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May 1, 2024

Geoffrey Spain
Iowa Department of Natural Resources
6200 Park Ave, Suite 200
Des Moines, IA 50321

Re: Barium Alternate Source Demonstration
Landfill of North Iowa
Permit No. 17-SDP-01-75P

Dear Geoffrey Spain:

As noted in the Report Priority of the *2023 Annual Water Quality Report* (Foth, 2023), a statistically significant increase (SSI) over background was identified for barium in the groundwater underdrain compliance point, GUA-1-2. Therefore, on behalf of the Landfill of North Iowa (LNI), Foth Infrastructure & Environment, LLC (Foth) is submitting the Barium Alternate Source Demonstration in accordance with 567 Iowa Administrative Code (IAC) 113.10(5)c(3).

Barium in Background

Barium is a naturally occurring metal and has consistently been detected in the background monitoring wells since October 2010. Since barium is found in background and normality could not be met, barium was analyzed using interwell non-parametric prediction limits with the maximum order statistic (highest maximum background value) from Fall 2010 to Spring 2022.

In Fall 2022, the analyte sample sizes of the cumulative background dataset were sufficiently large to warrant using the second highest maximum order statistic for the interwell non-parametric prediction limit as opposed to the maximum value. Based on power curve comparisons to the United States Environmental Protection Agency (USEPA) reference power curves, as well as statistical power estimates given in Unified Guidance Table 19-19 (USEPA, 2009b), the non-parametric prediction limits were approaching the point of no longer achieving good statistical power when using the maximum value with the current background sample sizes. Utilizing the second highest value as the non-parametric prediction limit attains good levels of statistical power. Therefore, the second highest maximum order statistic (second highest maximum value) of the background data was utilized starting with the Fall 2022 statistical evaluation (Foth, 2023). As a result, the non-parametric limit for barium went from 1.41 mg/L to 0.606 mg/L.

Barium in the Underdrain

Barium has been detected in the underdrain compliance point, GUA-1-2, above the practical quantitation limit (PQL) since monitoring began in Spring 2016. Prior to the Fall 2022 statistical evaluation, no single prediction limit exceedances or SSIs were identified for barium in GUA-1-2.

With the reduction in the interwell prediction limit from 1.41 to 0.606 mg/L in Fall 2022, a single prediction limit exceedance was identified in Fall 2022. The Winter 2023 retest sample was below the interwell prediction limit; therefore, an SSI was not identified. A single prediction limit exceedance was identified during the Spring 2023 statistical evaluation and the Summer 2023 retest remained above the interwell prediction limit; therefore, an SSI was identified. The SSI remained during the Fall 2023 statistical evaluation. In summary, barium in GUA-1-2 has only exceeded the interwell prediction limit during the Fall 2022, Spring 2023, Summer 2023, and Fall 2023 statistical evaluations with concentrations of 0.706 mg/L, 0.696 mg/L, 0.639 mg/L, and 0.851 mg/L, respectively. Note that these concentrations are below the maximum background concentration of 1.41 mg/L, and prediction limit exceedances were only identified at GUA-1-2 when the prediction limit was lowered to 0.606 mg/L. A figure depicting the location of the underdrain is included in Attachment 1, and a time series graph of the barium results at GUA-1-2 is included in Attachment 2.

Trend graphs for barium in GUA-1-2 are also included in Attachment 2. An increasing trend was identified in the 2016-2023 barium data in GUA-1-2. This trend is dictated primarily by the first four quarterly samples in 2016. No trend was identified in the 2018-2023 barium data in GUA-1-2.

For the remaining Appendix I parameters in GUA-1-2, no SSIs were identified between the Fall 2022 and Fall 2023 statistical evaluations. The barium SSIs identified at GUA-1-2 do not correlate with SSIs for other Appendix I parameters.

Barium Fate and Transport

Barium is commonly found in groundwater as barium ions, barium carbonate, and barium sulfate. Barium carbonate and barium sulfate have low solubility, 0.020 g/L and 0.001 g/L (WHO, 2001), in water and are more plentiful in groundwater than its free, more soluble, ionic form (Verbruggen, 2020). Due to the low solubility of barium carbonate and barium sulfate, the mobility of these larger structures is also low (Cappuyns, 2018).

In humans, ingestion of high levels of soluble barium compounds may cause gastroenteritis, hyper- or hypotension, cardiac arrhythmia, and skeletal muscle paralysis. However, insoluble barium sulfate has been extensively used at large doses (450 g) as an oral radiocontrast medium, and no adverse systemic effects have been reported. No experimental data are available on barium sulfate; however, due to the limited absorption of barium sulfate from the gastrointestinal tract or skin, it is unlikely that any significant systemic effects would occur (WHO, 2001).

Since barium in groundwater is more likely to be in insoluble, less mobile forms (i.e., barium carbonate and barium sulfate), barium detected in the underdrain is not likely to travel far. In addition, the flow from the underdrain does not supersede the infiltration rate. Therefore, groundwater from the underdrain primarily infiltrates into the ground surface and rarely, if ever, discharges into Crane Creek.

If groundwater from the underdrain were to discharge into Crane Creek, since barium is likely to be in insoluble forms, absorption rates would be low, and adverse effects would be minimal to aquatic and human life. As indicated above, the maximum barium concentration at GUA-1-2 is 0.851 mg/L, which is below the maximum barium concentration found in background (1.41 mg/L), and below the USEPA drinking water Maximum Contaminant Level (MCL) of 2 mg/L (USEPA, 2009a). There is no barium criterion maximum concentration set by the USEPA for aquatic life (USEPA, 2023).

Conclusions and Recommendations

Barium in underdrain compliance point GUA-1-2 has exceeded the interwell prediction limit during recent statistical evaluations due to the reduction of the prediction limit. However, the maximum barium concentration at GUA-1-2 (0.851 mg/L) is below the maximum background concentration onsite (1.41 mg/L) and USEPA drinking water MCL (2 mg/L). There are no ecological values for barium in surface water (USEPA, 2023).

Barium in the underdrain is not likely to reach the surface water of Crane Creek due to the low mobility of the forms of barium which are prevalent in groundwater (barium carbonate and barium sulfate), and infiltration rates at the underdrain exceed the flow rate. Due to the low solubility of barium carbonate and barium sulfate likely present in the underdrain, if groundwater from the underdrain were to reach Crain Creek, where barium concentrations would be further diluted, absorption rates in aquatic organisms and humans would be low. Therefore, health effects would be minimal, which is likely why the USEPA has not set a barium maximum concentration for aquatic life.

Since the mobility and solubility of the barium compounds likely present in GUA-1-2 is low, and the barium concentrations at GUA-1-2 are lower than the background maximum and drinking water MCL, human health and the environment are not likely impacted by the underdrain. In addition, since the barium SSIs identified at GUA-1-2 do not correlate with SSIs for other Appendix I parameters, it is unlikely that the barium SSIs are resulting from landfill gas or leachate impacts. The barium concentrations are anticipated to be due to natural variations in groundwater quality.

On behalf of LNI, Foth is requesting Iowa Department of Natural Resources (IDNR) approval of this alternate source demonstration and to continue detection monitoring at underdrain compliance point GUA-1-2 in accordance with 567 IAC 113.10(5)c(3). If approved, future statistical evaluations will consider utilizing intrawell statistical comparisons for barium in GUA-1-2 and/or trend tests from 2018 to current to demonstrate ongoing compliance.

Sincerely,

Foth Infrastructure & Environment, LLC

Hannah Dubbs
Project Environmental Scientist
(319) 297-2055

Gina Wilming
Senior Project Manager
(312) 485-6882

cc: Bill Rowland, Landfill of North Iowa
IDNR Field Office #2

Enclosure(s)

Attachment 1	Figure
Attachment 2	Graphs
Attachment 3	References

Attachment 1
Figure

LEGEND

- Shallow Delineation Well
- Bedrock Delineation Well
- Bedrock Water Level Monitoring Well
- Water Level Monitoring Well
- Shallow Monitoring Wells
- Shallow Background Well
- Groundwater Underdrain Locations
- 10' Ground Surface Contours
- Waste Boundaries

NOTES:

1. Date of Aerial Imagery Acquisition: Friday Oct 21, 2022.
2. Coordinate system is: NAD83(2011) Iowa North Zone, US feet. Vertical Datum is NAVD88.

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Foth

N

0 200 400 Feet

LANDFILL OF NORTH IOWA

FIGURE 1

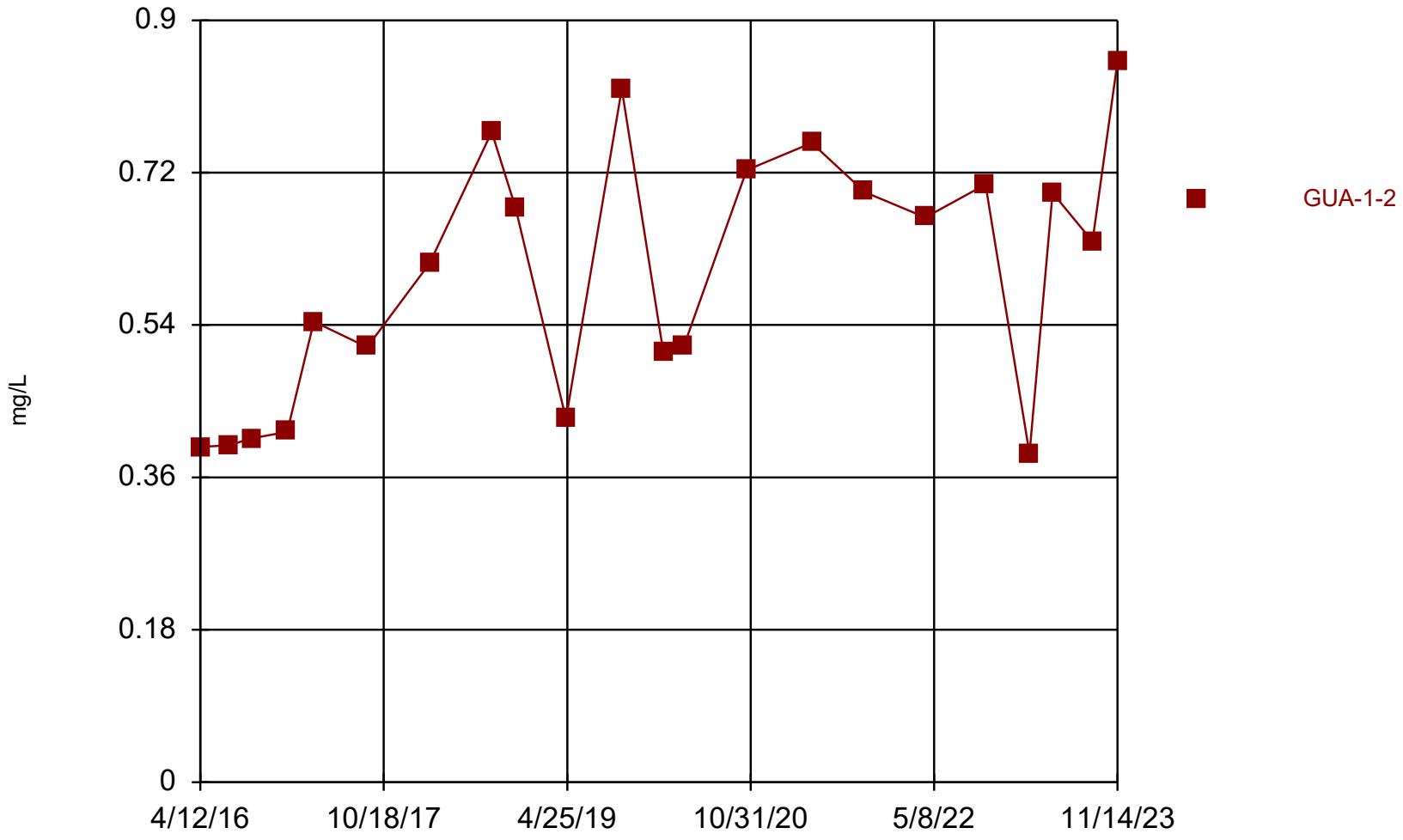
GROUNDWATER MONITORING NETWORK

Date: FEBRUARY 2024	Revision Date:	
Drawn By: DAT	Checked By: GMW	Project: 24L005.00

Path: Q:\Landfill of North Iowa\24L005.00\GIS\aprx\2023 AWQR\2023 AWQR.aprx Date: 2/21/2024

Attachment 2
Graphs

Time Series

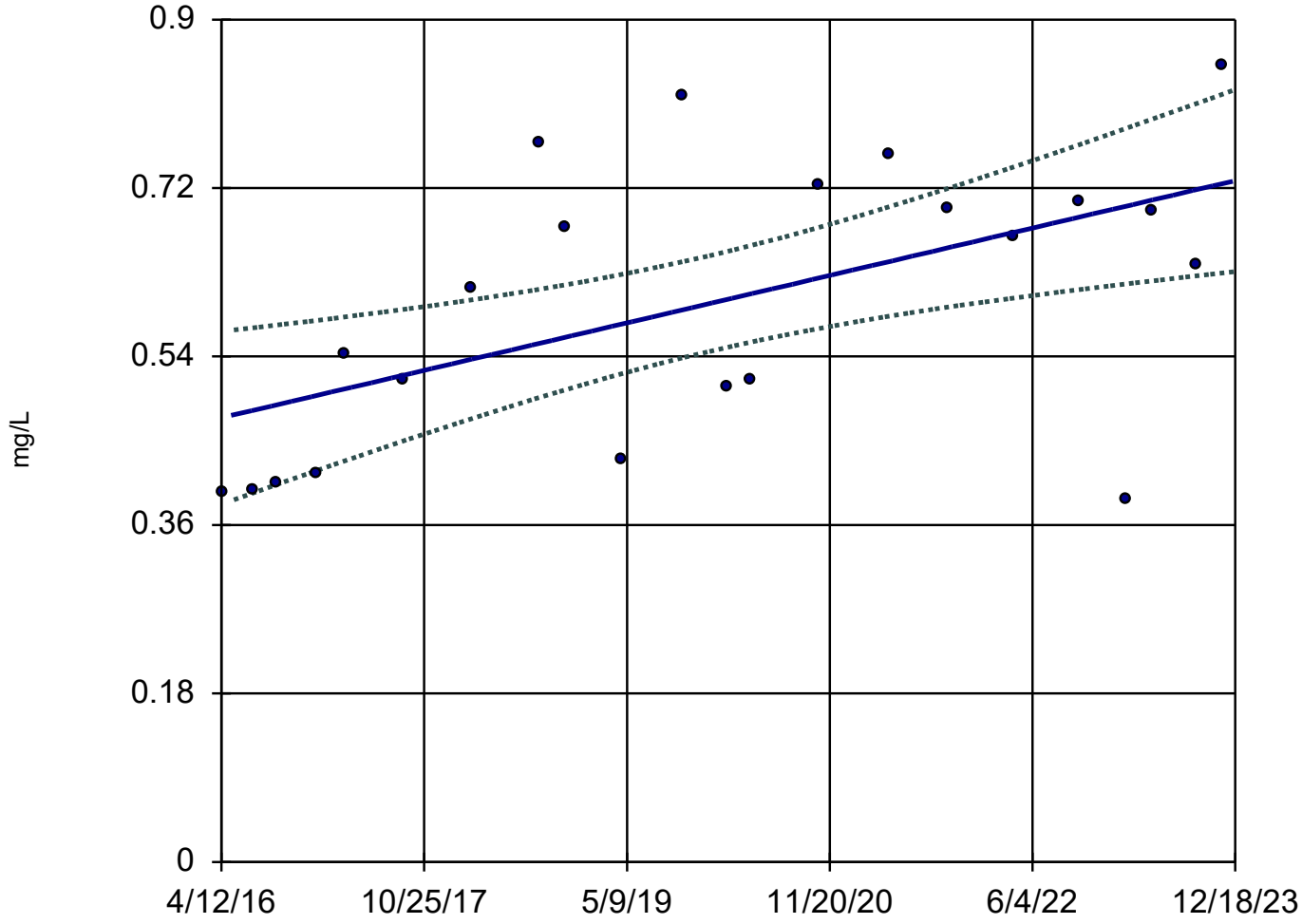


Constituent: Barium Analysis Run 4/11/2024 1:38 PM

Landfill of North Iowa Client: Foth Data: LNI Winter 2024 Evaluation

Linear Regression and 90% Confidence Band

GUA-1-2



n = 22

Slope = 0.03297
units/year.

alpha = 0.02
t = 2.969
critical = 2.197

Significant increasing trend.

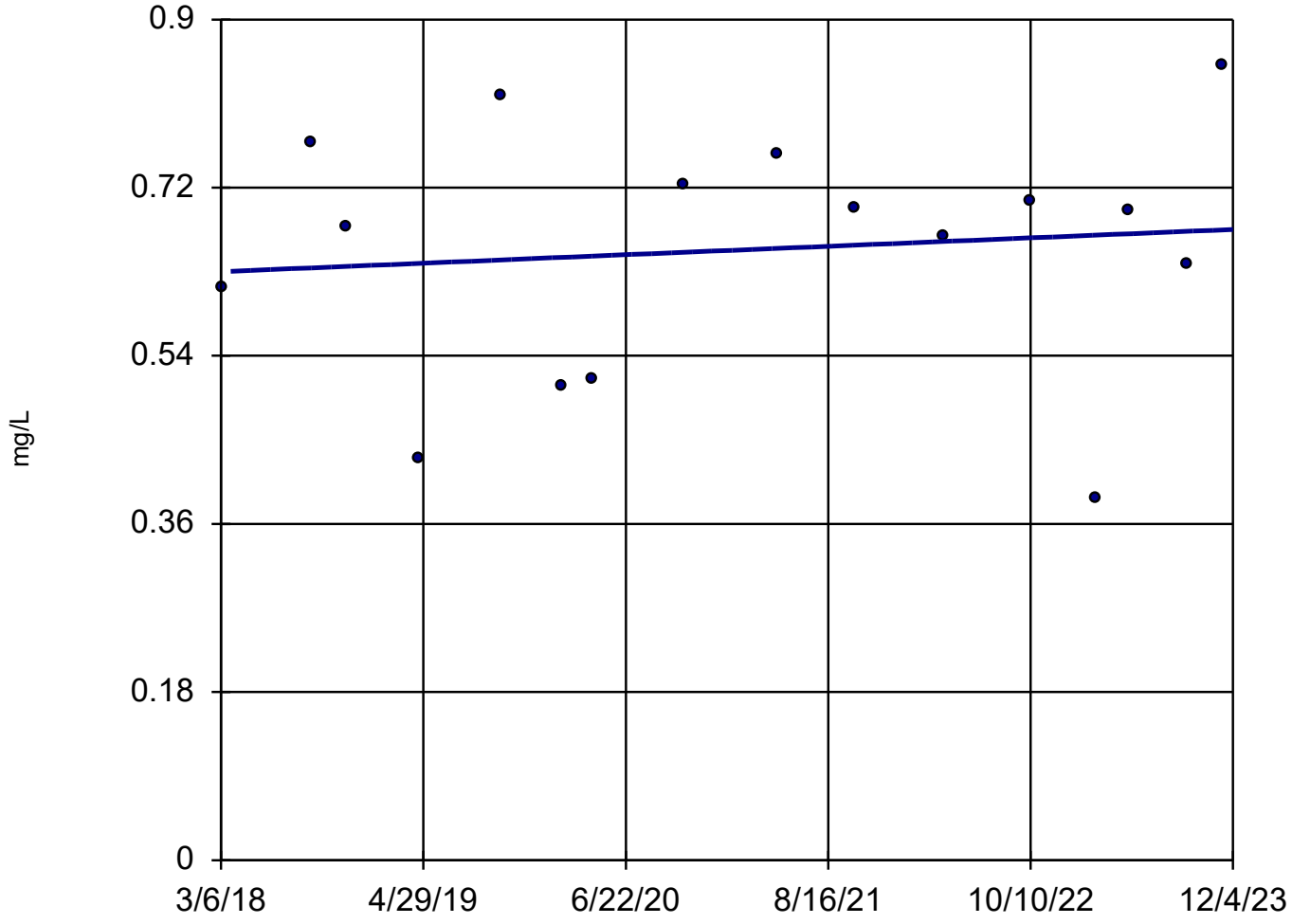
Normality test on residuals:
Shapiro Wilk @alpha
= 0.01, calculated
= 0.9563, critical
= 0.878.

Constituent: Barium Analysis Run 4/11/2024 2:25 PM

Landfill of North Iowa Data: LNI Winter 2024 Evaluation

Linear Regression

GUA-1-2



n = 16

Slope = 0.00786
units/year.

alpha = 0.02
t = 0.4226
critical = 2.264

No significant trend.

Normality test on residuals:
Shapiro Wilk @alpha
= 0.01, calculated
= 0.9383, critical
= 0.844.

Constituent: Barium Analysis Run 4/11/2024 2:26 PM

Landfill of North Iowa Data: LNI Winter 2024 Evaluation

Attachment 3
References

References

Cappuyns, Valerie. (2018). *Barium (Ba) Leaching from Soils and Certified Reference Materials.*

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USEPA, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. EPA 530-R-09-007. Office of Resource Conservation and Recovery, Program Implementation and Information Division, Washington, D.C.

USEPA, 2023. *National Recommended Aquatic Life Criteria Table.* h*ttps://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table.* October.

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World Health Organization (WHO), 2001. *Concise International Chemical Assessment Document 33. Barium and Barium Compounds.*