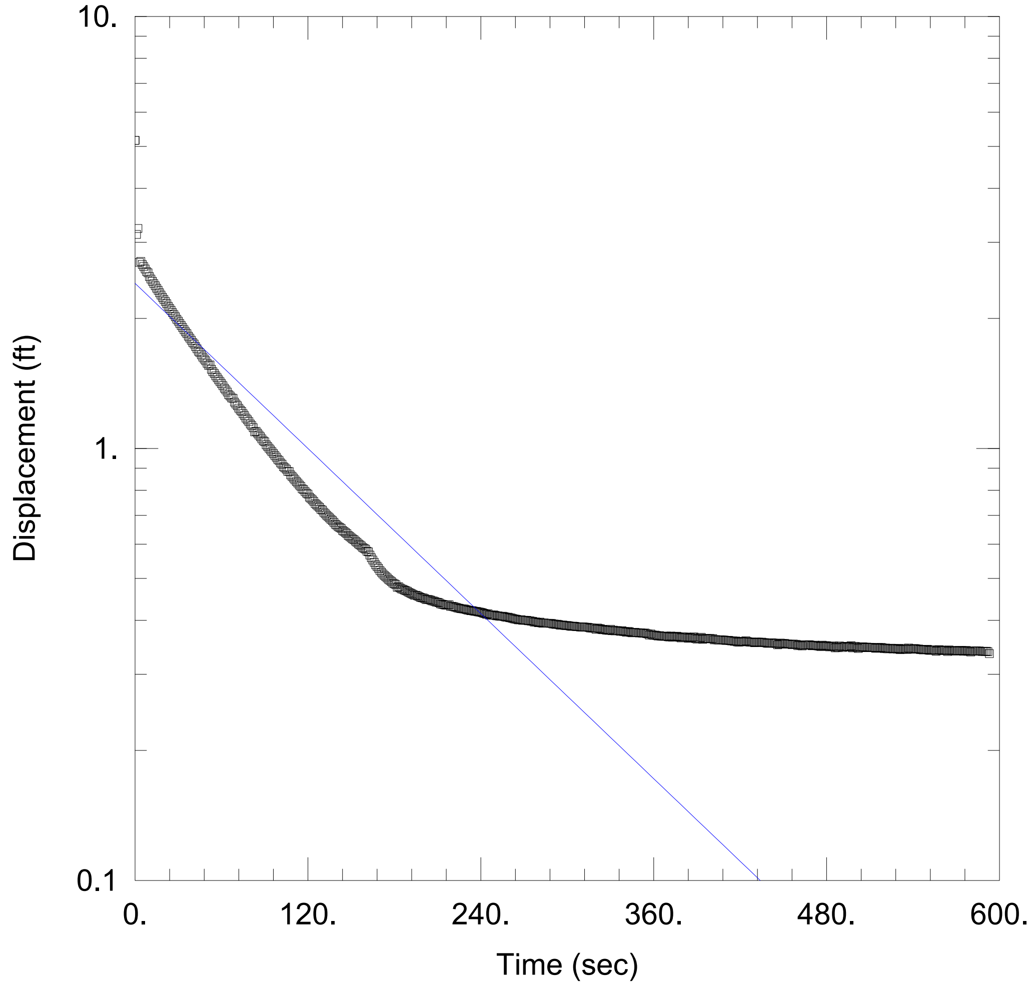
Initial Displacement: 5.168 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft

Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.536E-5 ft/sec y0 = 2.415 ft



CF-19-15D-IN2

Data Set: \...\CF-19-15D-IN2.aqt
Date: 05/31/19 Time: 13:56:41

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft
Anisotropy Ratio (Kz/Kr): 1.

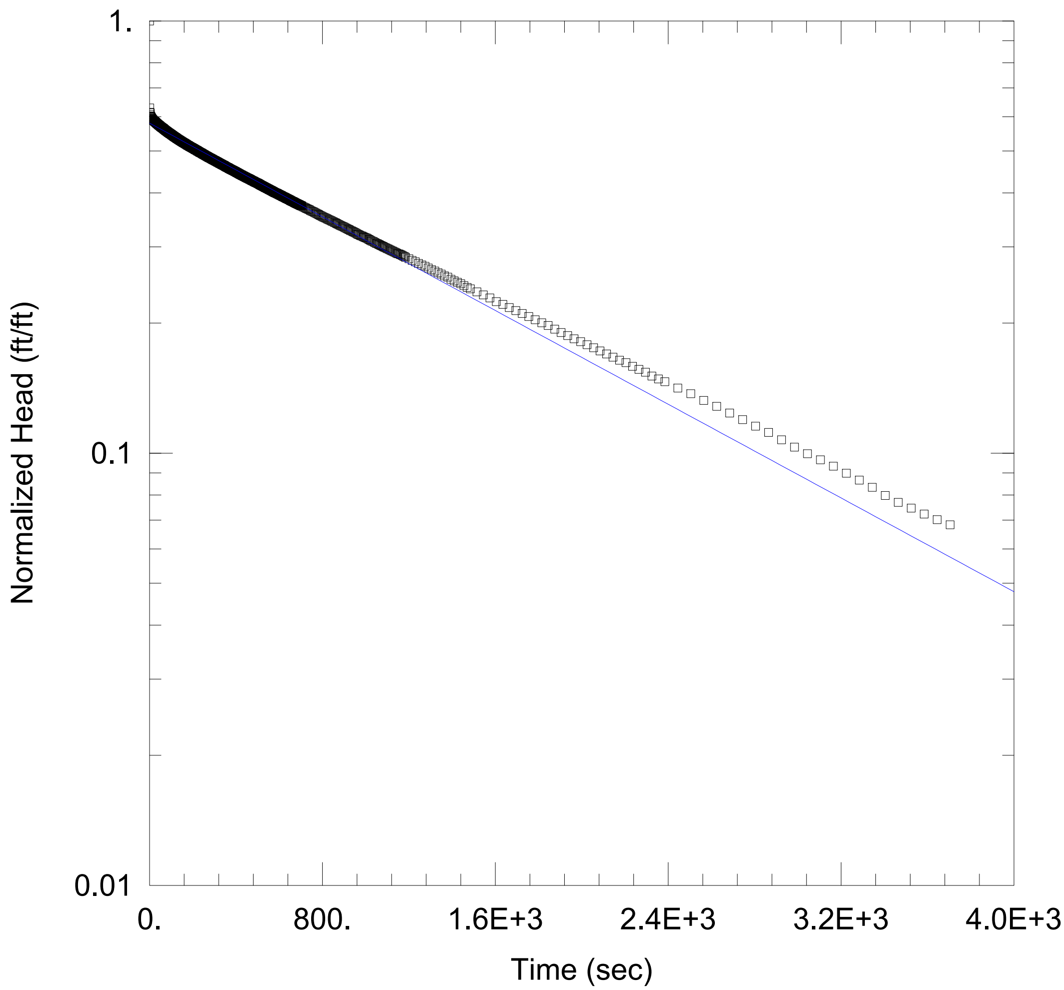
WELL DATA (CF-19-15D)

Initial Displacement: 5.168 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft
Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 1.673E-5 ft/sec
y0 = 2.41 ft



CF-15D-OUT1

Data Set: \...\CF-19-15D-OUT1.aqt
Date: 05/31/19 Time: 14:05:05

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft Anisotropy Ratio (Kz/Kr): 1.

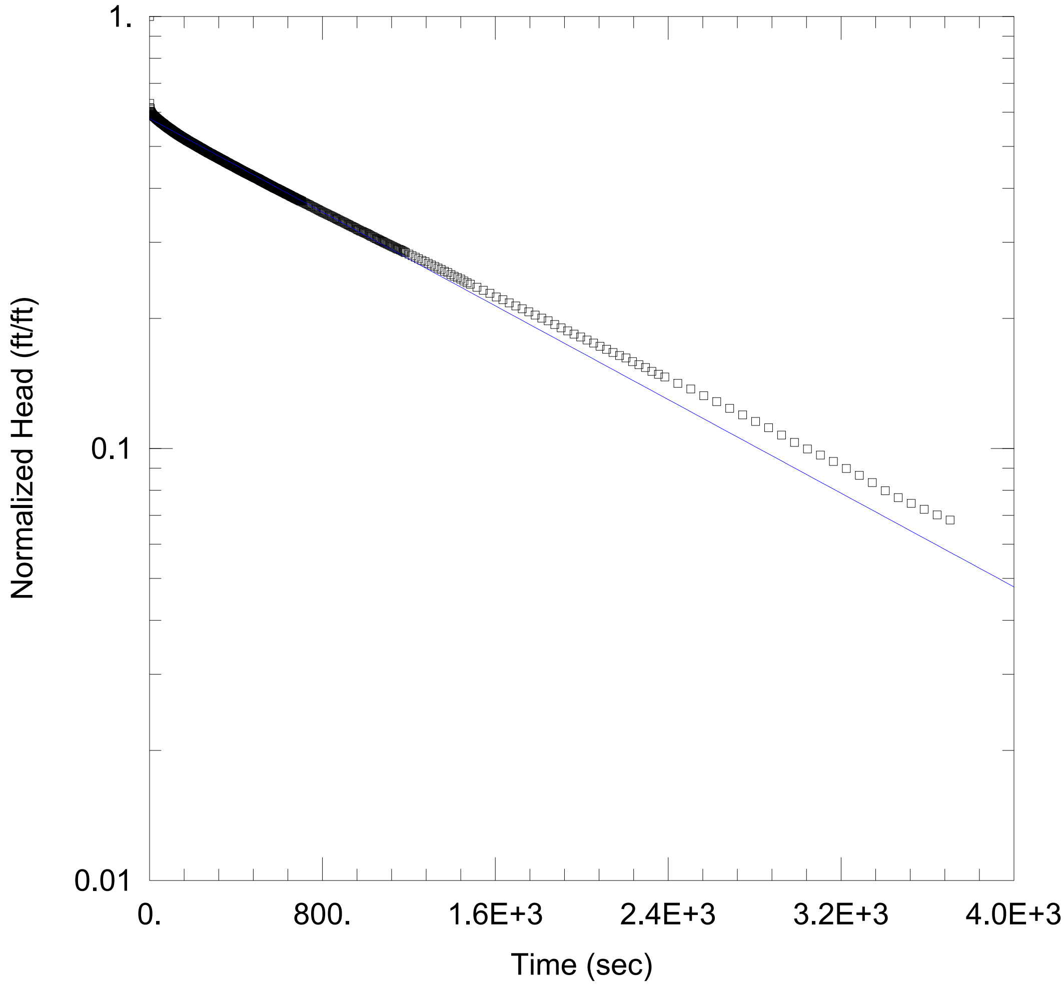
WELL DATA (CF-19-15D)

Initial Displacement: -5.008 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft
Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.303E-6 ft/sec y0 = -2.906 ft



CF-15D-OUT1

Data Set: \...\CF-19-15D-OUT1.aqt
Date: 05/31/19 Time: 14:05:43

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft Anisotropy Ratio (Kz/Kr): 1.

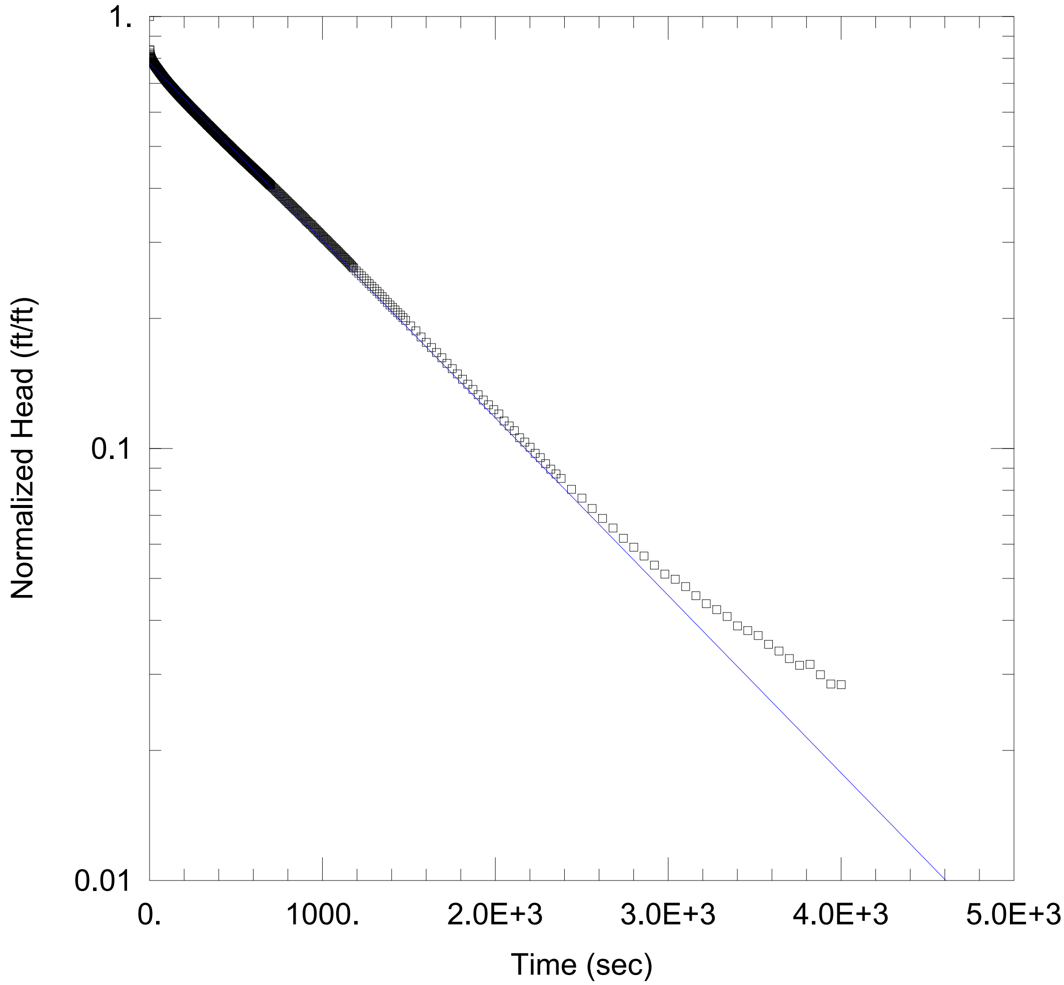
WELL DATA (CF-19-15D)

Initial Displacement: -5.008 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft
Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.424E-6 ft/sec y0 = -2.906 ft



CF-19-15D-OUT2

Data Set: \...\CF-19-15D-OUT2.aqt
Date: 05/31/19 Time: 14:13:00

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft
Anisotropy Ratio (Kz/Kr): 1.

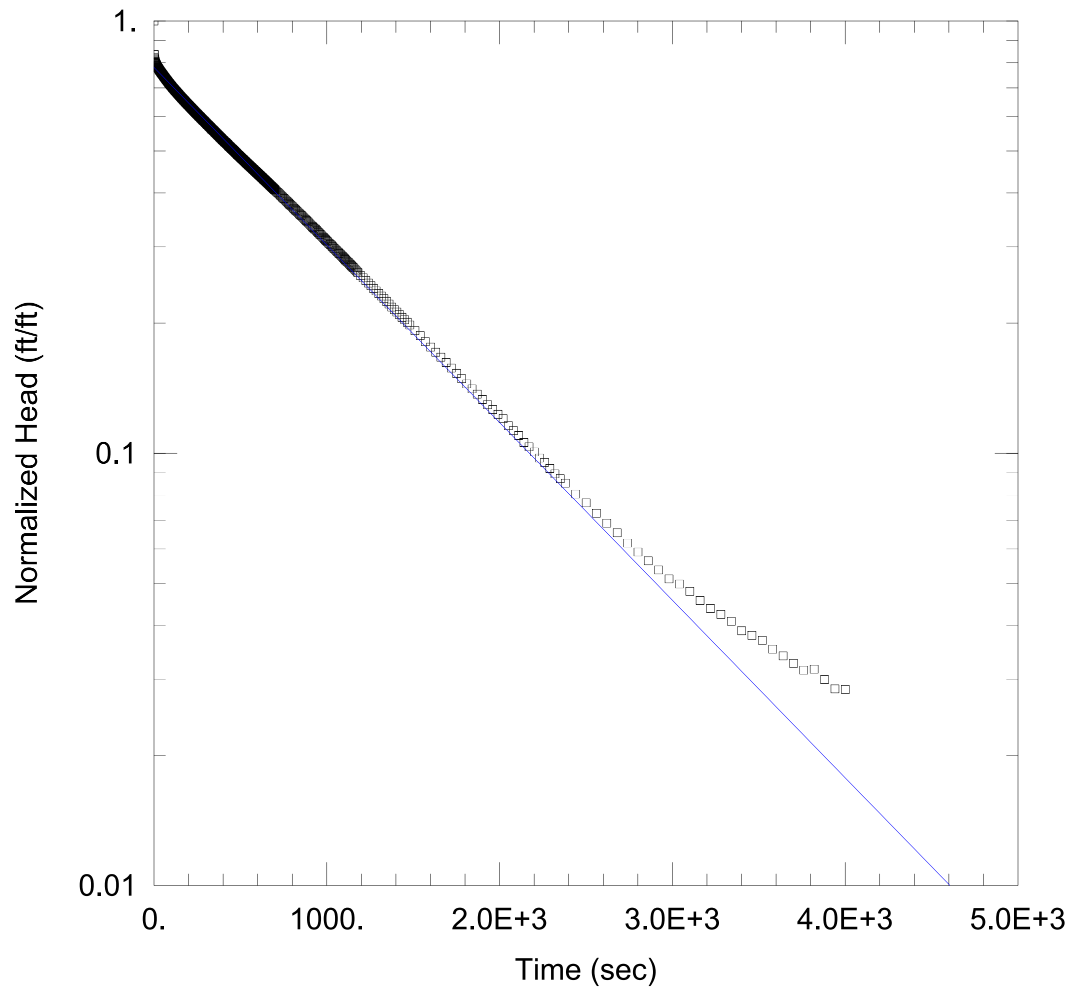
WELL DATA (CF-19-15D)

Initial Displacement: -3.748 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft
Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.975E-6 ft/sec
y0 = -2.925 ft



CF-19-15D-OUT2

Data Set: \...\CF-19-15D-OUT2.aqt
Date: 05/31/19
Time: 14:13:52

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15D
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 8. ft
Anisotropy Ratio (Kz/Kr): 1.

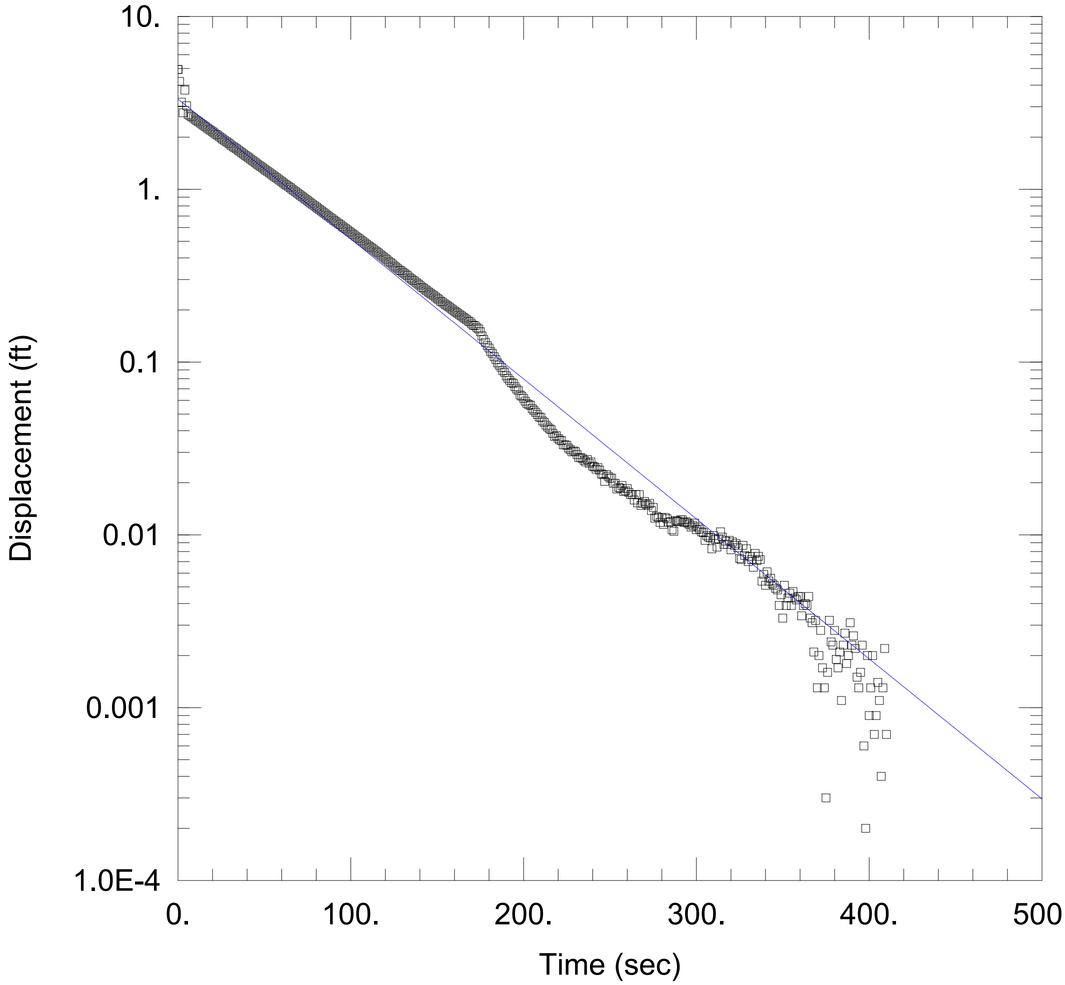
WELL DATA (CF-19-15D)

Initial Displacement: -3.748 ft
Total Well Penetration Depth: 72.07 ft
Casing Radius: 0.083 ft
Static Water Column Height: 53.91 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 2.158E-6 ft/sec
y0 = -2.925 ft



CF-19-15-IN1

Data Set: \...\CF-19-15-IN1.aqt
Date: 05/30/19 Time: 15:13:07

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

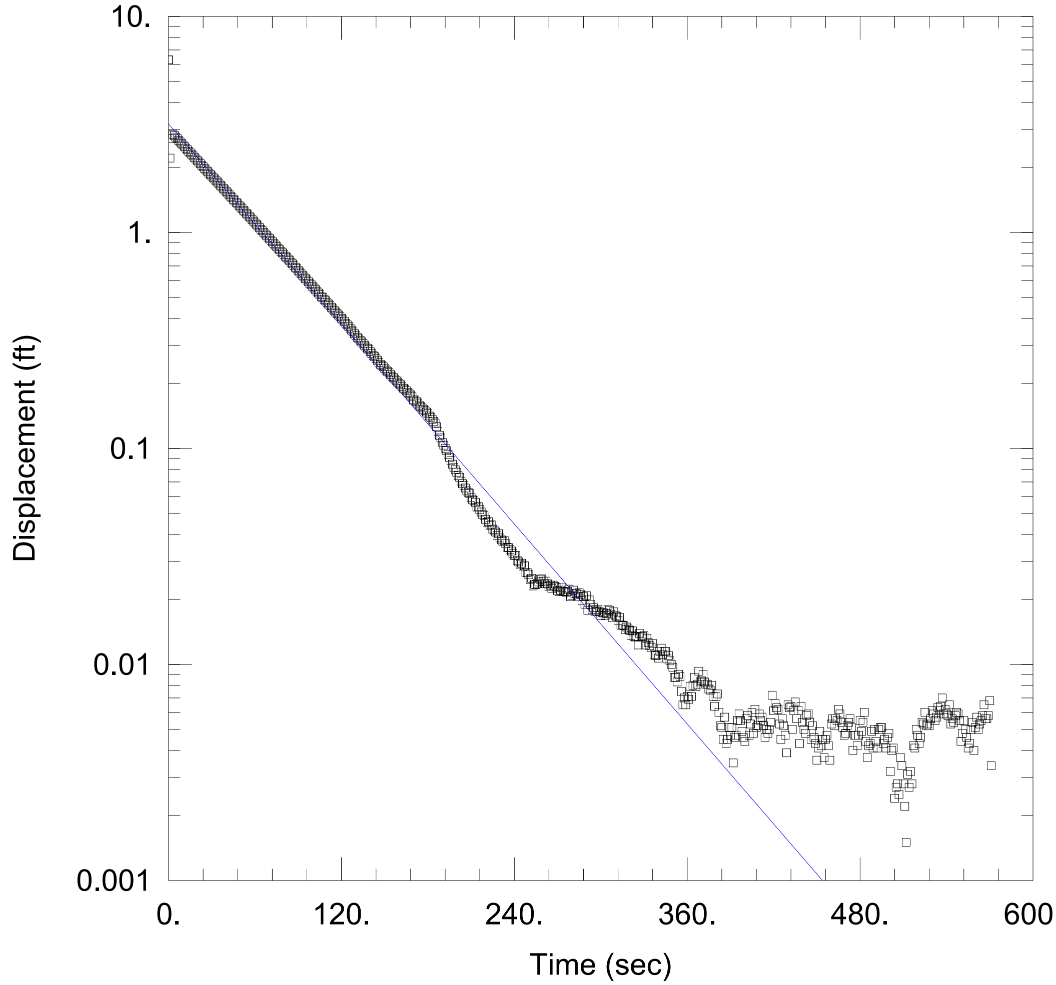
Initial Displacement: 4.937 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.89E-5 ft/sec y0 = 3.327 ft



CF-19-15-IN2

Data Set: \...\CF-19-15-IN2.aqt
Date: 05/30/19 Time: 15:43:33

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

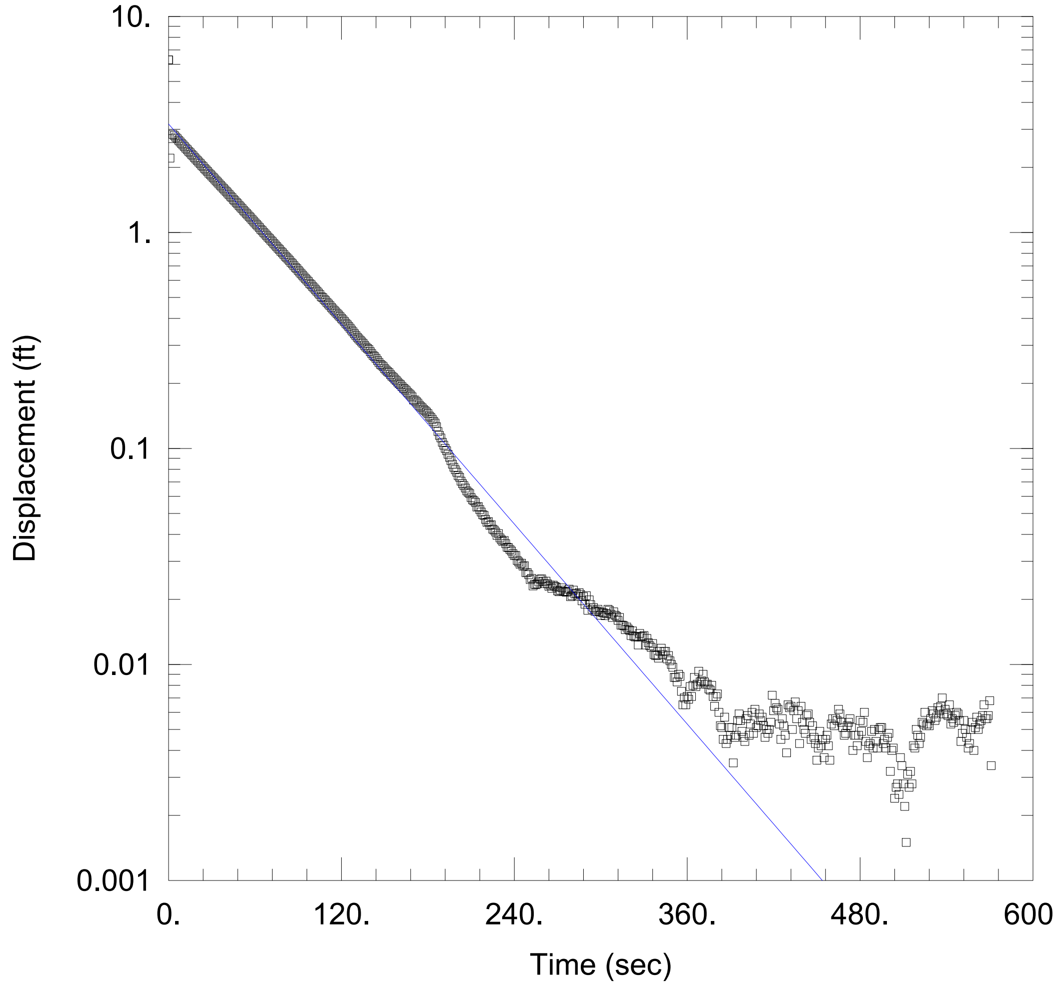
Initial Displacement: 6.297 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft

Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 3.356E-5 ft/sec y0 = 3.176 ft



CF-19-15-IN2

Data Set: \...\CF-19-15-IN2.aqt
Date: 05/31/19 Time: 13:41:24

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft Anisotropy Ratio (Kz/Kr): 1.

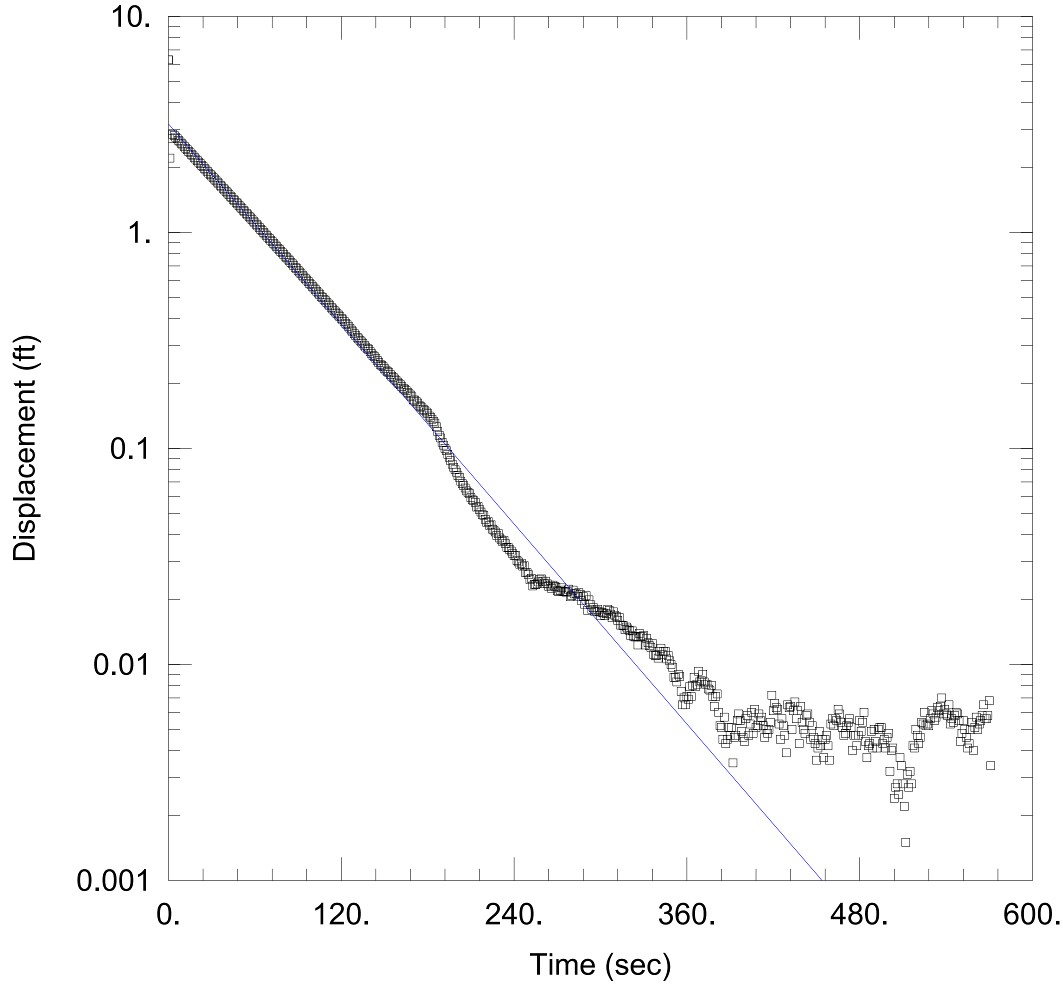
WELL DATA (CF-19-15)

Initial Displacement: 6.297 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft
Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.753E-5 ft/sec y0 = 3.177 ft



CF-19-15-IN2

Data Set: \...\CF-19-15-IN2.aqt
Date: 05/31/19 Time: 13:42:16

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft Anisotropy Ratio (Kz/Kr): 1.

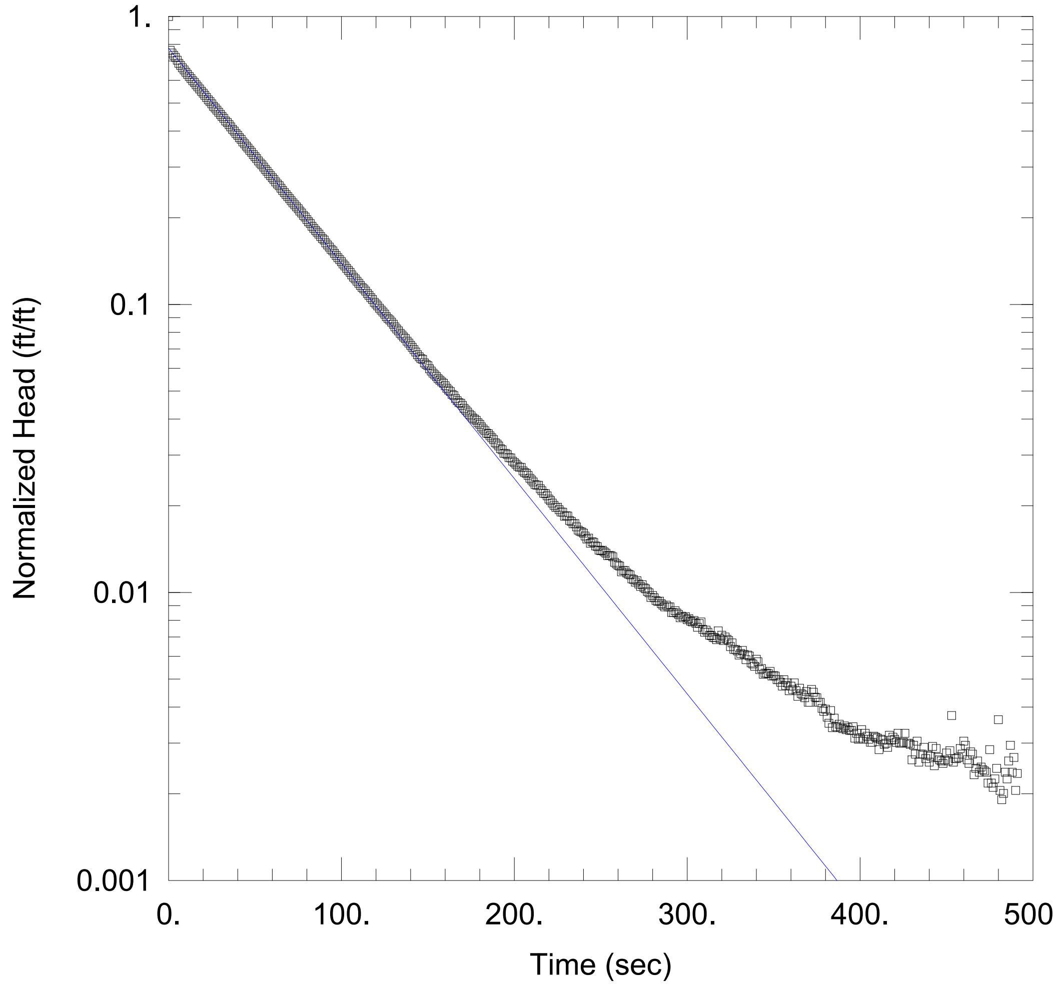
WELL DATA (CF-19-15)

Initial Displacement: 6.297 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft
Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 3.356E-5 ft/sec y0 = 3.176 ft



CF-19-15-OUT1

Data Set: \...\CF-19-15-OUT1.aqt
Date: 05/31/19 Time: 13:45:04

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft Anisotropy Ratio (Kz/Kr): 1.

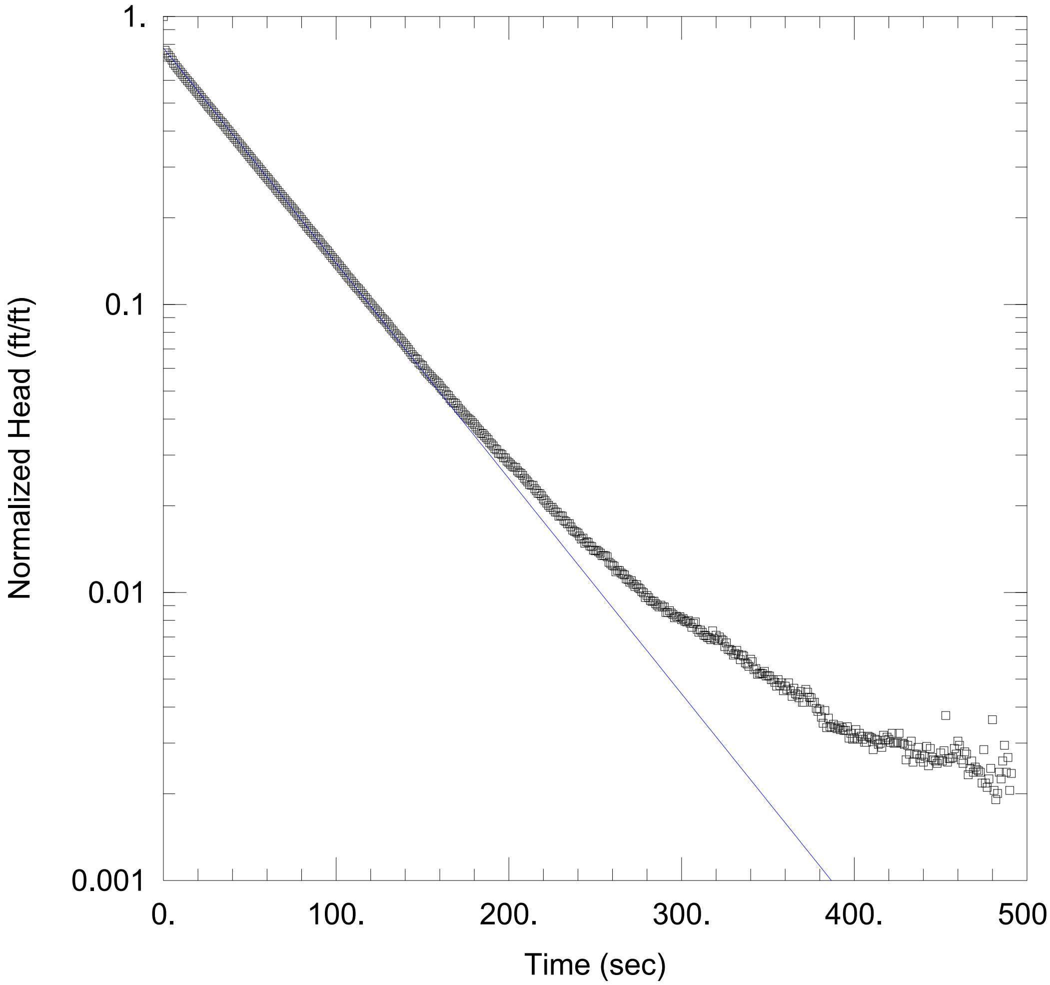
WELL DATA (CF-19-15)

Initial Displacement: -4.041 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft
Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.667E-5 ft/sec y0 = -3.137 ft



CF-19-15-OUT1

Data Set: \...\CF-19-15-OUT1.aqt
Date: 05/31/19 Time: 13:46:00

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft Anisotropy Ratio (Kz/Kr): 1.

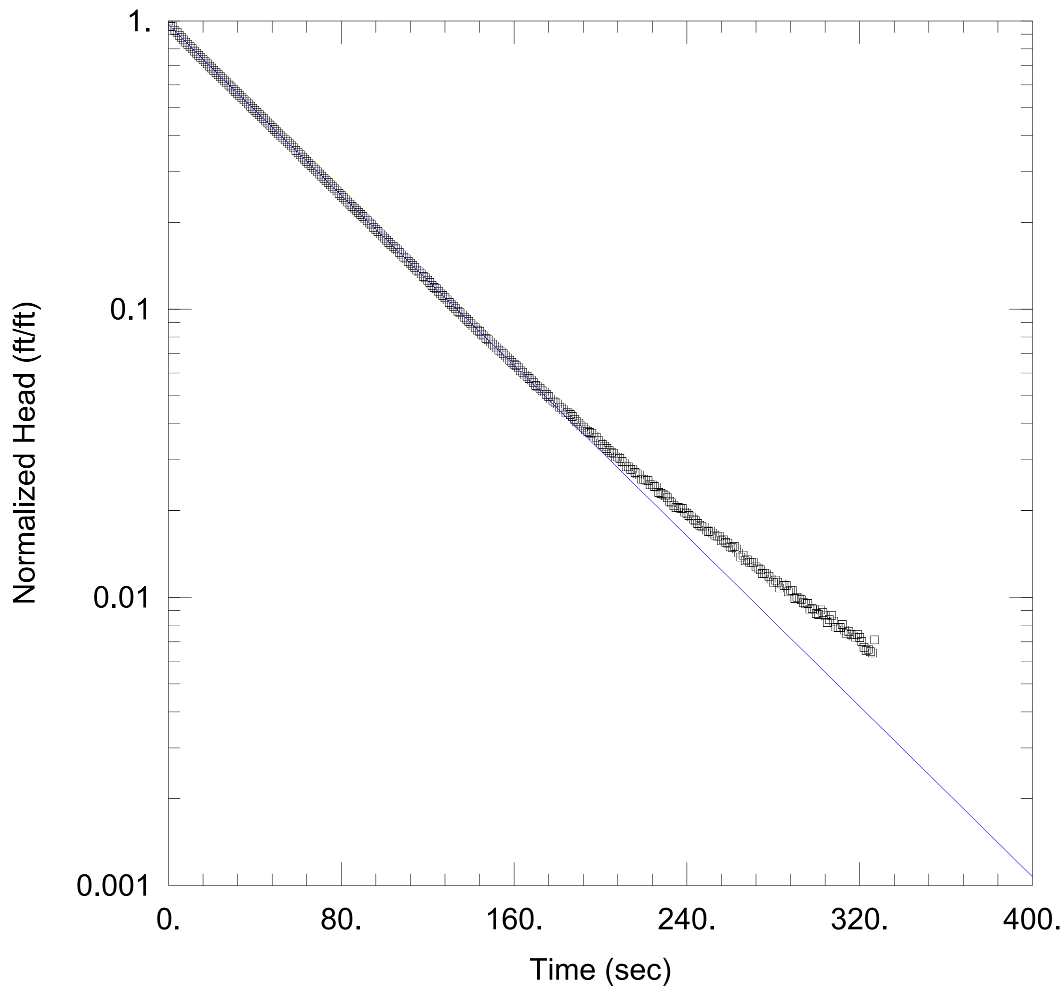
WELL DATA (CF-19-15)

Initial Displacement: -4.041 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft
Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 3.251E-5 ft/sec y0 = -3.137 ft



CF-19-15-OUT2

Data Set: \...\CF-19-15-OUT2.aqt
Date: 05/31/19 Time: 13:48:21

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft Anisotropy Ratio (Kz/Kr): 1.

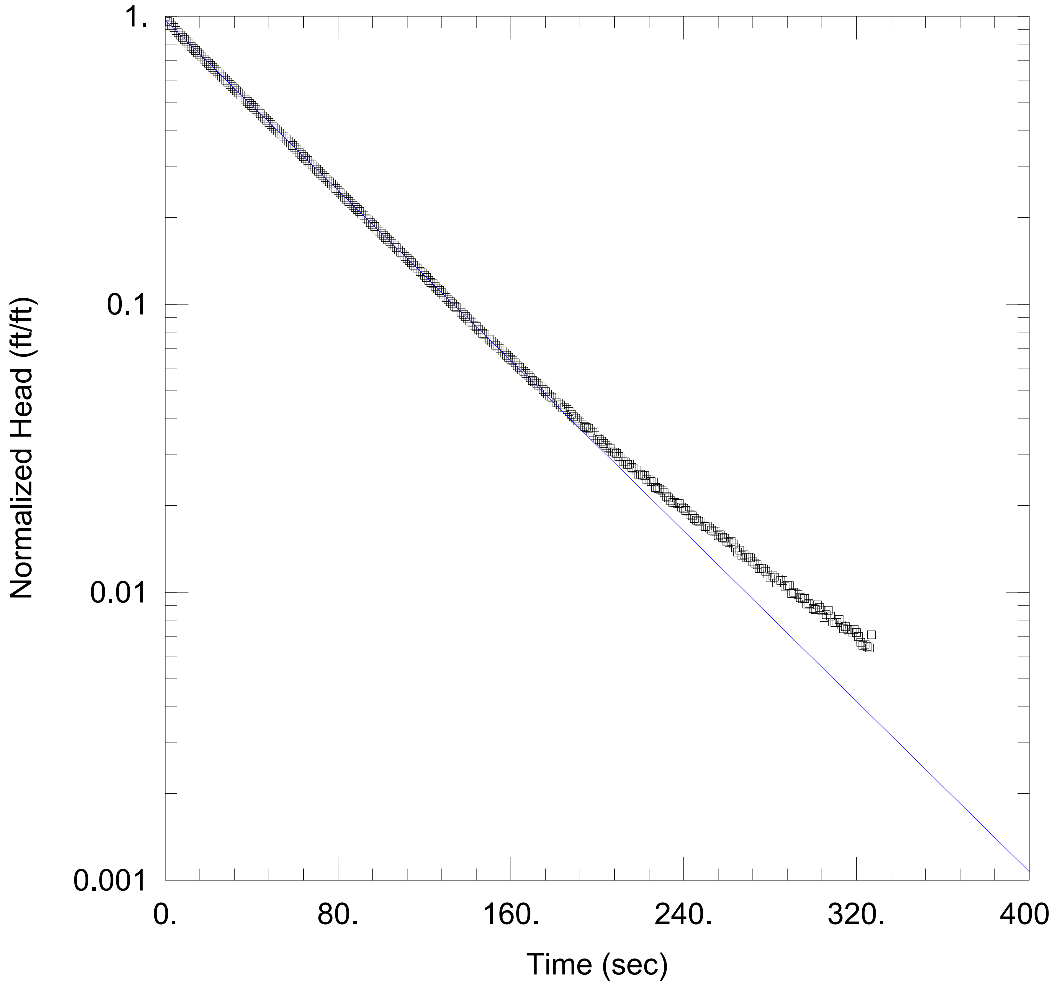
WELL DATA (CF-19-15)

Initial Displacement: -3.123 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft
Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.637E-5 ft/sec y0 = -3.027 ft



CF-19-15-OUT2

Data Set: \...\CF-19-15-OUT2.aqt
Date: 05/31/19 Time: 13:49:06

PROJECT INFORMATION

Company: AGES, Inc.
Client: OVEC
Project: 2019042-07
Location: Clifty Creek
Test Well: CF-19-15
Test Date: 4/16/2019

AQUIFER DATA

Saturated Thickness: 17.88 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (CF-19-15)

Initial Displacement: -3.123 ft
Total Well Penetration Depth: 35.91 ft
Casing Radius: 0.083 ft
Static Water Column Height: 17.88 ft
Screen Length: 10. ft
Well Radius: 0.083 ft
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.215E-5 ft/sec
y0 = -3.027 ft