

Revitalizing Auto Communities Environmental Response (RACER) Trust

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL - DRAFT

Lansing Industrial Land
Lansing, Michigan

January 6, 2021

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MODEL - DRAFT**

Lansing Industrial Land
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LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

CONTENTS

1 Introduction 1

 1.1 1,4-Dioxane..... 1

 1.2 Lower 1,4-Dioxane Investigations.....2

2 Conceptual Site Model.....3

 2.1 Geologic Setting.....3

 2.2 Hydrogeology.....5

 Hydraulic Characteristics.....5

 Vertical Groundwater Flow and the Bedrock Aquifer6

 Bedrock Groundwater Elevation and Apparent Flow6

 2.3 Source Characterization8

 Plant 3 Coliseum Source Area8

 Plant 2 LNAPL Area10

 2.4 Lower 1,4- Dioxane Plume and Municipal Water Supply11

 Deep Bedrock Well Installation11

 Deep Bedrock Monitoring Results.....12

 Regional Sources of 1,4-Dioxane.....13

 Former Adams Plating Company.....13

 Other Sources.....14

 2.5 Fate and Transport14

 Plume Stability.....15

 Natural Attenuation of 1,4-Dioxane15

 Biosparge System.....16

3 References.....17

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

FIGURES

Figure 1. Site Location and Lansing WHPAs

Figure 2. Lower 1,4-Dioxane Sample Locations - Plant 2 and 3

Figure 2a. Lower 1,4-Dioxane Sample Locations - Plant 2

Figure 3. Summary of Lower 1,4-Dioxane Analytical Results - 2019-2020

Figure 4. Lower 1,4-Dioxane Plume Cross-Section – North-South

Figure 5. Lower 1,4-Dioxane Plume Cross-Section – West-East

Figure 6. 3D Model of Lower 1,4-Dioxane Area Hydrostratigraphy

Figure 7. 3D Model of Lower 1,4-Dioxane Plume and Weathered Bedrock Surface – Looking Down

Figure 8. 3D Model of Lower 1,4-Dioxane Plume and Weathered Bedrock Surface – Oblique Views

Figure 9. Bedrock Wells and Low-Level 1,4-Dioxane Results

Figure 10. Summary of 1,4-Dioxane Trends in Deep Overburden and Weathered Bedrock - 2019

APPENDICES

A Historical Groundwater Elevation Contour Maps

B Trend Graphs – MW-12-21 & MW-13-22

C Deep Bedrock Boring and Geophysical Logs

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

1 INTRODUCTION

Arcadis has prepared this Lower 1,4-Dioxane Conceptual Site Model Summary on behalf of the Revitalizing Auto Communities Environmental Response (RACER) Trust and in cooperation with the Michigan Department of Energy, Great Lakes and Environment (EGLE) for the Lansing Industrial Land located in Lansing, Michigan (Site). The location of the Site is provided on **Figure 1**. This report is intended to supplement the 2021 *Lower 1,4-Dioxane Biosparge Completion Report* (Arcadis 2021) and provide a comprehensive conceptual site model (CSM) for the lower 1,4-dioxane groundwater impacts. This report includes findings from numerous previous investigations, including the following:

- RCRA Facilities Investigation (RFI) Phase 2 Supplemental Report (Arcadis 2014a)
- Corrective Measure Pre-Design Report – Lower 1,4-Dioxane Source Evaluation (Arcadis 2014b)
- Lower 1,4-Dioxane Plume Toe Investigation reports (Arcadis, 2016a, 2016b, 2017a)
- RACER Lansing Biosparge System Installation Data Package (Arcadis 2020a)

The intent is to compile a comprehensive summary of the data collected to date and present the resulting CSM that guided the design and installation of the lower 1,4-dioxane biosparge remedy.

1.1 1,4-Dioxane

The synthetic chemical 1,4-dioxane is a recalcitrant compound that is highly miscible in groundwater and may result in large plumes that are challenging to remediate. Its main application was as a stabilizer in common solvents such as 1,1,1-trichloroethane (TCA), and was used to enhance solvent life and prevent decomposition from light, heat, oxygen, and acids. Solvents used in metal cleaning, degreasing, electronics, and many other applications have contained 1,4-dioxane. 1,4-Dioxane has also been found to be present at TCE-impacted sites. It can be found in lacquers, paints, oils, and plastics, and as an impurity in antifreeze. Many common household products such as dish soap, laundry detergent, toothpaste and cosmetics contain low concentrations of 1,4-dioxane.

The primary occurrence of 1,4-dioxane at the Site is believed to be associated with TCA and its use as a solvent in the automobile manufacturing process. TCA degrades relatively quickly, particularly under anaerobic conditions, but 1,4-dioxane persists, preferentially partitions to groundwater, and migrates with groundwater flow. As a result, there are two 1,4-dioxane plumes at the Site; the perched plume, located in shallow perched groundwater across Plant 2 and to the east onto Plant 6, and the lower 1,4-dioxane plume. The lower 1,4-dioxane plume has formed deeper near two source areas and travels primarily within the permeable weathered bedrock extending from Plant 3 southeast to the central part of Plant 2. The Michigan Part 201 Drinking Water (DW) Criteria for 1,4-dioxane is 7.2 micrograms per liter ($\mu\text{g/L}$). The lower 1,4-dioxane plume is shown on **Figure 2** and is the focus of this CSM.

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

1.2 Lower 1,4-Dioxane Investigations

Numerous investigation activities have been completed at the Site to characterize the lower 1,4-dioxane plume. The Site layout, lower 1,4-dioxane plume and the locations of all deep soil borings and monitoring wells used to characterize and monitor the lower 1,4-dioxane plume are provided on **Figure 2**. A close-up of the central Plant 2 area is included as **Figure 2a**. Below is a summary of the key reports that form the basis for this lower 1,4-dioxane CSM:

- 2014 - RFI Phase 2 Supplemental Activities Summary Report (Arcadis 2014a). Supplement to the 2013 RFI Report focused primarily on the characterization of the lower 1,4-dioxane plume. Delineated the main lower 1,4-dioxane plume extending from Plant 3 to Plant 2. Plant 3 plume originates from the “coliseum” source area and migrates to the south-southeast within the deep overburden and weathered bedrock zone. The plume continues south from Plant 3, across Saginaw Road into the central portion of Plant 2.
- 2014 – Corrective Measure Pre-Design Report – Lower 1,4-Dioxane Source Evaluation (Arcadis 2014b). High resolution investigation within the Plant 3 “Coliseum” source area. The investigation identified only limited impacts within the perched zone with the highest concentrations located within the low permeability glacial till confining layer. Most of the residual source mass is located within the saturated deep overburden. The majority of the 1,4-dioxane present in the lower 1,4-dioxane plume is currently located downgradient of the source area, suggesting an overall depleted source mass.
- 2016 – Lower 1,4-Dioxane Plume Toe Investigations (Arcadis 2016a, 2016b). The toe investigations were completed to look at the potential for 1,4-dioxane leakage from the perched zone around the Plant 2 light non-aqueous phase liquid (LNAPL) area that may contribute to the southern portion of the lower 1,4-dioxane plume. The results of the investigations confirmed leakage, specifically to the area beneath and northeast of the LNAPL area in the central part of Plant 2.
- 2017 – Northeast Lobe Investigation (Arcadis 2017a). Additional work completed to delineate the extent of the 1,4-dioxane weathered bedrock plume extending to the northeast of the Plant 2 LNAPL area. The northeast lobe was initially delineated using vertical aquifer profile (VAP) borings and subsequent monitoring well installation. The work completed as part of this investigation also confirmed that although some comingling may occur with the main plume west of the Plant 2 LNAPL area, the 1,4-dioxane beneath the Plant 2 LNAPL area appears primarily related to leakage from the perched zone beneath and immediately surrounding the Plant 2 LNAPL.
- 2020 – Deep Bedrock Well Sampling Update (Arcadis 2020b), and follow-up response to Lansing Board of Water and Light comment. Provides a summary of the deep nested bedrock well installation along the western boundary of Plants 2 and 3. Results show vertical migration of 1,4-dioxane is limited in the bedrock Saginaw Formation, but may occur at low concentrations in the more homogeneous Grand River Formation. Concentrations of 1,4-dioxane in bedrock - both below the lower 1,4-dioxane plume and in deeper bedrock along the western Site boundary - are below the DW Criteria (7.2 µg/L). Migration of 1,4-dioxane to the west is limited by apparent east-southeast bedrock hydraulic gradient at the Site. Further, detections of 1,4-dioxane in the regional bedrock aquifer are likely influenced by other sources, both industrial point sources and non-point sources resulting from household products (e.g., detergents).

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

- 2020 - Biosparge Installation Data Package (Arcadis 2020a). Provides a summary of the data collected during the installation of the lower 1,4-dioxane biosparge system. Data includes soil boring logs, well construction logs and a summary of the VAP groundwater sample results collected as part of the installation.
- 2020 – Plant 2 LNAPL Conceptual Site Model (Arcadis 2020d). Includes a summary of the additional sampling completed for LNAPL and LNAPL impacted soils to evaluate the LNAPL composition and 1,4-dioxane partitioning. The data shows that 1,4-dioxane associated with the LNAPL is depleted and the majority of the 1,4-dioxane mass in the Plant 2 LNAPL area is present as dissolved phase in surrounding perched groundwater (Arcadis 2018a).
- 2021 - Lower 1,4-Dioxane Biosparge Construction Completion Report (Arcadis 2021). The lower 1,4-dioxane biosparge remedy was installed in 2019-2020 to treat 1,4-dioxane in weathered bedrock as it migrates southeast from Plant 3 to Plant 2. To help determine optimum placement of the biosparge wells during installation, vertical aquifer profile (VAP) groundwater samples were collected from the weathered bedrock zone and submitted for rush turn analysis. Additional VAP borings were completed as follow-up to the biosparge installation to fill in data gaps highlighted by the biosparge VAP data.

The most recent 1,4-dioxane analytical results, including the 2019 biosparge VAP results and June 2020 monitoring well data, are summarized on **Figure 3**. Additional VAP borings used to define the lower 1,4-dioxane plume during the various investigations are included on **Figure 2/2a** and **Figure 3**, but due to the dynamic nature of the plume, the older 1,4-dioxane data is not shown and is currently considered for general reference only.

2 CONCEPTUAL SITE MODEL

The following sections summarize the current understanding of the lower 1,4-dioxane plume. The lower 1,4-dioxane plume is dynamic and its morphology has changed since first identified in the deep overburden and weathered bedrock during the RFI investigation in 2012. These changes are partly due to increasing data resolution as additional investigations have been completed, but also, shifts in bedrock groundwater elevation and gradient have pushed migration and plume expansion in new directions since monitoring began in 2013. The full scale biosparge remediation system (Arcadis 2021) was started in 2020 and will likely lead to additional changes in plume morphology and mass reduction throughout the plume.

2.1 Geologic Setting

The geology of the Site is complex, consisting of an interbedded series of glacially derived sediments. The geology of the Site is divided into six general hydrostratigraphic units (from shallow to deep):

- Shallow fill – Typically 1 to 10 feet thick consisting of sand and gravel mixtures brought to the Site as part of construction activities. The shallow fill can be saturated when present below ~ 5 feet and above a clay layer.
- Interbedded Zone (a.k.a., Perched Zone) – At depths generally between 5 and 30 feet below ground surface (ft bgs). Typically composed of interbedded soft clay, glacial tills with isolated lenses of silt and sand. Sand and silt lenses are typically saturated, forming thin discontinuous zones of perched

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

groundwater. Saturated soils within the shallow fill and interbedded zone are generally referred to as “perched water” or collectively as the “perched zone.”

- Glacial till – Depth and thickness are highly variable but typically encountered at between approximately 25 and 45 ft bgs. A compact, dense silt/sand/gravel/clay mix that creates a confining unit and barrier to vertical flow. Separates the perched water from the deep overburden and weathered bedrock zone.
- Deep overburden – Consists of a mix of sand and sand-silt-clay till located above the bedrock. The deep overburden is dry and sandy beneath the glacial till but becomes saturated where encountered deeper than approximately 55 to 65 ft bgs. Saturated deep overburden is only observed at Plant 3 where a southwest-northeast trending bedrock valley dips below the regional water table. There is dense till layer overlying the bedrock across much of the area that varies in thickness and composition, consisting primarily of silt, fine sand with varying amounts of clay. Although lower permeability than the overlying vadose zone sand, this “bedrock capping till” appears permeable enough to allow 1,4-dioxane to migrate through it into the weathered bedrock, either gradually or preferentially through areas where the zone is thin, absent, or siltier/sandier. The deeper till can also create a confining unit for the bedrock aquifer creating semi confined aquifer conditions for weathered bedrock groundwater.
- Weathered Bedrock / Bedrock – Encountered anywhere from 100 ft bgs on Plant 3 within the bedrock valley, to 55 ft bgs at locations in the central part of Plant 2. The bedrock consists of the Grand River Formation in the southwest of Plant 3, transitioning to the Saginaw Formation in the central portion of Plant 2. The Grand River Formation is a fine to medium-grained sandstone that occupies erosional valleys within the Saginaw Formation. The Saginaw Formation consists primarily of fine-grained sandstone with lenses of shale that can vary from 15 feet thick to millimeter thin stringers threaded throughout the sandstone. The transition from weathered to consolidated rock is gradational with the weathered zone typically ranging from 5 to 15 feet thick. The weathered bedrock zone, especially the weathered sandstone, is a preferential pathway for groundwater flow.

Geologic cross-sections for the lower 1,4-dioxane plume are provided as **Figure 4** (north-south) and **Figure 5** (west-east). As shown on **Figure 4**, the bedrock transitions from the Grand River Formation in the north to the Saginaw formation in the central portion of Plant 2. Much of the Plant 3 source mass is tied up in the saturated lower permeability silt and fine sands present within the bedrock valley. Moving south, the bedrock surface rises and the 1,4-dioxane plume transitions entirely into the weathered bedrock in the northern part of Plant 2. The additional work completed during the biosparge system installation identified a bedrock high present in the Plant 2 LNAPL area as shown on **Figure 5**. This bedrock ridge or dome located just north of the Plant 2 LNAPL area, may partially deflect 1,4-dioxane mass migrating south from Plant 3 and serve to separate 1,4-dioxane leaking from the Plant 2 perched zone from the mass migrating south from Plant 3. Although co-mingling most likely occurs, the mass leaking from the Plant 2 perched zone appears to primarily spread northeast and east of the Plant 2 LNAPL area, whereas the Plant 3 plume continues to migrate to the west of the LNAPL area and bedrock high, continuing south.

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

A 3D model of the lower 1,4-dioxane plume was prepared using Earth Volumetric Studio (EVS, Ctech Inc.). Screenshots of the 3D model are provided as **Figure 6**, **Figure 7**, and **Figure 8**. The 3D model illustrates the weathered bedrock surface and the complexity of the 1,4-dioxane distribution in the central portion of Plant 2.

2.2 Hydrogeology

The lower 1,4-dioxane plume receives contributions from two shallow source areas (discussed in more detail in Section 2.3). The mass migrates through the glacial till perching layer, through the underlying vadose zone and into the saturated deep overburden and/or weathered bedrock before continuing laterally within the higher permeability weathered bedrock zone. The bedrock receives recharge from precipitation, as well as leakage from the Grand River, which flows through the region and is located to the south, east and north of the RACER site. Regional drinking water is obtained from the bedrock aquifer and the Site is located partially within a wellhead protection area (WHPA) associated with Lansing Township water supply wells located west of Plants 2 and 3 and partially within a WHPA associated with City of Lansing water supply wells to the east of Plants 3 and 6. The WHPAs are included on **Figure 1**. Changes in seasonal recharge and municipal pumping affects bedrock groundwater elevation and flow patterns. Evidence of these fluctuations have been observed at the Site, and when combined with the complex hydrostratigraphy and two source areas, have created a complex groundwater plume.

Hydraulic Characteristics

Various hydraulic testing has been completed in the confining till, deep overburden, weathered bedrock and consolidated bedrock zones in and around the lower 1,4-dioxane plume. The confining glacial till that separates the upper perched zone from the deep overburden is a dense relatively dry mixture of clay, silt, sand and gravel. Permeameter testing at multiple locations at Plant 6 suggest vertical hydraulic conductivity of the till is on the order of 10^{-8} centimeters per second (cm/sec) (Arcadis 2014a). However, there are areas where the confining layer is noted as thin (e.g., central Plant 2), or fractured. Further, the glacial till perching layer was excavated during construction in the southwestern portion of Plant 3. Source areas of the lower 1,4-dioxane plume are discussed further in Section 2.3.

Upon finding a pathway to the deep overburden and weathered bedrock zones, 1,4-dioxane migrates laterally away from the source areas. Slug tests and a geotechnical sample collected from the deep overburden below the Plant 3 source area show hydraulic conductivity (K) on the order of 5.0×10^{-5} cm/sec (Arcadis 2014b). This low permeability material provides storage of 1,4-dioxane mass within the silts and fine sands present above weathered bedrock in the bedrock valley. From this lower permeability reservoir, 1,4-dioxane migrates vertically into weathered bedrock and laterally to the southeast, both within the weathered bedrock and in the overlying, more permeable zones of deep overburden. Hydraulic testing has shown the weathered bedrock (Grand River Formation) at Plant 3 has a K on the order of 4×10^{-3} cm/sec (Arcadis 2015). Slug testing of the saturated deep overburden near Saginaw Street (MW-13-48) has indicated a K as high as 10^{-2} cm/sec. The horizontal gradient driving the mass from the Plant 3 source area to the southeast has been relatively consistent since monitoring began in 2013 ranging from 0.009 to 0.011 (ft/ft), with an exception for 2018 (0.004) corresponding to a high bedrock groundwater elevation (discussed further below).

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

As the plume migrates south from Plant 3 to Plant 2 the weathered bedrock surface rises above the deep overburden water table/potentiometric surface and the plume transitions entirely to the weathered bedrock zone. In the central part of Plant 2, the bedrock transitions to the Saginaw Formation (**Figure 4**). The Saginaw Formation includes a finer grained sandstone with significant layers of shale, both in thicker layers (up to 15 feet thick) and as small stringers in a sandstone matrix. In general, the weathered Saginaw Formation has lower permeability than the Grand River Formation. Hydraulic testing of the weathered Saginaw Formation suggests K ranges from 2.0×10^{-4} to 1.5×10^{-3} cm/sec (Arcadis 2015a).

Groundwater flow within the weathered bedrock and the resulting lower 1,4-dioxane plume morphology reflects these changing hydraulic conditions. The plume migrates relatively quickly from the Plant 3 coliseum source area to the southeast (estimated groundwater velocity ranging from 130 to 660 feet per year), then slows and spreads upon reaching the Saginaw Formation. Based on the estimated gradient and K of the Saginaw Formation, the groundwater velocity throughout the central portion of Plant 2 is much slower, ranging from 15 to 100 feet per year, primarily to the southeast, east and northeast. The horizontal gradient and resulting direction of groundwater flow at Plant 2 has varied since monitoring began in 2013, shifting between an apparent southeasterly flow to more easterly flow at different times, as detailed below

Vertical Groundwater Flow and the Bedrock Aquifer

Two factors limit vertical flow and the migration of 1,4-dioxane into the more consolidated bedrock aquifer: vertical anisotropy and overall low bulk hydraulic conductivity. The vertical anisotropy is limited in the relatively homogeneous Grand River Formation but increases dramatically within the Saginaw Formation due to the horizontal layers of shale. The measured vertical gradient using nested pairs of weathered bedrock and bedrock wells ranges as high as 0.5 (feet per foot) in the Saginaw Formation. Further, the hydraulic conductivity of the consolidated bedrock formation is one to two orders of magnitude less than the weathered zone. Based on specific capacity testing, wells installed within the Grand River Formation have shown a bulk K on the order of 10^{-4} cm/sec (Arcadis 2014a). The bulk K measured in wells installed in the Saginaw Formation is on the order of 10^{-5} cm/sec. Bulk K refers to the average hydraulic conductivity of a bedrock borehole accounting for both primary (bedrock matrix) and secondary (bedrock fractures/structures) hydraulic characteristics. The bedrock bulk K can be significantly higher if fracturing is encountered (e.g., MW-12-02, noted with several fractures, has a measured K of 10^{-2} cm/sec); however, bedrock fractures appear to be rare based on downhole geophysics completed at the deep bedrock wells MW-19-118 and MW-19-119, discussed further in Section 2.4.

Bedrock Groundwater Elevation and Apparent Flow

Because of the high vertical anisotropy observed within the Saginaw Formation, bedrock wells with slightly different depths can have dramatically different groundwater elevations. Measured bedrock groundwater elevation at the Site typically represents a potentiometric surface with weathered bedrock groundwater confined below a dense till located above bedrock. However, there are areas of the Site where the bedrock surface is above the water table creating an unconfined bedrock aquifer condition; for example, central and southeastern Plant 2, as well as Plant 6 further east. Groundwater elevation summaries are provided as part of the Annual Groundwater Monitoring reports (e.g., Arcadis 2020c). To

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

create bedrock contour maps the effective head or “corrected” potentiometric surface is calculated using the observed vertical gradients. Near the coliseum, where the bedrock consists of the more uniform and permeable Grand River Formation, the vertical gradient is negligible. The effective head correction is only applied to Saginaw Formation monitoring wells. Review of the bedrock wells and other deep boring logs suggests an approximate geologic contact between the Grand River and Saginaw Formations oriented roughly southwest to northeast. The approximate location of the geologic contact is included on **Figure 2/2A, 3, 4 and 5**.

To calculate the effective head for the bedrock the average downward gradient for a given monitoring event is applied to bedrock monitoring wells installed within the Saginaw Formation as follows:

$$GW_{\text{eff}} = GW - (dh/dl * \Delta\text{Elev})$$

Where:

GW_{eff} = effective hydraulic head

GW = measured hydraulic head

dh/dl = vertical gradient

ΔElev = difference in elevation between deepest bedrock well and measured well

Using this approach, the bedrock groundwater contours result is a relatively good match for the observed distribution of the lower 1,4-dioxane plume located within the weathered bedrock zone. A collection of the bedrock potentiometric surface maps spanning 2013 to 2020 is provided as **Appendix A**. Review of the historical bedrock contour maps illustrates the increasing resolution of the lower 1,4-dioxane plume as various investigations are completed through time. The bedrock horizontal groundwater gradient is relatively consistent within the Grand River Formation extending from Plant 3 to Plant 2 along the plume. Once within the Saginaw Formation the bedrock groundwater elevation contours vary considerably. The following provides some key observations:

- December 2013 - Although southerly, the corrected groundwater elevation indicates a relatively flat gradient in the central portion of Plant 2 with the corrected groundwater elevation varying by less than 2-feet across a large area.
- December 2014 – Appears to be an inward gradient along the axis of the lower 1,4-dioxane plume with a west to east gradient between wells MW-12-06 and MW-12-05.
- December 2015 – The apparent gradient shifts to more southeasterly on Plant 2 with the corrected elevation at MW-12-06 decreasing by 7 feet.
- May 2016 – Lower 1,4-dioxane plume morphology changes considerably with the completion of the Lower 1,4-Dioxane Toe Investigation (Arcadis 2016a). Gradient is southeasterly on Plant 2, relatively consistent with December 2015.
- April 2017 – Bedrock well MW-17-87 installed along Plant 2 western boundary and MW-12-05 is replaced with a deeper well (MW-12-05R). Easterly gradient becomes more pronounced and suggests a significant component of 1,4-dioxane migration may occur to the east, particularly as

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

associated with the Plant 2 LNAPL area source contribution. Additional weathered bedrock wells installed to the east of the Plant 2 LNAPL area have shown an increase in 1,4-dioxane concentration since installation, consistent with the concept of easterly migration.

- December 2018 - Between April 2017 and December 2018, measured bedrock groundwater elevation increased by 6 to 12 feet across the site. The increase was steady, generally increasing a consistent percentage each quarter before peaking in December 2018. The result of the relatively higher groundwater elevation is a flatter gradient across much of the site. The gradient in the central part of Plant 2 is still easterly. The cause of the rise in bedrock groundwater elevation is unknown, but likely associated with changes to municipal pumping and/or seasonal recharge. Bedrock groundwater elevation has since stabilized and begun to decrease but remains higher (~5-10 feet) in 2020 than it was in 2013.
- June 2019 - Additional changes to the lower 1,4-dioxane plume morphology were identified with the additional work completed during the installation of the biosparge system, including VAP sampling and installation of performance monitoring wells (**Figure 2/2a**). Although still an easterly component in the central portion of Plant 2, the gradient in June of 2019 is relatively flat with less than 2 feet of corrected head difference across the central and southern part of Plant 2.
- December 2020 – Similar to June 2019 with a relatively flat gradient across the central portion of Plant 3. Although gradient is easterly in the central portion of Plant 2, it is more southeasterly at the toe of the lower 1,4-dioxane plume, which is more consistent with the pre-2017 apparent gradient.

As noted above, the bedrock surface rises steadily from northwest to southeast. The southern extent of the lower 1,4-dioxane plume, as currently defined, is aligned with this higher bedrock elevation and may be effectively stationary as the plume encounters the reduced permeability of more consolidated bedrock (**Figure 7/8**). The primary areas of continued migration (prior to the installation of the biosparge system) appear to be to the east and northeast of the Plant 2 LNAPL area. The lower 1,4-dioxane plume stability evaluation supports this migration concept and is discussed further in Section 2.5.

2.3 Source Characterization

Two source areas have historically or are currently leaching mass to the lower 1,4-dioxane plume: the Plant 3 “coliseum” source area in the southeastern part of Plant 3, and the “Plant 2 LNAPL Area” in the central part of Plant 2.

Plant 3 Coliseum Source Area

The Plant 3 coliseum source area takes its name from the press pit basement and support columns exposed during the Plant 3 demolition (vaguely resembling a Roman ruin). The basement of a former Plant 3 press area extended to a depth of 15 to 20 feet below grade and was formerly used to house equipment for stamping automobile parts. Upon demolition of the Plant 3 building, the coliseum was exposed and created a 3-acre, 15 to 20-foot-deep pit that collected surface runoff and precipitation, which drained into the subsurface through cracks and other openings in the floor of the pit. When the coliseum was backfilled with fill material in 2015, holes were drilled through the floor to promote drainage and to continued source flushing in anticipation of remedy design.

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

Based on the depth of the coliseum, known depth of the glacial till confining layer, and soil borings completed through the floor of the coliseum, the construction of the press-pit basement removed most or all of the dense, low permeability glacial till confining layer. During the initial phases of the RFI, soil samples were not analyzed for 1,4-dioxane as it had not been identified as a constituent of concern at that time. However, soils in the perched zone south of the coliseum contained TCA and other VOCs (1,4-dioxane was used as a stabilizer for TCA), that extend from a former sump area up to the south wall of the coliseum. This breach in the confining layer has allowed shallow 1,4-dioxane to migrate vertically along the southern wall of the coliseum through the vadose zone and into the saturated deep overburden that occupies the bedrock valley in this area. Monitoring wells installed in 2012 within the deep overburden and 2013 within weathered bedrock below the perched zone impacts confirmed concentrations of 1,4-dioxane up to 500 micrograms per liter ($\mu\text{g/L}$) at that time. The timing of the 1,4-dioxane release is unknown, however, the demolition of Plant 3 in 2007, and subsequent preferential recharge through the coliseum has likely bolstered the horizontal gradient in the deep overburden and weathered bedrock and promoted migration of the lower 1,4-dioxane plume to the southeast.

Additional work, including high resolution soil and groundwater sampling, was completed in 2014 to characterize the coliseum source area prior to development of remedy options. Details regarding the scope of work and the results of the investigation are include in the *Corrective Measure Pre-Design Report - Lower 1,4-Dioxane Source Evaluation* report (Arcadis 2014b). Over 800 soil samples were collected as part of the Plant 3 coliseum source evaluation and analyzed on-site using a mobile laboratory. Results of the coliseum source investigation indicated the following:

Perched Zone: Concentrations of 1,4-dioxane were generally diffuse (typically less than 20 $\mu\text{g/Kg}$), with small zones of higher concentration near the coliseum. Of the more than 800 samples, only four had 1,4-dioxane concentrations greater than 1,000 $\mu\text{g/Kg}$. These four samples were collected from the perched zone near the southern wall of the coliseum. The high concentrations in the perched zone were observed in samples collected from the low-permeability glacial till. Samples collected for synthetic precipitation leaching procedure (SPLP) testing indicated the clay till does not leach at a concentration indicative of a significant ongoing source to the lower 1,4-dioxane plume. Further, the vertical hydraulic conductivity of the till ranges between 10^{-6} and 10^{-8} cm/sec suggesting limited potential for in-situ leaching. A temporary well installed at a depth of 12-19 ft bgs in the glacial till at a depth of the highest 1,4-dioxane concentration was dry.

Detections of 1,4-dioxane within the vadose zone located between the perched zone and saturated deep overburden are sporadic with a footprint coincident with the overlying perched impacts and soil concentrations less than 100 $\mu\text{g/Kg}$.

The perched zone results suggest limited residual source mass remains in the shallow area of release. What residual mass remains is primarily tied up in low conductivity glacial till. Leaching data suggests it is unlikely to continue to contribute significant additional mass to the deep overburden.

Deep Overburden/Weathered Bedrock: Results from saturated soil samples from the deep overburden and weathered bedrock indicate a diffuse zone of impacts. The maximum concentration of 1,4-dioxane observed within the deep overburden was 110 $\mu\text{g/Kg}$ at 70 feet bgs near existing monitoring well MW-12-21. The equilibrium partitioning equation, with adjustments for saturated soils suggests an equivalent groundwater concentration of 660 $\mu\text{g/L}$. This is in general agreement with the maximum 1,4-dioxane groundwater concentration of 510 $\mu\text{g/L}$ detected at MW-12-21 in 2013. 3D modeling of the source area

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

based on the high-resolution data suggests much of the residual mass is tied up in the lower permeability portions of the deep overburden within the bedrock valley. The concentration of 1,4-dioxane observed in the deep overburden and weathered bedrock monitoring wells installed within the coliseum source area (i.e., MW-12-21 and MW-13-22) show decreasing concentrations since 2013. The trend graphs for MW-12-21 and MW-13-22 are provided as **Appendix B**. These results, as well as the findings from the source investigation (perched mass tied up in dense till, generally limited concentrations in deep overburden) suggest a spent source mass with most of the mass released at this location currently located downgradient.

Plant 2 LNAPL Area

Several investigations were completed to evaluate the Plant 2 LNAPL and general "Plant 2 LNAPL area" as a source(s) of 1,4-dioxane that may contribute to the lower 1,4-dioxane plume. Following the 2012 and 2013 RFI activities, the glacial till confining layer was thought to be sufficient to prevent vertical migration of 1,4-dioxane to the weathered bedrock. At that time the lower 1,4-dioxane plume was assumed to be entirely associated with the Plant 3 coliseum source area. However, the detection of 1,4-dioxane at a concentration of up to 3,200 µg/L in a pilot test well installed at the southern toe of the lower 1,4-dioxane plume on Plant 2 prompted an additional round of investigation to determine the source of this relatively high concentration more than 2,000 feet from the coliseum.

Plant 2 LNAPL - Sampling of LNAPL and LNAPL-impacted soils at Plant 2 have shown high concentrations of chlorinated ethanes, including 1,1,1-trichloroethane, suggesting the LNAPL could be an ongoing source of 1,4-dioxane. Additional sampling completed in 2017 show that 1,4-dioxane associated with the LNAPL is depleted and the majority of the 1,4-dioxane mass in the Plant 2 LNAPL area is present as dissolved phase in surrounding perched groundwater (Arcadis 2018a, Arcadis 2020d). This data, coupled with the partitioning characteristics of 1,4-dioxane, show the majority of 1,4-dioxane available for leaching from LNAPL has already moved to the groundwater dissolved phase.

Lower 1,4-Dioxane Toe Investigations - During the *Lower 1,4-Dioxane Plume Toe Investigation* (Arcadis 2016a) and supplemental investigation (2016b), soil was sampled at high resolution at boring locations located adjacent to Plant 2 LNAPL plume to evaluate the potential for vertical migration of 1,4-dioxane. Based on the results of the investigation, the source of the elevated 1,4-dioxane at well TW-14-02 was still unclear; however, continuous soil samples collected through the overburden near the Plant 2 LNAPL showed that 1,4-dioxane impacts extended through the perched zone, confining glacial till layer, and into the dry deep overburden at several locations. A lobe of the lower 1,4-dioxane plume extends to the northeast from the Plant 2 LNAPL area. Additional investigation completed to delineate the northeast extent initially defined the extent to the northeast and confirmed the northeast lobe was likely a result of leakage from the Plant 2 LNAPL source area and not a result of bifurcation off the Plant 3 plume further to the north. Vertical migration of 1,4-dioxane from the Plant 2 LNAPL Area may be aided by preferential recharge through the former courtyard area present in the Plant 2 LNAPL area that is currently covered with degraded asphalt and vegetation. Routine monitoring has shown additional migration to the east and northeast in weathered bedrock following the 2016 toe investigations; however, further migration to the south and southeast appears to be limited by the shallower bedrock as described above.

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

2.4 Lower 1,4- Dioxane Plume and Municipal Water Supply

The RACER site falls partially within a WHPA associated with five municipal wells operated by Lansing Township (TWP-90-2 through TWP-90-06) and a WHPA associated with municipal wells operated by the City of Lansing east of Plants 3 and 6. The WHPAs are shown on **Figure 1**. The Lansing Township WHPA is based on a 10-year travel time predicted by a large-scale groundwater flow model prepared by the United States Geological Survey (USGS 1997, 2009, 2018). Annual sampling of the Township wells has identified low concentrations of 1,4-dioxane ranging from 0.1 to 0.4 µg/L.

Investigations completed at the RACER site have delineated the lower 1,4-dioxane plume to the MDEQ Part 201 Residential Drinking Water (DW) criteria of 7.2 micrograms (µg/L), both vertically, and horizontally. As noted above, the vertical anisotropy of the Saginaw Formation largely inhibits vertical migration in bedrock due to the prevalence of interbedded layers of shale and a distinct lack of bedrock structure that would create vertical migration pathways. Although vertical migration of 1,4-dioxane in the Grand River Formation appears more prevalent, the Grand River Formation is limited in extent and underlain by the Saginaw Formation at depth.

A network of sentinel wells in the weathered bedrock around the lower 1,4-dioxane plume, as well as consolidated bedrock wells along the axis of the plume and around the perimeter of the Site, are used for sentinel monitoring of the lower 1,4-dioxane plume. To date, low-level 1,4-dioxane analysis (USEPA Drinking Water Method 522) at bedrock monitoring wells installed along the core of the lower 1,4-dioxane plume have demonstrated a two to three order of magnitude reduction in concentration between the more permeable weathered bedrock zone and the shallow competent bedrock (Arcadis 2018b, Arcadis 2020c). Concentration of 1,4-dioxane in bedrock wells at the Site have ranged from non-detect to 4.0 µg/L (MW-13-28, 2019). The location and open borehole depth intervals of the Lansing Township wells, as well as existing RACER bedrock monitoring wells are included as **Figure 9**.

Deep Bedrock Well Installation

To allay concern of vertical migration of 1,4-dioxane into the bedrock and subsequent westward migration from the Site, two nested pairs of deeper bedrock monitoring wells were installed along the western Plant 2 and Plant 3 property boundaries (MW-19-118S/D and MW-19-119S/D, respectively). The location of the deep bedrock wells is shown on **Figures 2, 3 and 9**. The new bedrock monitoring wells were placed and constructed according to the following reasoning:

- Installed between the primary 1,4-dioxane source areas (Plants 2 and 3) and the nearest municipal wells (TWP-90-03 and TWP-90-04)
- Installed within the upper portion of the bedrock aquifer at depths overlapping nearby municipal wells (~125-200 feet below grade). This interval would be the first to be impacted should 1,4-dioxane migrate to deeper bedrock and move to the west.
- Completed downhole geophysics to log boreholes at high-resolution and determine preferential flow pathways for well screened placement.
- Include two screened intervals (15-foot screens) at each location to provide vertical coverage (30-feet total) of the upper portion of the bedrock aquifer.

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

The nested wells were installed by advancing a 10-inch borehole into consolidated rock to approximately 80 ft bgs using rotary-sonic drilling methods, then switch over to air rotary advanced to a depth of approximately 125 feet bgs. Steel casing (7-inch) was cemented in place and a 6-inch open borehole was opened below the casing using air-rotary to the final depth of 200 feet bgs. Once the borehole was completed, downhole geophysics (optical and acoustic televiwer; fluid temperature, resistivity, conductivity, and natural gamma) was used to characterize each borehole and select monitoring intervals. The nested wells were constructed by placing PVC well materials with centralizers into the borehole, placing appropriate filter pack around the screens, and backfilling intervals between and above the screens with bentonite (either grout or weighted pellets depending on the position relative to the screen). Details regarding the well installation are provided in the approved *Bedrock Monitoring Well Work Plan* (Arcadis 2019). The boring logs and geophysical logs for each location are included as **Appendix C**.

Review of the geophysical logs suggest very little fracturing or preferential pathways are present in bedrock. Two open fractures were noted at 149 and 189 ft bgs at location MW-19-119 at Plant 3. with the remainder of the borehole free of bedrock structure. No fractures were observed at location MW-19-118 on Plant 3. The well screens at MW-19-118 targeted a zone of sandstone with shale inclusions and an area of iron oxidation with a conductivity spike (154-156 and 181 ft bgs, respectively) as indications of preferential flow. Bedding within the boreholes was generally horizontal to dipping slightly south-southwest with no visible partings.

Deep Bedrock Monitoring Results

Groundwater samples were collected from the deep bedrock wells on March and June 2020 and submitted for analysis for 1,4-dioxane using USEPA Method 522. A summary of the results is provided in the following table:

	Summary of Deep Bedrock Well 1,4-Dioxane Results (Method 522) (µg/L)			
	MW-19-118S	MW-19-118D	MW-19-119S	MW-19-119D
March-20	3.9	<0.20	0.34	0.57
June-20	0.99	<0.20	0.41	0.89

Results of the deep bedrock sampling indicate limited vertical migration on Plant 2 (MW-19-118) consistent with the CSM and the anisotropy associated with the Saginaw Formation. The Plant 3 wells, although showing vertical migration of 1,4-dioxane away from the source area, only indicate low concentrations well below the Part 201 Drinking Water Criteria of 7.2 µg/L. As outlined further below, the detections at MW-19-118S are confounded by the presence of the upgradient former Adams Plating site, which appears to contribute 1,4-dioxane mass to the weathered bedrock (Arcadis 2016a).

Groundwater elevations collected at the time of sampling are summarized on the following table:

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

	Summary of Deep Bedrock Well 1,4-Dioxane Groundwater Elevation (ft msl)			
	MW-19-118S	MW-19-118D	MW-19-119S	MW-19-119D
March-20	796.51	796.48	800.88	790.22
June-20	796.23	796.20	801.42	789.54

The groundwater elevation results are representative of the bedrock noted at these depths and consistent with the conceptual site model and analytical results. At location MW-19-118 on Plant 2, after some initial shale layers the two wells are set in the same sandstone unit and display only a very small downward vertical gradient consistent with vertical communication at these depths. At Plant 3 (MW-19-119), the opposite is true, Grand River Formation sandstone is noted in the shallow bedrock and then transitions to Saginaw Formation with interbedded with shale present between the two well screen depths. The lack of hydraulic communication creates a large downward vertical gradient. The Plant 3 well nest is also closer to a municipal pumping well (TWP-90-04), which may enhance the vertical gradient at this location (i.e., lower hydraulic head in the deeper bedrock).

The results of the deep bedrock monitoring show that 1,4-dioxane does not migrate vertically at significant concentrations and is delineated in bedrock to the DW Criteria (7.2 µg/L). The 1,4-dioxane at the site is focused within the weathered zone and the plume distribution and apparent horizontal gradient do not support significant migration of 1,4-dioxane downward and to the west toward the Lansing Township municipal wells.

Regional Sources of 1,4-Dioxane

There are numerous point and non-point sources of 1,4-dioxane in the Lansing area that may contribute to the detections of 1,4-dioxane observed at the municipal wells. Although it is not possible to be 100 percent certain that 1,4-dioxane detected in the municipal wells is not partially attributable to the Site, the data presented above demonstrates that 1,4-dioxane associated with the Site is adequately characterized and delineated to Michigan Part 201 DW Criteria.

Former Adams Plating Company

The former Adams Planting Company (APC) Superfund National Priorities List site is located along Rosemary Street along the west side of Plant 2 and is currently managed and regulated under the USEPA Region 5 Superfund Program. Plating operations were performed at the APC Site from 1964 until it was destroyed by fire in 2010. Remedial action at the APC Site included excavation of former tanks and shallow soil impacted by VOCs and metals. Subsequent investigations have shown impacts to shallow groundwater, including metals, VOCs, 1,4-dioxane, and per- and polyfluoroalkyl substances (PFAS). The lateral extent of the perched 1,4-dioxane and PFAS plumes at the APC Site have not been delineated to EGLE Part 201 Criteria, and both plumes appear to extend east onto RACER property. Further, work completed by RACER to evaluate 1,4-dioxane impacts in weathered bedrock along the Plant 2 eastern property boundary have shown 1,4-dioxane in weathered bedrock south of APC on Genesee Street (Arcadis 2016a) at concentrations up to 33 µg/L. These detections suggest a weathered bedrock plume

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

associated with the APC Site with a southerly flow component, parallel to the RACER lower 1,4-dioxane plume.

To date, the extent of the deeper weathered bedrock or bedrock impacts associated with APC have not been investigated by USEPA. Apparent commingling of impacts from the APC Site and RACER Site, both in the perched and weathered bedrock zones (e.g., MW-15-73, MW-16-83, MW-14-56), confounds delineation of Site-related 1,4-dioxane along the western Plant 2 property boundary.

Other Sources

Other sources of 1,4-dioxane and/or chlorinated solvents, which are known to be associated with 1,4-dioxane, have been documented at sites near the Site. Several sites to the northeast of Plant 3 have shown elevated concentrations of vinyl chloride (degradation product of TCE) in bedrock that migrates along a northeast-southwest bedrock valley towards and onto the Site. At least one of the off-site sources has historically shown high concentrations of TCA. Migration of 1,4-dioxane in bedrock to the southwest from these source areas is supported by the higher concentrations of 1,4-dioxane observed in the northern Plant 3 bedrock monitoring wells that co-mingled with detections of vinyl chloride not otherwise observed anywhere else on Plant 3.

The Grand River was sampled for low-level 1,4-dioxane in 2017 (Arcadis 2018b). In some areas of Lansing (e.g., northwest of the site) the bedrock aquifer receives recharge from the Grand River. To better understand potential sources of 1,4-dioxane that may impact the bedrock aquifer, surface water samples were collected from the Grand River to the south and north of the site. Grab samples were collected from shore using a discrete sampling device. The sampling results indicate that 1,4-dioxane was detected in a sample north of the Site at an estimated concentration (J-flag) of 0.081 µg/L. The sample from the southern location was non-detect for 1,4-dioxane (less than 0.2 µg/L). Detections of 1,4-dioxane in a regional water body such as the Grand River illustrates the potential background condition that may be present in the Lansing area due to the common use in industrial and household goods and the persistence of 1,4-dioxane.

2.5 Fate and Transport

As noted above, the lower 1,4-dioxane plume is a result of two shallow source areas. The Plant 3 coliseum source area that is currently depleted and shows decreasing concentrations, and the Plant 2 LNAPL area, with stable concentrations in shallow perched groundwater, but showing increasing concentrations in weathered bedrock and plume expansion to the east and northeast (**Figure 3**). The lower 1,4-dioxane plume migrates relatively quickly to the southeast from the coliseum within the higher permeability deep overburden and weathered Grand River Formation, transitions to the weathered bedrock on Plant 2, and then encounters the lower permeability Saginaw Formation. Groundwater movement within the weathered Saginaw is complex with variable permeability and high vertical anisotropy, as well as shifting groundwater elevations and apparent groundwater flow direction. Leakage from the perched 1,4-dioxane plume in the Plant 2 LNAPL area likely comingles with the Plant 3 plume to the west of the perched LNAPL but appears to primarily move east and northeast. Additional lower 1,4-dioxane plume expansion to the south and southeast appears to have stalled, possibly due to the higher bedrock elevation that inhibits further movement in this direction as groundwater encounters the lower permeability consolidated Saginaw Formation. Furthermore, vertical migration within bedrock is limited by the reduced permeability of the

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

consolidated rock and the high vertical anisotropy of the Saginaw Formation with 1,4-dioxane concentration dropping by several orders of magnitude between the weathered zone and the underlying shallow consolidated bedrock.

Plume Stability

Since the initial plume stability assessment in 2014 (Arcadis 2014c), concentrations within the lower 1,4-dioxane plume have generally shifted toward decreasing to stable trends in the northern portion of the plume on Plant 3, and stable to increasing trends towards the toe of the plume and the Plant 2 LNAPL area (Arcadis 2020c). Nine weathered bedrock and deep overburden wells exhibited increasing trends for 1,4-dioxane on Plants 2 and 3 during the 2019 updated plume stability evaluation. **Figure 10** provides a summary of Mann-Kendall trend evaluation for the weathered bedrock wells. Notable trends within the lower 1,4-dioxane plume include the following:

- MW-12-21 (deep overburden) and MW-13-22 (weathered bedrock) installed within the Plant 3 coliseum source area exhibit stable to decreasing trends consistent with other wells installed along the axis of the plume as it migrates south from Plant 3 (exception MW-13-34).
- Most of the increasing trends observed in the lower 1,4-dioxane plume are located east and northeast of the Plant 2 LNAPL area consistent with the primary direction of plume expansion noted since 2016.
- Increasing trends are also observed on the western Plant 2 property boundary in weathered rock but are potentially related to vertical and then horizontal migration of impacts associated with the APC site.

Natural Attenuation of 1,4-Dioxane

As part of the pre-engineering design activities for the Site, additional sampling and characterization was completed to assess the potential for the aquifer to degrade 1,4-dioxane under ambient conditions.

In addition to standard geochemical parameters, dissolved gas concentrations within select wells located in the perched and lower 1,4-dioxane plumes were evaluated. Based on the results of the dissolved gas evaluation, Bio-Trap® samplers were deployed at five perched zone and four lower zone monitoring wells. These samplers incubated in monitoring wells and were then analyzed for deoxyribonucleic acid (DNA) and messenger ribonucleic acid (mRNA); specifically, the analysis was looking for evidence of methanotrophic and propanotrophic bacteria that can produce enzymes implicated in the cometabolism of 1,4-dioxane. These enzymes are known as soluble methane monooxygenase (SMMO) and propane monooxygenase (PPO). Results of sampling were encouraging and showed that at most of the locations sampled, genes encoding SMMO were expressed. This suggested that concentrations of dissolved methane (primarily in the perched zone) are sufficient to stimulate gene expression. These results provide evidence for 1,4-dioxane natural attenuation via microbial cometabolism, particularly in the perched zone where methane and dissolved oxygen are both present. The perched 1,4-dioxane has shown stable to decreasing concentrations since monitoring began in 2013 (Arcadis 2020c).

Although PPO was not expressed under ambient conditions in weathered bedrock, the results suggested the addition of propane to the lower 1,4-dioxane plume would aid the growth of the microbial communities present at depth and stimulate co-metabolism of the lower 1,4-dioxane plume.

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

Biosparge System

Biosparge was the selected remedy for the lower 1,4-dioxane plume based on results from two phases of pilot testing completed from 2016 through 2019 that showed a reduction in 1,4-dioxane concentration in performance monitoring wells (Arcadis 2017c, 2018c). The design of the biosparge system includes transects of biosparge wells (aka sparge points) to reduce the concentrations 1,4-dioxane along the core of the plume migrating south from Plant 3 and provides a perimeter of biosparge wells around the south, east and northeast of the Plant 2 LNAPL area to eliminate further migration and reduce overall concentrations in the central part of Plant 2. Each sparge point is designed to deliver propane, oxygen, and nutrients into the weathered bedrock to stimulate microbes that co-metabolically degrade 1,4-dioxane. Although PPO was not expressed under ambient conditions in weathered bedrock, the biosparge system adds propane to the lower 1,4-dioxane plume to aid the growth of the microbial communities present at depth and stimulate co-metabolism of the lower 1,4-dioxane plume. The biosparge system pilot testing and the initial performance monitoring data for the full-scale system both show a reduction in 1,4-dioxane concentrations in surrounding monitoring wells.

During installation of the sparge points, VAP sampling was completed near the edges of the known impact areas to define the endpoints of the transects. In general, a biosparge point was only installed if the detected 1,4-dioxane concentration was greater than 10 µg/L. The biosparge points consist of a 4-inch poly vinyl chloride (PVC) outer casing screened within the upper 10-15 feet of the weathered bedrock zone. Following casing installation, sand lenses were installed into the formation through the casing to ensure a consistent sparge radius around each biosparge well and a robust treatment transect. As a result of the VAP data, a transect originally planned in the central portion of Plant 2 was not installed (Arcadis 2021); however, well casings, which had been preemptively installed at 6 locations (**Figure 2/2A**), were left in place in the event it is determined the biosparge system should expand to include this transect. The data collected during the biosparge install, including borings logs, well construction logs and VAP groundwater data were provided as part of the *Biosparge System Installation Data Package* (Arcadis 2020a).

The performance of the biosparge system will be monitored through a network of performance monitoring wells located upgradient, downgradient and within the radius of influence of each treatment transect. The results of the performance monitoring will be documented in semi-annual biosparge performance monitoring reports. It is anticipated that the system will be decommissioned in phases over time as it is determined that a particular well or portion of the system is not providing meaningful reduction in 1,4-dioxane concentrations or mass.

LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

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LOWER 1,4-DIOXANE CONCEPTUAL SITE MODEL

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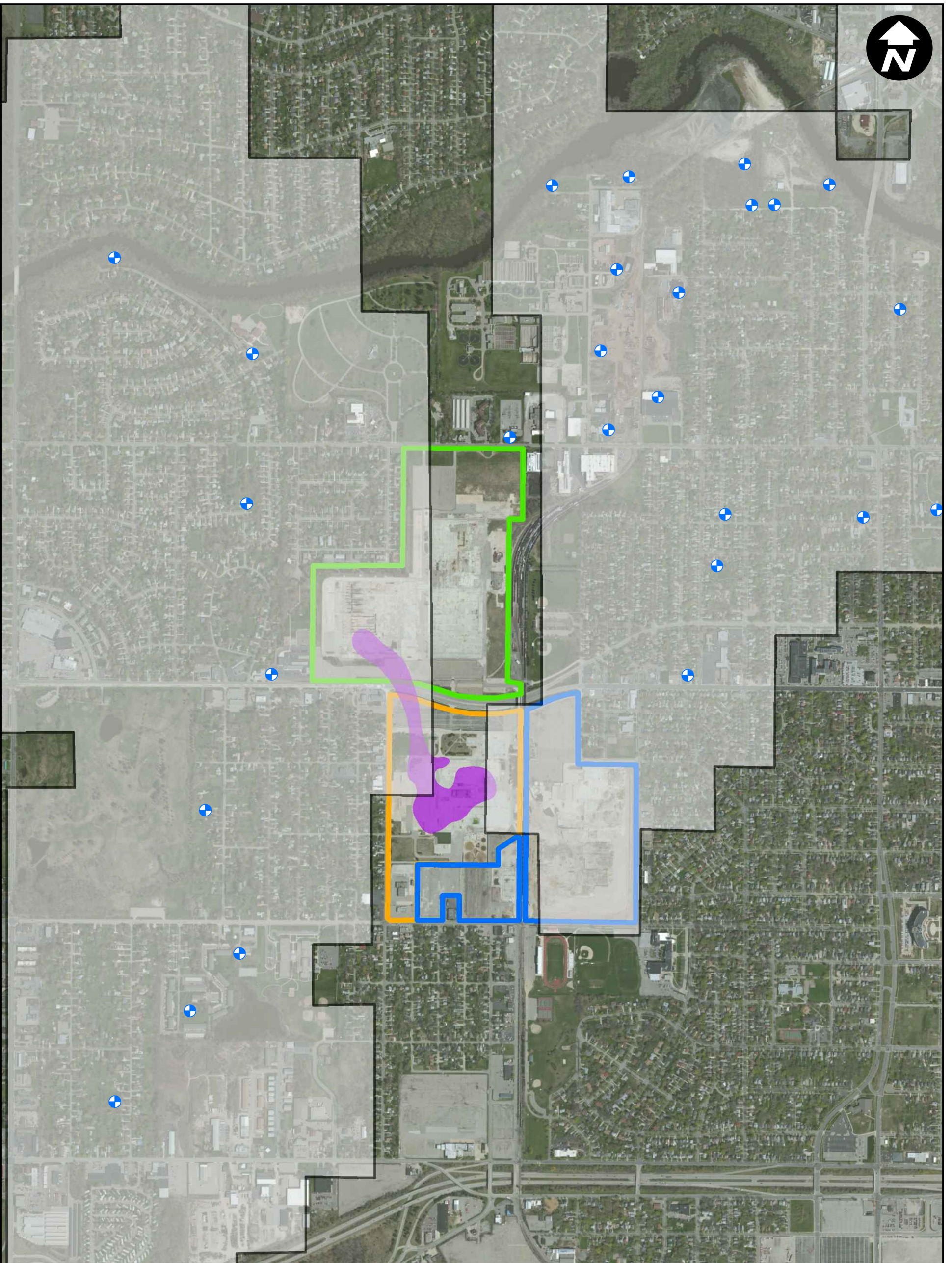
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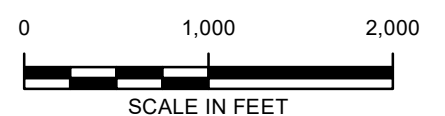
FIGURES





LEGEND

-  MUNICIPAL WELLS
-  LOWER 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 µg/L)
-  LANSING WHPAs
- APPROXIMATE PLANT BOUNDARIES**
-  PLANT 2
-  PLANT 3
-  PLANT 6

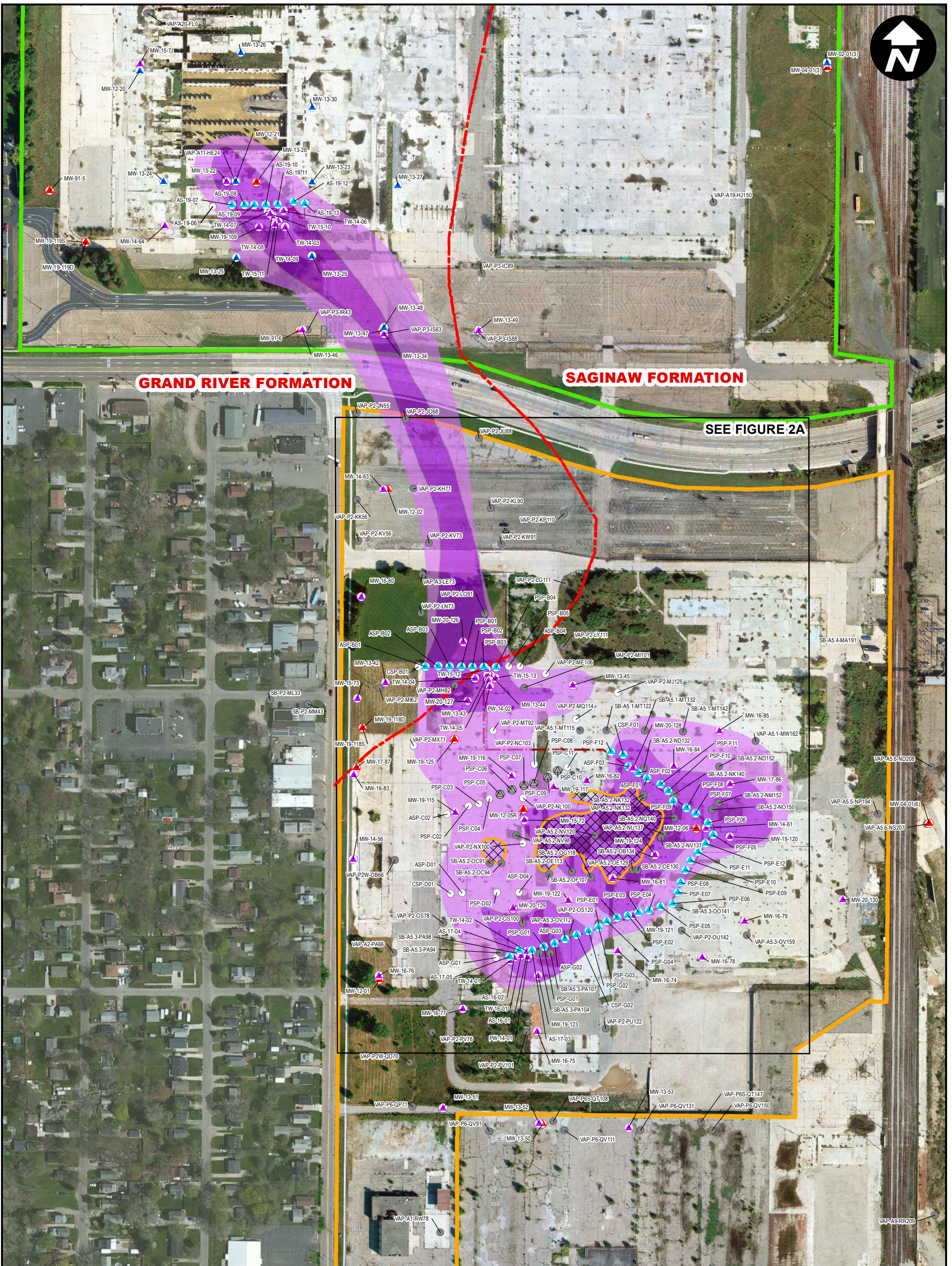


RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

SITE LOCATION AND LANSING WHPAs

NOTES:
 1. WHPA SOURCE <<https://www.deq.state.mi.us/GeoWebFace/>>
 2. MUNICIPAL WELL LOCATIONS INCLUDE WATER SUPPLY WELLS THAT HAVE OPERATED HISTORICALLY, BUT MAY CURRENTLY BE INOPERABLE OR ABANDONED.

CITY: Novi DIV: ENV PIC: J. BARRETT TR: P. CURRY PROJECT NUMBER: B0064479.2019 COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
 T:_ENV\RACER\Buffalo\MXDs\2020 1 - 4_Dioxane Analytical Results\Figure 1 - 1_4_Dioxane Analytical Results.mxd PLOTTED: 12/30/2020 3:46:41 PM BY: MJOYE



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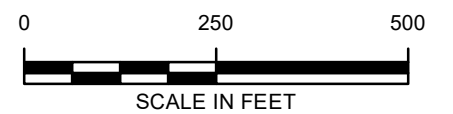
WELLS

- ▲ BIOSPARGE POINT
- DEEP OVERBUDEN MONITORING WELL
- ▲ WEATHERED BEDROCK MONITORING WELL
- ▲ BEDROCK MONITORING WELL
- BLANK CASING
- SOIL BORING/VAP (PRE-2019)
- SOIL BORING/VAP (2019-2020)
- PERCHED LNAPL EXTENT
- - - 1-INCH CONVEYANCE HOSE
- SYSTEM BUILDING

- - - ESTIMATED LOCATION OF SAGINAW / GRAND RIVER FORMATION BEDROCK CONTACT
- LOWER 1,4-DIOXANE PLUME > DW CRITERIA (7.2 µg/L)
- LOWER 1,4-DIOXANE PLUME > 72 µg/L

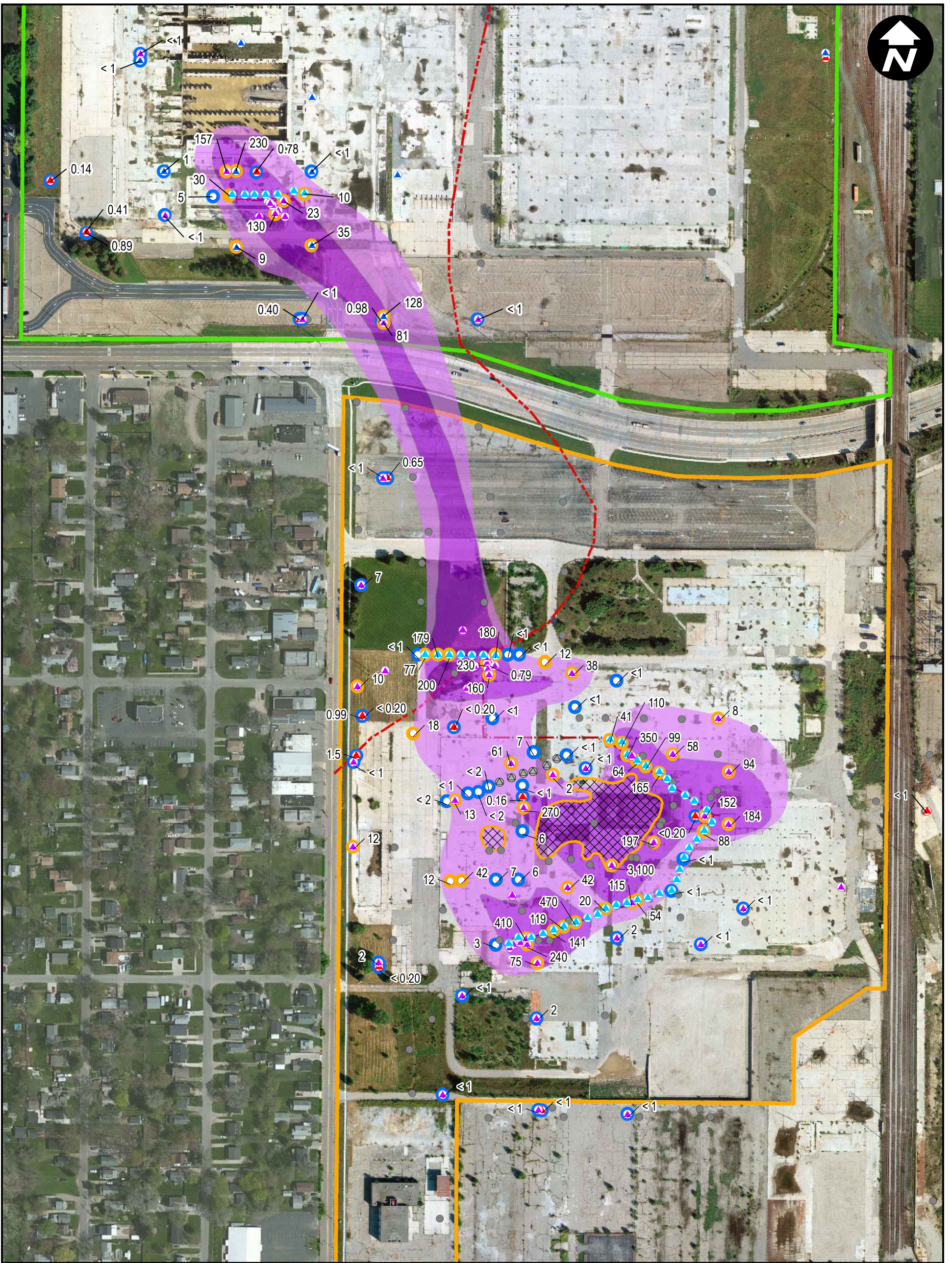
PLANT BOUNDARIES

- PLANT 2
- PLANT 3



RACER TRUST
 PLANTS 2, 3 & 6
 LANSING, MICHIGAN

**1,4-DIOXANE SAMPLE LOCATIONS
 PLANT 2 AND 3**



LEGEND

WELLS

- BIOSPARGE POINT
- DEEP OVERBUDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- BEDROCK MONITORING WELL
- BLANK CASING
- SOIL BORING/VAP (PRE-2019)
- SOIL BORING/VAP (ANALYTICAL 2019 ONLY)
- PERCHED LNAPL EXTENT
- 1-INCH CONVEYANCE HOSE
- SYSTEM BUILDING
- ESTIMATED LOCATION OF SAGINAW / GRAND RIVER FORMATION BEDROCK CONTACT

- LOWER 1,4-DIOXANE PLUME > DW CRITERIA (7.2 µg/L)
- LOWER 1,4-DIOXANE PLUME > 72 µg/L
- EXCEEDS RESIDENTIAL DRINKING WATER CRITERIA VALUE OF 7.2 µg/L
- DOES NOT EXCEED RESIDENTIAL DRINKING WATER CRITERIA OF 7.2 µg/L

PLANT

- PLANT 2
- PLANT 3

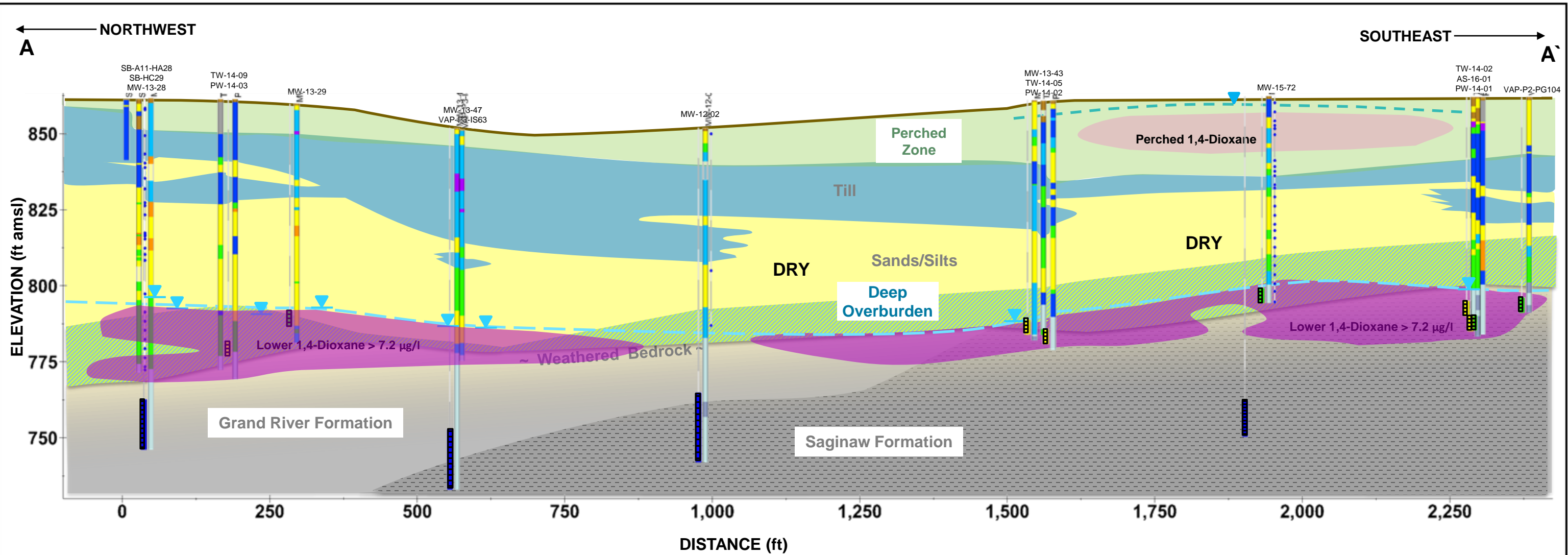


NOTES:

1. BIOSPARGE SAMPLES WERE COLLECTED FROM APRIL THROUGH SEPTEMBER 2019. VAP SAMPLES WERE COLLECTED FROM SEPTEMBER THROUGH OCTOBER 2019. MONITORING WELL SAMPLES WERE COLLECTED IN JUNE 2020.
2. ALL ANALYTICAL RESULTS LISTED IN MICROGRAMS PER LITER (µg/L).
3. ALL SAMPLES WERE ANALYZED VIA EPA METHOD 8260B-SIM.
4. FOR LOCATIONS WITH MULTIPLE VERTICAL AQUIFER PROFILE (VAP) SAMPLES COLLECTED, THE HIGHEST DETECTED CONCENTRATION IS SHOWN.

RACER TRUST
 PLANTS 2, 3 & 6
 LANSING, MICHIGAN

SUMMARY OF LOWER 1,4-DIOXANE ANALYTICAL RESULTS 2019-2020



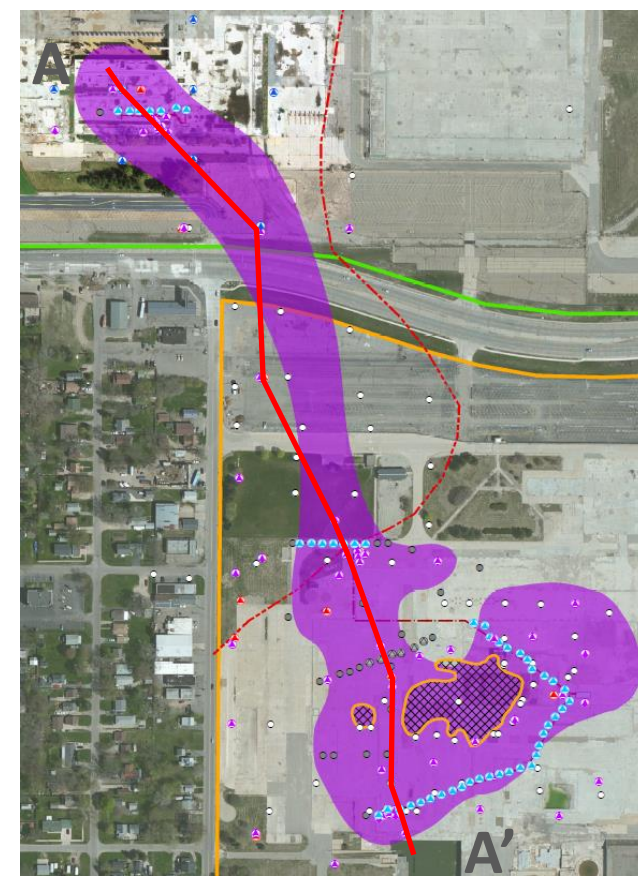
Borehole Stratigraphy

- Topsoil/Concrete/Asphalt
- Fill
- Gravelly Sand
- Sand
- Sandy Silt/Silt
- Silty/Sandy/Gravelly Clay
- Clay
- Peat
- Bedrock (Primarily Sandstone)
- Bedrock (Primarily Shale)
- No Recovery

1,4-Dioxane

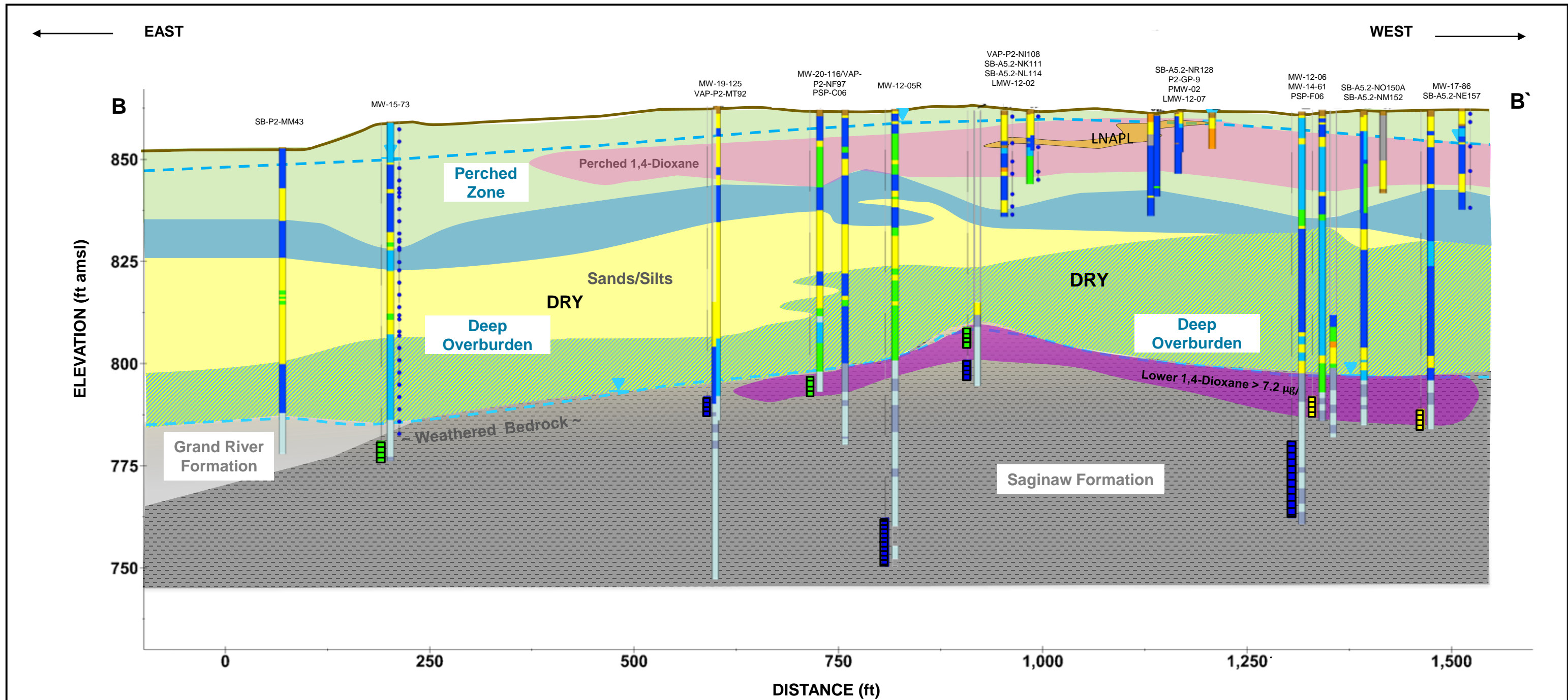
- > 1,000 ppb
- 72 to 1,000 ppb
- 7.2 to 72 ppb
- Non-detect to 7.2 ppb

- MONITORING WELL SCREEN
- TOP OF SATURATED BEDROCK/
DEEP OVERBURDEN
- APPROXIMATE PERCHED
POTENTIOMETRIC SURFACE



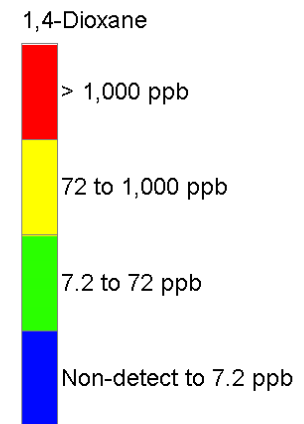
V.E. = 5x

RACER TRUST PLANTS 2, 3, AND 6 LANSING, MICHIGAN
LOWER 1,4-DIOXANE PLUME CROSS SECTION NORTH - SOUTH
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="font-weight: bold; font-size: 1.2em;">ARCADIS</div> <div style="font-size: 0.8em;"> Design & Consultancy for natural and built assets </div> <div style="font-weight: bold; font-size: 1.2em;">FIGURE 4</div> </div>



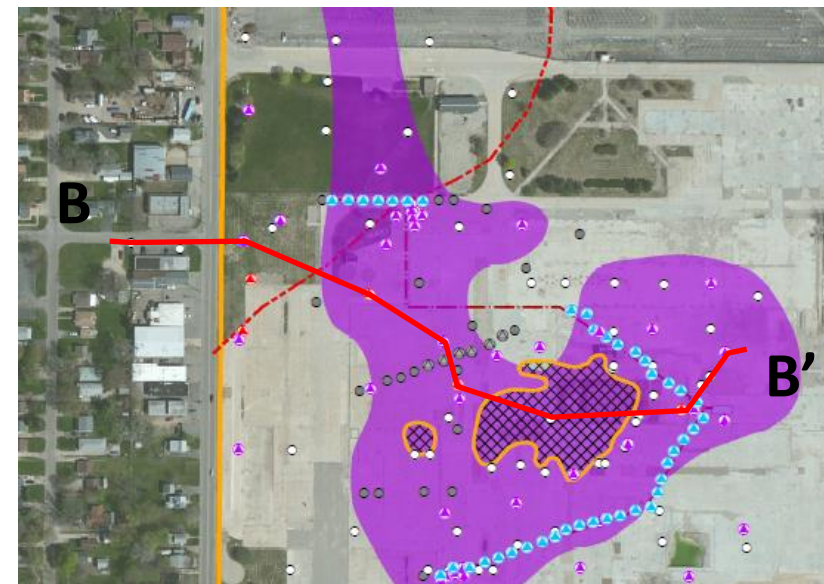
Boring Stratigraphy

- Topsoil/Concrete/Asphalt
- Fill
- Gravelly Sand
- Sand
- Sandy Silt/Silt
- Silty/Sandy/Gravelly Clay
- Clay
- Peat
- Bedrock (Primarily Sandstone)
- Bedrock (Primarily Shale)
- No Recovery



- MONITORING WELL SCREEN
- TOP OF SATURATED BEDROCK
- APPROXIMATE PERCHED POTENTIOMETRIC SURFACE

DISTANCE (ft)

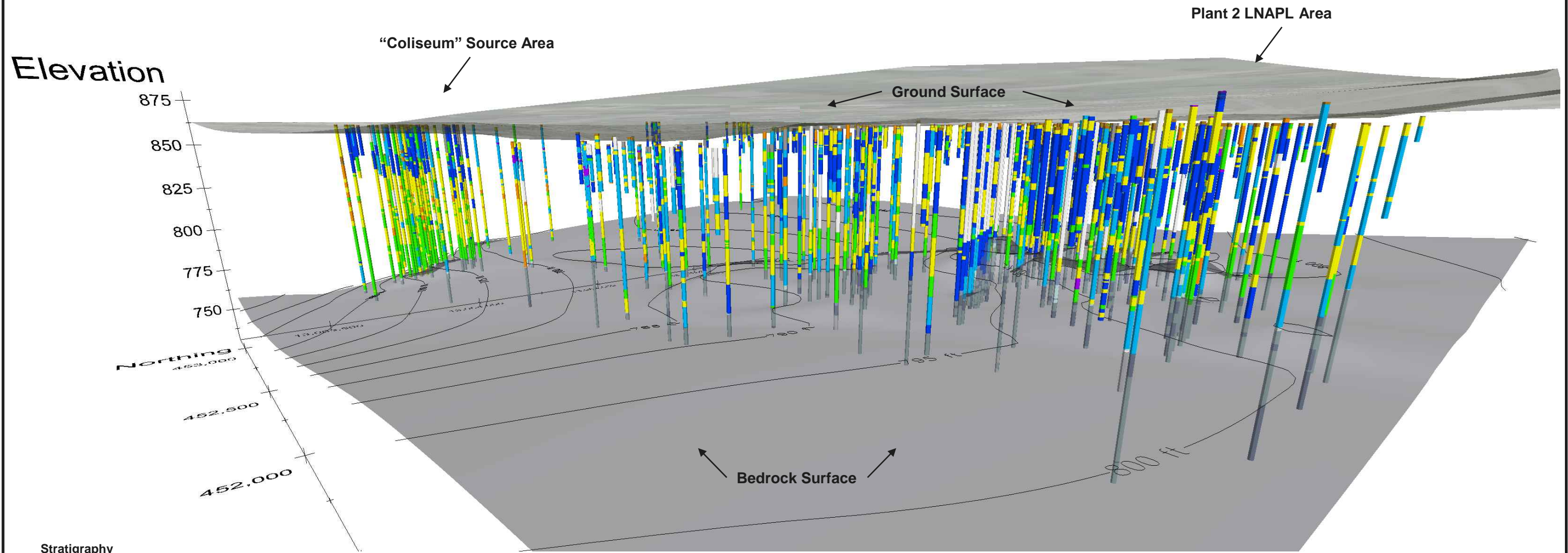


V.E. = 2.5x

RACER TRUST
PLANTS 2, 3, AND 6
LANSING, MICHIGAN

**LOWER 1,4-DIOXANE PLUME
CROSS SECTION
WEST - EAST**

Lower 1,4-Dioxane Area Stratigraphy



Stratigraphy

- Topsoil/Concrete/Asphalt
- Fill
- Gravelly Sand
- Sand
- Sandy Silt/Silt
- Silty/Sandy/Gravelly Clay
- Clay
- Peat
- Bedrock (Primarily Sandstone)
- Bedrock (Primarily Shale)
- No Recovery

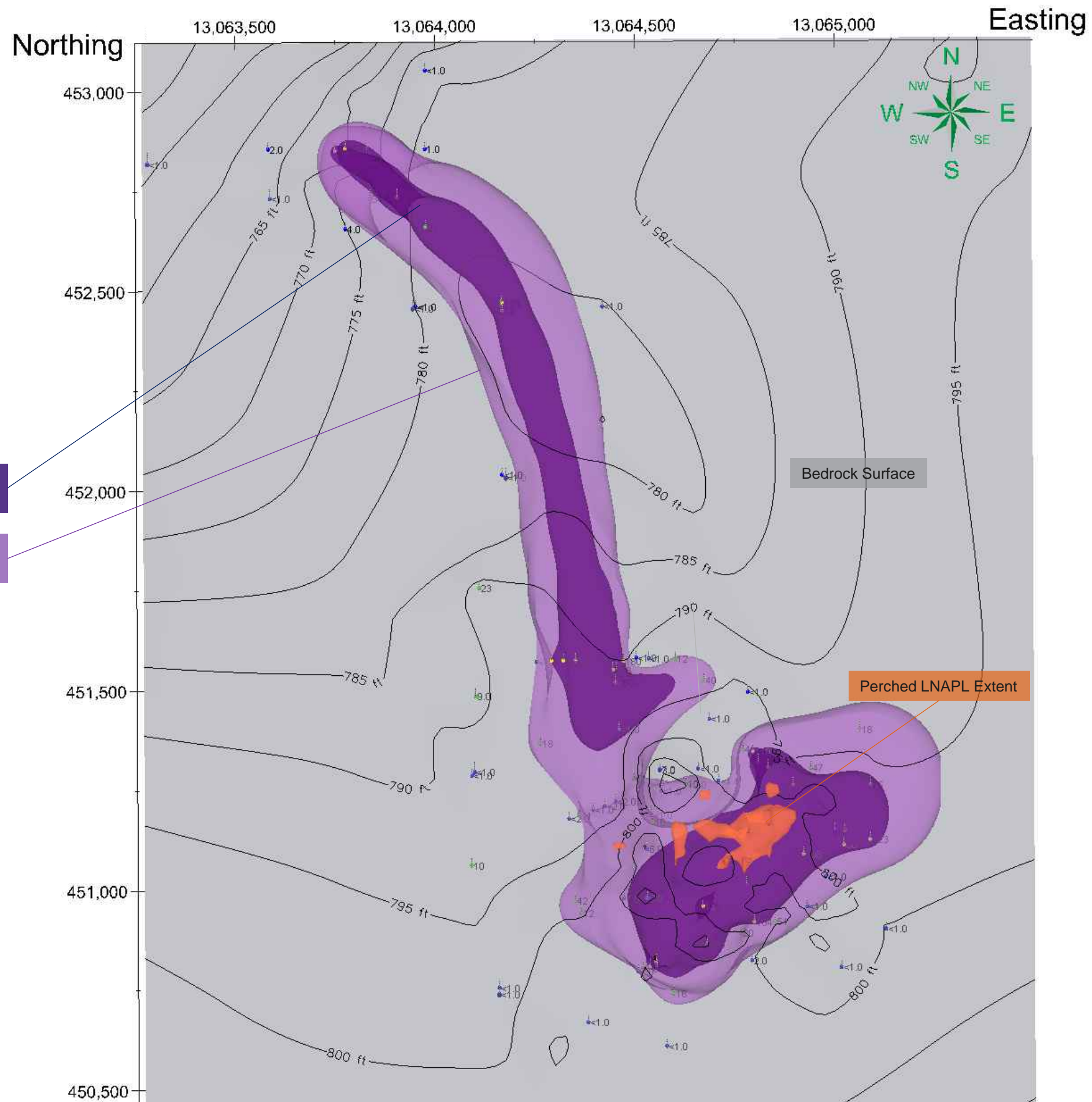
LOOKING NORTHEAST

NOTES

Elevation provided in ft above mean sea level
 Northing shown in feet (state plane)
 ppb – parts per billion

RACER TRUST
 PLANTS 2 AND 3
 LANSING, MICHIGAN

3D MODEL OF LOWER 1,4-DIOXANE
 AREA HYDROSTRATIGRAPHY



NOTES

Perched LNAPL extent is based on drilling observations, LNAPL measurements and delineation of residual LNAPL by laser induced fluorescence (LIF)

Elevation provided in ft above mean sea level
 Northing shown in feet (state plane)
 ppb – parts per billion

RACER TRUST
 PLANTS 2 & 3
 LANSING, MICHIGAN

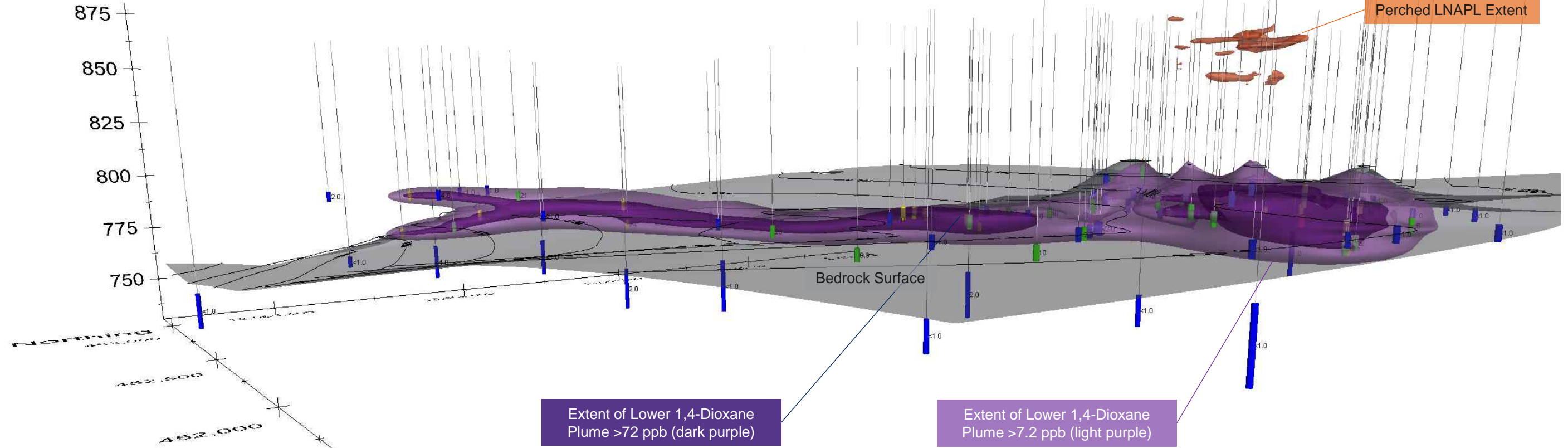
**3D MODEL OF LOWER 1,4-DIOXANE PLUME
 MODEL & WEATHERED BEDROCK
 SURFACE – LOOKING DOWN**

Lower 1,4-Dioxane Plume Extent

Elevation

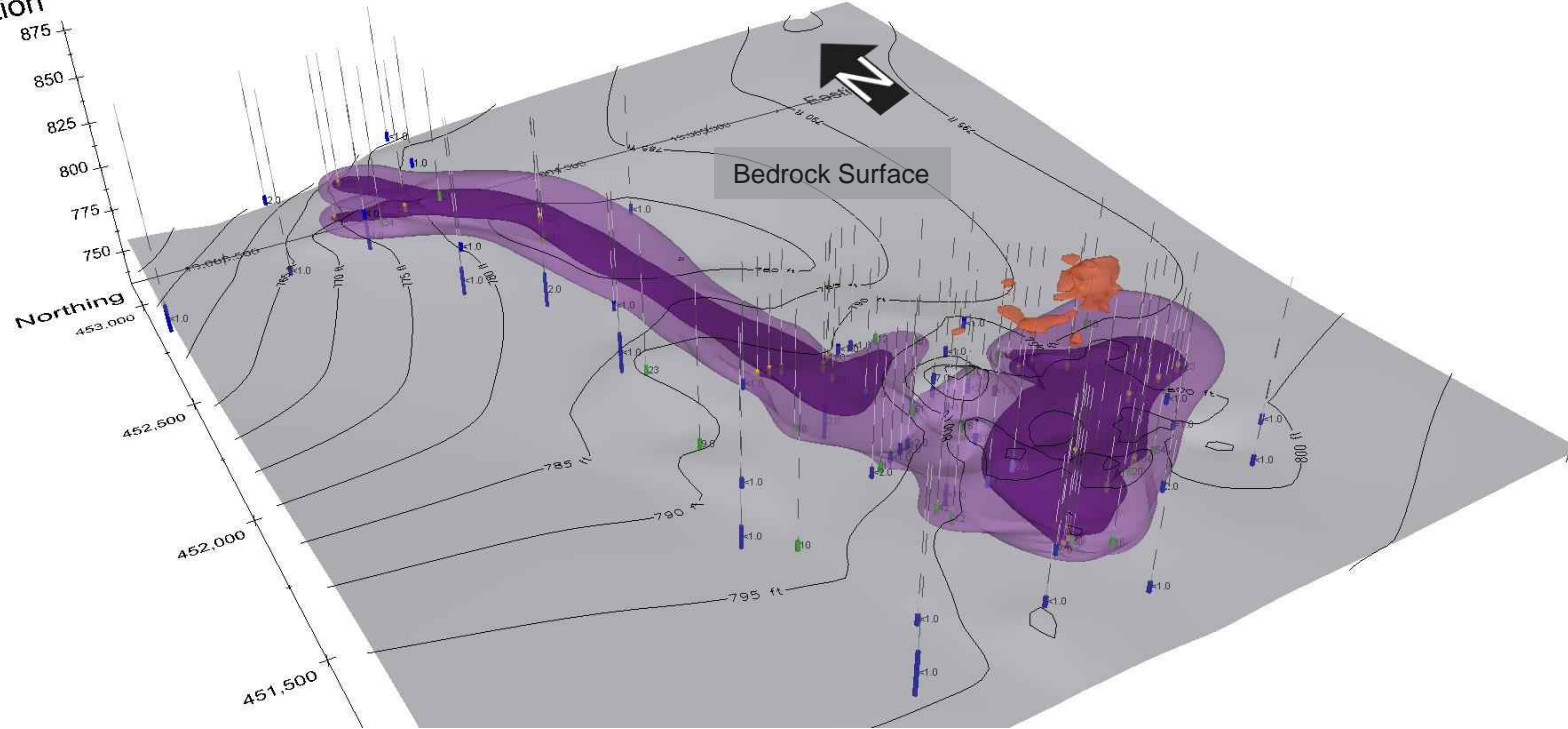
LOOKING NORTHEAST

Perched LNAPL Extent



Elevation

Bedrock Surface



Legend

- Groundwater Sample Interval

1,4-Dioxane Concentration

- > 1,000 ppb
- 72 to 1,000 ppb
- 7.2 to 72 ppb
- Non-detect to 7.2 ppb

NOTES

Perched LNAPL extent is based on drilling observations, LNAPL measurements and delineation of residual LNAPL by laser induced fluorescence (LIF)

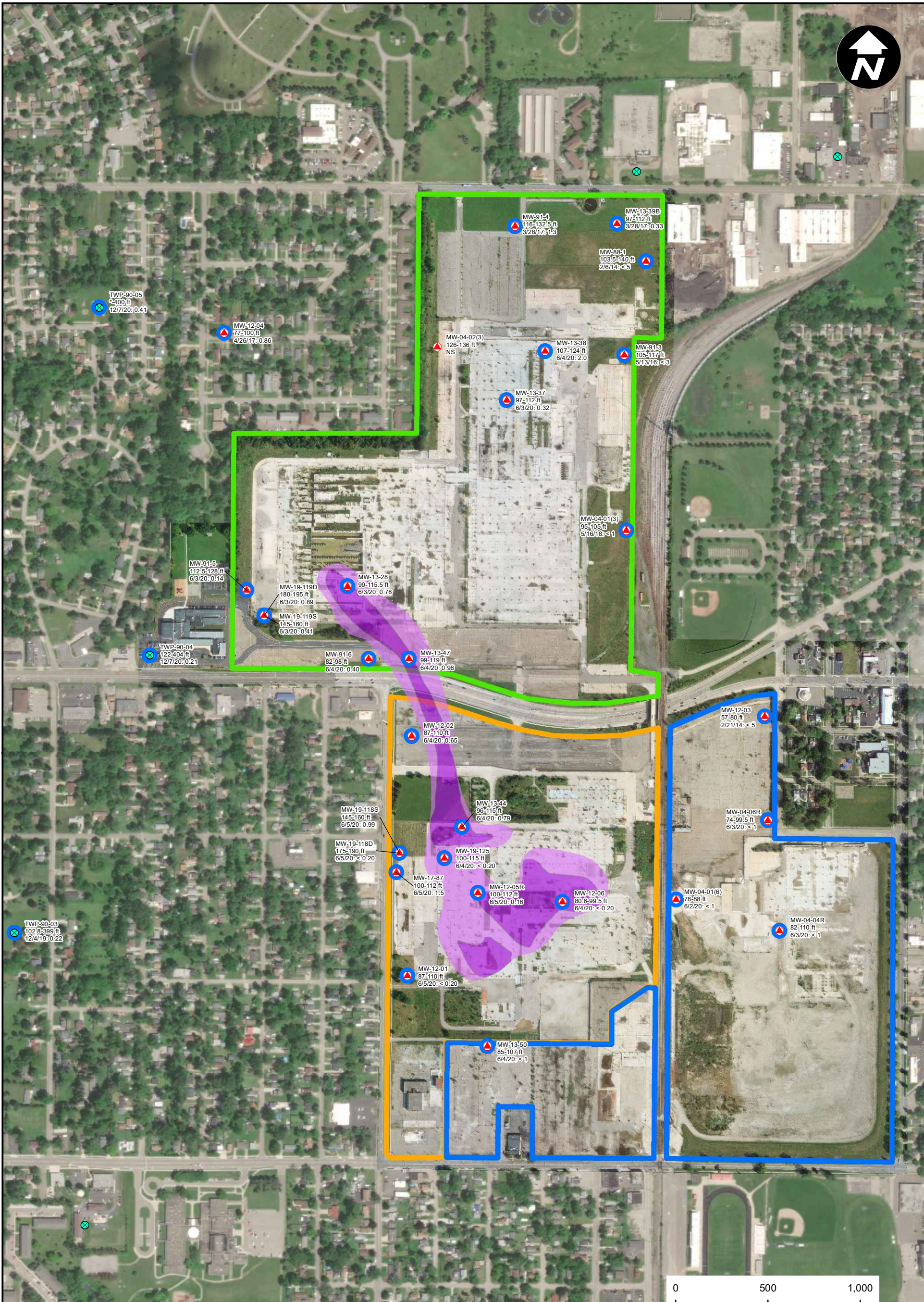
Elevation provided in ft above mean sea level
 Northing shown in feet (state plane)
 ppb – parts per billion

RACER TRUST
 PLANTS 2 AND 3
 LANSING, MICHIGAN

**3D MODEL OF LOWER 1,4-DIOXANE PLUME
 MODEL & WEATHERED BEDROCK
 SURFACE – OBLIQUE VIEWS**



CITY: Novi DIV: ENV DB: TRY PIC: J.Barrett PM: R.Christensen TM: A.Villhauer TR: PROJECT NUMBER: 30042872 COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl T:_ENV\RACER\Buffalo\MXDs\2020_AnnualReport\Figure 9 - AnnualGWS\Figure_BEDROCK_1,4-DIOXANE_WellIDs.mxd PLOTTED: 1/4/2021 11:07:21 PM BY: M.Joye



LEGEND

- MUNICIPAL WELL
- BEDROCK MONITORING WELL
- WELLS SAMPLED AND 1,4-DIOXANE DOES NOT EXCEED DW CRITERIA
- LOWER 1,4-DIOXANE PLUME > DW CRITERIA (7.2 µg/L)
- LOWER 1,4-DIOXANE PLUME > 72 µg/L

APPROXIMATE PLANT BOUNDARIES

- PLANT 2
- PLANT 3
- PLANT 6

NOTE:
 MOST RECENT SAMPLE DATA IS SHOWN AT EACH LOCATION.
 ALL ANALYTICAL DATA IS IN ng/L
 ng/L: NANOGRAM PER LITER
 NS: NOT SAMPLED FOR 1,4-D



RACER TRUST
 PLANT 6
 LANSING, MICHIGAN

SUMMARY OF BEDROCK 1,4-DIOXANE ANALYTICAL RESULTS

FIGURE
9

ARCADIS Design & Consultancy for natural and built assets



CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: J. Barrett PM: R. Christensen TM: A. Villhauer TR: PROJECT NUMBER: 30042872 COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl Z:\GIS\Projects\ENV\RACER_BuffaloLansing\MXDs\Annual Report Figures\2019_Summary\Figure 13 - Deep OB Weathered BR Trends.mxd PLOTTED: 4/28/2020 11:24:42 AM BY: ebeyer

LEGEND

- INCREASING TREND OBSERVED
 - DECREASING, STABLE, OR NO SIGNIFICANT TREND OBSERVED
 - DOES NOT MEET CRITERIA FOR TREND ANALYSIS*
 - LOWER 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 µg/L)
- APPROXIMATE PLANT BOUNDARIES**
- PLANT 2
 - PLANT 3
 - PLANT 6

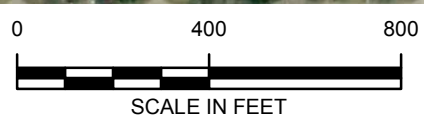
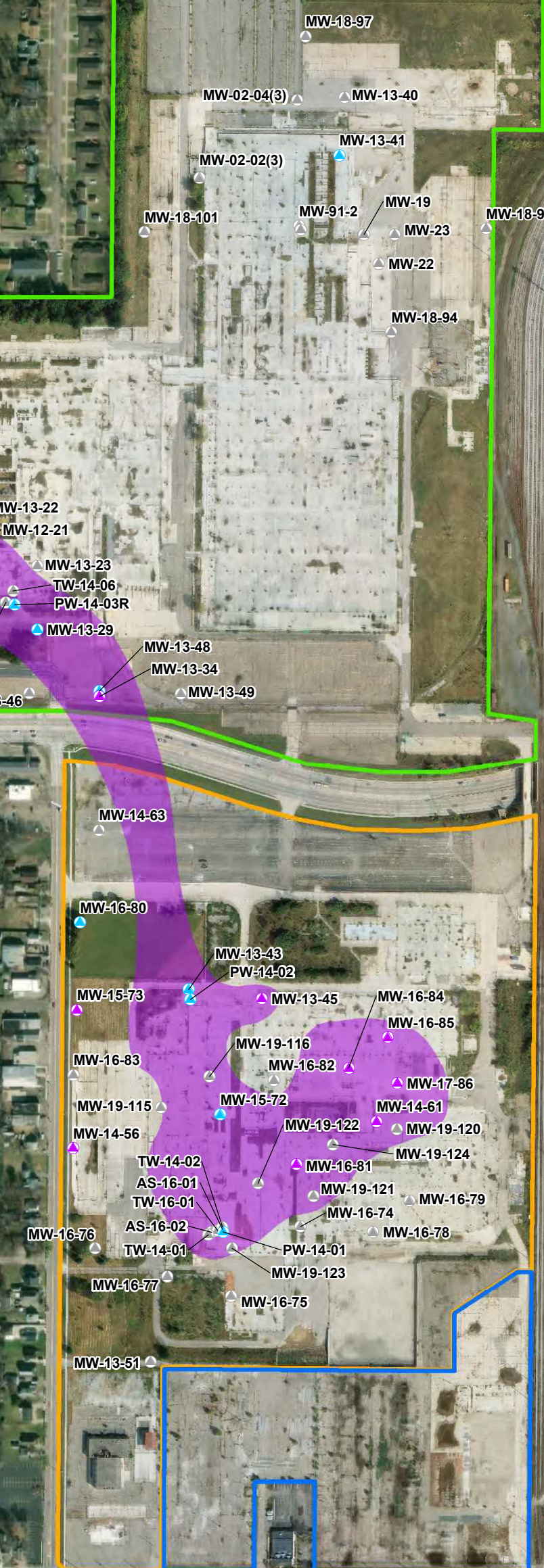
NOTES:

* MANN-KENDALL TREND ANALYSIS CONDUCTED AT 90% CONFIDENCE LEVEL FOR WELL/COC PAIRS MEETING THE FOLLOWING CRITERIA:

- AT LEAST FOUR SAMPLING EVENTS HAVE BEEN COMPLETED
- AT LEAST 65% OF SAMPLING RESULTS WERE ABOVE DETECTION LIMITS
- AT LEAST ONE DETECTION IN THE DATASET EXCEEDED THE LOWEST CRITERIA
- EITHER AN INCREASING TREND WAS IDENTIFIED DURING THE PREVIOUS ANALYSIS, THE WELL IS LOCATED AT THE PROPERTY BOUNDARY, OR THE TREND HAS NOT BEEN ANALYZED PREVIOUSLY DUE TO INSUFFICIENT DATA.
- ALL DATA COLLECTED THROUGH DECEMBER 2019 IS SHOWN.

ANALYTICAL DATA AVAILABLE IN TABLE 2. TREND RESULTS SUMMARIZED IN TABLE 7.

DW: DRINKING WATER
COC: CONSTITUENT OF CONCERN
µg/L: MICROGRAMS PER LITER



RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

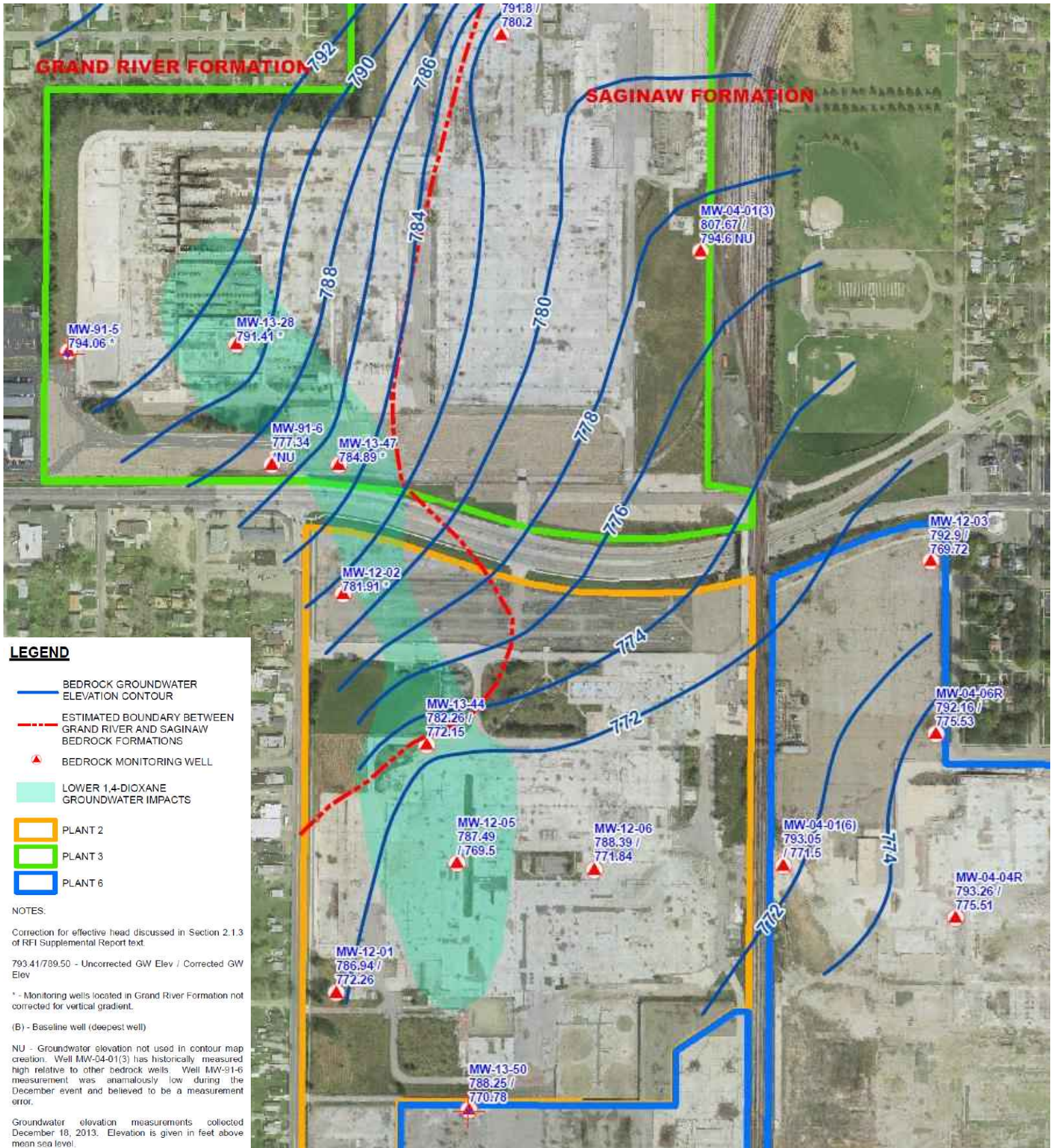
**SUMMARY OF 1,4-DIOXANE TRENDS
IN DEEP OVERBURDEN AND
WEATHERED BEDROCK - 2019**

APPENDIX A

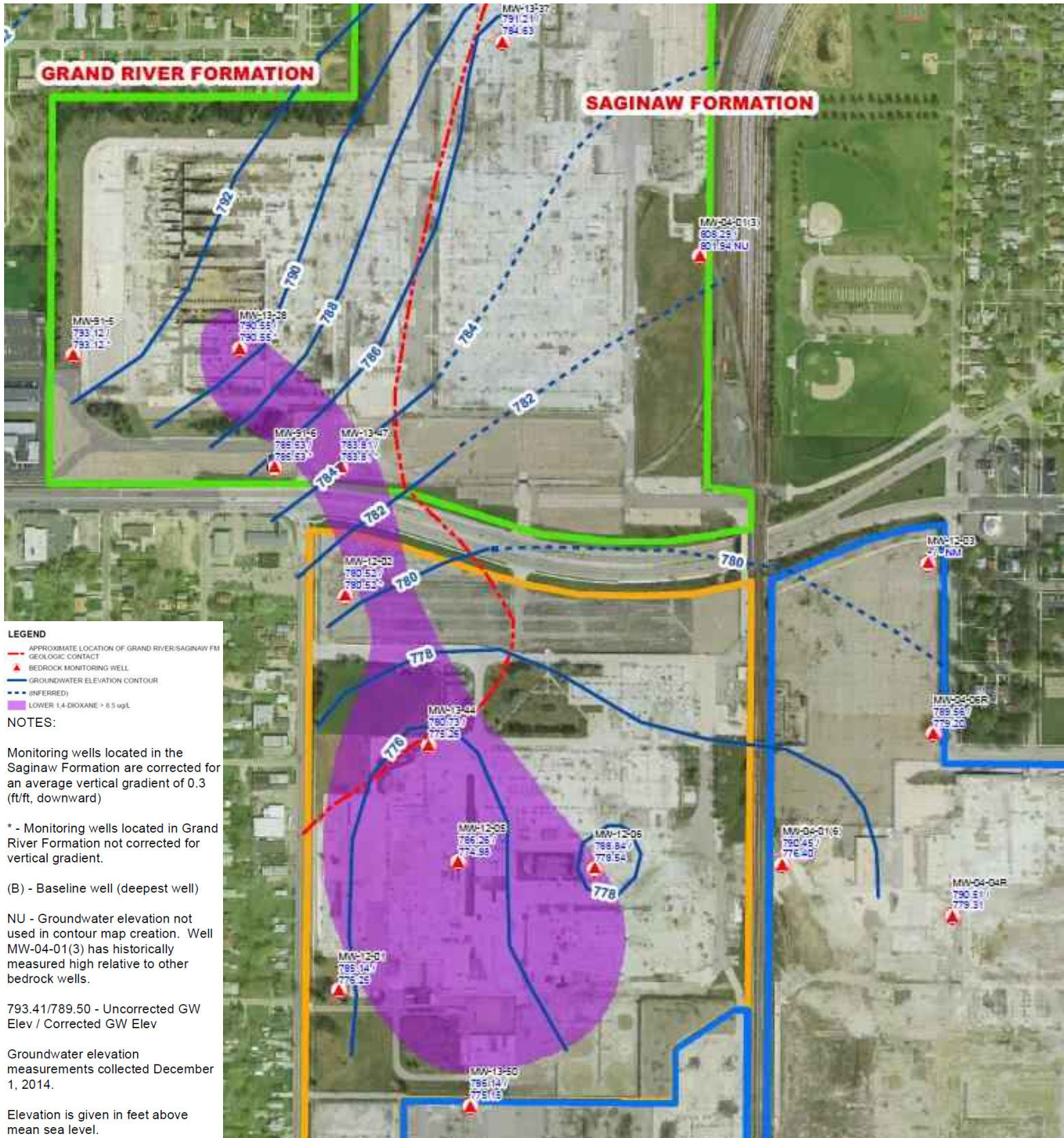
Historical Groundwater Elevation Contour Maps



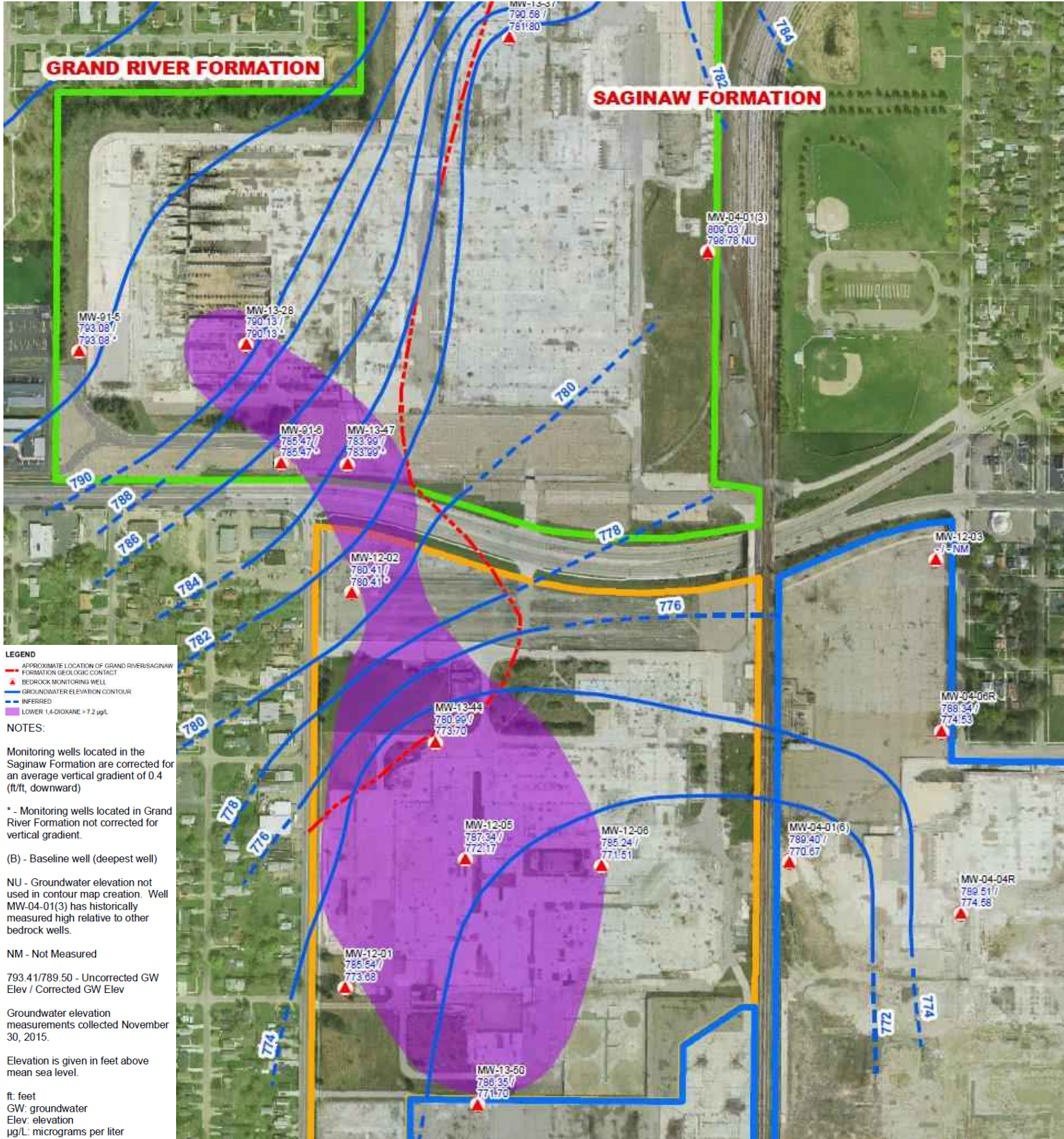
Dec 2013



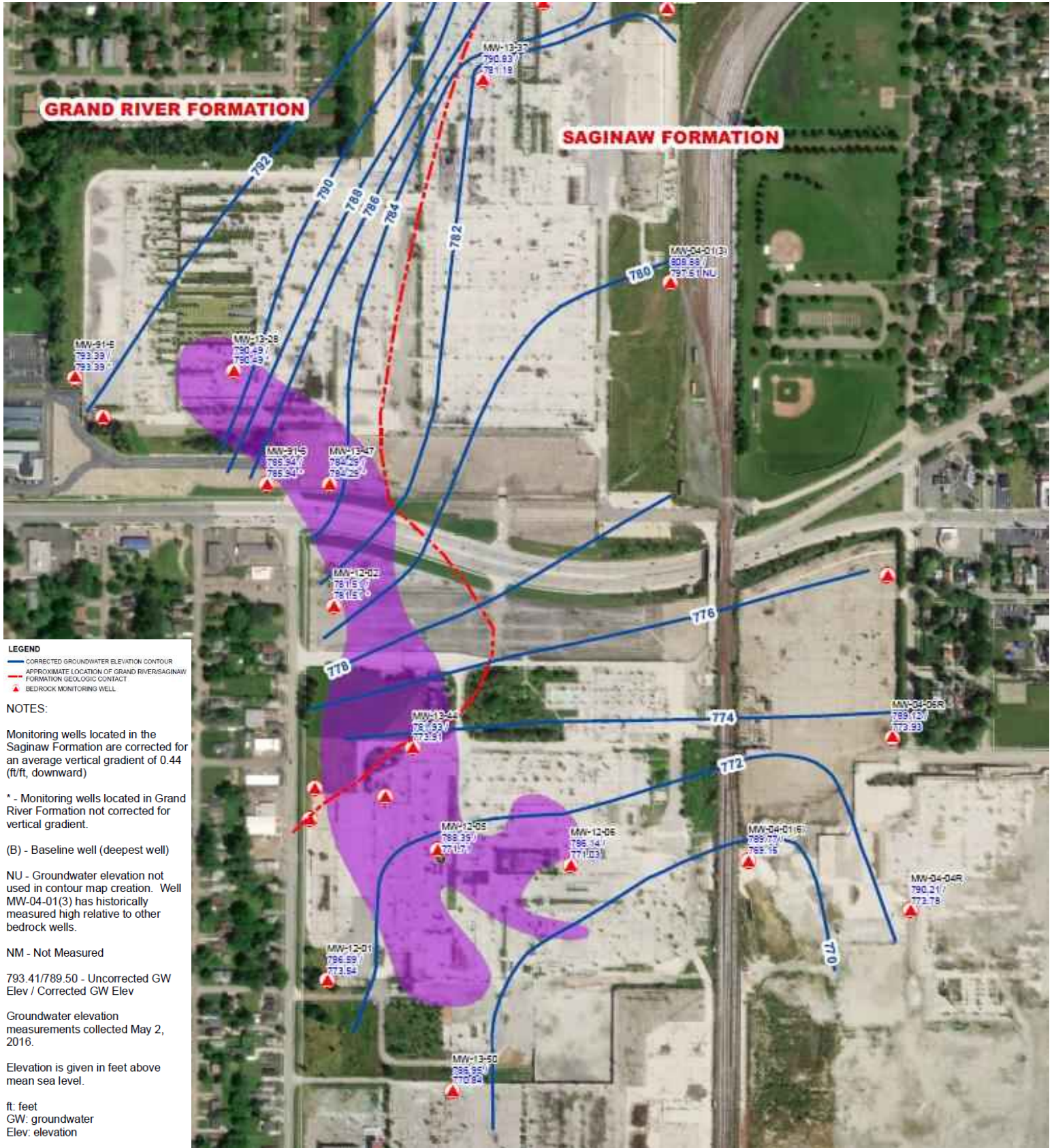
Dec 2014



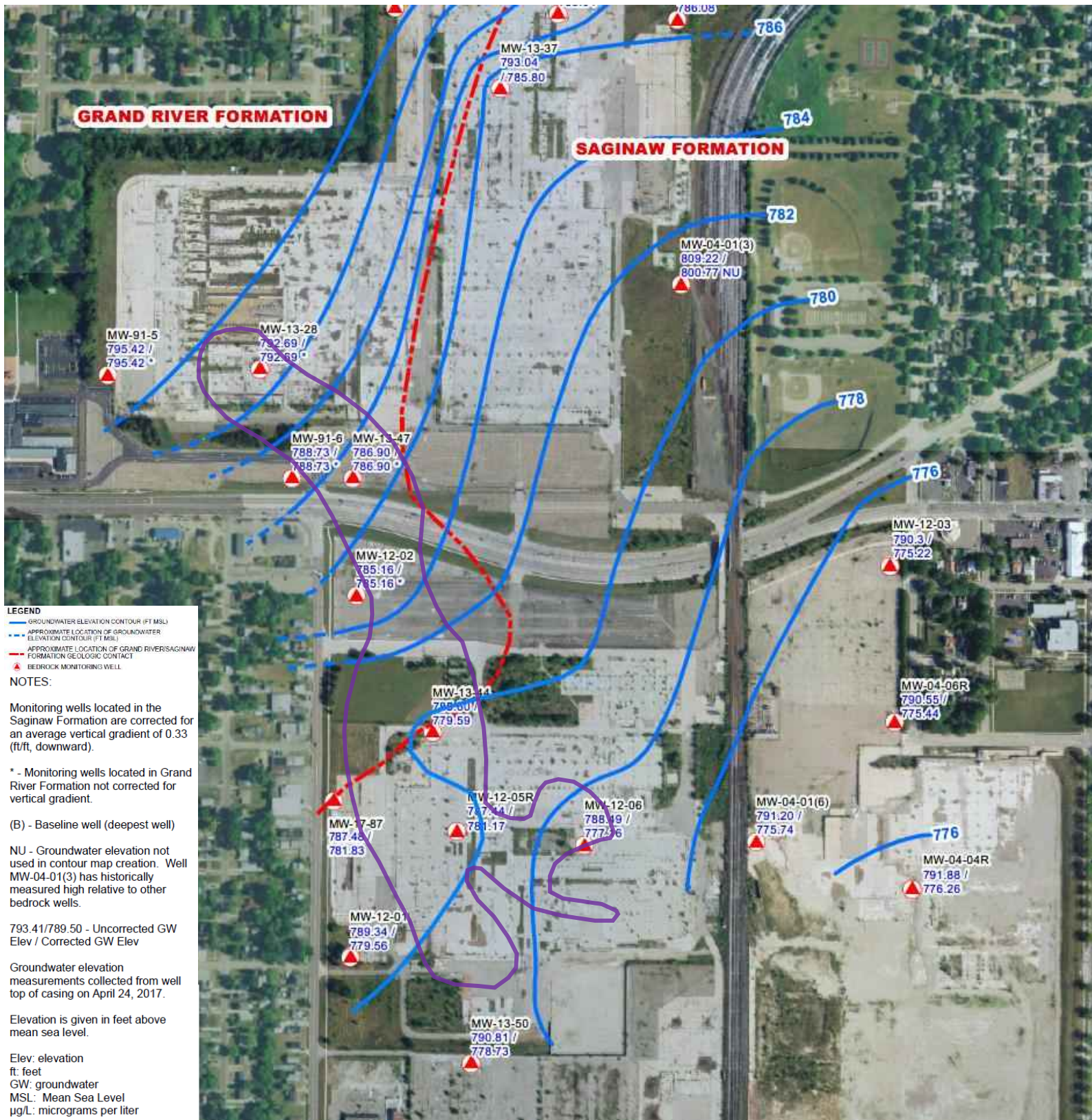
Dec 2015



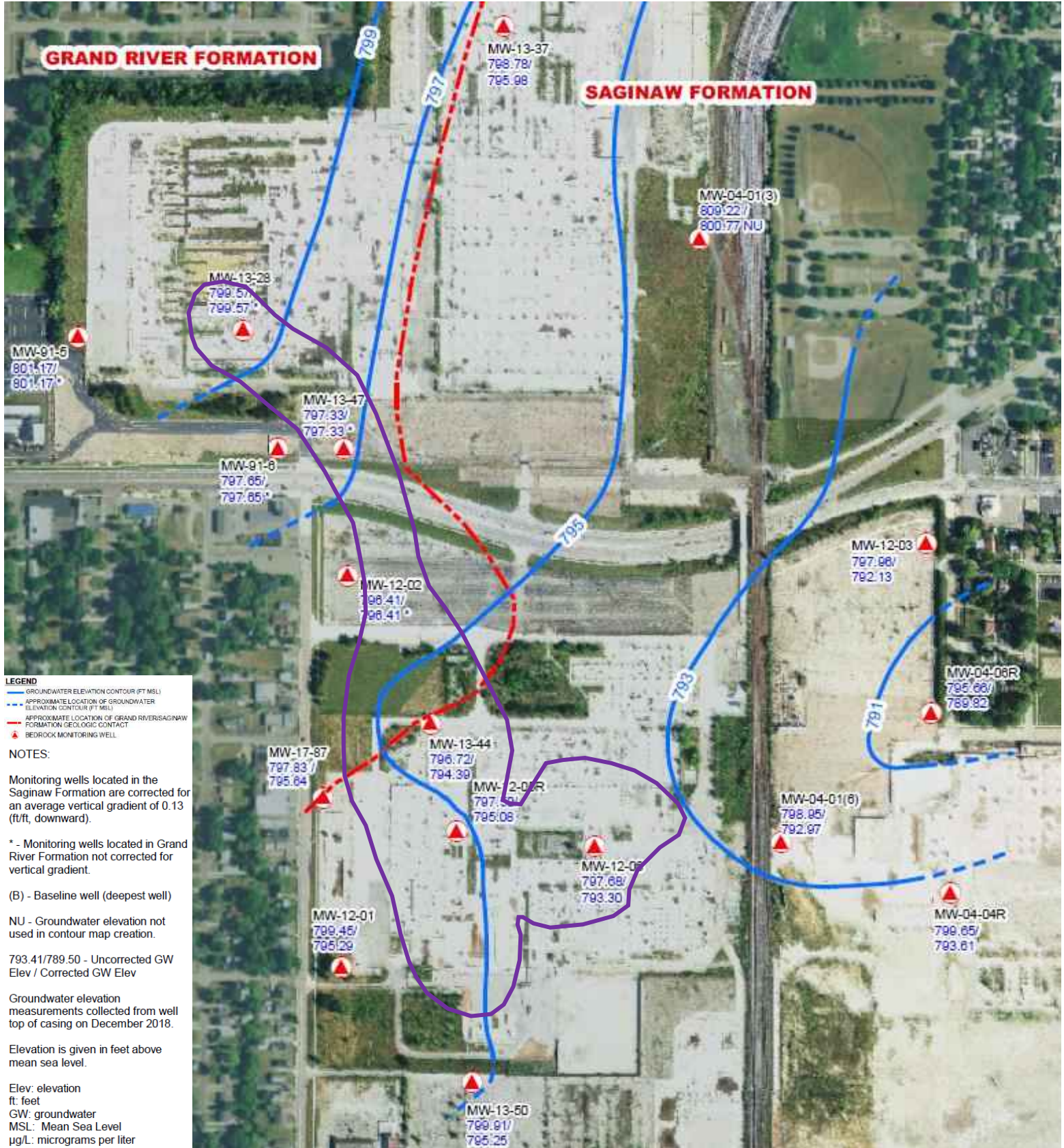
May 2016



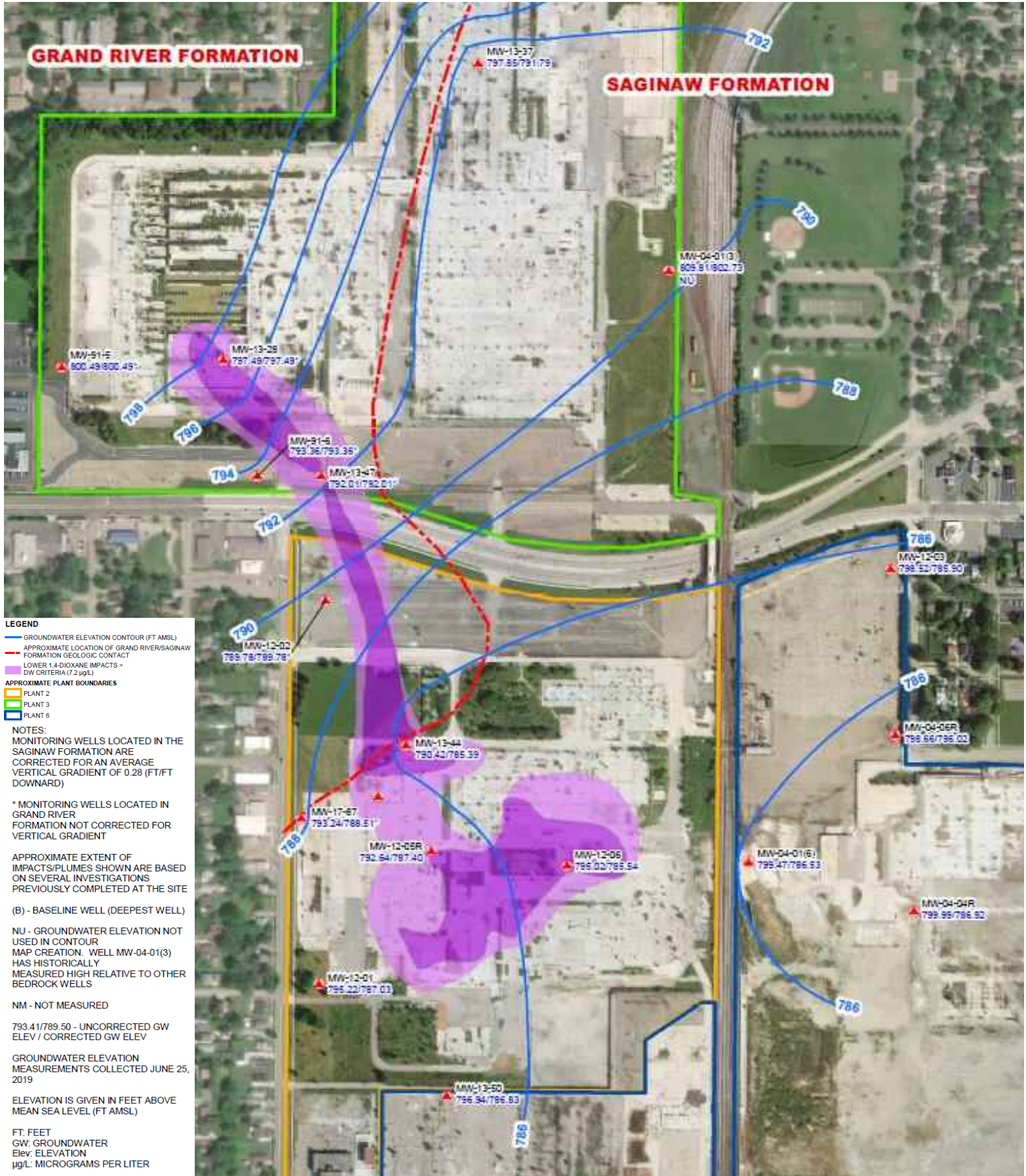
April 2017



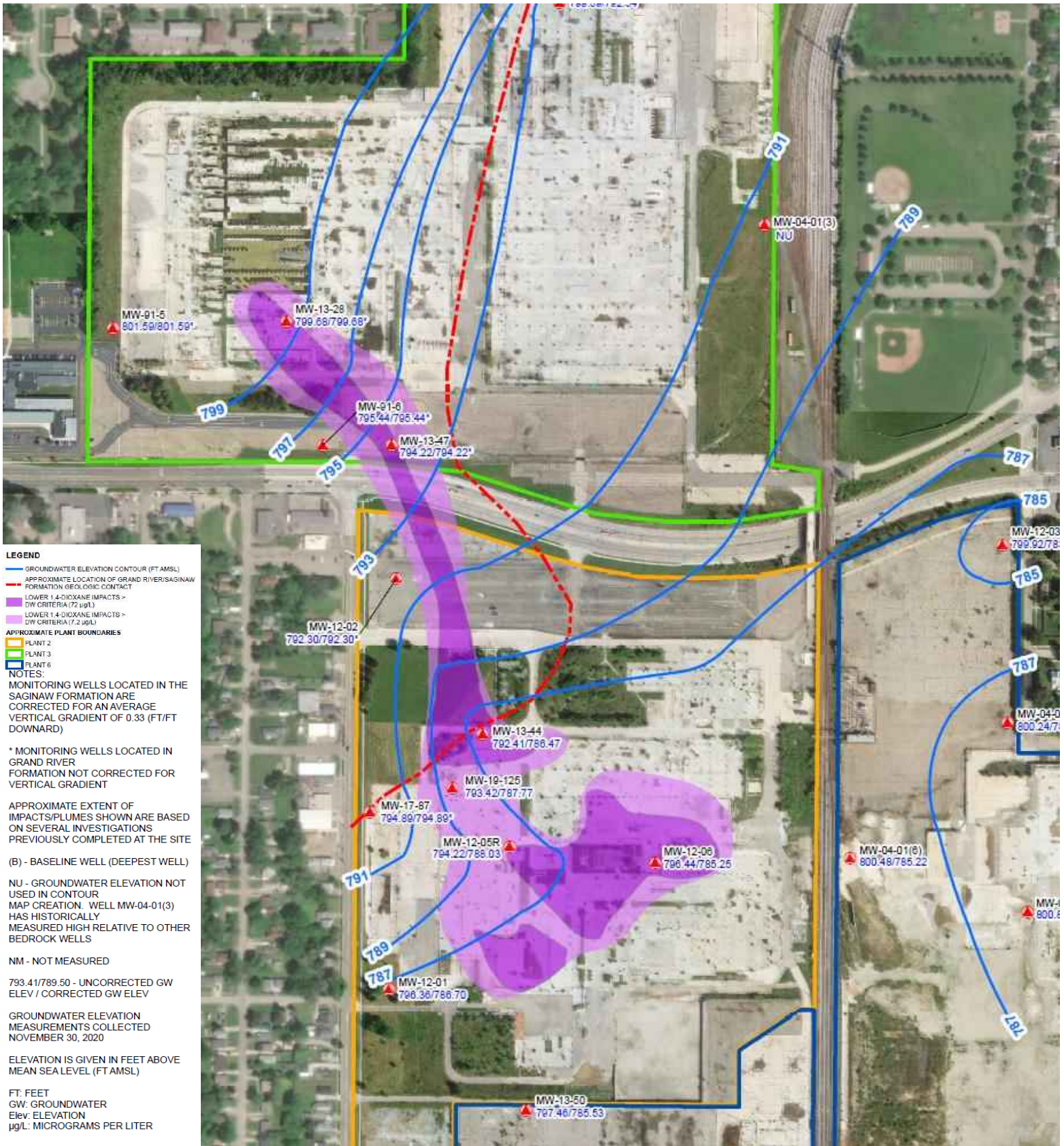
Dec 2018



June 2019



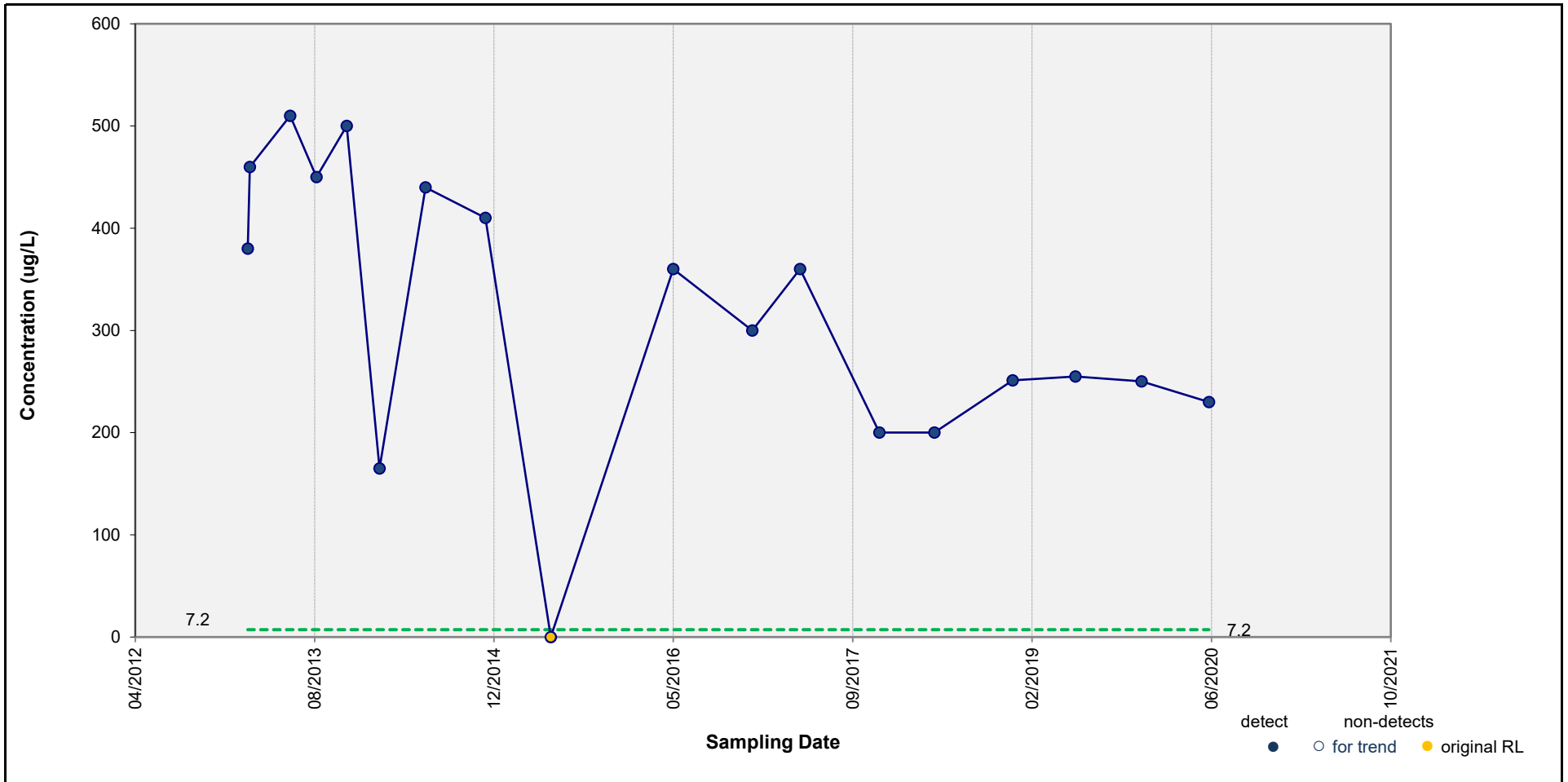
Dec 2020



APPENDIX B

TREND GRAPHS – MW-12-21 & MW-13-22





Results of Mann-Kendall Test for Trend:

DECREASING TREND

p value = Note: p value < 0.1 indicates a statistically significant trend (90% Confidence Interval).

Results of Sen's Estimator of Slope:

NA

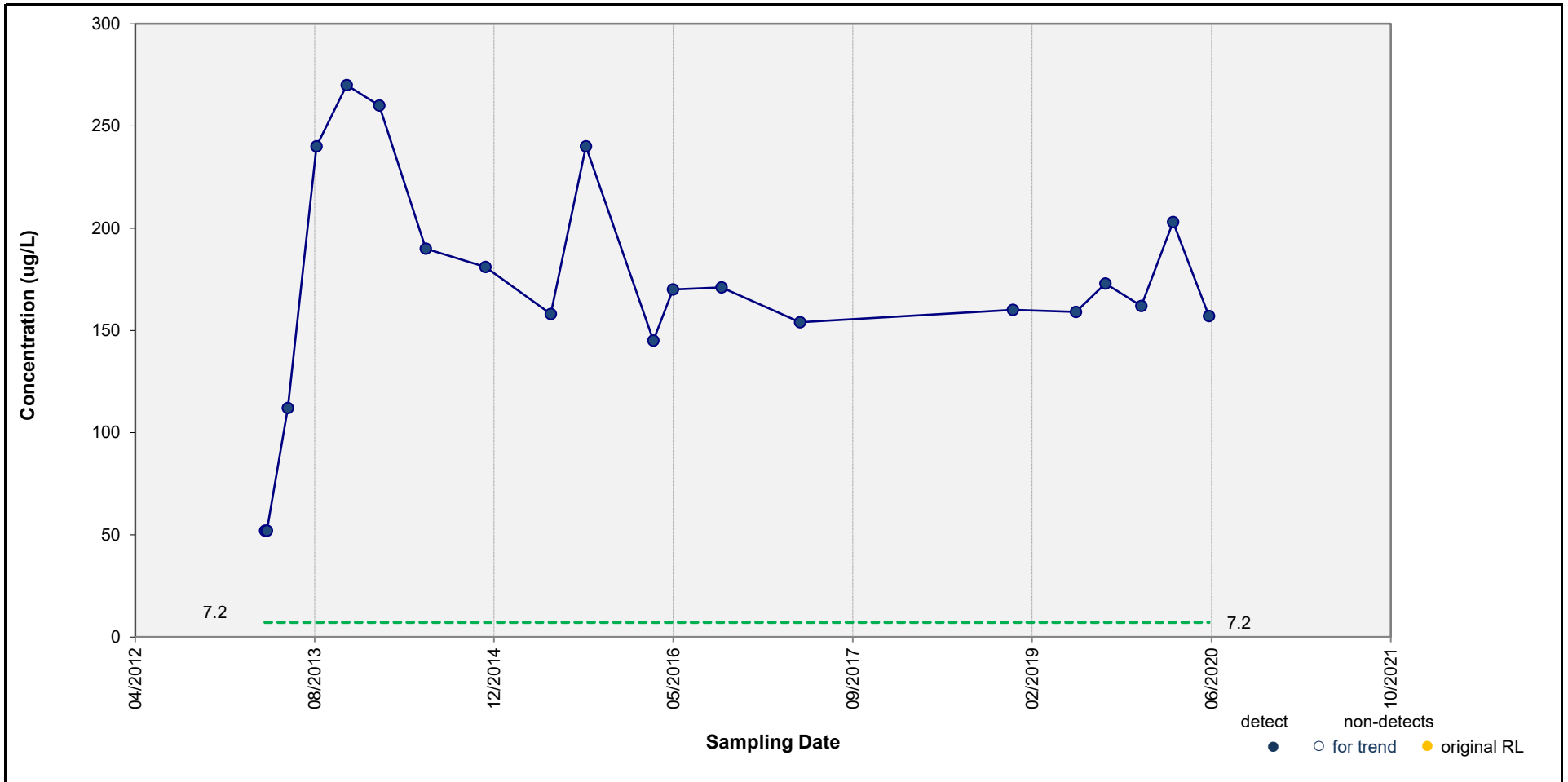
Median Slope Estimate = mg/L per day

Confidence Interval on the Slope = to mg/L per day



Concentration Plot: MW-12-21, 1,4-Dioxane
 RACER Lansing located at 2801 West Saginaw Street in Lansing, Michigan

Attachment 1



Results of Mann-Kendall Test for Trend:

No Significant Trend

p value = Note: p value < 0.1 indicates a statistically significant trend (90% Confidence Interval).

Results of Sen's Estimator of Slope:

NA

Median Slope Estimate = mg/L per day
 Confidence Interval on the Slope = to mg/L per day



Concentration Plot: MW-13-22, 1,4-Dioxane
 RACER Lansing located at 2801 West Saginaw Street in Lansing, Michigan

Attachment 1

APPENDIX C

DEEP BEDROCK BORING AND GEOPHYSICAL LOGS



Soil Boring Log

Project Name: RACER Lansing Date Started: 10/17/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/11/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 39° F, Cloudy

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
1							(0.0-0.3') TOPSOIL/GRASS.		
2							(0.3-8.5') CLAY, medium plasticity, no dilatancy; little sand, fine to medium, subrounded; trace granules to large pebbles, subrounded to subangular; poorly sorted; dry; medium stiff; brown (10YR 4/3). Note: Some small cobbles, subrounded from 0.2-1.3' bgs. Note: Color change to dark yellowish brown (10YR 4/6) from 4.1 to 5.8' bgs.		
3									
4		84							
5									
6							(5.8-6.2') SAND, medium to coarse, subrounded to subangular; trace sand, very coarse, subrounded to subangular; trace granules, subrounded to subangular; trace silt; well sorted; moist; brown (10YR 4/3).		
7									
8									
9									
10							(6.2-15.3') CLAY, high plasticity, no dilatancy; trace silt; trace sand, fine to medium, subrounded to subangular; trace granules to small pebbles, subrounded; poorly sorted; moist; medium stiff to stiff; grayish brown (10YR 5/2). Note: Boring appeared wet at 15.0' bgs.	(0.0-80.0') 10.0" dia. drilled hole	
11									
12		120							
13									
14							(15.3-15.4') CLAY, high plasticity, no dilatancy; and SAND, fine to medium, subrounded; little granules to medium pebbles, subrounded; poorly sorted; wet; grayish brown (10YR 5/2). Note: Some black coloration present.	(0.0-127.0') 7.0" dia. permanent steel casing cemented in-place	
15									
16									
17									
18							(15.4-21.1') CLAY, high plasticity, no dilatancy; little sand, very fine to fine, subrounded; poorly sorted; moist; medium stiff to soft; gray (10YR 5/1). Note: Trace small to medium pebbles, subrounded present from 16.1-16.4' bgs.		
19									
20									
21									
22		120					(21.0-21.5') SAND, medium to coarse, subrounded; trace silt; poorly sorted; moist; pale brown (10YR 6/3).	(0.0-145.0') 2.0" dia. SCH-40 PVC Casing	
23									
24									
25									
26							(21.5-35.0') CLAY, medium to high plasticity, no dilatancy; some silt; some sand, medium, subrounded; trace small to large pebbles, subrounded; poorly sorted; moist; stiff; gray (10YR 5/1).		
27									
28									
29									
30							(0.0-175.0') 2.0" dia. SCH-40 PVC Casing		
31									
32		120							
33									
34							(35.0-35.5') SAND, very fine to fine, subrounded; trace silt; well sorted; moist; light brownish gray (10YR 6/2).		
35									
36									

Drilling Co.: Cascade Sampling Method: 10.0' Sonic
 Driller: Joe Lary III Sampling Interval: Continuous
 Drilling Method: Sonic Drilling / Air Rotary Water Level Start (ft. bgs.): 15.0
 Drilling Fluid: None Water Level Finish (ft. btoc.): NA
 Remarks: Located ~60' north of MW-17-87. Converted to Well: Yes No
MW-19-118S screened from 145.0-160.0' bgs. Surface Elev.: 859.8
MW-19-118D screened from 175.0-190.0' bgs. North Coord.: 451409.2
 East Coord.: 13064095.0

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/17/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/11/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 39° F, Cloudy

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
37							(35.0-47.0') CLAY, medium to high plasticity, no dilatancy; some silt; some sand, fine to medium, subrounded to subangular; trace granules to large pebbles, subrounded; moist; medium stiff; gray (10YR 5/1).		
38									
39									
40									
41									
42			120						
43									
44									
45									
46									
47									
48							(47.0-48.0') SILT, nonplastic, no to slow dilatancy; little sand, fine, subrounded; moist; soft; gray (10YR 5/1).		
49							(48.0-52.0') SAND, very fine to fine, subrounded; trace granules, subrounded; well sorted; moist; light brownish gray (10YR 6/2).		
50									
51									
52			120						
53							(52.0-53.0') CLAY, low plasticity, no dilatancy; some silt; little sand, fine, subrounded; trace granules to large pebbles, subrounded; moist; stiff; gray (10YR 5/1).		
54							(53.0-56.5') SAND, fine to medium, subrounded; little silt; well sorted; moist; brown (10YR 5/3).		
55									
56									
57							(56.5-63.0') CLAY, nonplastic to medium plasticity, slow dilatancy; and SILT; little to some sand, fine, subrounded; trace granules to very large pebbles, subrounded; moist; stiff; grayish brown (10YR 5/2) to dark gray (10YR 4/1). Note: Glacial till, some large pebbles to small cobbles, subrounded to subangular; trace medium to large cobbles, subrounded from 57.0-61.0' bgs.		
58								Note: Large sandstone fragments from 61.0-63.0' bgs.	
59			42						
60									
61								Note: Trace shale from 65.0-67.0' bgs. Note: Some sand from 66.0-70.0' bgs.	
62									
63									
64			72				(63.0-70.0') CLAY, nonplastic, no dilatancy; and SILT; trace granules to medium pebbles, subangular; poorly sorted; dry; stiff to very stiff; dark gray (10YR 4/1).		
65								Note: Large sandstone fragments from 67.5-69.0' bgs.	
66									
67									
68								Note: Boring appeared wet at 71.0' bgs.	
69			24						
70								(70.0-80.0') SANDSTONE, fine; light gray (10YR 7/1).	
71									
72									
73									
74			24						

Remarks:

SOIL BORING LOG 2013 G:\COMMON\RACER LANSING\WORKING DATA ANALYSIS\BORING LOGS\RACER LANSING MASTER DATABASE 04/01/20.GPJ ARCADIS 2013.GDT 4/1/20

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/17/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/11/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 39° F, Cloudy

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
76							(70.0-80.0') SANDSTONE, fine; light gray (10YR 7/1).	(80.0-127.0') 8.0" dia. drilled hole	
77									
78									
79									
80									
81							(80.0-83.0') SHALE, very dark gray (10YR 3/1); and SANDSTONE, very fine to fine, light gray (10YR 7/1). Note: Finely interbedded.		
82		36							
83									
84							(83.0-85.0') SHALE; very dark gray (10YR 3/1). Note: Some fine sandstone inclusions present as laminations.		
85									
86							(85.0-87.0') SANDSTONE, fine; light gray (10YR 7/1). Note: Black shale inclusions.		
87							Note: Large sandstone cores more prevalent from 86.5-87.0' bgs.		
88							(87.0-87.5') SHALE; very dark gray (10YR 3/1). Note: Some sandstone laminations present.		
89							(87.5-88.5') SANDSTONE, hard; gray (10YR 5/1).		
90							(88.5-89.0') Finely interbedded SHALE and SANDSTONE.		
91							(89.0-98.0') SANDSTONE; some shale inclusions.		
92		120							
93									
94									
95									
96									
97									
98									
99							(98.0-102.0') Finely interbedded SANDSTONE and SHALE; very dark gray (10YR 3/1).		
100									
101									
102							(102.0-105.0') SANDSTONE, hard; gray (10YR 5/1).		
103		72							
104							Note: Black shale inclusions from 104.0-105.0' bgs.		
105									
106							(105.0-114.0') SANDSTONE, hard; dark gray (10YR 4/1).		
107									
108									
109									
110		18							
111									
112									
113									

Remarks:

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/17/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/11/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 39° F, Cloudy

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
114							(105.0-114.0') SANDSTONE, hard; dark gray (10YR 4/1).		
115							(114.0-115.0') SHALE. Note: Some thin sandstone laminations present.		
116							(115.0-117.0') SANDSTONE, hard; gray (10YR 5/1). Note: Some shale inclusions, very dark gray (10YR 3/1)		
117			42				(117.0-117.5') Finely interbedded SHALE and SANDSTONE.		
118							(117.5-141.0') SANDSTONE, very fine to fine, hard; gray (10YR 5/1) to light brownish gray (10YR 6/2).		
119									
120									
121									
122									
123									
124									
125			48					(126.0-132.0') Bentonite Grout	
126									
127								(127.0-205.0') 6.0" dia. drilled hole	
128									
129									
130									
131									
132			108					(132.0-142.0') Weighted Bentonite Pellets	
133									
134									
135									
136									
137							Note: Little shale inclusions at 136.5' bgs.		
138									
139									
140									
141									
142			102				(141.0-142.0') SANDSTONE, very fine to fine, subrounded; gray (10YR 5/1). Note: Some shale inclusions.	(142.0-144.0') Choker Sand	
143							(142.0-158.0') SANDSTONE, very fine to medium, subrounded; little clay; light brownish gray(10YR 6/2) to gray (10YR 5/1).	(144.0-163.0') Filter Pack Sand	
144									
145									
146									
147								(145.0-160.0') 2.0" dia. Stainless-Steel 0.010-Slot Screen	
148							Note: Little shale inclusions from 147.0-148.0' bgs.		
149							Note: Little shale inclusions at 148.5' bgs.		
150							Note: Little shale inclusions at 149.5' bgs.		
151									

Remarks:

SOIL BORING LOG 2013 G:\COMMON\RACER LANSING\WORKING DATA ANALYSIS\BORING LOGS\RACER LANSING MASTER DATABASE 04/01/20.GPJ / ARCADIS 2013.GDT 4/1/20

Soil Boring Log



Project Name: RACER Lansing Date Started: 10/17/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/11/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 39° F, Cloudy

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
153			120				(142.0-158.0') SANDSTONE, very fine to medium, subrounded; little clay; light brownish gray(10YR 6/2) to gray (10YR 5/1).		
154									
155									
156							(158.0-160.0') GRANULES to MEDIUM PEBBLES, subrounded to subangular; poorly sorted; gray (10YR 5/1). Note: Glacial till.		
157									
158									
159							(160.0-205.0') SANDSTONE, very fine to fine, subrounded; light gray (10YR 7/1) to light brownish gray (10YR 6/2).	(163.0-172.0') Weighted Bentonite Pellets	
160									
161			120						
162							Note: Thin shale seams from 170.0-175.0' bgs.		
163									
164									
165							Note: Sand grain size changes to very fine to medium from 174.0-178.0' bgs.	(172.0-174.0') Choker Sand	
166									
167									
168							Note: Finely-interbedded SANDSTONE and SHALE from 179.0-179.5' bgs.	(174.0-193.0') Filter Pack Sand	
169									
170									
171							(175.0-190.0') 2.0" dia. Stainless-Steel 0.010-Slot Screen		
172			120						
173									
174									
175									
176									
177									
178									
179									
180									
181									
182			120						
183									
184									
185									
186									
187									
188									
189									
190									

Remarks:

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/17/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/11/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 39° F, Cloudy

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
191	◆		120				(160.0-205.0') SANDSTONE, very fine to fine, subrounded; light gray (10YR 7/1) to light brownish gray (10YR 6/2).	(193.0-205.0') Weighted Bentonite Pellets	
192									
193									
194									
195									
196									
197									
198	◆		90				Note: Finely-interbedded SANDSTONE and SHALE from 197.5-198.0' bgs.		
199									
200									
201									
202									
203									
204									
205									
206							End of boring at 205.0' bgs.		
207									
208									
209									
210									
211									
212									
213									
214									
215									
216									
217									
218									
219									
220									
221									
222									
223									
224									
225									
226									
227									
228									

Remarks: _____

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/22/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/08/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 48° F, Cloudy/Rain/Hail

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
1							(0.0-0.5') ASPHALT.		
2							(0.5-1.5') CONCRETE. Note: Reinforcement bars (3/4" dia.) present.		
3			84				(1.5-2.0') SAND, fine to very coarse, subrounded; trace granules, subrounded; trace silt; poorly sorted; dry; yellowish brown (10YR 5/4).		
4							(2.0-14.5') CLAY, low to medium plasticity, no dilatancy; some silt; little sand, fine; trace granules to large pebbles, subrounded; poorly sorted; moist; soft to medium stiff; yellowish brown (10YR 5/4) to brown (10YR 4/3).		
5									
6									
7									
8									
9								(0.0-80.0') 10.0" dia. drilled hole	
10			120						
11									
12									
13									
14									
15							(14.5-15.0') SAND, medium to very coarse, subrounded to subangular; some silt; trace granules, subrounded; poorly sorted; moist; yellowish brown (10YR 5/4).		
16							(15.0-22.0') CLAY, low to medium plasticity, no dilatancy; some silt; little sand, fine; little granules to large pebbles, rounded; poorly sorted; dry; stiff; grayish brown (10YR 5/2) to gray (10YR 5/1) to dark grayish brown (10YR 4/2).	(0.0-126.0') 7.0" dia. Permanent Steel Casing cemented in place	
17									
18									
19									
20									
21									
22			108				(22.0-24.0') SAND, medium to very coarse, subrounded to subangular; some granules, subrounded; little small to large pebbles, subrounded; trace silt; poorly sorted; dry; light yellowish brown (10YR 6/4).	(0.0-145.0') 2.0" dia. SCH-40 PVC Casing	
23							(24.0-27.0') SAND, very fine to fine, subrounded to subangular; and SILT; well sorted; dry; brownish yellow (10YR 6/6).		
24									
25									
26									
27									
28							(27.0-28.5') SAND, medium to very coarse, subrounded to subangular; some granules to small pebbles, subrounded to subangular; poorly sorted; moist; brown (10YR 5/3).	(0.0-180.0') 2.0" dia. SCH-40 PVC Casing	
29							(28.5-35.0') SILT, medium plasticity, no dilatancy; little sand, very fine to fine, subrounded to subangular; some clay; well sorted; dry; brown (10YR 5/3).		
30			84						
31									
32									
33									
34									
35							Note: Some pebbles, small to medium, subrounded to subangular from 34.0-35.0' bgs.		
36									

Drilling Co.: Cascade Sampling Method: 10.0' Sonic
 Driller: Joe Lary III Sampling Interval: Continuous
 Drilling Method: Sonic Drilling / Air Rotary Water Level Start (ft. bgs.): 66.0
 Drilling Fluid: None Water Level Finish (ft. btoc.): NA
 Remarks: Located in the southwest corner of Plant 3. Converted to Well: Yes No
MW-19-119S screened from 145.0-160.0' bgs. Surface Elev.: 861.7
MW-19-119D screened from 180.0-195.0' bgs. North Coord.: 452665.4
 East Coord.: 13063463.9

SOIL BORING LOG - 2013 G:\COMMON\RACER LANSING\WORKING DATA ANALYSIS\BORING LOGS\RACER LANSING MASTER DATABASE (04/01/20).GPJ / ARCADIS - 2013.GDT 4/1/20

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/22/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/08/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 48° F, Cloudy/Rain/Hail

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
37							(35.0-44.0') SAND, fine to coarse, subrounded to subangular; and SILT, medium plasticity, no dilatancy; some pebbles, small to medium, subrounded to subangular; well sorted; moist; brown (10YR 5/3).		
38									
39			48						
40									
41							(44.0-47.0') SILT, nonplastic, rapid dilatancy; some sand, very fine; well sorted; moist; grayish brown (10YR 5/2).		
42									
43							(47.0-60.0') SILT, nonplastic, slow dilatancy; and CLAY; some sand, fine, subrounded; trace granules to medium pebbles, subrounded; dry; stiff; grayish brown (10YR 5/2) to dark grayish brown (10YR 4/2).		
44									
45			36						
46									
47							(60.0-67.0') SILT, low plasticity, slow dilatancy; some sand, fine, subrounded; little clay; well sorted; moist; medium stiff to soft; grayish brown (10YR 5/2).		
48									
49									
50			120						
51							Note: Boring appeared wet at 66.0' bgs.		
52									
53									
54									
55							(67.0-77.0') No Recovery.		
56									
57									
58									
59									
60									
61									
62			120						
63									
64									
65									
66									
67									
68									
69									
70			0						
71									
72									
73									
74									

Remarks:

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/22/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/08/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 48° F, Cloudy/Rain/Hail

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
75			0				(67.0-77.0') No Recovery.	(80.0-126.0') 8.0" dia. drilled hole	
76									
77									
78							(77.0-97.0') SILT, nonplastic to low plasticity, slow dilatancy; and CLAY; trace sand, fine, subrounded; well sorted; dry to moist; medium stiff to soft; grayish brown (10YR 5/2) to gray (10YR 5/1).		
79									
80									
81									
82			120						
83									
84									
85									
86									
87									
88									
89									
90									
91									
92			120						
93									
94									
95									
96									
97									
98							(97.0-126.0') SANDSTONE, very fine to fine; little silt; well sorted; wet; light brownish gray (10YR 6/2) to gray (10YR 6/1).		
99									
100									
101									
102			66						
103									
104									
105									
106									
107									
108									
109									
110									
111			0						
112									
113									

Remarks: _____

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/22/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/08/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 48° F, Cloudy/Rain/Hail

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
114							(97.0-126.0') SANDSTONE, very fine to fine; little silt; well sorted; wet; light brownish gray (10YR 6/2) to gray (10YR 6/1). Note: Some black shale inclusions from 116.5-117.0' bgs.		
115									
116									
117									
118									
119									
120									
121			90						
122									
123									
124							(126.0-143.0') SANDSTONE, very fine to fine, subrounded; some to little silt; well sorted; wet; light brownish gray (10YR 6/2). Note: Some small black inclusions (10YR 2/1).	(126.0-215.0') 6.0" dia. drilled hole	
125									
126									
127									
128									
129									
130									
131			114						
132									
133									
134							Note: Coarser grained sand, fine to very coarse from 136.0-143.0' bgs.	(127.0-132.0') Bentonite Grout	
135									
136									
137									
138									
139									
140									
141			102						
142									
143									
144						(143.0-144.0') SHALE; dark gray (10YR 4/1).	(132.0-142.0') Weighted Bentonite Pellets		
145						(144.0-149.0') SANDSTONE, fine to coarse, subrounded; light brownish gray (10YR 6/2).			
146									
147									
148									
149									
150						(149.0-152.0') Finely interbedded SHALE and SANDSTONE.			
151			120						

Remarks:

SOIL BORING LOG 2013 G:\COMMON\RACER LANSING\WORKING DATA ANALYSIS\BORING LOGS\RACER LANSING MASTER DATABASE 04\10\20.GPJ / ARCADIS 2013.GDT 4/1/20

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/22/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/08/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 48° F, Cloudy/Rain/Hail

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
153							(152.0-155.5') SANDSTONE, fine to coarse, subrounded; little silt; light brownish gray (10YR 6/2).		
154									
155									
156							(155.5-156.5') Finely interbedded SHALE and SANDSTONE.		
157							(156.5-160.0') SANDSTONE, very fine to fine, subrounded; some silt; light brownish gray (10YR 6/2).		
158									
159									
160									
161			114				(160.0-160.5') Finely interbedded SHALE and SANDSTONE.		
162							(160.5-163.8') SANDSTONE, very fine to fine, subrounded; some silt; light brownish gray (10YR 6/2).	(163.0-177.0') Weighted Bentonite Pellets	
163									
164							(163.8-164.2') Finely interbedded SHALE and SANDSTONE.		
165							(164.2-166.0') SANDSTONE, very fine to fine; light brownish gray (10YR 6/2).		
166							(166.0-167.5') SHALE; dark gray (10YR 4/1).		
167									
168							(167.5-175.0') SANDSTONE, very fine to fine, subrounded; light brownish gray (10YR 6/2).		
169									
170									
171			108						
172									
173									
174									
175									
176							(175.0-180.0') SANDSTONE, very fine to coarse, subrounded; and SILT, nonplastic, rapid dilatancy; light brownish gray (10YR 6/2). Note: Sandstone with shale inclusions from 175.5-176.0' bgs.	(177.0-179.0') Choker Sand	
177									
178									
179									
180									
181			108				(180.0-198.0') SANDSTONE, very fine to medium, subrounded; some silt, nonplastic, rapid dilatancy; light brownish gray (10YR 6/2). Note: Shale seam from 181.5-181.6' bgs.	(179.0-198.0') Filter Pack Sand (180.0-195.0') 2.0" dia. Stainless-Steel 0.010-Slot Screen	
182									
183									
184									
185									
186									
187									
188									
189							Note: Shale inclusions from 188.5-189.0' bgs.		
190									

Remarks:

SOIL BORING LOG 2013 G:\COMMON\RACER LANSING\WORKING DATA ANALYSIS\BORING LOGS\RACER LANSING MASTER DATABASE 04\10\20.GPJ / ARCADIS 2013.GDT 4/1/20

Soil Boring Log

Project Name: RACER Lansing Date Started: 10/22/2019 Logger: C. Cisco
 Project Number: 30006870.04600 Date Completed: 11/08/2019 Editor: C. Cisco
 Project Location: Lansing, MI Weather Conditions: 48° F, Cloudy/Rain/Hail

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details	Well
191			120				(180.0-198.0') SANDSTONE, very fine to medium, subrounded; some silt, nonplastic, rapid dilatancy; light brownish gray (10YR 6/2).		
192									
193									
194									
195									
196			108				(198.0-198.6') SHALE; dark gray (10YR 4/1).	(198.0-215.0') Weighted Bentonite Pellets	
197									
198									
199									
200									
201			120				(198.6-215.0') SANDSTONE, very fine to medium, subrounded; some silt, nonplastic, rapid dilatancy; light brownish gray (10YR 6/2).		
202									
203									
204									
205									
206									
207									
208									
209									
210									
211									
212									
213									
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218									
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221									
222									
223									
224									
225									
226									
227									
228									

End of boring at 215.0' bgs.

Remarks:



Acoustic Televiewer

COMPANY: Arcadis

PROJECT: Lancing

DATE LOGGED: 1 November 2019

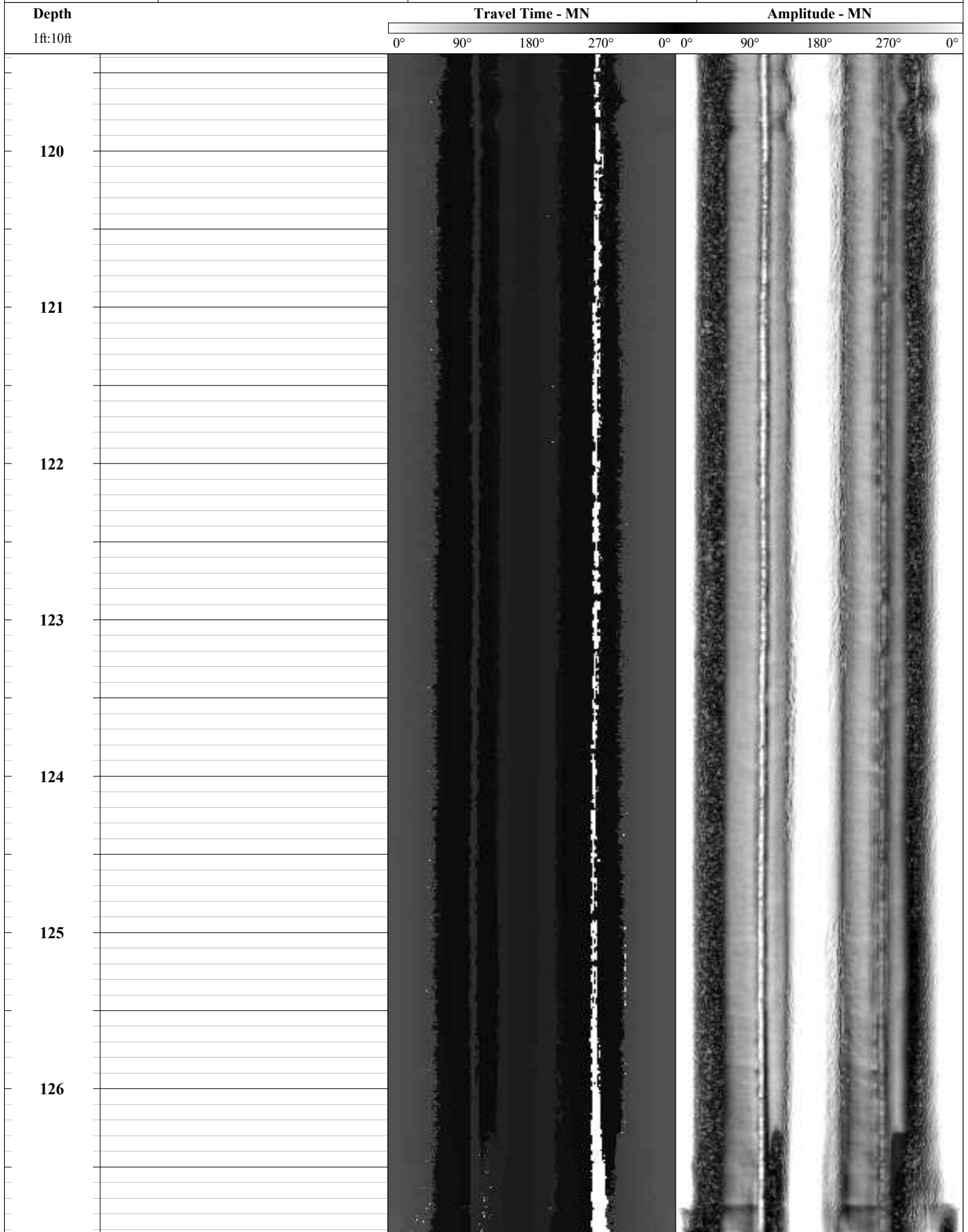
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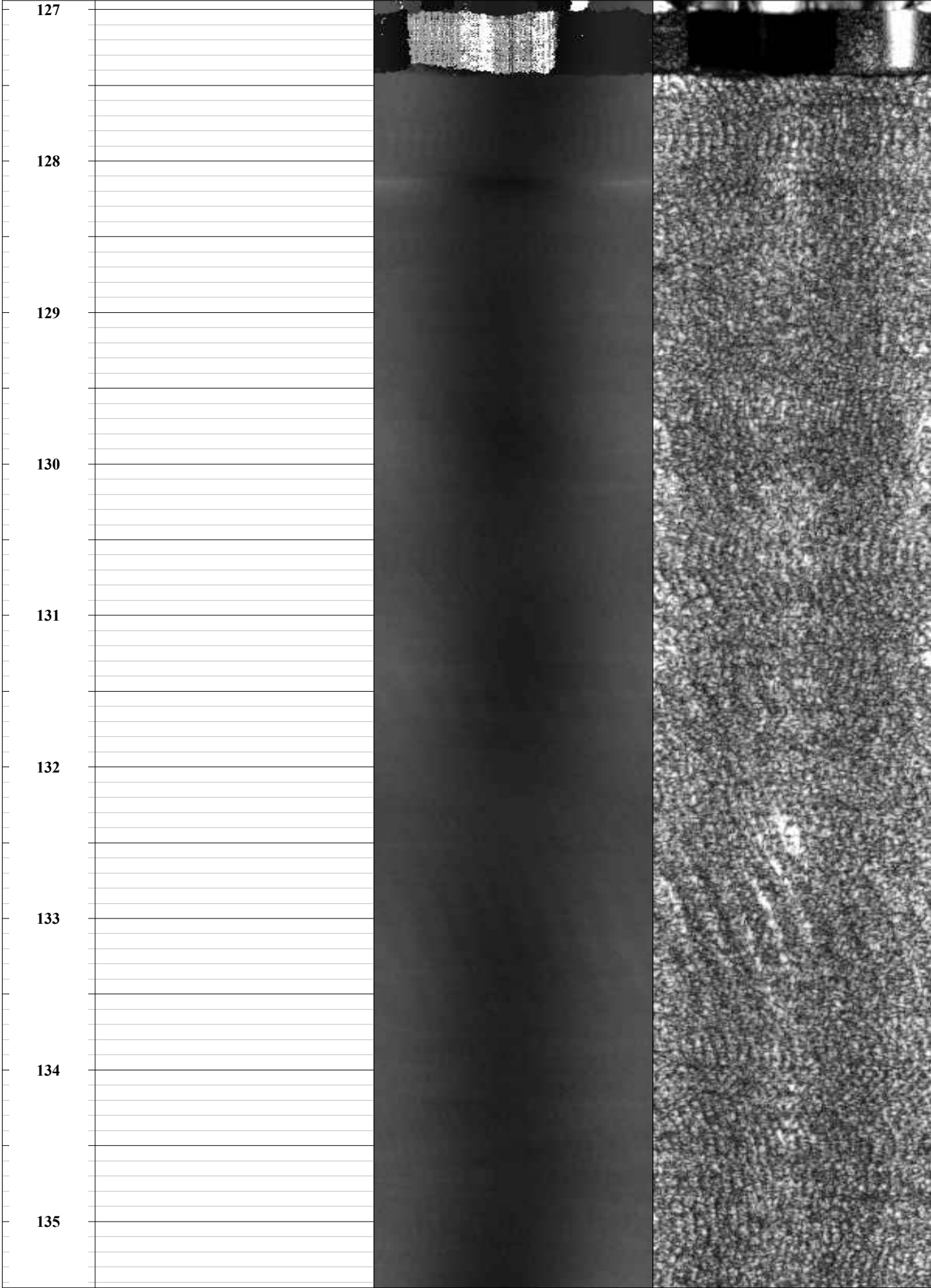
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136

137

138

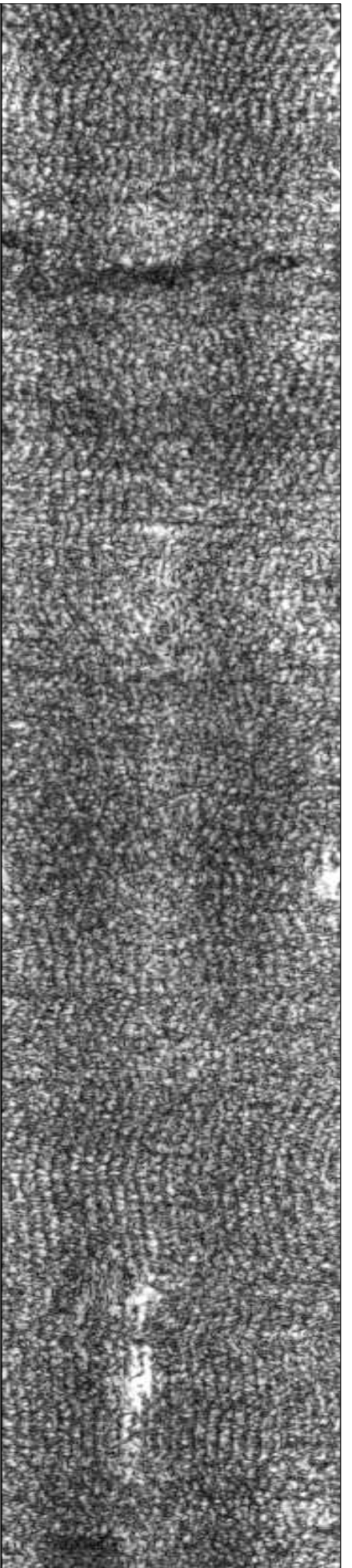
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140

141

142

143



144

145

146

147

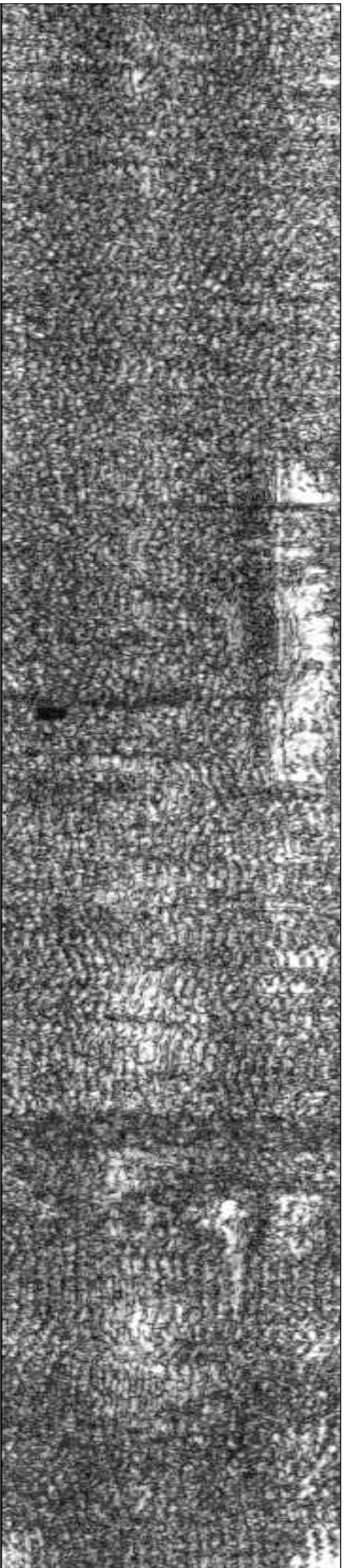
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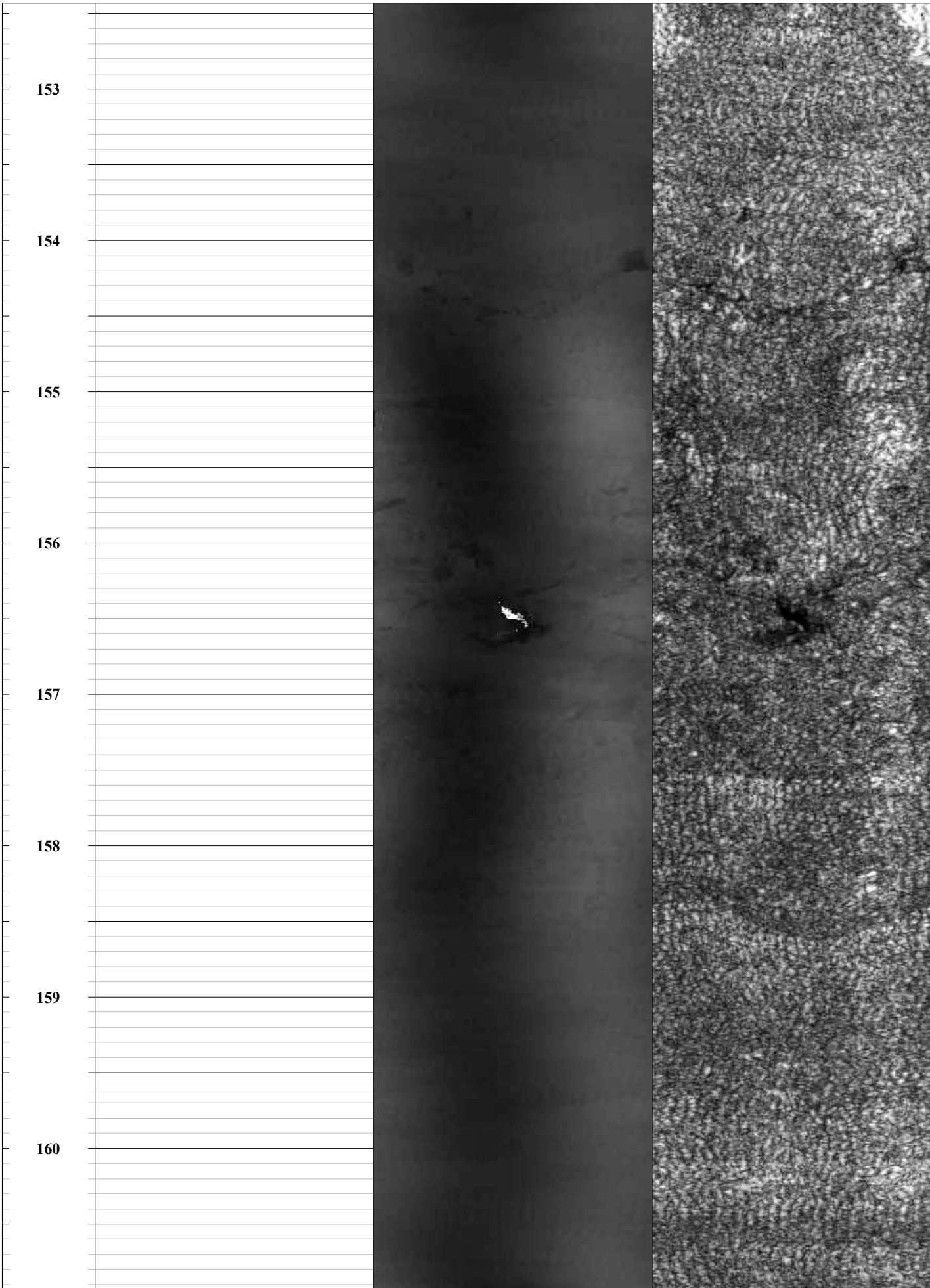
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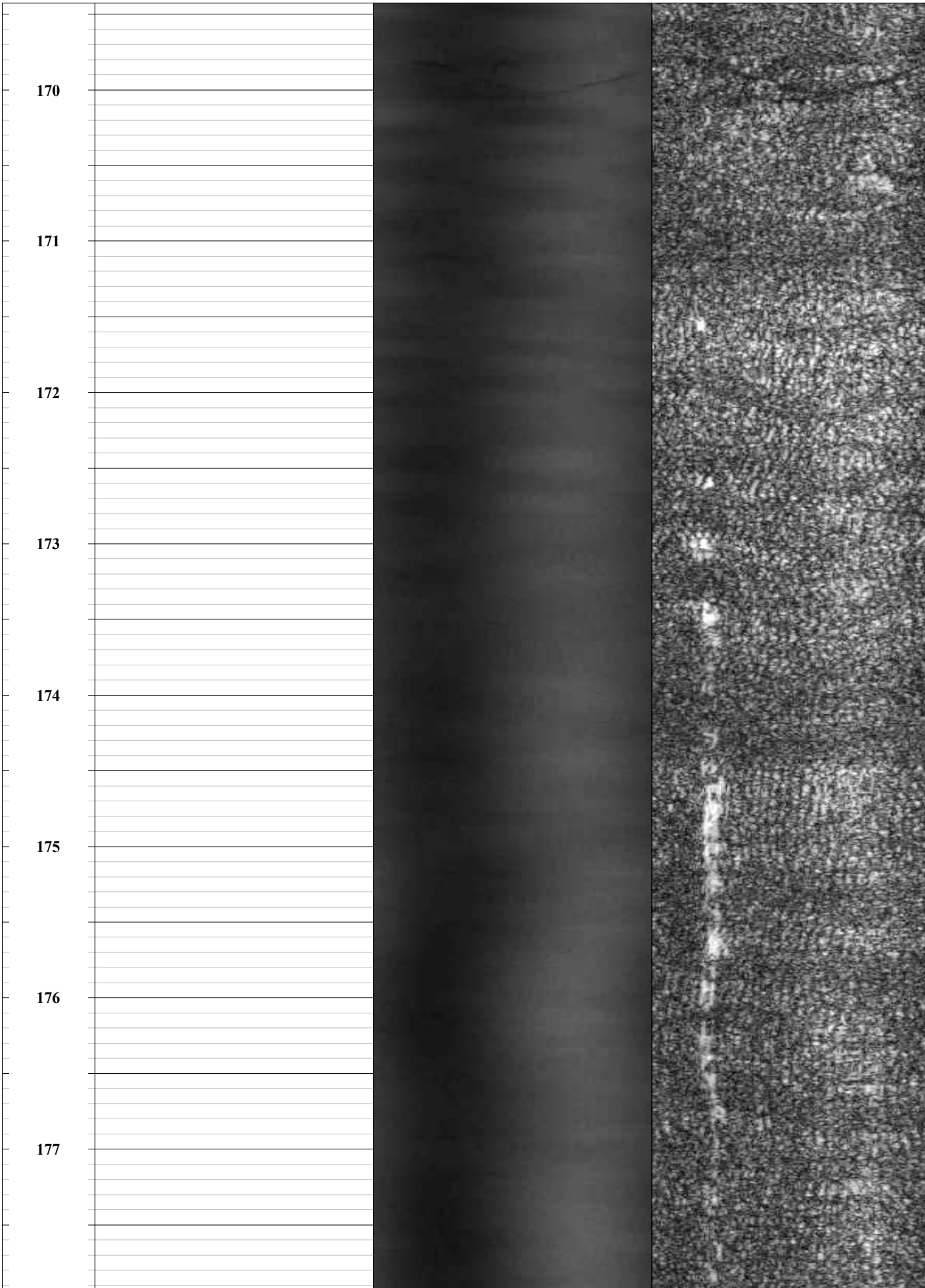
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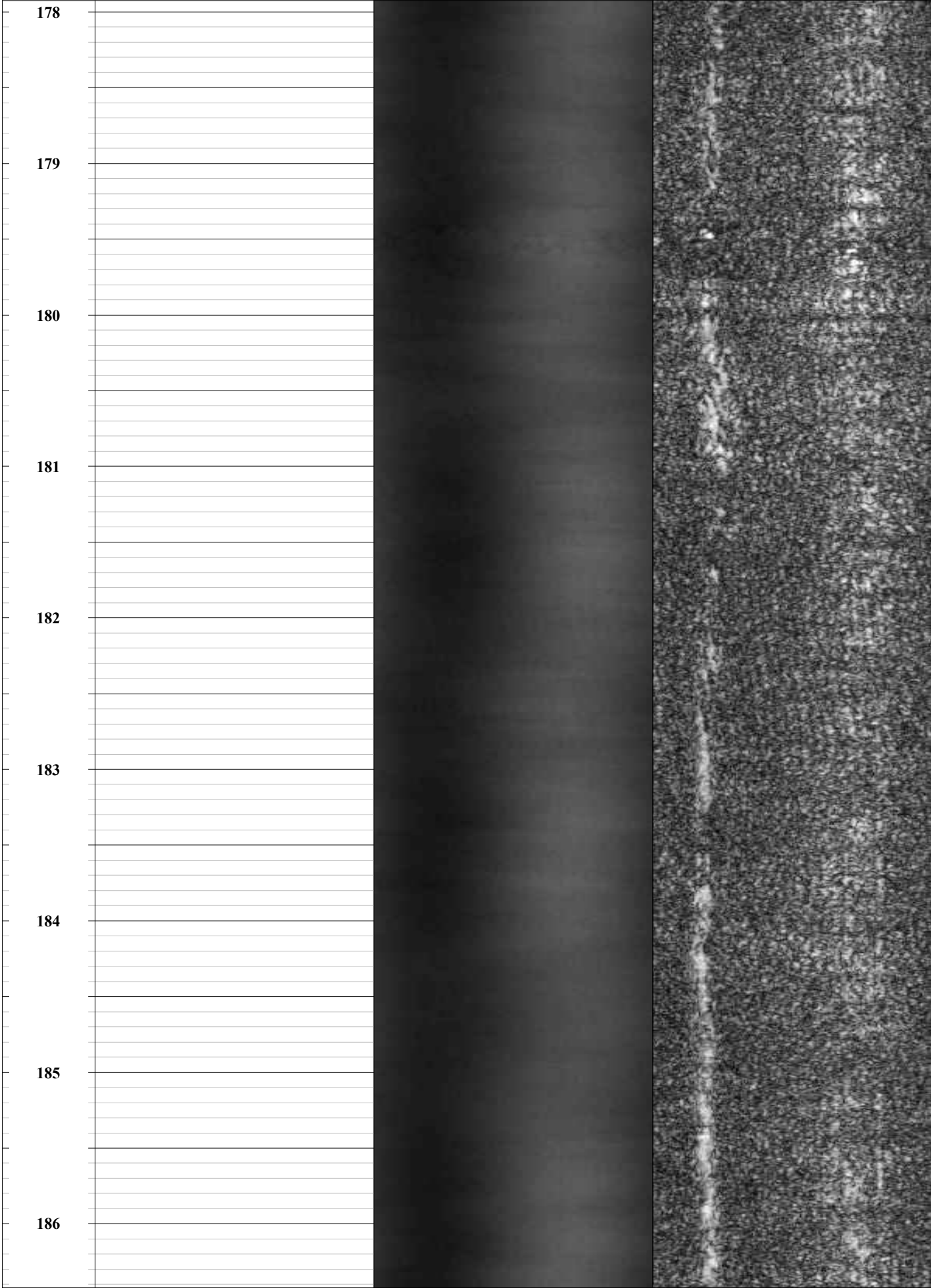
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152









187

188

189

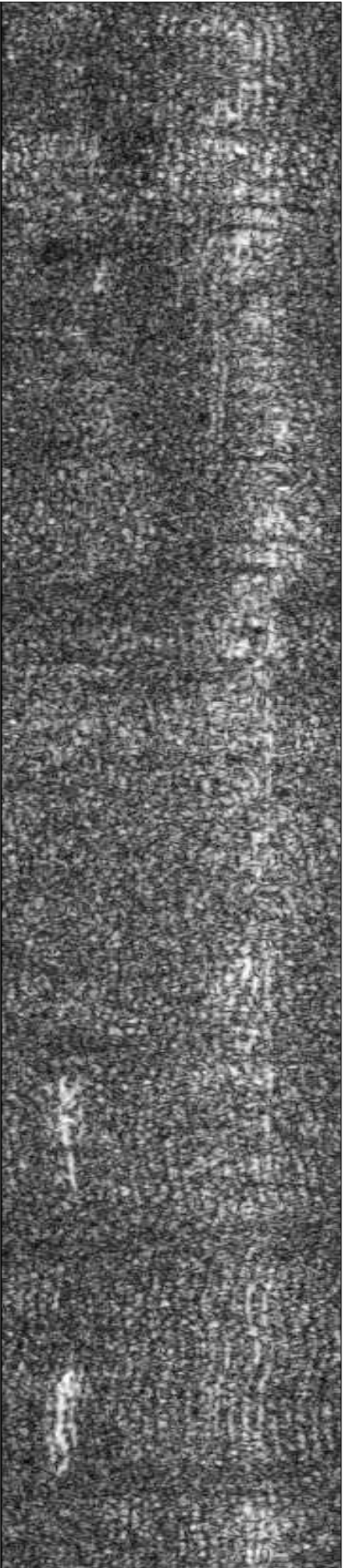
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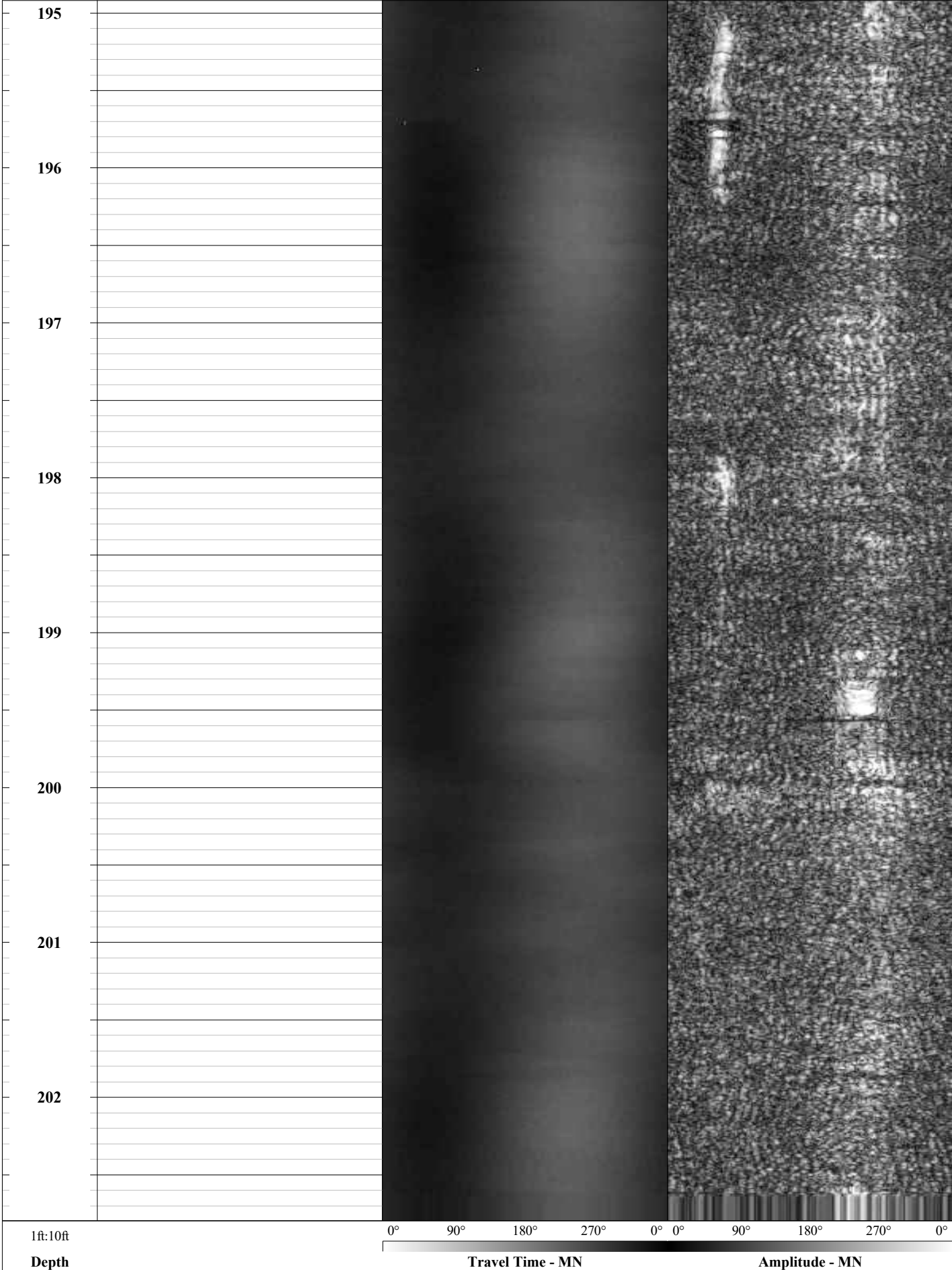
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192

193

194







Natural Gamma & FTC

COMPANY: Arcadis

PROJECT: Lancing

DATE LOGGED: 1 November 2019

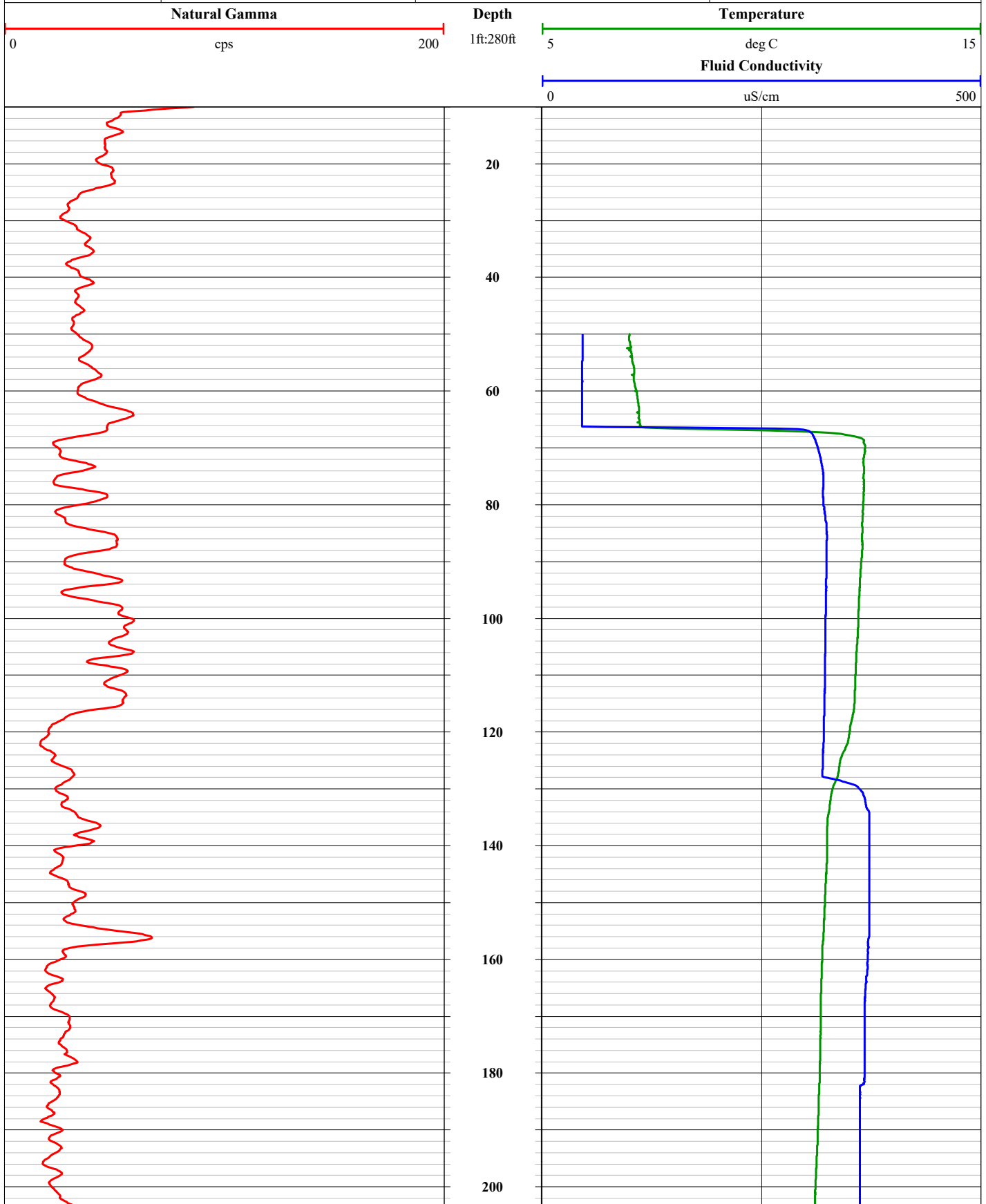
WELL: MW-19-118

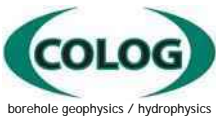
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Optical Televiewer

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COMPANY: Arcadis

PROJECT: Lancing

DATE LOGGED: 1 November 2019

WELL: MW-19-118

Depth 1ft:10ft	Optical Image - MN				
	0°	90°	180°	270°	0°
120					
121					
122					
123					
124					
125					
126					
127					



Acoustic Televiever

COMPANY: Arcadis

PROJECT: Lancing

DATE LOGGED: 1 November 2019

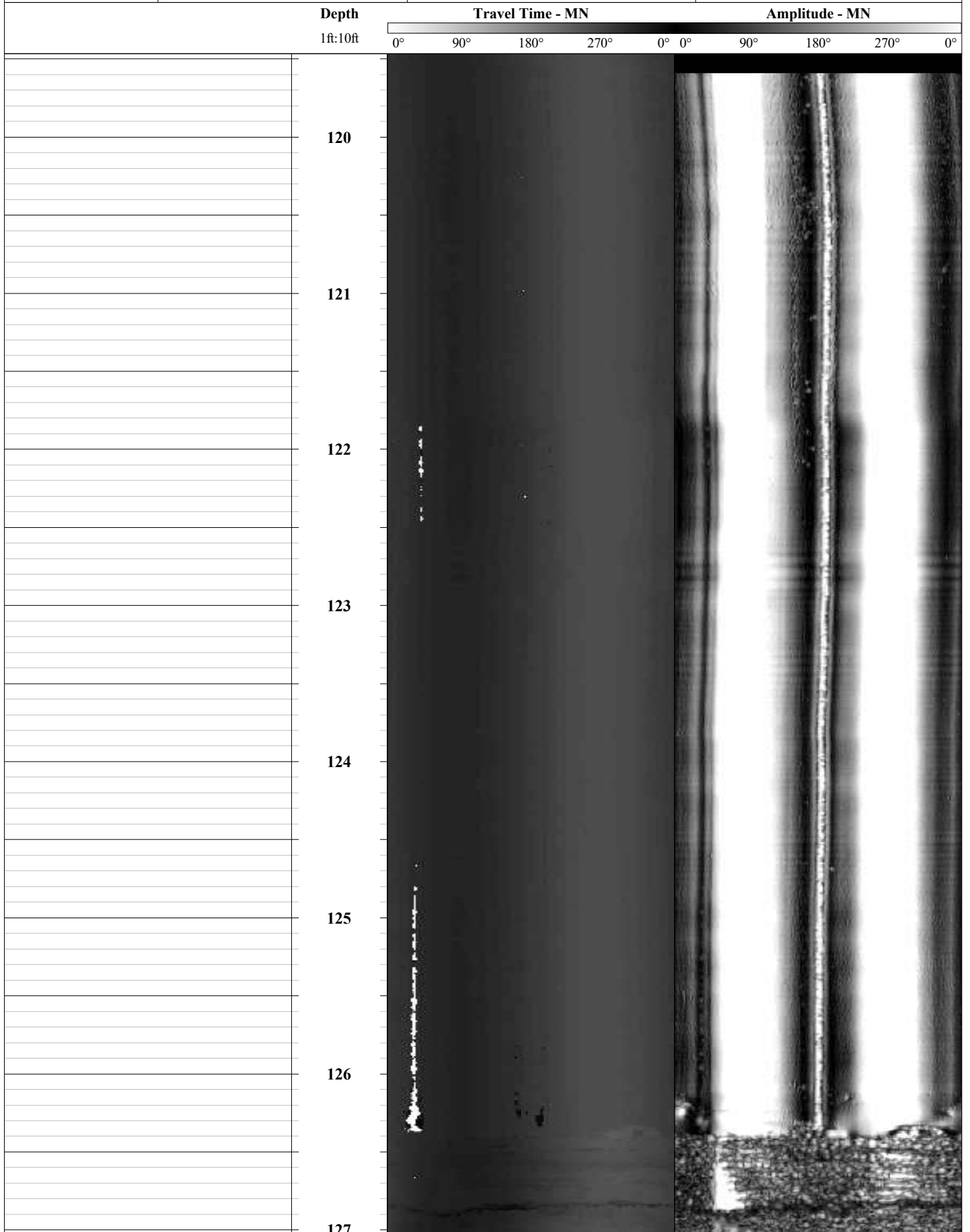
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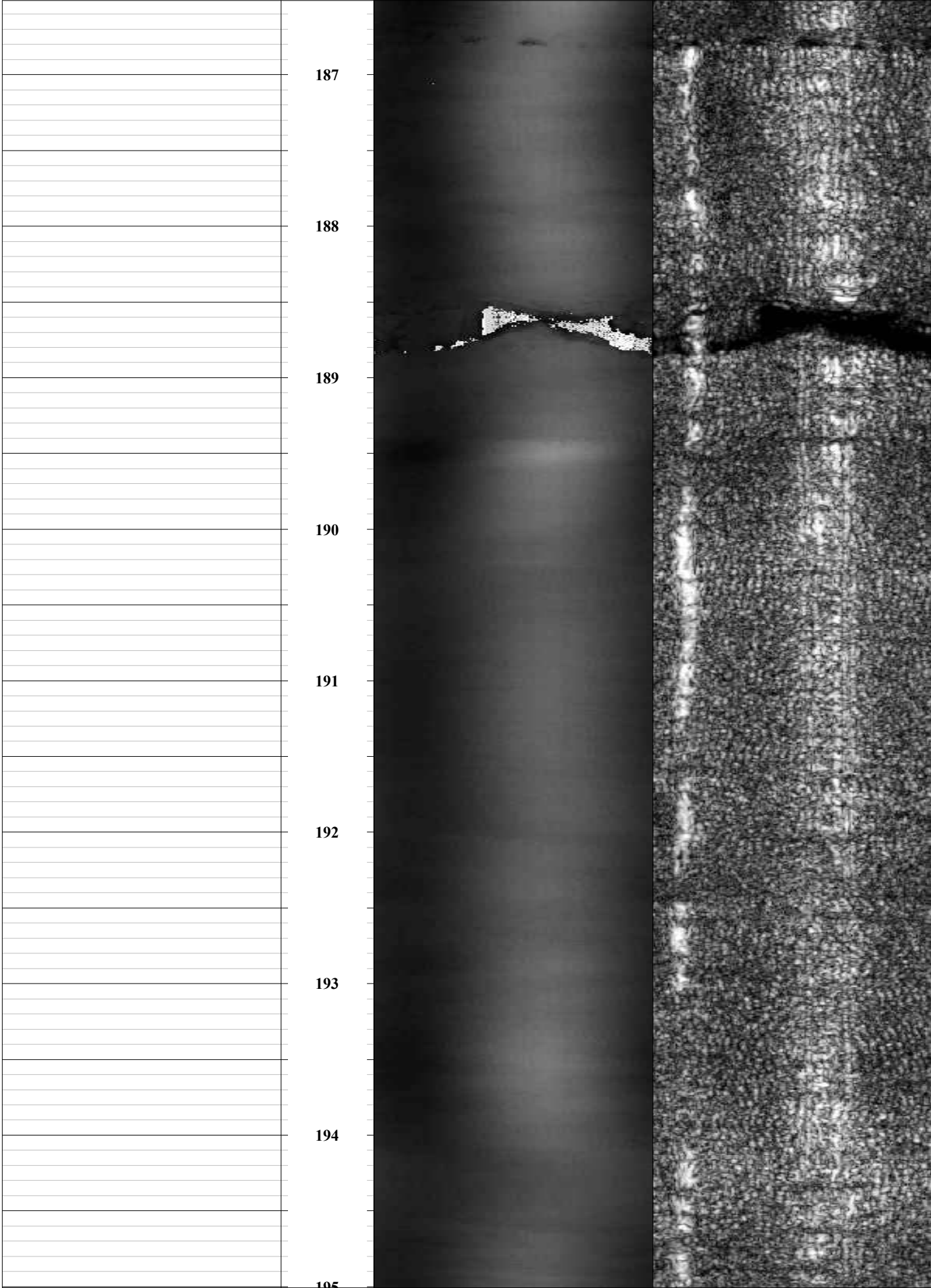
Colog, Inc.

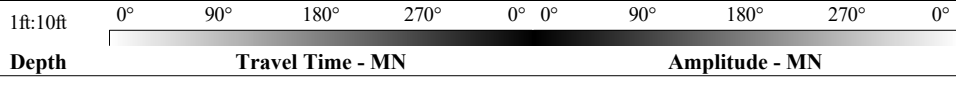
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Natural Gamma & FTC

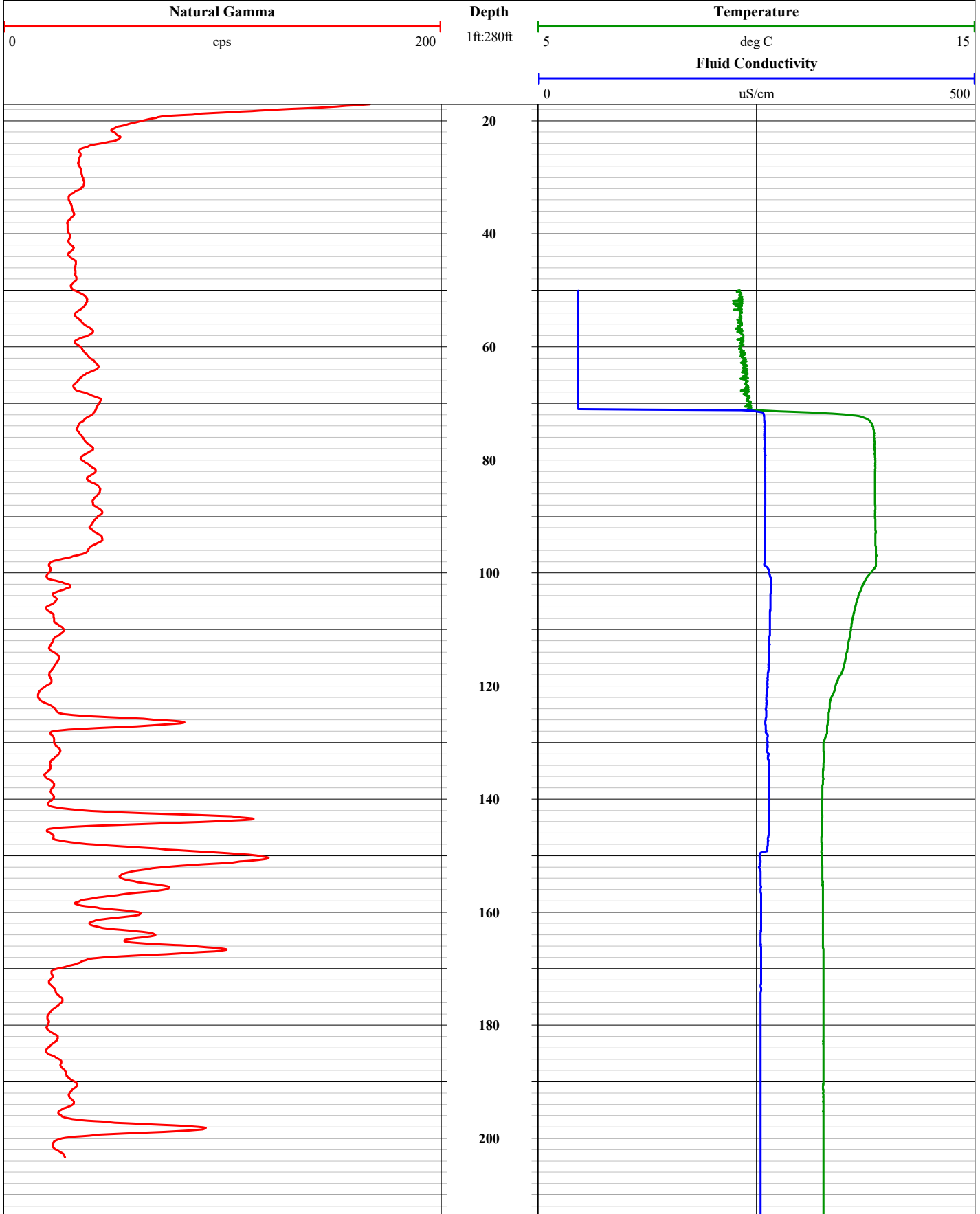
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COMPANY: Arcadis

PROJECT: Lancing

DATE LOGGED: 1 November 2019

WELL: MW-19-119





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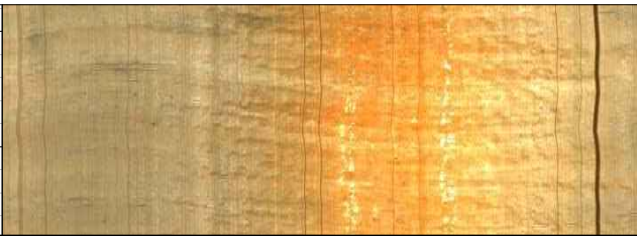
PROJECT: Lancing

DATE LOGGED: 1 November 2019

WELL: MW-19-119

Depth 1ft:10ft	Optical Image - MN				
	0°	90°	180°	270°	0°
120					
121					
122					
123					
124					
125					
126					
127					

204



1ft:10ft

0° 90° 180° 270° 0°

Depth

Optical Image - MN

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