

SUBJECT
RACER Lansing
Biosparge Transect F Shutdown

TO
Joe Rogers, EGLE
Shawn Shields, EGLE

DATE
3/23/26

OUR REF
Task 0470B

DEPARTMENT
Environment

PROJECT NUMBER
30321421

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As part of ongoing efforts to optimize the biosparge system at the RACER Lansing Site (Site) and as mentioned to Michigan Department of Environment, Great Lakes, and Energy (EGLE) on recent quarterly project calls, shutdown of Plant 2, Transect F is being proposed. The purpose of this memorandum is to document that Transect F, shown in **Figure 1**, has satisfied the criteria necessary for shutdown and to outline the plan for monitoring to confirm the short- and long-term objectives of the biosparge system continue to be met after shutdown.

To recap, the long-term objectives of the biosparge system are to:

- Provide for continued protection of the municipal drinking water supply wells by preventing Site-related 1,4-dioxane-impacted groundwater from migrating offsite laterally in the weathered bedrock zone at concentrations greater than 7.2 micrograms per liter (µg/L); and
- Reduce the potential for substantial migration of 1,4-dioxane downward into less weathered bedrock.

The short-term objective of the biosparge system is to reduce Site-related 1,4-dioxane concentrations along the core of the lower 1,4-dioxane weathered bedrock plume.

As presented in the Interim Measures Work Plan (IMWP, Arcadis 2018), the biosparge system will be operated until:

- Concentrations of Site-related 1,4-dioxane in weathered bedrock and bedrock monitoring wells along the core of the plume and in monitoring wells along the western Plant 2 property boundary exhibit stable to decreasing trends based on statistical evaluation (e.g., Mann-Kendall or other method acceptable to EGLE);
- Further reduction in groundwater concentrations reaches the point of diminishing returns. Evaluation of the point of diminishing returns is detailed below. The diminishing return evaluation process has been updated, in collaboration with EGLE, over the course of operation of the biosparge system as the information gained during operation and monitoring activities has allowed for better operation and evaluation over time; or
- The short- and long-term objectives have been met.

Performance Relative to Short- and Long-Term Objectives

IMWP and biosparge performance monitoring indicates that the short- and long-term objectives have been met in the vicinity of Transect F. Relative to the short-term objective, **Figure 2** is a comparison of the 1,4-dioxane plume prior to system start up in 2019, and in 2024 and 2025 after 4 and 5 years of operation, respectively. The lateral extent of the core of the plume (e.g. the 72 ug/L contour) has decreased compared to the original size showing that the short-term objective has been met. Relative to the long-term objective, **Figure 2** shows the overall lateral extent of the weathered bedrock plume in the vicinity of Transect F has also reduced in size. Additionally, based on the location of Transect F and all the available monitoring data, there is very limited potential of offsite migration of 1,4-dioxane from upgradient of Transect F to the east of Plant 2 and even if some migration does occur, migration would be to RACER Plant 6 property which is east of the Plant 2 property. There is even a smaller potential that 1,4-dioxane-impacted groundwater would ever migrate beyond the Plant 6 property boundary. The Plant 6 property has Declaration of Restrictive Covenant recorded on the deed that includes a provision prohibiting installation of groundwater wells and use of groundwater for drinking purposes. Data trend graphs for nearby bedrock well MW-12-06 in the vicinity of Transect F shows stable trends (**Figure 3** and **Appendix A**) indicating the long-term objective has been met with respect to the potential for vertical migration. Note a Mann Kendall analysis cannot be completed for bedrock well MW-12-06 because it doesn't meet the Site-specific criteria for Mann Kendall (i.e. at least 7 samples, minimum of 50% detected values, and at least 25% criteria exceedances in the last six samples).

Point of Diminishing Returns

As you know, the biosparge system is designed and monitored to operate adaptively. This adaptive design allows individual sparge wells and/or transects to be activated or deactivated as needed to modify and optimize performance, particularly in areas of the Site that have reached the point of diminishing returns.

Assessment of the point of diminishing returns is an important aspect to evaluate the effectiveness of ongoing biosparge treatment. The current framework for evaluating the point of diminishing returns involves four main lines of evidence:

1. Assessment of upgradient well trends to evaluate the stability and magnitude of concentrations of 1,4-dioxane entering the biosparge system and requiring treatment.
2. Assessment of average plume concentrations to evaluate the trend of overall reductions year over year (i.e., 12-month reductions) to determine if ongoing treatment is meaningful.
3. Comparison of the 12-month average reduction of 1,4-dioxane to 20% of a reference reduction value (RRV).
4. Financial assessment of the cost per unit of treatment to understand the cost benefit of ongoing treatment.

To evaluate these lines of evidence in terms of localized system effectiveness, biosparge performance monitoring wells have been grouped based on proximity to Transect F.

The Transect F performance monitoring network is presented on **Figure 3**. Performance monitoring wells are set within the biosparge well radius of influence (ROI), upgradient, and downgradient positioned approximately every 300 feet along the transects. **Figure 3** shows the 1,4-dioxane and dissolved oxygen concentrations for performance monitoring wells.

Upgradient Trends

Monitoring well MW-16-82 is the only weathered bedrock monitoring well upgradient of Transect F. Data trend graph (**Figure 3** and **Appendix A**) for this well indicates an increasing trend, but relatively low concentrations with a maximum concentration of 11 ug/L. Bedrock monitoring well MW-12-06 is upgradient of Transect F and shows a stable trend (**Figure 3** and **Appendix A**). Note a Mann Kendall analysis cannot be completed for either of these wells because they do not meet the Site-specific criteria for Mann Kendall (i.e. at least 7 samples, minimum of 50% detected values, and at least 25% criteria exceedances in the last six samples).

Average Plume Concentrations

An average concentration is calculated after each sampling event. **Table 1** presents the average 1,4-dioxane plume concentrations. In the vicinity of Transect F, the average plume concentration before startup of the biosparge system was 128 µg/L. The average plume concentration over four quarters in 2025 ranged from 7 µg/L to 12 µg/L, a 91% to 95% reduction over baseline. The average plume concentration in the fourth quarter of 2025 was approximately the same as the average plume concentration in the fourth quarter of 2024. The average plume concentrations for Transect F have been relatively consistent since 2022 as shown on **Figure 4** and in **Table 1**. Data trend graphs for performance monitoring wells associated with Transect F are included in **Appendix A**. Mann Kendall analysis has been completed for any wells that meet the Site-specific criteria for Mann Kendall (i.e. at least 7 samples, minimum of 50% detected values, and at least 25% criteria exceedances in the last six samples).

Reference Reduction Value Comparison

A 12-month reduction in the 1,4-dioxane concentration is calculated by subtracting the current average plume concentration from the average plume concentration 12 months prior. The maximum 12-month reduction in 1,4-dioxane observed during the first 3 years of operation serves as the reference reduction value (RRV). While RACER proposed that 20% of the RRV be considered the point of diminishing returns and EGLE has not fully accepted, the diminishing returns evaluation also includes an evaluation of the overall trends for average plume concentration and 12-month reduction values, as shown on **Figure 4**. Looking at these trends provides a visual representation of the asymptotic conditions that occur when there are no longer changes in the average plume concentration and the 12-month reduction values, which is a strong line of evidence that the point of diminishing returns has been achieved. As shown in **Table 1** and **Figure 4**, the average 12-month reduction has been below 20% of the RRV since Q2 2022, and since then has plateaued near zero indicating the average plume concentration is no longer significantly changing. The smaller average 12-month reductions in plume concentration are due to the system reaching the point of diminishing returns.

Financial Assessment

A financial assessment of the cost per unit of treatment was completed for Transect F to evaluate the cost versus benefit of ongoing treatment. The cost of treatment was calculated using the annual O&M cost and the annual average reduction of 1,4-dioxane. **Exhibit 1** below summarizes the approximate cost per 1 µg/L of 1,4-dioxane treated.

Exhibit 1. Transect F Operations Cost per µg/L Treated

Year	P2 East – Transects F	
	Annual Average Reduction in Plume Concentration (µg/L)	Unit Treatment Cost (\$ per µg/L reduction)
2020*	84*	\$348
2021	21	\$3,427
2022	8	\$8,601
2023	-3	--
2024	8	\$9,162
2025	-2	--

*The Plant 2 system began operation in August 2020 – concentrations and costs are based on five months of operation (August to December 2020).

As indicated by the table above, the annual average reduction in plume concentration has been below 10 ug/L for the last 4 years. This has resulted in the unit cost for equivalent effective treatment increasing significantly as indicated by the above table. In addition, the fluctuation between a slight reduction and a slight increase in concentration over the last three years suggests that continued operation of the system has reached the point of diminishing returns.

Transect F Shut Down Monitoring Plan

As demonstrated, Transect F has met the short- and long-term objectives and has met the point of diminishing returns. Therefore, shut down of Transect F at this juncture is recommended. To verify the short- and long-term objectives continue to be met, following Transect F shutdown, groundwater monitoring wells surrounding Transect F (**Figure 3**) will be sampled quarterly according to **Exhibit 2** for the first 12 months following shut down. Lessons learned from the Transect A and G shut down test indicate that it may not be appropriate to compare performance monitoring data to quantitative re-start triggers on an individual well basis. It is important to have the context of the entire performance monitoring network data set to best understand implications of the shut down as opposed to individual data points compared to a well specific re-start criteria. Therefore, for the Transect F shutdown, RACER is proposing that data collected from each quarterly event will be presented and discussed with EGLE during routine quarterly meetings. RACER will make path forward recommendations for EGLE's consideration with respect to the Transect F shut down based on the entire data set collected. The data set will include concentration data from all wells monitored during each event, as well as concentration trends from quarter to quarter. Recommendations may include continued shutdown of Transect F, re-start of a portion of Transect F, or re-start of the entire Transect depending on the data. During and following each meeting, EGLE would have the opportunity to concur or comment on the recommendations for RACER to consider and address.

Exhibit 2. Plant 2 Transect F Monitoring Locations and Frequency

Well ID	Location	Type	Sampling Frequency
MW-16-82	Central P2	Upgradient Weathered Bedrock	Quarterly
MW-20-128	Transect F	Radius of Influence Weathered Bedrock	Quarterly
MW-14-61	Transect F	Radius of Influence Weathered Bedrock	Quarterly
MW-16-84	Eastern P2	Near Downgradient Weathered Bedrock	Quarterly
MW-19-120	Eastern P2	Near Downgradient Weathered Bedrock	Quarterly
MW-17-86	Eastern P2	Downgradient Weathered Bedrock	Quarterly
MW-16-85	Eastern P2	Downgradient Weathered Bedrock	Quarterly
MW-12-06	Eastern P2	Upgradient Bedrock	Quarterly

After one year of quarterly monitoring if RACER and EGLE agree that no re-start of Transect F is necessary, the frequency of monitoring will be re-visited and adjusted, as appropriate, based on the data set.

Reporting

As noted, data collected from each quarterly event will be presented and discussed with EGLE during routine quarterly meetings. RACER will make path forward recommendations for EGLE's consideration with respect to the Transect F shut down based on the entire data set collected. The slides from each quarterly meeting will be submitted as documentation of ongoing data collection and recommendations with respect to the Transect F shut down . All data and operational decisions made during the shutdown will be documented in the annual biosparge reports.

Schedule

Transect F will be shutdown after receipt of EGLE's approval and approximately 4-6 weeks prior to the first quarterly post-shutdown sampling event.

Joe Rogers
EGLE
March 23, 2026

References:

Arcadis. 2018. Interim Measures Work Plan: Lower 1,4-Dioxane Biosparge. RACER Industrial Land, Lansing, MI. October 19.
Arcadis. 2025a. Revised Biosparge Shut Down Test Proposal Memo. RACER Industrial Land, Lansing, MI. January 17.
Arcadis. 2025b. Revised Interim Monitoring Work Plan – 2025. RACER Industrial Land, Lansing, MI. April 18.

Enclosures.

Table 1: Biosparge Performance Tracking Transect F
Figure 1: Transect Location Map
Figure 2: Lower 1,4-Dioxane Plume Comparison 2019 vs 2024 vs 2025
Figure 3: Transect F Biosparge Performance Monitoring Results
Figure 4: Transect F Average Plume Concentration and 12-Month Reduction of 1,4-Dioxane
Appendix A: Trend Graphs and MK Analysis

Table 1

Biosparge Performance Tracking Transect F

Table 1
Biosparge Performance Tracking Transect F
Biosparge Transect F Shutdown
Lansing Industrial Land, Lansing, Michigan

Plant 2 East (Transect F)

Descriptor: Distance (ft):		Well 1,4-Dioxane (µg/L)						Average (µg/L)	Average 12-month Reduction (µg/L)*
		MW-14-61 ROI 13	MW-19-120 ROI 44	MW-20-128 ROI 17	MW-16-84 DG 69	MW-16-85 DG 200	MW-17-86 DG 115		
Year	Date								
1	3/1/2020	148	198	--	66	--	99		--
	6/1/2020	152	184	270	58	8	94	128	--
	9/1/2020	98	137	112	57	--	88	98	--
	12/1/2020	18	28	20	81	8	106	44	--
2	3/1/2021	21	73	9	66	--	79	50	--
	6/1/2021	9	49	4	15	4	69	25	103
	9/1/2021	9	7	11	43	--	48	24	75
	12/1/2021	5	15	5	60	10	43	23	21
3	3/1/2022	--	--	--	--	--	--	--	--
	6/1/2022	16	12	6	44	8	27	19	6
	9/1/2022	--	--	--	--	--	--	--	--
	12/1/2022	21	13	< 1	29	6	19	15	8
4	3/1/2023	--	--	--	--	--	--	--	--
	6/1/2023	13	15	4	44	6	20	17	2
	9/1/2023	--	--	--	--	--	--	--	--
	12/1/2023	13	11	1	39	28	16	18	-3
5	3/1/2024	--	--	--	--	--	--	--	--
	6/1/2024	8	7	2	32	18	16	14	3
	9/1/2024	--	--	--	--	--	--	--	--
	12/1/2024	7	8	3	20	8	16	10	8
6	3/1/2025	--	--	--	--	--	--	--	--
	6/1/2025	6	7	1	14	4	10	7	7
	9/1/2025	--	--	--	--	--	--	--	--
	12/1/2025	3	4	7	27	20	10	12	-2

Notes:

All concentrations are in micrograms per liter.

Actual sample date varies, sample date displayed represents first day of quarter for graphing purposes.

ROI = radius of influence

DG = downgradient

UG = upgradient

µg/L = micrograms per liter

< = less than lab reporting limit

-- = Not Analyzed

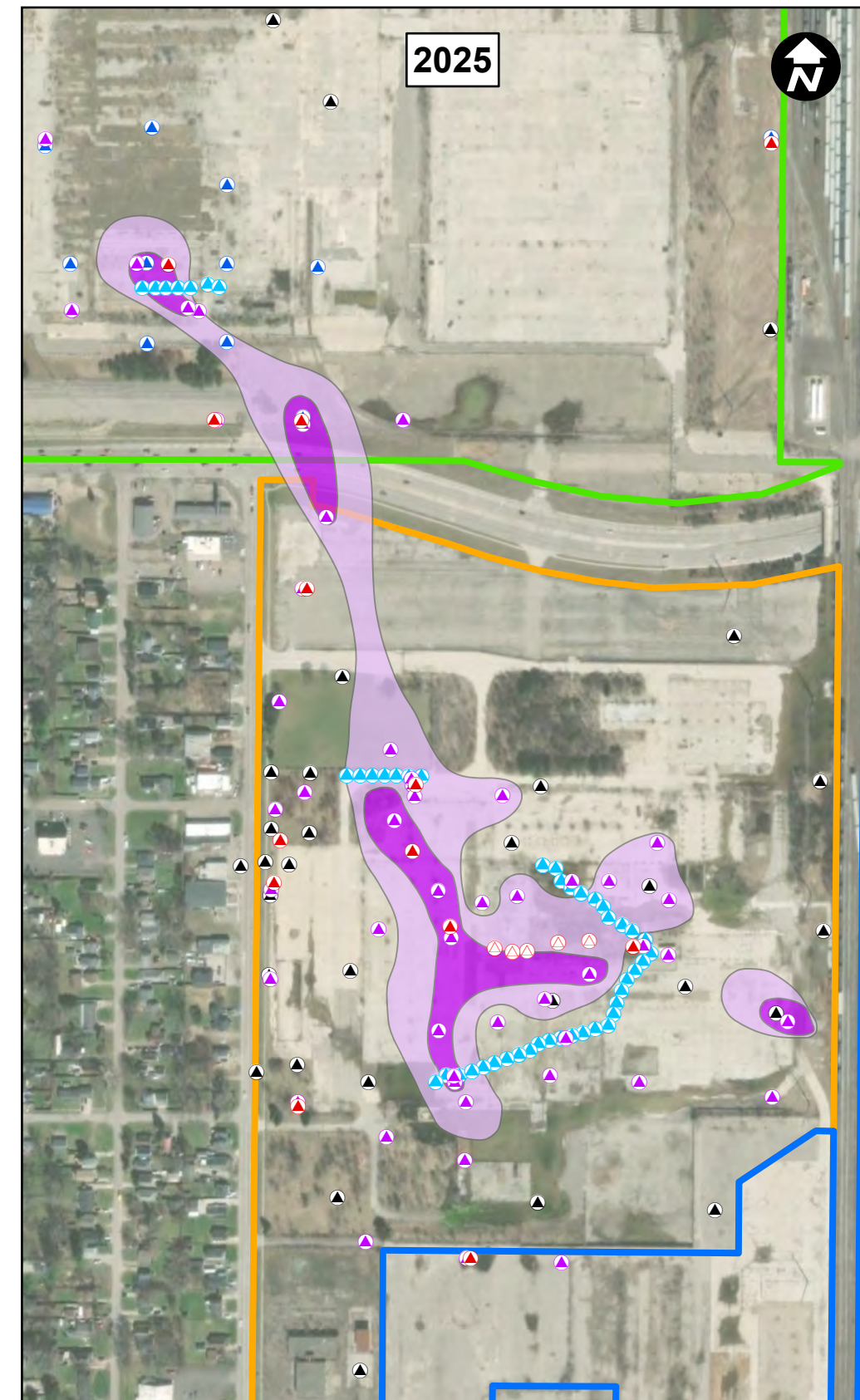
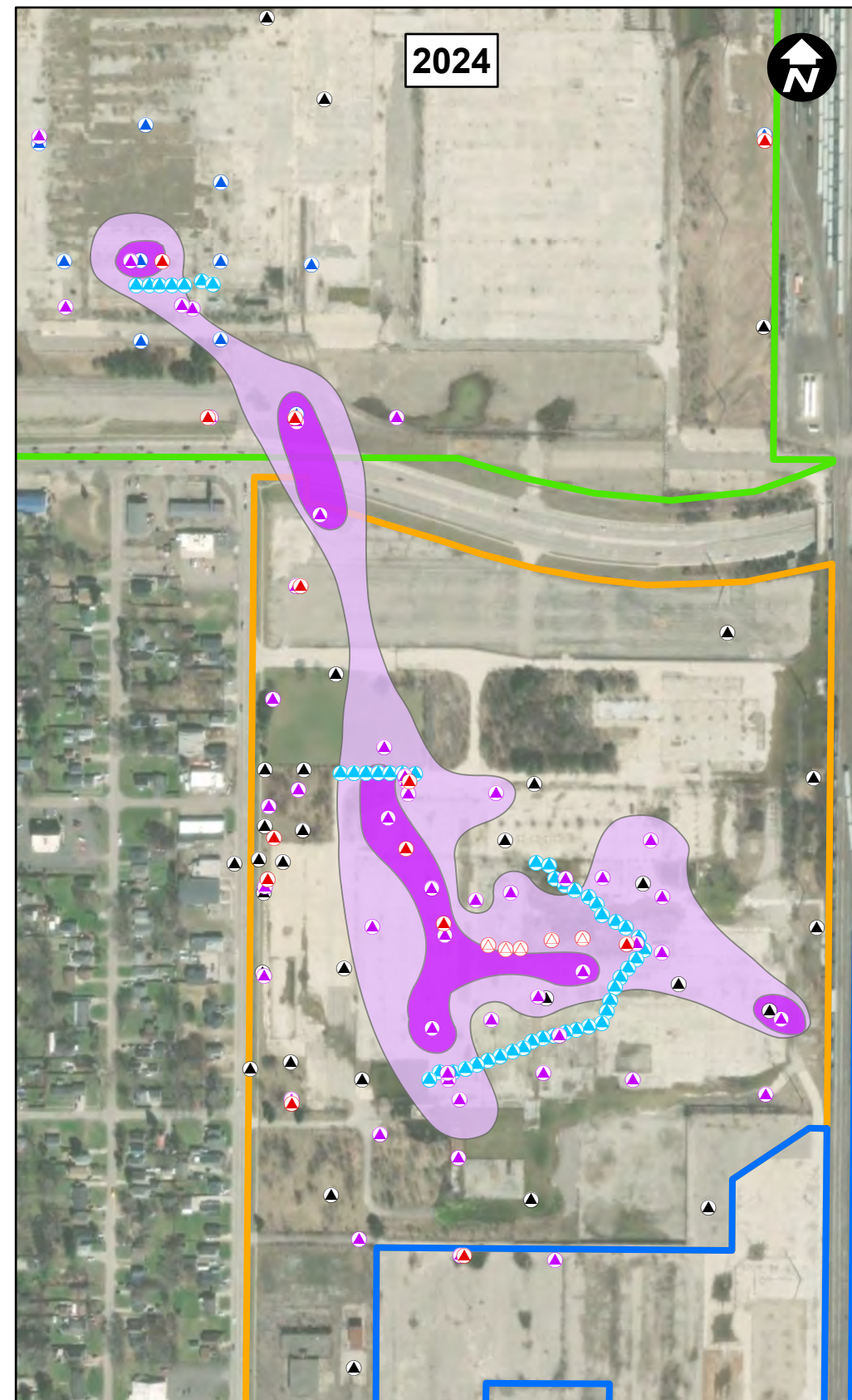
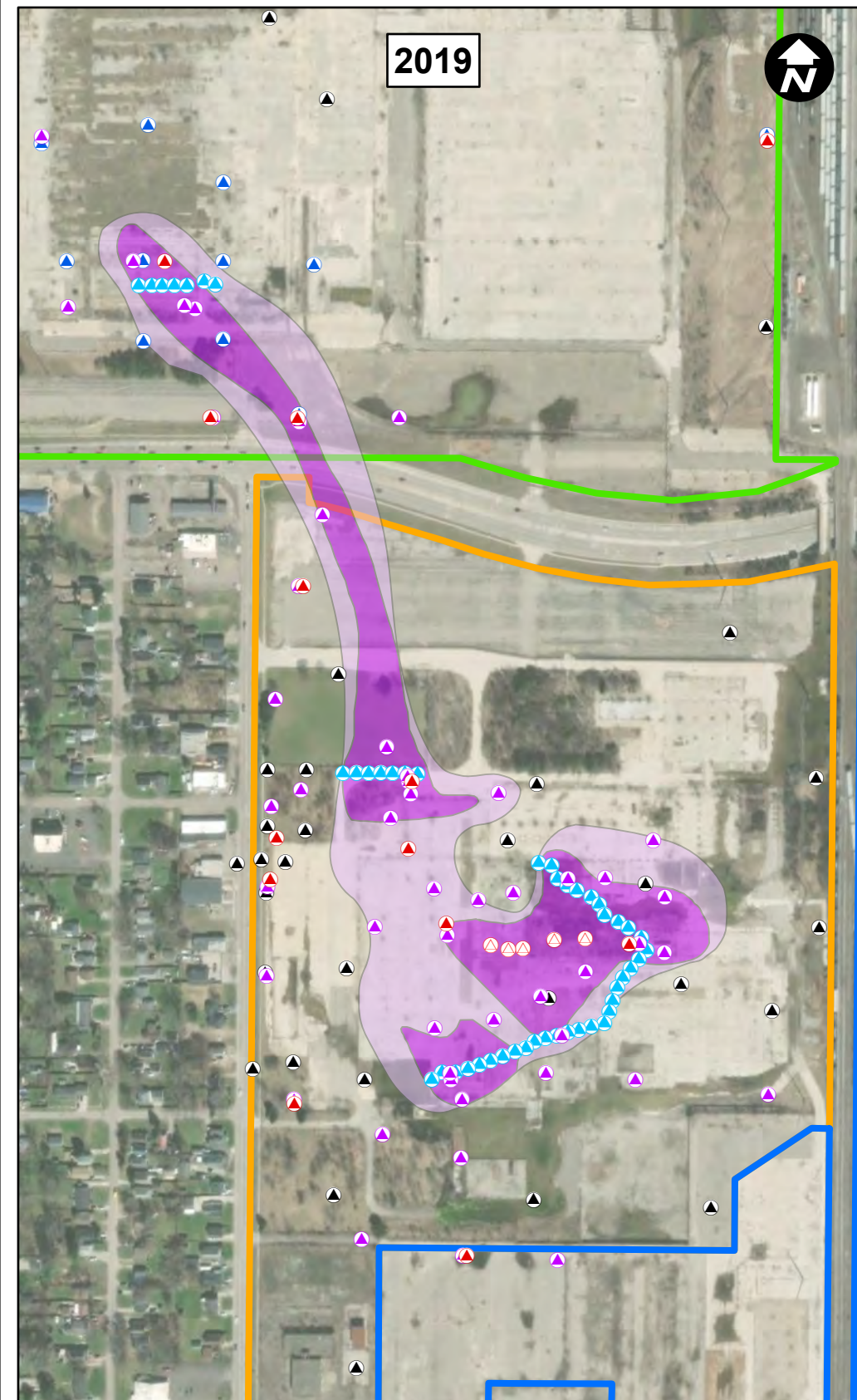
Bold and Italic = below 20% of the RRV

Figures

FIGURE
1

Imagery Source:
ESRI World Imagery Service
Imagery Date: 7/30/2023

CITY: Novi DIV: ENV PIC: J. BARRETT PM: T. LINDER TM: A. VILLHAUER TR: PROJECT NUMBER: 30171056 COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
T:_ENV\RACER\Lansing_BuffaloData\MXDs\2024 Biosparge\Biosparge_2024.aprx PLOTTED: 3/20/2026 1:34 PM BY: AKENS



LEGEND:

- | | |
|-----------------------------------|--|
| BIOSPARGE | LOWER 1,4-DIOXANE PLUME > 72 µg/L |
| PERCHED MONITORING WELL | LOWER 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 µg/L) |
| LNAPL MONITORING WELL | PLANT 2 |
| DEEP OVBURDEN MONITORING WELL | PLANT 3 |
| WEATHERED BEDROCK MONITORING WELL | PLANT 6 |
| BEDROCK MONITORING WELL | |

0 200 400 800
Feet

Imagery Source:
ESRI World Imagery Service
Imagery Date: 7/30/2023

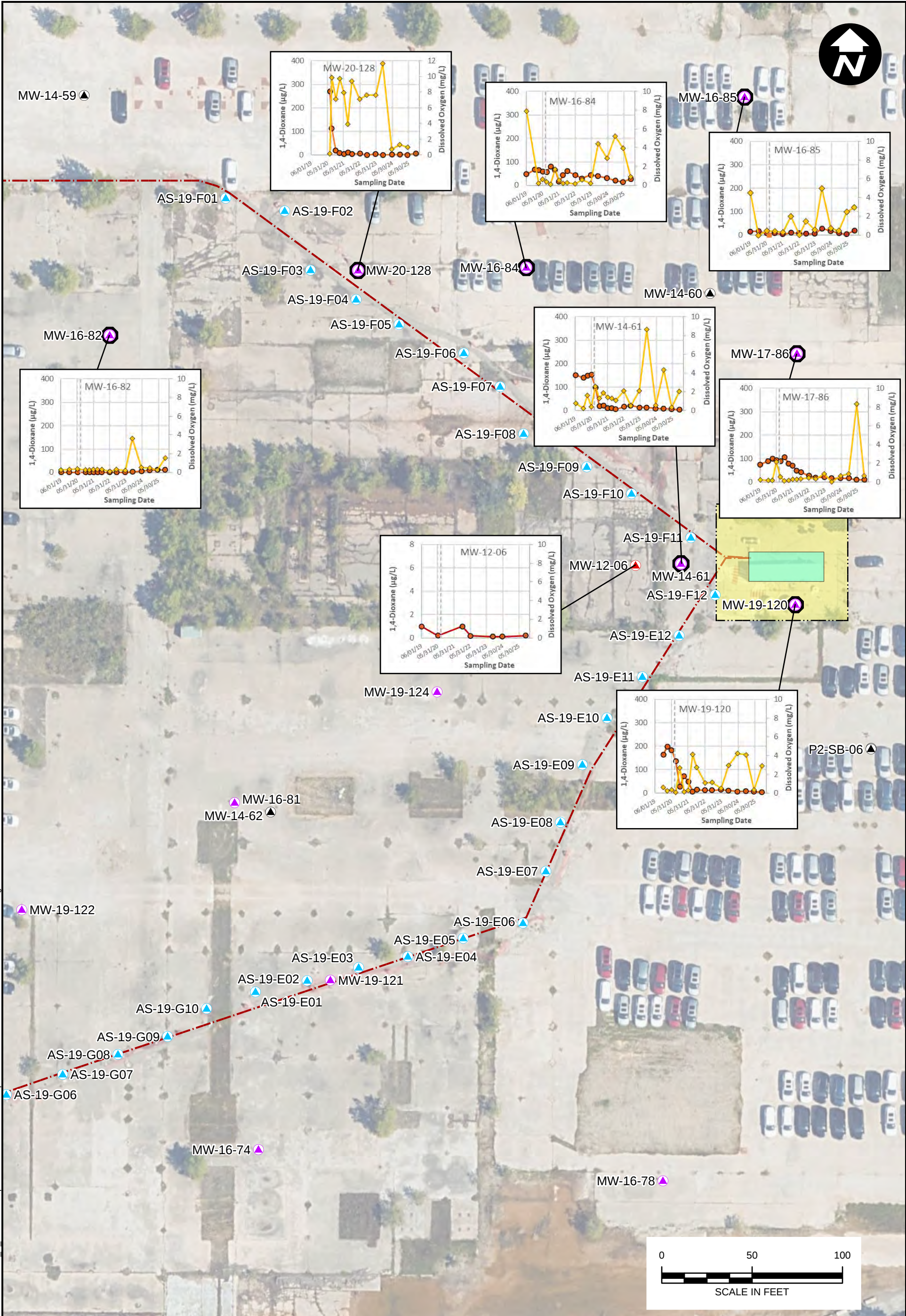
RACER TRUST
LANSING INDUSTRIAL LAND
LANSING, MICHIGAN

**LOWER 1,4-DIOXANE PLUME
COMPARISON 2019 VS 2024 VS 2025**

ARCADIS

FIGURE
2

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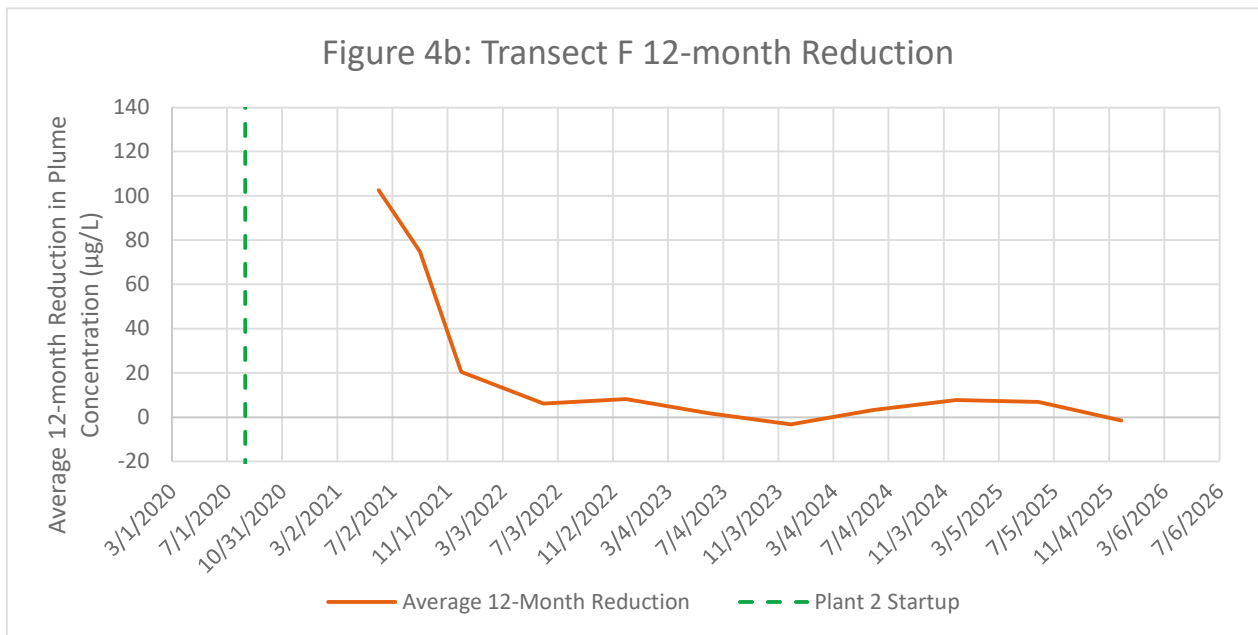
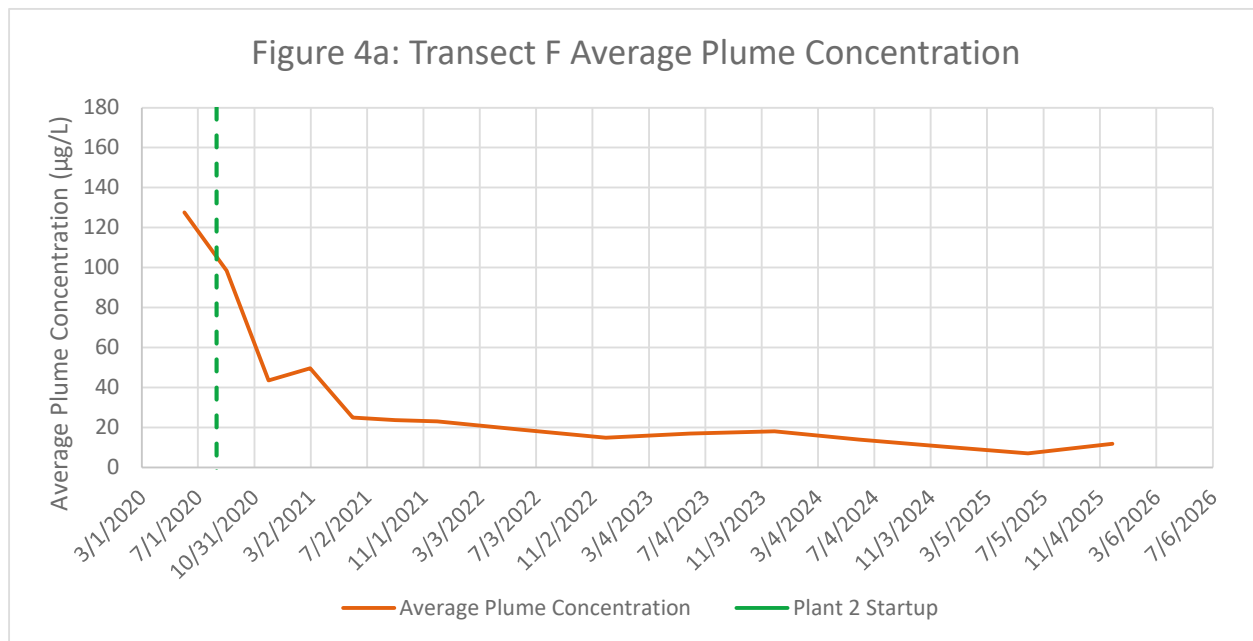
RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

**TRANSECT F BIOSPARGE
PERFORMANCE MONITORING RESULTS**

ARCADIS

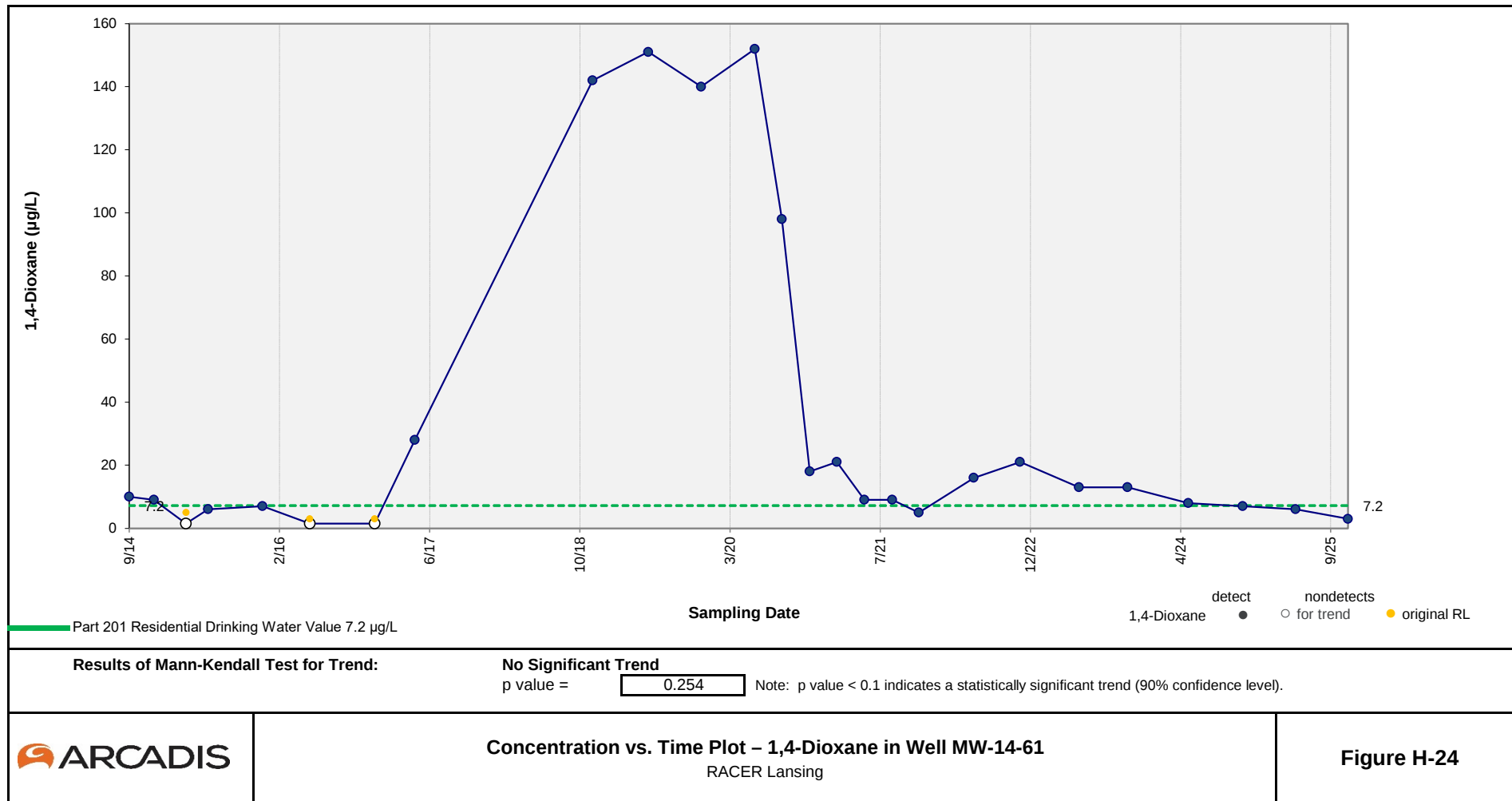
FIGURE
3

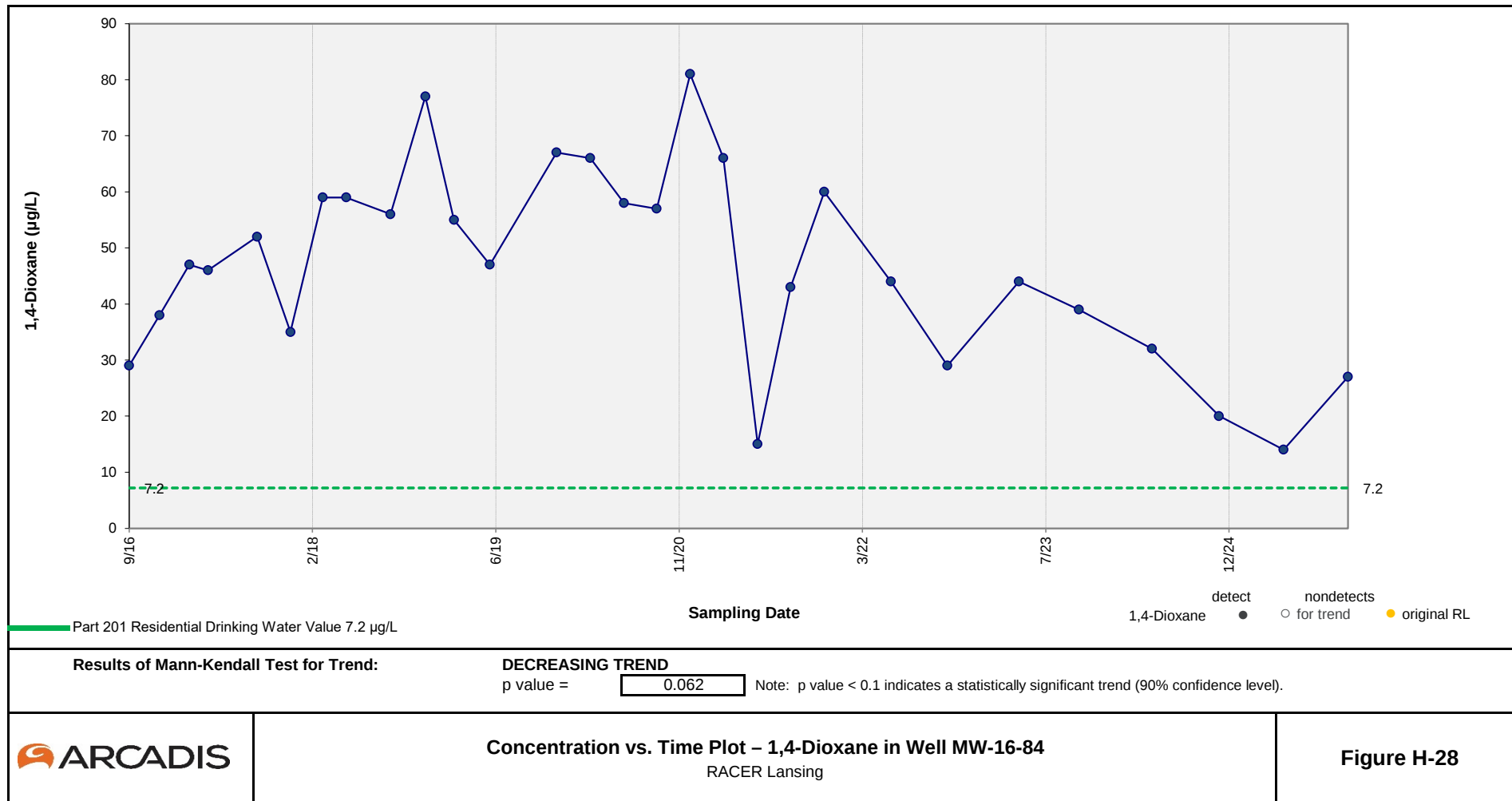
Figure 4
Transect F Average Plume Concentration and 12-month Reduction of 1,4-Dioxane
Biosparge Transect F Shutdown
Lansing Industrial Land, Lansing, Michigan

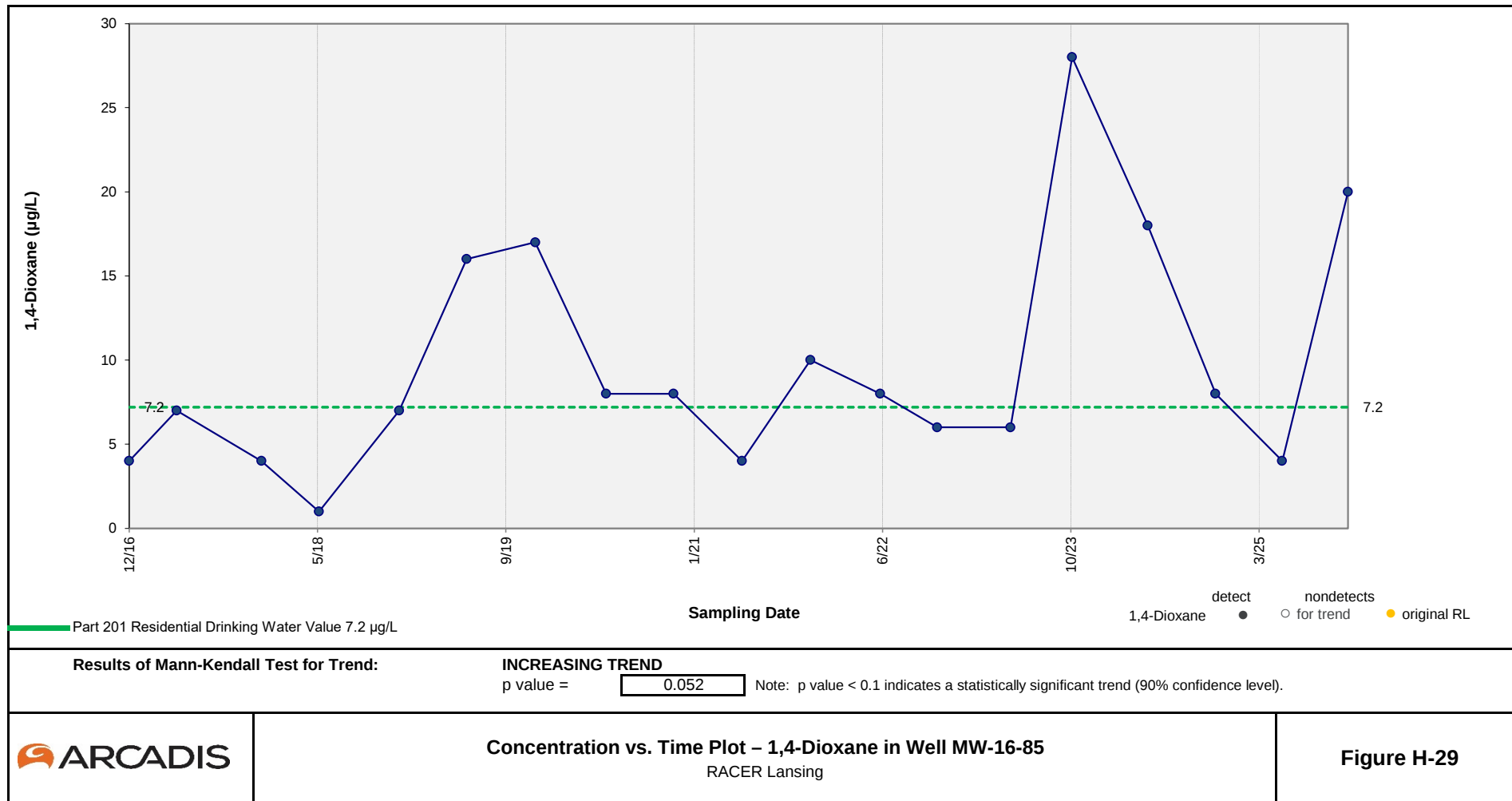


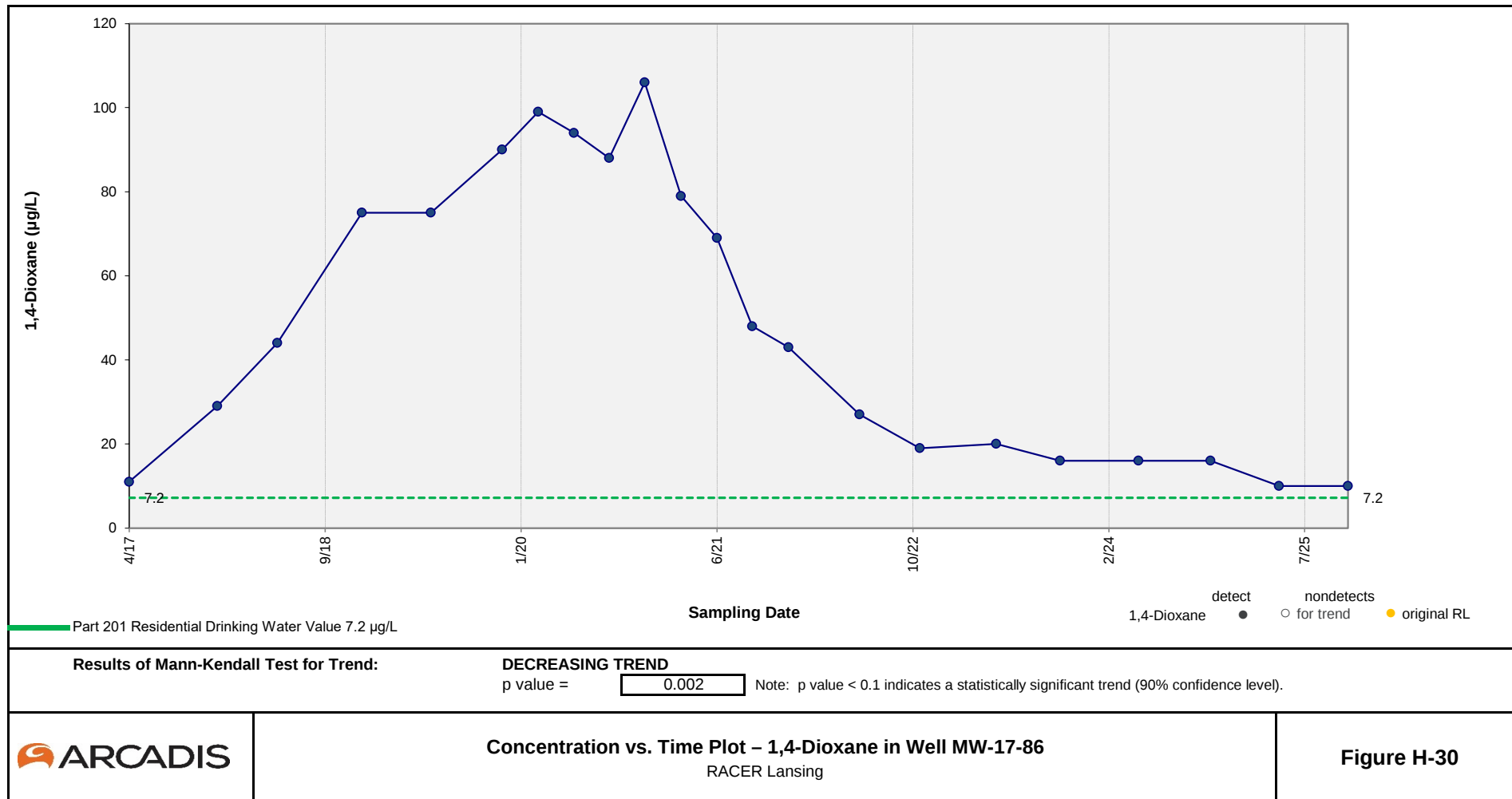
Appendix A

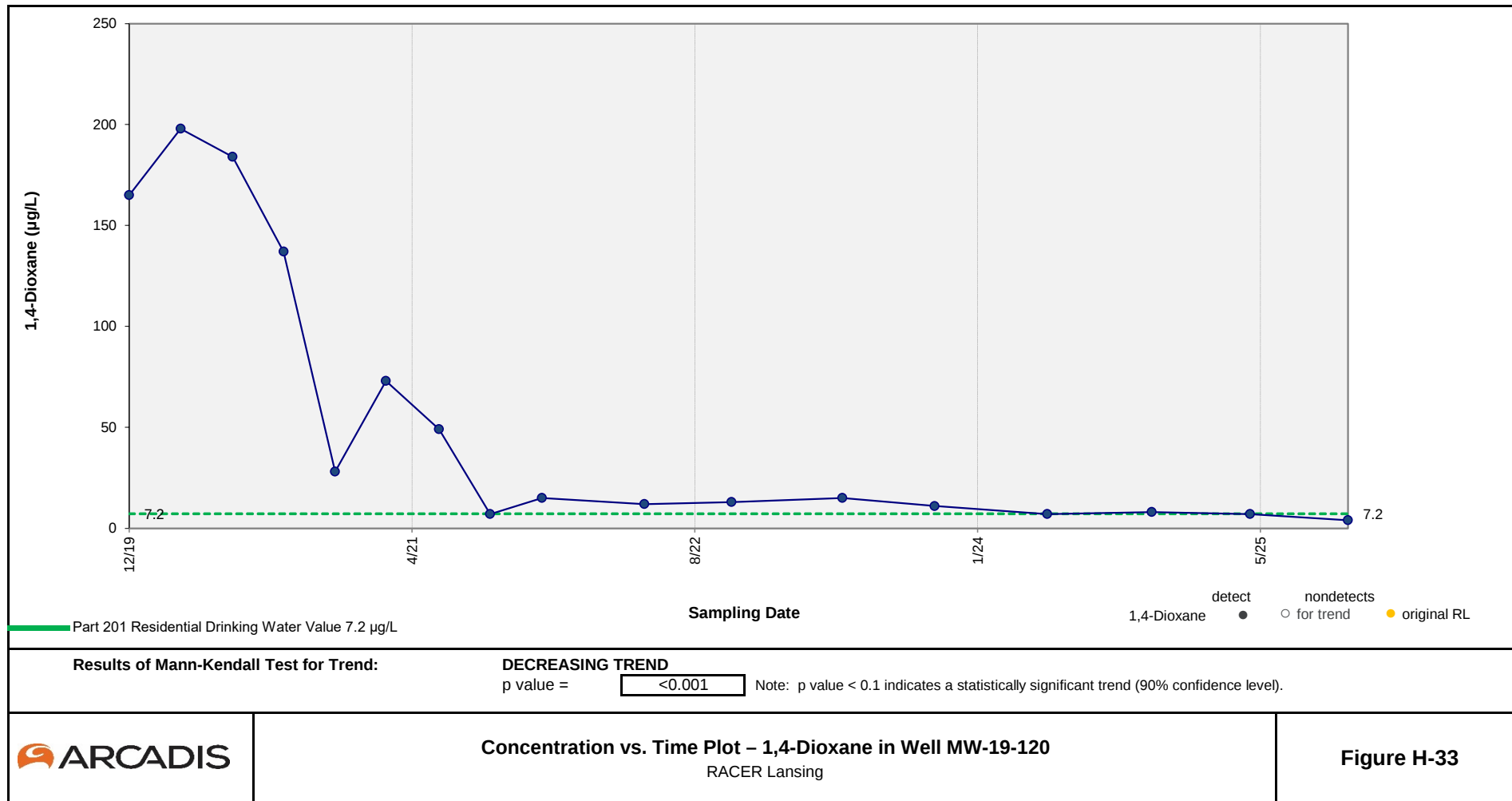
Trend Graphs and MK Analysis



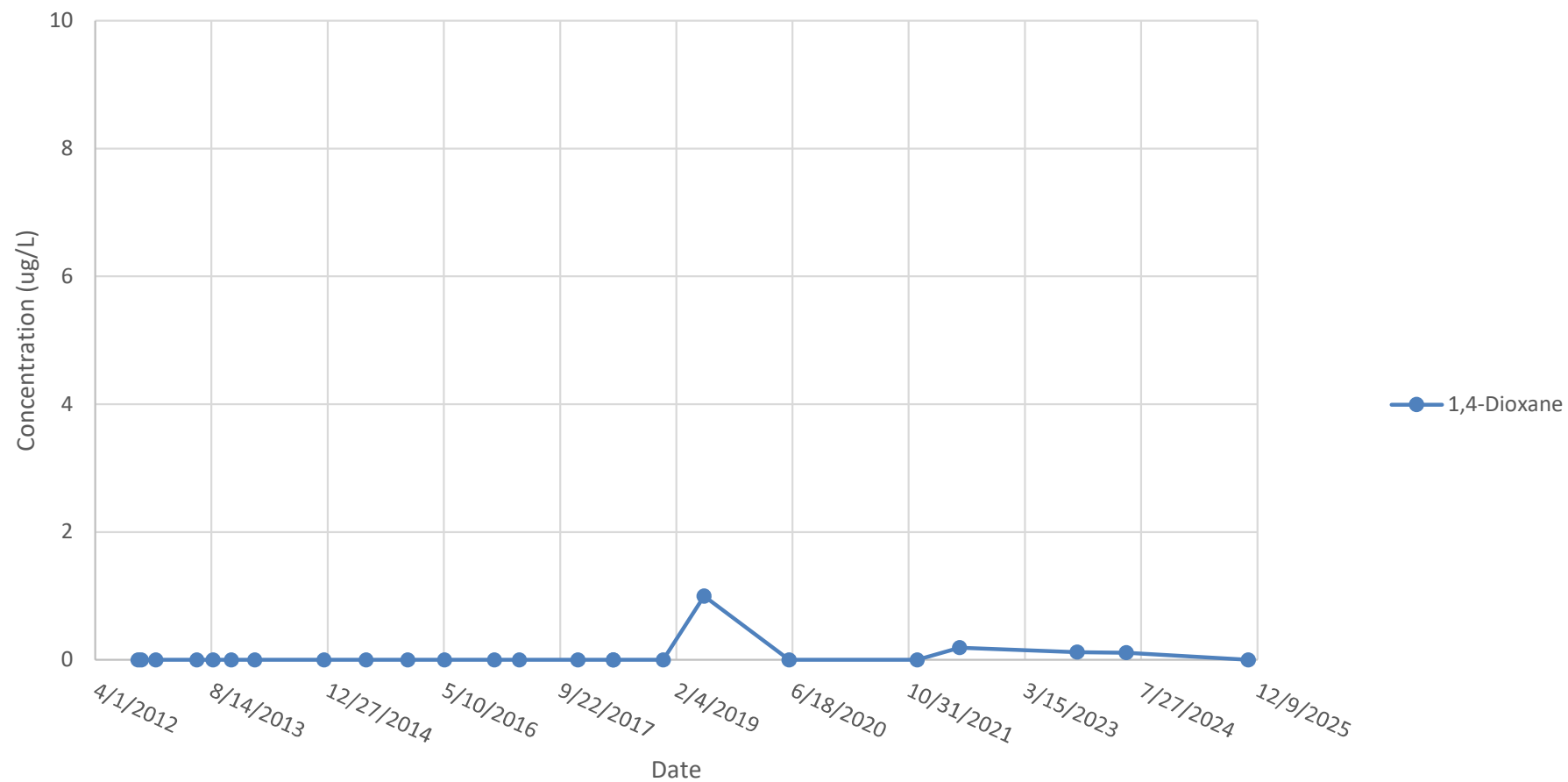




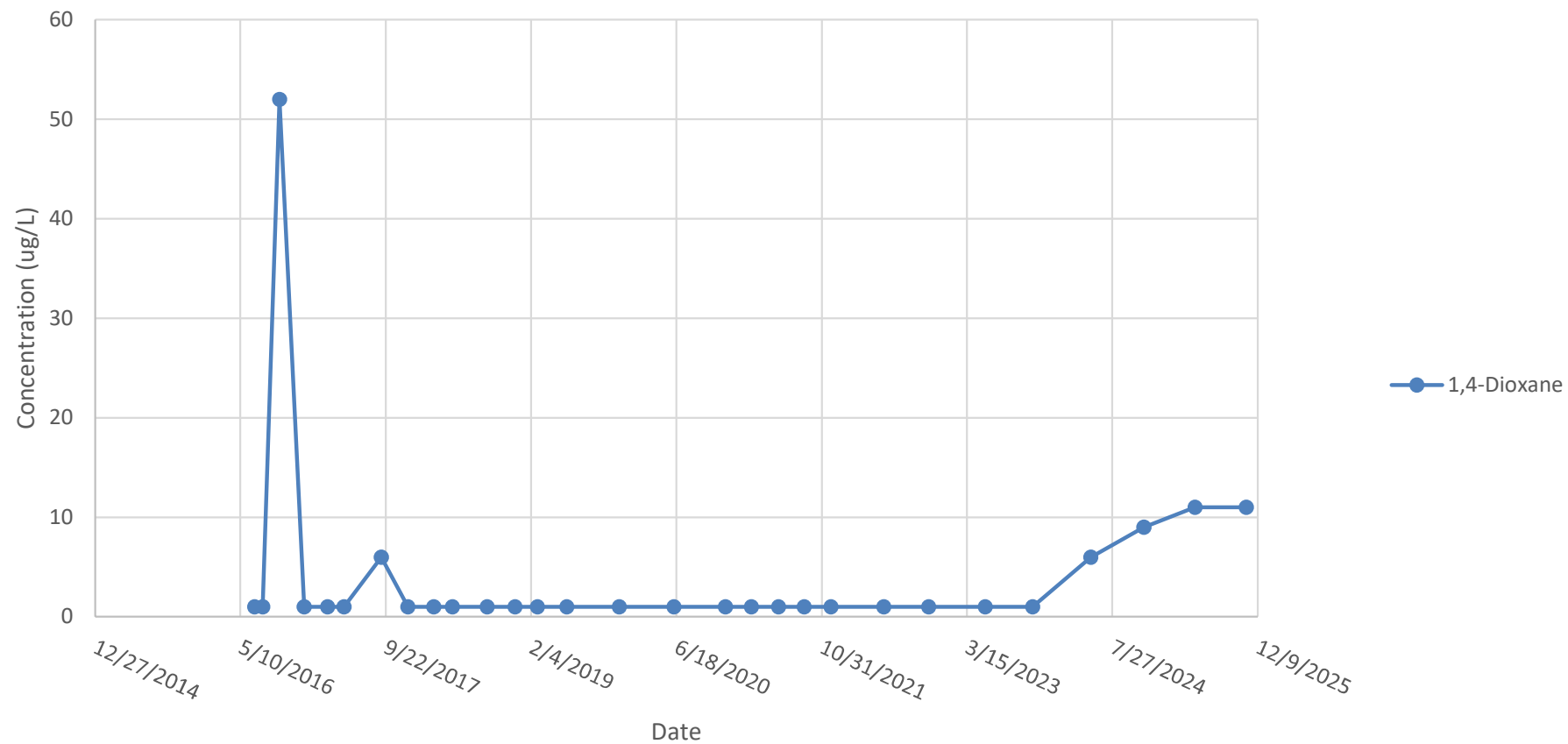




MW-12-06



MW-16-82



MW-20-128

