ERM

GWET System Effectiveness Evaluation

Arkema Inc. Facility.

PREPARED FOR
Legacy Site Services LLC

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GWET System Effectiveness Evaluation

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
Arkema	Arkema Inc.
COC	contaminants of concern
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
ERM	Environmental Resources Management, Inc.
EW	extraction well
FDR	Final Design Report
GCC	gradient control cluster
GEE	groundwater extraction enhancement
gpm	gallon per minute
GW SCM	Groundwater Source Control Measure
GWBW	groundwater barrier wall
GWET	Groundwater Extraction and Treatment
IRAM	Interim Remedial Action Measure
ISS	in-situ soil stabilization
LSS	Legacy Site Services LLC, agent for Arkema Inc.
NAVD88	North American Vertical Datum of 1988
PDI	Preliminary Design Investigation
PMP	Performance Monitoring Plan
RW	recovery well
SEE	System Effectiveness Evaluation
Site	Former Arkema Portland Plant located at 6400 NW Front Avenue in Portland, Oregon
TCZ	Target Capture Zone
TCZO	Target Capture Zone Objective

PROFESSIONAL ENGINEER'S CERTIFICATION

I, Brendan Andrew Robinson, Licensed Professional Engineer in the State of Oregon, hereby certify to the best of my knowledge and belief that this document is true and correct and has been prepared in accordance with general industry standards and applicable federal, state, and local requirements, and hereunto set out hand and affix my seal this 4th day of April 2025.

Brendan Andrew Robinson

Oregon Professional Engineer No. 78496

<u>REGISTERED GEOLOGIST'S CERTIFICATION</u>

I, Catherine Avery Soplata, Licensed Registered Geologist in the State of Oregon, hereby certify to the best of my knowledge and belief that this document is true and correct and has been prepared in accordance with general industry standards and applicable federal, state, and local requirements, and hereunto set out hand and affix my seal this 4th day of April 2025.

Exp: 10/1/2025

Avery Soplata

Oregon Registered Geologist No. G2883

RESPONSES TO AGENCY COMMENTS

Legacy Site Services LLC (LSS), agent for Arkema Inc., submitted the 2023 System Effectiveness Evaluation (SEE) report (ERM 2024) to the Oregon Department of Environmental Quality (DEQ) and received the following comments on 13 May 2024. Environmental Resources Management, Inc. (ERM) has prepared these responses on behalf of LSS.

DEQ GENERAL COMMENTS

1. *DEQ has previously provided comments on chloride concentrations and increasing concentrations in riverside wells (PA-19D and PA-30D). In addition, DEQ continues to watch increasing chlorobenzene concentrations in well PA-30D and perchlorate concentrations in well MWA-56D. DEQ will continue to evaluate concentrations trends over the next year while additional operation refinements are implemented.*

LSS/ERM Response:

Comment noted.

2. [Section 9, Recommendations]: *The last bullet that states "As outlined in Section 8 above, the annual groundwater monitoring data evaluation concluded that increasing concentrations identified are sporadic and overall conclusions are consistent with previous evaluations, which indicated that mounding behind the GWBW [groundwater barrier wall] is not causing significant migration of COCs." is not supported by the data presented earlier in the SEE that indicate concentrations of chloride, chlorobenzene, and perchlorate are increasing in select areas outside the GWBW.*

LSS/ERM Response:

Limited increasing chloride and perchlorate trends observed in 2024 outside the GWBW are discussed in Section 7.4.2, Chloride, Perchlorate, and Chlorobenzene Plumes. The upcoming Data Gaps Investigation will examine possible areas of residual contamination outside the GWBW that may be causing or contributing to increased concentration of contaminants of concern (COC) outside the GWBW.

EPA PRIMARY COMMENTS

1. *General comment on hydraulic capture based on groundwater elevation evaluation line of evidence. Given that the Report presents an evaluation of hydraulic capture behind the groundwater barrier wall, EPA expects relevant figures and information that support the evaluation and conclusions to be provided in the main body of the text. Instead, this document refers the reader to Appendix A that contains over 400 pages of summary technical memos which requires the reviewer to locate and evaluate the information pertinent to what is being presented in the Report. With the current format approach, EPA can only tentatively accept the conclusions stated in the Report with regards to hydraulic capture based on the groundwater elevation evaluation line of evidence. Future Reports should present relevant figures and information supporting the narrative, evaluation, and conclusions in the main body of the document.*

LSS/ERM Response:

Comment noted. Appendix A is searchable and has electronic bookmarks to aid with navigation.

EPA TO BE CONSIDERED COMMENTS

1. [Section 4.1.1, GWET Well Extraction Rates and Relationships with Seasonal Conditions, pages 12 through 13, Tables 1a and 1b and Figure 3b]: *The text should explain the purpose of presenting average operational monthly recovery well extraction rates (Table 1b and Figure 3b). EPA notes that the project groundwater flow model indicates an average monthly extraction rate of 60 gallons per minute [gpm] is necessary to achieved capture zone objectives, so the comparison of this modeled extraction rate is relevant to the average monthly recovery well extraction rates presented in Table 1a. It is unclear what the purpose is for developing and presenting the data in Table 1b/Figure 3b. EPA suggests Table 1b/Figure 3b be removed from the Report to avoid confusion if a purpose cannot be articulated for an operational average flow rate.*

LSS/ERM Response:

See Section 4.1.2, GWET Well Extraction Rates and Relationships with Seasonal Conditions, of this 2024 SEE report for a discussion of average operational monthly pumping rates. Definitions for both “Average Monthly Pumping Rate” and “Average Operational Monthly Pumping Rate” have been added to the introduction of Section 3, GWET System Operating Status, and the notes of Tables 1a and 1b of this 2024 SEE report, respectively.

2. [Section 7.3, Statistical Data Evaluation Methodology, page 20]: *Only data from a “historical” period (i.e., 2007 to 2010) and a “current” period (i.e., 2019 to 2023) have been used in the used in the evaluation, which included a Mann-Kendall test for trends over the total “study” period of 2007 to 2023. It is unclear whether data from 2010 to 2019 do not exist or if those data have been excluded for some other reason. Attempting to detect trends over a 17-year period with an 8-year data gap (i.e., 2011 to 2018) in the middle is inadvisable. If no data for this period exist, or if events during this period (e.g., construction of barrier wall in 2012, startup of pump and treat system in 2014) resulted in non-monotonic trends, then an alternative statistical test should be employed. For example, if a Mann-Kendall test applied to the current period for a well fails to detect a trend, then a generalized Wilcoxon test (Helsel 2012, page 171) could be used to evaluate if the measurements from the two periods are significantly different (note that expanding the historical period to include more than four measurements would probably be advisable to achieve adequate statistical power.) The statistical evaluation currently includes a comparison based on orders-of-magnitude, but a generalized Wilcoxon test would be able to detect smaller differences while also accounting for censored information caused by non-detect concentration measurements.*

LSS/ERM Response:

A DEQ-required pause in groundwater monitoring occurred between 2011 and 2018 while LSS developed the Feasibility Study Work Plan (ERM 2017) and the Hot Spot Evaluation (ERM 2021a). The purpose of the groundwater monitoring performed between 2019 to the present was to evaluate if contaminants were moved around or under the GWBW. The order of magnitude comparison is the method used to evaluate potential changes between historical contaminant concentrations and current concentrations, as described in the DEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan (ERM 2019).

Use of the generalized Wilcoxon test to compare the historical (2007 to 2010) to the current (2019 to 2024) period is not appropriate because the historical (2007 to 2010) period does not meet the minimum requirement of five distinct data point values. As of this 2024 SEE report, ERM is only performing a Mann-Kendall test for trends on the current (2019 to 2024) dataset and continues to perform order of magnitude comparisons between historical (2007 to 2010) and current (2019 to 2024) data sets to highlight large concentration changes.

3. [Appendix C, Mann-Kendall Scatterplots and Trend Analysis]: *The Appendix B tables indicate that the number of samples for the historical period (i.e., 2007-2010) is four for sampling locations with data, but the scatterplots in Appendix C only show two datapoints. Clarify why four datapoints are not shown in the scatterplots for the historical period.*

LSS/ERM Response:

See Appendix B of this 2024 SEE report for updated tables reflecting the correct number of historical period samples.

FIVE TRIBES SUBSTANTIVE COMMENTS

1. *Section 4.1.2 of the 2023 GWET SEE Report indicates that "the TCZOs [Target Capture Zone Objectives] are not being fully achieved as of the end of the reporting period." Section 6.4 describes various planned actions but states "More time at elevated extraction rates is necessary to evaluate whether GWET objectives are being met systemwide." ERM (2023), the 2022 GWET SEE Report, reached a similar conclusion: "Target Capture Zone Objectives are unlikely to be achieved until Q3 or Q4 of 2023. As the new extraction trenches come online and higher pumping rates are consistently achieved, compliance with Target Capture Zone Objectives will continue to be evaluated…" Based on our review of the 2023 GWET SEE Report, we conclude that the upgraded system, like the version before it, is undersized and not performing as designed. A variety of measures have been carried out and are proposed to remedy this situation; however, we are concerned that these minor adjustments will not achieve TCZOs. We recommend DEQ require LSS conduct an exhaustive evaluation as to whether the existing system can achieve TCZOs, and if not, what type of system should replace it.*

LSS/ERM Response:

Since the enhanced Groundwater Extraction and Treatment (GWET) system became operational in November 2022, horizontal gradients across the Site have significantly improved towards inwards, and at times at various gradient control clusters (GCCs) have been inwards, reducing the potential of contaminated groundwater migration across the GWBW. Additionally, groundwater is unable to flow around the north end of GWBW due to the localized pressure zone ERM discussed in the Preliminary Design Investigation (PDI) report (ERM 2021b); hydraulic monitoring and groundwater analytical data also suggests that groundwater is not flowing around the southern end of the GWBW; see Section 7.4, Statistical Data Evaluation Results, for more information. All data suggest that at best negligible amounts of groundwater are flowing through the GWBW. As shown in this 2024 SEE report, gradients continue to improve, further reducing the mobility of COCs across the GWBW.

2. *Section 3.2 indicates that many of the pressure transducers (12 out of 54 piezometers) were inoperative for a month or more during 2023. The report states, "Transducers are typically inspected within 1 week of an issue being identified and typically repaired within 1 week to 1 month depending on whether a transducer replacement is required or not." Although not explicitly stated, the text implies that several weeks are needed to order and obtain a replacement transducer. Since transducers seem to fail with regularity, we recommend that spare transducers be purchased so that defective transducers can be replaced more expeditiously. Since transducers seem to fail with regularity, we recommend that spare transducers be purchased so that defective transducers can be replaced more expeditiously.*

LSS/ERM Response:

Comment noted. Spare transducers are generally kept onsite and used as needed, and additional transducers were procured in 2024. Transducer uptime also improved in 2024 compared to 2023. See Section 3.2, Gradient Monitoring and RW Control Transducer Malfunction, for more details.

3. *Table 1a indicates that of the four recovery wells (RW), three (RW-14, -22, -25) were out of service due to equipment issues for all of May, June, and July. We recommend this extended outage be discussed and explained in Section 3.3 of the report.*

LSS/ERM Response:

Comment noted. Due to the low potential productivity of the RWs, work to improve the extraction rates from the groundwater extraction trenches is sometimes prioritized. Additional efforts were made in 2024 to increase uptime of the RWs.

4. *Table 1a also shows that during the month of April seven of the fourteen trench extraction wells (EW) (EW-06, -08, -09, -10, -11, -12, -14) were out of service and an additional two extraction wells were below capacity (EW-02, -05). We recommend that this problematic period be discussed and explained in Section 3.3 of the report.*

LSS/ERM Response:

The observations made in this comment do not reflect unplanned downtime. Generally, only one pump in one of the EWs in a given trench is required to dewater the trench at any one time. As a result, individual EWs can be off for extended periods when their adjacent EW is operational and consistently drawing down the water table. When EWs become fouled or fault, they are restored to operating status promptly.

5. *Section 4.1.1 describes operational difficulties due to "excessive friction loss at higher flows in the 3-inch conveyance line." This implies that the conveyance line, a holdover from the system pre-upgrade, is under-designed for the current system despite design calculations showing it would be adequate (ERM 2022). Section 6.1 states that "an event in January 2024 is planned to connect EWs in Trenches 5, 6, and 7 to the currently out-of-use conveyance line for Intermediate Zone based RWs." We recommend that the report indicate the size (diameter) of*

this conveyance line and provide calculations that show the increase in conveyance capacity. Friction coefficients used previously (ERM 2022) should be adjusted based on the performance of the existing conveyance line. Also, the SEE report is dated March 2024, which is after the so-called "planned event." We recommend that events that have occurred be reported, at least parenthetically, even if they occurred outside of the reporting period.

LSS/ERM Response:

The configuration of the system as of January 2024 provides adequate water conveyance capacity. Pressure monitoring is performed monthly to evaluate if and when conveyance lines need to be cleaned to remove accumulated solids. The scope of each report is the reporting period. Effort has been made in this 2024 SEE report to address important milestones made to date in 2025.

6. *Section 6.2 lists numerous system shutdowns due to "solids handling issues," but without much specificity as to the nature of the problems other than their locale in the treatment system. We recommend more details be provided. We also recommend a more complete explanation of the system problems in general. Section 6.2 ascribes treatment-system problems to "variable solids and flowrates coming from new EWs." Variability seems unlikely to be the sole source of these problems. Rather, the descriptions in the text imply the system simply lacks adequate capacity for the new higher flows. If so, this represents a serious and systematic deficiency in the GWET system.*

LSS/ERM Response:

Comment noted. Section 6.2, GWET System Shutdowns, Maintenance, and Upgrades, of this 2024 SEE report includes more detailed descriptions of individual system shutdowns and no longer uses "solids handling issues" to broadly describe problems leading to GWET system shutdowns. Solids handling issues have been addressed since implementation of the filter press in the GWET system.

7. *Section 6.4 indicates that "Solids handling was resolved in early 2023 through chemical trials, cleaning pressure filters, and replacing media in July 2023." This statement seems to be contradicted by the frequency of shutdowns listed in Section 6.2 that occurred after July 2023. We recommend LSS provide additional detail to explain why the maintenance performed in the first half of 2023 did not reduce the frequence of shutdowns in the second half of 2023. We also recommend that the list in Section 6.2 differentiate routine maintenance events from non-routine maintenance events.*

LSS/ERM Response:

Comment noted. This 2024 SEE report and future reports will differentiate between routine and non-routine maintenance shutdowns.

8. *Appendix C, page 3 of 47, reveals a distinct seasonal pattern in the concentration of chloride at shallow well MWA-63, which is located just beyond the eastern end of the barrier wall (i.e., on the river side of the wall). The data suggest a seasonal release of chloride to the river and may reveal important aspects of GWET system behavior. We recommend the concentration patterns at this well be discussed in Section 7.4.2.*

LSS/ERM Response:

Comment noted. The seasonality of chloride concentrations at MWA-63 is discussed in Section 7.4.2 of this 2024 SEE report.

9. *The analysis of chloride in Section 7.4.2 includes a statement that trends at GCC5 and Proximal Wells "indicat[e] that the GWBW is effectively preventing chloride migration towards the river." We recommend that this statement be qualified by adding "in this part of the site."*

LSS/ERM Response:

Comment noted. See Section 7.4.2, Chloride, Perchlorate, and Chlorobenzene Plumes, of this 2024 SEE report.

10. *The analysis of perchlorate in Section 7.4.2 explains the trend of consistently increasing concentrations at deep well MWA-56D (see Appendix C, page 18 of 47) to be "likely from a proximal source on the exterior side of GCC4." This seems speculative. We recommend the report discuss what activities occurred or were likely to have occurred in this area that would give rise to a source of perchlorate, how such a source could give rise to increasing rather than steady concentration trends, and whether concentrations in the shallow and intermediate zones support the hypothesis there is a local source.*

LSS/ERM Response:

The upcoming Data Gaps Investigation will examine perchlorate extent and concentration near MWA-56D and MWA-58D to better understand the trends observed at MWA-56D.

11. *We recommend the statement from Section 4.1.2 that "TCZOs are not being fully achieved as of the end of the reporting period" be included in Section 8.1 as it is a significant conclusion from the 2023 GWET SEE results.*

LSS/ERM Response:

Comment noted. See Section 4.1.1, Horizontal and Vertical Gradients, for further discussion of the improved horizontal hydraulic gradients.

12. *We recommend striking the first bullet item in Section 8.2 as the conclusion that equipment failures and malfunctions were resolved is not supported by the continued transducer failure rates reported in Section 3.2.*

LSS/ERM Response:

See Section 8.2, GWET SEE Groundwater Recovery and Hydraulic Monitoring Equipment Results, for the updated bullet item. See Section 3.2, Gradient Monitoring and RW Control Transducer Malfunction, for the current assessment of transducer uptime, which improved in 2024.

13. *We recommend Section 8.2 include a statement that the upgrades to the GWET system have yet to achieve the forecasted 60 [gpm] extraction rate on a sustained basis owing to system inadequacies and malfunctions.*

LSS/ERM Response:

Comment rejected. The GWET system has frequently achieved flow rates in excess of 60 gpm during 2024 and had an unplanned downtime rate of 7 percent as discussed in Section 3, GWET System Operating Status. The forecasted value of 60 gpm is based on the groundwater model. Conservative assumptions were input into the model to estimate the maximum expected flow rates for the proposed GWET system treatment design. The existing groundwater model is based on one high water and one low water condition for groundwater elevations, and the actual target capture rate needed to achieve the capture zone objectives relative to river elevation and groundwater elevation may be different than estimated by the model.

Linear regression analysis spanning the past 5 years shows a decreasing trend in Willamette River elevation, resulting in lower groundwater elevation and therefore lower potential groundwater extraction rates by GWET. Despite the observed decrease in Willamette River elevation, the average pumping rate has increased when comparing the flow rate of the legacy GWET and the upgraded GWET, as shown in Table 4.1-1. See Section 4.1.3, Conclusions Related to the TCZOs, for a summary of the GWET system improvements in 2024 and Section 5, Groundwater Flow Model, for details regarding anticipated updates to the groundwater flow model.

14. *This report contains many grammatical and typographical errors. We recommend greater attention to quality assurance and quality control.*

LSS/ERM Response:

Comment noted.

FIVE TRIBES EDITORIAL COMMENTS

1. *Tables 1a and 1b report "Average Monthly Extraction Rates" and "Average Operational Monthly Extraction Rates." We recommend that these terms be defined in a footnote to each table.*

LSS/ERM Response:

Comment noted. Definitions for each have been added to the notes section of Tables 1a and 1b of this 2024 SEE report.

2. *Page 11 states "In accordance with the PMP [Performance Monitoring Plan], groundwater elevations are being monitored using the transducers and monthly manual groundwater elevation gauging." This phrasing leaves ambiguous how many of the 54 piezometers are monitored using pressure transducers, how many are monitored manually, or whether all are monitored both ways. We recommend this be clarified.*

LSS/ERM Response:

Comment noted. Due to sporadic transducer failure, operational transducer variability is expected month to month. Please refer to the Monthly Progress Reports (Appendix A) for information on operational transducers in any given month.

3. *Page 11 states "cones of depression are apparent around each groundwater extraction trench." Inspection of contour plots in Appendix A shows this is not actually true for all months and all trenches.*

LSS/ERM Response:

An updated description is provided in Section 4.1, Groundwater Elevations, of this 2024 SEE report.

4. *Page 13 includes this vague description of future upgrades: "reconfiguring the conveyance line connections to EW Trenches 5, 6, and 7." We recommend a clearer description—for example, "connecting EW Trenches 5, 6, and 7 to an alternative discharge line."*

LSS/ERM Response:

An updated description is provided in Section 6.1, GWET System Shutdowns, Maintenance, and Upgrades, of this 2024 SEE report.

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) has prepared this Groundwater Extraction and Treatment (GWET) System Effectiveness Evaluation (SEE) report on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema facility located at 6400 NW Front Avenue in Portland, Oregon (Site). The primary objectives of this report are to address the Oregon Department of Environmental Quality (DEQ), U.S. Environmental Protection Agency (EPA), and Five Tribes comments from the 2023 report and to provide updates associated with system operation conducted in this 2024 reporting period (January 2024 through December 2024).

ERM has provided a Site Location Map as Figure 1 and a Study Area Layout Map as Figure 2. The Study Area discussed in this report consists of the Target Capture Zone (TCZ) for the Groundwater Source Control Measure (GW SCM) within Lots 3 and 4 that was presented in the *Revised Final Performance Monitoring Plan—Groundwater Source Control Measure* (ERM 2014). The original GWET system was unable to meet the Target Capture Zone Objectives (TCZOs). Between 2019 and 2022, ERM designed and installed the groundwater extraction enhancement (GEE) features for the GWET system. GEE implementation included installing seven groundwater extraction trenches consisting of two extraction wells (EWs) each between July 2022 and October 2022, replacing 18 recovery wells (RWs), and leaving four existing productive RWs in operation. The updated GW SCM now consists of seven groundwater extraction trenches with two EWs each (ERM 2022), four groundwater RWs, a groundwater barrier wall (GWBW), and the GWET Plant. Collectively, these components are referred as the GW SCM.

This 2024 SEE report provides an update on the current performance of the GW SCM, discusses corrective actions implemented to improve the performance of the GW SCM, evaluates the extent of capture currently achieved by the GW SCM, and proposes actions to improve hydraulic capture. Additionally, Section 7 presents the annual groundwater monitoring data evaluation. This includes an assessment of historical and current groundwater analytical trends in the vicinity of the GWBW.

2. BACKGROUND

The current GW SCM at the Site consists of:

- A GWBW to physically separate the affected upland portions and in-water portions of the Site;
- A groundwater extraction system intended to induce inverse gradients across the GWBW within the TCZ (ERM 2014); and
- Management of extracted groundwater using the GWET Plant, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System Permit.

The GWET system was updated in 2022 because the original system was unable to meet the TCZOs. The original GWET system was composed of 13 groundwater RWs screened in the Shallow Zone and 9 RWs screened in the Intermediate Zone. Seven groundwater extraction trenches were installed, each with two EWs, in the summer and fall of 2022 as part of GEE implementation (Figure 2). Each extraction trench was backfilled with a sand mixture designed to have greater hydraulic conductivity than the native alluvium while retaining the fine sand in the native alluvium. Each trench is fitted with U-shaped extraction piping consisting of two vertically screened sections connected by a 30-foot-long horizontal screened section that intercepts groundwater in the Shallow and Intermediate Zones. The newly installed extraction trench system provides approximately 10 times the overall saturated surface area of the original GWET system, greatly increasing the system's ability to capture and treat groundwater within TCZ (ERM 2022).

The current GWET system consists of:

- Four RWs screened in the Shallow Zone (RW-14, RW-22, RW-23, and RW-25) from before GEE implementation.
- Seven groundwater extraction trenches comprising two EWs each (EW-1 through EW-14) screened through both the Shallow and Intermediate Zones; one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement.
- The seven groundwater extraction trenches replaced 18 RWs as part of GW SCM enhancements described in the FDR (ERM 2022). The 18 non-pumping RWs were upgraded in 2023 to operate as transducers to provide additional groundwater elevation data; ERM has incorporated these data into the potentiometric surface maps presented in the Monthly Progress Reports (Appendix A).
- A groundwater treatment system that employs the following:
    - A chemical precipitation train equipped with a reactor, pH adjustment, coagulant feed, clarifier, and multiple pressure filters. Holding tanks contain the residual solids that result from the precipitation process, mechanically thickens them, and dewaters them prior to transport and offsite disposal.
    - Biological treatment within a fluidized bed reactor. This train includes biological digestion of contaminants followed by two stages of filtration (gravity and bag) to remove excess biological solids, which are then contained in storage, mechanically thickened, dewatered, and transported offsite for disposal.
    - A bag filter followed by three liquid-phase-granular-activated carbon vessels in series.

A network of 54 piezometers is used to monitor the groundwater elevation in the Shallow, Intermediate, and Deep Zones. These data are used to evaluate the hydraulic gradients across the GWBW and control the operation of the adjacent groundwater extraction trenches and RWs as described in the EPA-approved Performance Monitoring Plan (PMP; ERM 2014) and the EPA- and DEQ-approved FDR (ERM 2022). Figure 2 shows the location of the GWET wells, gradient control clusters (GCCs), and the GWBW.

3. GWET SYSTEM OPERATING STATUS

GWET startup and optimization commenced in May 2014. Approximately 117 million gallons of groundwater have since been extracted, treated, and discharged as of the end of December 2024. No National Pollutant Discharge Elimination System permit violations have occurred since the GWET system began operating in a continuous flow-through mode in September 2015.

Two measurements are used for evaluating the GWET system capacity and performance: the Average Monthly Pumping Rate and the Average Operational Monthly Pumping Rate. Average Monthly Pumping Rate is defined as the total number of gallons pumped during a calendar month divided by the number of minutes in the month. The Average Operational Monthly Pumping Rate is defined as the number of gallons pumped during the month divided by the number of minutes the GWET was operational. During the 2024 reporting period, the GWET system achieved an Average Monthly Pumping Rate of 34.03 gallons per minute (gpm) and an Average Operational Monthly Pumping Rate of 49.35 gpm.

During the 2024 reporting period, uptime was approximately 85 percent, similar to the 85 percent reported in the 2023 SEE report (ERM 2024). Shutdowns occurred due to regular maintenance activities, system repairs, conveyance line upgrades, upset conditions, and improvements in the solids handling system. Of the 15 percent downtime during the reporting period, approximately 8 percent was due to planned outages for system repairs and maintenance, and approximately 7 percent was unplanned downtime. A list of GWET system shutdowns, maintenance, and upgrades is provided in Section 6.2, System Optimization Efforts in 2024.

Details of GWET system operations, system interruptions, and the resolution of specific issues were reported to the DEQ via email correspondence.

3.1 GROUNDWATER RECOVERY AND HYDRAULIC MONITORING EQUIPMENT

The GWET system is designed to achieve the TCZOs. Performance is evaluated with respect to the TCZOs in real-time using piezometers equipped with pressure transducers and monthly manual groundwater elevation measurements. The pressure transducers have been arranged in a series of six GCCs along the length of the GWBW.

The pressure transducer data demonstrate that the monitoring system effectively controls RW and EW operations and provides data for evaluating hydraulic containment. These data are also combined with manual potentiometric surface measurements to gather Site-wide groundwater elevations, which in turn are used to calibrate transducers. Water levels are manually measured when groundwater elevations are shown as anomalous or during the monthly event if there is uncertainty in the transducers' results due to fluctuations or an otherwise errant signal.

3.2 GRADIENT MONITORING AND RW CONTROL TRANSDUCER MALFUNCTION

Gradient monitoring and RW operations were historically interrupted intermittently due to sporadic failure of the pressure transducers, which limited the ability to 1) continuously monitor groundwater elevations in piezometers and 2) operate some RWs. RW groundwater elevation data is required to operate the pumps safely (e.g., provide instrumentation data for low-level alarms/shutoff). Upgrades to the transducers that were implemented from 2017 to 2019 improved transducers performance, with limited failures and malfunctions reported in 2024 compared to before 2019 (i.e., before upgrades). The existing transducers equipment and maintenance practices allow for sufficient groundwater elevation data to effectively operate the groundwater extraction system, reduce interruptions to pumping operations, and evaluate the GW SCM capture objectives.

Transducer data anomalies are tracked and reviewed regularly to determine when repairs or re-calibration is needed. Eight transducers had issues, making them inoperable for longer than 1 month during the reporting period:

- EW-11
- MWA-19
- MWA-34i
- MWA-58d
- PA-07
- PA-26d
- RW-13
- RW-25

These transducers experienced faults or were determined to be out of calibration for 1 month or longer during the reporting period. These transducers have been repaired and are back online.

Ongoing maintenance of the transducers to prevent failures includes conducting visual pressure transducer integrity checks and replacing transducers as necessary, as well as using machine learning algorithms to detect evidence of improper transducer operation. Transducers are typically inspected within 1 week of an issue being identified and typically repaired within 1 week to 1 month, depending on whether a transducer replacement or repair is required. Transducers are not immediately replaced, as repairs and re-calibration are often effective.

3.3 EXTRACTION TRENCH AND RW OPERATIONS

A summary of well operations and outages is included in Tables 1a and 1b. All trenches and RWs were operational during every month of the year except for outages detailed in Table 1a and 1b. All groundwater extraction trenches contain two EWs. Depending on extraction capacity and due to the hydraulic connectivity of these two paired trench wells, both EWs are often not operated in the same extraction trench at the same time.

The following four legacy RWs remain in operation due to sufficient recovery capacity:

- RW-14
- RW-22
- RW-23
- RW-25

RW-22 has been non-operational since December 2023 due to a motor fault and low extraction rate. Due to the low potential productivity of RW-22, work to improve the extraction rates from the groundwater extraction trenches was prioritized. RW-22 is planned to be rehabilitated and returned to operation in Q2 2025.

As part of the planned GEE activities implemented in 2022, the remaining RWs were taken out of service, retrofitted with pressure transducers, and are now used as water level monitoring wells:

- RW-08
- RW-09i
- RW-13i
- RW-24i
- RW-05
- RW-06i
- RW-07
- RW-10
- RW-11i
- RW-12
- RW-15
- RW-16i
- RW-17
- RW-18
- RW-19i
- RW-20
- RW-21i
- RW-26i

4. CAPTURE ZONE ANALYSIS

As ERM discussed in the PMP (ERM 2014), the capture zone evaluation criteria were developed using EPA's six steps to evaluate hydraulic capture (EPA 2008).

- **Step 1:** Review Site data and Site conceptual model and remedy objectives.
- **Step 2:** Define Site-specific TCZ(s).
- **Step 3:** Interpret groundwater elevations-potentiometric surface maps (horizontal), groundwater elevation difference maps (vertical), and groundwater elevation pairs (gradient control points).
- **Step 4:** Perform calculations including estimated flow rate calculation, capture zone width calculation (can include drawdown calculation), and model (analytical or numerical) to simulate groundwater elevations in conjunction with particle tracking and/or transport modeling.
- **Step 5:** Evaluate concentration trends.
- **Step 6:** Interpret actual capture based on Steps 1 through 5, compare them to TCZ(s), and assess uncertainties and data gaps.

Per the PMP and EPA steps mentioned above, capture is evaluated consistent with the PMP and Steps 1 through 3 of the EPA guidance, including Site data review, Site-specific TCZ determination, and groundwater elevations interpretation through both potentiometric surface and vertical difference maps. Steps 4 through 6 were not applicable in 2024 and are expected to be evaluated after the in-situ soil stabilization (ISS) remedy is installed. The ISS field effort is anticipated to begin in fall 2025.

4.1 GROUNDWATER ELEVATIONS

In accordance with the PMP, groundwater elevations are being monitored using the transducers and monthly manual groundwater elevation gauging. Potentiometric surface maps developed from monthly measurements are used to evaluate groundwater flow directions. ERM has provided monthly Shallow, Intermediate, and Deep Zones potentiometric surface maps, vertical difference maps, horizontal gradients, and vertical gradient hydrographs in Appendix A.

The ambient groundwater flow direction in the Shallow, Intermediate, and Deep Zones is generally from the western Site boundary of NW Front Ave towards the Willamette River. Groundwater is unable to flow around the north end of the GWBW due to the localized pressure zone ERM discussed in the Preliminary Design Investigation (PDI) report (ERM 2021b), and hydraulic monitoring and groundwater analytical data suggest that groundwater is not flowing around the southern end of the GWBW. Cones of depression in potentiometric surface maps (provided in Appendix A, Compiled Monthly Progress Reports) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping. Cones of depression are present around extraction trenches throughout the year, with minor exceptions often related to system shutdowns (e.g., September 2024).

4.1.1 HORIZONTAL AND VERTICAL GRADIENTS

Since completion of the enhanced GWET system (seven groundwater extraction trenches replaced 18 RWs) in November 2022, horizontal gradients on average have trended towards inward across the GWBW in the Shallow, Intermediate, and Deep Zones. Inward horizontal gradients are defined as when groundwater elevations on the interior of the GWBW are lower than groundwater elevations on the exterior of the GWBW and show as positive values in gradient calculations. Figures 4a through d show the horizontal and vertical gradients at each GCC from January 2021 through December 2024 with a break in 2022 during GEE implementation.

Horizontal gradients improved towards inward across all the GCCs and aquifer zones from before GEE implementation (January 2021 to November 2022) and after GEE implementation (December 2022 to December 2024). Horizontal gradient improvements after GEE implementation were most notable in the Shallow Zone, with average gradients going from -0.047 to -0.023 (+51%); in the Intermediate Zone, average gradients went from -0.028 to -0.016 (+43%); and in the Deep Zone, average gradients went from -0.018 to -0.010 (+45%). Except for the Shallow Zone at GCC1—which is impacted by the localized pressure zone discussed in the PDI report (ERM 2021b)—and the Intermediate Zone at GCC5, horizontal gradients improved towards neutral or inward after GEE implementation. During 2024, inward (positive) gradients were achieved for prolonged periods in the Shallow Zone at GCC2 (0.0042) and the Intermediate and Deep Zones at GCC6 (0.0015 and 0.0016, respectively). In addition to the overall trend towards inward horizontal gradients, the enhanced GWET system also reduced the magnitude of variability of the horizontal gradients since implementation. These improvements have helped reduce the likelihood of contaminant migration around the GWBW as groundwater is being consistently pumped into the GWET system.

Vertical gradients at the Site were generally mixed in 2024 and fluctuated from upward to downward at most monitoring locations, generally in response to changes in river stage. Upward vertical gradients are defined as the difference between the potentiometric surfaces for the two adjacent aquifer zones (e.g., Shallow Zone minus Intermediate Zone or Intermediate Zone minus Deep Zone). Upward gradients are seen as a negative value in the gradient calculations. Downward vertical gradients are greatest and most consistent from the Shallow to Intermediate Zones at GCC1 because of the localized pressure zone ERM discussed in the PDI report (ERM 2021b). Despite this large gradient, it is believed that very little water is moving between these zones near GCC1 due to the nature of the stratigraphy (i.e. it is a locally confined aquifer).

In 2024, on the interior of the GWBW, an average upward vertical gradient was only seen at GCC2 Shallow to Intermediate Zone (-0.1291) and GCC6 Intermediate to Deep Zone (-0.0125). Average upward vertical gradients are seen in the same GCCs and zones on the exterior side of the GWBW (-0.0071 and -0.0132, respectively). Average 2024 gradients at other GCCs and zones were downward. See Appendix A for vertical and horizontal gradient maps from January 2024 through December 2024.

4.1.2 GWET WELLS EXTRACTION RATES AND RELATIONSHIP WITH SEASONAL CONDITIONS

Figures 3a and 3b present the Average Monthly Pumping Rates and Average Operational Monthly Pumping Rates for the groundwater pumping network from March 2021 through December 2024, the Willamette River stage, and the average interior Shallow and Intermediate Zones groundwater elevations. Tables 1a and 1b present Average Monthly Pumping Rates and Average Operational Monthly Pumping Rates, respectively, for each RW and EW in each month from January 2024 through December 2024.

The Willamette River stage elevation at the Site varied between a high of 15.23 feet North American Vertical Datum of 1988 (NAVD88) in January 2024 to a low of approximately 4.71 feet NAVD88 in September 2024. The tidal oscillation in the Willamette River shows an amplitude of approximately 3.52 feet in the low-stage season (fall to early winter) and an amplitude of 2.51 feet during the high stage (spring to early summer) season. Linear regression analysis spanning the past 5 years shows a decreasing trend in Willamette River elevations, resulting in lower groundwater elevations. The Willamette River's influence on groundwater elevations in the Shallow and Intermediate Zones can be seen in Figure 3a and 3b; as the river elevation rises or falls, so do the groundwater elevations in the Shallow and Intermediate Zones.

Figures 3a and 3b also demonstrate a historical correlation between groundwater elevation and groundwater extraction rates during pumping operations that may remain once the TCZOs are met. However, the influence of river elevation on the groundwater elevations in the Shallow and Intermediate Zones is tempered by GWET system's pumping, which reduces the amount of change seen in groundwater elevations as the river elevation changes. The GWET system is able to pump more water as the river elevation rises, reducing the rise of groundwater elevations in the Shallow and Intermediate Zones. Despite lower river elevations leading to less water being extracted by the GWET system, it is still improving horizontal gradients towards inward, reducing the potential contaminant migration.

Average Shallow and Intermediate Zone groundwater elevations interior to the GWBW were calculated using an average of interior well transducer groundwater elevation data over the course of each month. For the Shallow Zone calculation, PA-04 was excluded, as it is within a geologically constrained, localized, high-pressure zone and is not representative of the overall Shallow Zone groundwater elevation in the Study Area (ERM 2021b). The table below shows a summary of average GWET pumping rates and groundwater elevations.

TABLE 4.1-1 SUMMARY OF AVERAGE GWET PUMPING RATES AND GROUNDWATER ELEVATIONS

Operational Period	Average Pumping Rate (gpm)	Average Operational Pumping Rate (gpm)	Average River Elevation (NAVD88)	Shallow Average Groundwater Elevation (NAVD88)	Intermediate Average Groundwater Elevation (NAVD88)
Pre-Trench (May 2019–May 2022)	12.92	14.36	9.837	14.912	13.424
Post-Trench (Dec 2022–Dec 2024)	36.49	52.33	9.353	13.178	11.868
2024 Average	34.03	49.35	9.307	12.516	11.629
Percent Increase, Average Pumping Rate, May 2019–2022, to 2024 Average	164%				

gpm = gallons per minute; NAVD88 = North American Vertical Datum of 1988

Average Pumping Rate and Average Operational Pumping Rates have increased since startup of the extraction trenches in November 2022. As represented in the table above, the average pumping rate increased by 164 percent, comparing pre-trench startup from May 2019 to May 2022 and the Average Pumping rate from 2024. Comparing the same periods, the Average Operational Pumping Rate increased by 244 percent. The groundwater elevations in the Shallow and Intermediate Zones have dropped more than the river elevation has lowered, showing the influence the operation of the GWET system has had on the groundwater elevation on the Site, interior of the GWBW, and therefore on horizontal and vertical gradients.

4.1.3 CONCLUSIONS RELATED TO THE TCZOS

Average Pumping Rates were 164 percent higher in 2024 than historical Average Pumping Rates before the groundwater extraction trenches were brought online. Although horizontal and vertical gradient analyses during the reporting period indicate that the TCZOs are not being fully achieved as of the end of the reporting period, they have continued to show an improvement since the GEE implementation. Low river levels have also impacted the ability of the GWET system to achieve inward gradients by lowering water levels outside the barrier wall. More aggressive well redevelopment is planned in Q1 and Q2 2025 at Trenches 1, 4, 5, 6, and 7 to continue improving extraction rates in this part of the Site, and to continue improving horizontal and vertical gradients.

5. GROUNDWATER FLOW MODEL

ERM originally developed a three-dimensional groundwater model for LSS to support the design decision making during installation of the GWBW and GWET system. The model has not been approved by DEQ or other stakeholders for use in evaluating the TCZOs. LSS and the DEQ agreed to rely on empirical groundwater elevation data to evaluate the TCZOs, and the DEQ-approved PMP (ERM 2014) was developed based on this principle. Performance of the GW SCM following implementation of additional extraction will continue to be empirically evaluated. The model is, however, a useful tool for comparing the relative differences in flows between groundwater extraction layouts and estimating maximum expected flows for the purpose of sizing treatment system components.

As ERM discussed in the 2018 SEE (ERM 2018), the current three-dimensional model was calibrated in steady-state and transient conditions to match the individual RW pumping tests that had been conducted at the Site in 2015. The groundwater model was further updated in 2018, and the results were presented in the 2018 SEE. The model was used to evaluate maximum potential system flows required for hydraulic capture under dry, wet, and average seasonal flow conditions and to evaluate the effects of different RW configurations (e.g., Deep Zone RWs), with respect to meeting the TCZOs.

In 2020 and 2021, the ERM groundwater flow model was updated and utilized to evaluate alternatives for additional groundwater extraction. The updates involved hydraulic conductivity modification and boundary condition updates based on additional data collected during the 2021 PDI report (ERM 2021b). ERM completed a high- and low-stage model verification for the conceptual design assessment to produce results reflective of the variable groundwater conditions within the Study Area (ERM 2021c). The model produced simulated groundwater elevations and extraction rates associated with the proposed expanded extraction system operating under steady-state conditions. A detailed description of model updates, verification, and results are discussed in the FDR (ERM 2022). Based on the updated groundwater model using conservative assumptions, 60 gpm is the estimated maximum GWET system extraction rate when TCZOs are met. The actual extraction rate required to maintain inward gradient’s is uncertain and depends primarily on the average river elevation, and actual (rather than simulated) hydraulic conductivity values of the hydrogeological zones.

The groundwater model is expected to be updated in 2025 to reflect updated geology with data from the drilling investigation conducted between August and October 2024. Hydraulic conductivity values may also be revised to reflect pumping operations that have occurred since the trenches were installed. The updated groundwater model will be used to simulate the effect of implementing Interim Remedial Action Measure (IRAM) #1 (specifically, how will the new low permeability zone affect where water flows at the Site), which will be used to inform a PMP for IRAM #1.

6. SYSTEM OPTIMIZATION

The key objective of the GW SCM is to achieve the TCZOs. LSS took numerous steps in 2024 to meet these goals, as ERM has outlined below.

6.1 GWET SYSTEM SHUTDOWNS, MAINTENANCE, AND UPGRADES

The GWET system operated within permit conditions during the reporting period. Shutdowns, maintenance, and upgrades occurred during the reporting period to further optimize the system to meet the TCZOs. Routine downtime accounted for approximately 9 percent of the 2023 reporting period and 8 percent of the 2024 reporting period, while non-routine downtime accounted for approximately 6 percent of the 2023 reporting period and 7 percent of the 2024 reporting period. Process improvements made in 2023 and 2024 reduced the amount of downtime due to the solids handling issues referenced in previous SEE reports. Non-routine downtime during the 2024 reporting period was made up mainly of a single tank malfunction event in August and September 2024 and smaller pump failures throughout the year. The IRAM #1 pre-design investigation work that occurred in 2024 required the GWET system to be shut down briefly at various times so the well-field could be de-energized for worker safety. These shutdowns and maintenance upgrade activities for 2024 are listed below:

- **6 January 2024:** ERM, on behalf of LSS, shut down the GWET system to perform planned GWET system upgrades. The DEQ was notified of the shutdown, and discharge was restarted on 29 January 2024. Upgrades included connecting the EWs at Trenches 5, 6, and 7 to the intermediate conveyance line and EW vault upgrades.
- **13 February 2024:** Through 29 February, ERM and subcontractor performed Hydropuls redevelopment of the EWs at Trenches 1, 4, 5, and 6 to address the accumulation of fine solids in the filter pack around the trenches. The GWET system remained operational at reduced flows during redevelopment.
- **16 February 2024:** The GWET system was shut down for 10 hours due to a power outage; discharge restarted on 17 February 2024.
- **1 March 2024:** ERM, on behalf of LSS, shut down the GWET system for 2 hours to perform routine plate separator maintenance.
- **5 March 2024:** The GWET system was shut down for 4 hours after a failed pump triggered a high-pressure alarm.
- **11 March 2024:** ERM, on behalf of LSS, shut down the GWET system for 3 hours due to an unplanned failure of the mixer AG-1 in the fluidized bed reactor.
- **16 March 2024:** ERM, on behalf of LSS, shut down the GWET system due to unplanned issues with the pressure filters allowing solids to pass into the bio-side of the GWET system. This required re-circulating water through the system to clean out the fouling and discharge was restarted 26 March 2024.
- **7 April 2024:** The GWET system was shut down for 11 hours due to a failed pump causing an automatic shutoff.
- **10 April 2024:** The GWET system was shut down for 27 hours due to routine pH probe maintenance.

- **29 April 2024:** ERM, on behalf of LSS, shut down the GWET system to perform a planned carbon change-out at carbon vessel CT-2. The DEQ was notified of the shutdown and the GWET system was restarted on 2 May 2024.
- **8 May 2024:** The GWET system was shut down for 1 hour due to a failed level alarm.
- **20 May 2024:** ERM performed chemical redevelopment of Trench 1, injecting glycolic acid into MWA-83. Completed injections on 21 May 2024. The GWET system remained operational at reduced flows during redevelopment.
- **29 May 2024:** ERM and subcontractor performed Hydropuls redevelopment at EW-07, EW-09, and EW-11. The GWET system remained operational at reduced flows during redevelopment.
- **5 June 2024:** ERM, on behalf of LSS, shut down the GWET system for 2 hours due to planned conveyance line maintenance.
- **22 June 2024:** The GWET system was shut down for 0.5 hour due to fouled bag filters.
- **5 July 2024:** ERM, on behalf of LSS, shut down the GWET system for approximately 1.5 hours to perform routine plate separator maintenance.
- **11 July 2024:** ERM, on behalf of LSS, performed line jetting of the horizontal screened section of Trench 6, between EW-11 and EW-12, to address fouling of the screened section.
- **2 August 2024:** ERM, on behalf of LSS, shut down the GWET system for approximately 1 hour to perform routine plate separator maintenance.
- **10 August 2024:** The GWET system was shut down for approximately 8 hours due to a failed pump causing an automatic shutoff.
- **13 August 2024:** ERM and subcontractor performed Hydropuls redevelopment at EW-09, EW-10, EW-11, and EW-12 (Trenches 5 and 6). The GWET system remained operational at reduced flows during redevelopment.
- **16 August 2024:** ERM, on behalf of LSS, shut down the GWET system for approximately 3 hours to perform routine pump maintenance.
- **26 August 2024:** ERM, on behalf of LSS, shut down the GWET system due to a tank malfunction. The system was restarted on 8 September 2024.
- **17 September 2024:** ERM and subcontractor performed Hydropuls well redevelopment at EW-09, EW-10, EW-11, and EW-12 (Trenches 5 and 6). The GWET system remained operational at reduced flows during redevelopment.
- **19 September 2024:** ERM, on behalf of LSS, shut down the GWET system for approximately 0.5 hour due to planned pressure gauge maintenance.
- **30 September 2024:** ERM, on behalf of LSS, shut down the GWET system for 30 hours to perform preclearance work for Phase 2 of the ISS PDI.
- **7 October 2024:** The GWET system was shut down for approximately 0.5 hour due to a failed pump causing an automatic shutoff.
- **22 October 2024:** The GWET system was shut down for approximately 1 hour due to a routine programmable logic controller program download causing the system to shut off.

- **28 October 2024:** ERM, on behalf of LSS, shutdown the GWET system for 25 hours to de-energize the well-field for the ISS PDI drilling effort, in accordance with ERM sub-surface clearance policy.
- **20 December 2024:** The GWET system was shut down for approximately 0.25 hour due to a routine programmable logic controller program download causing the system to shut off.

6.2 SYSTEM OPTIMIZATION EFFORTS IN 2024

During 2024, several optimization efforts were taken to improve the GWET system and well-field operations, to include the following:

- In January 2024, the EWs at Trenches 5, 6, and 7 were connected to the intermediate conveyance line.
- Throughout 2024 (February, May, August, and September), Hydropuls well redevelopment was performed at Trenches 1, 4, 5, and 6 to increase well performance and remove fines from the filter pack.
- In May 2024, chemical redevelopment was conducted at Trench 1 using glycolic acid to kill off biological growth in the filter pack and EWs. Prior to conducting this work, an Underground Injection Permit was obtained from DEQ.
- In June 2024, conveyance lines were jetted to reduce back pressure and improve flow rates.
- In April and May 2024, pressure filter media was replaced. The old media was degrading and affected by biofouling.
- From July to December 2024, pass-through packers were installed in the EWs at Trenches 5 and 6.

6.2.1 WELL REDEVELOPMENT EFFORTS IN 2025

Beyond the efforts in 2024, additional Hydropuls redevelopment was performed in January, February, and March 2025. Hydropuls well redevelopment was performed at Trenches 1, 4, 5, 6, and 7 to improve flows by removing fine sand and silt from the well screens and the trench filter pack. ERM staff were trained to use the Hydropuls tool in January 2025, so that redevelopment could be performed without a subcontractor onsite. After consultation with the manufacturer of the Hydropuls tool and aboveground testing, ERM staff were able to access the horizontal well screens in the trenches with the tool, allowing for redevelopment of the horizontal sections and increasing the impact of the redevelopment efforts. These 2025 redevelopment efforts have brought in increased flows from the redeveloped trenches.

- At EW-08 (Trench 4), flows increased by 163 percent (change from 1.71 gpm to 4.51 gpm), with flows reducing over 3 weeks to 2.15 gpm. Flows at EW-08 improved to 3.65 gpm after a second round of redevelopment. A third round of redevelopment was conducted on 17 and 18 March 2025, after which flows increased to 6.93 gpm (as of 27 March 2025).
- At EW-11 (Trench 6), after one round of redevelopment, flows increased by 46 percent (change from 2.51 gpm to 3.67 gpm) and stayed at that elevated flow until the well was redeveloped again on 4 and 5 March 2025, after which flows increased another 28 percent to an average of 4.74 gpm (as of 27 March 2025).

- At EW-09 (Trench 5), flows increased by 94 percent (change from 3 gpm to 5.82 gpm), with flows still above pre-redevelopment flows 6 weeks after (as of 27 March 2025).
- At EW-01 (Trench 1), flows increased by 41 percent (change from 1.85 gpm to 2.61 gpm), with flows remaining above pre-development flows 3 weeks after (as of 27 March 2025).

This redevelopment work is improving the flow rates from these trenches and increasing the ability of the GWET system to pump more water despite persistently low river elevation.

6.3 SYSTEM OPTIMIZATION CONCLUSION

Trench extraction rates and hydrograph analysis show an increase in groundwater extraction rates compared to the legacy system, both in terms of the GWETs capacity to pump a greater volume of water in a given period of time, and in terms of increased uptime of GWET, despite the fact that river and therefore groundwater elevations were generally lower since the GEE was implemented. Within the alluvial sequence, potentiometric surface maps indicate the GW SCM is producing areas of hydraulic capture throughout the TCZ, especially in the Shallow Zone. The analysis of horizontal gradients suggests that gradients have trended inward and have been less variable since GEE implementation.

The groundwater extraction flow rate is limited by groundwater elevation, which has been influenced by low river levels in 2024; by fouling of the filter pack in the trenches with fine sand and silt from the native soils; and by the need to regularly replace EW pumps for cleaning and maintenance. The number of GWET shutdowns caused by maintenance issues was further reduced in 2024 due to the process improvements made in 2023 and 2024, well redevelopment efforts, proactive cleaning of pressure filters, and replacing the pressure filter media in 2023.

The upgrades to GWET operations planned for 2025 include continued trench redevelopment and optimizing the timing of repeated redevelopment efforts. Throughout 2024, the GWET system has continued to outperform the system prior to GEE implementation, as shown through increased extraction rates and improved horizontal gradients (see Section 4.1.1, Horizontal and Vertical Gradients, and Figures 4a through 4d).

7. ANNUAL GROUNDWATER MONITORING DATA EVALUATION

7.1 GROUNDWATER ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the DEQ's 31 May 2019 comments on the 2018 SEE report (ERM 2018) and the subsequent meeting held on 2 July 2019. Table 7.1-1 outlines the sampling and submittal dates related to groundwater monitoring in 2024.

TABLE 7.1-1 2024 GROUNDWATER MONITORING SAMPLING AND SUBMITTAL DATES

Report	Sampling Dates	Report Submittal Date
2024 Quarter 1	25–28 February 2024	12 June 2024
2024 Quarter 2	10–14 June 2024	20 September 2024
2024 Quarter 3	9–11 September 2024	18 December 2024
2024 Quarter 4	9–12 December 2024	17 March 2024

7.2 BACKGROUND

Starting with the 2020 groundwater data collected, included in the 2020 SEE report, a historical assessment (2007 to 2010) and current (2019 to present) groundwater analytical data in the vicinity of the GWBW has been included as part of this assessment to evaluate changes in groundwater contaminants of concern (COCs) concentrations due to the operation of the GWET system between 2014 and present. The statistical evaluation of historical and current groundwater data for the following COCs has been conducted.

- Chloride
- Chlorobenzene
- Hexavalent chromium
- Perchlorate
- DDx (sum of 2,4- and 4,4-dichloro-diphenyl-dichloroethane, 2,4- and 4,4-dichloro-diphenyl-dichloroethethylene, and 2,4- and 4,4-dichloro-diphenyl-trichloroethane)

Following the DEQ's 19 July 2021 review of the GWET SEE (2020 SEE; ERM 2021d), a memorandum was submitted on 9 September 2021 regarding monitoring program modifications. On 14 September 2021, DEQ approved the reduced monitoring program focusing on areas of potential migration of chlorobenzene, perchlorate, and chloride around the ends of the GWBW in the Shallow, Intermediate, and Deep Zones. This reduced program will be conducted until the TCZOs are met. Table 2 is a matrix summarizing the groundwater monitoring program.

As requested by the DEQ, the areas of focus for this evaluation have been revised from nine regions to six GCCs, starting with the 2022 SEE report.

ERM has presented the results of the 2024 evaluation in Appendix B, Tables B1 through B7, and a summary of overall trends by GCC, hydrogeological zone, and compound is presented in Table 3. The results, with inclusion of 2024 sample results, are largely consistent with those presented in the 2023 SEE report. Table 3 highlights changes in statistical trends between 2023 and 2024, and these changes are discussed further in the sections below.

7.3 STATISTICAL DATA EVALUATION METHODOLOGY

On behalf of LSS, ERM evaluated groundwater analytical data in general accordance with the 2020 data evaluation presented in the 2020 SEE (ERM 2021d) and implemented in subsequent SEE reports. The evaluation is presented by hydrogeologic zones (Shallow, Intermediate, and Deep Zones) and spatial regions relative to the six GCCs. Figure 5 depicts the sampled monitoring well locations relative to each GCC evaluated.

The following statistical evaluations were performed.

- **Order of Magnitude Change:** Maximum concentrations from the study period (2007 to 2024) were evaluated for the presence of an order of magnitude change between historical (2007 to 2010) and current (2019 to 2024) conditions. This has been categorized as follows.
  - **Increase:** The current maximum concentration was at least an order of magnitude greater than the historical maximum concentration.
  - **Decrease:** The current maximum concentration was at least an order of magnitude less than the historical maximum concentration.
  - **None:** The current maximum concentration was the same order of magnitude as the historical maximum concentration.
  - **N/A:** Either the detection status differs between historical and current concentrations, both concentrations were non-detect, or historical concentrations do not exist.
- **Detect Status Change:** The change in detection status between historical (2007 to 2010) and current (2019 to 2024) data were evaluated. They have been categorized as follows.
  - **Non-Detect to Detect:** The status changed from non-detect to detect.
  - **Detect to Non-Detect:** The status changed from detect to non-detect.
  - **Non-Detect to Detect, High Historical Detection Limit:** The historical detection limit was greater than the current detection.
  - **Detect to Non-Detect, High Current Detection Limit:** The current detection limit was greater than the historical detection.
  - **None:** The same detection status was between historical and current.
  - **N/A:** No historical data was available for comparison.
- **Statistical Trend (Current):** Mann-Kendall trends were calculated at 95 percent confidence with minimum data requirements of at least eight detected values and 50 percent detection frequency for the current (2019 to 2024) data set (Appendix C). Guidance recommends that trend tests be performed with at least eight detected data points to allow for a reasonable amount of confidence in results (EPA 2009). If a data set comprises more than 50 percent of non-detect values, the loss of information is considered too great to support a reliable analysis of trends, so a Mann-Kendall test was not performed. The trends have been categorized as follows:
  - **Stable, Increasing, or Decreasing:** The trend criteria was met and calculated.

- **Insufficient Detects or Insufficient Samples or Insufficient Frequency of Detects:** The minimum data requirements were not met, and the trend was not calculated.
- **N/A:** No historical data was available for comparison.

7.4 STATISTICAL DATA EVALUATION RESULTS

On behalf of LSS, ERM evaluated chloride, chlorobenzene, and perchlorate concentration trends using current (2019 to 2024) data for each hydrogeological zone (Shallow, Intermediate, and Deep). Additionally, ERM evaluated concentration trends based on spatial location relative to the GWBW in GCCs and classified them as follows (Figure 5).

- **GCC1 and Proximal Wells:** This includes four Shallow, three Intermediate, and two Deep Zone wells located between the groundwater treatment plant and the GWBW.
- **GCC2:** This includes two Deep Zone wells located south of GCC1, within and outside of the GWBW.
- **GCC3:** This includes two Deep Zone wells located south of GCC2, within and outside of the GWBW.
- **GCC4 and Proximal Wells:** This includes three Deep Zone wells located south of GCC3, within and outside of the GWBW.
- **GCC5 and Proximal Wells:** This includes three Deep Zone wells located at the most southeast corner of the Site, including monitoring wells within and outside of the GWBW.
- **GCC6 and Proximal Wells:** This includes four Shallow, four Intermediate, and two Deep Zone wells located west of GCC5, including monitoring wells within and outside of the GWBW.
- **Wells Distal from the GWBW and GCC:** This includes one Deep Zone well located west of GCC3.

The resulting trend evaluation is presented in Appendix B, Tables B1 through B7 and summarized in Table 3. Appendix D details statistical evaluation results for individual well COCs, including Mann-Kendall test results and sample distribution status.

7.4.1 CHANGES IN TRENDS WITH INCLUSION OF 2024 DATA

The results of the evaluation indicate that limited isolated increases (e.g., order of magnitude increase or calculated increasing trend) are present.

As Table 3 outlines, most concentrations are either stable or decreasing, indicating that there have been no significant lateral or vertical changes in contaminant distribution. The changes in trends resulting from the inclusion of 2024 data are as follows:

- **GCC1 and Proximal Wells**
  - **Chloride, Deep Zone—**The current trend at PA-18D changed from insufficient detect results to stable. The current trend at PA-27D remains decreasing.
  - **Chlorobenzene, Intermediate Zone—**The current trend at PA-10I changed from increasing to stable. The current trend at PA-32I remains stable and a trend could not be calculated at PA-17IR due to insufficient frequency of detects.

- **GCC2**
  - **Chloride, Deep Zone—**The current trend at PA-19D changed from increasing to stable and remains stable at PA-30D.
  - **Chlorobenzene, Deep Zone—**The current trend at PA-30D changed from increasing to stable and remains stable at PA-19D.
- **GCC3**
  - **Chlorobenzene, Deep Zone—**The current trend at PA-21D changed from decreasing to stable and remained decreasing at PA-20D.
- **GCC4 and Proximal Wells**
  - **Perchlorate, Deep Zone—**The current trend at MWA-58D changed from stable to increasing and remained increasing at MWA-56D and decreasing at PA-22D. An order of magnitude increase in concentration was detected at MWA-56D.
- **GCC5 and Proximal wells**
  - **Chloride, Deep Zone—**The current trend at MWA-31I(D) changed from stable to decreasing while remaining decreasing at PA-24D and increasing at PA-23D.
- **GCC6 and Proximal Wells**
  - **Chloride, Intermediate Zone—**The current trend at MWA-81I and PA-16I changed from stable to decreasing and from decreasing to stable at PA-44I. The current trend at PA-15I remains stable.

7.4.2 CHLORIDE, PERCHLORATE, AND CHLOROBENZENE PLUMES

In response to the 2020 SEE (ERM 2021d) and the Q4 2022 Groundwater Monitoring Report (ERM 2023a), the DEQ requested further discussion regarding the effectiveness of the GWET system in containing perchlorate and chloride plumes, particularly in the Deep Zone. ERM has also included an evaluation of chlorobenzene containment by the GWET system.

- **Chlorobenzene:** Concentration trends at most GCCs could not be established because there were not enough detected results to create a statistical trend. Remaining chlorobenzene concentration trends are stable or decreasing, indicating that containment by the GWET and the GWBW is effectively preventing chlorobenzene migration beneath the GWBW towards the river.
- **Chloride:** ERM identified increasing concentration trends in the Deep Zone at GCC5 and Proximal Wells (PA-23D, GWBW interior), and GCC6 and Proximal Wells (PA-26D, GWBW exterior). The concentration trend at the complementary Deep Zone well on the interior side of the GWBW at GCC6 and Proximal Wells (PA-25D) has remained stable with lower overall concentrations. The concentration trends at Deep Zone wells on the exterior side of the GWBW at GCC5 and Proximal Wells (MWA-31I[D] and PA-24D) are decreasing, indicating that the GWBW is effectively preventing chloride migration towards the river in this part of the Site. Generally, chloride concentrations in the Shallow, Intermediate, and Deep Zones are decreasing or stable. A possible seasonal variation was observed in chloride concentrations in the Shallow Zone at MWA-63 (GCC1 and Proximal Wells), with high concentrations occurring during periods of low groundwater elevation (Q3 and/or Q4) and low concentrations occurring

during periods of high groundwater elevation (Q1 and/or Q2). The observed seasonal variation in chloride concentration is possibly related to river water influence on the Shallow Zone near MWA-63, with high river stages diluting groundwater concentrations. Overall, chloride concentrations at MWA-63 have decreased and are under the Groundwater Hot Spot Screening Criteria of 230 mg/L (Revised Hot Spot Evaluation, ERM 2021a) cleanup levels.

- **Perchlorate**: Generally, perchlorate concentration trends in the Shallow, Intermediate, and Deep Zones could not be established due to insufficient detects apart from two decreasing trends (GCC3—Deep Zone; GCC4 and Proximal Wells—Deep Zone), three stable trends (GCC3—Deep Zone; GCC5 and Proximal Wells—Deep Zone; and GCC6 and Proximal Wells – Shallow Zone), and two increasing trends (GCC4 and Proximal Wells—Deep Zone). Current concentrations decreased by an order of magnitude compared to historical records at MWA-58D (GCC4 and Proximal Wells, GWBW exterior and southeast of MWA-56D). Increasing concentration trends were observed at exterior wells MWA-56D and MWA-58D in the GCC4 and Proximal Wells region. However, the trends observed at the complimentary interior Deep Zone well PA-22D were decreasing. This indicates that the increasing concentration trends observed at MWA-56D and MWA-58D are limited to the exterior side of the GWBW. Intermediate Zone perchlorate concentrations outside the GWBW at GCC4 were last measured in March 2021 at MWA-34I and MWA-49I and are at least one order of magnitude lower than current Deep Zone concentrations within the same well clusters. Per the DEQ 19 January 2024 letter (DEQ 2024) proposing an alternative remedial approach to the September 2023 Draft Feasibility Study (ERM 2023b), the upcoming Data Gaps Investigation will examine perchlorate residual areas near MWA-56D and MWA-58D.

While the inclusion of the 2024 dataset suggests that no significant changes in the horizontal or lateral distribution of the COCs have occurred, additional stable concentrations were observed, particularly at GCC2 and GCC3. Of the monitoring well locations with sufficient concentration detections for a statistical trend to be calculated, trends are predominantly decreasing or stable. These concentration trends along the GWBW in conjunction with groundwater flow depicted on the potentiometric surface maps (included in Appendix A) indicate that the GWBW is functioning to impede groundwater flow. As noted above, the GWET system is undergoing continuous optimization and upgrades and is expected to be able to continue to increase groundwater extraction capacity over the legacy RW system. The limited increasing trends will be further evaluated as part of the upcoming Data Gaps Investigation.

8. CONCLUSIONS

8.1 2024 GWET SYSTEM TREATMENT EFFECTIVENESS

- The GWET system is operating within permit conditions and is effectively treating extracted groundwater prior to discharge to the Willamette River.
- The GWBW is functioning to impede groundwater flow.
- Improvements to the GWET system are continuously being made and will continue through 2025 to maximize treatment capacity, efficacy, and safety.
- The GWET system was upgraded in 2022, and the upgraded system is pumping more water with greater uptime, producing more inward gradients and less potential for contaminant flux towards the Willamette River as compared to the legacy system.

8.2 GWET SYSTEM GROUNDWATER RECOVERY AND HYDRAULIC MONITORING EQUIPMENT EFFECTIVNESS

- The groundwater recovery equipment operating limitations related to transducer failure and electrical malfunction were reduced by changes made in 2019, and they continue to be effective. Transducer downtime was reduced in 2024 compared to 2023, with fewer transducers being inoperable for an extended period. Transducer data provided by the system is sufficient to evaluate and operate the GWET system.
- The new groundwater extraction trenches installed in 2022 as part of the GEE increased the GWET's ability to remove groundwater within the TCZ. Additionally, GWET uptime has increased in 2024, also resulting in a greater volume of extracted and treated groundwater. Horizontal gradients trends at the GCCs have improved since GEE implementation and are either inward or trending towards inward as demonstrated in Figures 4a through 4c and the Monthly Progress Reports (e.g., achieving or trending towards achieving the TCZOs).
- In January 2024, three trenches (5, 6, and 7) were connected to an out-of-use intermediate conveyance line that helped to increase extraction rates by reducing back pressure.
- To continue optimizing the average system influent flow rate, both conveyance lines were jetted in June 2024, and maintenance of these lines is planned to become routine. Backpressure is measured on at least a monthly basis to evaluate the conveyance system performance so that it does not limit pumping rates.
- Trench 1 EWs were chemically redeveloped in May 2024 to mitigate biofouling and sediment buildup within the formation and well screens.
- In February, May, August, and September 2024, EWs in Trenches 4, 5, and 6 were redeveloped using Hydropuls technology to mitigate the buildup of fine sediments in the formation and well screens. Routine redevelopment of Trenches 1, 4, 5, 6, and 7 is continuing in 2025 and being performed by trained ERM staff, allowing for an increased cadence in redevelopment efforts and the ability to redevelop the horizontal screened sections at each trench.

8.3 GROUNDWATER MONITORING DATA EVALUATION

An evaluation of the current groundwater data was performed, and this evaluation incorporated the 2024 data to determine if the current GWET system operating conditions were impacting the lateral or vertical distribution of contaminants. Per the 2024 data, there were limited changes in statistical trends, as summarized in Section 7.4.1 above. As indicated in Section 7.4.2 above, the limited increasing trends will be further evaluated as part of the upcoming Data Gaps Investigation and the implementation of IRAMs to address areas with residual contamination, with IRAM #1 (dense non-aqueous phase liquid in Acid Plant Area) as the top priority for 2025 to 2026. Performance monitoring will continue in accordance with the 2021 agreement with the DEQ, pending changes to the monitoring program related to the implementation of IRAM 1. LSS will obtain approval from DEQ before any changes are implemented.

9. RECOMMENDATIONS

ERM makes the following recommendations with respect to this evaluation of the effectiveness of the GWET system:

- Continue to evaluate EW, RW, and transducer performance and troubleshoot and repair them as necessary to maximize pump uptime and the data collected by the transducers.
- Continue to maintain the GWET system and perform preventative maintenance to maximize uptime.
- Optimize trench extraction rates through routine redevelopment using Hydropuls technology, including redevelopment of horizontal and vertical well screens.
- The planned activities for implementing IRAM #1, currently scheduled for Fall 2025, will require shutting down all or a significant portion of the GWET system.

As outlined in Section 8 above, the annual groundwater monitoring data evaluation indicated that operation of the GW SCM is not resulting in significant migration of COCs. Observations of increasing concentrations are limited and isolated. The overall conclusions are consistent with previous evaluations. Additionally, the groundwater mound continues to be substantially dewatered on the north end of the GWBW in the vicinity of Trenches 1, 2, and 3, and has been substantially dewatered on the south end of the GWBW in the vicinity of Trenches 4, 5, 6, and 7. Groundwater monitoring will continue as part of the upcoming Data Gaps Investigation and the implementation of IRAMs to address areas with residual contamination, with IRAM #1 (dense non-aqueous phase liquid in Acid Plant Area) as the top priority for 2025 to 2026.

10. REFERENCES

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TABLES

Table 1a
Average Monthly Pumping Rates
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Trench	Well ID	Average Monthly Pumping Rates (gpm)											
		Jan-24		Feb-24		Mar-24		Apr-24		May-24		Jun-24	
Recovery wells	RW-14	0.20	0.61	0[2]	0.00	0[1]	0.00	0[1]	1.03	0[1]	1.61	0[1]	1.67
	RW-22	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]	
	RW-23	0[2]		0[2]		0[1]		0[1]		0[1]		0.48	
	RW-25	0.41		0[1]		0[1]		1.03		1.61		1.19	
Trench 1	EW-01	0.21	0.59	0[1]	3.11	1.42	2.04	0[3]	0.00	0.56	0.92	0.33	0.50
	EW-02	0.38		3.11		0.62		0[3]		0.36		0.17	
Trench 2	EW-03	1.33	2.74	2.93	11.37	2.52	5.64	4.77	9.63	6.96	10.06	15.41	17.90
	EW-04	1.41		8.44		3.12		4.86		3.10		2.49	
Trench 3	EW-05	3.53	3.90	13.28	14.94	6.72	7.45	6.27	10.52	6.83	9.55	8.04	8.45
	EW-06	0.37		1.66		0.73		4.25		2.72		0.41	
Trench 4	EW-07	0[2]	0.61	2.20	5.16	0.92	5.96	0.01	2.08	2.24	4.11	0.04	3.14
	EW-08	0.61		2.96		5.04		2.07		1.87		3.10	
Trench 5	EW-09	0.41	1.08	0.49	2.85	3.60	4.98	2.57	5.91	0.08	4.35	0.04	3.03
	EW-10	0.67		2.36		1.38		3.34		4.27		2.99	
Trench 6	EW-11	0.61	0.84	0.83	5.16	0.56	3.84	0.46	3.72	1.21	2.37	1.51	1.76
	EW-12	0.23		4.33		3.28		3.26		1.16		0.25	
Trench 7	EW-13	0.33	2.91	7.41	17.20	4.41	10.26	3.78	9.98	0.97	7.50	0[1]	9.02
	EW-14	2.58		9.79		5.85		6.20		6.53		9.02	
Total Trench Recovery		12.67		59.79		40.17		41.84		38.86		43.80	
Total Extraction		13.28		59.79		40.17		42.87		40.47		45.47	

Trench	Well ID	Average Monthly Pumping Rates (gpm)											
		Jul-24		Aug-24		Sep-24		Oct-24		Nov-24		Dec-24	
Recovery wells	RW-14	2.10	3.88	0.92	2.64	0.16	2.14	0.91	2.41	0.59	2.37	0.95	3.25
	RW-22	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]	
	RW-23	0.36		0.24		0.98		0.28		0.62		0.91	
	RW-25	1.42		1.48		1.00		1.22		1.16		1.39	
Trench 1	EW-01	0.88	0.88	0.50	0.50	0.56	0.56	0.43	0.43	0.84	0.84	1.04	1.04
	EW-02	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]	
Trench 2	EW-03	12.51	13.34	8.06	8.06	7.66	7.66	8.71	8.71	8.73	8.78	9.93	10.14
	EW-04	0.83		0[2]		0[2]		0[2]		0.05		0.21	
Trench 3	EW-05	7.18	7.18	3.19	4.68	3.79	3.79	0.26	4.52	0[1]	4.75	3.79	5.90
	EW-06	0[2]		1.49		0[2]		4.26		4.75		2.11	
Trench 4	EW-07	0.99	1.79	0[2]	1.09	0[2]	0.92	0[2]	0.71	0[2]	1.76	0[2]	1.74
	EW-08	0.80		1.09		0.92		0.71		1.76		1.74	
Trench 5	EW-09	0.04	1.72	0.41	1.03	0.24	1.36	1.15	1.15	1.50	1.50	1.68	1.68
	EW-10	1.68		0.62		1.12		0[1]		0[1]		0[1]	
Trench 6	EW-11	1.54	1.54	0.80	0.80	0.99	0.99	0.98	0.98	0.57	1.77	0.83	2.07
	EW-12	0[1]		0[1]		0[1]		0[1]		1.20		1.24	
Trench 7	EW-13	6.68	7.67	0[2]	5.22	1.09	3.96	5.47	5.47	5.70	5.77	5.05	5.12
	EW-14	0.99		5.22		2.87		0[1]		0.07		0.07	
Total Trench Recovery		34.12		21.38		19.24		21.97		25.17		27.69	
Total Extraction		38.00		24.02		21.38		24.38		27.54		30.94	

Notes:
Shaded cells indicate recovery/extraction well was off
Average Monthly Pumping Rate = total gallons extracted / time
([1]) Extraction wells off due to equipment issue
([2]) Extraction well off due to low water table
([3]) Extraction well off due to chemical redevelopment

Table 1b
Average Operational Monthly Pumping Rates
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Trench	Well ID	Average Operational Monthly Pumping Rates (gpm)											
		Jan-24		Feb-24		Mar-24		Apr-24		May-24		Jun-24	
Recovery wells	RW-14	1.05	3.16	0[2]	0.00	0[1]	0.00	0[1]	2.37	0[1]	2.00	0[1]	2.63
	RW-22	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]	
	RW-23	0[2]		0[2]		0[1]		0[1]		0[1]		1.21	
	RW-25	2.11		0[1]		0[1]		2.37		2.00		1.42	
Trench 1	EW-01	1.08	4.05	0[1]	3.11	4.41	7.16	0[3]	0.00	2.17	3.58	0.98	1.53
	EW-02	2.97		3.11		2.75		0[3]		1.41		0.55	
Trench 2	EW-03	6.88	12.36	7.09	15.53	4.59	9.19	4.93	9.96	7.19	10.40	15.94	19.67
	EW-04	5.48		8.44		4.60		5.03		3.21		3.73	
Trench 3	EW-05	12.16	15.98	13.28	15.95	9.92	11.80	6.49	10.89	7.06	9.87	8.32	10.35
	EW-06	3.82		2.67		1.88		4.40		2.81		2.03	
Trench 4	EW-07	0[2]	2.38	3.99	8.08	2.86	9.96	0.32	5.09	3.65	7.27	0.45	3.78
	EW-08	2.38		4.09		7.10		4.77		3.62		3.33	
Trench 5	EW-09	1.84	12.26	3.55	12.12	5.07	8.36	2.66	6.12	0.49	4.90	0.29	3.88
	EW-10	10.42		8.57		3.29		3.46		4.41		3.59	
Trench 6	EW-11	2.38	5.88	1.85	6.88	2.92	7.54	2.78	6.16	2.89	4.61	2.39	4.88
	EW-12	3.50		5.03		4.62		3.38		1.72		2.49	
Trench 7	EW-13	1.47	11.45	7.41	17.20	6.21	14.45	3.91	10.33	2.14	8.88	0[1]	9.67
	EW-14	9.98		9.79		8.24		6.42		6.74		9.67	
Total Trench Recovery		64.36		78.87		68.46		48.55		49.51		53.76	
Total Extraction		67.52		78.87		68.46		50.92		51.51		56.39	

Trench	Well ID	Average Operational Monthly Pumping Rates (gpm)											
		Jul-24		Aug-24		Sep-24		Oct-24		Nov-24		Dec-24	
Recovery wells	RW-14	2.17	4.02	1.36	3.43	1.18	3.81	0.91	2.45	0.59	2.41	0.95	3.25
	RW-22	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]	
	RW-23	0.43		0.30		1.27		0.28		0.66		0.91	
	RW-25	1.42		1.77		1.36		1.26		1.16		1.39	
Trench 1	EW-01	1.05	1.05	0.60	0.60	0.74	0.74	0.61	0.61	1.20	1.20	1.35	1.35
	EW-02	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]	
Trench 2	EW-03	12.51	15.10	9.61	9.61	9.99	9.99	8.71	8.71	8.73	9.23	9.93	10.86
	EW-04	2.59		0[2]		0[2]		0[2]		0.50		0.93	
Trench 3	EW-05	7.18	7.18	5.20	9.82	4.94	4.94	2.64	7.19	0[1]	4.75	5.34	9.78
	EW-06	0[2]		4.62		0[2]		4.55		4.75		4.44	
Trench 4	EW-07	1.53	3.31	0[2]	1.29	0[2]	1.21	0[2]	0.88	0[2]	1.76	0[2]	1.74
	EW-08	1.78		1.29		1.21		0.88		1.76		1.74	
Trench 5	EW-09	1.15	3.52	1.59	3.35	1.77	3.54	1.42	1.42	1.50	1.50	2.00	2.00
	EW-10	2.37		1.76		1.77		0[1]		0[1]		0[1]	
Trench 6	EW-11	1.84	1.84	1.24	1.24	1.30	1.30	1.22	1.22	2.13	4.14	1.99	3.52
	EW-12	0[1]		0[1]		0[1]		0[1]		2.01		1.53	
Trench 7	EW-13	7.39	13.52	0[2]	6.22	6.53	11.07	5.47	5.47	5.70	5.99	5.05	5.34
	EW-14	6.13		6.22		4.54		0[1]		0.29		0.29	
Total Trench Recovery		45.52		32.13		32.79		25.50		28.57		34.59	
Total Extraction		49.54		35.56		36.60		27.95		30.98		37.84	

Notes:
Shaded cells indicate recovery/extraction well was off
Average Operational Monthly Pumping Rate = total gallons extracted / total uptime of the GWET system
([1]) Extraction wells off due to equipment issue
([2]) Extraction well off due to low water table
([3]) Extraction well off due to chemical redevelopment

Table 2
2024 Groundwater Sample Summary
System Effectiveness Evaluation
Arkema Inc. Facility
Portland, Oregon

Analyte	Chlorobenzene					DDx					Chloride					Perchlorate					Hexavalent Chromium				
Location ID	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Total Samples	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Total Samples	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Total Samples	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Total Samples	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Total Samples
MWA-02	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-15r	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-18	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-19	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-20	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-22	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-24	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-29	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-30	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-33	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-40	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-41	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-42	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-46	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-47	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-61	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-63	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-69	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	X	--	--	--	**1**	--	--	--	--	**0**
MWA-82	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-03	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-04	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-05	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-06	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-07	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-08	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-09	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-28	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-31	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-36	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-38	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-42	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-08i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-32i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-34i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-49i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-51i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-53i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-54i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-64i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-66i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-70i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-81i	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-10i	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-11i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-12i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-13i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-14i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-15i	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-16i	X	X	--	X	**3**	--	--	--	--	**0**	X	X	--	X	**3**	X	X	--	X	**3**	--	--	--	--	**0**

Table 2
2024 Groundwater Sample Summary
System Effectiveness Evaluation
Arkema Inc. Facility
Portland, Oregon

Analyte	Chlorobenzene					DDx					Chloride					Perchlorate					Hexavalent Chromium				
Location ID	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Total Samples**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Total Samples**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Total Samples**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Total Samples**	**Q1 2024**	**Q2 2024**	**Q3 2024**	**Q4 2024**	**Total Samples**
PA-17iR	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-29i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-32i	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-37i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-39i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-44i	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-11i(d)	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-31i(d)	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-56d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-58d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-18d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-19d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-20d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-21d	X	X	--	--	**2**	--	--	--	--	**0**	X	X	--	--	**2**	X	X	--	--	**2**	--	--	--	--	**0**
PA-22d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-23d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-24d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-25d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-26d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-27d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-30d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**

Table 3
Groundwater Concentration Trend Summary (Gradient Control Cluster, Hydrogeological Zone, and Compound)
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

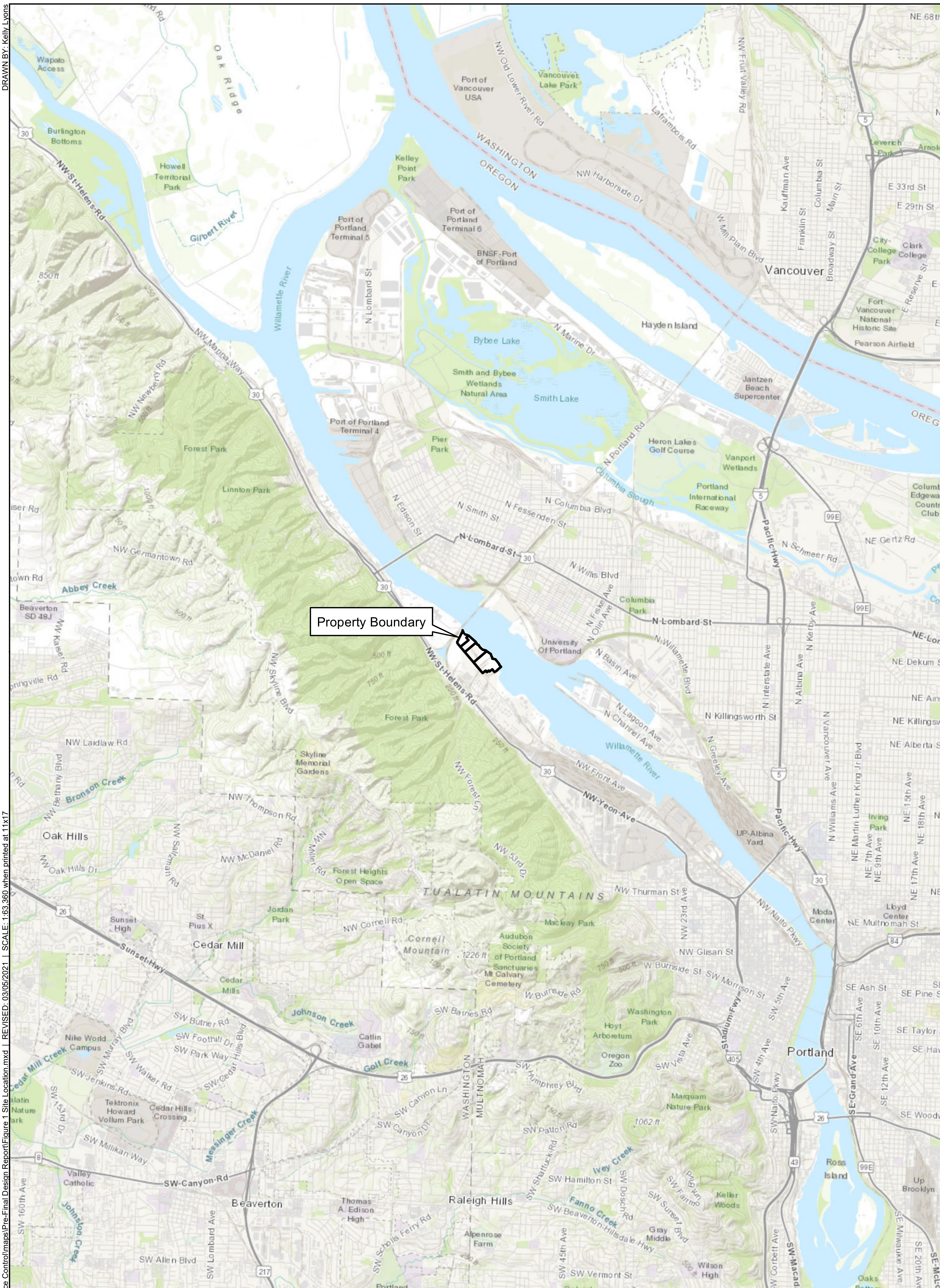
Region	Hydrogeological Zone (# of wells)	Chloride		Chlorobenzene		Perchlorate	
		Statistical Evaluation Results	*Notes*	*Statistical Evaluation Results*	*Notes*	*Statistical Evaluation Results*	*Notes*
GCC1 and Proximal Wells Historical data limited to MWA - 63	*Shallow (4)*	Current decreasing trend (PA-03, PA-04, PA-31). The current chloride concentration trend at MWA-63 is stable with an overall order of magnitude decrease between historical and current results.		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
	Intermediate (3)	Current decreasing trend (PA-10I, PA-17IR, PA-32I).		**Stable Current Trend (PA-10I and PA-32I).** Trend could not be calculated at PA-17IR due to insufficient frequency of detects.		Trend could not be calculated due to insufficient detect results.	
	Deep (2)	**Current Decreasing trend (PA-27D).** The current chloride concentration trend at PA-18D is stable.		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
GCC2 Historical data not available	*Deep (2)*	**Stable Current Trend (PA-19D abd PA-30D).**		**Stable Current Trend (PA-19D abd PA-30D).**		Trend could not be calculated due to insufficient detect results.	
GCC3 Historical data not available	*Deep (2)*	Current decreasing trend (PA-21D). Current chloride concentration at PA-20D is stable.		**Current decreasing trend (PA-20D).** Current chlorobenzine concentration at PA-21D is stable.		Current decreasing trend (PA-21D). Current perchlorate concentration at PA-20D is stable.	
GCC4 and Proximal Wells Historical data limited to MWA-56D and MWA-58D	*Deep (3)*	Current decreasing trend (MWA-56D and PA-22D). MWA-58D has a stable current trend.		Trend could not be calculated due to insufficient detect results.		**Increasing current trend at MWA-56D and MWA-58D and order of magnitude increase from historical to current period at MWA-56D.** Decreasing current trend at PA-22D and order of magnitude decrease in concentration from historical to current period at MWA-58D.	MWA-56D perchlorate concentration is an order of magnitude greater (2,430 to 16,000 µg/L) than historical max. MWA-58D current concentrations increased from 38,000 to 61,000 µg/L between 2019 and 2024.
GCC5 and Proximal Wells Historical data limited to MWA-31I(D)	*Deep (3)*	**Decreasing current trend (MWA-31I(D) and PA-24D).** PA-23D has an increasing current trend.	PA-23D Chloride concentrations increased from 12,500 to 33,000,000 µg/L between 2019 and 2024	Trend could not be calculated due to insufficient detect results.		Order of magnitude concentration increase from historical to current period at MWA-31I(D). Current trend remains stable at MWA-31I(D). Trends could not be established for PA-23D and PA-24D due to insufficient detect results.	MWA-31I(D) current perchlorate concentration is an order of magnitude greater (5,730 to 100,000 µg/L) than historical max.
GCC6 and Proximal Wells Historical data limited to MWA-41	*Shallow (4)*	Current trends are stable, except MWA-82, which has a decreasing current trend.		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results except for stable current trend at MWA-82.	
	Intermediate (4)	**Current decreasing trend (MWA-81I and PA-16I).** Chloride concentrations at PA-15I and PA-44I are stable.		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
	Deep (2)	Increasing current trend (PA-26D). PA-25D has stable current trend.	PA-26D current concentrations increased from 6,500 to 80,000 µg/L between 2019 and 2024.	Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
Wells Distal from GWBW and GCCs Historical data available for MWA-11I(D)	*Deep (1)*	Stable current trend.		Trend could not be calculated due to insufficient frequency of detect results.		Trend could not be calculated due to insufficient detect results.	

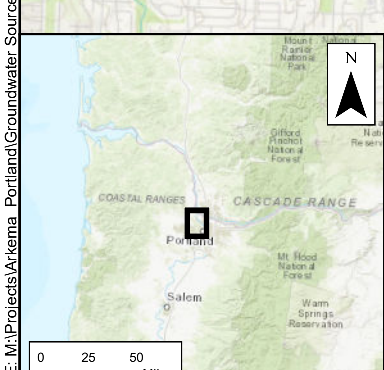
Legend:
Change in trend(s) to increasing with inclusion of 2024 data set
Change in trend(s) to stable or decreasing with inclusion of 2024 data set
Order of magnitude increase: The current concentration is at least an order of magnitude greater than the maximum historical concentration, and current concentrations trends are increasing.
*Increasing concentrations - **no change from 2023 results***
*Decreasing, stable, or primarily non-detect concentrations - **no change from 2023 results***
*Order of magnitude increase: The current concentration is at least an order of magnitude greater than the maximum historical concentration. Current concentration trends are stable - **no change from 2023 results***
Insufficient number of samples collected for calculation of trend (no color)
Historical Period includes dates from 2007 - 2010
Current Period includes dates from Q4 2019 - Q4 2024

ERM

FIGURES

DRAWN BY: Kelly Lyons





Legend

Parcel and Property Boundaries

N

0 1 2
Miles

Figure 1
Site Location
System Effectiveness Evaluation
Groundwater Source Control Measure
Former Arkema Inc. Facility Portland, Oregon

Environmental Resources Management
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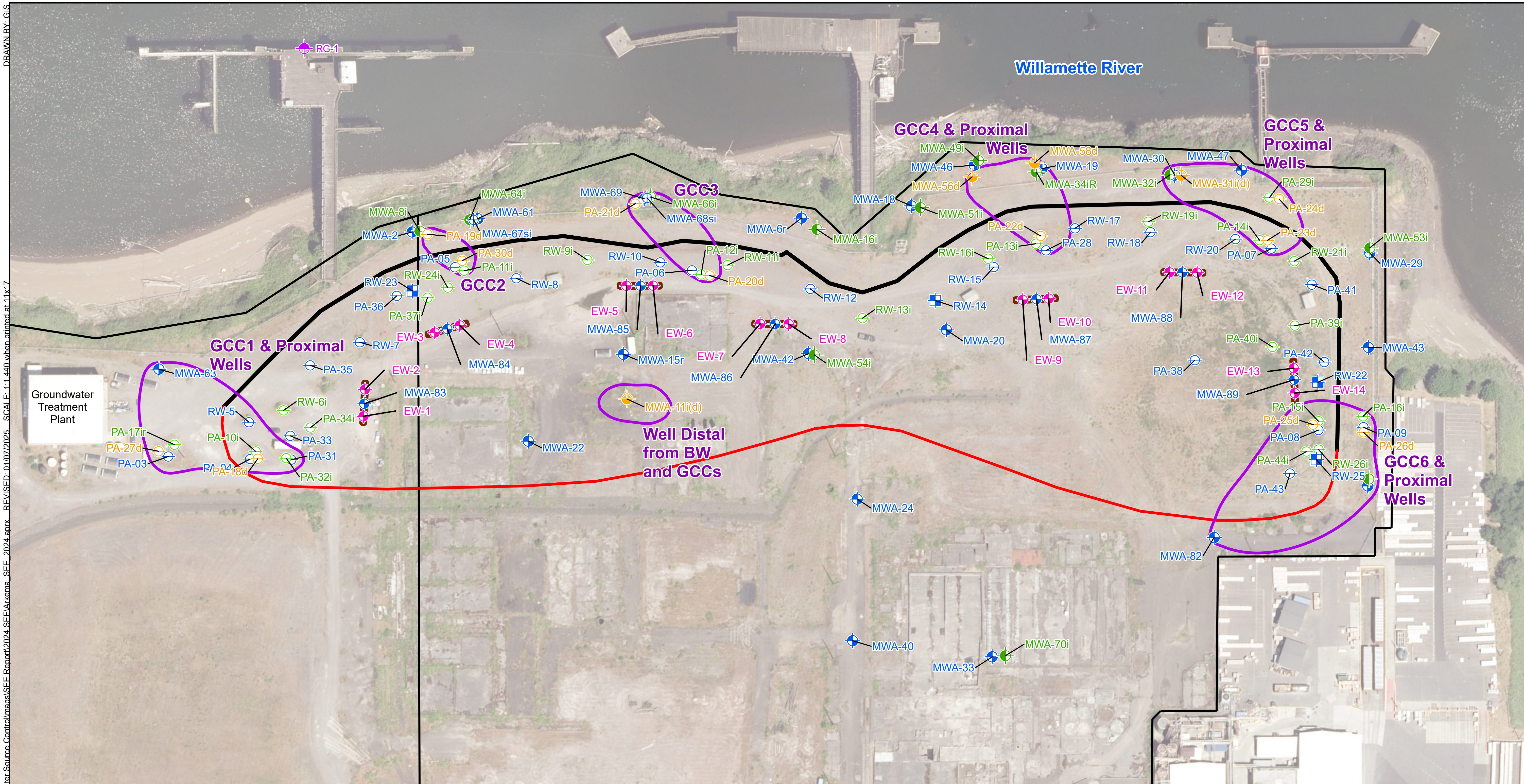
ERM

FILE: M:\Projects\Arkema Portland\Groundwater Source Control\maps\Pre-Final Design Report\Figure 1 Site Location.mxd | REVISED: 03/05/2021 | SCALE: 1:63,360 when printed at 11x17

Source: Esri - World Topoographic Map; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



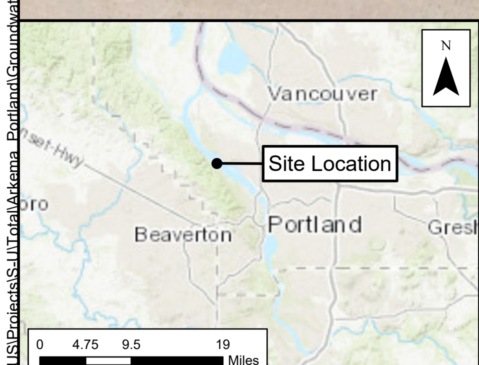


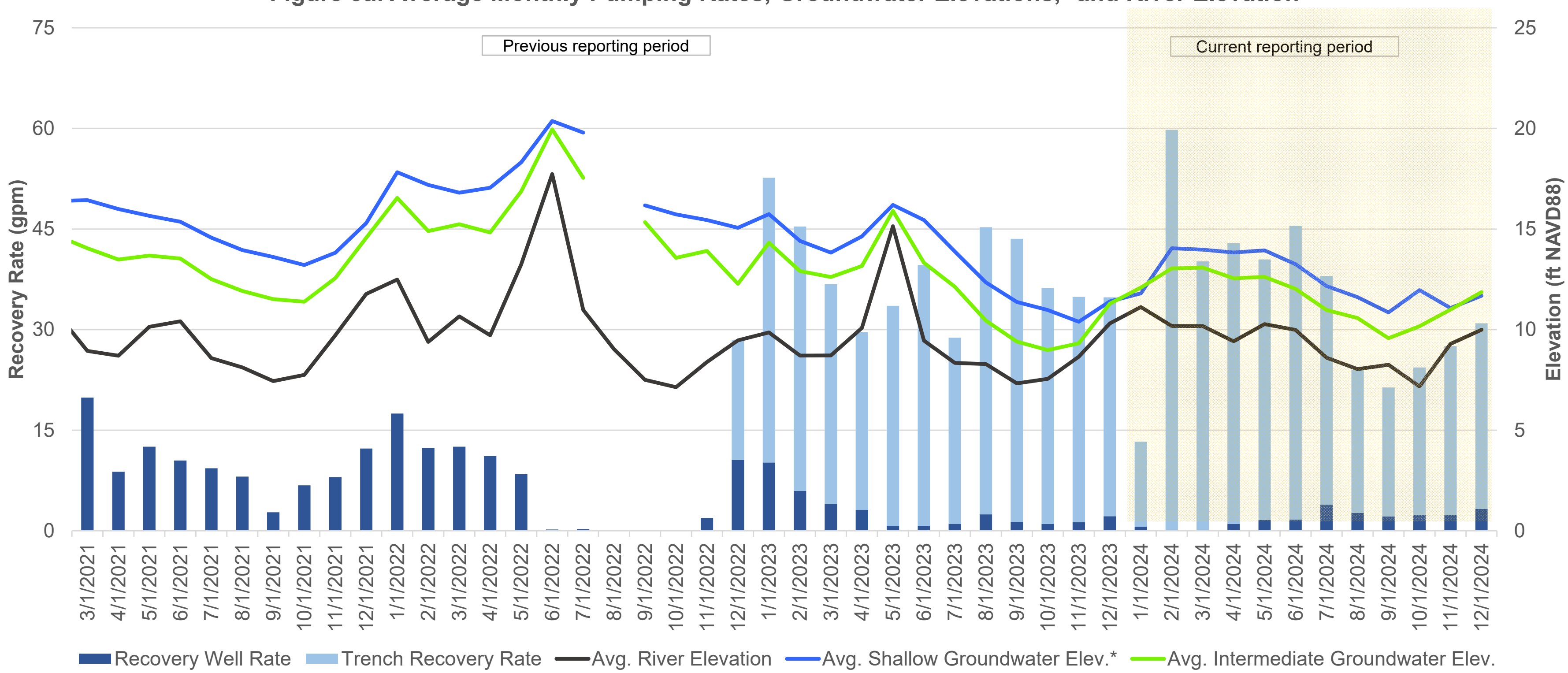
Figure 2
Site Layout
System Effectiveness Evaluation
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

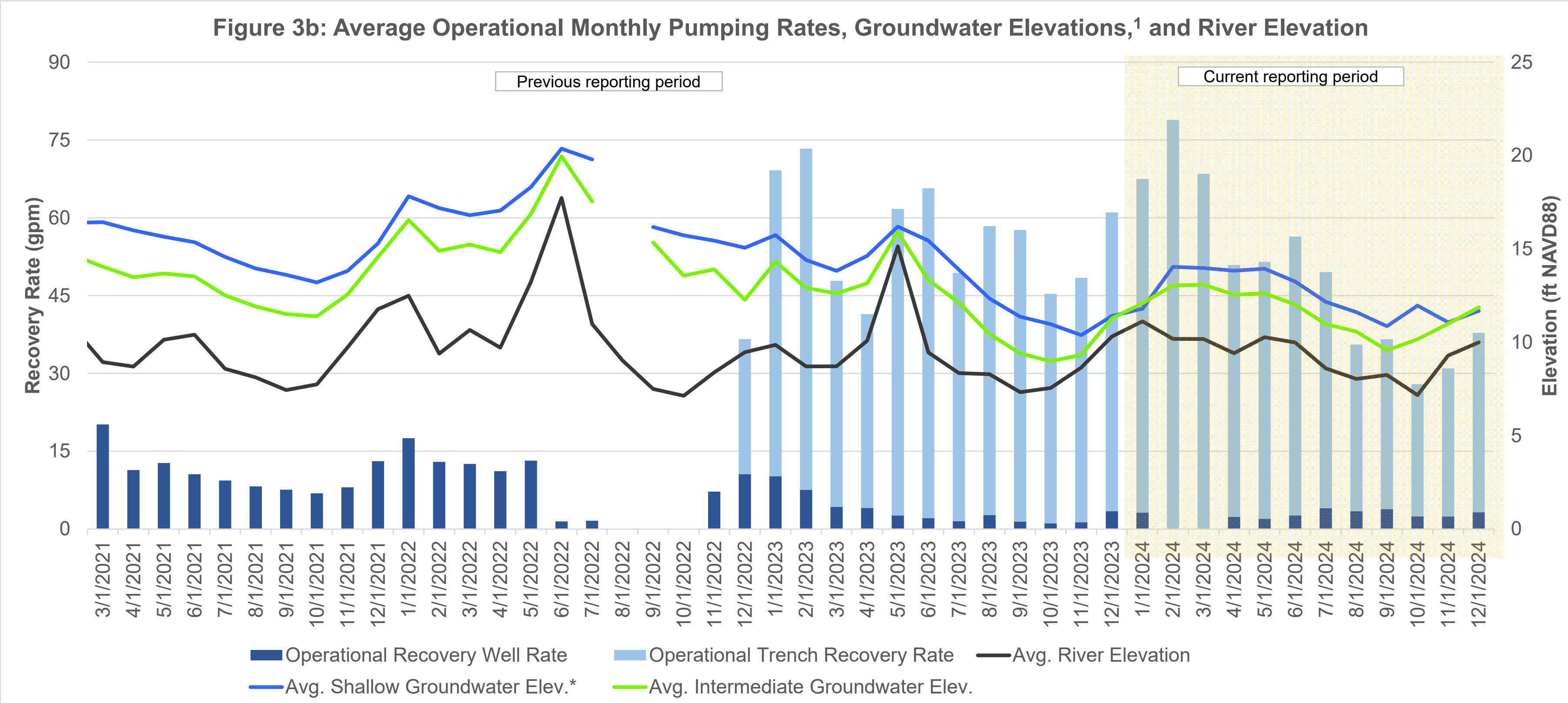
M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\SEE Report\2024 SEE\Arkema_SEE_2024.aprx REVISED: 01/07/2025 SCALE: 1:1,440 when printed at 11x17 DRAWN BY: GIS

Figure 3a: Average Monthly Pumping Rates, Groundwater Elevations,[1] and River Elevation



[1] Average groundwater elevations during trench construction from July through October were calculated using data sourced from manual and transducer values, dependent on data variablity and accuracy. Transducers were off for August 2022 and no manual water levels were recorded.

*The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the shallow aquifer.



[1] Average groundwater elevations during trench construction from July through October were caculated using data sourced from manual and transducer values, dependent on data variablity and accuracy. Transducers were off for August 2022 and no manual water levels were recorded.

*The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the shallow aquifer.

Figure 4a: Shallow Zone Monthly Horizontal Gradients

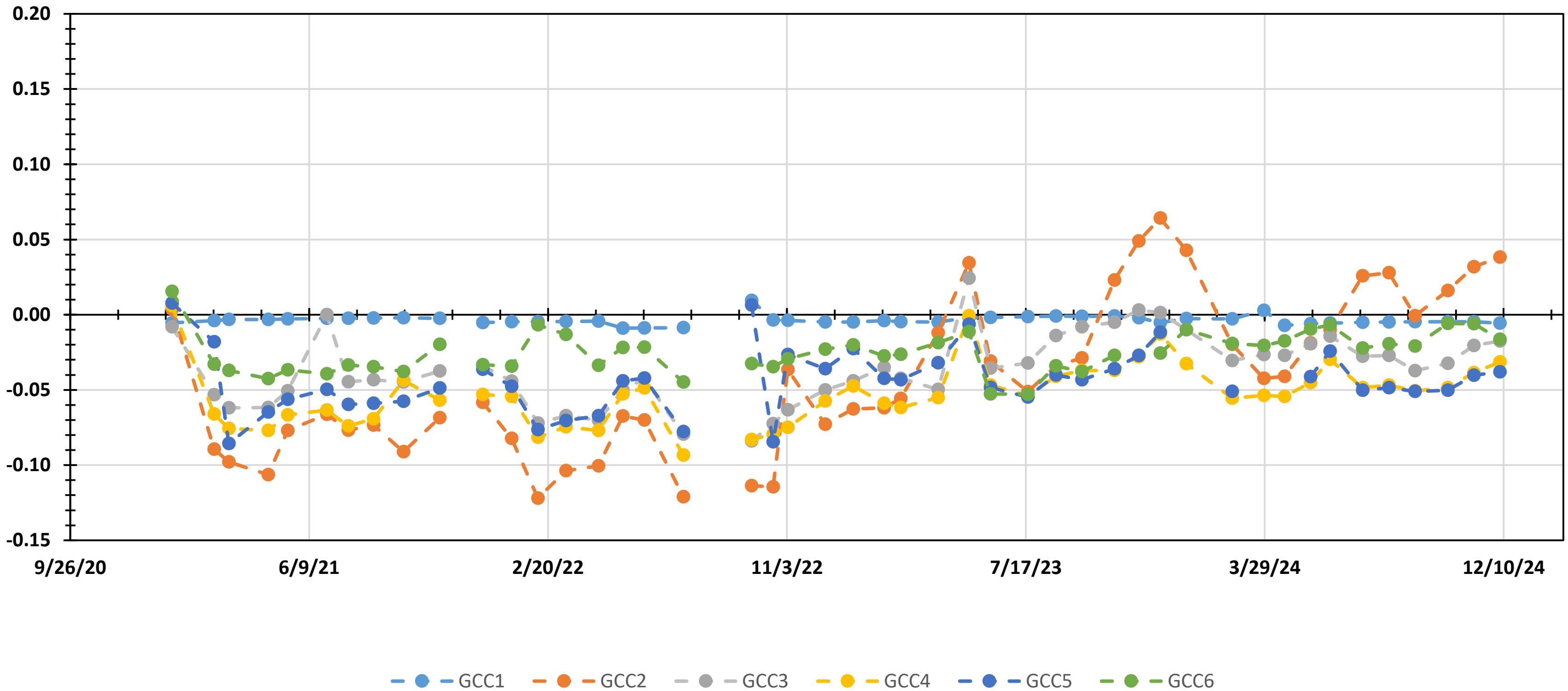


Figure 4b: Intermediate Zone Monthly Horizontal Gradients

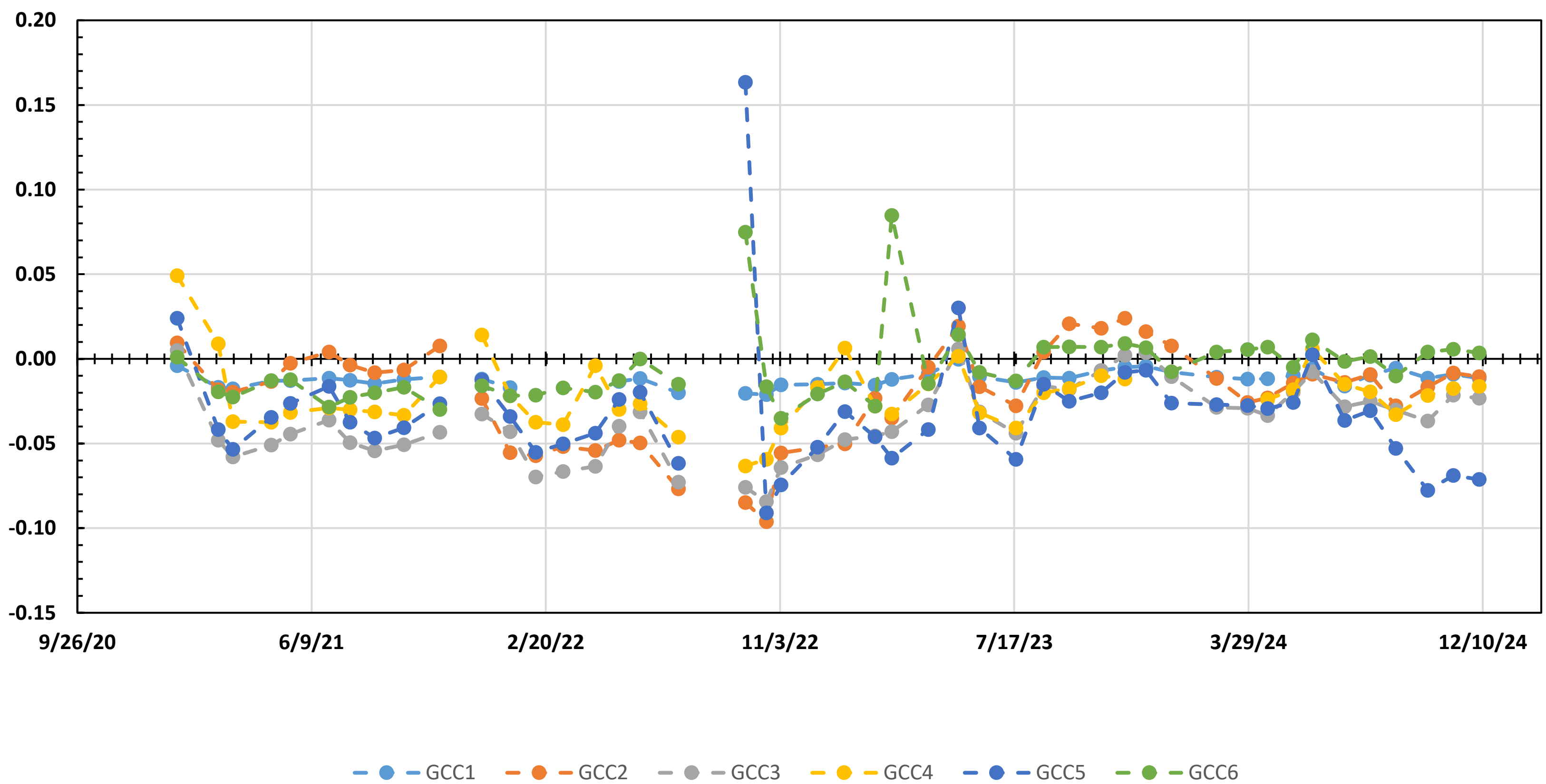


Figure 4c: Deep Zone Monthly Horizontal Gradients

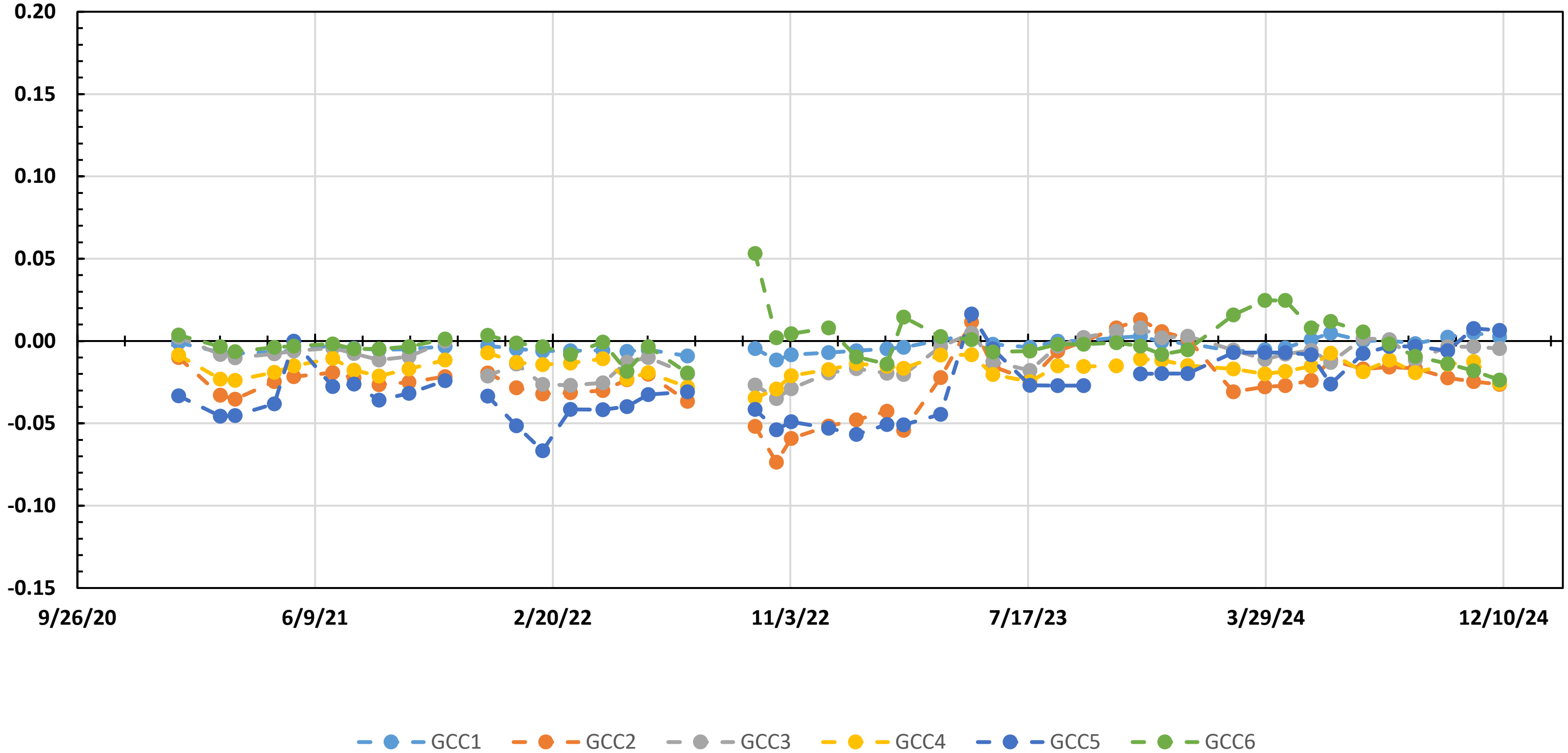
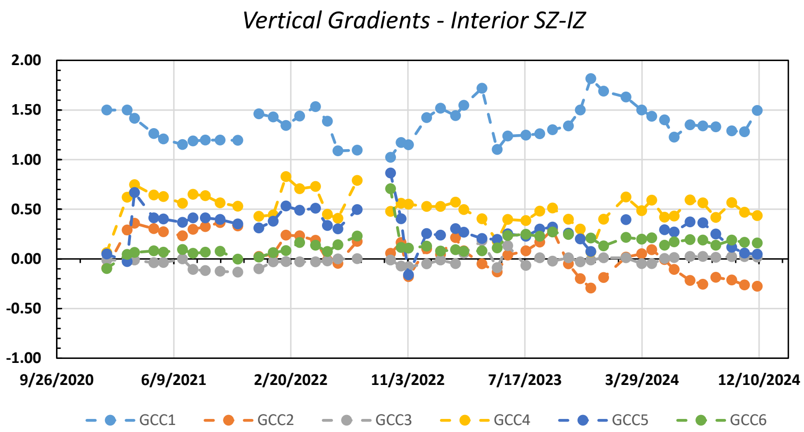
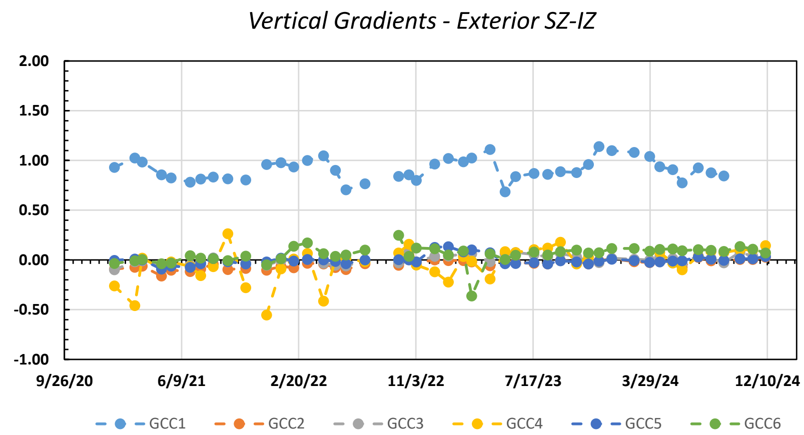
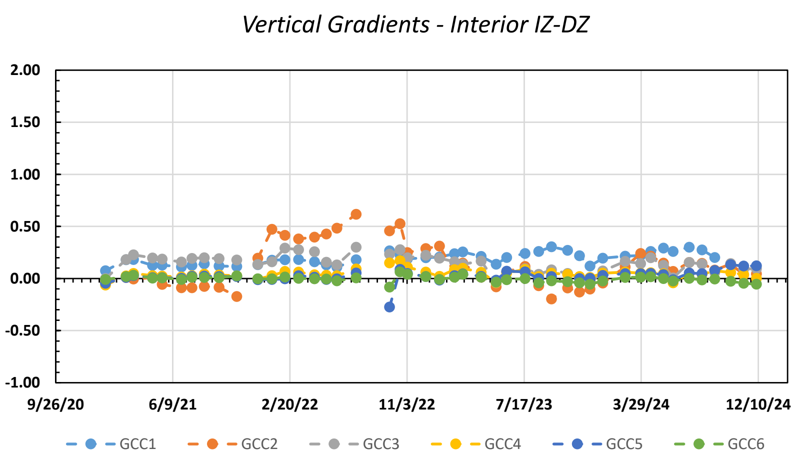
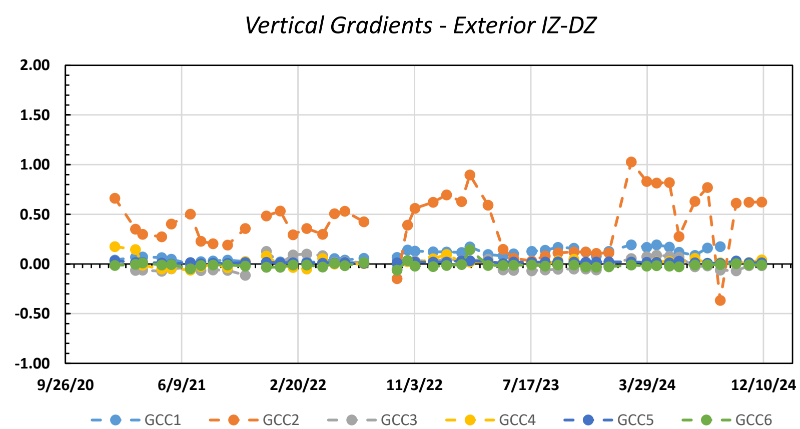


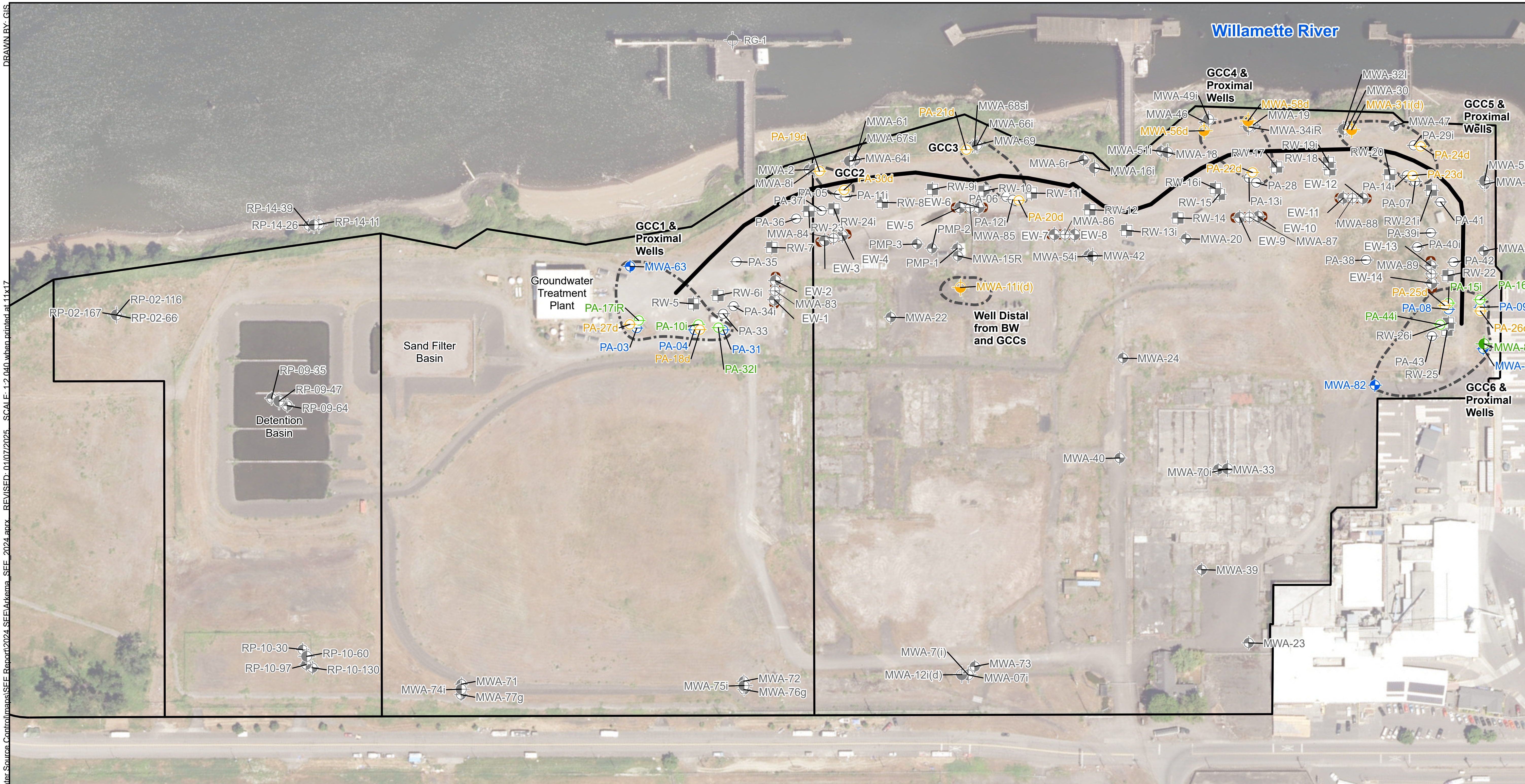
Figure 4d: Monthly Vertical Gradients











Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- River Gauge
- Shallow-Intermediate Zone Monitoring Well
- Extraction Trench (Not To Scale)
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Well Regions

Notes:
Greyed out locations not sampled.
GCC = Gradient Control Cluster.
GWBW = Ground water barrier wall.

Figure 5
Wells by Region
System Effectiveness Evaluation
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\SEE Report\2024 SEE\Arkema_SEE_2024.aprx REVISED: 01/07/2025 SCALE: 1:2,040 when printed at 11x17 DRAWN BY: GIS

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

APPENDIX A COMPILED MONTHLY PROGRESS REPORTS

1050 SW 6th Avenue
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Portland, OR 97204

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erm.com

MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	15 March 2024
REFERENCE	0719595 Phase 106
SUBJECT	January 2024 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This January 2024 MPR summarizes the GW SCM performance monitoring data collected in January 2024. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four-remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four-remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 5 January 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of June to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during January 2024, the following transducers were:

<u>Fully out of service pending repairs:</u>

- PA-07
- PA-26d

<u>Out of service for a period but returned to full operation:</u>

- N/A

PA-07 and PA-26d both had faulted transducers, and replacements were ordered on 29 January 2024.

Some transducers onsite had the water elevations adjusted based on the recalibration event completed 20 February 2024. The January 2024 hydrographs shown in Attachment B-1 are the water elevations prior to adjusting for recalibration, but hydraulic gradients (Attachment B-2 and B-3) and groundwater elevation maps (Figures 2 through 4) account for the adjusted water table elevations. The revisions in water table elevations are noted in Attachment B.

3.2 HORIZONTAL AND VERTICAL GRADIENTS AT GRADIENT CONTROL POINTS

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After January 2024 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 5 January 2024 are shown below at each GCC (Table 1-1 and Table 1-2).

TABLE 1-1 JANUARY HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	29.01	PA-04	29.27	-0.003
	Intermediate	PA-17iR	11.73	PA-10i	12.55	-0.008

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
	Deep	PA-27d	10.90	PA-18d	11.07	-0.001
GCC2	Shallow	MWA-2	9.61	PA-05	6.69	0.043
	Intermediate	MWA-8i	9.40	PA-11i	8.84	0.008
	Deep	PA-19d	9.22	PA-30d	9.15	0.001
GCC3	Shallow	MWA-69	9.13	PA-06	10.18	-0.010
	Intermediate	MWA-66i	8.87	PA-12i	10.06	-0.010
	Deep	PA-21d	9.00	PA-20d	8.62	0.003
GCC4	Shallow	MWA-19	10.15	PA-28	13.43	-0.033
	Intermediate	MWA-34i	*	PA-13i	10.88	**
	Deep	MWA-58d	8.55	PA-22d	9.90	-0.015
GCC5	Shallow	MWA-47	9.51	PA-07	*	**
	Intermediate	PA-29i	9.42	PA-14i	10.83	-0.026
	Deep	PA-24d	8.60	PA-23d	9.65	-0.020
GCC6	Shallow	PA-09	11.84	PA-08	12.39	-0.010
	Intermediate	PA-16i	10.20	PA-15i	10.62	-0.008
	Deep	PA-26d	11.21	PA-25d	11.55	-0.005

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
M = manual groundwater elevation measurement

TABLE 1-2 JANUARY VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	29.27	PA-10i	12.55	1.69
		GCC2	PA-05	6.69	PA-11i	8.84	-0.19
		GCC3	PA-06	10.18	PA-12i	10.06	0.01
		GCC4	PA-28	13.43	PA-13i	10.88	0.40
		GCC5	PA-07	*	PA-14i	10.83	**

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
		GCC6	PA-08	12.39	PA-15i	10.62	0.132
	IZ-DZ	GCC1	PA-10i	12.55	PA-18d	11.07	0.20
		GCC2	PA-11i	8.84	PA-30d	9.15	-0.04
		GCC3	PA-12i	10.06	PA-20d	8.62	0.07
		GCC4	PA-13i	10.88	PA-22d	9.90	0.05
		GCC5	PA-14i	10.83	PA-23d	9.65	0.03
		GCC6	PA-15i	10.62	PA-25d	11.55	-0.02
Exterior	SZ-IZ	GCC1	PA-03	29.01	PA-17iR	11.73	1.10
		GCC2	MWA-2	9.61	MWA-8i	9.40	0.01
		GCC3	MWA-69	9.13	MWA-66i	8.87	0.02
		GCC4	MWA-19	10.15	MWA-34i	*	**
		GCC5	MWA-47	9.51	PA-29i	9.42	0.01
		GCC6	PA-09	11.84	PA-16i	10.20	0.12
	IZ-DZ	GCC1	PA-17iR	11.73	PA-27d	10.90	0.13
		GCC2	MWA-8i	9.40	PA-19d	9.22	0.11
		GCC3	MWA-66i	8.87	PA-21d	9.00	-0.01
		GCC4	MWA-34i	*	MWA-58d	8.55	**
		GCC5	PA-29i	9.42	PA-24d	8.60	0.02
		GCC6	PA-16i	10.20	PA-26d	11.21	-0.03

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation − Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; M = manual groundwater elevation measurement; SZ = Shallow Zone

3.3 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 5 January 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The GWET system was shut down for 23 days to reconfigure the trunk line to connect to Trenches 5, 6, and 7 to the previously unused Intermediate Zone conveyance line to mitigate back pressure effects on pumping rates. However, the upgrades to the GWET system impacted pumping operations.

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. As shown in Attachment B-2, Shallow Zone horizontal gradient trends historically have been trending toward inward at GCC5 and GCC6. During the month of January, however, horizontal gradients are only trending toward inward at GCC1 and GCC6. Despite this month’s changes, overall gradients are still substantially closer to inward than observed in January 2024.

In January 2024, horizontal gradients in the Shallow and Intermediate Zone were inward at GCC2. The horizontal gradients in the Deep Zone were inward at GCC2 and GCC3.

River elevations are shown over time on Figure 1-1 and 1-2 below, and in an inset on the potentiometric surface maps i(Figures 2 through 4). The river elevation in January 2024 varied with an average of 11.12 feet NAVD88 with a minimum elevation of 6.99 feet NAVD88 and a maximum elevation of 15.23 feet NAVD88 observed toward the end of the month, a higher maximum than in January 2024 (12.69 feet NAVD88). Historically, the river elevation is at its highest in May and decreases until its lowest in October, making it more challenging during late summer and fall months to achieve inward gradients. As the wet season continues, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise with exterior groundwater elevations, there may be increasing trends toward inward horizontal gradients at all GCCs throughout the wet season.

The difference between average interior Shallow Zone groundwater elevations and river level elevation were 5.88 ft and 0.68 ft in January 2023 and January 2024, respectively. A potentiometric separation is still noticeable exterior to the GWBW, indicating that it is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward, except for GCC2 being upward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were downward as shown on Figure 5 and in Attachment B-2.

The vertical groundwater gradient at GCC4 was unable to be calculated due to an anomalous groundwater elevation reading at MWA-34i. Compared to other wells in the Intermediate Zone, the rate of change of the water level elevation at MWA-34i during large rainfall events is much higher and will be investigated. The vertical gradient at GCC5 was unable to be calculated due to an anomalous groundwater elevation reading at PA-07 from a faulted transducer. A replacement transducer was ordered on 29 January 2024.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2 and GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6 and Attachment B. The vertical groundwater gradient at GCC4 exterior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at and MWA-34i as previously discussed.

3.3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

- 6 January 2024: ERM, on behalf of LSS, shut down the GWET system due to GWET system upgrades, which included reconfiguring the trunk line to connect to Trenches 5, 6, and 7 to the Intermediate Zone conveyance line. The ODEQ was notified of the shutdown, and discharge was restarted on 29 January 2024.

3.3.2 RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 13.30 gallons per minute (gpm) for the entire month of January 2024, including non-operational periods. The average influent flow during operational periods was 67.51 gpm. Reconfiguring the trunk line to connect to Trenches 5, 6, and 7 to the Intermediate Zone conveyance line was completed on 29 January 2024. Prior to reconfiguring the trunk line the operational average flow rate was 45.04 gpm. After reconfiguring the trunk line the operational average flow rate was 66.02 gpm with flows as high as 87.56 gpm observed immediately after startup. The trunk line was reconfigured to mitigate back pressure effects on pumping rates. However, to reconfigure the trunk line, the GWET system was shut down for 23 days, reducing the total flow rate for January 2024. LSS is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

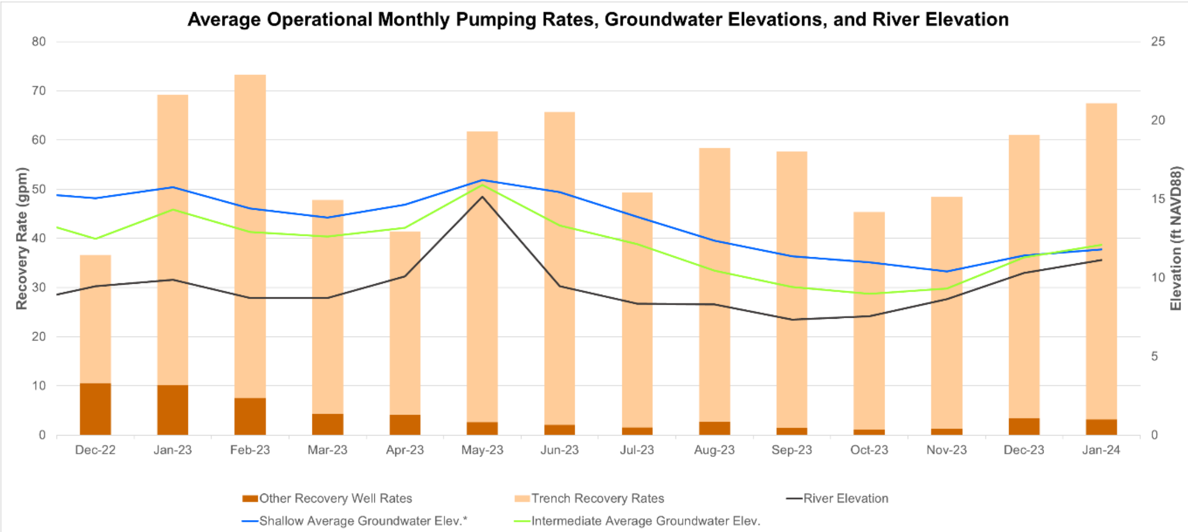
Site-wide redevelopment of the EW in the extraction trenches is planned for Q1 2024 to mitigate the biofouling and turbidity within the EWs that is affecting flow rates.

TABLE 1-3 RECOVERY WELL PUMPING RATES

Recovery Well	January 2024 Average Operational Pumping Rate (gpm)	January 2024 Average Monthly Pumping Rate (gpm)
RW-14	1.05	0.20
RW-22*	0.00	0.00
RW-23*	0.00	0.00
RW-25	2.11	0.41
EW-01	1.08	0.21
EW-02	2.97	0.38
EW-03	6.88	1.33
EW-04	5.48	1.41
EW-05	12.16	3.53
EW-06	3.82	0.37
EW-07*	0.00	0.00
EW-08	2.38	0.61
EW-09	1.84	0.41
EW-10	10.42	0.67
EW-11	2.38	0.61
EW-12	3.50	0.23
EW-13	1.47	0.33
EW-14	9.98	2.58
Total	67.51	13.30

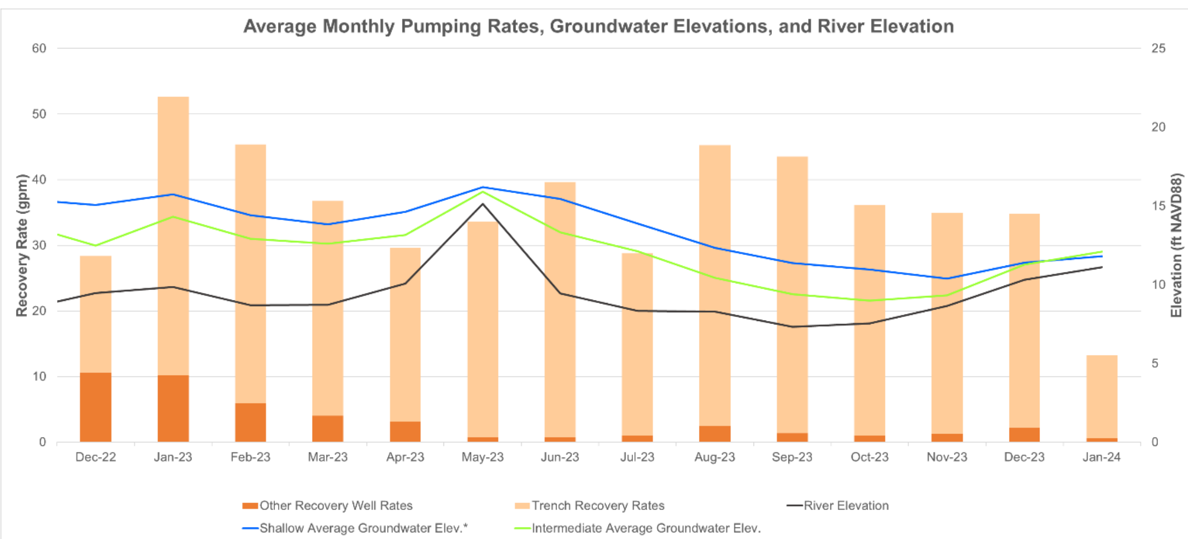
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

3.3.3 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The RWs and EWs that are not operating as designed due to possible biofouling and sediment accumulation in the Trenches filter pack will be redeveloped in February 2024. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	5/29/2024 *

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in January 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided in Attachment B-2 for the Shallow, Intermediate, and Deep Zones were inward at GCC2 and trending toward inward at GCC5 and GCC6 in the Shallow Zone and GCC3 in the Deep Zone. Additionally, groundwater elevations show a noticeable difference in elevation across the GWBW, indicating the GWBW is functioning via impeding groundwater flow.

- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward, except for GCC2 being inward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2 and GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6.
- The average river elevation in January 2024 was 11.12 feet NAVD88 with a minimum elevation of 6.99 feet NAVD88 and a maximum elevation of 15.23 feet NAVD88. The seasonal river level elevation trends indicate a seasonal high in May and a seasonal low in October.

5.2 GROUNDWATER EXTRACTION

Based on January 2024 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, and 3 has diminished. The realignment on the south end of the wellfield discussed previously is anticipated to substantially improve extraction rates at Trenches 5, 6, and 7. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. More time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

The groundwater extraction flow rate is currently limited by a combination of groundwater elevation, fouling of the EWs within the trenches, and back pressure in the conveyance line. In November and December 2023, water from Trench 7 was routed via overland hoses to the Intermediate Zone trunk line to reduce the effects of back pressure in the Shallow Zone trunk line on pumping rates. In January, the wellfield was reconfigured to connect three of the trenches to the Intermediate Zone trunk line and this is anticipated to mitigate the impact of back pressure in the conveyance lines.

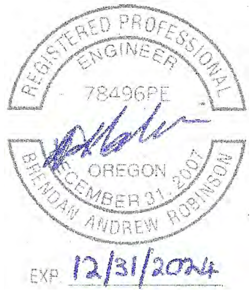
Additionally, the trenches will be redeveloped in February 2024 to mitigate the impact of silt on pumping rates.

5.3 RECOMMENDATIONS AND FUTURE WORK

LSS will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

Brendan Robinson, PE
Partner



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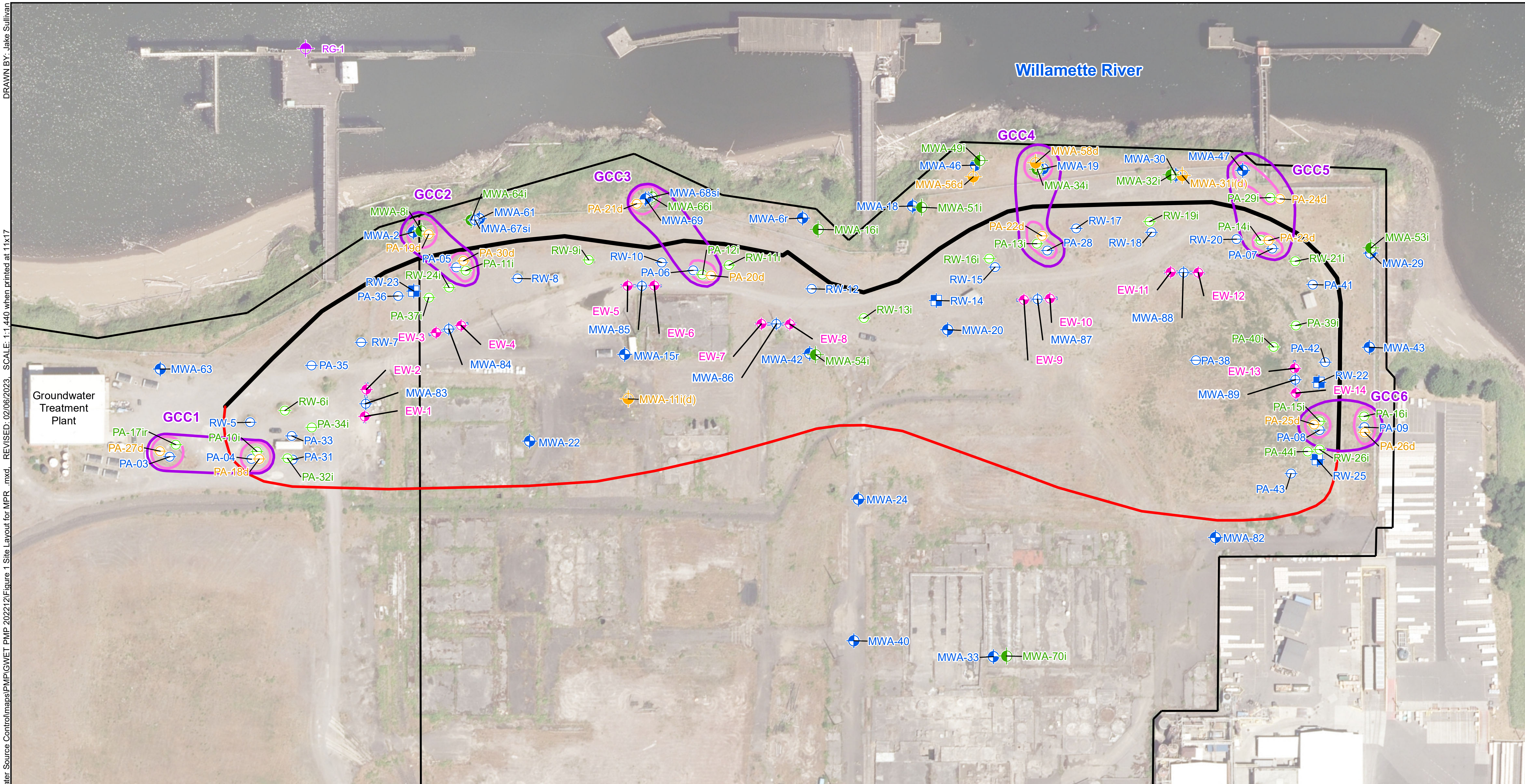
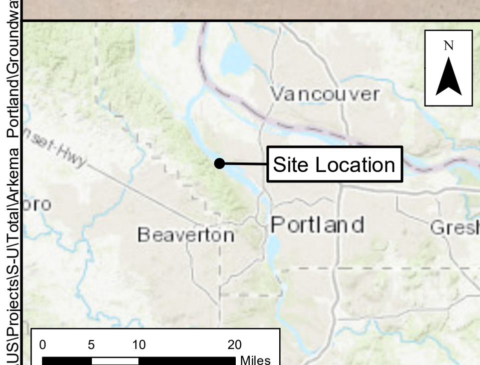
FIGURES





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

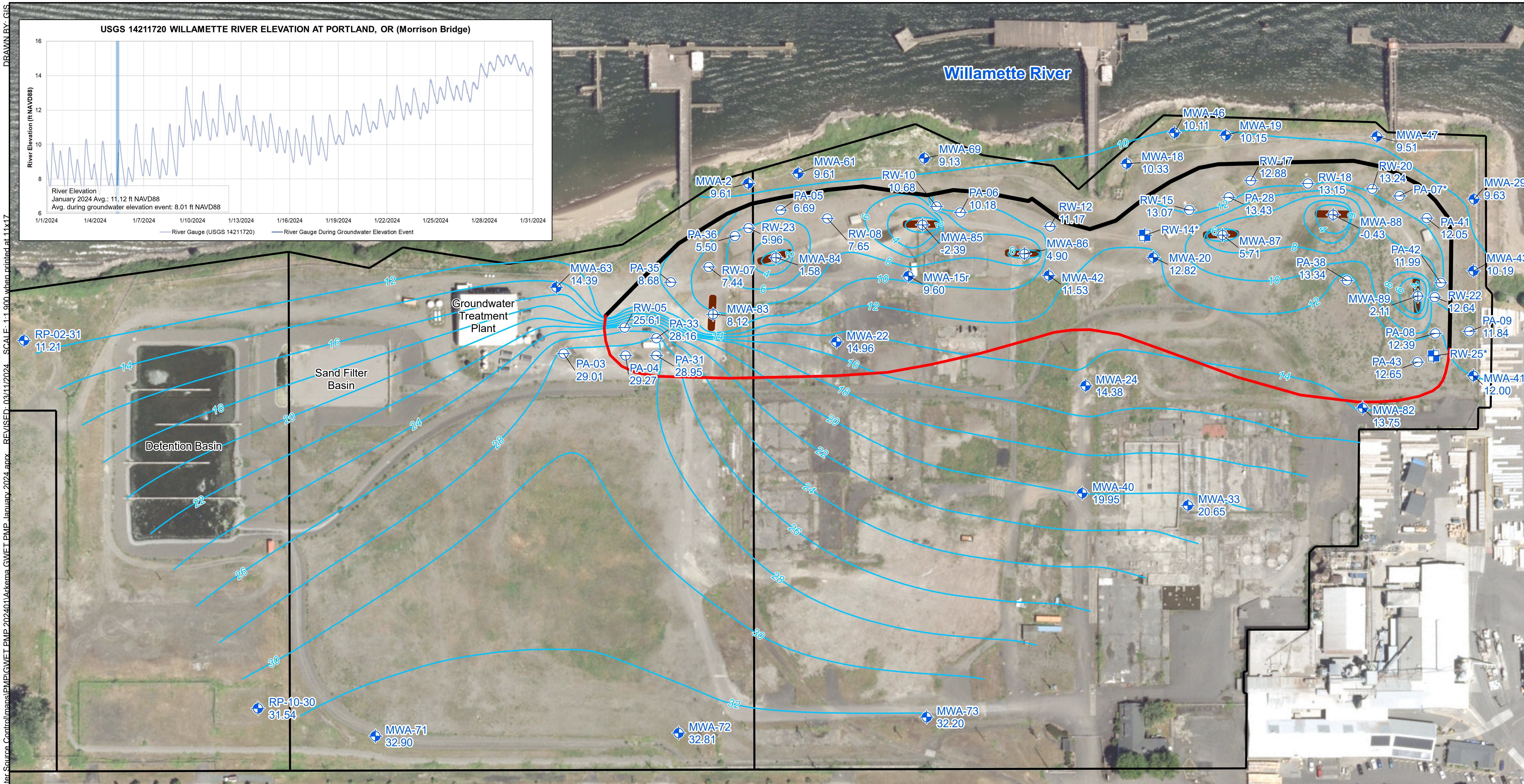
0 120 240
Feet

Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR_.mxd REVISED: 02/06/2023 SCALE: 1:1,440 when printed at 11x17 DRAWN BY: Jake Sullivan

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

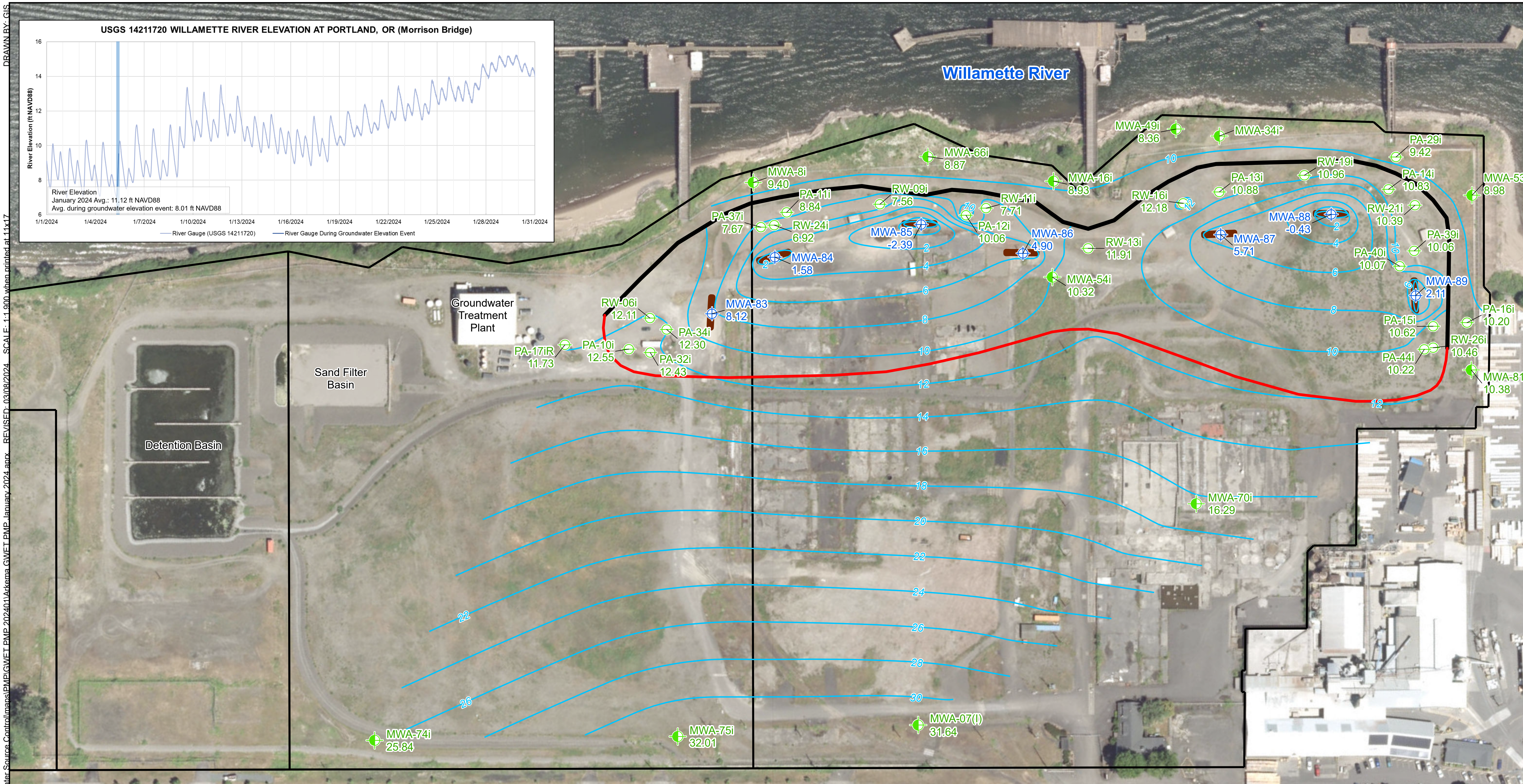
Notes:
* Value not used for contouring.
Water levels collected January 5, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
January 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected January 5, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
January 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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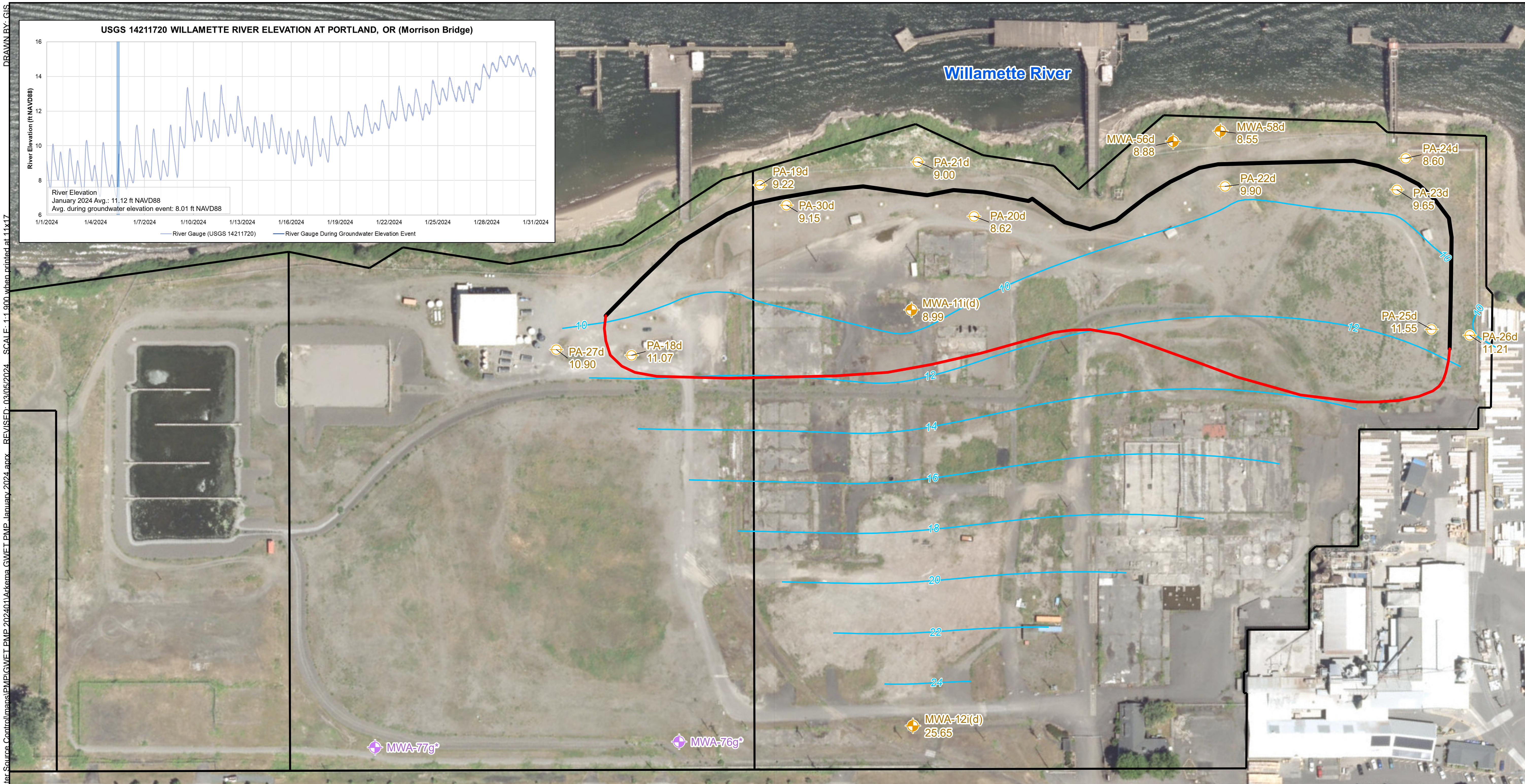

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected January 5, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
January 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

DRAWN BY: GIS SCALE: 1:1,900 when printed at 11x17 REVISED: 03/05/2024 M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\01\Arkema GWET PMP January 2024.aprx

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected January 5, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
January 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\01Arkema GWET PMP January 2024.aprx REVISED: 03/05/2024 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: GIS

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected January 5, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
January 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\01\Arkema GWET PMP January 2024.aprx REVISED: 03/05/2024 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: GIS

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Fla

Table A-1
Transducer Malfunction Log: January 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC3	PA-26d	Deep	1/29/2024	Present	Transducer faulted, replacement ordered.
N/A	RW-13	Intermediate	1/29/2024	Present	Transducer faulted, replacement ordered.
N/A	RW-25	Shallow	1/29/2024	Present	Transducer faulted, replacement ordered.
GCC5	PA-07	Shallow	1/29/2024	Present	Transducer faulted, replacement ordered.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ERM

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

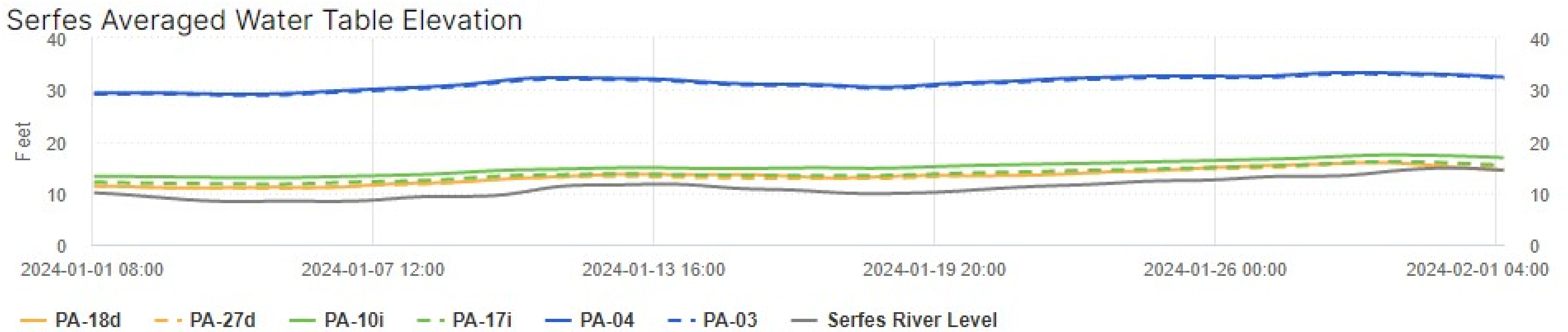
Table A-2
Recovery Well Status: January 2024
Arkema Inc. Facility
Portland, Oregon

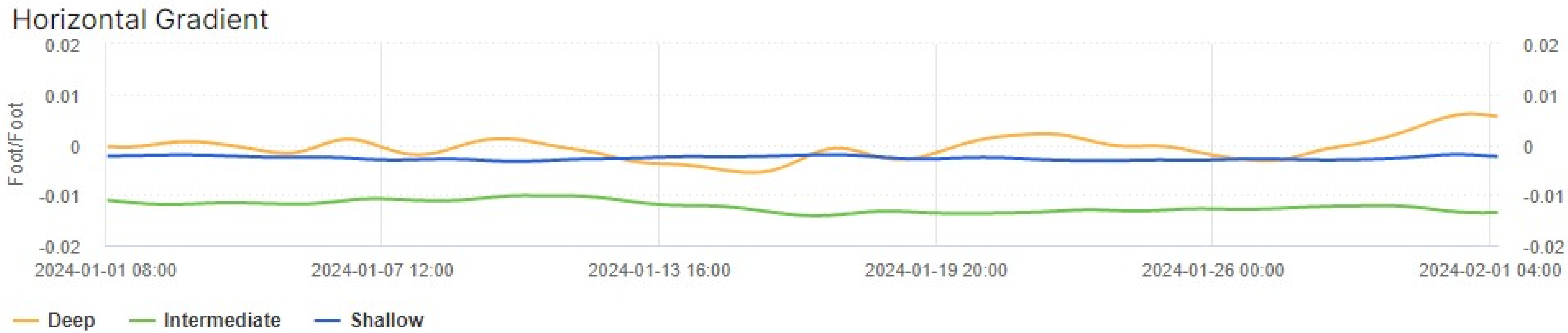
Recovery Well ID	Status as of 12/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Active	None	N/A	N/A	Good	Good	1.05	M	
RW-22	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to ground fault
RW-23	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels
RW-25	Active	None	N/A	N/A	Good	Good	2.11	M	
EW-01	Active	None	N/A	N/A	Good	Good	1.08	M	Off for part of the month due to plumbing repairs
EW-02	Active	None	N/A	N/A	Good	Good	2.97	M	
EW-03	Active	None	N/A	N/A	Good	Good	6.88	G	
EW-04	Active	None	N/A	N/A	Good	Good	5.48	G	
EW-05	Active	None	N/A	N/A	Good	Good	12.16	G	
EW-06	Active	None	N/A	N/A	Good	Good	3.82	G	Off for part of the month due to plumbing repairs
EW-07	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels in trench
EW-08	Active	None	N/A	N/A	Good	Good	2.38	M	
EW-09	Active	None	N/A	N/A	Good	Good	1.84	M	
EW-10	Active	None	N/A	N/A	Good	Good	10.42	G	
EW-11	Active	None	N/A	N/A	Good	Good	2.38	M	
EW-12	Active	None	N/A	N/A	Good	Good	3.50	G	
EW-13	Active	None	N/A	N/A	Good	Good	1.47	M	
EW-14	Active	None	N/A	N/A	Good	Good	9.98	G	

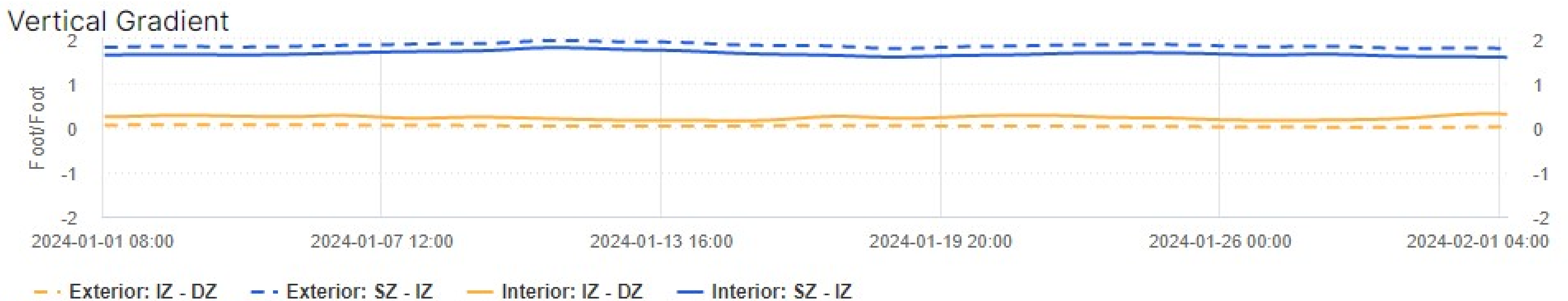
Notes:
* Recovery wells not in service
** Recovery wells in service part of the month
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1



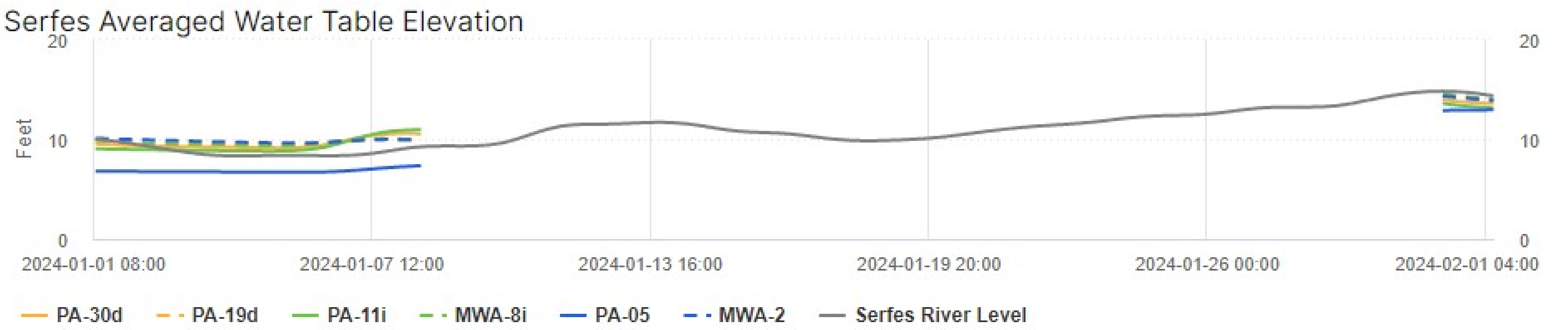


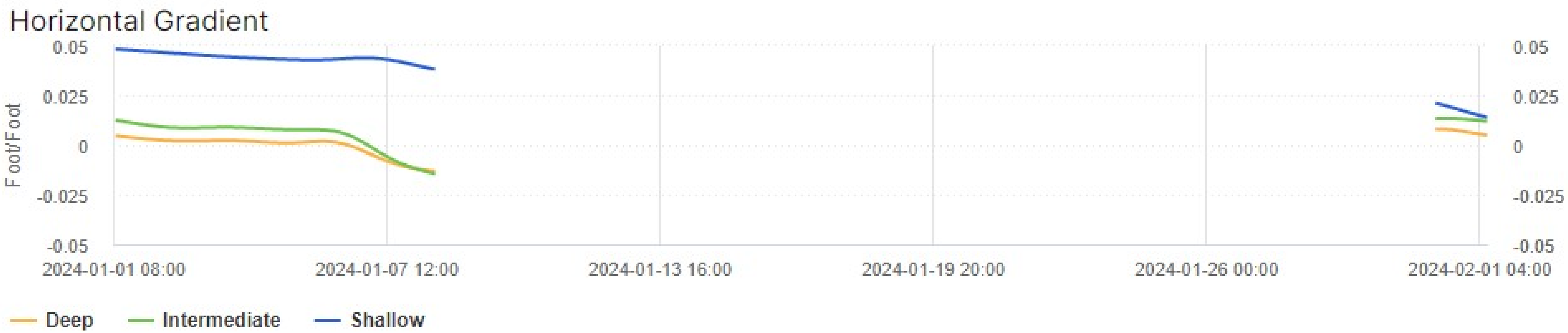


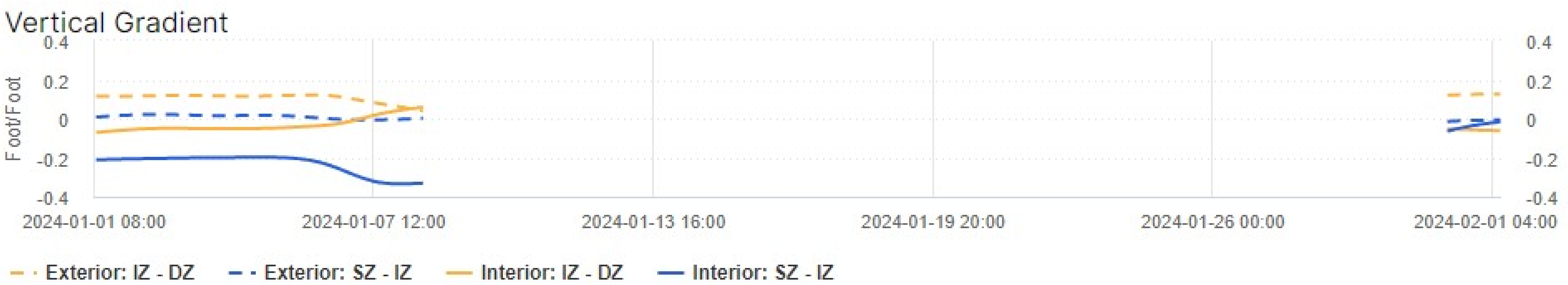
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

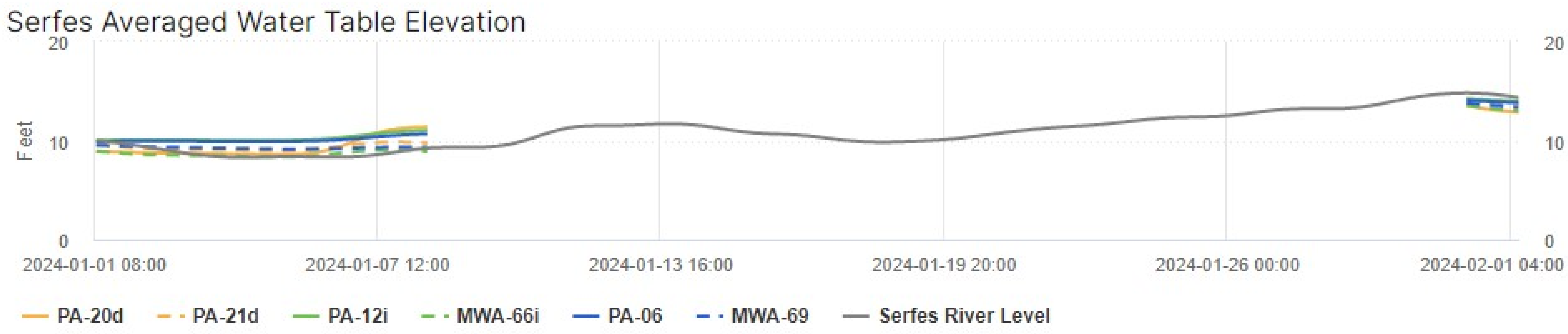


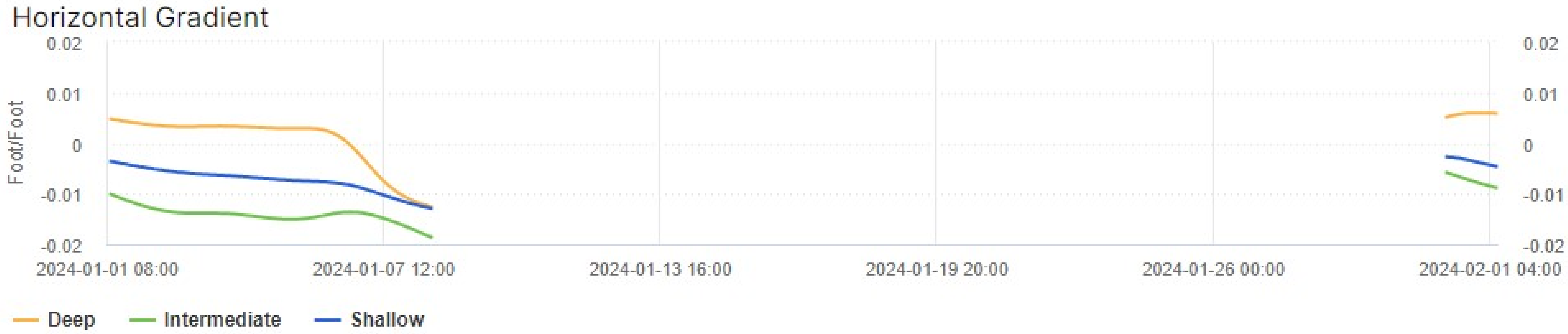


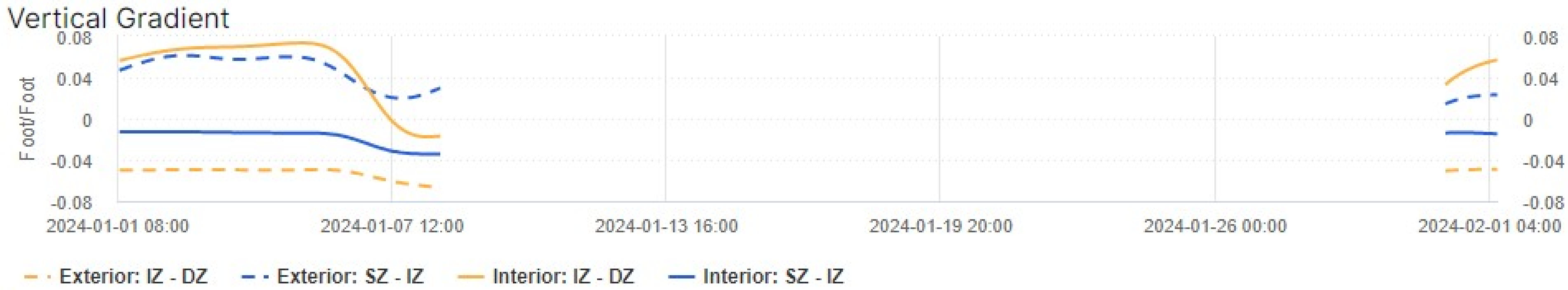


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3



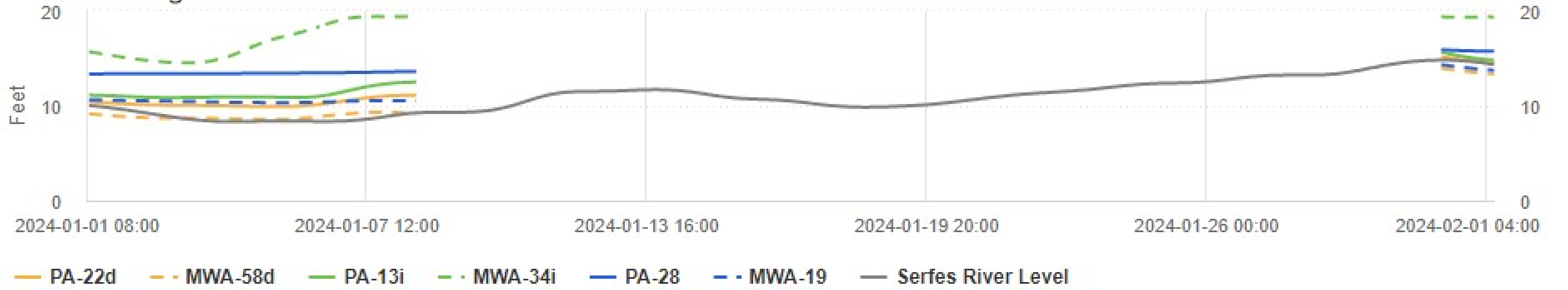




Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

Serfes Averaged Water Table Elevation

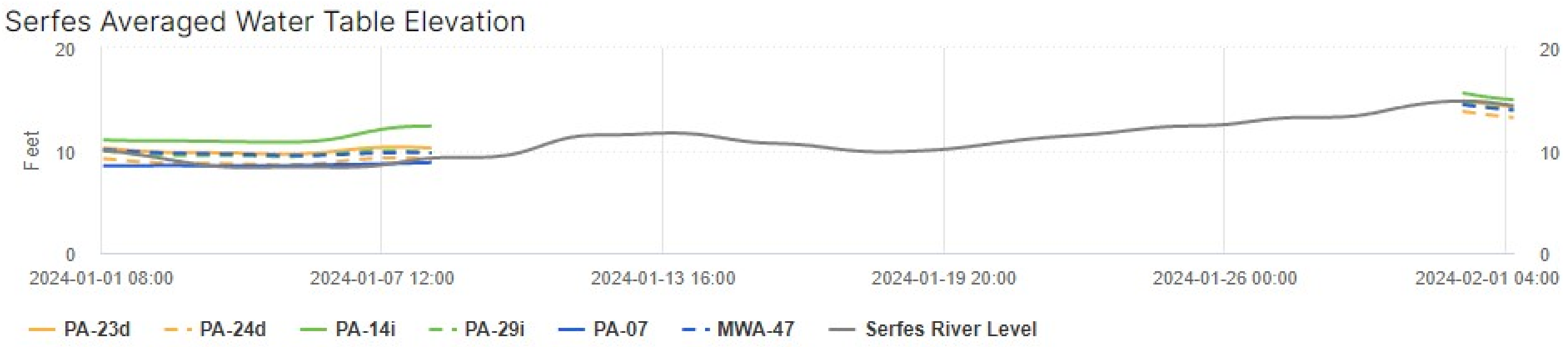


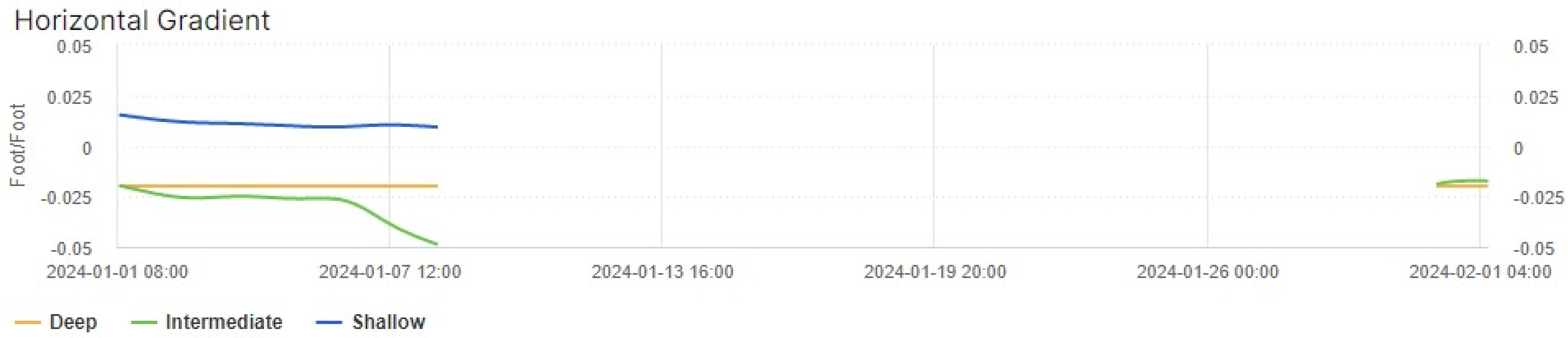
Horizontal Gradient

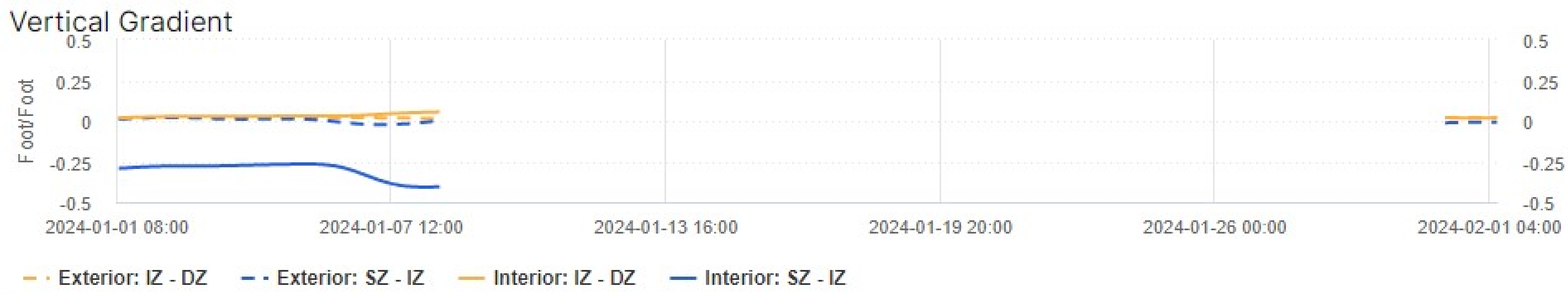
Vertical Gradient

Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5



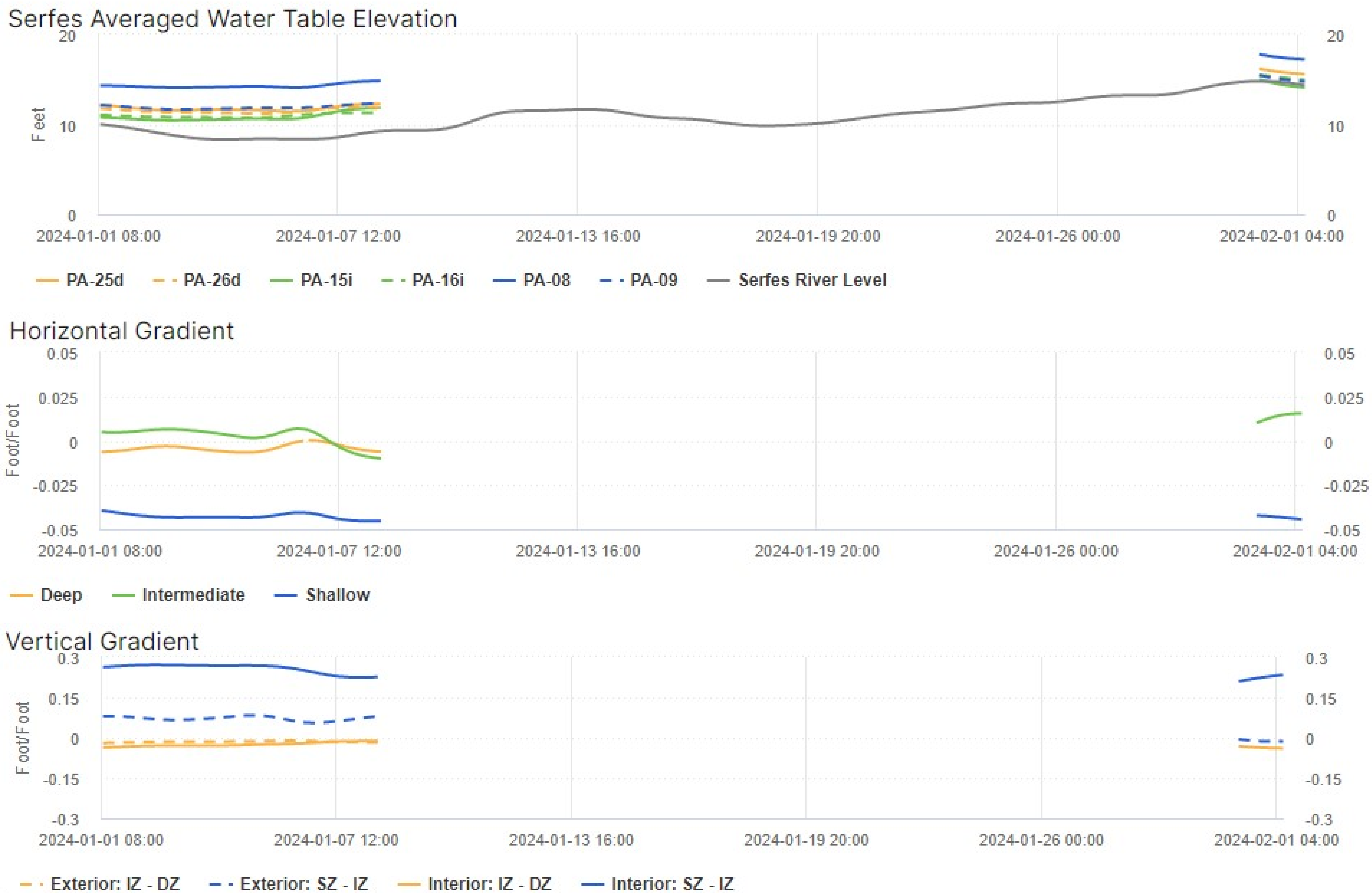




Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

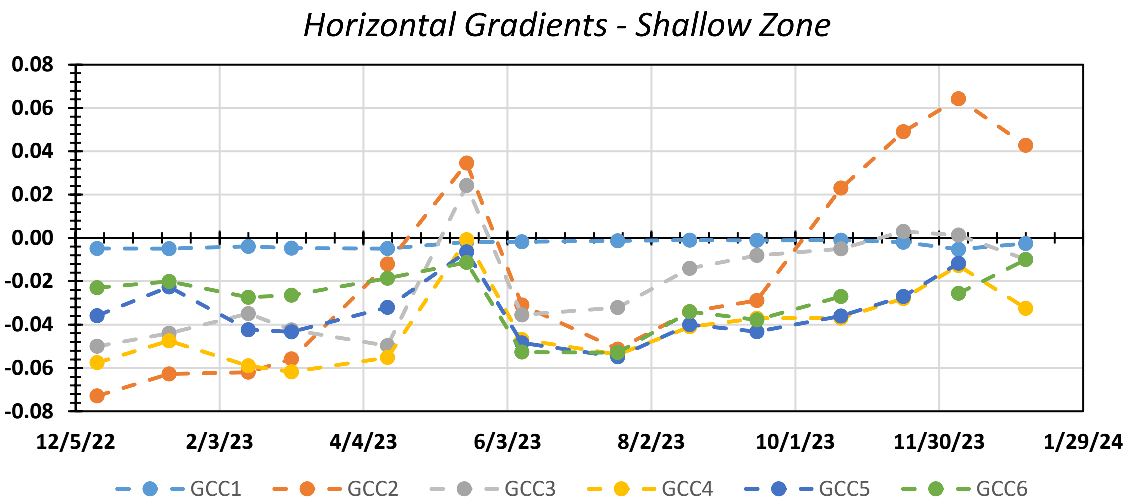


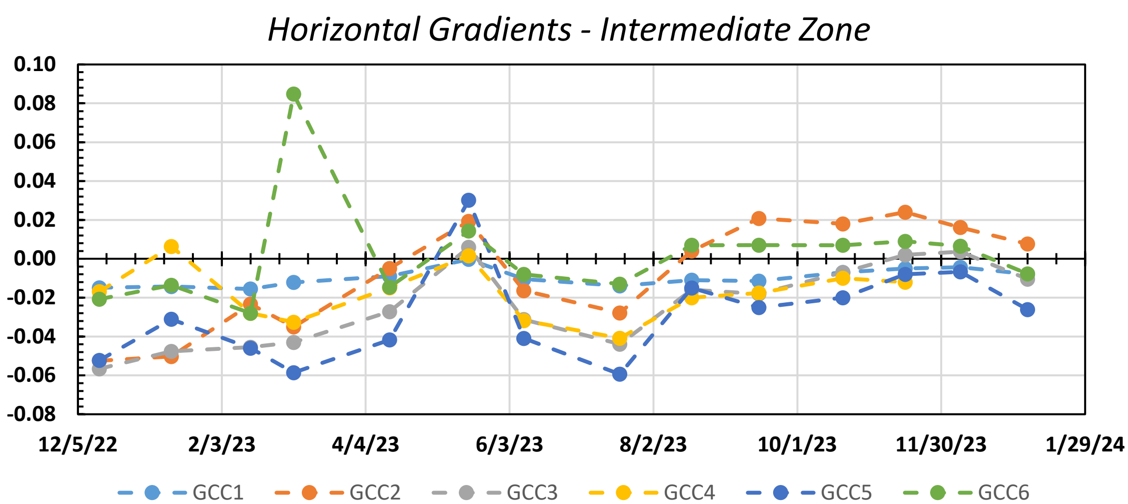
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

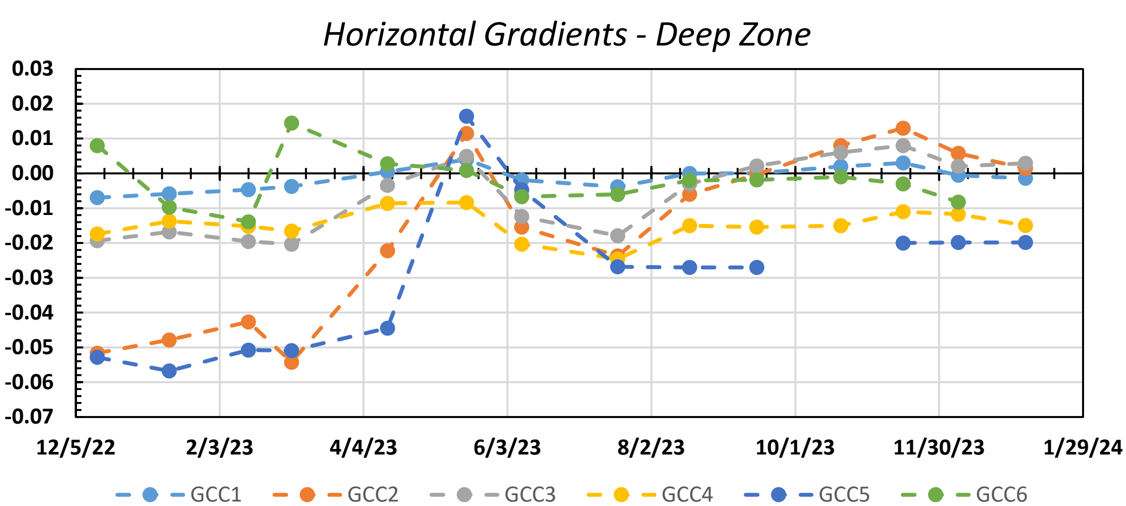
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: January 2024
Arkema Inc. Facility
Portland, Oregon





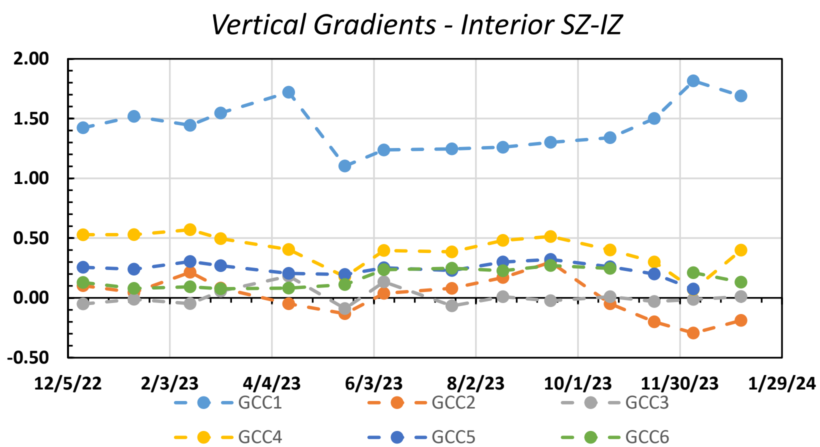


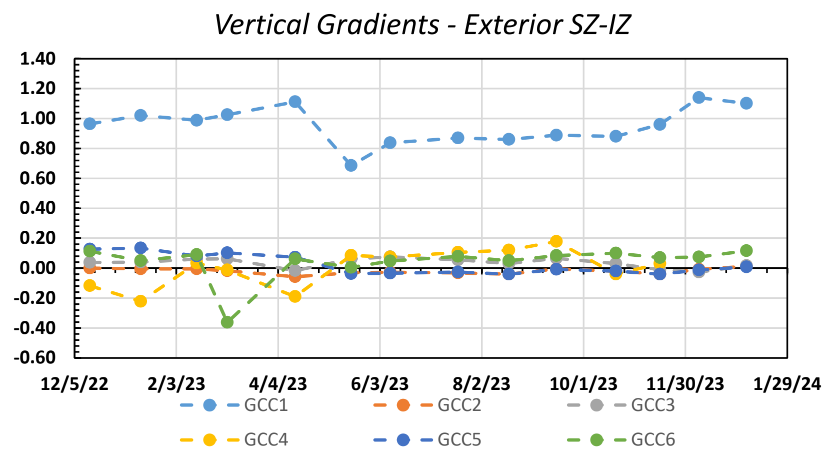
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

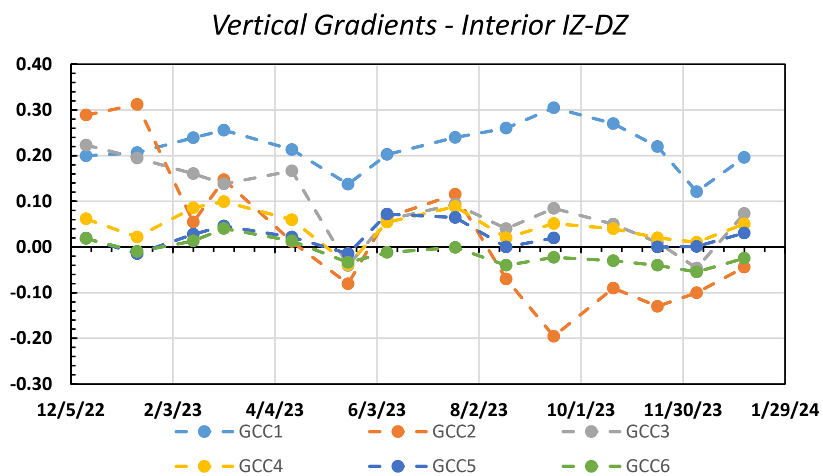
ATTACHMENT B-3 VERTICAL GRADIENTS

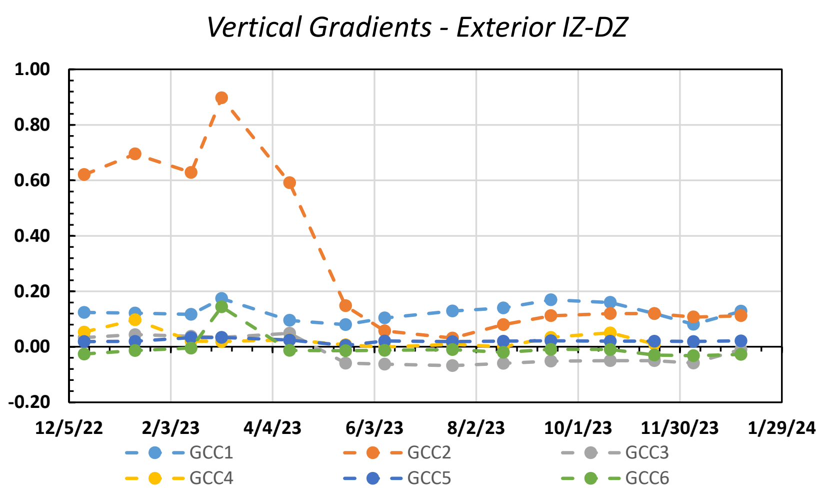
Attachment B-3

Vertical Gradients Summary: January 2024
Arkema Inc. Facility
Portland, Oregon









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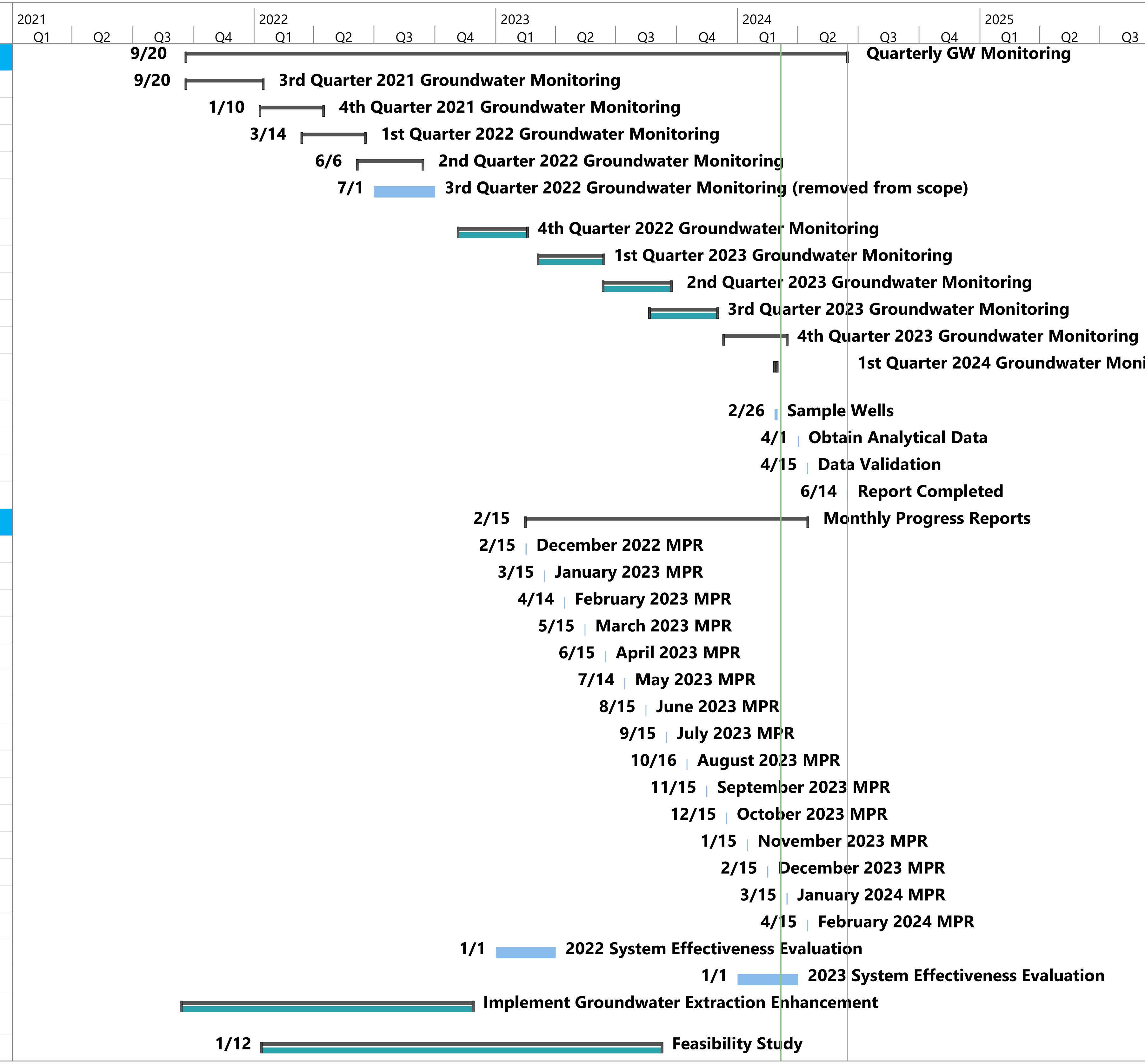
ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**719 days**	**Mon 9/20/21**	**Fri 6/14/24**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	*2nd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 6/12/23*	*Fri 9/22/23*
37	*3rd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 8/21/23*	*Fri 12/1/23*
42	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
47	**1st Quarter 2024 Groundwater Monitoring ***	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
48	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
49	Obtain Analytical Data	1 day	Mon 4/1/24	Mon 4/1/24
50	Data Validation	1 day	Mon 4/15/24	Mon 4/15/24
51	Report Completed	1 day	Fri 6/14/24	Fri 6/14/24
52	**Monthly Progress Reports**	**305 days**	**Wed 2/15/23**	**Mon 4/15/24**
53	*December 2022 MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
54	*January 2023 MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
55	*February 2023 MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
56	*March 2023 MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
57	*April 2023 MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
58	*May 2023 MPR*	*1 day*	*Fri 7/14/23*	*Fri 7/14/23*
59	*June 2023 MPR*	*1 day*	*Tue 8/15/23*	*Tue 8/15/23*
60	*July 2023 MPR*	*1 day*	*Fri 9/15/23*	*Fri 9/15/23*
61	*August 2023 MPR*	*1 day*	*Mon 10/16/23*	*Mon 10/16/23*
62	*September 2023 MPR*	*1 day*	*Wed 11/15/23*	*Wed 11/15/23*
63	*October 2023 MPR*	*1 day*	*Fri 12/15/23*	*Fri 12/15/23*
64	*November 2023 MPR*	*1 day*	*Mon 1/15/24*	*Mon 1/15/24*
65	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
66	January 2024 MPR	1 day	Fri 3/15/24	Fri 3/15/24
67	February 2024 MPR	1 day	Mon 4/15/24	Mon 4/15/24
68	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
69	2023 System Effectiveness Evaluation	66 days	Mon 1/1/24	Sun 3/31/24
70	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
78	***Feasibility Study***	***436 days***	***Wed 1/12/22***	***Fri 9/8/23***



Arkema Portland
Monthly Progress Report
Attachment C

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	19 April 2024
REFERENCE	0719595 Phase 106
SUBJECT	February 2024 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This February 2024 MPR summarizes the GW SCM performance monitoring data collected in February 2024. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four-remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four-remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 23 February 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of June to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during February 2024, the following transducers were:

<u>Fully out of service pending repairs:</u>

- PA-07
- PA-26d
- RW-13
- RW-25

<u>Out of service for a period but returned to full operation:</u>

- N/A

PA-07, PA-26d, RW-13, and RW-25 have faulted transducers, and are scheduled for repair in April 2024. RW-13 and RW-25 are not in the GCCs.

Some transducers onsite had the water elevations adjusted based on the recalibration event completed 13 March 2024. The February 2024 hydrographs shown in Attachment B-1 are the water elevations prior to adjusting for recalibration. Hydraulic gradients (Attachment B-2 and B-3) and groundwater elevation maps (Figures 2 through 4) account for the adjusted groundwater elevations measurements. The revisions in water table elevations are noted in Attachment B.

3.2 HORIZONTAL AND VERTICAL GRADIENTS AT GRADIENT CONTROL POINTS

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After February 2024 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 23 February 2024 are shown below at each GCC (Table 1-1 and Table 1-2).

TABLE 1-1 FEBRUARY HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	29.95	PA-04	30.22	-0.003
	Intermediate	PA-17iR	12.95	PA-10i	14.09	-0.011

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
	Deep	PA-27d	11.70	PA-18d	12.47	-0.006
GCC2	Shallow	MWA-2	10.15	PA-05	11.50	-0.020
	Intermediate	MWA-8i	10.45	PA-11i	11.29	-0.012
	Deep	PA-19d	8.85	PA-30d	10.51	-0.031
GCC3	Shallow	MWA-69	9.80	PA-06	13.03	-0.030
	Intermediate	MWA-66i^M	9.68	PA-12i	12.93	-0.029
	Deep	PA-21d^M	8.96	PA-20d	9.65	-0.005
GCC4	Shallow	MWA-19	10.66	PA-28	16.26	-0.056
	Intermediate	MWA-34i	*	PA-13i	12.28	**
	Deep	MWA-58d	9.57	PA-22d	11.09	-0.017
GCC5	Shallow	MWA-47	10.30	PA-07^M	15.57	-0.051
	Intermediate	PA-29i	10.37	PA-14i	11.83	-0.027
	Deep	PA-24d	9.64	PA-23d	10.01	-0.007
GCC6	Shallow	PA-09	13.07	PA-08	14.13	-0.019
	Intermediate	PA-16i	11.44	PA-15i	11.21	0.004
	Deep	PA-26d^M	11.83	PA-25d	10.83	0.016

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
M = manual groundwater elevation measurement

TABLE 1-2 FEBRUARY VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	30.22	PA-10i	14.09	1.63
		GCC2	PA-05	11.50	PA-11i	11.29	0.02
		GCC3	PA-06	13.03	PA-12i	12.93	0.01
		GCC4	PA-28	16.26	PA-13i	12.28	0.62
		GCC5	PA-07^M	15.57	PA-14i	11.83	0.39

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
		GCC6	PA-08	14.13	PA-15i	11.21	0.217
	IZ-DZ	GCC1	PA-10i	14.09	PA-18d	12.47	0.22
	IZ-DZ	GCC2	PA-11i	11.29	PA-30d	10.51	0.11
	IZ-DZ	GCC3	PA-12i	12.93	PA-20d	9.65	0.17
	IZ-DZ	GCC4	PA-13i	12.28	PA-22d	11.09	0.06
	IZ-DZ	GCC5	PA-14i	11.83	PA-23d	10.01	0.05
	IZ-DZ	GCC6	PA-15i	11.21	PA-25d	10.83	0.01
Exterior	SZ-IZ	GCC1	PA-03	29.95	PA-17iR	12.95	1.08
Exterior	SZ-IZ	GCC2	MWA-2	10.15	MWA-8i	10.45	-0.02
Exterior	SZ-IZ	GCC3	MWA-69	9.80	MWA-66i[M]	9.68	0.01
Exterior	SZ-IZ	GCC4	MWA-19	10.66	MWA-34i	*	**
Exterior	SZ-IZ	GCC5	MWA-47	10.30	PA-29i	10.37	-0.01
Exterior	SZ-IZ	GCC6	PA-09	13.07	PA-16i	11.44	0.11
Exterior	IZ-DZ	GCC1	PA-17iR	12.95	PA-27d	11.70	0.19
Exterior	IZ-DZ	GCC2	MWA-8i	10.45	PA-19d	8.85	1.03
Exterior	IZ-DZ	GCC3	MWA-66i[M]	9.68	PA-21d[M]	8.96	0.06
Exterior	IZ-DZ	GCC4	MWA-34i	*	MWA-58d	9.57	**
Exterior	IZ-DZ	GCC5	PA-29i	10.37	PA-24d	9.64	0.02
Exterior	IZ-DZ	GCC6	PA-16i	11.44	PA-26d[M]	11.83	-0.01

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; M = manual groundwater elevation measurement; SZ = Shallow Zone

3.3 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 23 February 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. As shown in Attachment B-2, the Shallow, Intermediate, and Deep Zones horizontal gradients are outward during the month of February, except at GCC6 in the Intermediate and Deep Zones.

River elevations are shown over time on Figure 1-1 and 1-2 below, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in February 2024 varied with an average of 10.18 feet NAVD88 with a minimum elevation of 7.95 feet NAVD88 and a maximum elevation of 13.83 feet NAVD88 observed toward the end of the month, a higher maximum than in February 2023 (11.75 feet NAVD88). Historically, the river elevation is at its highest in May and decreases until its lowest in October, making it more challenging during late summer and fall months to achieve inward gradients.

The difference between average interior Shallow Zone groundwater elevations and river level elevation were 5.70 ft and 3.86 ft in February 2023 and February 2024, respectively. The difference between river level and Shallow Zone groundwater elevations is anticipated to grow as water levels rise on the exterior of the wall and extraction capacity is maintained in the Target Capture Zone. A potentiometric separation is still noticeable exterior to the GWBW, indicating that is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were downward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 upward and the rest downward as shown on Figure 5 and in Attachment B-2.

The vertical groundwater gradient at GCC4 was unable to be calculated due to an anomalous groundwater elevation reading at MWA-34i. After a camera inspection was completed at MWA-34i, a hole in the well casing was discovered. This well is scheduled for inspection by a licensed driller, and then repair or replacement.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were primarily downward with GCC6 being upward, as shown on Figure 6 and Attachment B.

The vertical groundwater gradient at GCC4 exterior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at and MWA-34i as previously discussed.

As discussed below in section 3.3.2, GWET pumping rates have been operating at lower levels since December 2023 through the end of February 2024 due system maintenance and upgrade activities. The water level measurements collected on 23 February 2024 were within in this period of reduced groundwater extraction. These lower rates of groundwater extraction have resulted in the inward gradients observed in December 2023 trending to outward gradients in February 2024. Extraction rates achieved after the maintenance and upgrades are higher than previously achieved in December 2023, and are anticipated to restore a trend toward inward gradients.

3.3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

16 February 2024: The GWET system was shut down for 10 hours due to a power outage, discharge restarted 17 February 2024.

During December 2023, jetting of the Shallow Zone trunk line was completed to address fouling of the conveyance piping. This maintenance reduced the back pressure and increased operational average flow rates from 33.13 gpm to 55.20 gpm. During January 2024, the GWET system was shut down for 23 days to reconfigure the conveyance lines to connect to Trenches 5, 6, and 7 to the previously unused Intermediate Zone conveyance line. This upgrade to mitigated back pressure effects on pumping rates. Operational average flow rates increased to 66.02 gpm after reconfiguration.

The EWs in Trenches 1, 4, 5, and 6 were redeveloped between 13 February and 29 February 2024 to address solids accumulation in the gravel backfill filter pack. The pumps from these EWs were removed during the redevelopment activities, however the remaining extraction trenches 2, 3, and 7 remained active. This resulted in lower overall groundwater extraction rates during this period. Following redevelopment extraction flows have increased from these trenches. Individual flow rates are discussed in the following section.

3.3.2 RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 59.80 gallons per minute (gpm) for the entire month of February 2024, including non-operational periods. The average influent flow during operational periods was 78.86 gpm. Redevelopment of Trenches 1, 4, and 6 was completed 29 February 2024 to mitigate biofouling and solids accumulation within the EWs and trench gravel backfill that were limiting flow rates. Prior to redevelopment the operational average flow rate was 2.43 gpm at Trench 4, and 1.93

gpm at Trench 6. After redevelopment the operational average flow rates increased to 7.45 gpm at Trench 4, and 2.54 gpm at Trench 6. Since redevelopment was completed 29 February, continued improvement in extraction rates and hydraulic gradient performance is expected during March 2024.

Despite the partial shutdown of the extraction system during February 2024, the average operational influent rate (78.86 gpm), and the overall average monthly extraction rate (59.8 gpm) were the highest sustained extraction rates ever achieved by the GW SCM, and achieved a monthly cumulative maximum extracted volume of 2,382,140 gallons.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

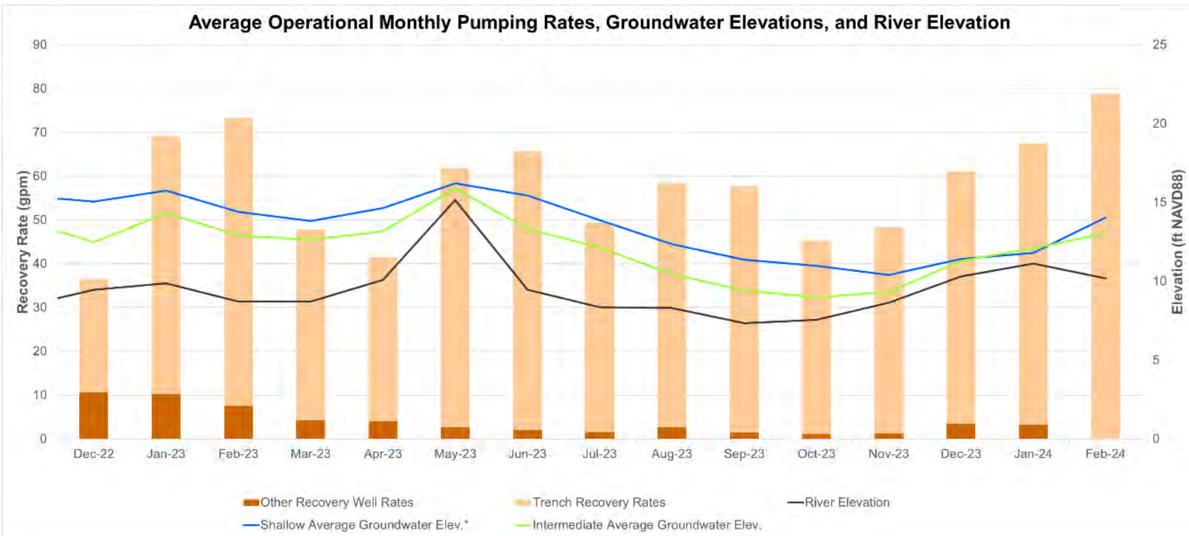
TABLE 1-3 RECOVERY WELL PUMPING RATES

Recovery Well	February 2024 Average Operational Pumping Rate (gpm)	February 2024 Average Monthly Pumping Rate (gpm)
RW-14*	0.00	0.00
RW-22*	0.00	0.00
RW-23*	0.00	0.00
RW-25*	0.00	0.00
EW-01*	0.00	0.00
EW-02	3.11	3.11
EW-03	7.09	2.93
EW-04	8.44	8.44
EW-05	13.28	13.28
EW-06	2.67	1.66
EW-07	3.99	2.20
EW-08	4.09	2.96
EW-09	3.55	0.49
EW-10	8.57	2.36
EW-11	1.85	0.83
EW-12	5.03	4.33
EW-13	7.41	7.41
EW-14	9.79	9.79

Recovery Well	February 2024 Average Operational Pumping Rate (gpm)	February 2024 Average Monthly Pumping Rate (gpm)
Total	78.86	59.80

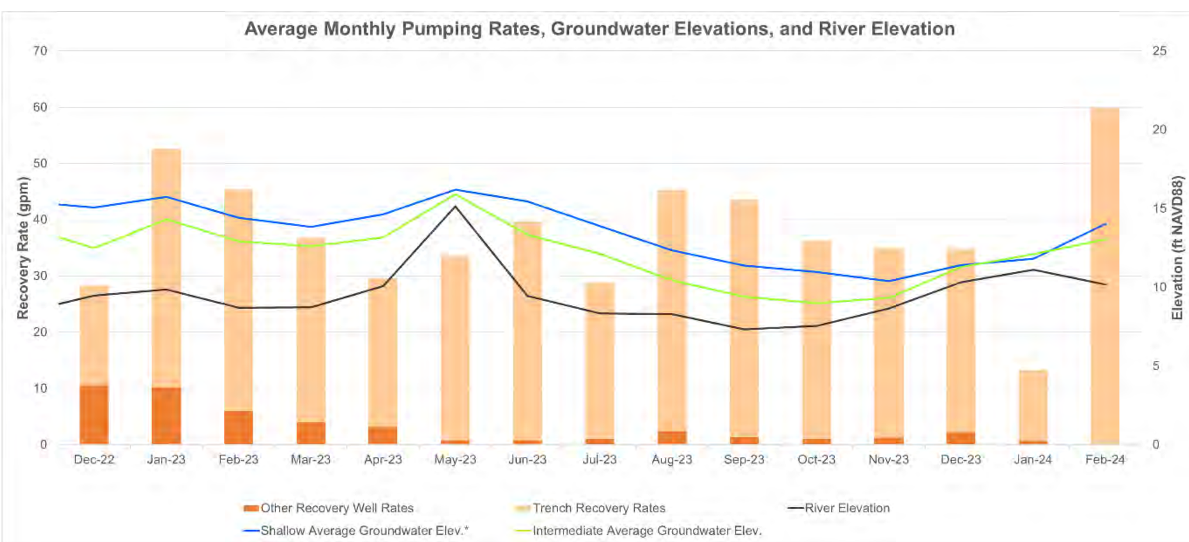
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.

ft NAVD88 = feet North American Vertical Datum of 1988

3.3.3 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates indicate that the active RWs and EWs are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	5/29/2024 *

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in February 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided in Attachment B-2 for the Shallow, Intermediate, and Deep Zones were outward, except GCC6 in the Intermediate and

Deep Zones, likely due to reduced flows rates during development efforts and seasonal increases to groundwater flows upgradient.

- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and the rest downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were generally downward with GCC6 being upward, as shown on Figure 6.
- The average river elevation in February 2024 was 10.18 feet NAVD88 with a minimum elevation of 7.95 feet NAVD88 and a maximum elevation of 13.83 feet NAVD88.

5.2 GROUNDWATER EXTRACTION

Based on February 2024 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, and 3 has diminished. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. More time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

The groundwater extraction flow rate has been limited by a combination of groundwater elevation, fouling of the EWs within the trenches, and back pressure in the conveyance line. In January, the wellfield was reconfigured to connect three of the trenches to the Intermediate Zone trunk line and this is anticipated to mitigate the impact of back pressure in the conveyance lines. In February EW Trenches 1, 4, and 6 were redeveloped to mitigate the impact of silt and biofouling on pumping rates. These efforts are anticipated to mitigate the limitations observed in Q4 2023 and Q1 2024.

5.3 RECOMMENDATIONS AND FUTURE WORK

Redevelopment of several Intermediate Zone groundwater elevation monitoring locations (RW-6i, RW-9i, RW-11i, RW-13i, RW-16i, RW-19i, RW-21i, RW-24i, RW-26i, and PA-12i) is planned for Q2 2024 to mitigate turbidity impacts. LSS will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

Brendan Robinson, PE
Partner

6. REFERENCES

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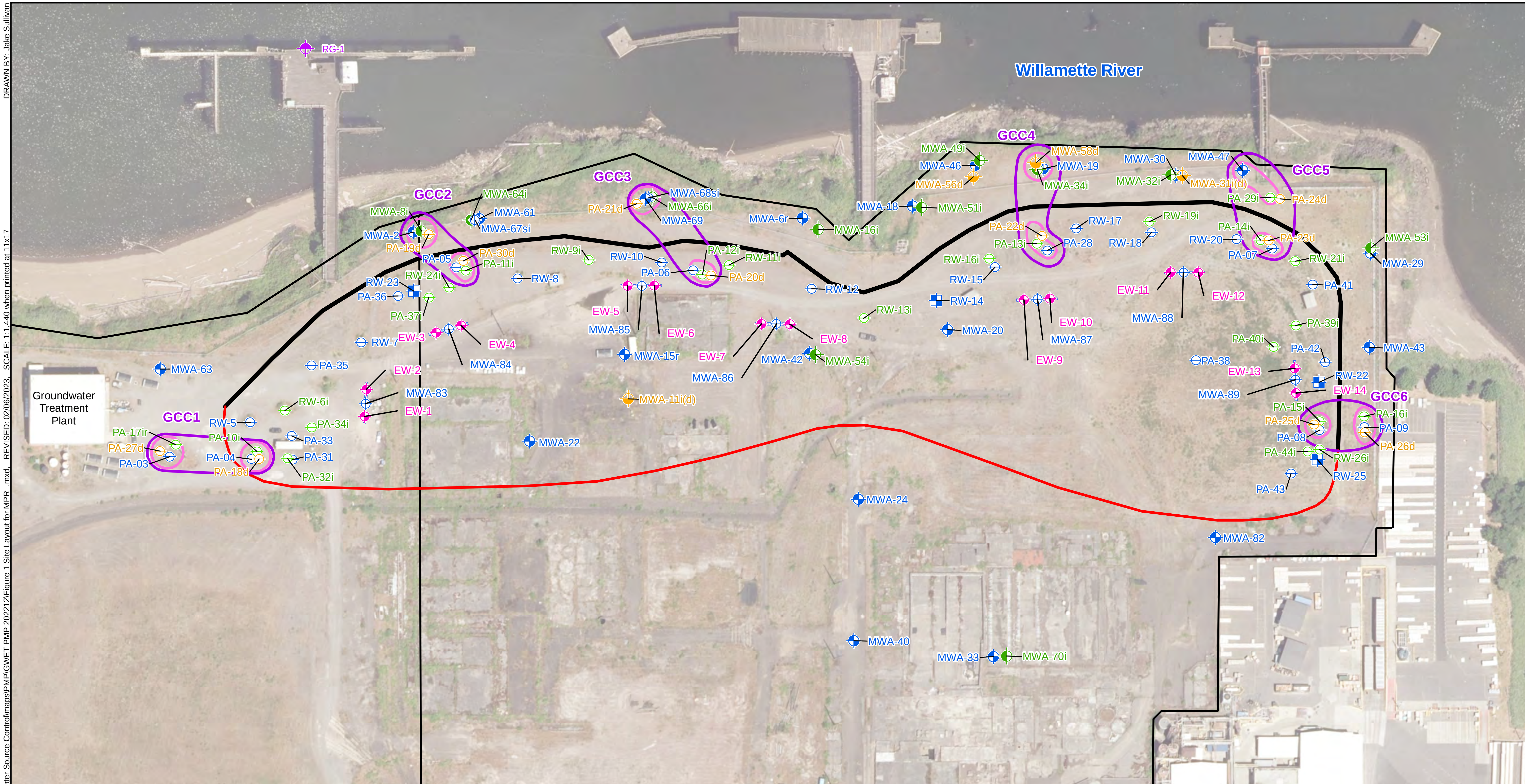
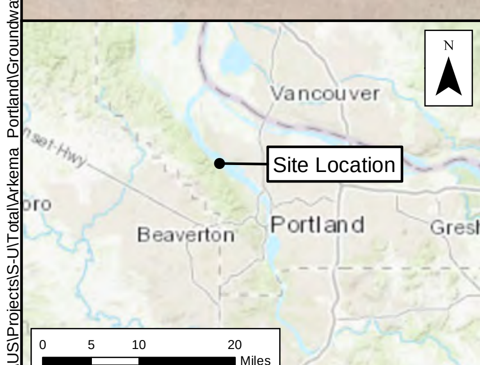
Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater*, Vol. 29. No 4. July–August 1991.

FIGURES

DRAWN BY: Jake Sullivan
M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR_.mxd. REVISED: 02/06/2023. SCALE: 1:1,440 when printed at 11x17





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

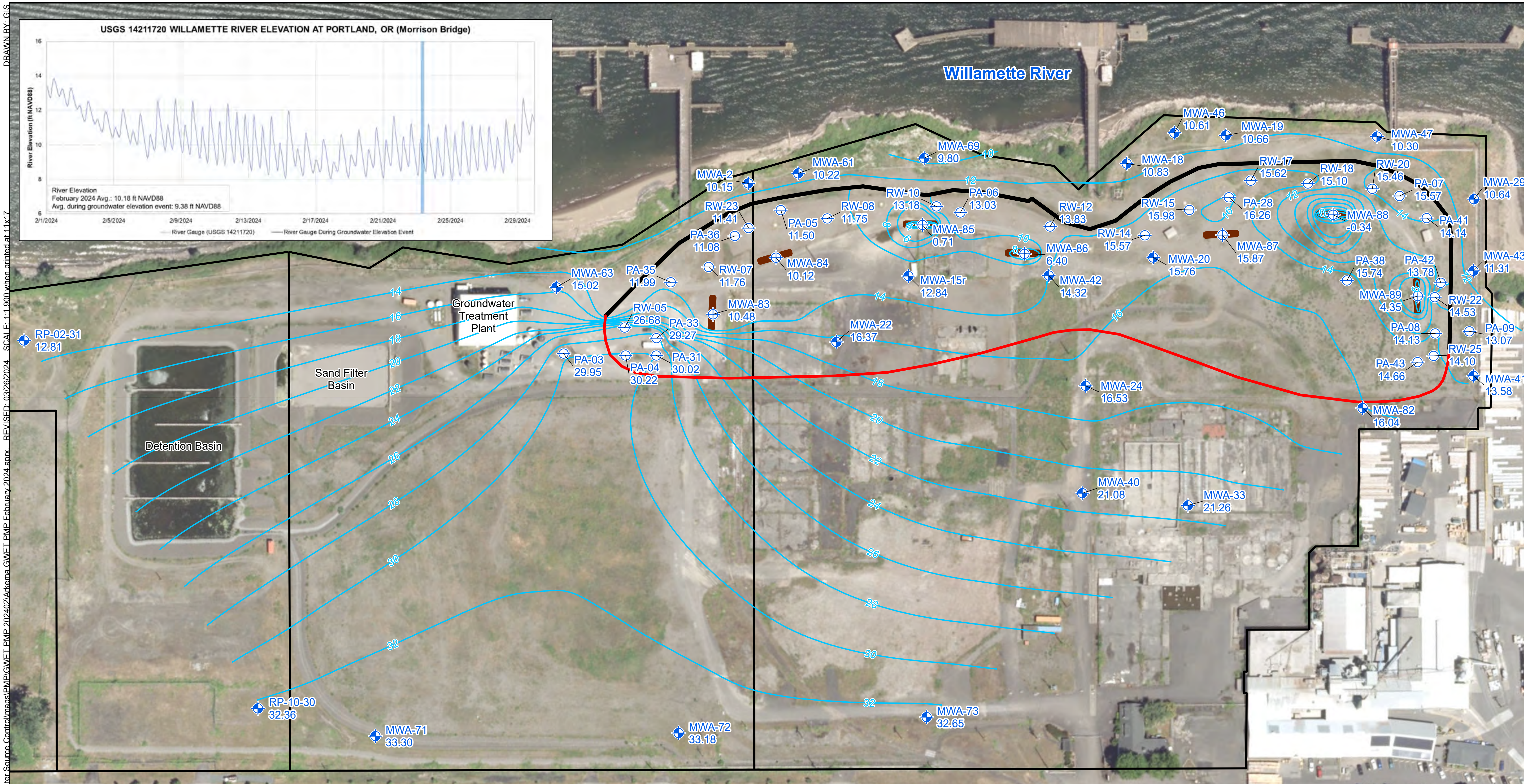
0 120 240

Feet

Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected February 23, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
February 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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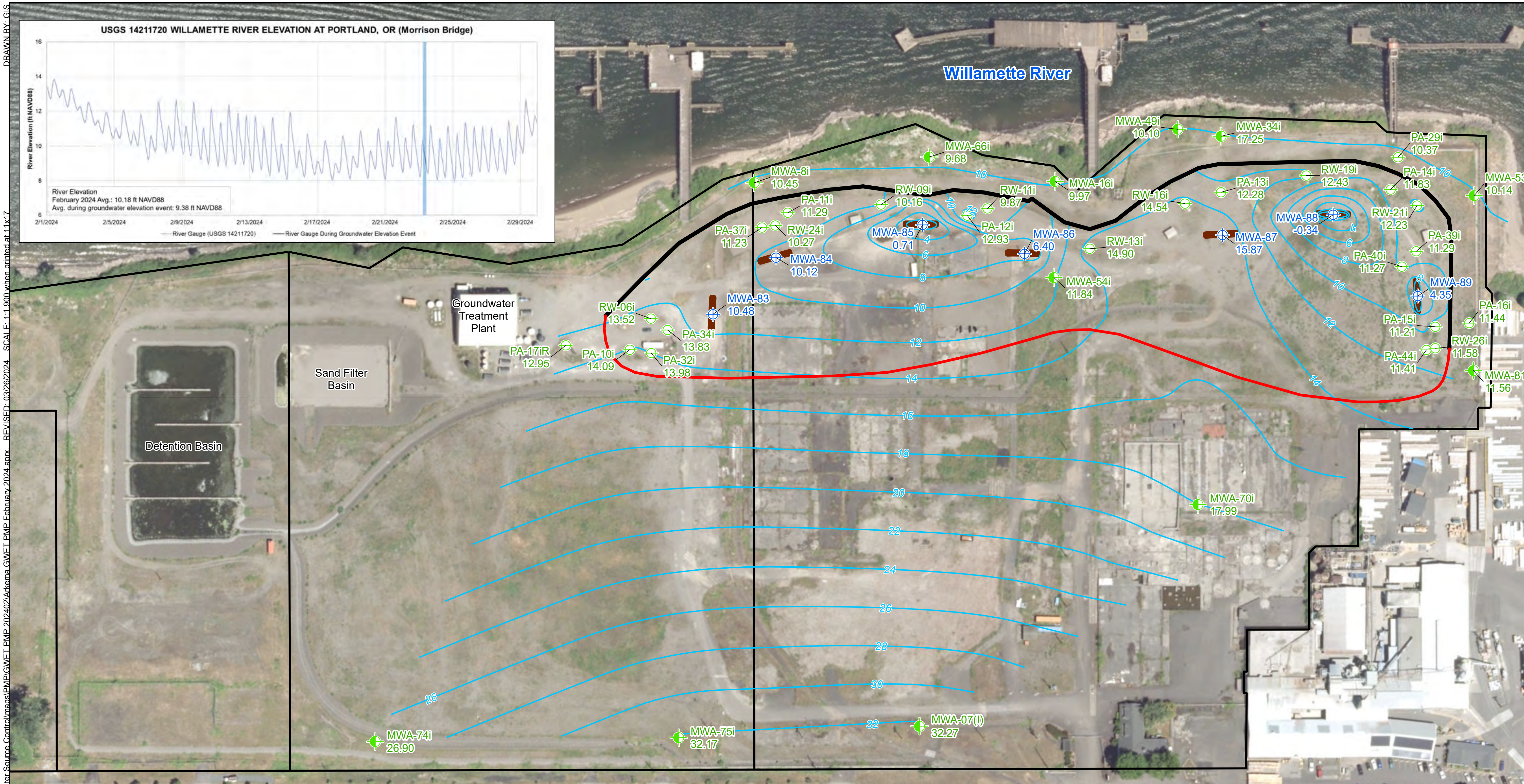

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected February 23, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
February 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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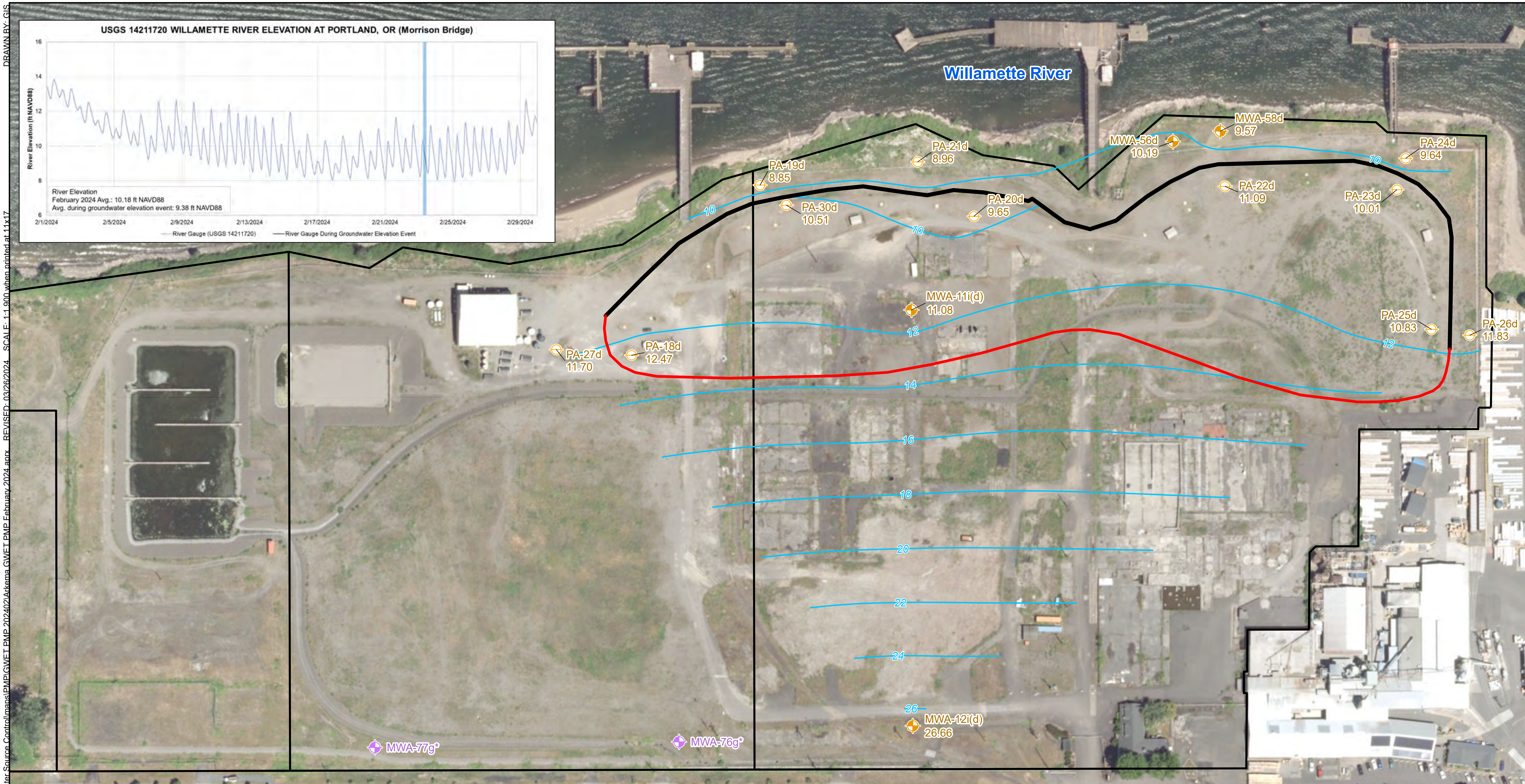
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected February 23, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
February 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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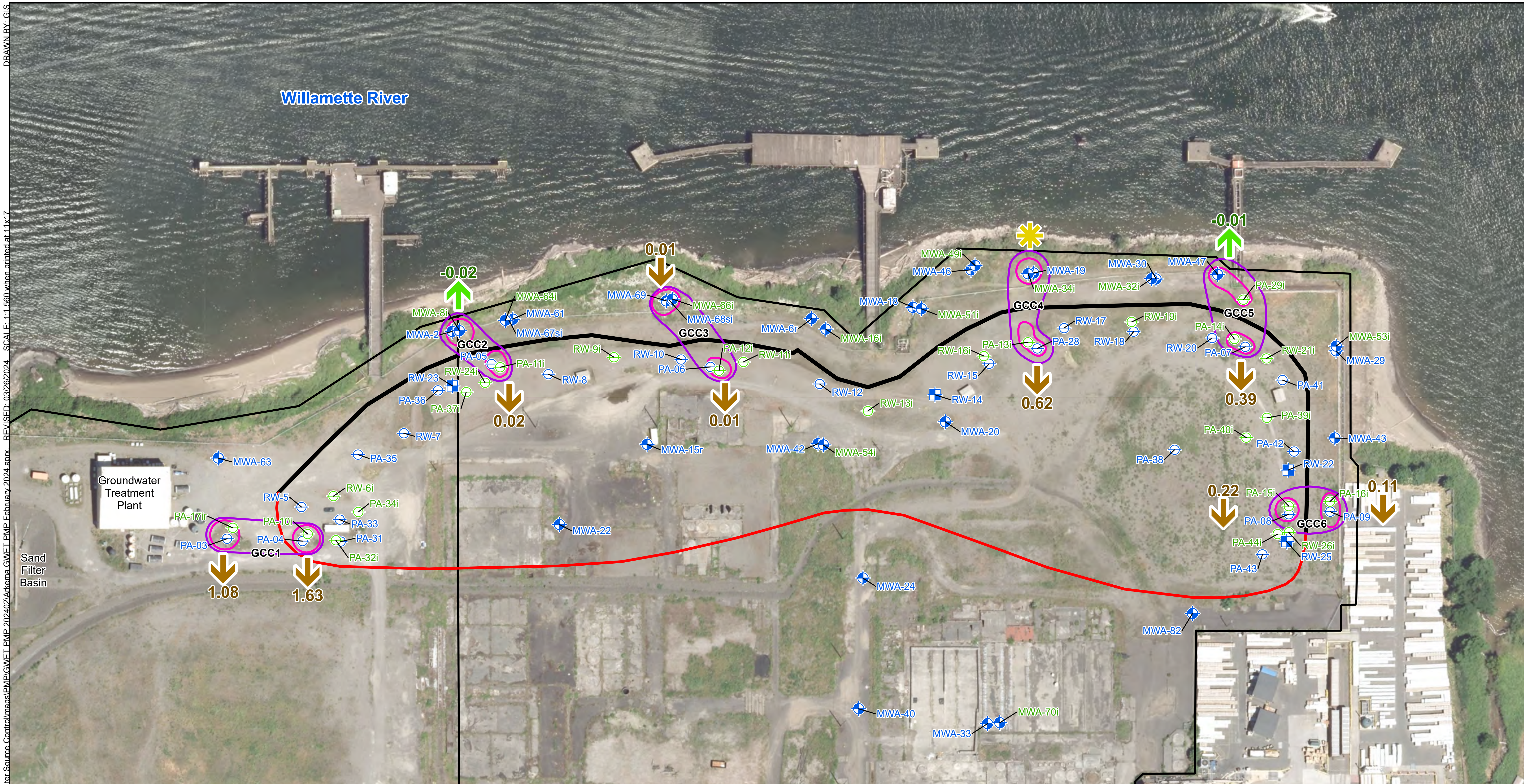

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected February 23, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
February 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected February 23, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
February 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ERM

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: February 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC3	PA-26d	Deep	1/29/2024	Present	Transducer faulted, replacement ordered.
N/A	RW-13	Intermediate	1/29/2024	Present	Transducer faulted, replacement ordered.
N/A	RW-25	Shallow	1/29/2024	Present	Transducer faulted, replacement ordered.
GCC5	PA-07	Shallow	1/29/2024	Present	Transducer faulted, replacement ordered.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: February 2024
Arkema Inc. Facility
Portland, Oregon

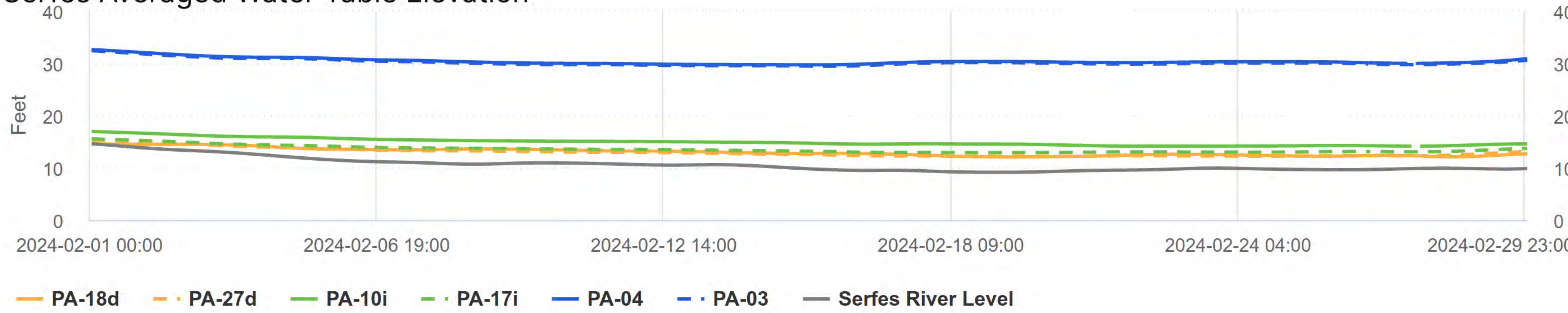
Recovery Well ID	Status as of 2/29/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Off due to ground fault
RW-23	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels
RW-25	Inactive	Transducer Malfuction	New transducer ordered	N/A	Not Working	Good	0.00	OFF*	Off due to Transducer malfunction
EW-01	Inactive	Plumbing	Repair	3/5/2024	Good	Good	0.00	OFF*	Off for plumbing repairs and redevelopment
EW-02	Active	None	N/A	N/A	Good	Good	3.11	G	Off for part of the month due to redevelopment
EW-03	Active	Plumbing	N/A	2/12/2024	Good	Good	7.09	G	Off for part of the month due to plumbing repairs
EW-04	Active	None	N/A	N/A	Good	Good	8.44	G	
EW-05	Active	None	N/A	N/A	Good	Good	13.28	G	
EW-06	Active	None	N/A	N/A	Good	Good	2.67	M	Off for part of the month due to low water levels
EW-07	Active	Plumbing	Repair	2/12/2024	Good	Good	3.99	G	Off for part of the month due to plumbing repairs and redevelopment
EW-08	Active	None	N/A	N/A	Good	Good	4.09	G	Off for part of the month due to redevelopment
EW-09	Active	None	N/A	N/A	Good	Good	3.55	G	Off for part of the month due to redevelopment
EW-10	Active	None	N/A	N/A	Good	Good	8.57	G	Off for part of the month due to redevelopment
EW-11	Active	None	N/A	N/A	Good	Good	1.85	M	Off for part of the month due to redevelopment
EW-12	Active	None	N/A	N/A	Good	Good	5.03	G	Off for part of the month due to redevelopment
EW-13	Active	None	N/A	N/A	Good	Good	7.41	G	
EW-14	Active	None	N/A	N/A	Good	Good	9.79	G	

Notes:
* Recovery wells not in service
** Recovery wells in service part of the month
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

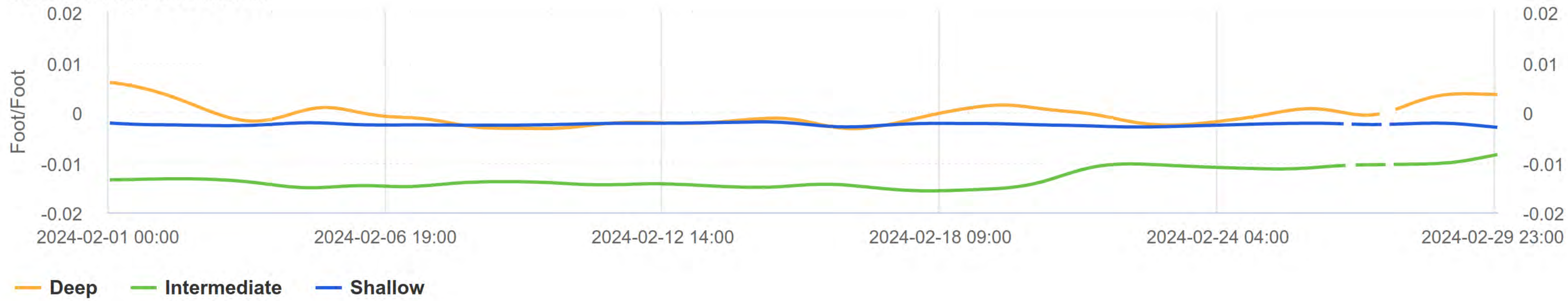
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

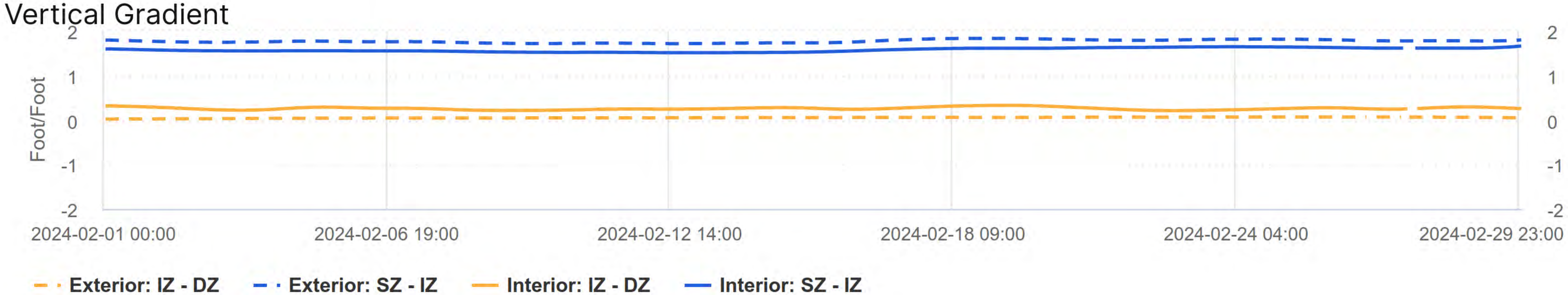
Serfes Averaged Water Table Elevation



Horizontal Gradient

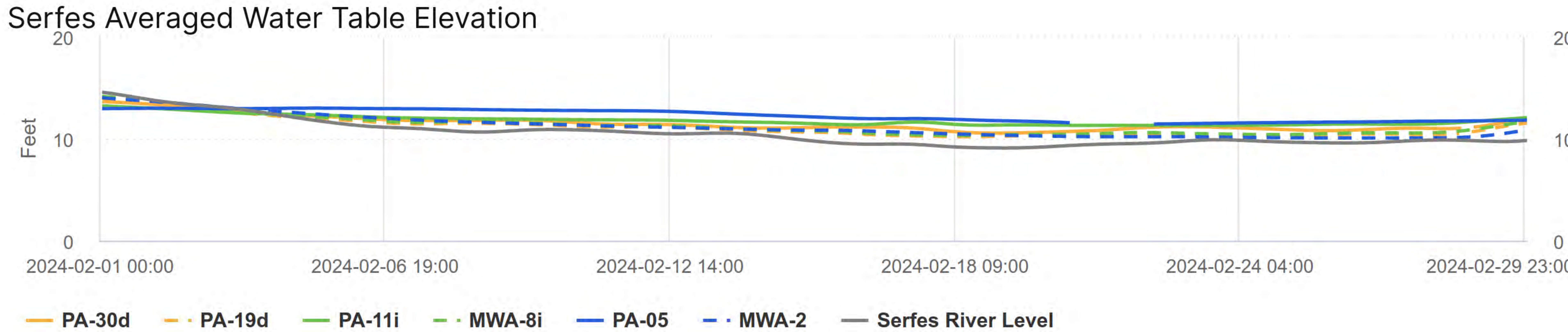


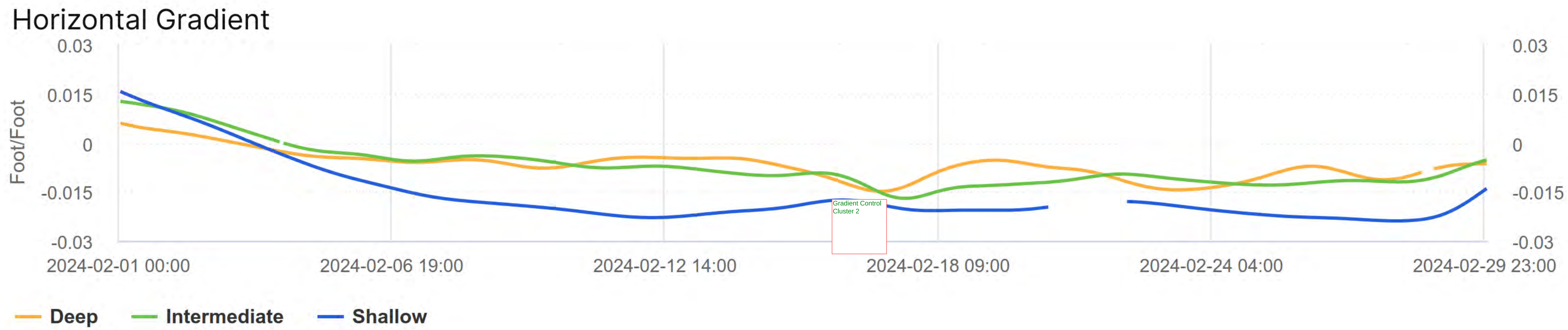
Vertical Gradient

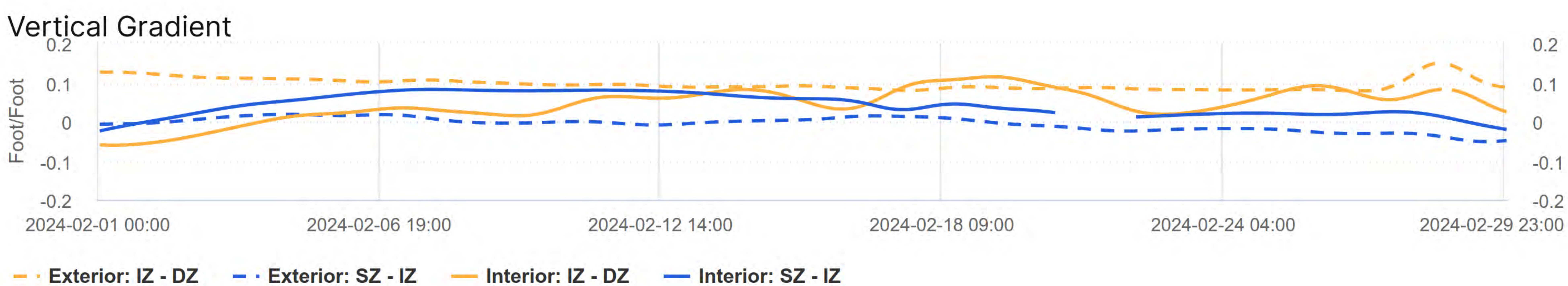


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

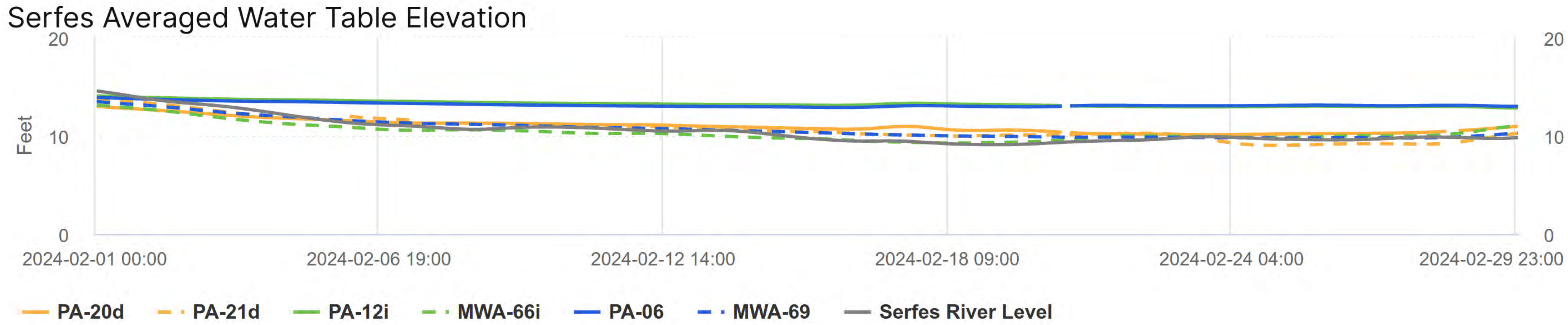


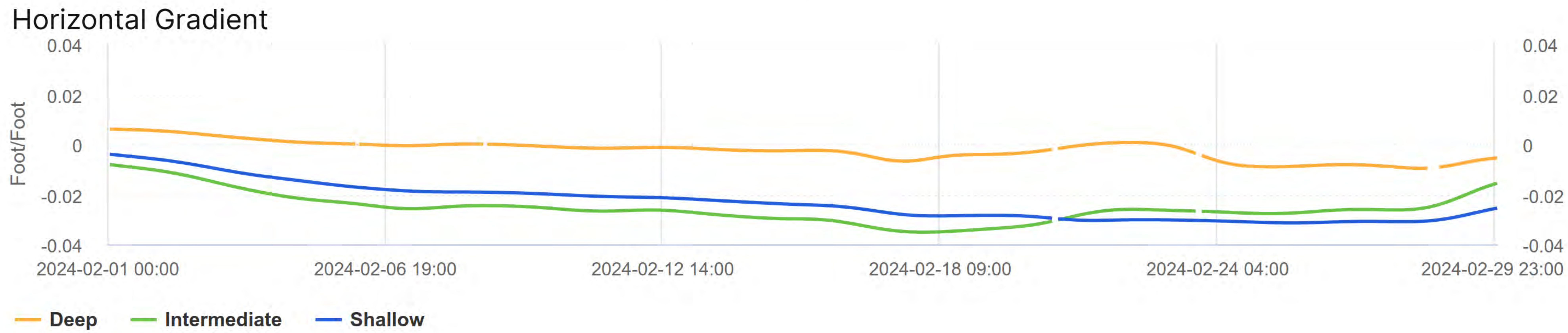


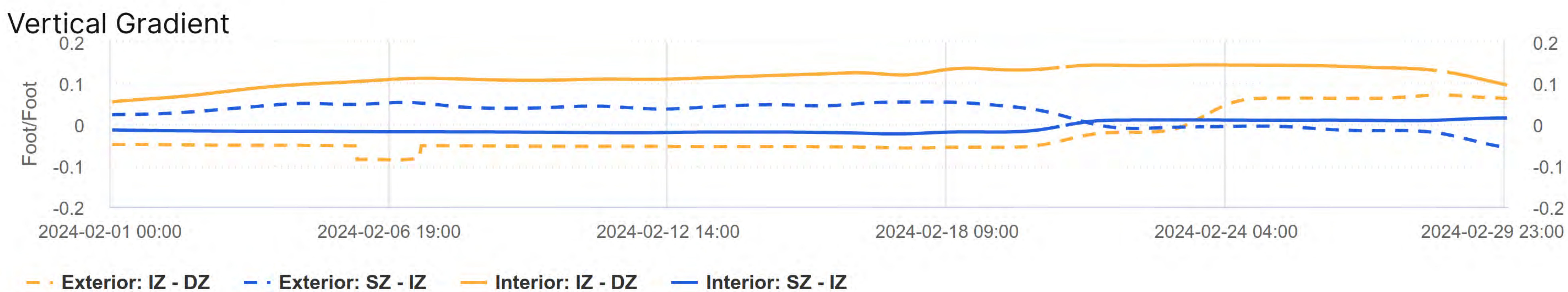


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3



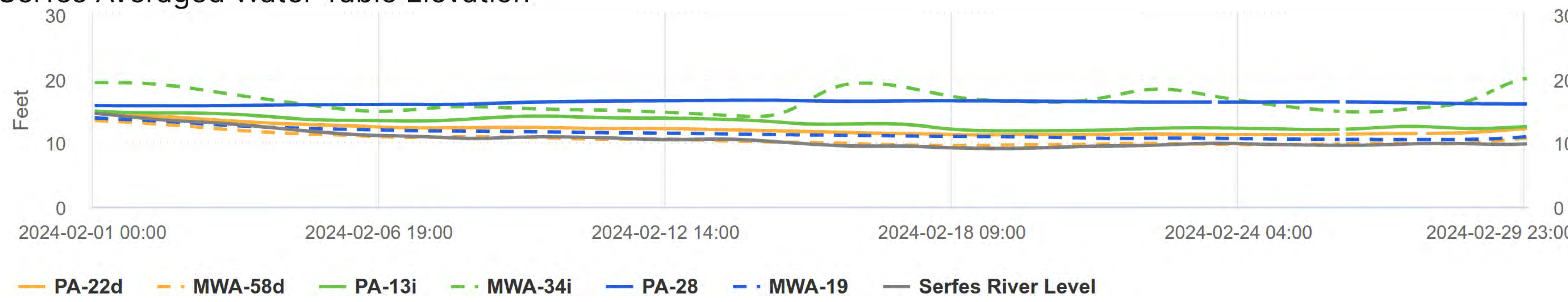




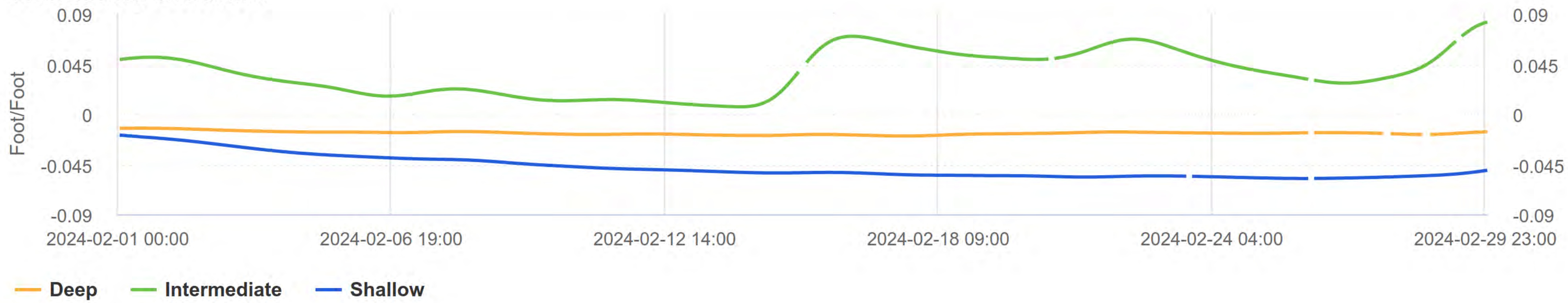
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

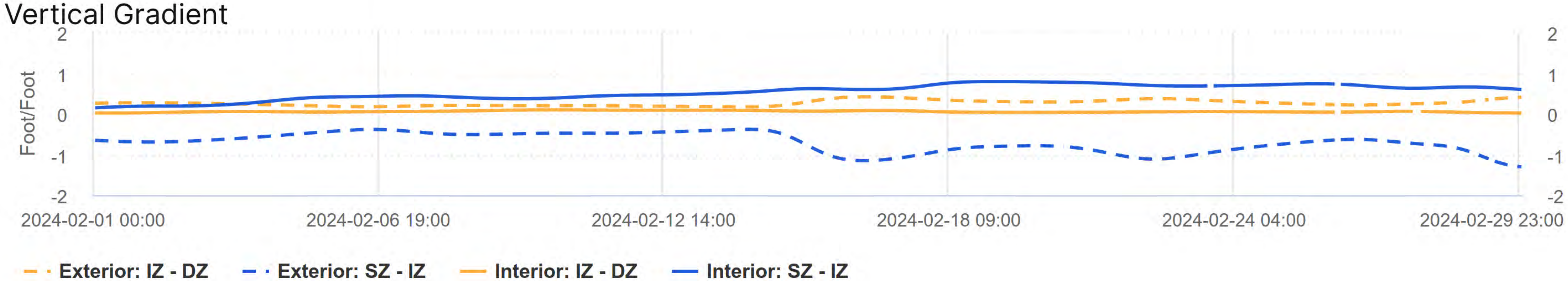
Serfes Averaged Water Table Elevation



Horizontal Gradient

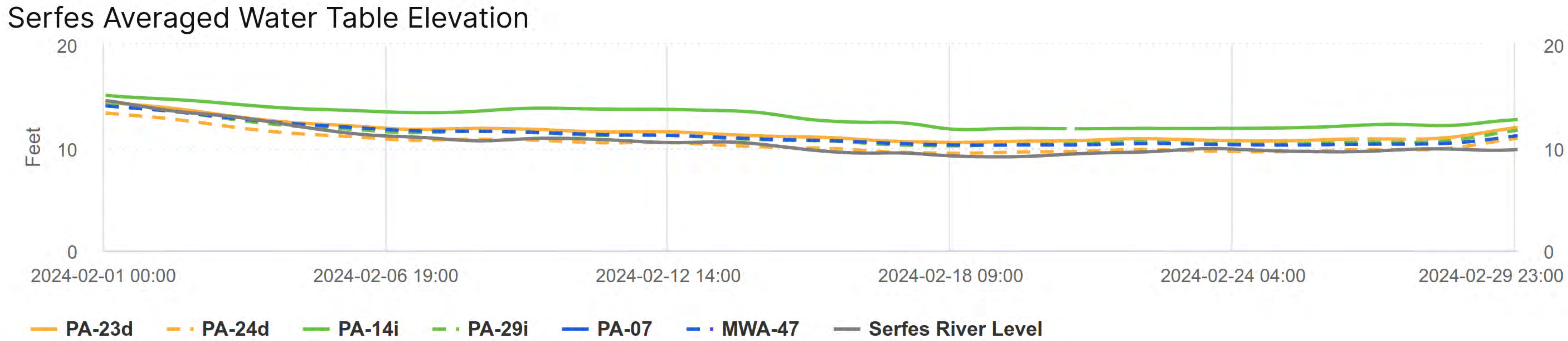


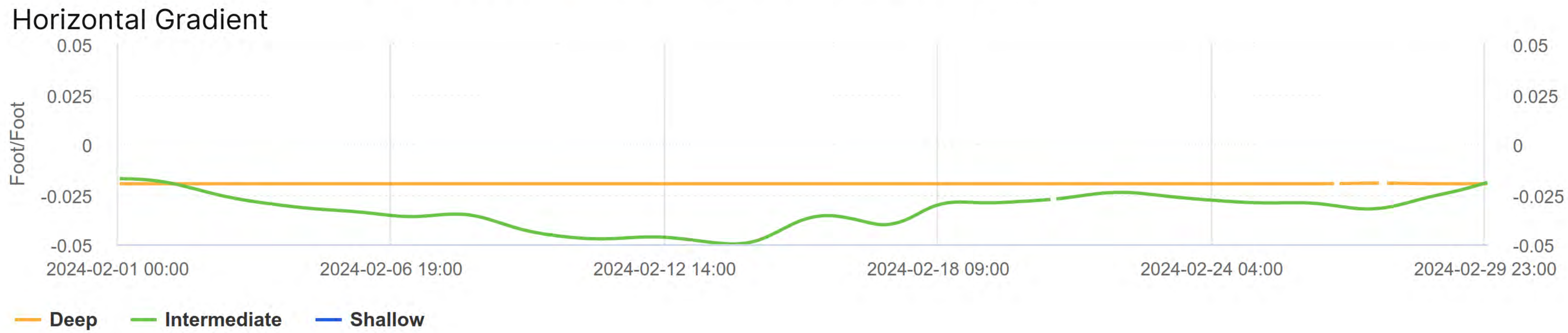
Vertical Gradient

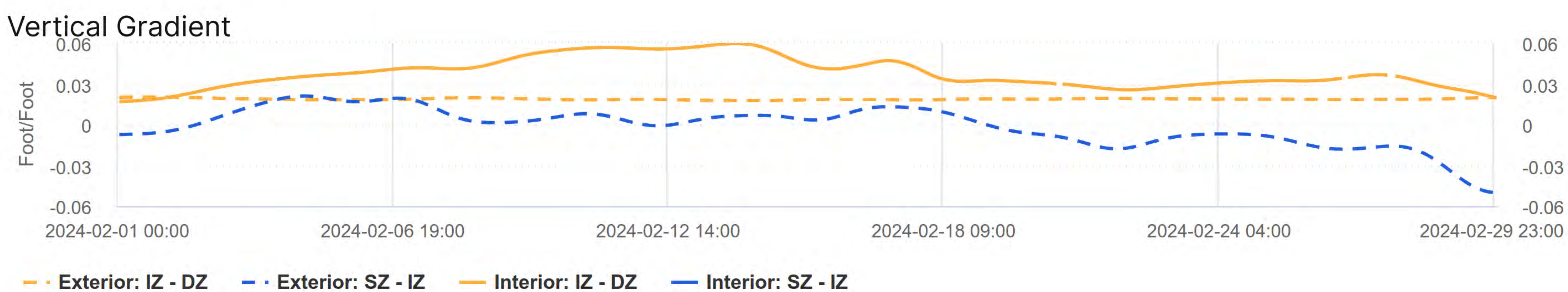


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5





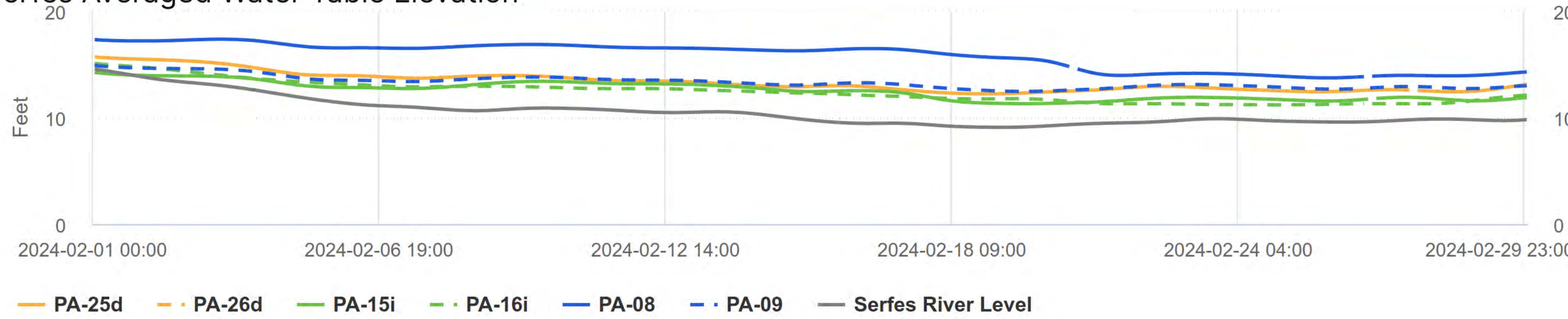


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

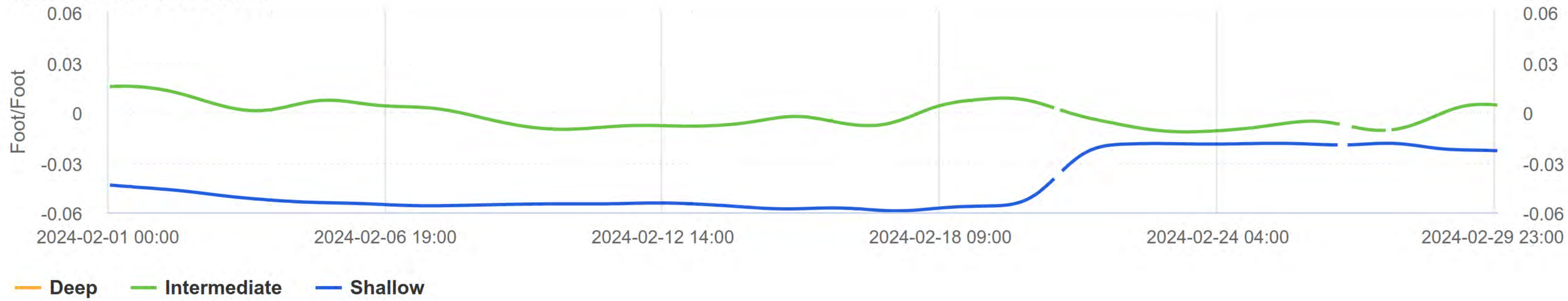
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

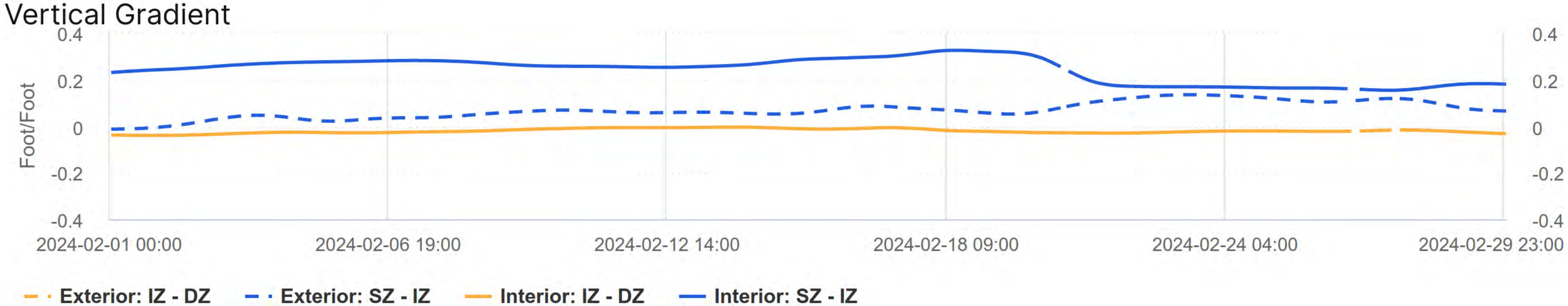
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

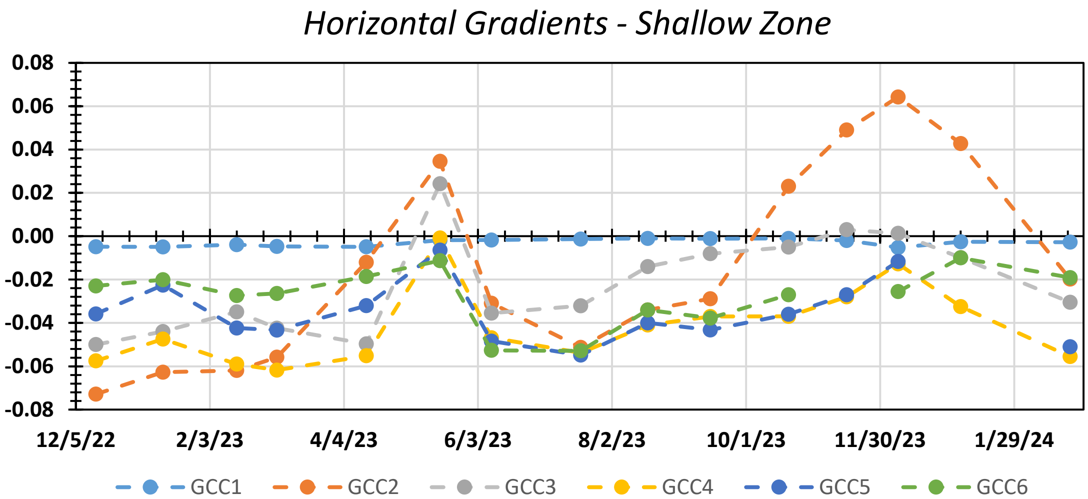


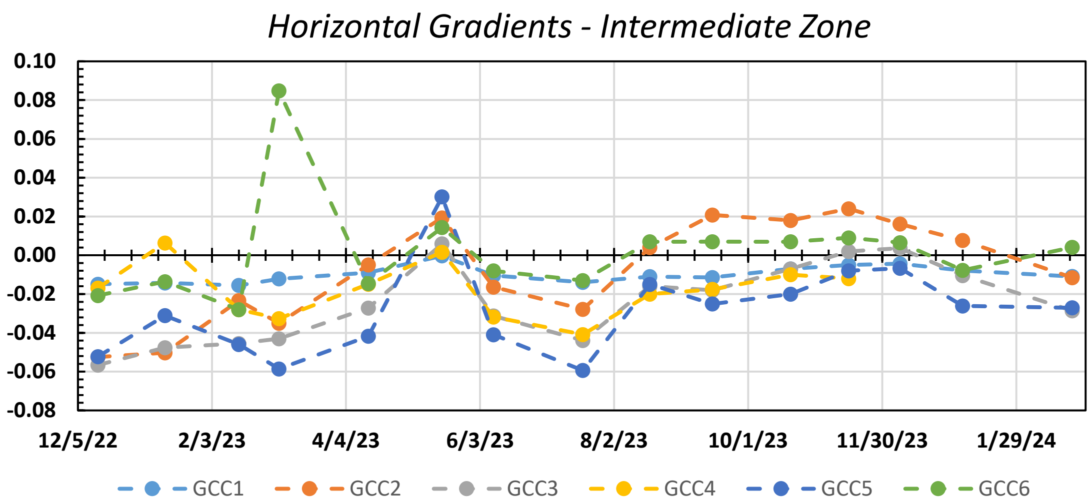
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

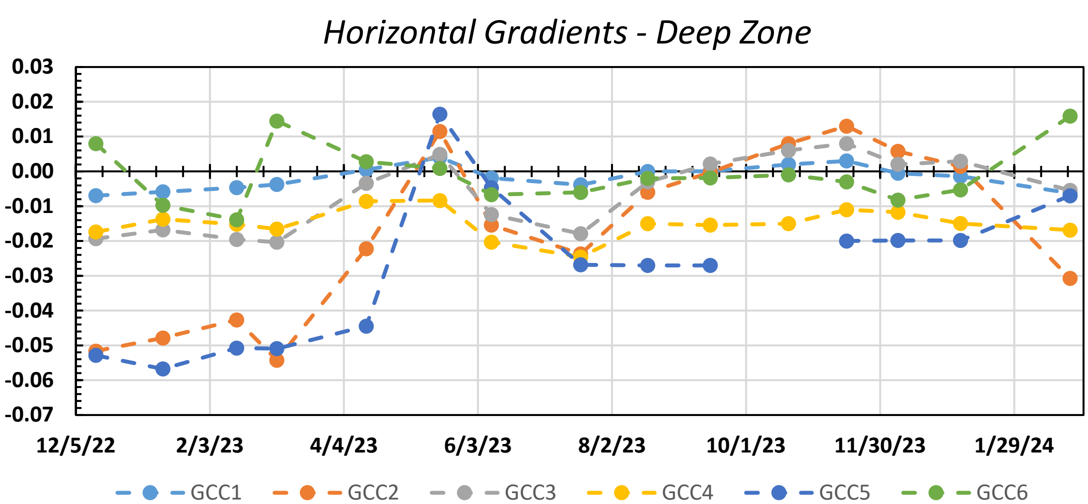
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: February 2024
Arkema Inc. Facility
Portland, Oregon





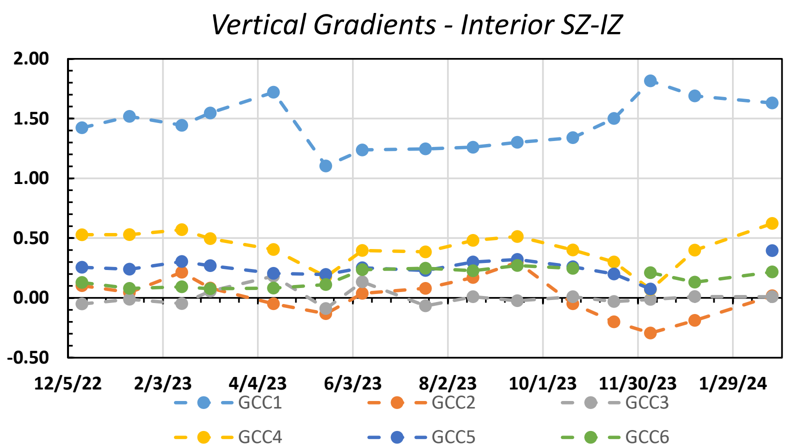


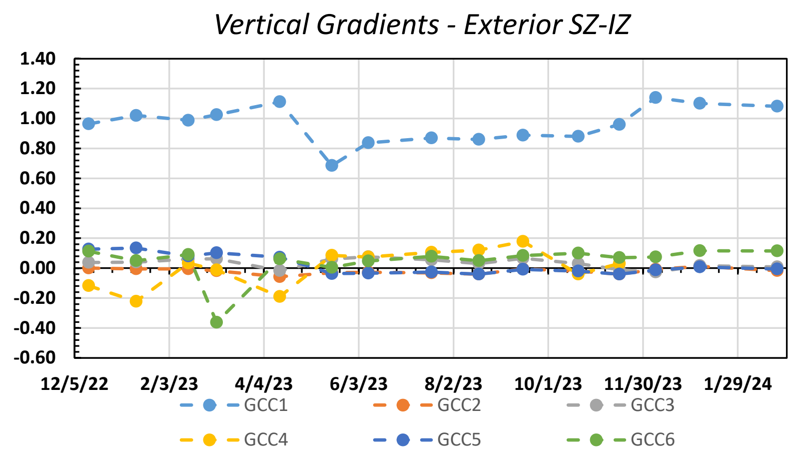
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

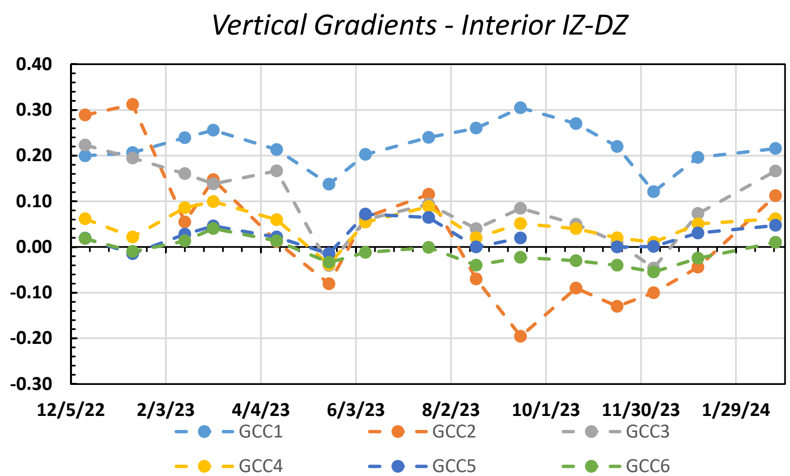
ATTACHMENT B-3 VERTICAL GRADIENTS

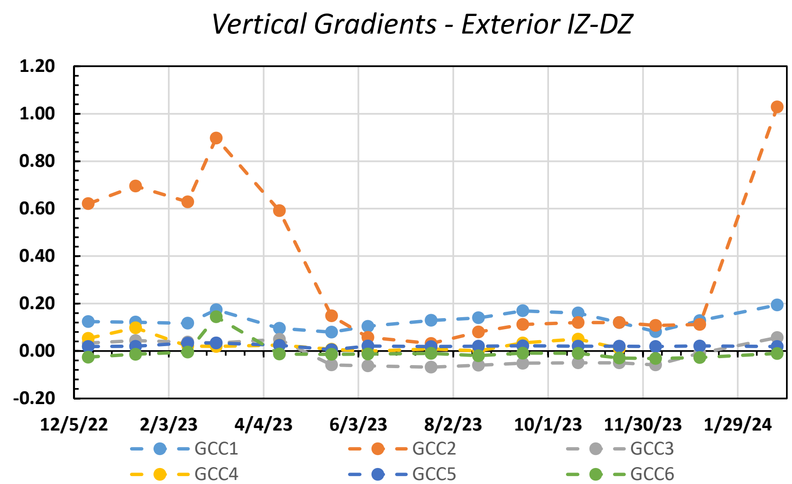
Attachment B-3

Vertical Gradients Summary: February 2024
Arkema Inc. Facility
Portland, Oregon



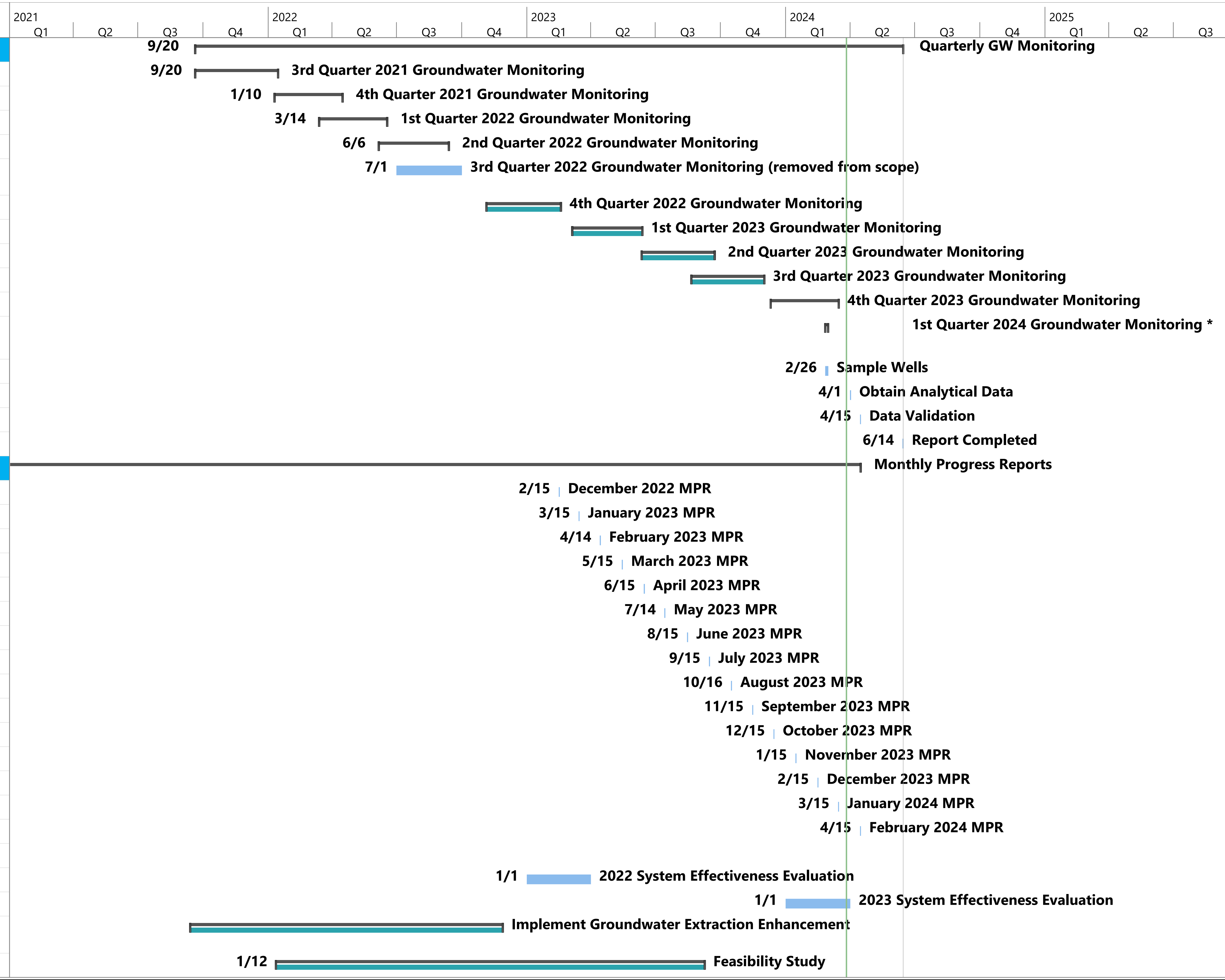






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start
1	**Quarterly GW Monitoring**	**719 days**	**Mon 9/20/21**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*
32	*2nd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 6/12/23*
37	*3rd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 8/21/23*
42	*4th Quarter 2023 Groundwater Monitoring*	*70 days*	*Mon 12/11/23*
47	**1st Quarter 2024 Groundwater Monitoring ***	**4 days**	**Mon 2/26/24**
48	*Sample Wells*	*4 days*	*Mon 2/26/24*
49	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*
50	Data Validation	1 day	Mon 4/15/24
51	Report Completed	1 day	Fri 6/14/24
52	**Monthly Progress Reports**	**1217 days**	**Thu 8/22/19**
53	*December 2022 MPR*	*1 day*	*Wed 2/15/23*
54	*January 2023 MPR*	*1 day*	*Wed 3/15/23*
55	*February 2023 MPR*	*1 day*	*Fri 4/14/23*
56	*March 2023 MPR*	*1 day*	*Mon 5/15/23*
57	*April 2023 MPR*	*1 day*	*Thu 6/15/23*
58	*May 2023 MPR*	*1 day*	*Fri 7/14/23*
59	*June 2023 MPR*	*1 day*	*Tue 8/15/23*
60	*July 2023 MPR*	*1 day*	*Fri 9/15/23*
61	*August 2023 MPR*	*1 day*	*Mon 10/16/23*
62	*September 2023 MPR*	*1 day*	*Wed 11/15/23*
63	*October 2023 MPR*	*1 day*	*Fri 12/15/23*
64	*November 2023 MPR*	*1 day*	*Mon 1/15/24*
65	*December 2023 MPR*	*1 day*	*Thu 2/15/24*
66	*January 2024 MPR*	*1 day*	*Fri 3/15/24*
67	February 2024 MPR	1 day	Mon 4/15/24
68	March 2024 MPR	1 day	Thu 8/22/19
69	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***
70	***2023 System Effectiveness Evaluation***	***66 days***	***Mon 1/1/24***
71	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***
79	***Feasibility Study***	***436 days***	***Wed 1/12/22***



Arkema Portland
Monthly Progress Report
Attachment C

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	17 May 2024
REFERENCE	0732445 Phase 204
SUBJECT	March 2024 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This March 2024 MPR summarizes the GW SCM performance monitoring data collected in March 2024. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells (RWs), and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 RWs prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four-remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is approximately 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and

GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 40.16 gallons per minute (gpm) for the entire month of March 2024, including non-operational periods. The average influent flow during operational periods was 68.46 gpm. The average operational flow rates for March 2024 are higher than flow rates during March 2023 through January 2024, which ranged from 41.44 gpm to 67.51 gpm.

Extraction pumps become fouled with accumulated solids over time. A Proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. In late February 2024, a recordable injury occurred onsite during pump removal and maintenance activities. As a result, pump maintenance activities were paused while a root cause analysis was performed and procedures updated to mitigate ergonomic and fall risks. An updated pump pulling and maintenance procedure was implemented in April 2024. Extraction rates and hydraulic gradient performance are expected to improve following resumption of pump maintenance activities.

EW redevelopment activities in March 2024 resulted in elevated solids concentrations in the extracted groundwater. These elevated solids concentrations reduced the GWET's ability to process groundwater. These elevated solids concentrations also further exacerbated the impacts of pump fouling that and limited pump maintenance activities discussed above. Solids concentrations in extracted groundwater have decreased throughout March and allowed resumption of normal treatment capacity of the GWET system.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

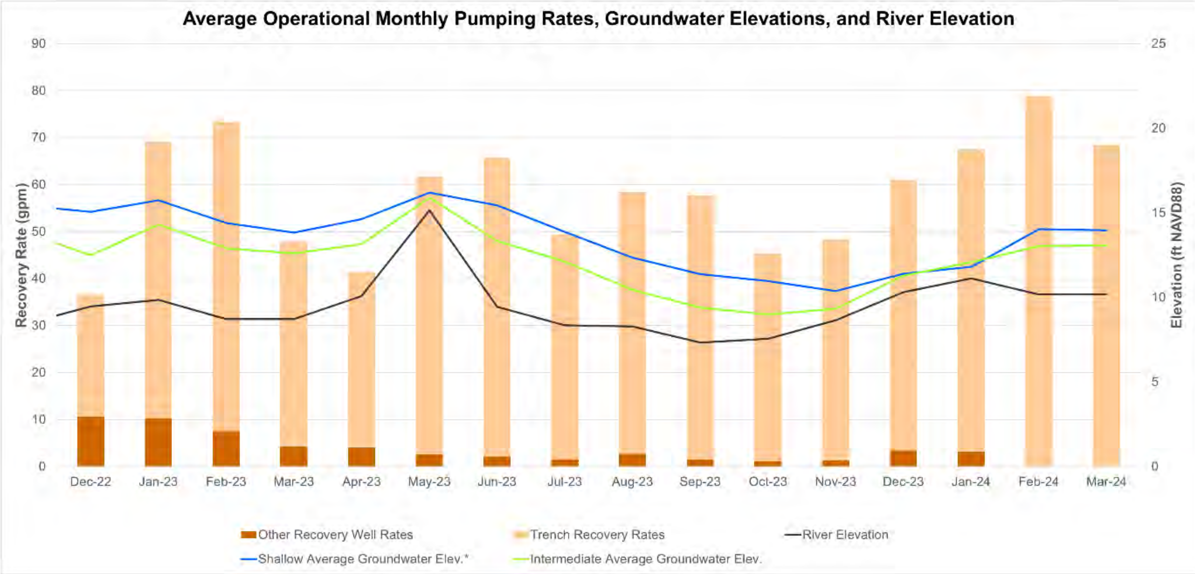
TABLE 1-1 RECOVERY WELL PUMPING RATES

Recovery Well	March 2024 Average Operational Pumping Rate (gpm)	March 2024 Average Monthly Pumping Rate (gpm)
RW-14*	0.00	0.00
RW-22*	0.00	0.00
RW-23*	0.00	0.00

Recovery Well	March 2024 Average Operational Pumping Rate (gpm)	March 2024 Average Monthly Pumping Rate (gpm)
RW-25*	0.00	0.00
EW-01	4.41	1.42
EW-02	2.75	0.62
EW-03	4.59	2.52
EW-04	4.60	3.12
EW-05	9.92	6.72
EW-06	1.88	0.73
EW-07	2.86	0.92
EW-08	7.10	5.04
EW-09	5.07	3.60
EW-10	3.29	1.38
EW-11	2.92	0.56
EW-12	4.62	3.28
EW-13	6.21	4.41
EW-14	8.24	5.85
Total	68.46	40.16

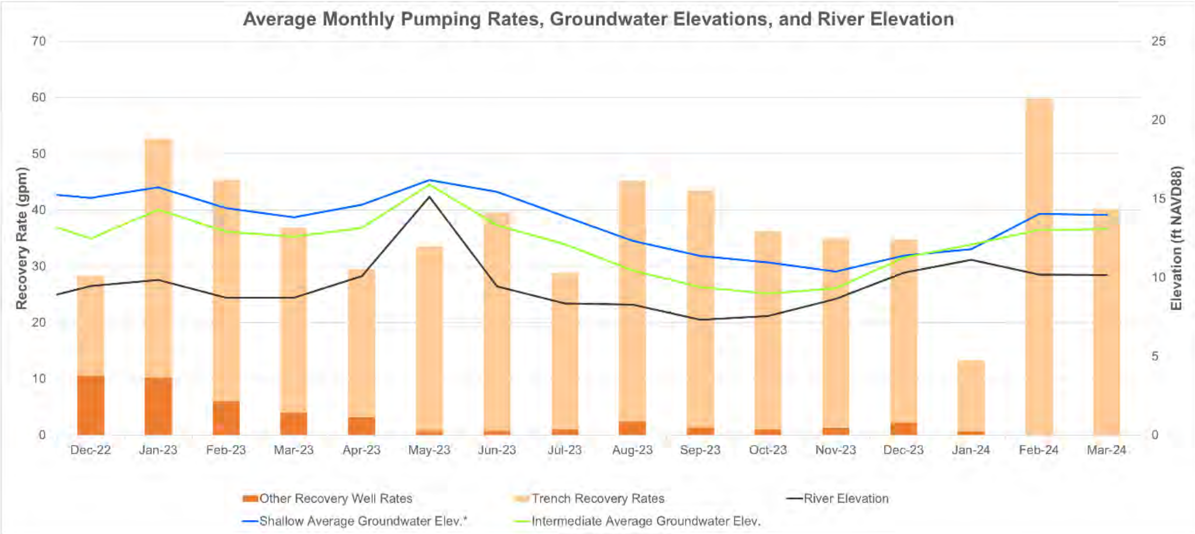
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

- 16 March 2024: The GWET system was shut down for solids handling associated with the extraction trench redevelopment in February 2024. The ODEQ was notified and discharge restarted 26 March 2024.

The redevelopment of EWs in Trenches 1, 4, 5, and 6 in February 2024 resulted in solids removal. Total suspended solids were <2.0 mg/L on 1 February 2024 prior to redevelopment and 94 mg/L on 7 March 2024 after redevelopment. Solids included mostly clay and silts that were limiting the performance of the EWs, and not the historically observed sands that impeded flows of the legacy RWs.

Well redevelopment caused an increase in solids transported into the GWET plant via the conveyance line causing a solids handling issue that resulted in a 10-day shutdown period. The extended shutdown period and pause on pump maintenance resulted in lower flow rates in March 2024. Once regular pump maintenance is resumed flow rates are expected to increase.

4. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four-remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

4.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 28 March 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of June to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during March 2024, the following transducers were:

Fully out of service pending repairs:

- PA-07
- PA-26d
- RW-13
- RW-25

Out of service for a period but returned to full operation:

- N/A

RW-13, PA-07, and PA-26d had faulted transducers that will be replaced in April 2024. RW-25 had a faulted transducer that will be rechecked and repaired in April 2024. RW-13 and RW-25 are not in the GCCs.

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After March 2024 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 28 March 2024 are shown below at each GCC (Table 1-2 and Table 1-3).

TABLE 1-2 MARCH HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	29.89	PA-04	29.60	0.003
	Intermediate	PA-17iR	13.52	PA-10i	14.76	-0.012
	Deep	PA-27d	12.44	PA-18d	13.09	-0.005
GCC2	Shallow	MWA-2	10.47	PA-05	13.37	-0.042
	Intermediate	MWA-8i^{M}	10.90	PA-11i	12.78	-0.026
	Deep	PA-19d	9.61	PA-30d	11.11	-0.028
GCC3	Shallow	MWA-69	10.58	PA-06^{M}	13.39	-0.026
	Intermediate	MWA-66i	10.59	PA-12i	13.90	-0.029
	Deep	PA-21d	9.65	PA-20d	11.06	-0.011
GCC4	Shallow	MWA-19	10.60	PA-28	16.01	-0.054
	Intermediate	MWA-34i	*	PA-13i	12.91	**
	Deep	MWA-58d	10.13	PA-22d	11.92	-0.020
GCC5	Shallow	MWA-47^{M}	10.80	PA-07^{M}	*	**
	Intermediate	PA-29i	11.06	PA-14i^{M}	12.55	-0.028
	Deep	PA-24d	10.38	PA-23d	10.75	-0.007
GCC6	Shallow	PA-09	13.30	PA-08	14.43	-0.020
	Intermediate	PA-16i	12.07	PA-15i	11.77	0.005
	Deep	PA-26d^{M}	12.81	PA-25d	11.26	0.025

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
M = manual groundwater elevation measurement

TABLE 1-3 MARCH VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	29.60	PA-10i	14.76	1.50
		GCC2	PA-05	13.37	PA-11i	12.78	0.05
		GCC3	PA-06[M]	13.39	PA-12i	13.90	-0.05
		GCC4	PA-28	16.01	PA-13i	12.91	0.48
		GCC5	PA-07[M]	*	PA-14i[M]	12.55	**
		GCC6	PA-08	14.43	PA-15i	11.77	0.20
	IZ-DZ	GCC1	PA-10i	14.76	PA-18d	13.09	0.22
		GCC2	PA-11i	12.78	PA-30d	11.11	0.24
		GCC3	PA-12i	13.90	PA-20d	11.06	0.14
		GCC4	PA-13i	12.91	PA-22d	11.92	0.05
		GCC5	PA-14i[M]	12.55	PA-23d	10.75	0.05
		GCC6	PA-15i	11.77	PA-25d	11.26	0.01
Exterior	SZ-IZ	GCC1	PA-03	29.89	PA-17iR	13.52	1.04
		GCC2	MWA-2	10.47	MWA-8i[M]	10.90	-0.03
		GCC3	MWA-69	10.58	MWA-66i	10.59	0.00
		GCC4	MWA-19	10.60	MWA-34i	*	**
		GCC5	MWA-47[M]	10.80	PA-29i	11.06	-0.02
		GCC6	PA-09	13.30	PA-16i	12.07	0.09
	IZ-DZ	GCC1	PA-17iR	13.52	PA-27d	12.44	0.17
		GCC2	MWA-8i[M]	10.90	PA-19d	9.61	0.83
		GCC3	MWA-66i	10.59	PA-21d	9.65	0.07
		GCC4	MWA-34i	*	MWA-58d	10.13	**
		GCC5	PA-29i	11.06	PA-24d	10.38	0.02
		GCC6	PA-16i	12.07	PA-26d[M]	12.81	-0.02

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; M = manual groundwater elevation measurement; SZ = Shallow Zone

4.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 28 March 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Shallow Zone at GCC1. Inward gradient was observed in the Intermediate and Deep Zones at GCC6. GCC1 and GCC2 are trending toward an inward gradient in the Deep Zones.

River elevations are shown over time on Figures 1-1 and 1-2 above, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in March 2024 had an average elevation of 10.17 feet NAVD88 with a minimum elevation of 7.87 NAVD88 and a maximum elevation of 13.22 NAVD88.

The difference between average interior Shallow Zone groundwater elevations and river level elevation were 5.11 ft and 3.81 ft in March 2023 and March 2024, respectively. The difference between river level and Shallow Zone groundwater elevations is expected to decrease when extraction capacity is maintained in the Target Capture Zone. A potentiometric separation is still noticeable exterior to the GWBW, indicating that is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed with GCC3 upward and the rest downward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, and GCC5 upward and GCC1 and GCC6 downward as shown on Figure 5 and in Attachment B-2.

The vertical groundwater gradient at GCC4 was unable to be calculated due to an anomalous groundwater elevation reading at MWA-34i. After a camera inspection was completed at MWA-34i, a hole in the well casing was discovered. This well is scheduled in May 2024 for abandonment and replacement by a licensed driller. The vertical gradient at GCC5 was unable to be calculated due to an anomalous groundwater elevation reading at PA-07. The transducer is scheduled to be replaced during April 2024.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were primarily downward with exception to GCC6 being upward, as shown on Figure 6 and Attachment B. The vertical groundwater gradient at GCC4 exterior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at and MWA-34i as previously discussed.

As discussed above, GWET pumping rates have been operating at lower levels since December 2023 through the end of February 2024 due to system maintenance and upgrade activities. During pump maintenance activities on 29 February 2024 an Operator had a recordable injury, which resulted in a stop work on all pump maintenance activities. An updated pump maintenance procedure is currently under review by ERM and Retia Health and Safety. The stop work on pump maintenance has reduced the flow rate capacity of the EWs during March 2024. The water level measurements collected on 28 March 2024 were within in this period of reduced groundwater extraction. These lower rates of groundwater extraction have resulted in the previously observed inward gradients observed in December 2023 trending to outward gradients in March 2024. Extraction rates achieved after the maintenance and upgrades are higher than previously achieved in December 2023, and are anticipated to restore a trend toward inward gradients once pump maintenance is resumed.

4.2.1 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates indicate that the active RWs and EWs are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

5. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022

Report	Sampling Dates	Report Submittal Date
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	6/7/2024

6. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in March 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

6.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided in Attachment B-2 for the Shallow Zone was inward at GCC1. The Intermediate and Deep Zones were inward at GCC6 and trending inward at GCC1 and GCC2 in the Deep Zone. The decreased inwards gradient are likely due to reduced average groundwater extraction rates in March 2024.
- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were mixed with GCC3 upward and the rest downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1 and GCC6 downward. GCC3 exterior to the wall was observed to be slightly upward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were generally downward with GCC6 being upward, as shown on Figure 6.
- The average river elevation in March 2024 was 10.17 feet NAVD88 with a minimum elevation of 7.87 feet NAVD88 and a maximum elevation of 13.22 feet NAVD88.

6.2 GROUNDWATER EXTRACTION

Based on March 2024 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, and 3 has diminished. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. More operational time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

The groundwater extraction flow rate has been limited by a combination of groundwater elevation, fouling of the EWs within the trenches, back pressure in the conveyance line, and a pause on pump maintenance. In January, the wellfield was reconfigured to connect three of the trenches to the Intermediate Zone trunk line and this is anticipated to mitigate the impact of back pressure in the conveyance lines. In February, EW Trenches 1, 4, and 6 were redeveloped to mitigate the impact of silt and biofouling on pumping rates. After pump maintenance procedures are revised it is anticipated that pump maintenance will resume in May 2024. These efforts are anticipated to mitigate the limitations observed in Q4 2023 through Q1 2024.

6.3 RECOMMENDATIONS AND FUTURE WORK

Redevelopment of several Intermediate Zone groundwater elevation monitoring locations (RW-6i, RW-9i, RW-11i, RW-13i, RW-16i, RW-19i, RW-21i, RW-24i, RW-26i, and PA-12i) is planned for May 2024 to mitigate turbidity and improve accuracy of Intermediate Zone groundwater contour maps. Quarterly redevelopment of EWs is recommended to mitigate turbidity and increase flow rates. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

Brendan Robinson, PE
Partner

7. References

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FIGURES

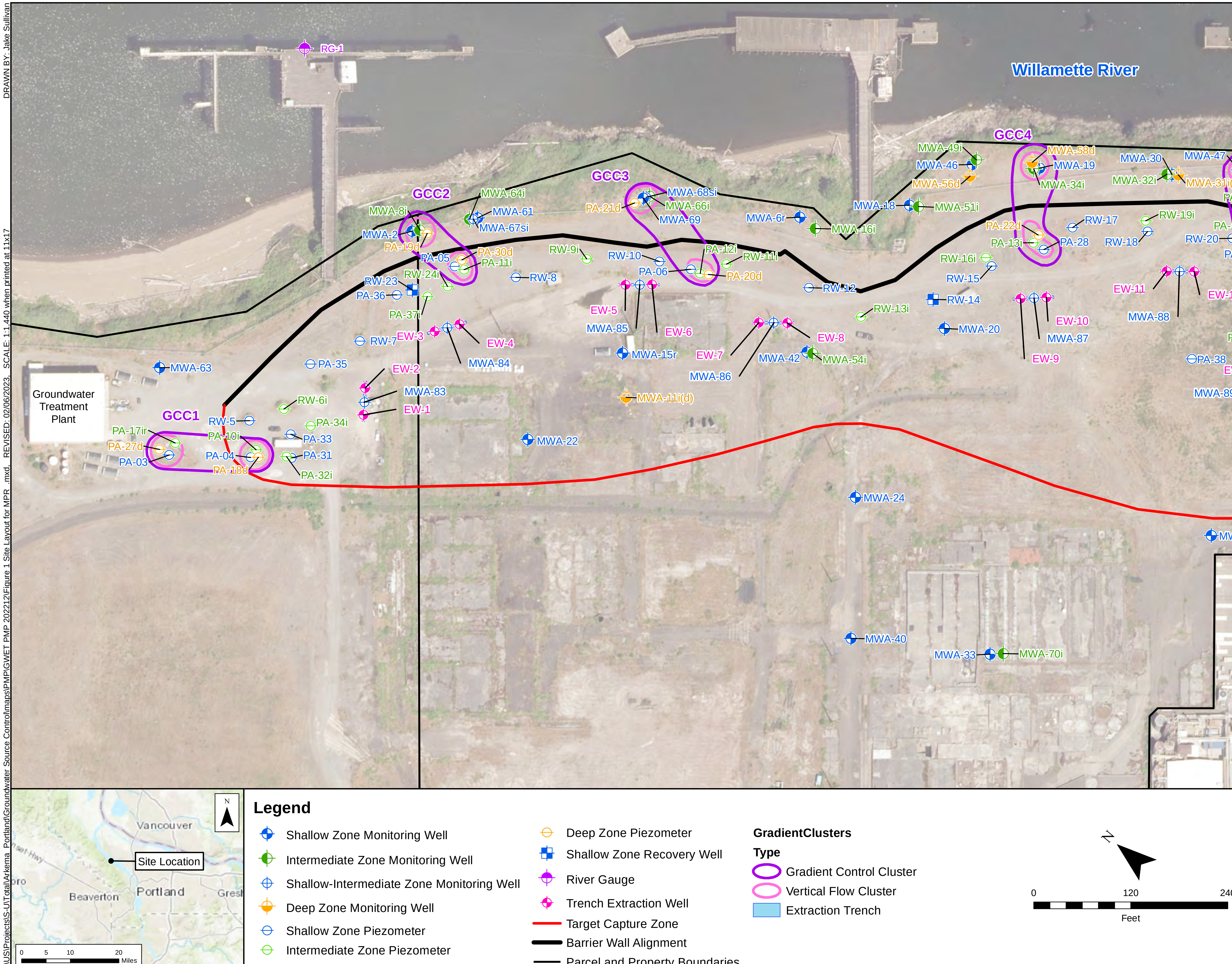

Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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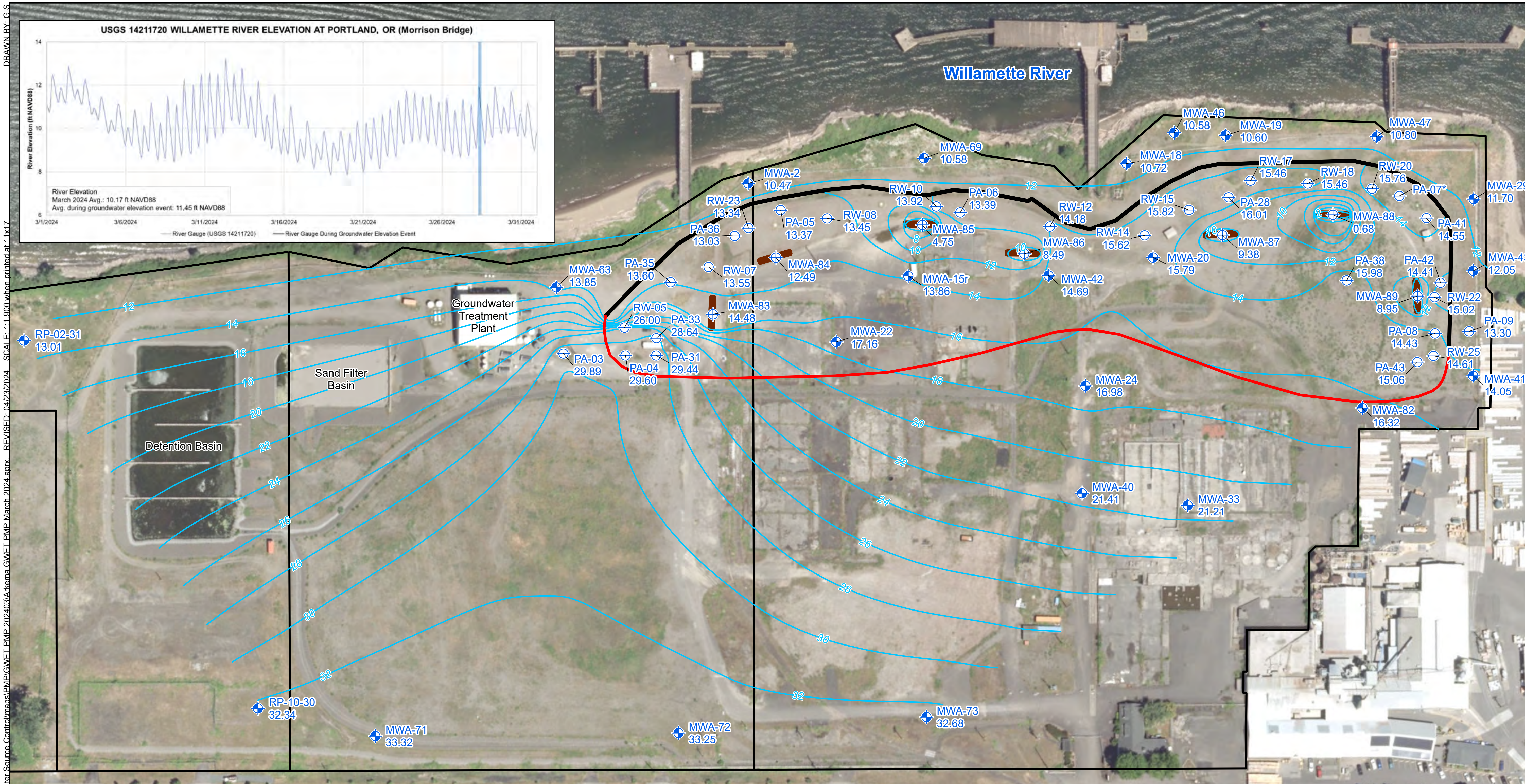

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Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected March 28, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

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Feet

Figure 2
March 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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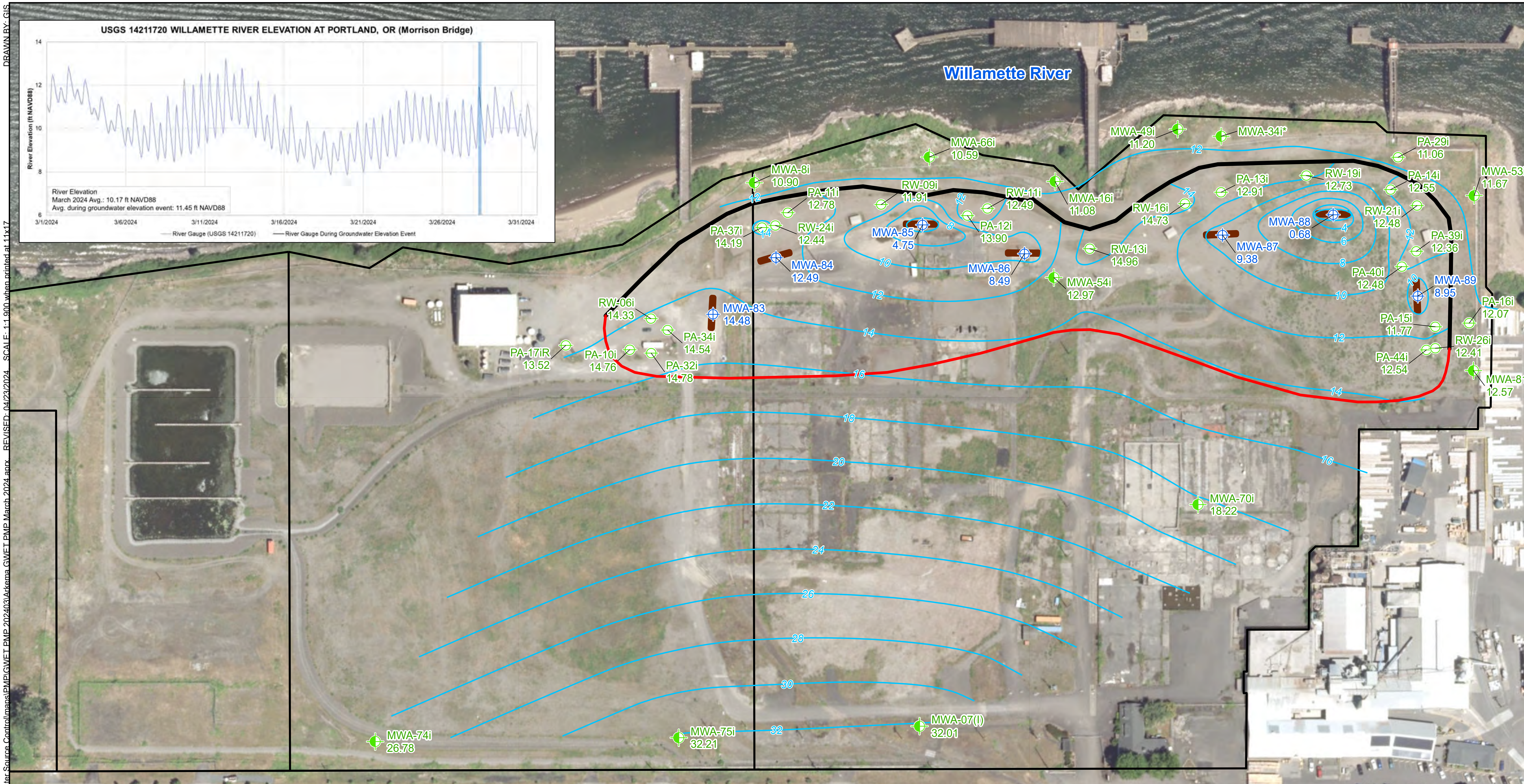
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected March 28, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

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Figure 3
March 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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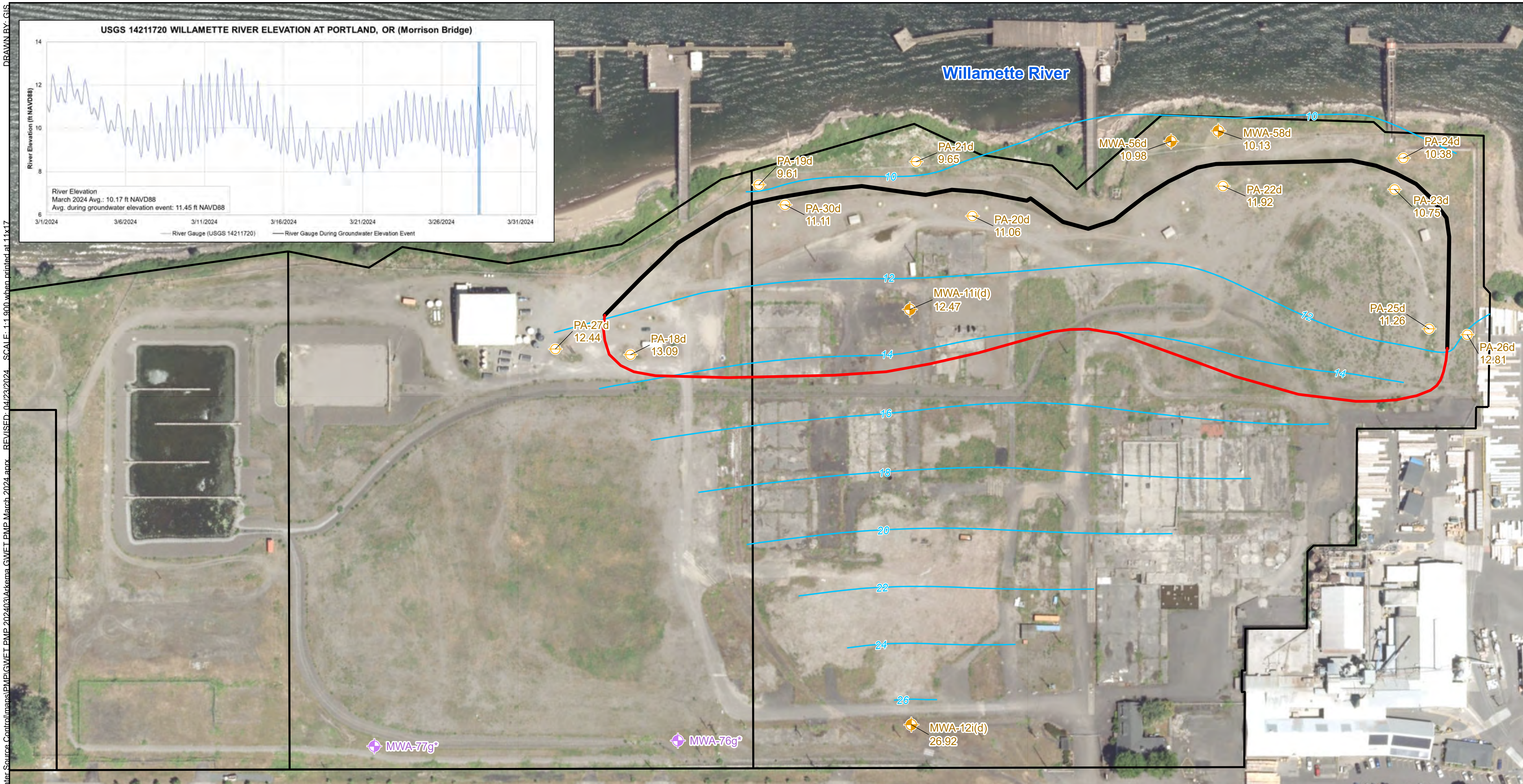

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected March 28, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

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Figure 4
March 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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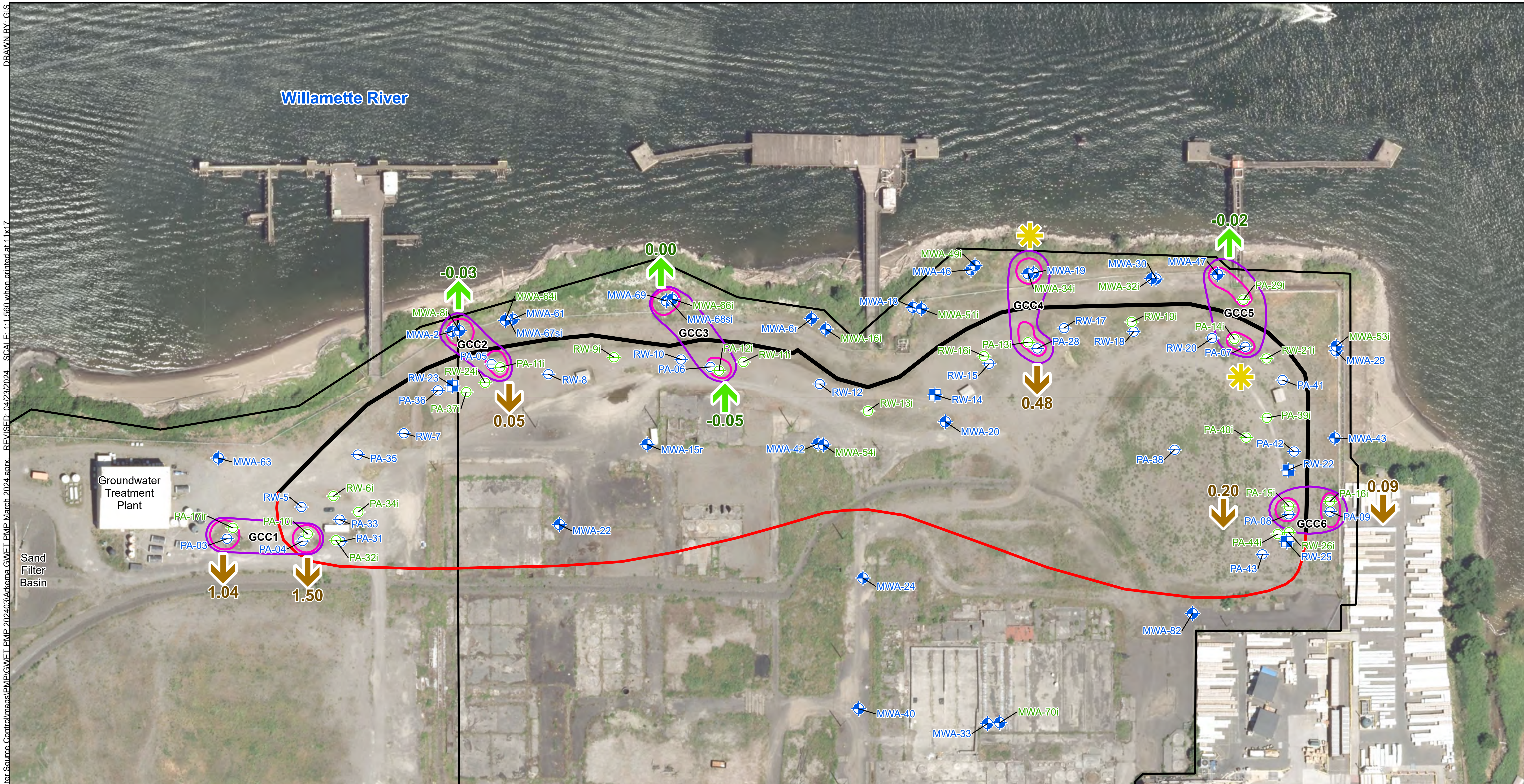

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Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected March 28, 2024.
Aerial Photo: City of Portland, Summer 2017.

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Feet

Figure 5
March 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected March 28, 2024.
Aerial Photo: City of Portland, Summer 2017.

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Feet

Figure 6
March 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: March 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
N/A	RW-13	Intermediate	1/29/2024	4/16/2024	Transducer faulted, checked and repaired.
N/A	RW-25	Shallow	1/29/2024	4/16/2024	Transducer faulted, checked and repaired.
GCC3	PA-26d	Deep	1/29/2024	Present	Transducer faulted, replacement ordered.
GCC5	PA-07	Shallow	1/29/2024	Present	Transducer faulted, replacement ordered.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

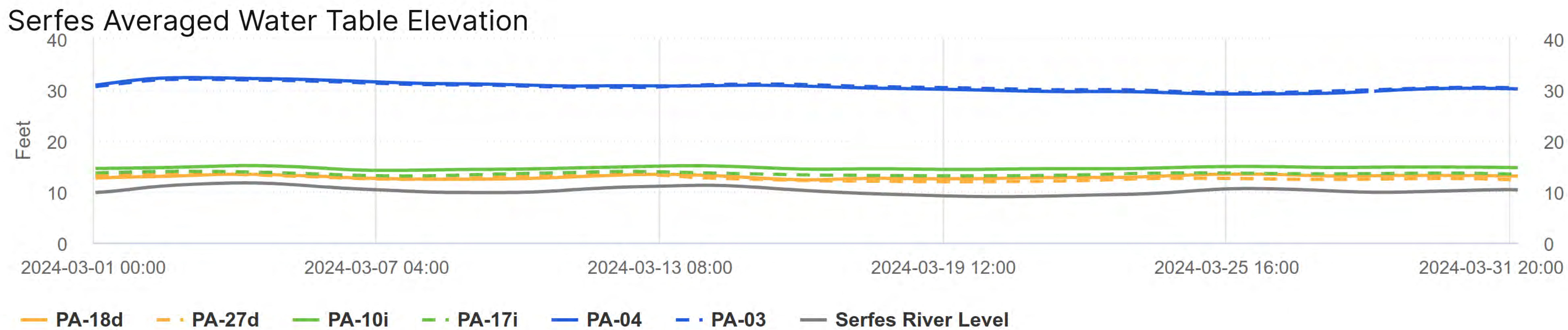
Table A-2
Recovery Well Status: March 2024
Arkema Inc. Facility
Portland, Oregon

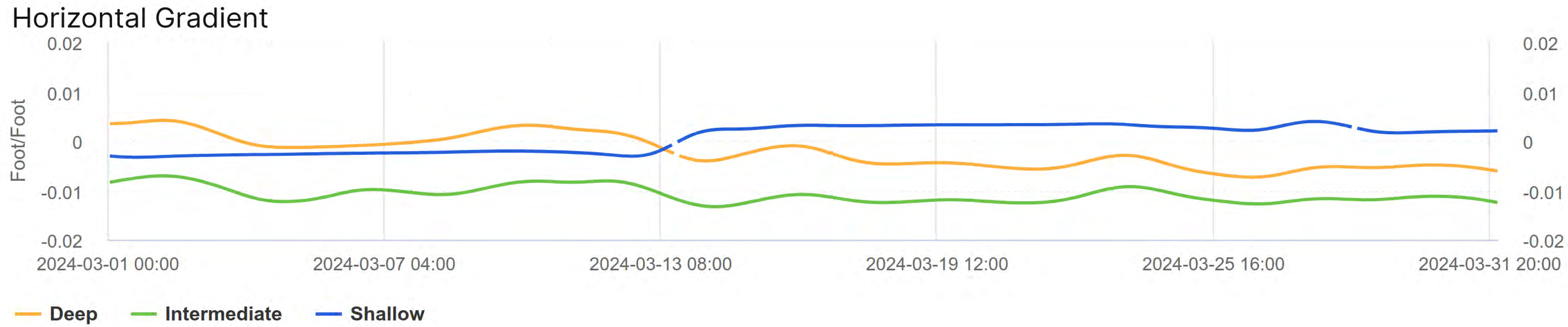
Recovery Well ID	Status as of 3/31/2024 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Not turned on
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Cable leads need to be replaced
RW-23	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Not turned on
RW-25	Inactive	Transducer Malfuction	New transducer ordered	N/A	Not Working	Good	0.00	OFF*	Transducer malfunction
EW-01	Inactive	None	Chemical Redevelopment	N/A	Good	Good	2.55	M	Waiting on UIC permit
EW-02	Inactive	None	Chemical Redevelopment	N/A	Good	Good	0.61	M	Waiting on UIC permit
EW-03	Active	None	N/A	N/A	Good	Good	3.38	G	
EW-04	Active	None	N/A	N/A	Good	Good	3.42	G	
EW-05	Active	None	N/A	N/A	Good	Good	7.02	G	
EW-06	Active	None	N/A	N/A	Good	Good	1.32	M	
EW-07	Inactive	Load Fault	Change out fouled pump	N/A	Good	Good	1.44	M	Pump fouled and needs to be changed out with clean pump
EW-08	Active	None	N/A	N/A	Good	Good	5.61	G	
EW-09	Active	None	N/A	N/A	Good	Good	3.76	G	
EW-10	Active	None	N/A	N/A	Good	Good	3.01	G	
EW-11	Active	None	N/A	N/A	Good	Good	2.19	M	
EW-12	Active	None	N/A	N/A	Good	Good	3.96	G	
EW-13	Active	None	N/A	N/A	Good	Good	5.95	G	
EW-14	Active	None	N/A	N/A	Good	Good	7.72	G	

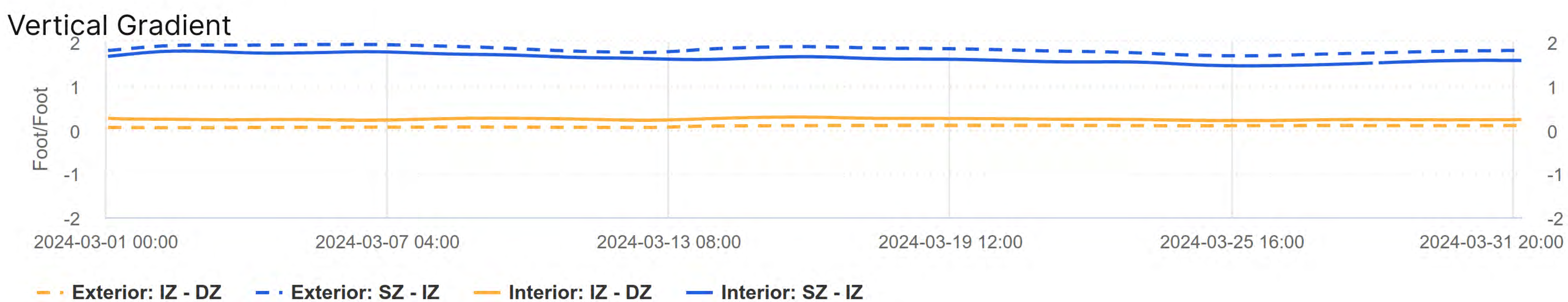
Notes:
* Recovery wells not in service
** Recovery wells in service part of the month
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1



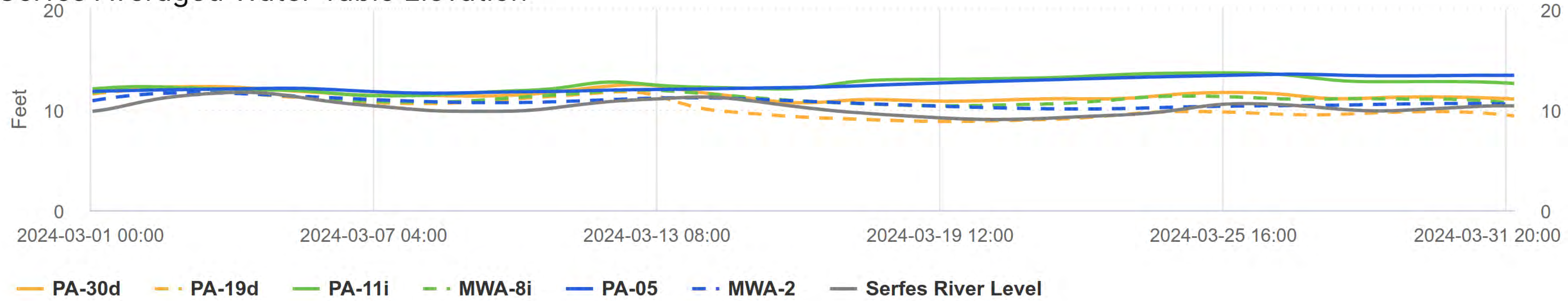




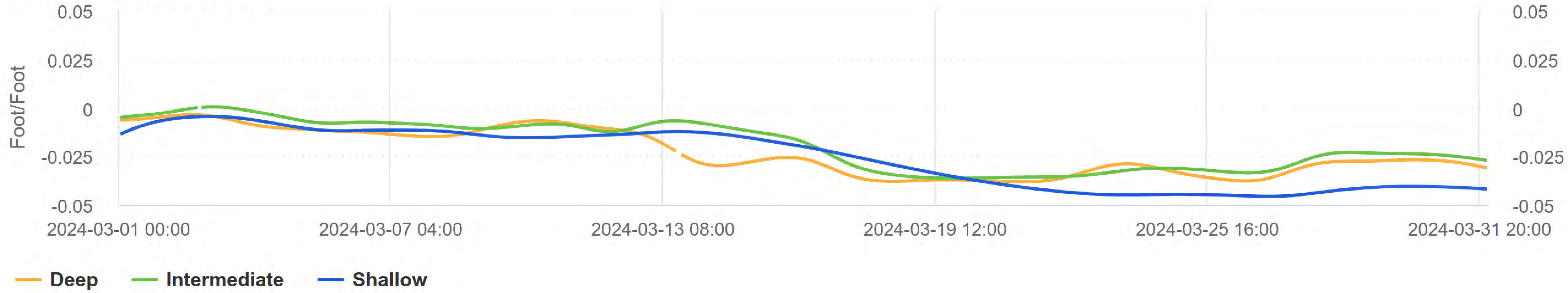
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

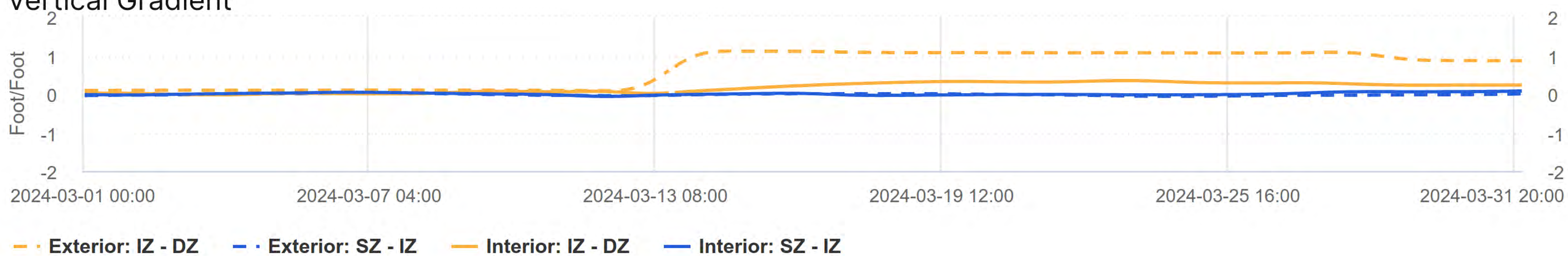
Serfes Averaged Water Table Elevation



Horizontal Gradient

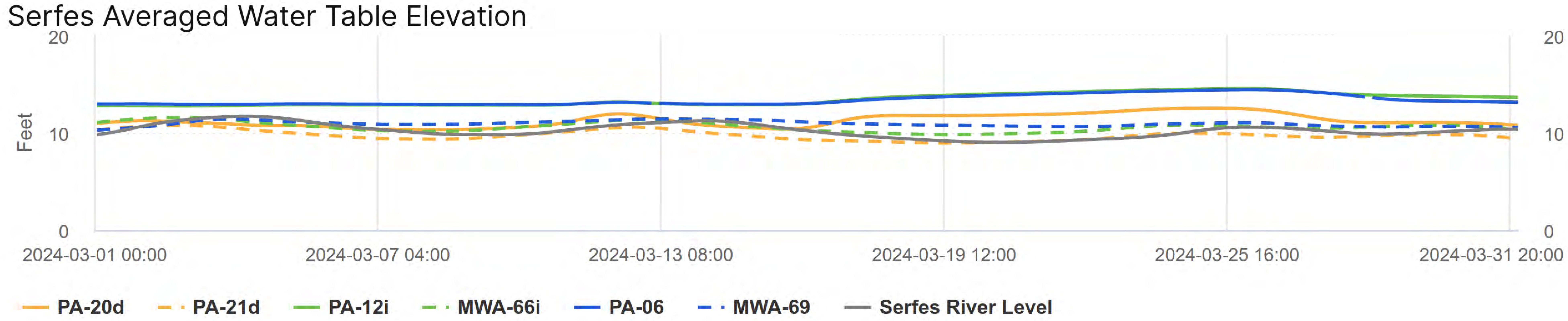


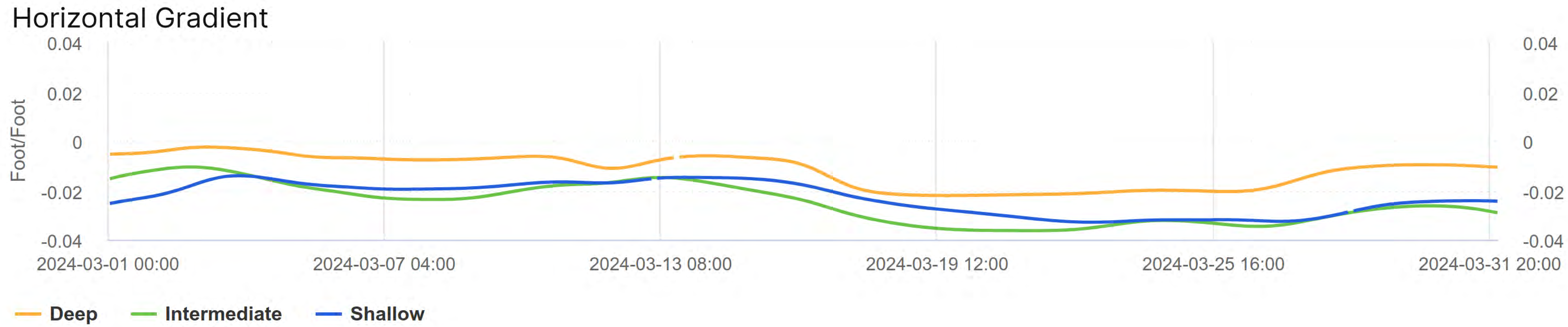
Vertical Gradient

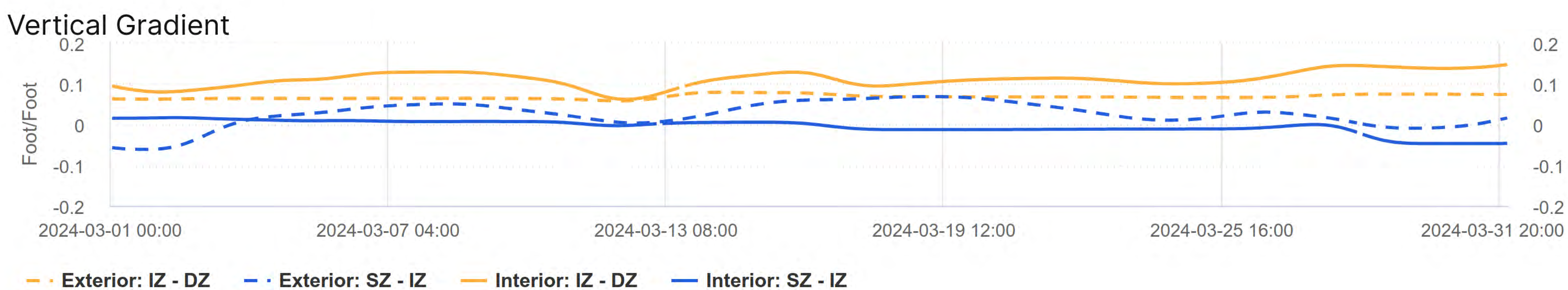


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3



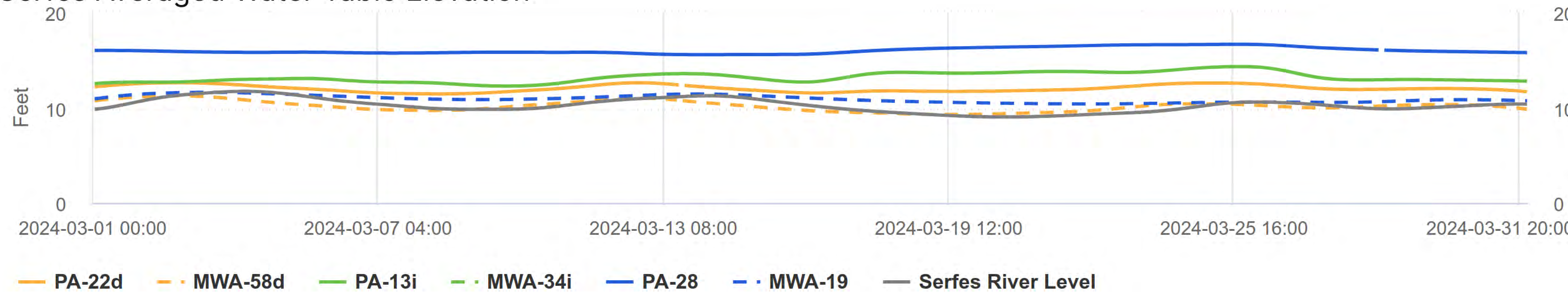




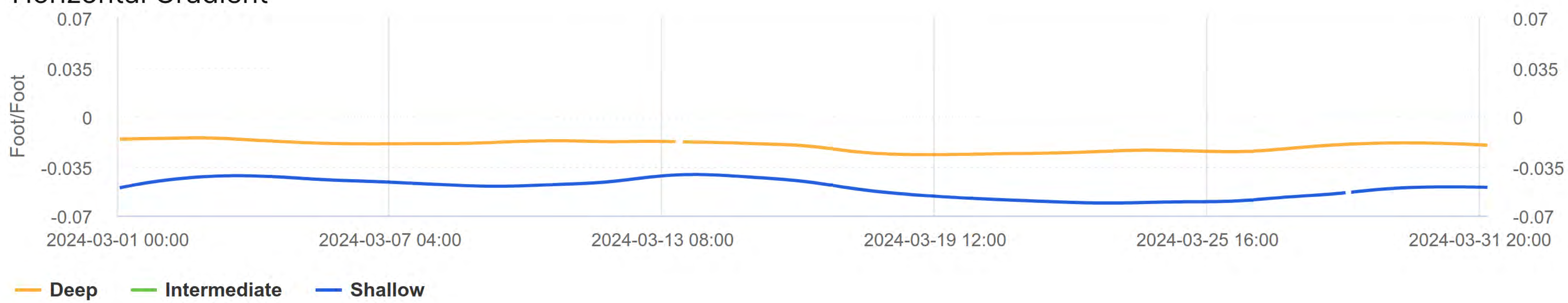
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

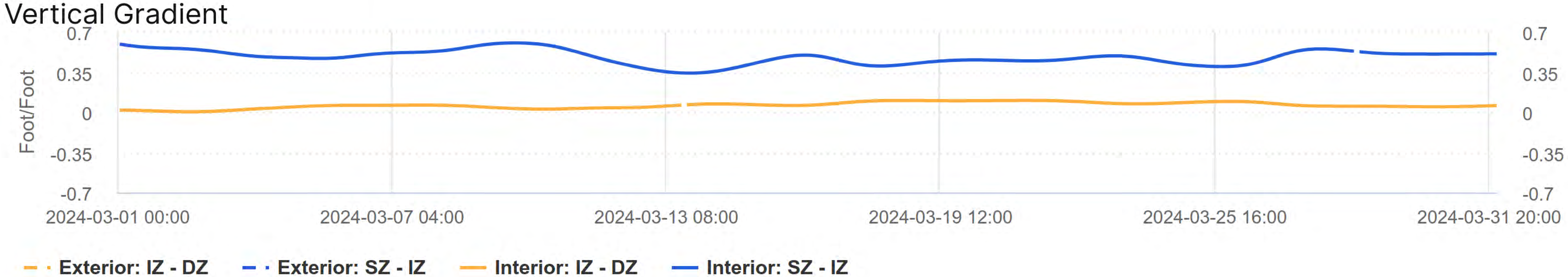
Serfes Averaged Water Table Elevation



Horizontal Gradient

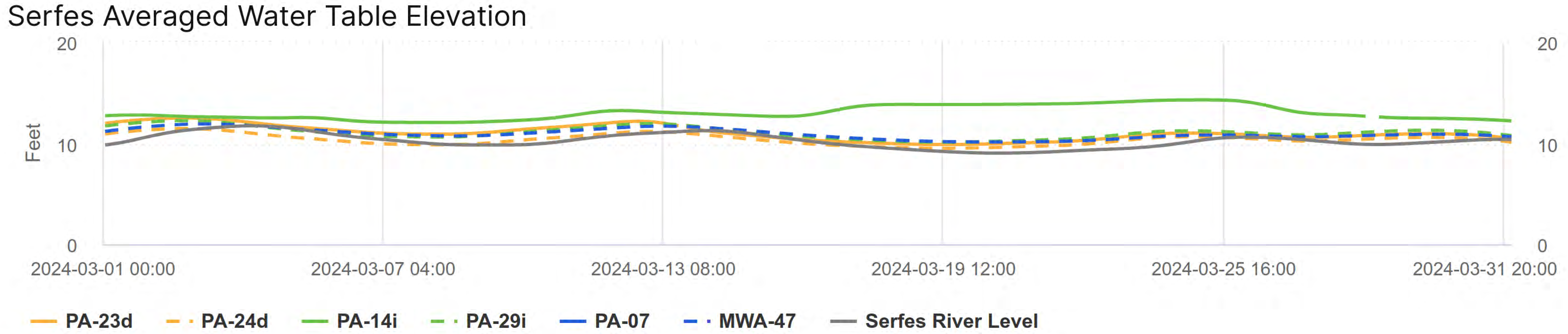


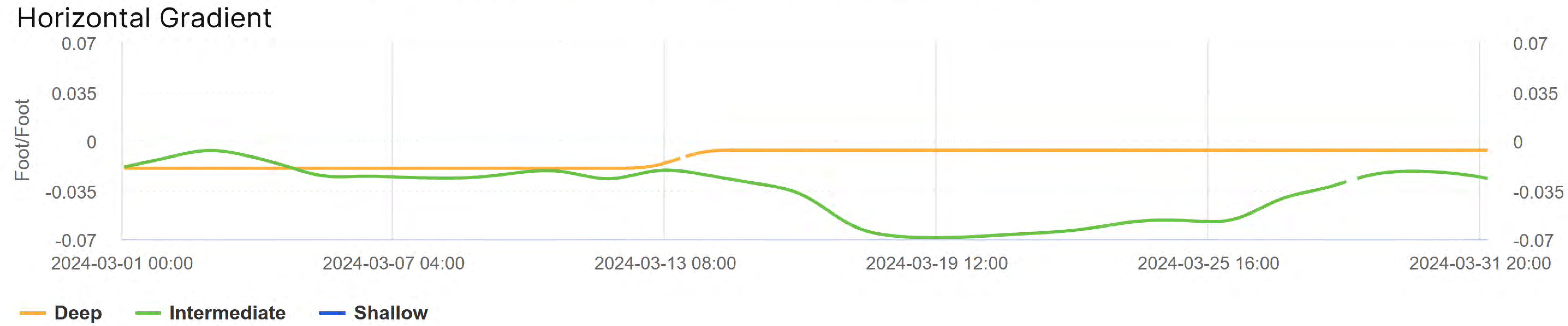
Vertical Gradient

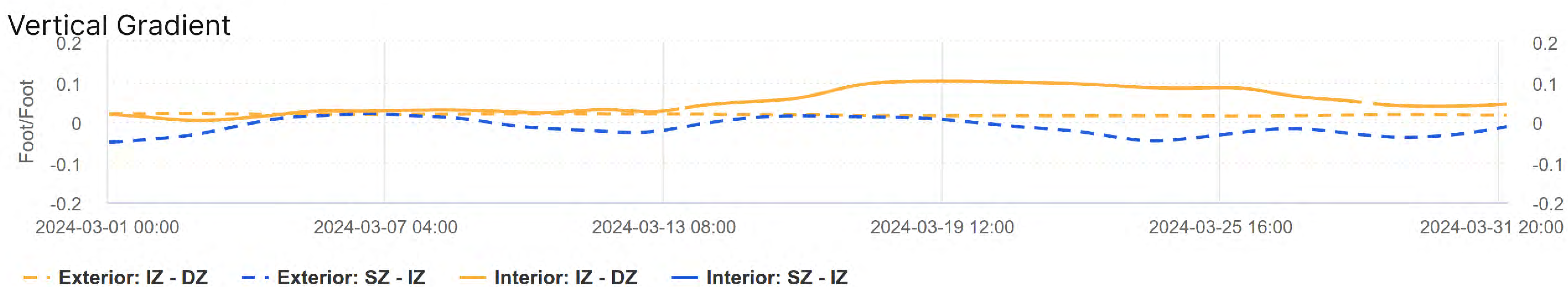


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5



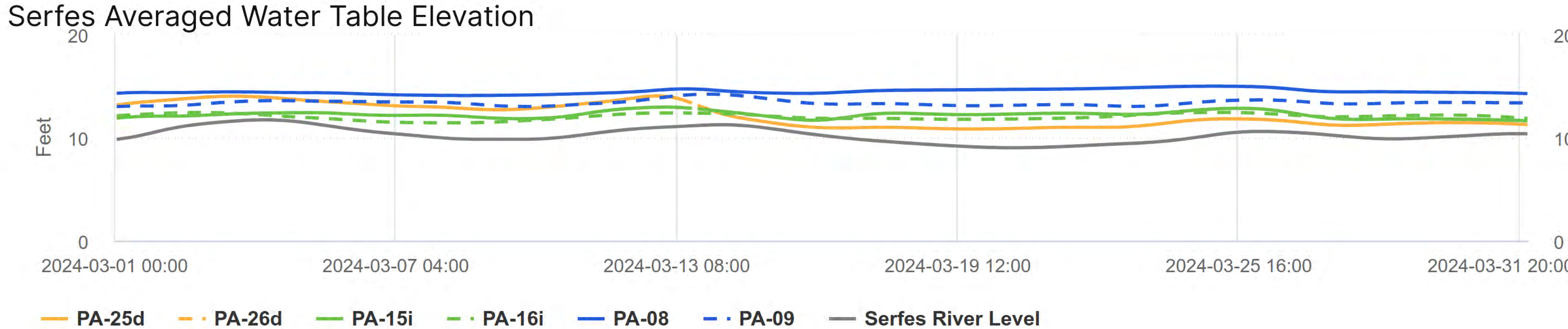


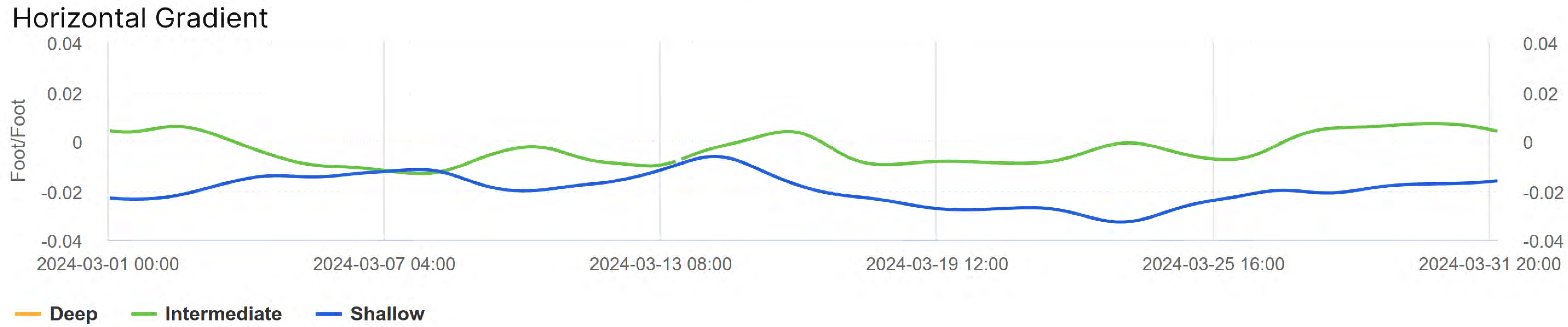


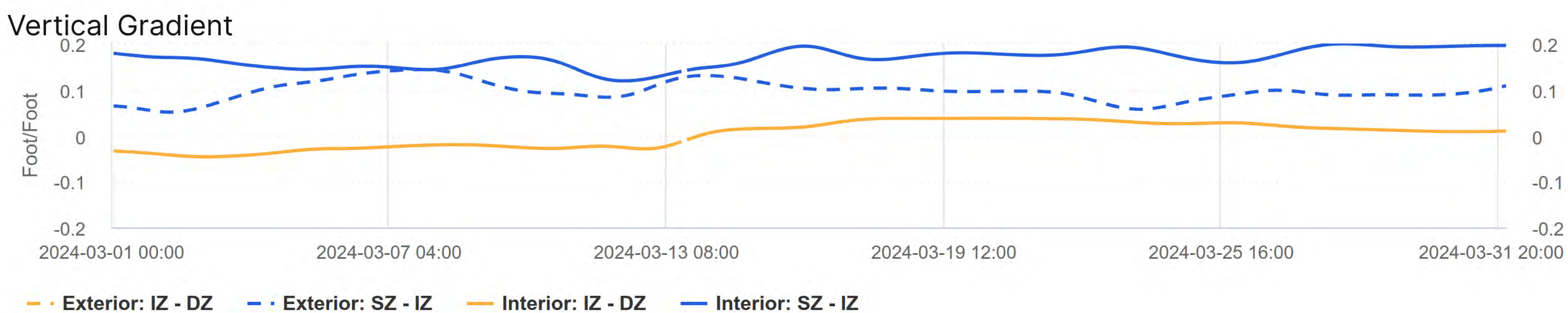
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6





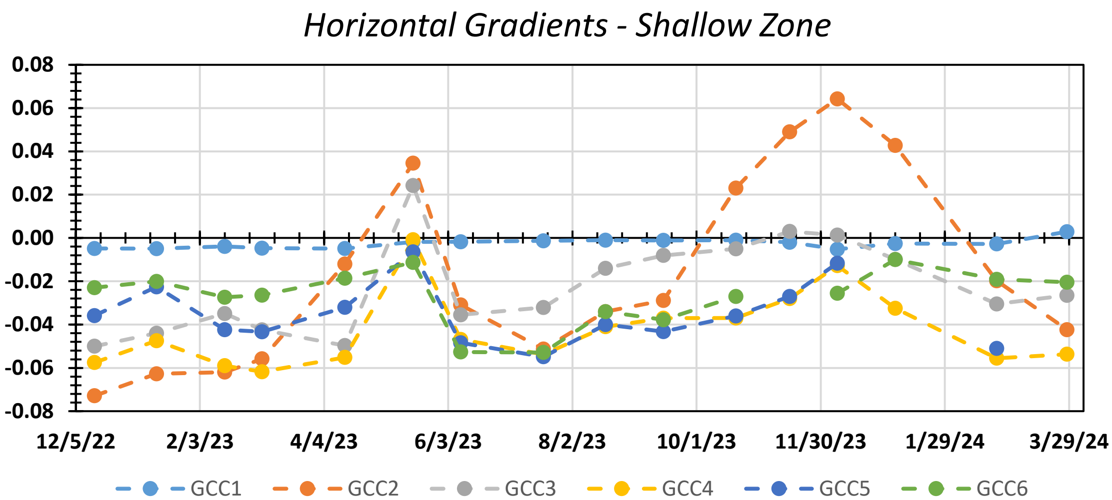


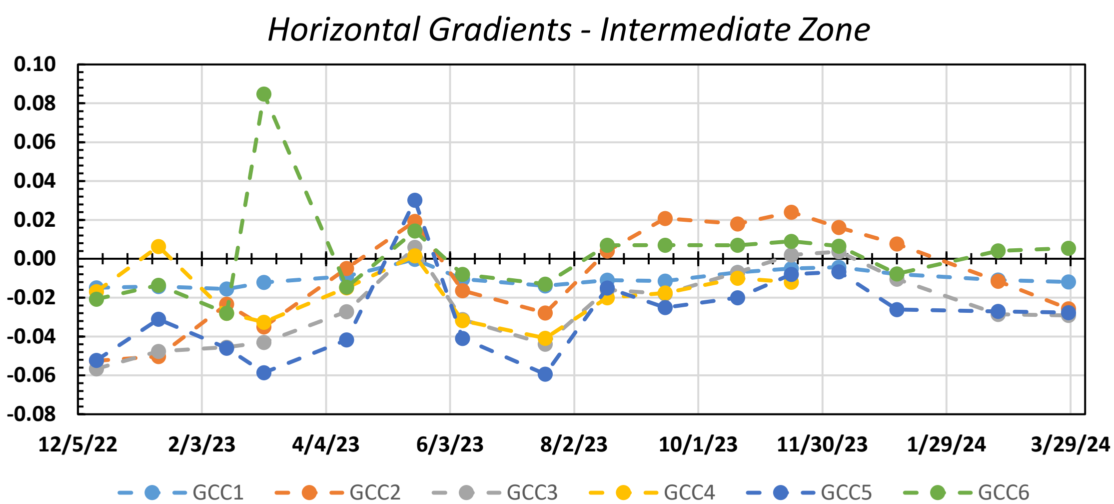
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

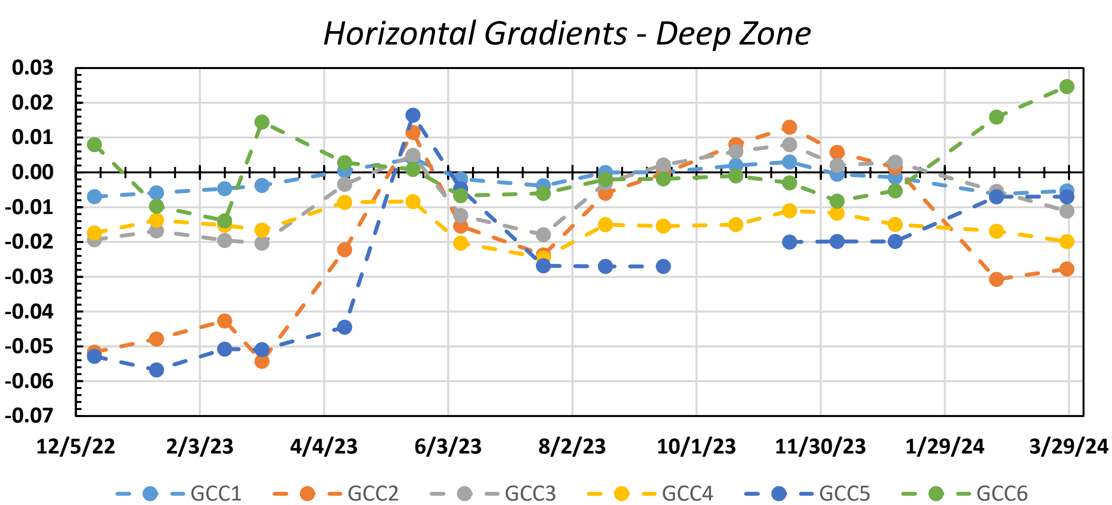
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: March 2024
Arkema Inc. Facility
Portland, Oregon







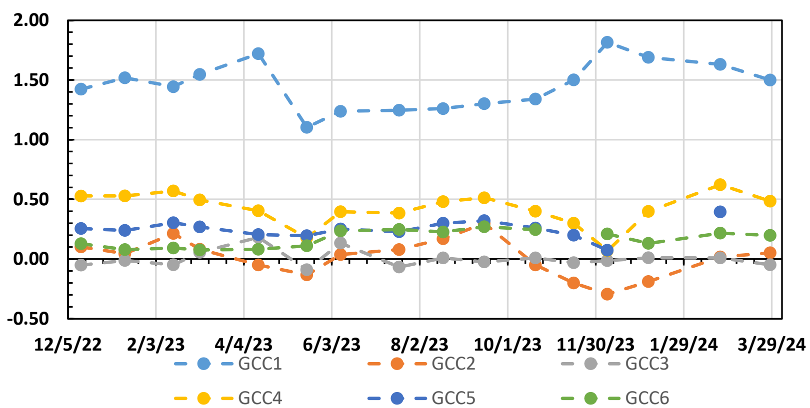
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

ATTACHMENT B-3 VERTICAL GRADIENTS

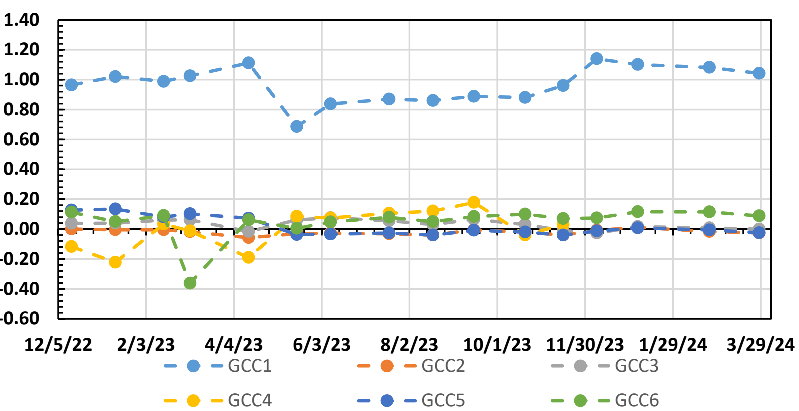
Attachment B-3

Vertical Gradients Summary: March 2024
Arkema Inc. Facility
Portland, Oregon

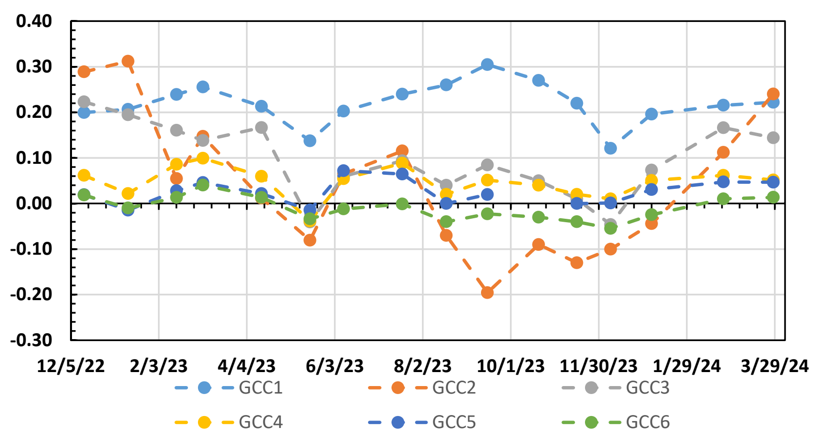
Vertical Gradients - Interior SZ-IZ



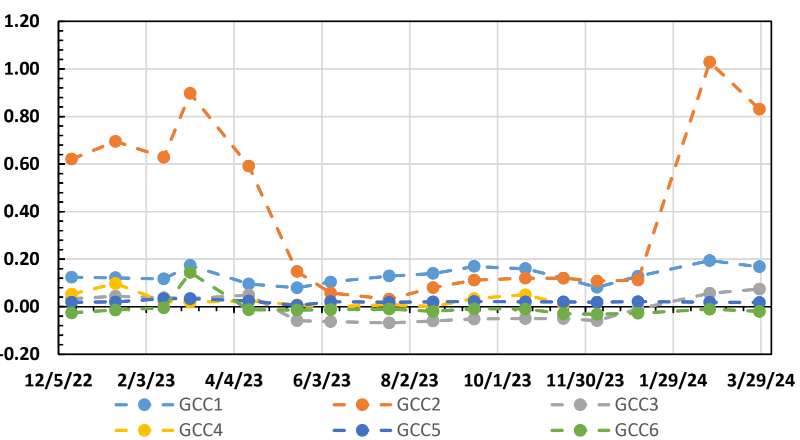
Vertical Gradients - Exterior SZ-IZ



Vertical Gradients - Interior IZ-DZ

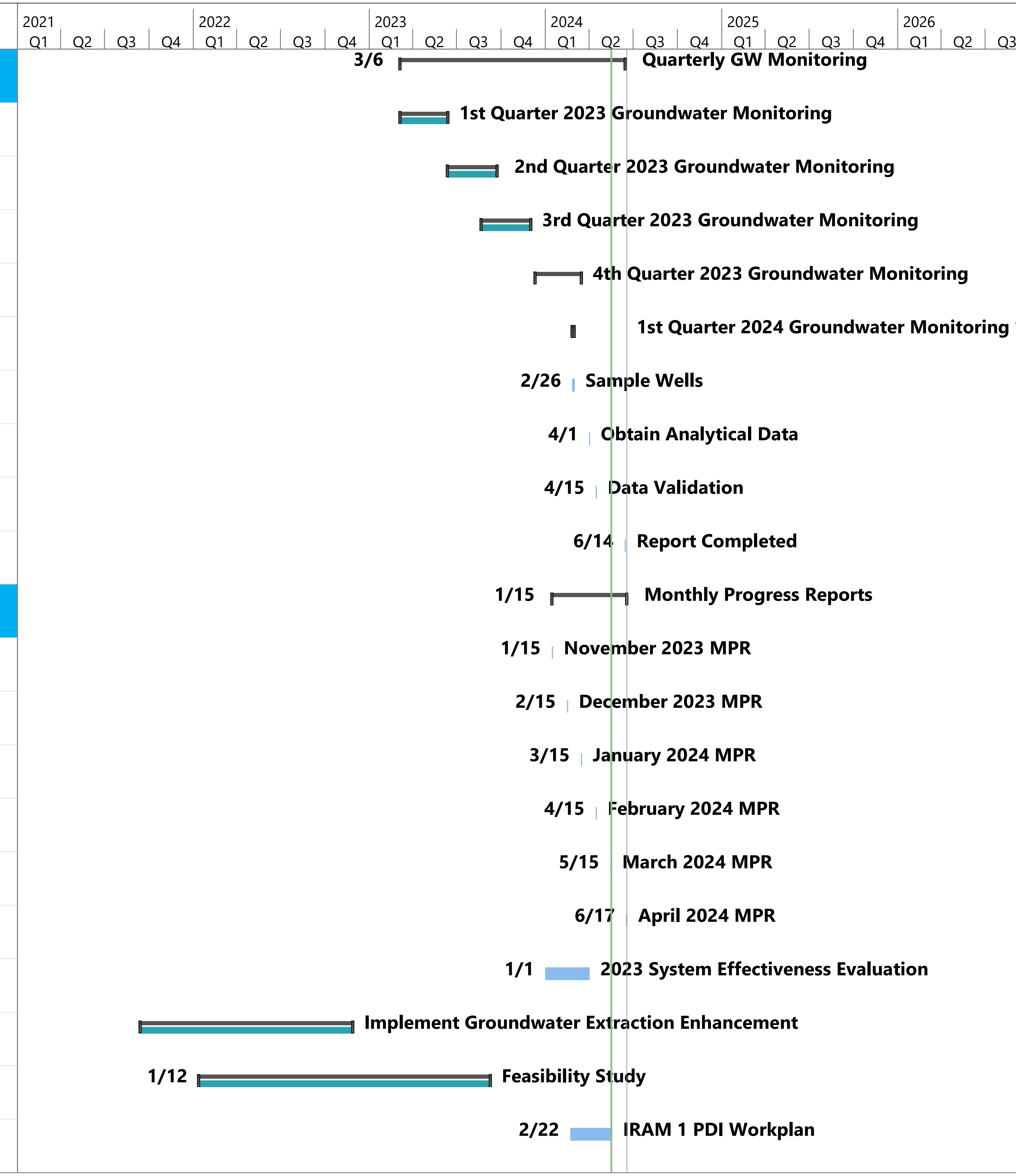


Vertical Gradients - Exterior IZ-DZ



ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start
1	**Quarterly GW Monitoring**	**336 days**	**Mon 3/6/23**
2	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*
7	*2nd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 6/12/23*
12	*3rd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 8/21/23*
17	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23
22	**1st Quarter 2024 Groundwater Monitoring ***	**4 days**	**Mon 2/26/24**
23	*Sample Wells*	*4 days*	*Mon 2/26/24*
24	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*
25	*Data Validation*	*1 day*	*Mon 4/15/24*
26	Report Completed	1 day	Fri 6/14/24
27	**Monthly Progress Reports**	**112 days**	**Mon 1/15/24**
28	*November 2023 MPR*	*1 day*	*Mon 1/15/24*
29	*December 2023 MPR*	*1 day*	*Thu 2/15/24*
30	*January 2024 MPR*	*1 day*	*Fri 3/15/24*
31	*February 2024 MPR*	*1 day*	*Mon 4/15/24*
32	March 2024 MPR	1 day	Wed 5/15/24
33	April 2024 MPR	1 day	Mon 6/17/24
34	***2023 System Effectiveness Evaluation***	***66 days***	***Mon 1/1/24***
35	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***
43	***Feasibility Study***	***436 days***	***Wed 1/12/22***
52	**IRAM 1 PDI Workplan**	63 days	Thu 2/22/24



Arkema Portland
Monthly Progress Report
Attachment C

Task | Project Summary | Manual Task | Start-only | Deadline
Split | Inactive Task | Duration-only | Finish-only | Progress
Milestone | Inactive Milestone | Manual Summary Rollup | External Tasks | Manual Progress
Summary | Inactive Summary | Manual Summary | External Milestone

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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	19 June 2024
REFERENCE	0732445 Phase 204
SUBJECT	April 2024 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This April 2024 MPR summarizes the GW SCM performance monitoring data collected in April 2024. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells (RWs), and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 RWs prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four-remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is approximately 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and

GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 42.88 gallons per minute (gpm) for the entire month of April 2024, including non-operational periods. The average operational influent flow during operational periods was 50.90 gpm, a decrease from March 2024 (68.46 gpm), due to an increase in the number of fouled pumps. The average monthly influent flow rate in April 2024 increased from March 2024 monthly average flow rate (40.16 gpm), due to increased uptime.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. In late February 2024, a recordable injury occurred onsite during pump removal and maintenance activities. As a result, pump maintenance activities were paused while a root cause analysis was performed, and procedures updated to mitigate ergonomic and fall risks. An updated pump pulling and maintenance procedure was approved 30 April 2024 and implemented in May 2024. Additionally, Trench 1 was off during April 2024 in preparation for chemical redevelopment to mitigate the impact of silt and biofouling at EW-01 and EW-02. Extraction rates and hydraulic gradient performance are expected to improve following resumption of pump maintenance activities and chemical redevelopment in early June 2024.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

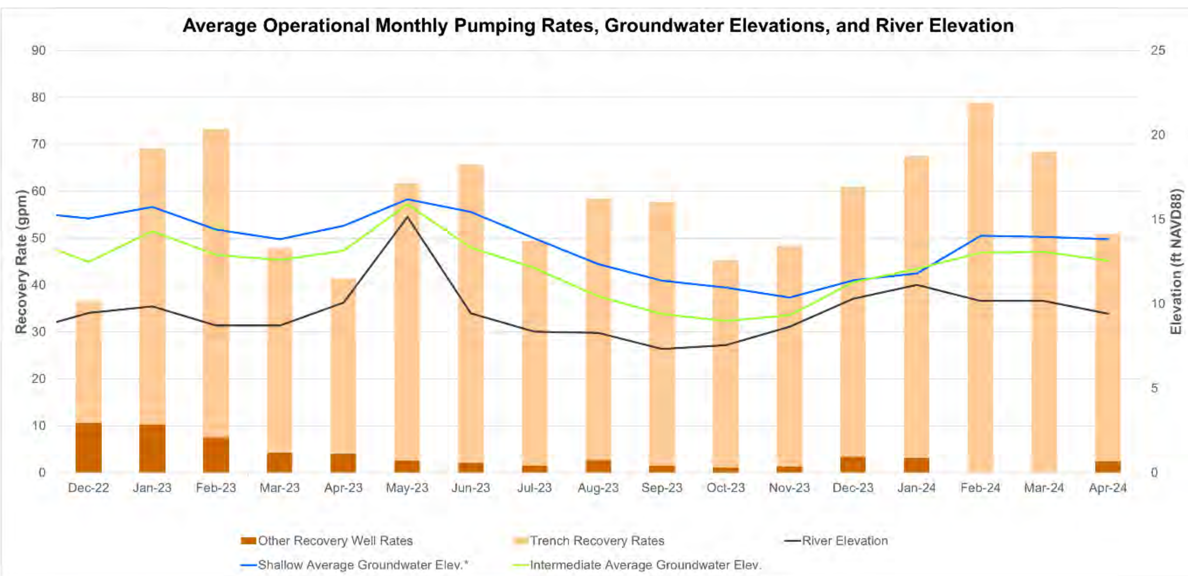
TABLE 1-1 RECOVERY WELL PUMPING RATES

Recovery Well	April 2024 Average Operational Pumping Rate (gpm)	April 2024 Average Monthly Pumping Rate (gpm)
RW-14*	0.00	0.00
RW-22*	0.00	0.00
RW-23*	0.00	0.00
RW-25	2.37	1.03
EW-01*	0.00	0.00
EW-02*	0.00	0.00

Recovery Well	April 2024 Average Operational Pumping Rate (gpm)	April 2024 Average Monthly Pumping Rate (gpm)
EW-03	4.93	4.77
EW-04	5.03	4.86
EW-05	6.49	6.27
EW-06	4.40	4.25
EW-07	0.32	0.01
EW-08	4.77	2.07
EW-09	2.66	2.57
EW-10	3.46	3.34
EW-11	2.78	0.46
EW-12	3.38	3.26
EW-13	3.91	3.78
EW-14	6.42	6.20
Total	50.90	42.88

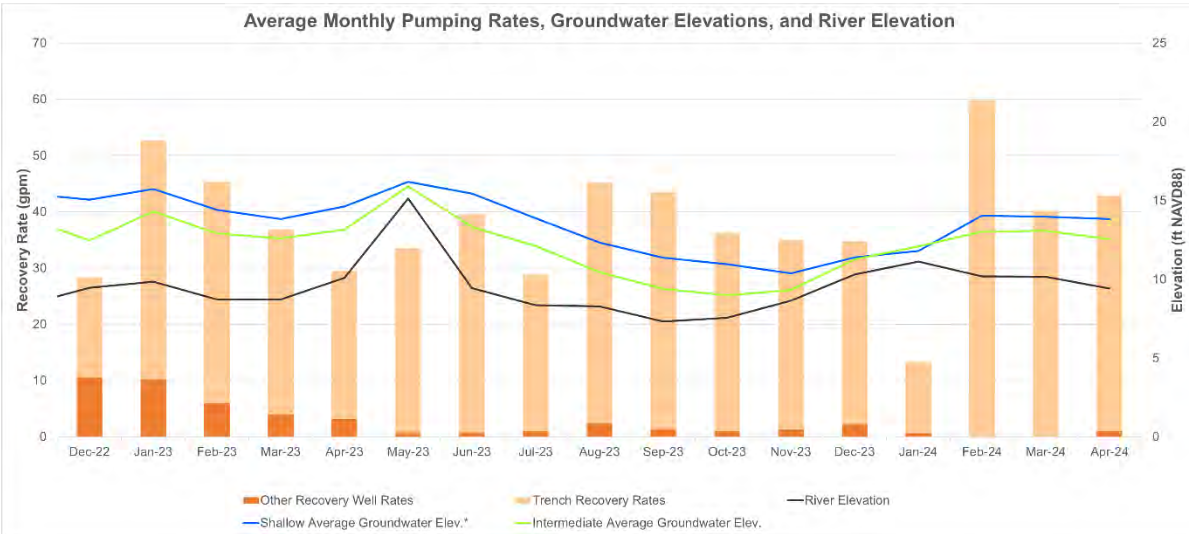
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There were two shutdowns:

- 5 April 2024: The GWET system was shut down intermittently due to the GWET effluent pH probe malfunctioning. The ODEQ was notified, the pH probe was replaced and discharge restarted 11 April 2024.
- 29 April 2024: The GWET system was shut down due to a carbon changeout on the lead carbon vessel. The ODEQ was notified, and discharge restarted 2 May 2024.

The unplanned and planned shutdowns in April 2024 resulted in 8 total days of downtime. The extended shutdown period and pause on pump maintenance continued to result in lower flow rates in April 2024. Regular pump maintenance is planned to resume 1 May 2024 and flow rates are expected to increase.

4. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four-remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

4.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 19 April 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during April 2024, the following transducers were:

<u>Fully out of service pending repairs:</u>

- PA-07
- PA-26d

<u>Out of service for a period but returned to full operation:</u>

- RW-25
- RW-13

RW-13 had a faulted transducer that was replaced 16 April 2024. RW-25 had a faulted transducer that was rechecked and repaired 16 April 2024. PA-07, and PA-26d have faulted transducers that are scheduled to be replaced in May 2024. RW-13 and RW-25 are not in the GCCs.

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour

- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After April 2024 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 19 April 2024 are shown below at each GCC (Table 1-2 and Table 1-3).

TABLE 1-2 APRIL HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	27.31	PA-04	28.02	-0.007
	Intermediate	PA-17iR	12.59	PA-10i	13.81	-0.012
	Deep	PA-27d	11.34	PA-18d	11.85	-0.004
GCC2	Shallow	MWA-2	9.65	PA-05	12.45	-0.041
	Intermediate	MWA-8i	9.72	PA-11i^{M}	11.41	-0.023
	Deep	PA-19d	8.46	PA-30d	9.91	-0.027
GCC3	Shallow	MWA-69	10.03	PA-06	12.91	-0.027
	Intermediate	MWA-66i^{M}	9.60	PA-12i^{M}	13.41	-0.034
	Deep	PA-21d	8.46	PA-20d	9.47	-0.008
GCC4	Shallow	MWA-19	10.00	PA-28	15.49	-0.054
	Intermediate	MWA-34i^{M}	9.50	PA-13i	11.71	-0.024
	Deep	MWA-58d	8.97	PA-22d	10.64	-0.018
GCC5	Shallow	MWA-47	9.67	PA-07^{M}	*	**
	Intermediate	PA-29i^{M}	9.86	PA-14i	11.44	-0.029
	Deep	PA-24d	9.22	PA-23d	9.59	-0.007
GCC6	Shallow	PA-09	12.50	PA-08	13.47	-0.017
	Intermediate	PA-16i	11.05	PA-15i	10.67	0.007
	Deep	PA-26d^{M}	11.62	PA-25d	10.06	0.025

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
M = manual groundwater elevation measurement

TABLE 1-3 APRIL VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	28.02	PA-10i	13.81	1.44
		GCC2	PA-05	12.45	PA-11i[M]	11.41	0.09
		GCC3	PA-06	12.91	PA-12i[M]	13.41	-0.05
		GCC4	PA-28	15.49	PA-13i	11.71	0.59
		GCC5	PA-07[M]	*	PA-14i	11.44	**
		GCC6	PA-08	13.47	PA-15i	10.67	0.21
	IZ-DZ	GCC1	PA-10i	13.81	PA-18d	11.85	0.26
		GCC2	PA-11i[M]	11.41	PA-30d	9.91	0.22
		GCC3	PA-12i[M]	13.41	PA-20d	9.47	0.20
		GCC4	PA-13i	11.71	PA-22d	10.64	0.06
		GCC5	PA-14i	11.44	PA-23d	9.59	0.05
		GCC6	PA-15i	10.67	PA-25d	10.06	0.02
Exterior	SZ-IZ	GCC1	PA-03	27.31	PA-17iR	12.59	0.94
		GCC2	MWA-2	9.65	MWA-8i	9.72	0.00
		GCC3	MWA-69	10.03	MWA-66i[M]	9.60	0.03
		GCC4	MWA-19	10.00	MWA-34i[M]	9.50	0.08
		GCC5	MWA-47	9.67	PA-29i[M]	9.86	-0.02
		GCC6	PA-09	12.50	PA-16i	11.05	0.11
	IZ-DZ	GCC1	PA-17iR	12.59	PA-27d	11.34	0.19
		GCC2	MWA-8i	9.72	PA-19d	8.46	0.82
		GCC3	MWA-66i[M]	9.60	PA-21d	8.46	0.09
		GCC4	MWA-34i[M]	9.50	MWA-58d	8.97	0.02
		GCC5	PA-29i[M]	9.86	PA-24d	9.22	0.02
		GCC6	PA-16i	11.05	PA-26d[M]	11.62	-0.02

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; M = manual groundwater elevation measurement; SZ = Shallow Zone

4.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 19 April 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Intermediate and Deep Zones at GCC6. Horizontal gradients at GCCs across the Site remained mostly unchanged between March and April.

River elevations are shown over time on Figures 1-1 and 1-2 above, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in April 2024 had an average elevation of 9.42 feet NAVD88 with a minimum elevation of 7.11 NAVD88 and a maximum elevation of 12.25 NAVD88, a decrease from the river elevation in March 2024.

The difference between average interior Shallow Zone groundwater elevations and river level elevation were 4.54 feet and 4.41 feet in April 2023 and April 2024, respectively. The difference between river level and Shallow Zone groundwater elevations is expected to decrease when increased groundwater extraction rates are maintained in the Target Capture Zone. A potentiometric separation is still noticeable exterior to the GWBW, indicating that is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC3 being upward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 upward and the rest downward as shown on Figure 5 and in Attachment B-2.

The vertical gradient at GCC5 was unable to be calculated due to an anomalous groundwater elevation reading at PA-07. The transducer is scheduled to be replaced 1 May 2024.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were primarily downward with exception to GCC6 being upward, as shown on Figure 6 and Attachment B-3.

As discussed above, GWET uptime was reduced in January 2024 due to reconfiguring the trunk line, and also in February 2024 for the redevelopment of EW trenches. During pump maintenance activities on 29 February 2024 an operator had a recordable injury, which resulted in a stop work on pump pulling and replacement activities. An updated pump maintenance procedure was approved 30 April 2024 by ERM and LSS. The stop work on pump maintenance reduced the flow rate capacity of the EWs during March 2024 and April 2024 because pumps could not be pulled, cleaned, and replaced. The water level measurements collected on 19 April 2024 were within in this period of reduced groundwater extraction. The lower groundwater extraction rates in March 2024 and April 2024 resulted in horizontal gradients trending more outward than previously observed. Planned EW trench redevelopment, conveyance line maintenance, and resumed pump maintenance are expected to result in greater uptime and groundwater extraction rates in May and June 2024.

4.2.1 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates indicate that the active RWs and EWs are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

5. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022

Report	Sampling Dates	Report Submittal Date
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	6/7/2024
2024 Quarter 2	6/10/2024–6/13/2024	9/13/2024*

* Dates are tentative.

6. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in April 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

6.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided for the Intermediate and Deep Zones in Attachment B-2 show gradients were inward GCC6. Horizontal gradients at GCCs across the Site remained mostly unchanged between March and April due to a pause on pump maintenance activities. Improvements in gradients are anticipated as higher flow rates and uptime are able to be achieved.
- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC3 being upward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and the rest downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were generally downward with GCC6 being upward, as shown on Figure 6.
- The average river elevation in April 2024 was 9.42 feet NAVD88 with a minimum elevation of 7.11 feet NAVD88 and a maximum elevation of 12.25 feet NAVD88. A decrease from river elevations observed in March 2024.

6.2 GROUNDWATER EXTRACTION

Based on April 2024 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, 3, and 4 largely gone, and the mound around Trenches 5, 6, and 7 is being reduced with increased extraction rates.

Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. More operational time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

The groundwater extraction flow rate has been limited by a combination of groundwater elevation, fouling of the pumps within the EW trenches, accumulation of silt within the EW trenches filter pack, back pressure in the conveyance line, and a pause on pump maintenance. In January, the wellfield was reconfigured to connect three of the trenches to the Intermediate Zone trunk line to mitigate the impact of back pressure in the conveyance lines. In February, Trenches 1, 4, and 6 were redeveloped to mitigate the impact of silt and biofouling on pumping rates. Pump maintenance procedures were approved and pump maintenance resumed in May 2024. Additional redevelopment is also planned for May 2024. These efforts are anticipated to mitigate the limitations observed in Q4 2023 through Q1 2024.

6.3 RECOMMENDATIONS AND FUTURE WORK

Redevelopment of several Intermediate Zone groundwater elevation monitoring locations (RW-6i, RW-9i, RW-11i, RW-13i, RW-16i, RW-19i, RW-21i, RW-24i, RW-26i, and PA-12i) is planned for May 2024 to mitigate turbidity and improve accuracy of Intermediate Zone groundwater contour maps. Abandonment and replacement of MWA-34i is planned for May 2024. Chemical redevelopment of Trench 1 is planned for May 2024 and redevelopment of EWs is planned for May 2024 to mitigate silt impacts and increase flow rates. Additionally, conveyance line cleaning is planned for June 2024 to mitigate the observed backpressure in the conveyance lines. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

Brendan Robinson, PE
Partner

7. References

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FIGURES

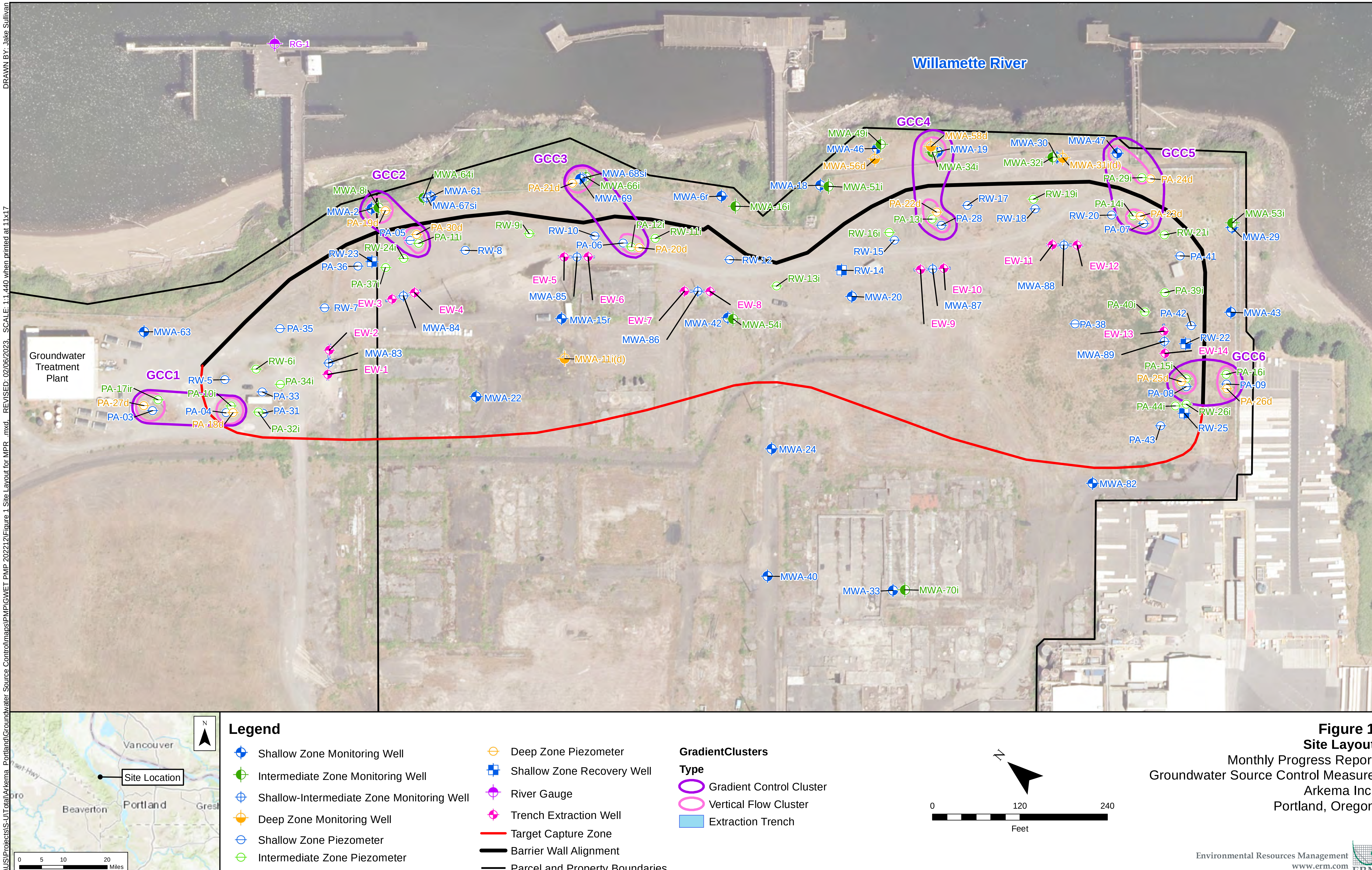
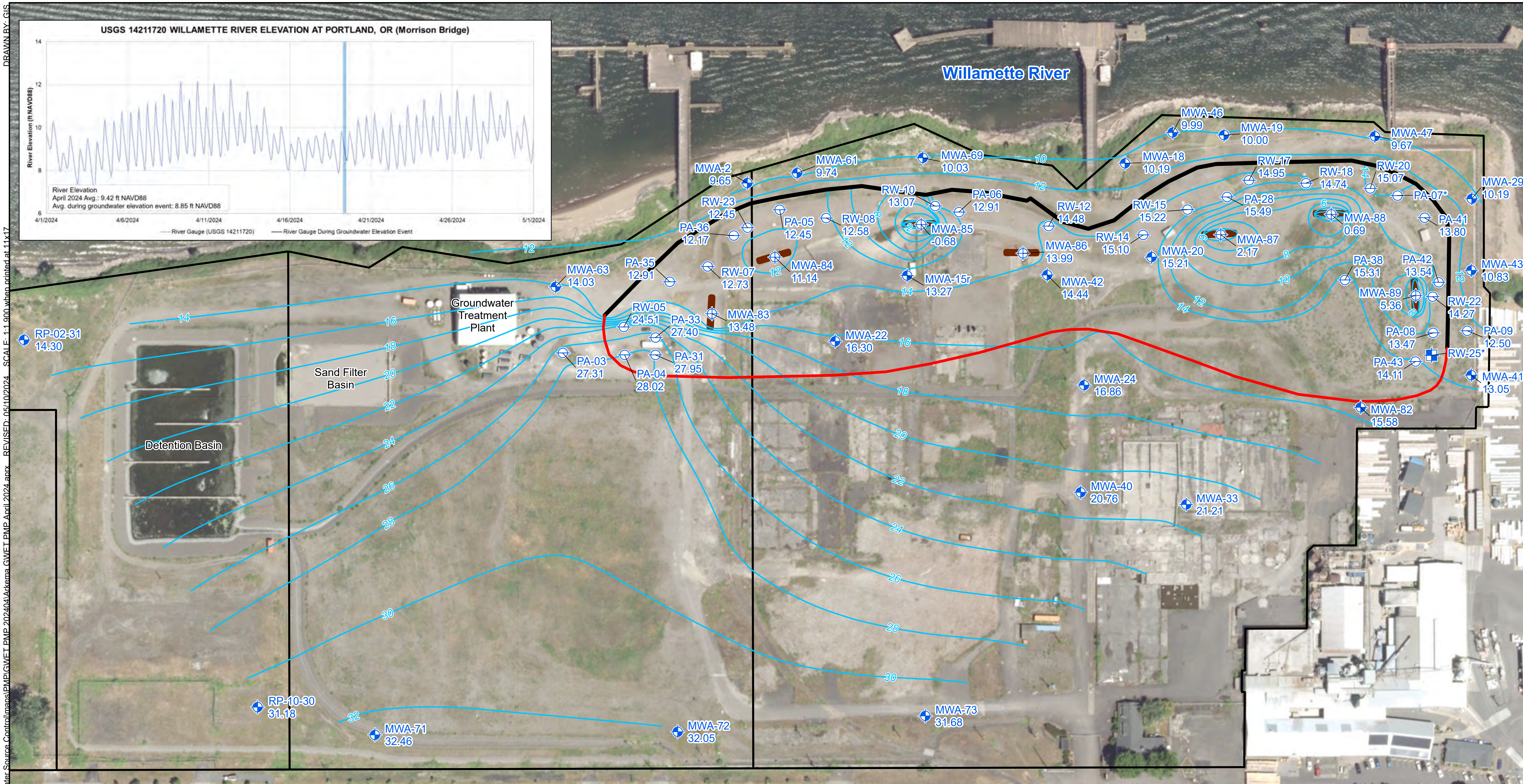


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected April 19, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

Figure 2
April 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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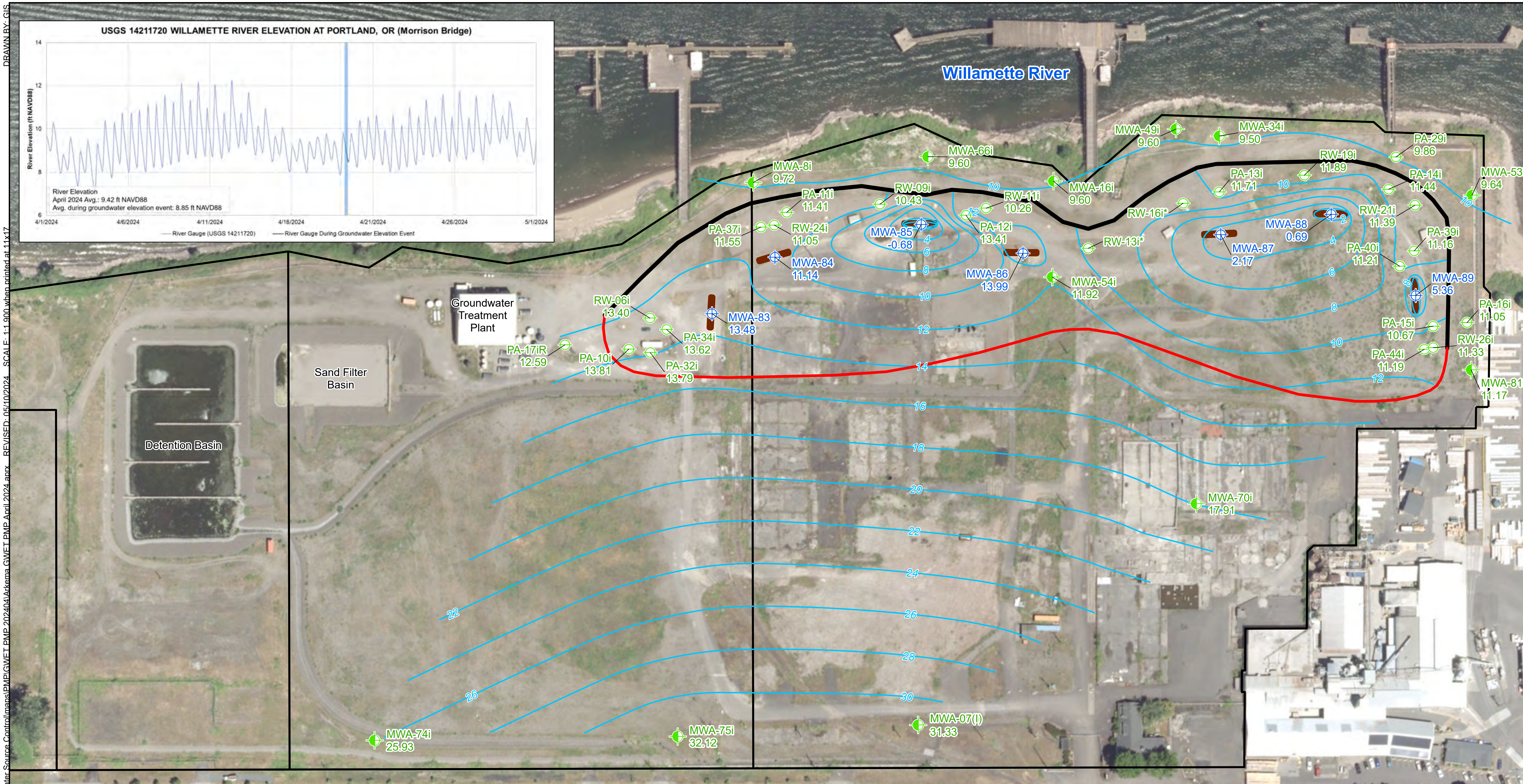

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected April 19, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320

Feet

Figure 3
April 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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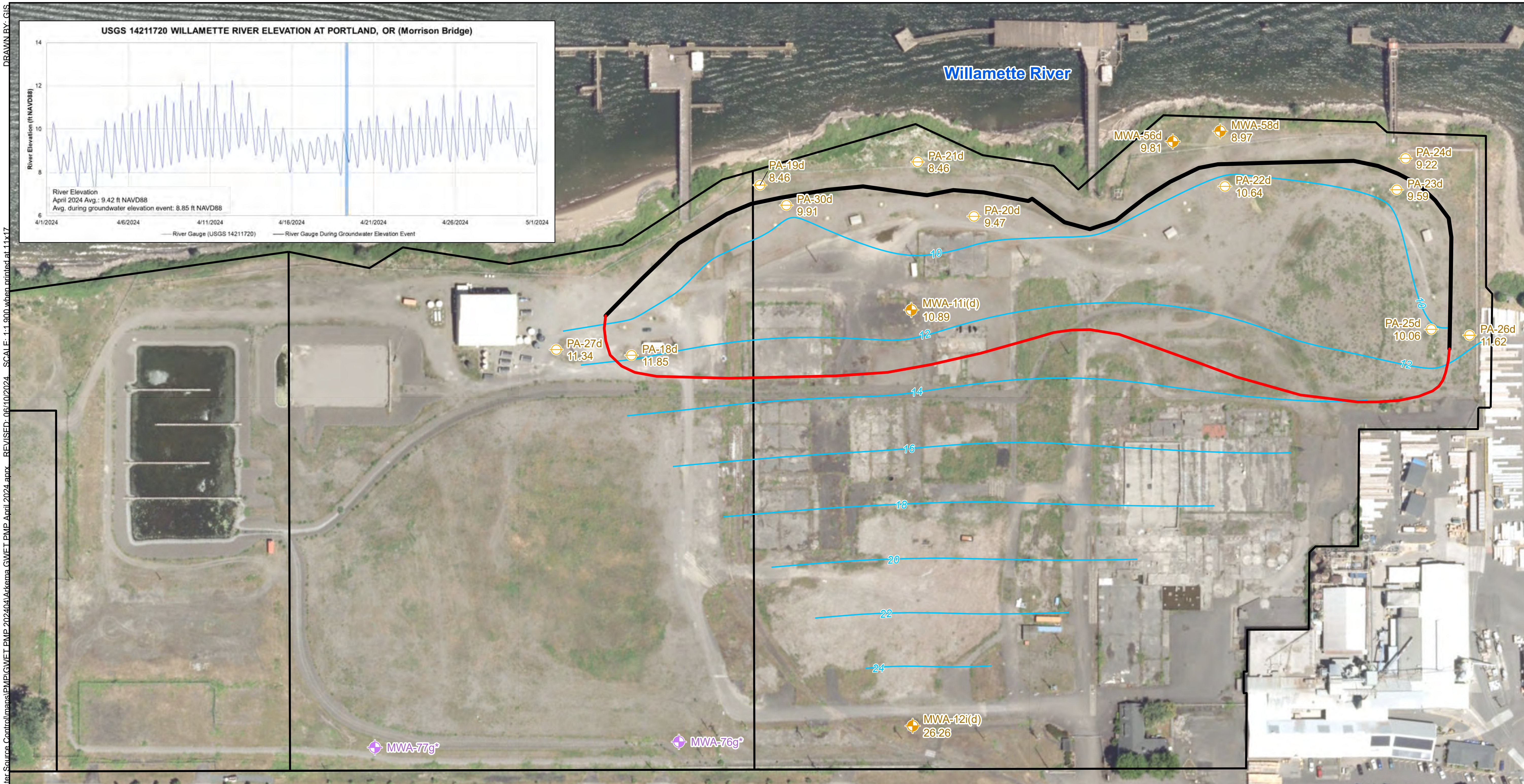
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected April 19, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

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Feet

Figure 4
April 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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ERM

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected April 19, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
April 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

DRAWN BY: GIS SCALE: 1:1,560 when printed at 11x17 REVISED: 05/10/2024

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected April 19, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
April 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: April 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
N/A	RW-13	Intermediate	1/29/2024	4/16/2024	Transducer faulted, checked and replaced.
N/A	RW-25	Shallow	1/29/2024	4/16/2024	Transducer faulted, checked and repaired.
GCC3	PA-26d	Deep	1/29/2024	5/1/2024	Transducer faulted and replaced.
GCC5	PA-07	Shallow	1/29/2024	5/1/2024	Transducer faulted and replaced.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

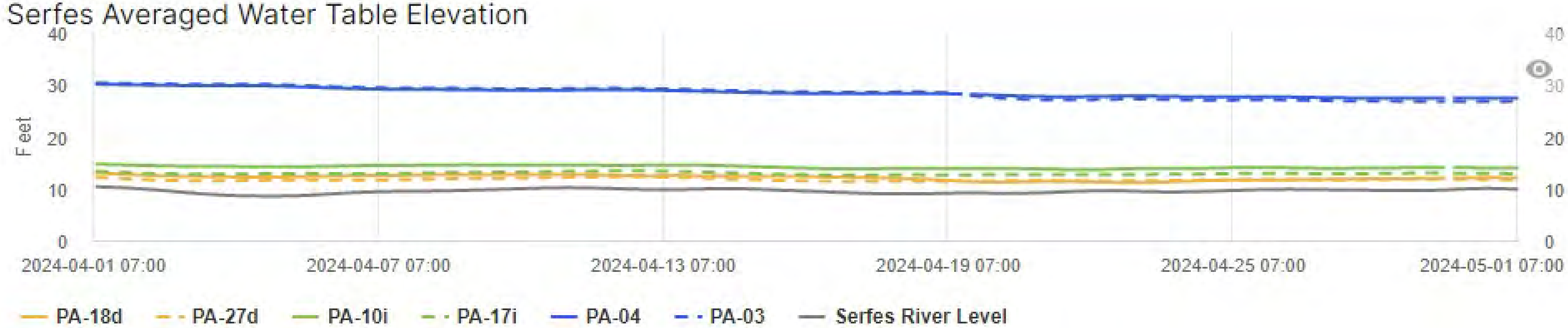
Table A-2
Recovery Well Status: April 2024
Arkema Inc. Facility
Portland, Oregon

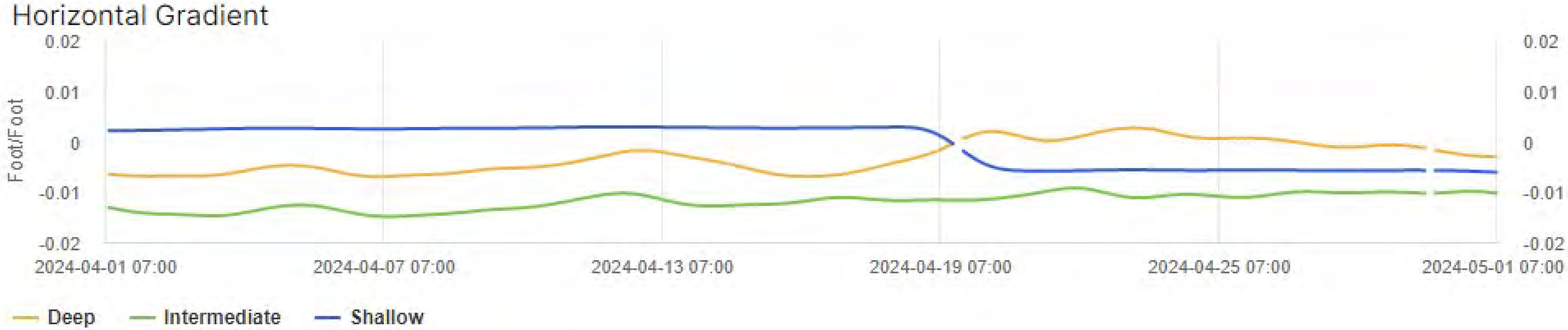
Recovery Well ID	Status as of 4/30/2024 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Not turned on
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Cable leads need to be replaced
RW-23	Inactive	None	Redeploy clean pump	N/A	Good	Good	0.00	OFF*	To be switched from 1hp to 0.5hp pump
RW-25	Active	Transducer Malfuction	Repaired transducer	4/16/2024	Good	Good	2.37	M**	Repaired transducer and pump operating as of 4/17
EW-01	Inactive	None	Chemical Redevelopment	N/A	Good	Good	0.00	OFF*	Waiting on UIC permit
EW-02	Inactive	None	Chemical Redevelopment	N/A	Good	Good	0.00	OFF*	Waiting on UIC permit
EW-03	Active	None	N/A	N/A	Good	Good	4.93	G	
EW-04	Active	None	N/A	N/A	Good	Good	5.03	G	
EW-05	Active	None	N/A	N/A	Good	Good	6.49	G	
EW-06	Active	None	N/A	N/A	Good	Good	4.40	G	
EW-07	Inactive	Load Fault	Change out fouled pump	5/1/2024	Good	Good	0.32	OFF*	Fouled pump to be changed out with clean pump
EW-08	Active	Motor Overload Fault	Change out fouled pump	5/3/2024	Good	Good	4.77	G**	Motor overload at higher frequency, possibly change motor
EW-09	Active	None	N/A	N/A	Good	Good	2.66	M	
EW-10	Active	None	N/A	N/A	Good	Good	3.46	G	
EW-11	Active	None	N/A	N/A	Good	Good	2.78	M**	
EW-12	Active	None	N/A	N/A	Good	Good	3.38	G	
EW-13	Active	None	N/A	N/A	Good	Good	3.91	G	
EW-14	Active	None	N/A	N/A	Good	Good	6.42	G	

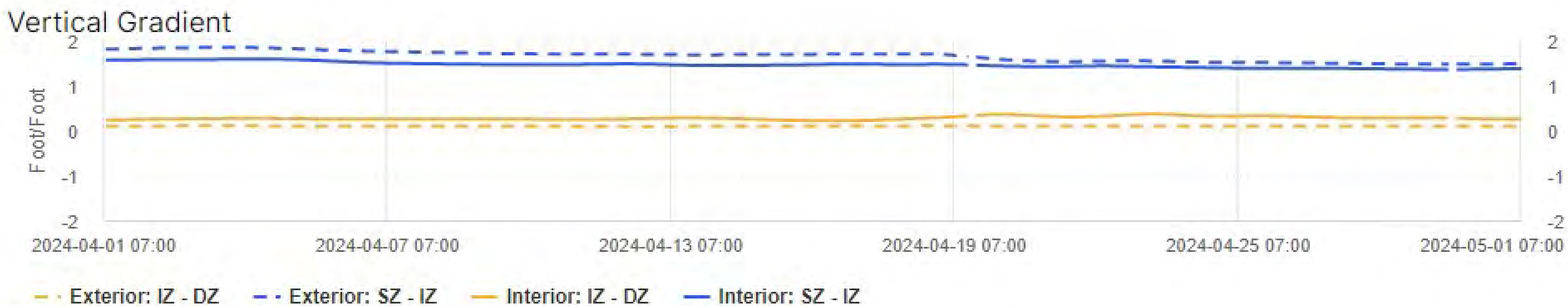
Notes:
* Recovery wells not in service
** Recovery wells in service part of the month
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1



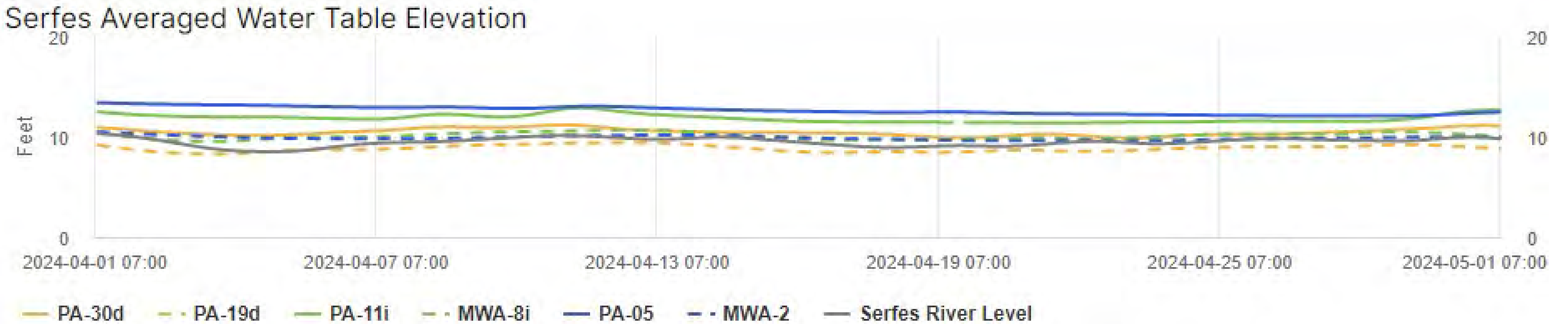


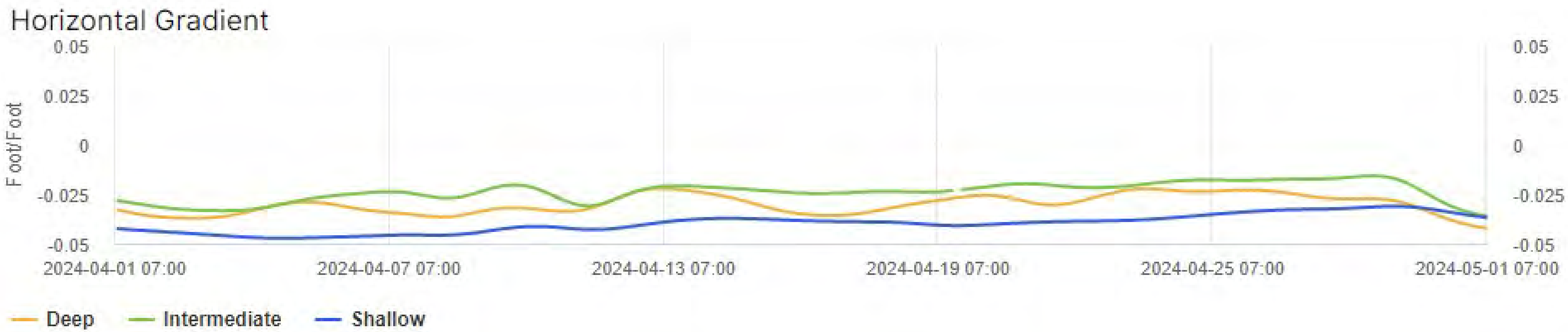


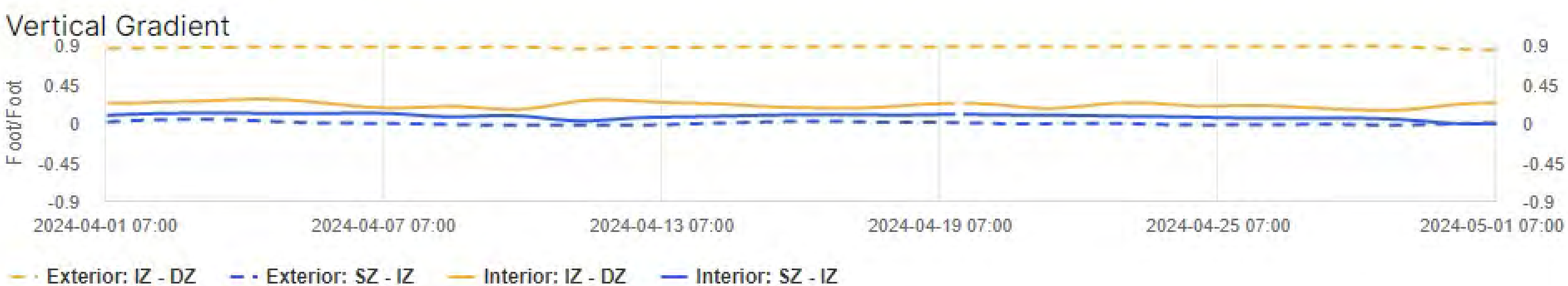
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

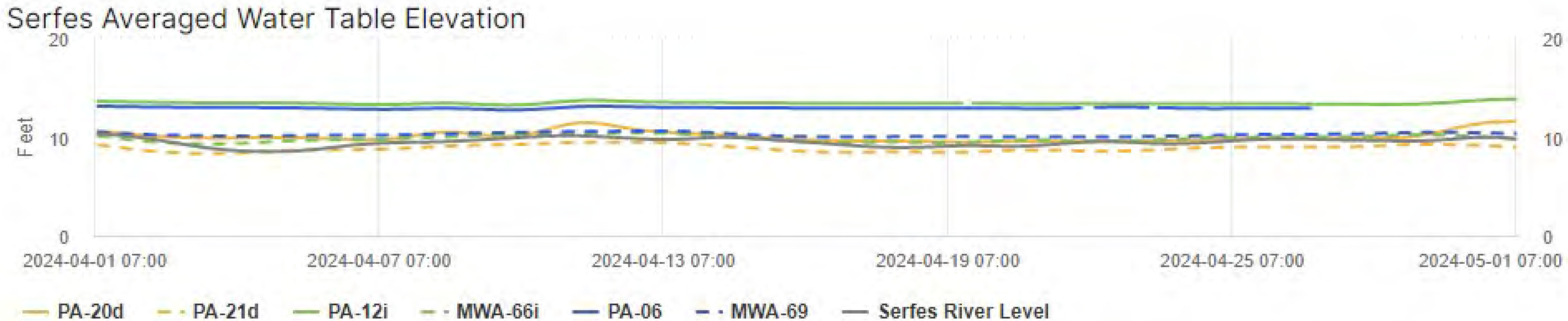


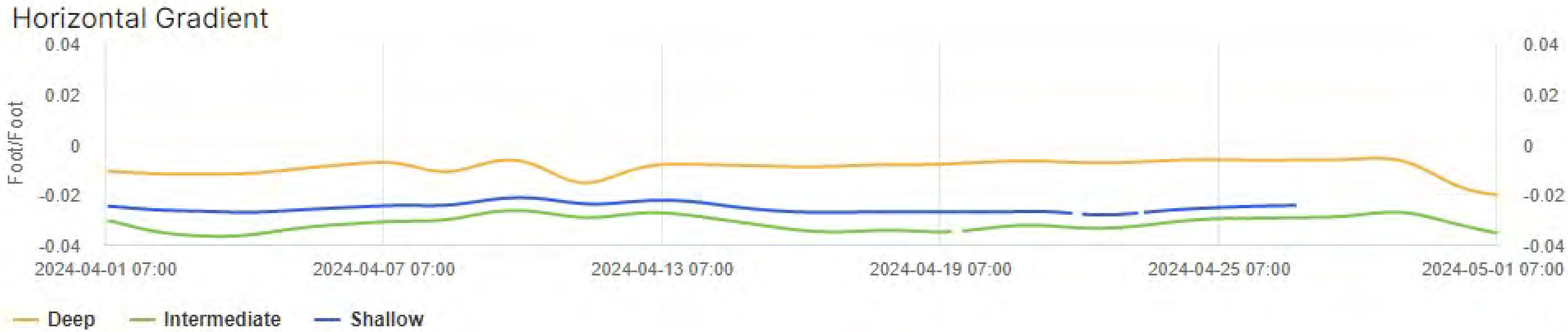


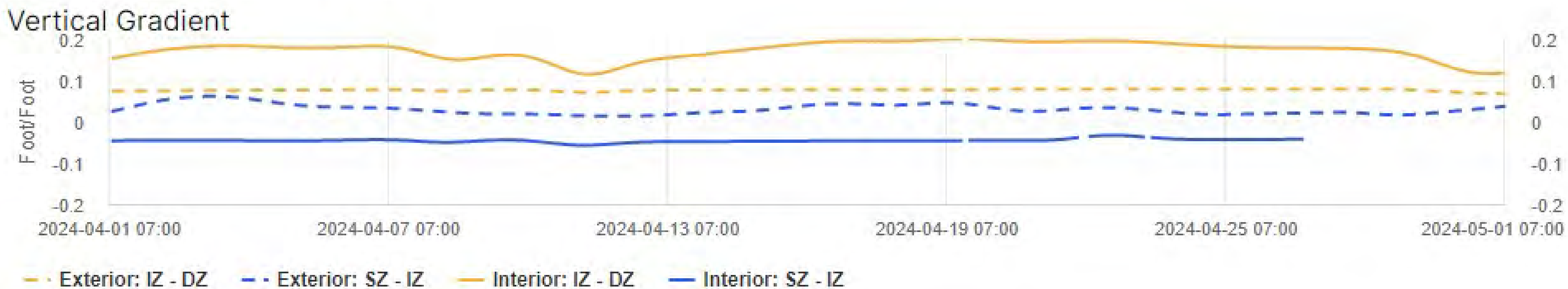


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior − Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

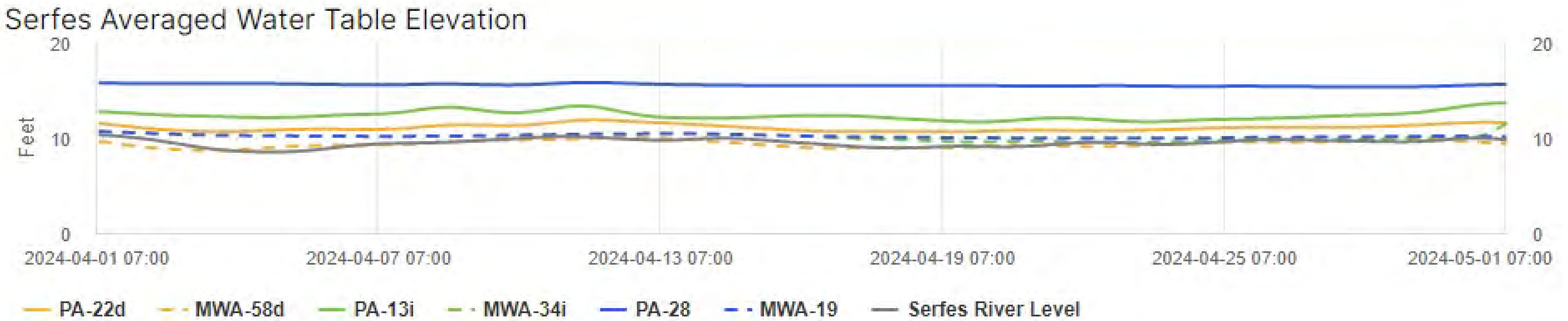


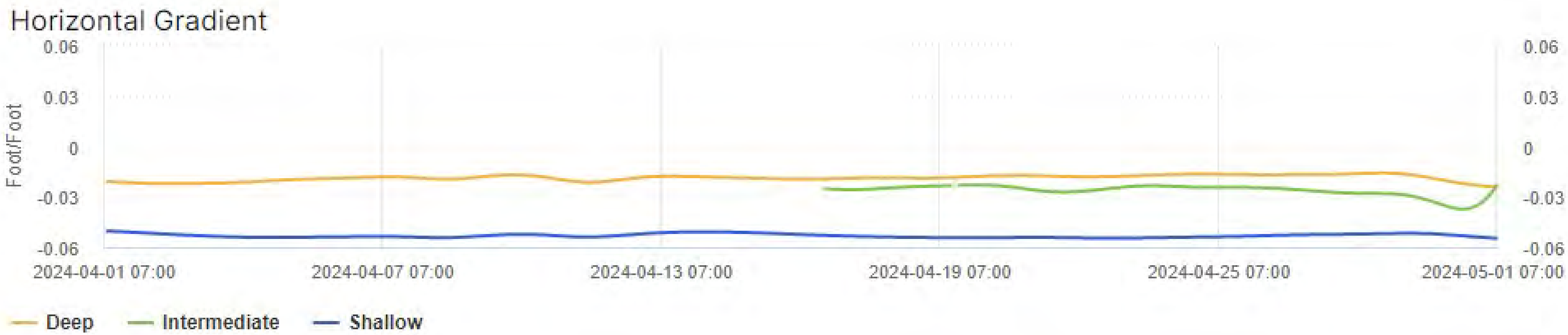


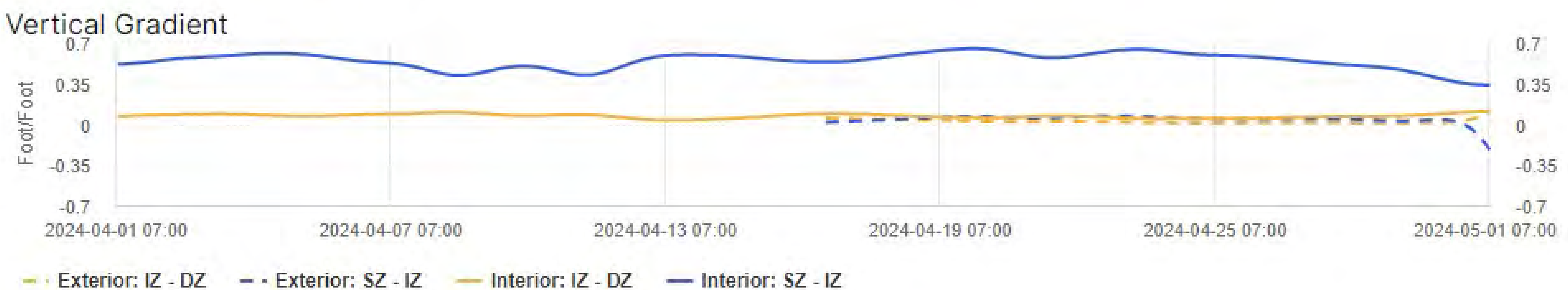


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

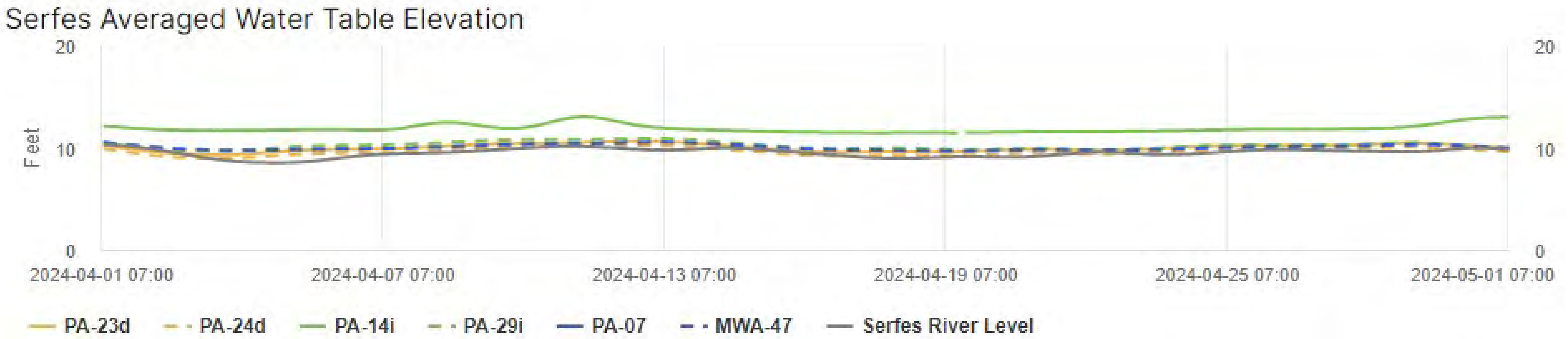


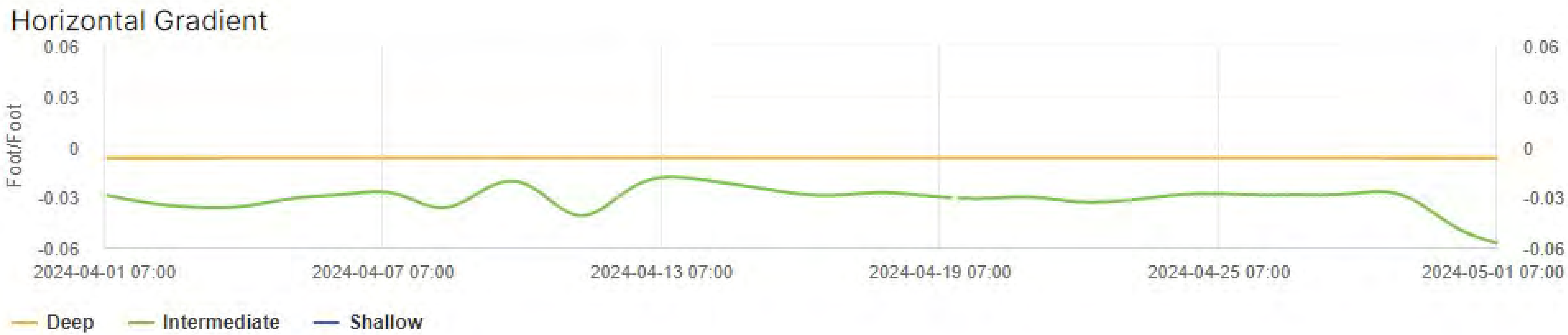


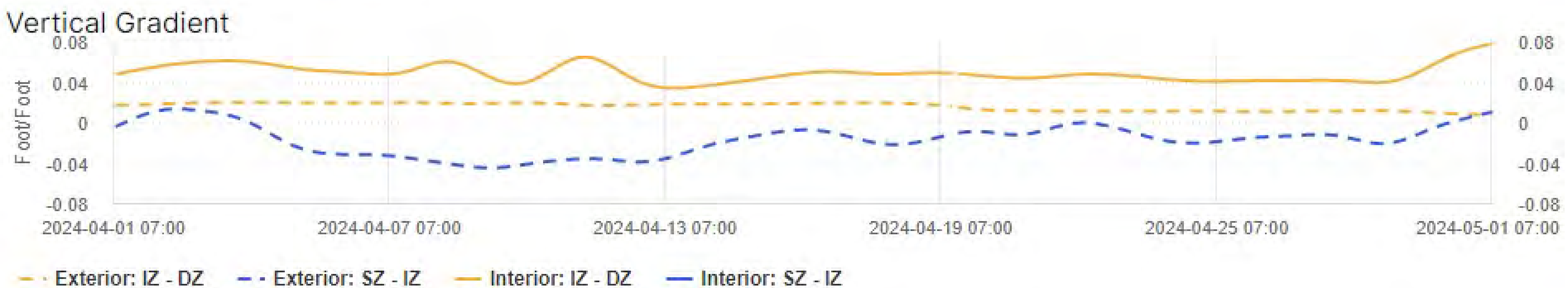


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5



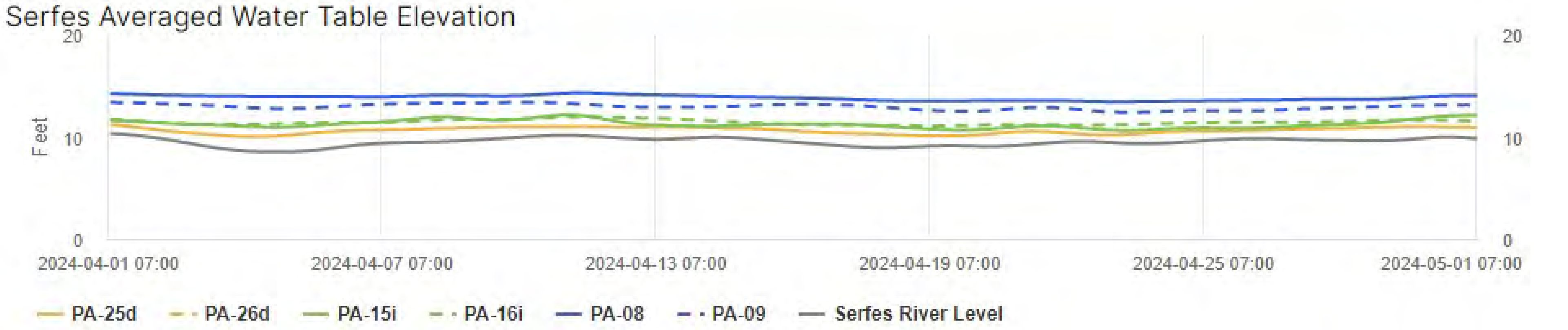


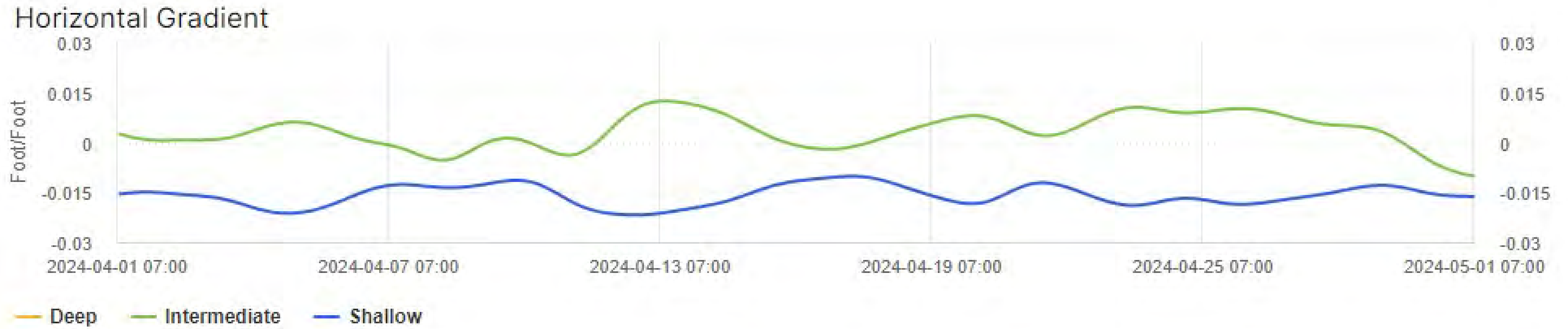


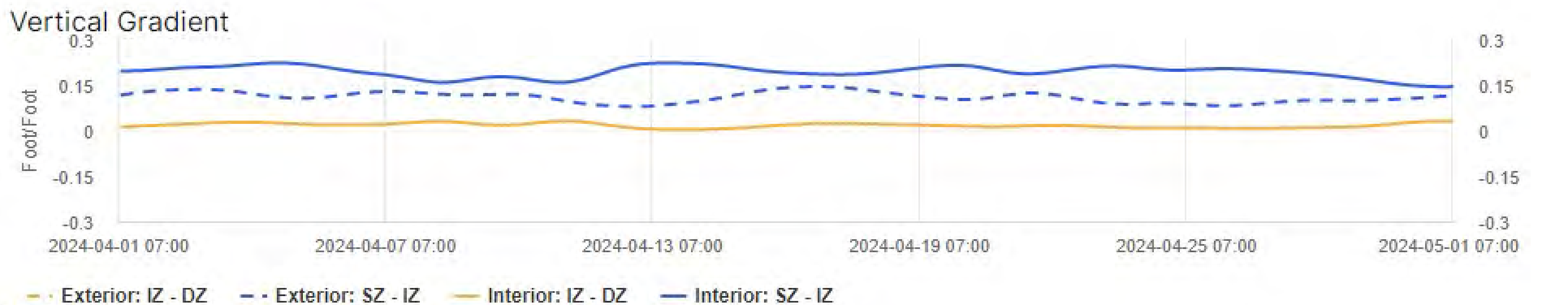
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior − Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6





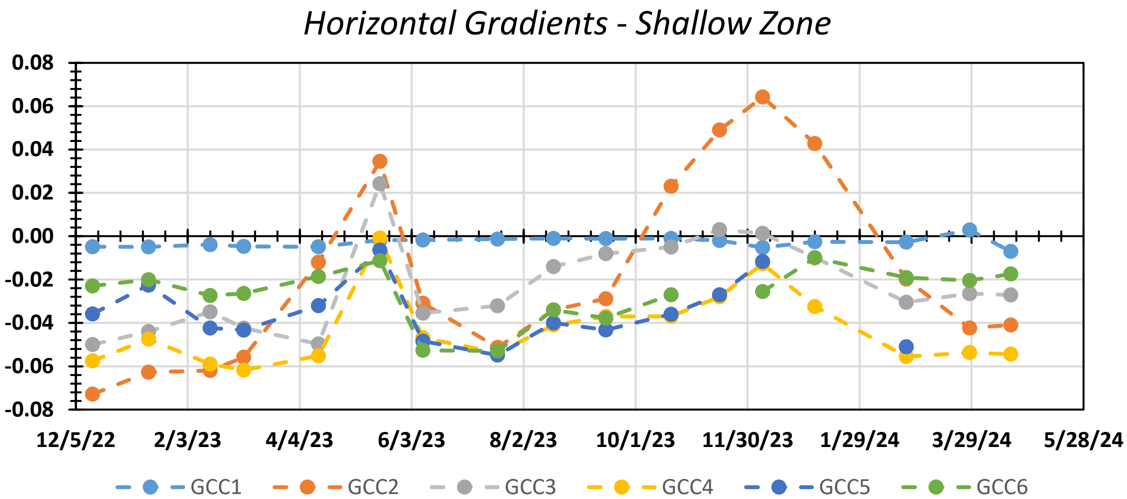


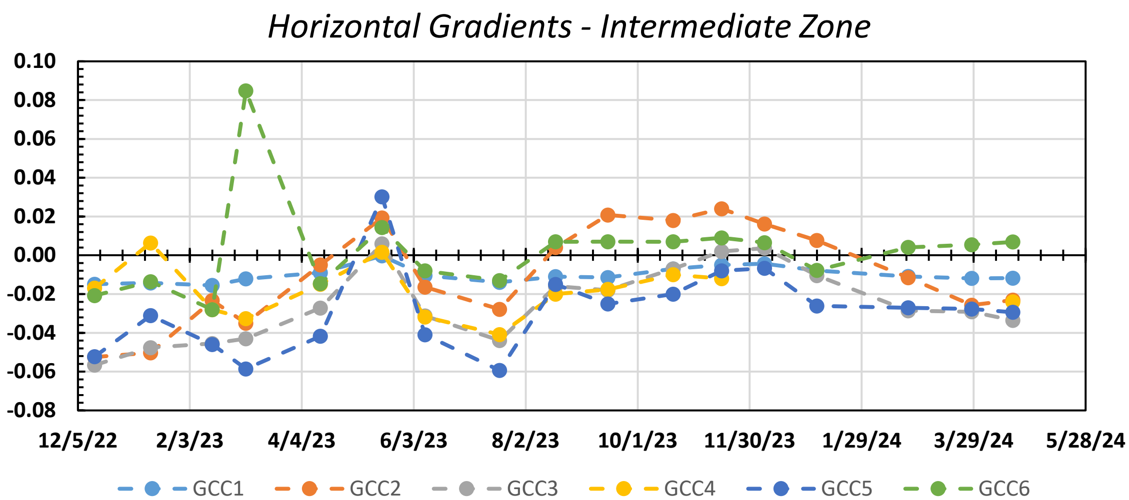
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior − Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

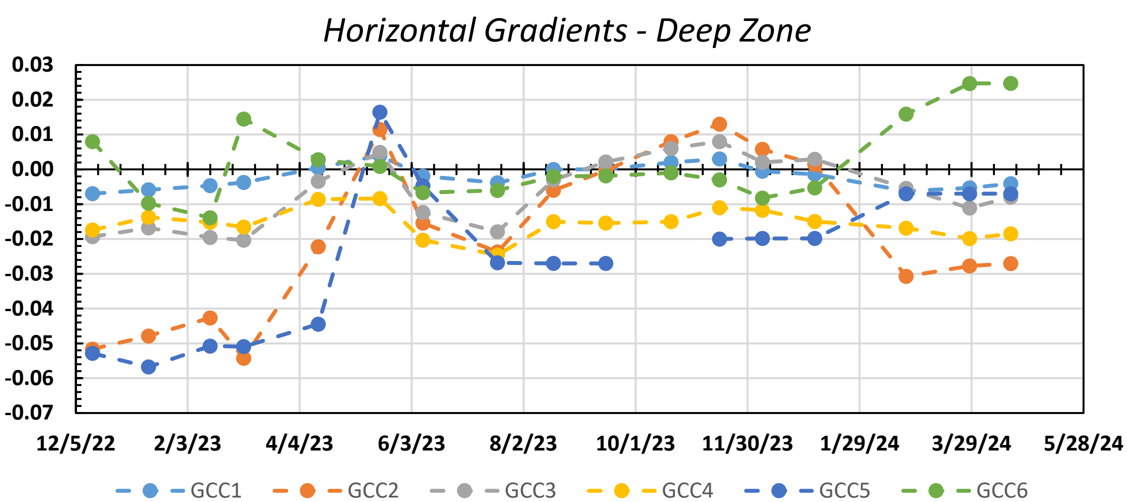
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: April 2024
Arkema Inc. Facility
Portland, Oregon





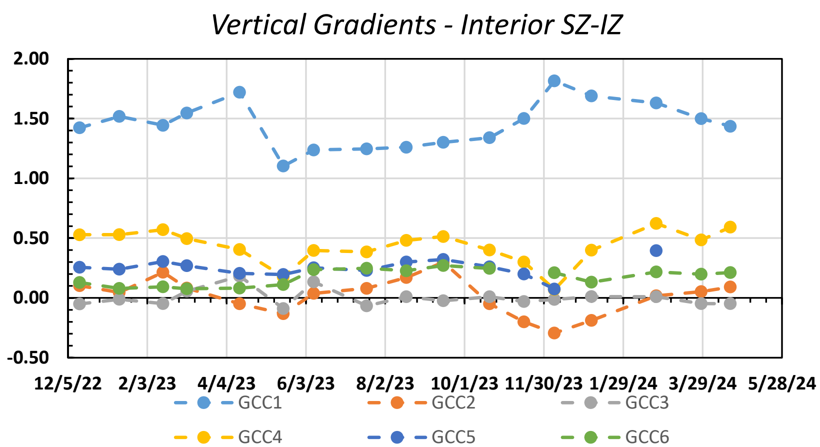


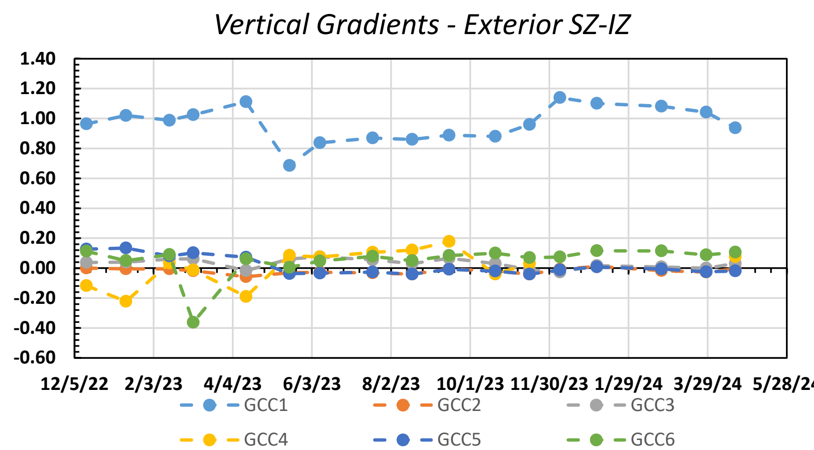
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

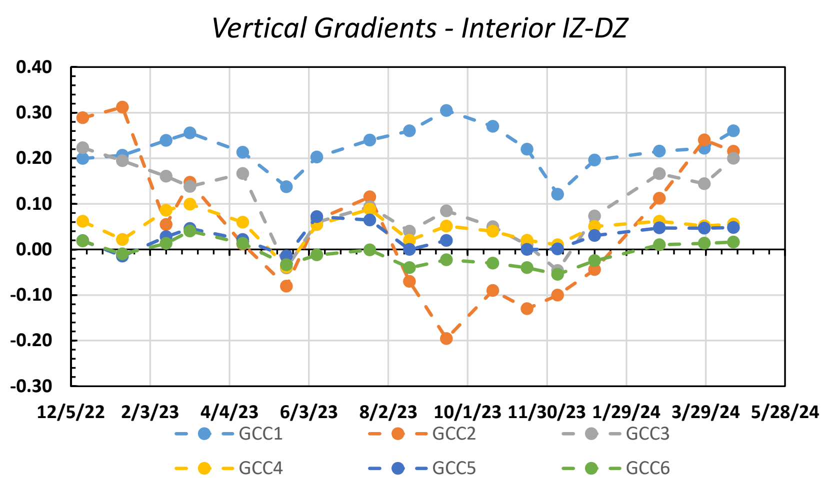
ATTACHMENT B-3 VERTICAL GRADIENTS

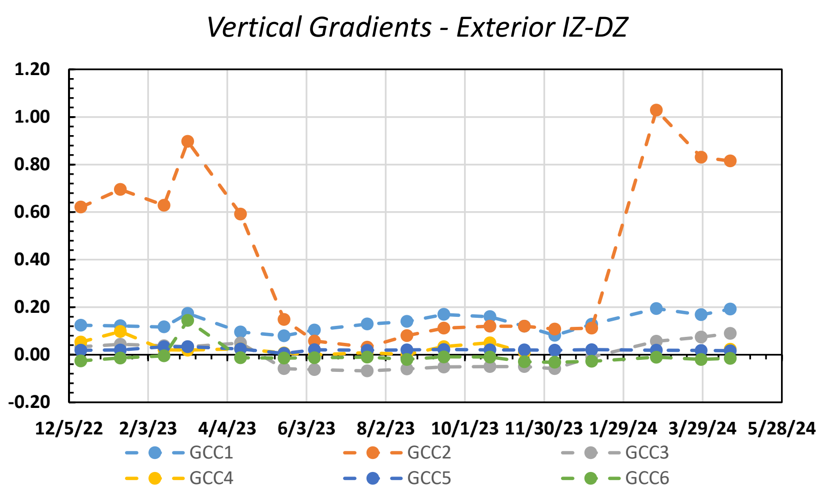
Attachment B-3

Vertical Gradients Summary: April 2024
Arkema Inc. Facility
Portland, Oregon



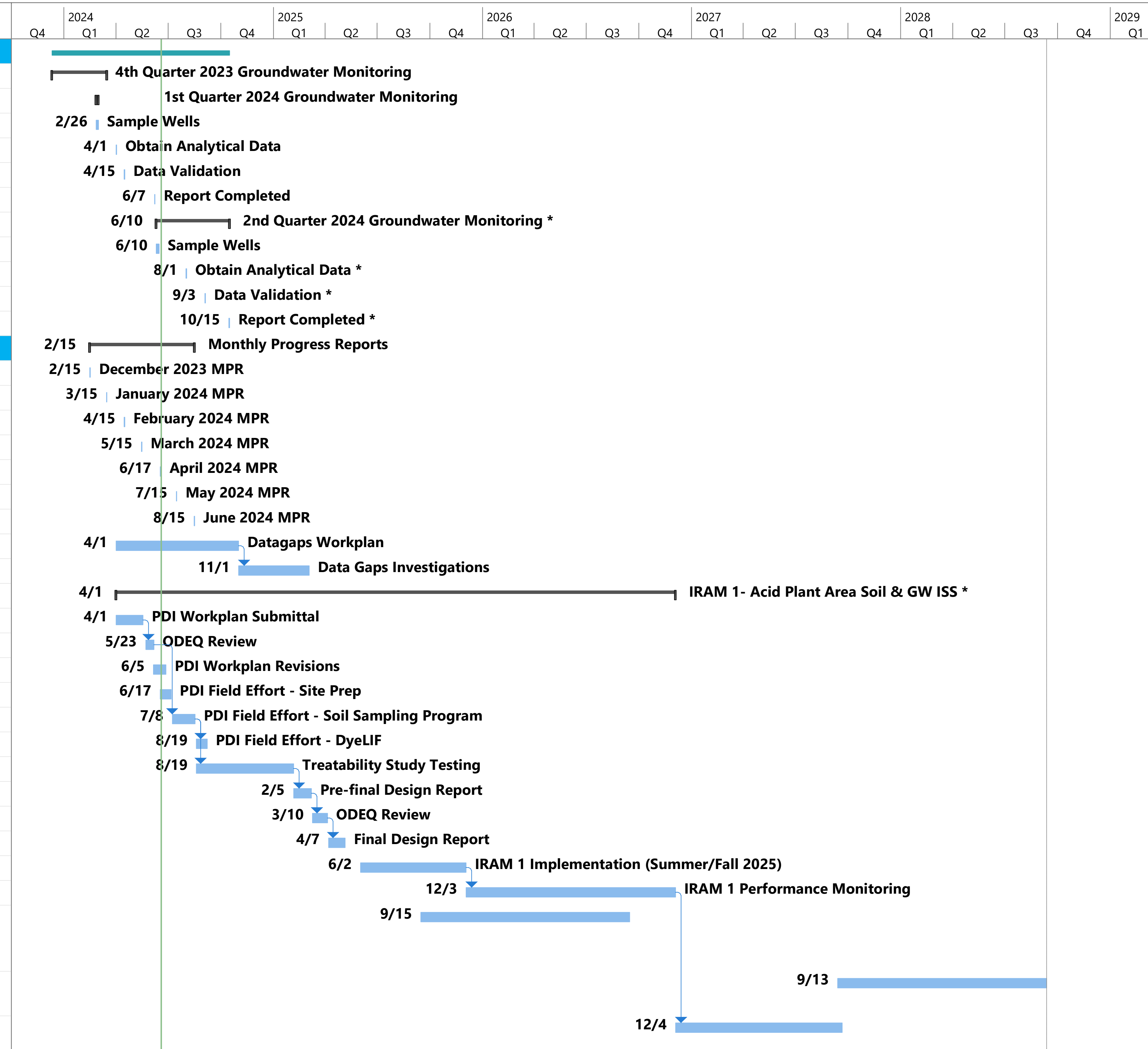






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring ***	**92 days**	**Mon 6/10/24**	**Tue 10/15/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	Obtain Analytical Data *	1 day	Thu 8/1/24	Thu 8/1/24
15	Data Validation *	1 day	Tue 9/3/24	Tue 9/3/24
16	Report Completed *	1 day	Tue 10/15/24	Tue 10/15/24
17	**Monthly Progress Reports**	**132 days**	**Thu 2/15/24**	**Thu 8/15/24**
18	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
19	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
20	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
21	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
22	April 2024 MPR	1 day	Mon 6/17/24	Mon 6/17/24
23	May 2024 MPR	1 day	Mon 7/15/24	Mon 7/15/24
24	June 2024 MPR	1 day	Thu 8/15/24	Thu 8/15/24
25	**Datagaps Workplan**	154 days	Mon 4/1/24	Thu 10/31/24
26	**Data Gaps Investigations**	87 days	Fri 11/1/24	Mon 3/3/25
27	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
28	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
29	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
30	PDI Workplan Revisions	16 days	Wed 6/5/24	Wed 6/26/24
31	PDI Field Effort - Site Prep	15 days	Mon 6/17/24	Fri 7/5/24
32	PDI Field Effort - Soil Sampling Program	30 days	Mon 7/8/24	Fri 8/16/24
33	PDI Field Effort - DyeLIF	15 days	Mon 8/19/24	Fri 9/6/24
34	Treatability Study Testing	122 days	Mon 8/19/24	Tue 2/4/25
35	Pre-final Design Report	23 days	Wed 2/5/25	Fri 3/7/25
36	ODEQ Review	20 days	Mon 3/10/25	Fri 4/4/25
37	Final Design Report	21 days	Mon 4/7/25	Mon 5/5/25
38	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
39	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
40	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
41	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
42	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	15 July 2024
REFERENCE	0732445 Phase 204
SUBJECT	May 2024 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This May 2024 MPR summarizes the GW SCM performance monitoring data collected in May 2024. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells (RWs), and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 RWs prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four-remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is approximately 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and

GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 40.48 gallons per minute (gpm) for the entire month of May 2024, including non-operational periods. The average operational influent flow during operational periods was 51.52 gpm, roughly the same as in April 2024.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. In late February 2024, a recordable injury occurred onsite during pump removal and maintenance activities. As a result, pump maintenance activities were paused while a root cause analysis was performed, and procedures updated to mitigate ergonomic and fall risks. An updated pump pulling and maintenance procedure was approved 30 April 2024, and implemented in May 2024. Additionally, Trench 1 was off during April 2024 through 20 May 2024 in preparation for chemical redevelopment to mitigate the impact of silt and biofouling at EW-01. Redevelopment was also completed at EW-07, EW-09, and EW-11 during May 2024. Conveyance and lateral lines maintenance is planned for June 2024 to mitigate back pressure impeding flow rates. Extraction rates and hydraulic gradient performance are expected to improve following resumption of pump maintenance activities, chemical redevelopment, and conveyance line maintenance in July 2024.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

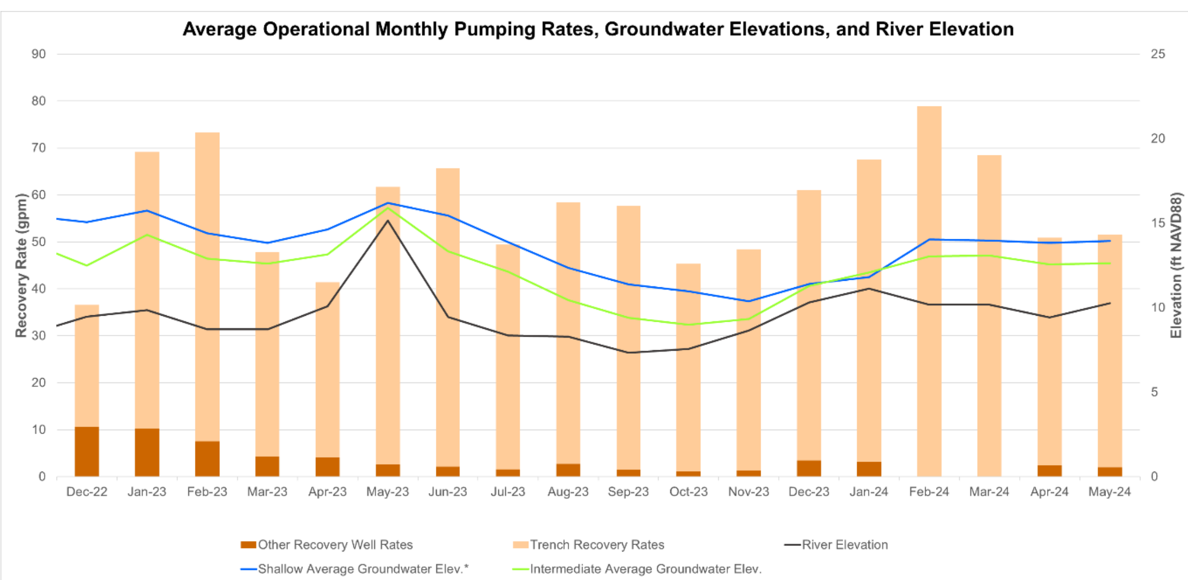
TABLE 1-1 RECOVERY WELL PUMPING RATES

Recovery Well	May 2024 Average Operational Pumping Rate (gpm)	May 2024 Average Monthly Pumping Rate (gpm)
RW-14*	0.00	0.00
RW-22*	0.00	0.00
RW-23*	0.00	0.00
RW-25	2.00	1.61
EW-01	2.17	0.56

Recovery Well	May 2024 Average Operational Pumping Rate (gpm)	May 2024 Average Monthly Pumping Rate (gpm)
EW-02	1.41	0.36
EW-03	7.19	6.96
EW-04	3.21	3.10
EW-05	7.06	6.83
EW-06	2.81	2.72
EW-07	3.65	2.24
EW-08	3.62	1.87
EW-09	0.49	0.08
EW-10	4.41	4.27
EW-11	2.89	1.21
EW-12	1.72	1.16
EW-13	2.14	0.97
EW-14	6.74	6.53
Total	51.52	40.48

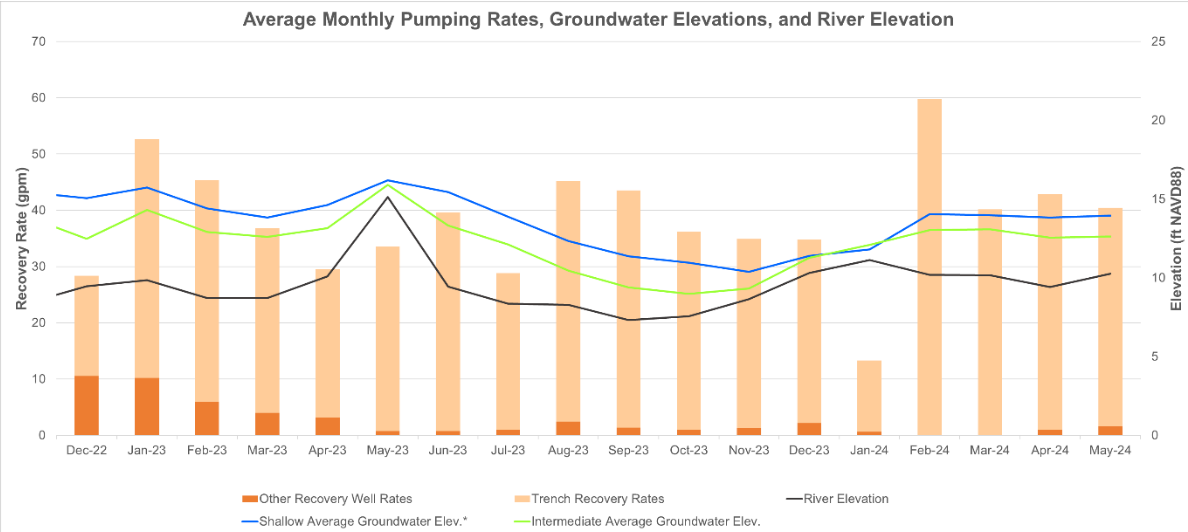
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There were two shutdowns:

- 29 April 2024: The GWET system was shut down due to a carbon changeout on the lead carbon vessel. The ODEQ was notified, and discharge restarted 2 May 2024.
- 8 May 2024: The GWET system was shut down for one hour due to T-1 overflowing within the GWET plant. All water from tank T-1 was captured in the plant sump and processed.

4. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four-remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

4.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 17 May 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during May 2024, the following transducers were:

<u>Fully out of service pending repairs:</u>

- MWA-58d
- MWA-19
- MWA-34i

<u>Out of service for a period but returned to full operation:</u>

- PA-06
- PA-07
- PA-26d

MWA-58d and MWA-19 were taken out of service due to the abandonment and replacement of MWA-34i but will be back online 12 June 2024. PA-06, PA-07 and PA-26d had faulted transducers that were replaced 1 May 2024. MWA-34i was abandoned and replaced with MWA-34iR on 30 May 2024.

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot

- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After May 2024 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 19 April 2024 are shown below at each GCC (Table 1-2 and Table 1-3).

TABLE 1-2 MAY HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	27.53	PA-04	28.14	-0.006
	Intermediate	PA-17iR	13.26	PA-10i	14.27	-0.010
	Deep	PA-27d	12.17	PA-18d	12.07	0.001
GCC2	Shallow	MWA-2	10.56	PA-05	11.85	-0.019
	Intermediate	MWA-8i	10.90	PA-11i	11.94	-0.014
	Deep	PA-19d	9.62	PA-30d	10.91	-0.024
GCC3	Shallow	MWA-69	10.87	PA-06^{M}	12.92	-0.019
	Intermediate	MWA-66i	10.65	PA-12i	12.88	-0.020
	Deep	PA-21d	9.66	PA-20d	10.38	-0.006
GCC4	Shallow	MWA-19	10.66	PA-28	15.22	-0.045
	Intermediate	MWA-34i^{M}	10.87	PA-13i^{M}	12.53	-0.018
	Deep	MWA-58d	10.25	PA-22d	11.62	-0.015
GCC5	Shallow	MWA-47	10.77	PA-07^{M}	15.04	-0.041
	Intermediate	PA-29i	10.88	PA-14i	12.27	-0.026
	Deep	PA-24d^{M}	10.38	PA-23d	10.82	-0.008
GCC6	Shallow	PA-09	13.21	PA-08	13.74	-0.010
	Intermediate	PA-16i^{M}	11.65	PA-15i^{M}	11.92	-0.005
	Deep	PA-26d^{M}	12.42	PA-25d^{M}	11.92	0.008

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988; M = manual groundwater elevation measurement

TABLE 1-3 MAY VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	28.14	PA-10i	14.27	1.40
		GCC2	PA-05	11.85	PA-11i	11.94	-0.01
		GCC3	PA-06^{M}	12.92	PA-12i	12.88	0.00
		GCC4	PA-28	15.22	PA-13i^{M}	12.53	0.42
		GCC5	PA-07^{M}	15.04	PA-14i	12.27	0.29
		GCC6	PA-08	13.74	PA-15i^{M}	11.92	0.14
	IZ-DZ	GCC1	PA-10i	14.27	PA-18d	12.07	0.29
		GCC2	PA-11i	11.94	PA-30d	10.91	0.15
		GCC3	PA-12i	12.88	PA-20d	10.38	0.13
		GCC4	PA-13i^{M}	12.53	PA-22d	11.62	0.05
		GCC5	PA-14i	12.27	PA-23d	10.82	0.04
		GCC6	PA-15i^{M}	11.92	PA-25d^{M}	11.92	0.00
Exterior	SZ-IZ	GCC1	PA-03	27.53	PA-17iR	13.26	0.91
		GCC2	MWA-2	10.56	MWA-8i	10.90	-0.02
		GCC3	MWA-69	10.87	MWA-66i	10.65	0.02
		GCC4	MWA-19	10.66	MWA-34i^{M}	10.87	-0.03
		GCC5	MWA-47	10.77	PA-29i	10.88	-0.01
		GCC6	PA-09	13.21	PA-16i^{M}	11.65	0.11
	IZ-DZ	GCC1	PA-17iR	13.26	PA-27d	12.17	0.17
		GCC2	MWA-8i	10.90	PA-19d	9.62	0.82
		GCC3	MWA-66i	10.65	PA-21d	9.66	0.08
		GCC4	MWA-34i^{M}	10.87	MWA-58d	10.25	0.03
		GCC5	PA-29i	10.88	PA-24d^{M}	10.38	0.01
		GCC6	PA-16i^{M}	11.65	PA-26d^{M}	12.42	-0.02

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; M = manual groundwater elevation measurement; SZ = Shallow Zone

4.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 17 May 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Deep Zone at GCC1 and GCC6. Horizontal gradients at GCCs across the Site mostly improved and are trending toward inward gradients in all hydrogeological zones.

River elevations are shown over time on Figures 1-1 and 1-2 above, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in May 2024 had an average elevation of 10.27 feet NAVD88 with a minimum elevation of 7.70 NAVD88 and a maximum elevation of 12.96 NAVD88, a small increase from April 2024. Compared to last May, the current river elevation is 30 percent lower, and has not changed materially since December 2023. Because the river did not experience a seasonal rise this year, groundwater elevations outside the GWBW did not increase, making hydraulic containment more difficult to achieve.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC2 being upward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC4, and GCC5 upward and the rest downward as shown on Figure 5 and in Attachment B-2.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were primarily downward with exception to GCC6 being upward, as shown on Figure 6 and Attachment B-3. While vertical groundwater gradients interior of the GWBW are generally downward, the magnitude of the gradients is getting smaller and approaching zero, indicating that mass flux of COCs is decreasing.

4.2.1 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates indicate that the active RWs and EWs are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

5. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	6/7/2024
2024 Quarter 2	6/10/2024–6/13/2024	9/13/2024*

* Dates are tentative.

6. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in May 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

6.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided for the Deep Zone in Attachment B-2 show gradients were inward GCC1 and GCC6. Horizontal gradients at GCCs across the Site mostly improved and are trending toward inward gradients except for GCC6 in the Intermediate Zone. Additional improvements in gradients are anticipated as higher flow rates and uptime are achieved.
- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC2 being upward (Figure 5), and the magnitude of downward gradients continues to decrease. Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC4, and GCC5 being upward and the rest downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were generally downward with GCC6 being upward, as shown on Figure 6.
- The average river elevation in May 2024 was 10.27 feet NAVD88 with a minimum elevation of 7.70 feet NAVD88 and a maximum elevation of 12.96 feet NAVD88. A increase from river elevations observed in April 2024.

6.2 GROUNDWATER EXTRACTION

Based on May 2024 groundwater extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, 3, and 4 is largely gone, and the mound around Trenches 5, 6, and 7 is being reduced with increased extraction rates. Average monthly pumping rates in February to May 2023 were significantly lower than February to May 2024, resulting in improved horizontal and vertical gradients and increased COC containment.

Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing generalized hydraulic capture throughout the Target Capture Zone. More operational time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

Due to work conducted throughout 2024 issues limited groundwater extraction rates including fouling of the pumps within the EW trenches, back pressure in the conveyance line, and a pause on pump maintenance, have all been addressed resulting in improved average pumping rates. As of May 2024, the main limitations to groundwater extraction are water levels, and the accumulation of silt within the EW trenches filter pack. Efforts to successfully redevelop the trenches and remove silt are ongoing.

6.3 RECOMMENDATIONS AND FUTURE WORK

Redevelopment of several Intermediate Zone groundwater elevation monitoring locations (RW-6i, RW-9i, RW-11i, RW-13i, RW-16i, RW-19i, RW-21i, RW-24i, RW-26i, and PA-12i) is planned for June 2024 to mitigate turbidity and improve accuracy of Intermediate Zone groundwater contour maps. Conveyance line cleaning is planned for June 2024 to mitigate the observed backpressure in the conveyance lines. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

Brendan Robinson, PE
Partner

7. REFERENCES

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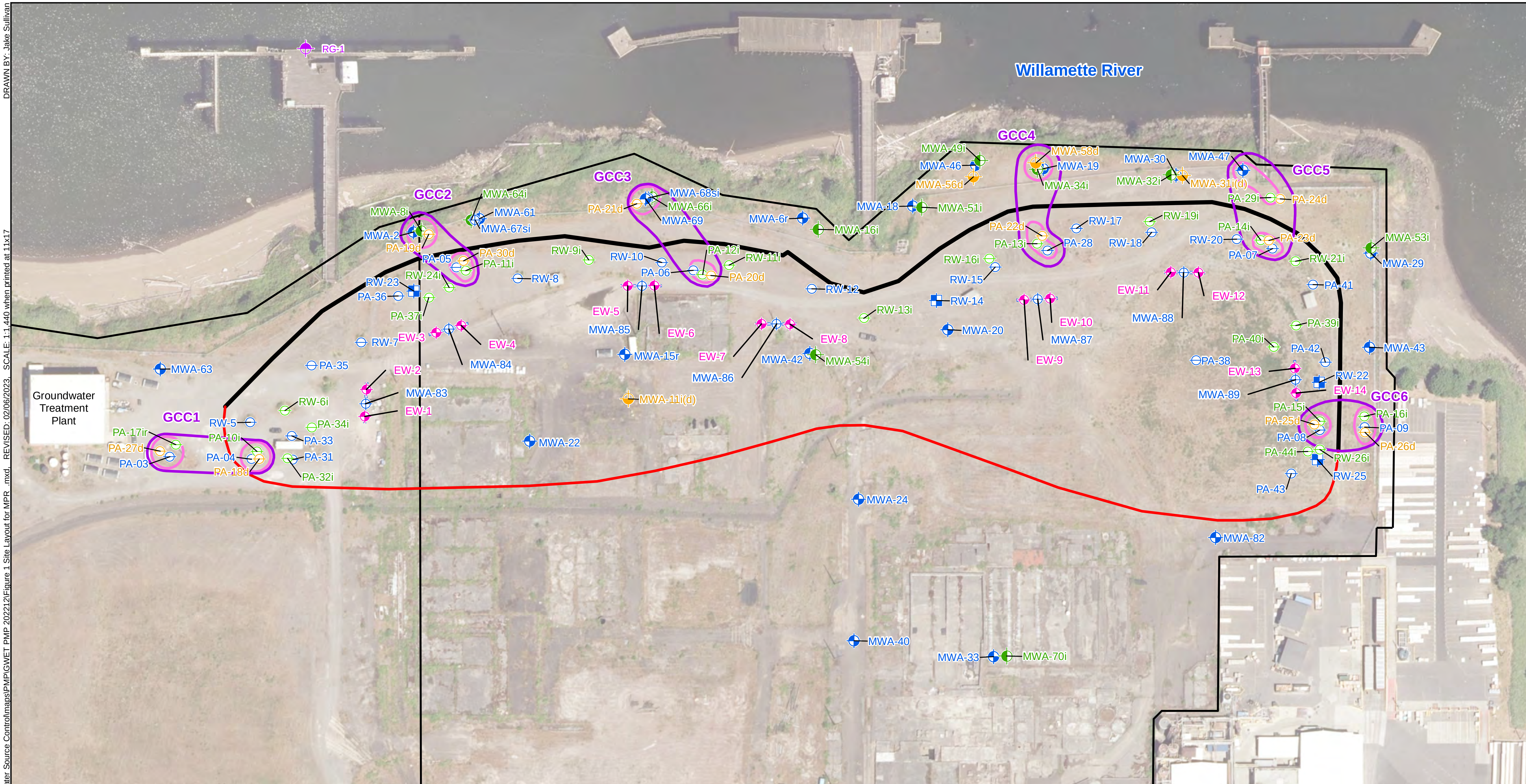
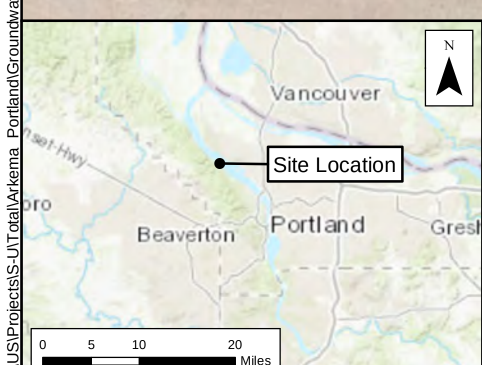
FIGURES





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

0 120 240

Feet

Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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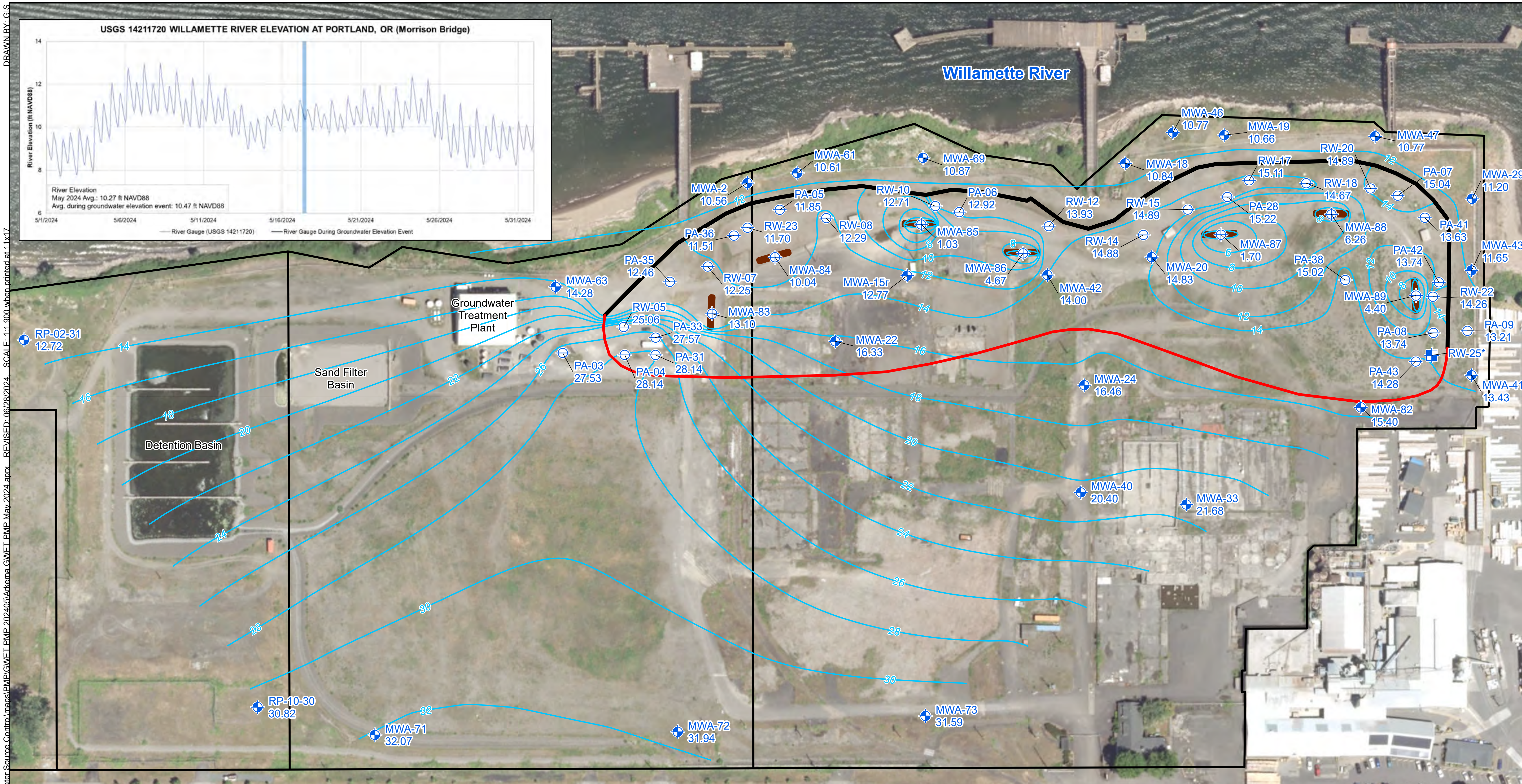


Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

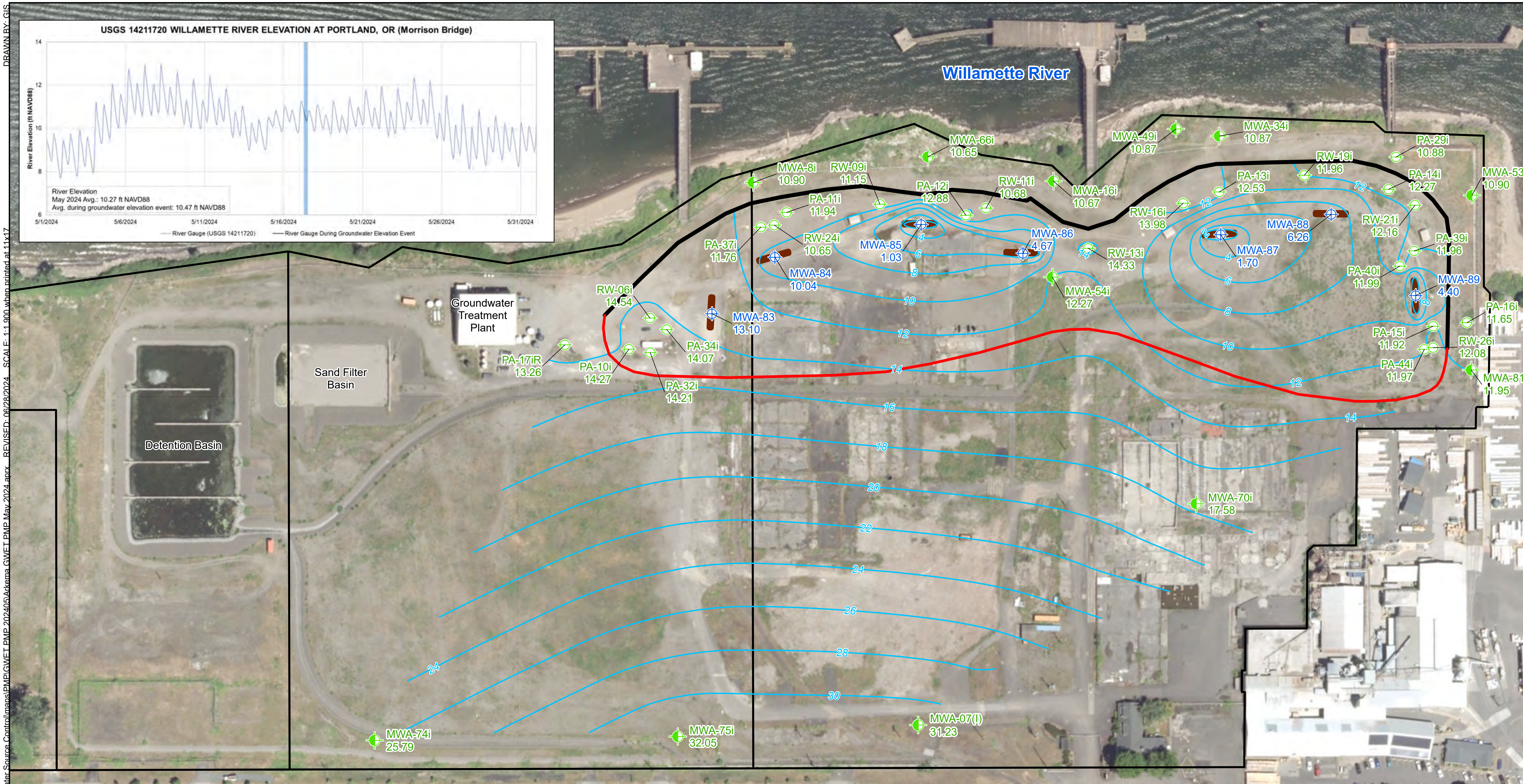
Notes:
* Value not used for contouring.
Water levels collected May 17, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
May 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected May 17, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
May 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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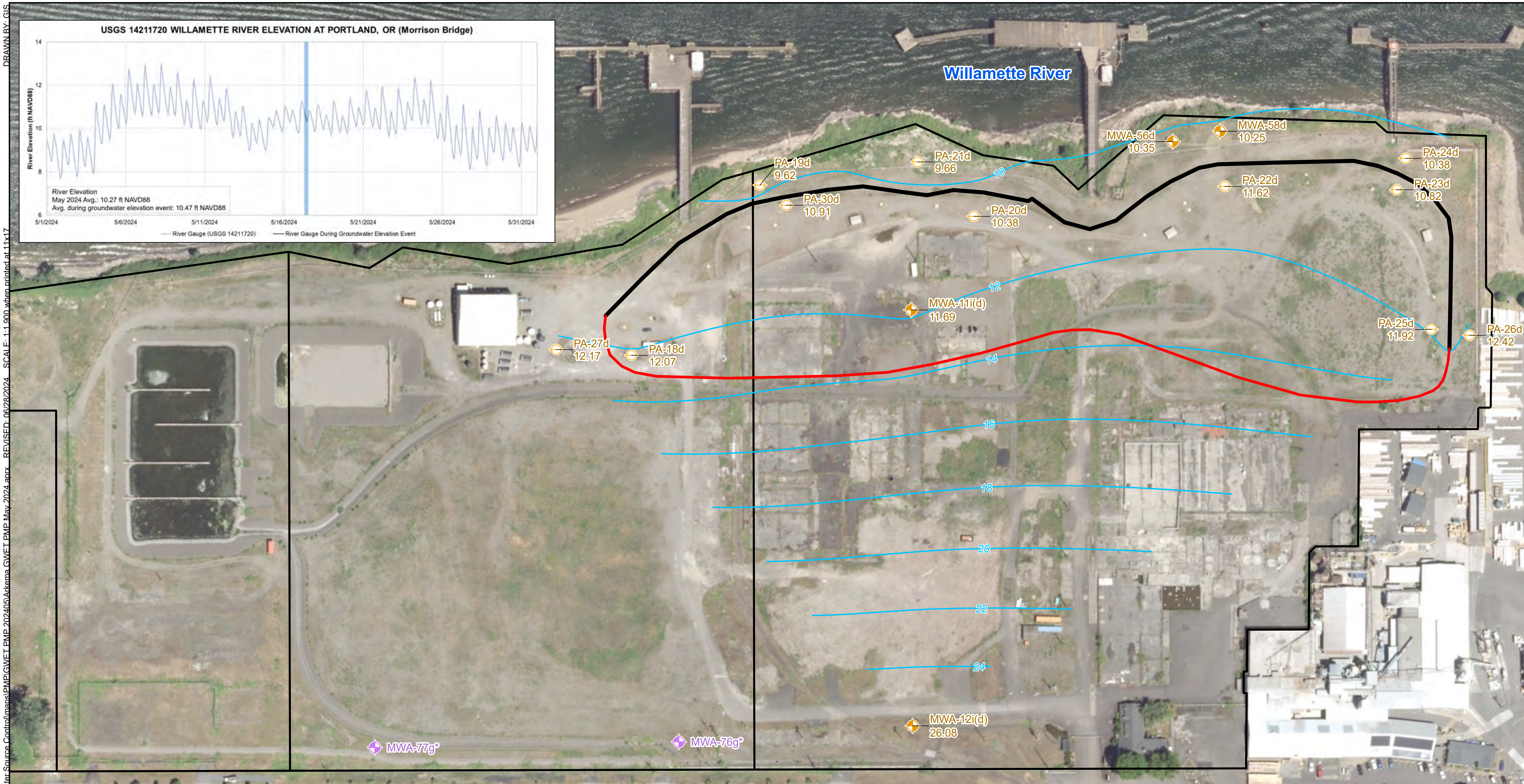

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected May 17, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
May 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected May 17, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
May 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected May 17, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
May 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: May 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC3	PA-26d	Deep	1/29/2024	5/1/2024	Transducer faulted and replaced.
GCC5	PA-07	Shallow	1/29/2024	5/1/2024	Transducer faulted and replaced.
GCC4	MWA-34i	Intermediate	5/28/2024	6/12/2024	Transducer taken out of service for MWA-34i abandonment and replacement.
GCC4	MWA-58d	Deep	5/28/2024	6/12/2024	Transducer taken out of service for MWA-34i abandonment and replacement.
GCC4	MWA-19	Shallow	5/28/2024	6/12/2024	Transducer taken out of service for MWA-34i abandonment and replacement.
GCC3	PA-06	Shallow	5/22/2024	5/31/2024	Transducer faulted and replaced.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: May 2024
Arkema Inc. Facility
Portland, Oregon

Recovery Well ID	Status as of 5/31/2024 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Not turned on
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Cable leads need to be replaced
RW-23	Inactive	None	Redeploy clean pump	6/19/2024	Good	Good	0.00	OFF*	
RW-25	Active	None	N/A	N/A	Good	Good	2.00	M**	
EW-01	Inactive	Low pH	Adjust pH	7/1/2024	Good	Good	2.17	M**	Transfer Trench 1 water to Frac tank to adjust pH
EW-02	Inactive	Low pH	Adjust pH	7/1/2024	Good	Good	1.41	M**	Transfer Trench 1 water to Frac tank to adjust pH
EW-03	Active	None	N/A	N/A	Good	Good	7.19	G	½-Hp pump swapped out for a 1-Hp pump
EW-04	Active	None	N/A	N/A	Good	Good	3.21	G	Operating but Motor Overload Fault at higher frequency
EW-05	Active	None	N/A	N/A	Good	Good	7.06	G	
EW-06	Active	None	N/A	N/A	Good	Good	2.81	M**	Operating but Motor Overload Fault at higher frequency
EW-07	Inactive	Load Fault	Clean conveyance line	6/1/2024	Good	Good	3.65	G**	Pulled for Hydropuls redevelopment and conveyance line cleaning
EW-08	Active	Motor Overload Fault	N/A	N/A	Good	Good	3.62	G**	Motor overload at higher frequency, possibly change motor
EW-09	Active	None	Clean conveyance line	6/5/2024	Good	Good	0.49	P**	Pulled for Hydropuls redevelopment and conveyance line cleaning
EW-10	Active	None	N/A	N/A	Good	Good	4.41	G**	
EW-11	Active	None	Clean conveyance line	6/5/2024	Good	Good	2.89	M**	Pulled for Hydropuls redevelopment and conveyance line cleaning
EW-12	Active	None	N/A	N/A	Good	Good	1.72	M**	
EW-13	Active	None	Repair pumbing	6/5/2024	Good	Good	2.14	M**	Check valve leaking
EW-14	Active	None	N/A	NA	Good	Good	6.74	G	

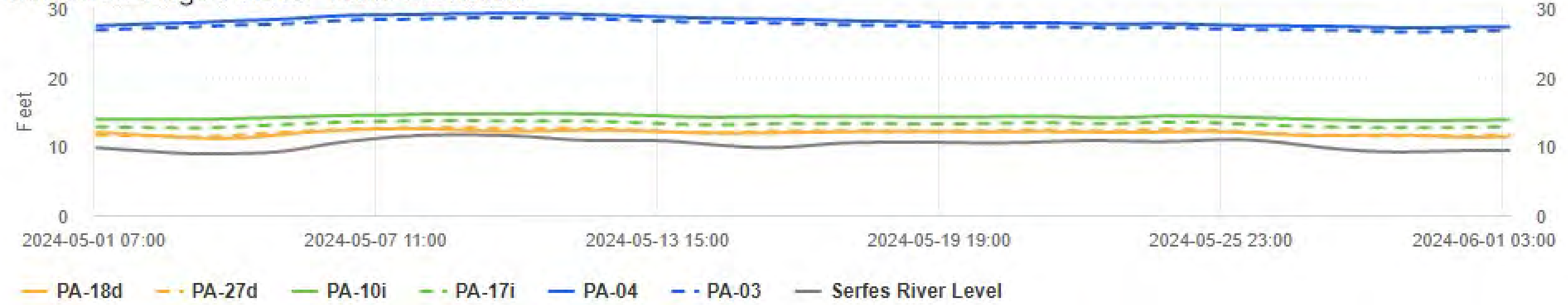
Notes:
* Recovery wells not in service
** Recovery wells in service part of the month
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ERM

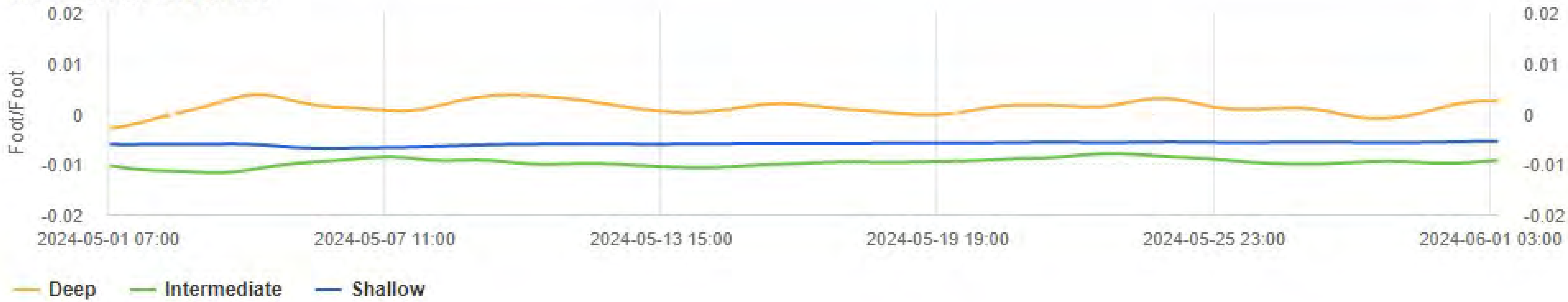
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

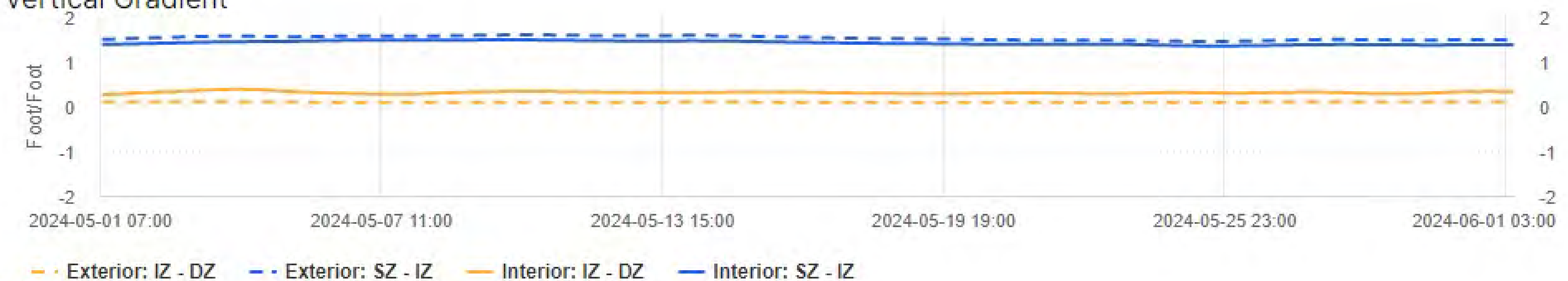
Serfes Averaged Water Table Elevation



Horizontal Gradient



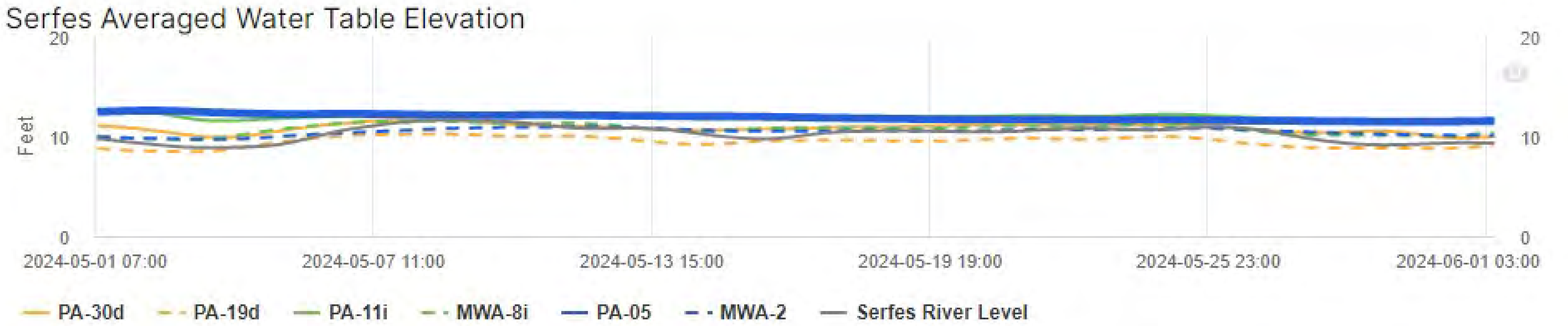
Vertical Gradient

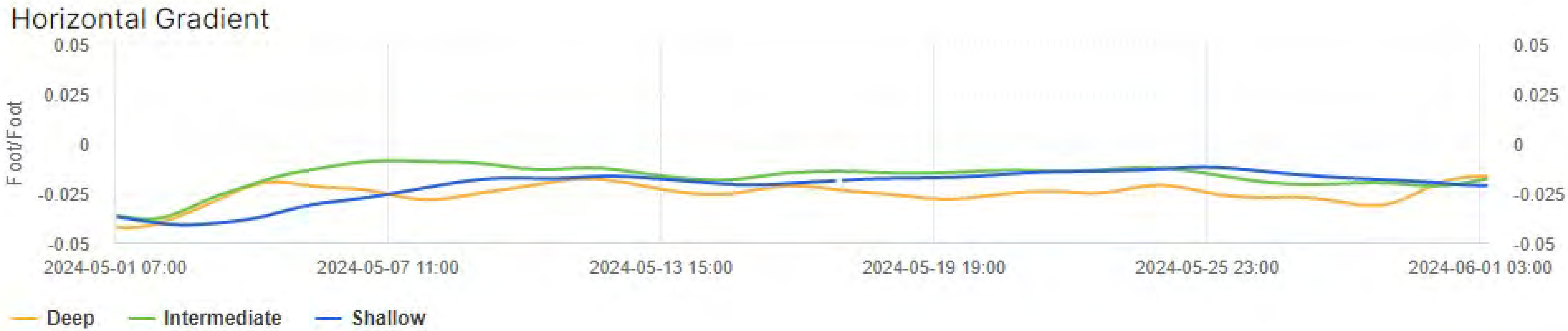


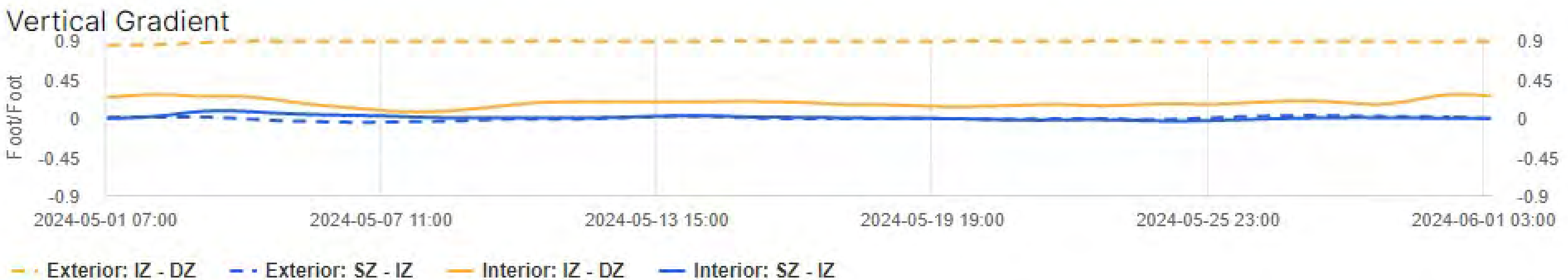
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

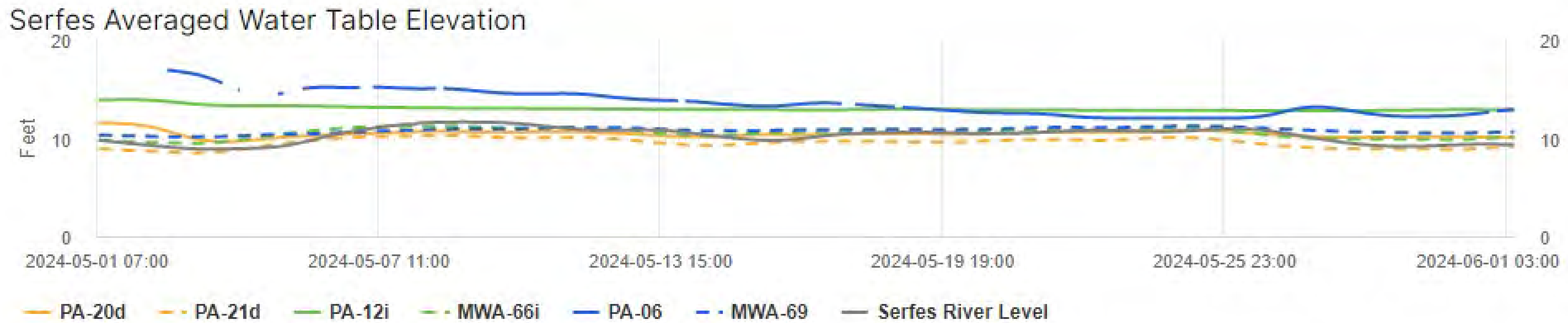


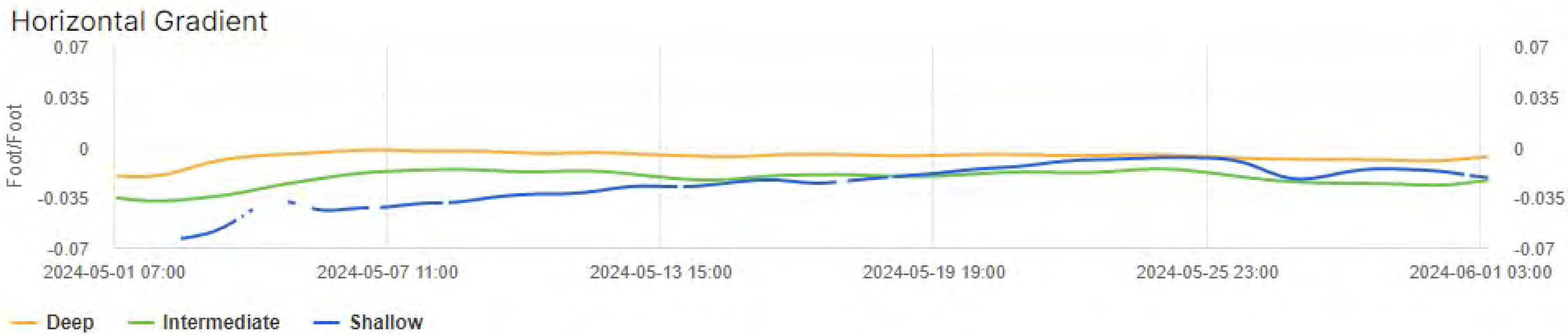


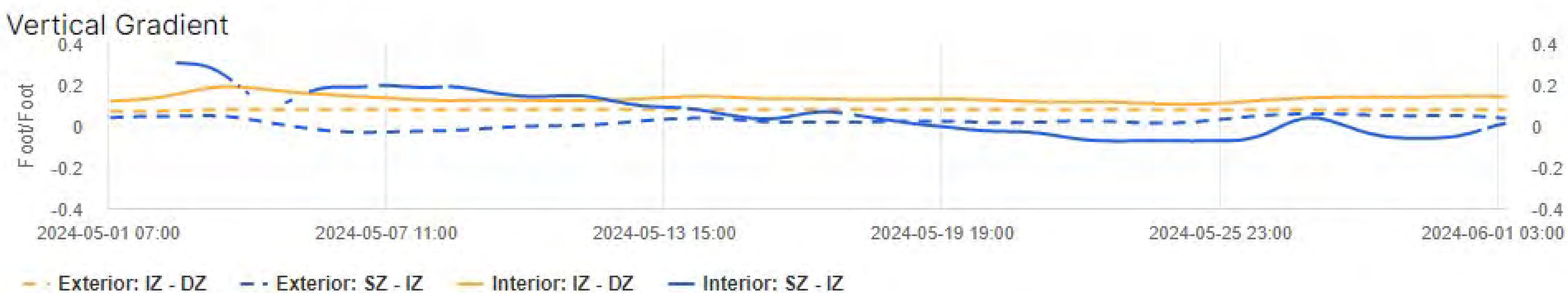


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

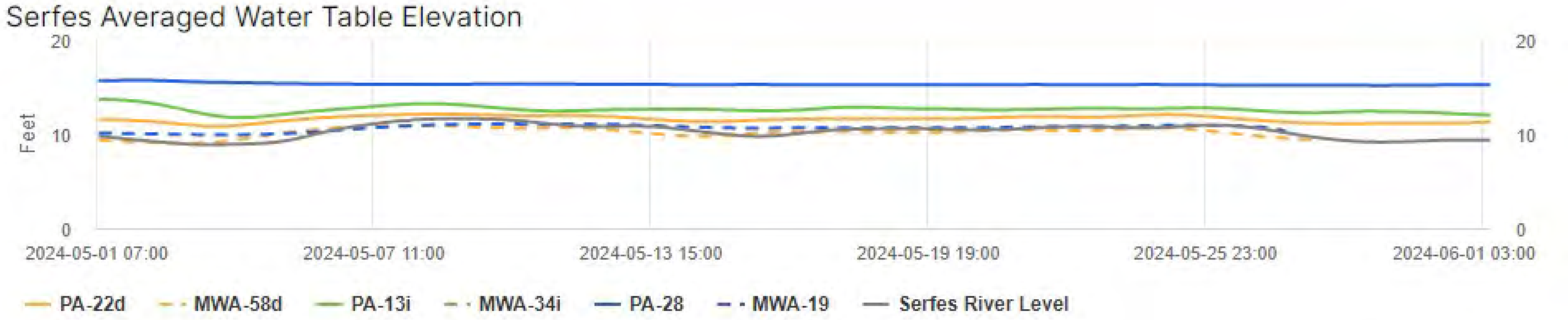


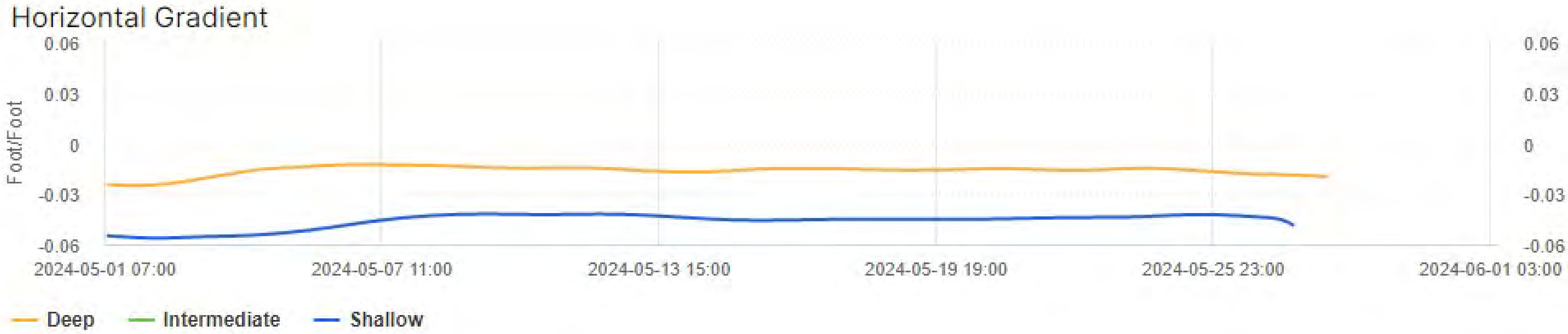


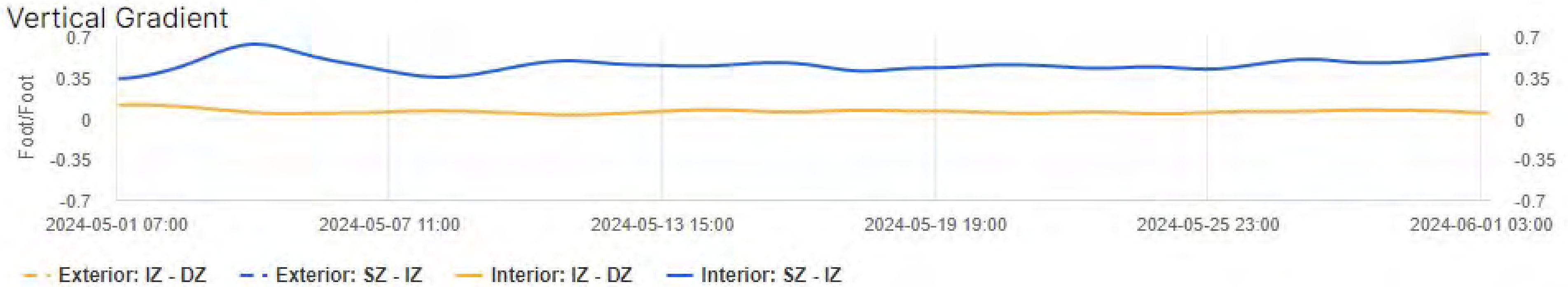


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4



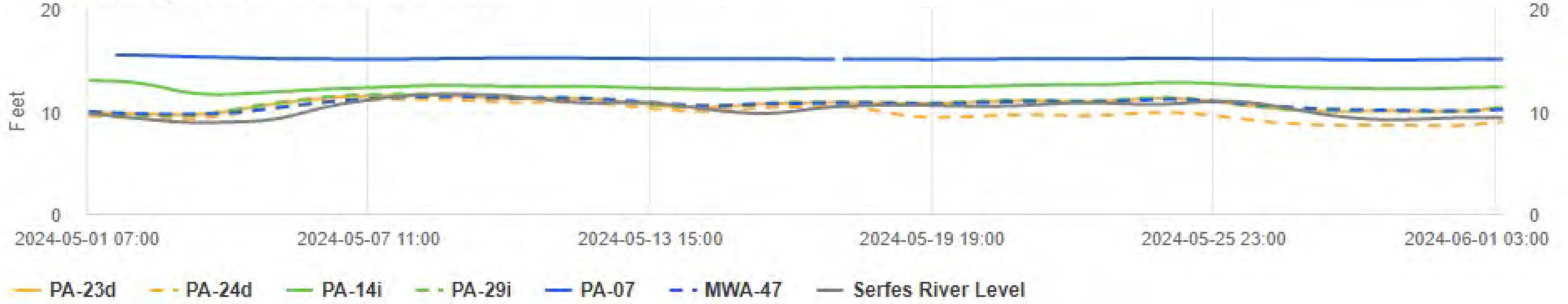




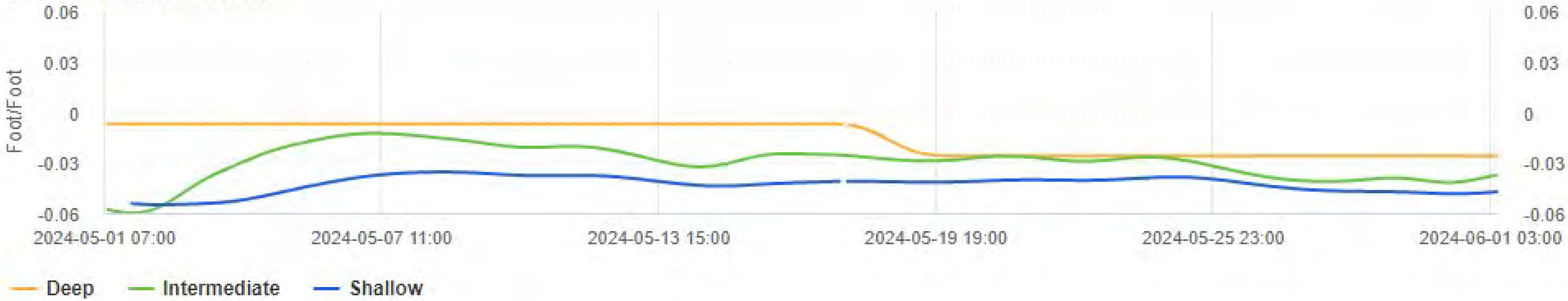
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5

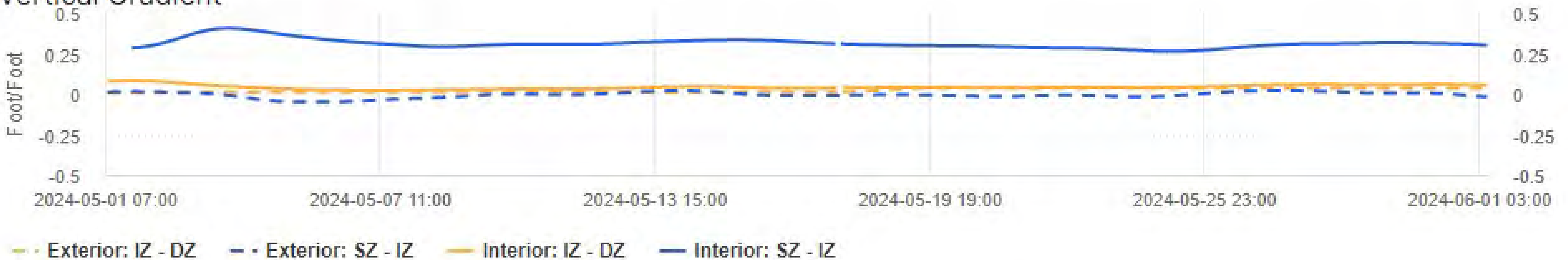
Serfes Averaged Water Table Elevation



Horizontal Gradient



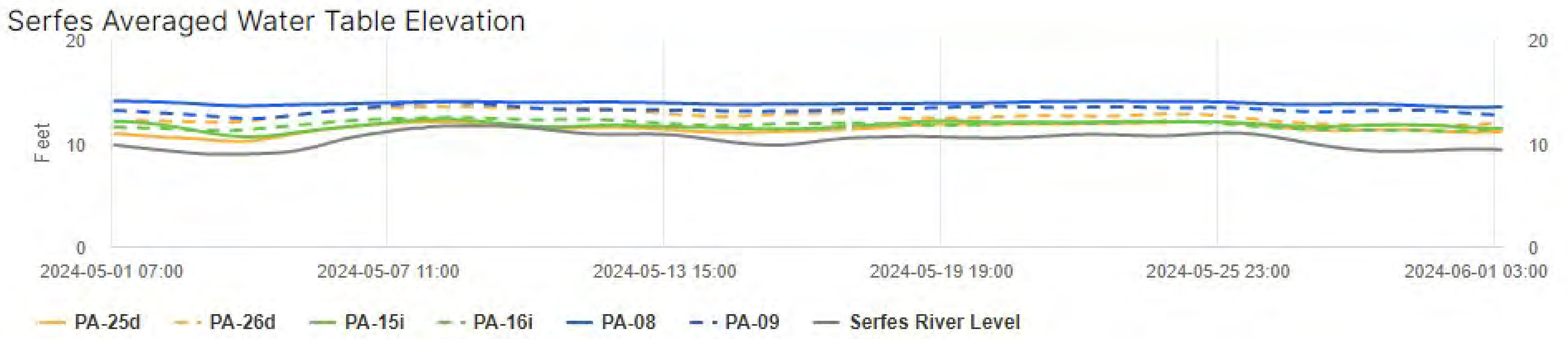
Vertical Gradient

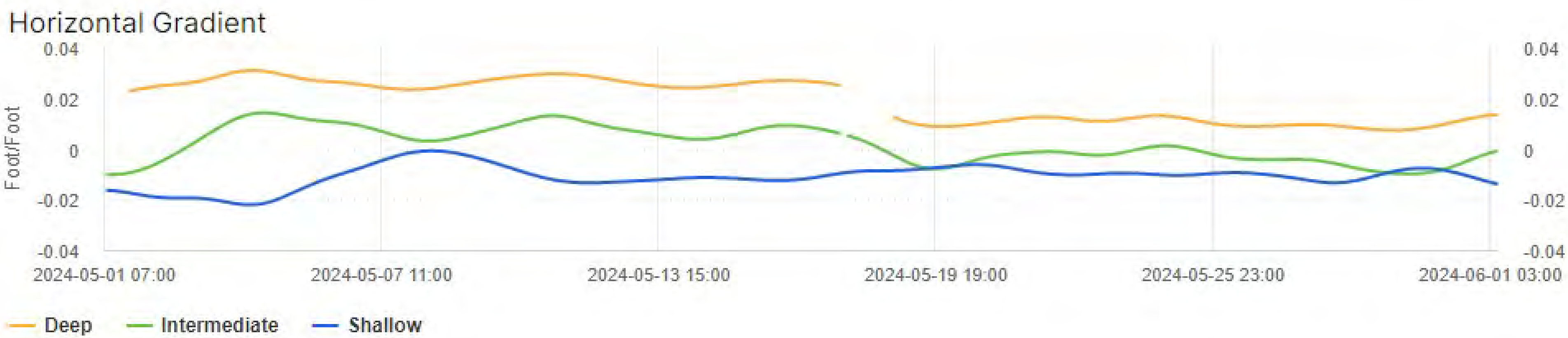


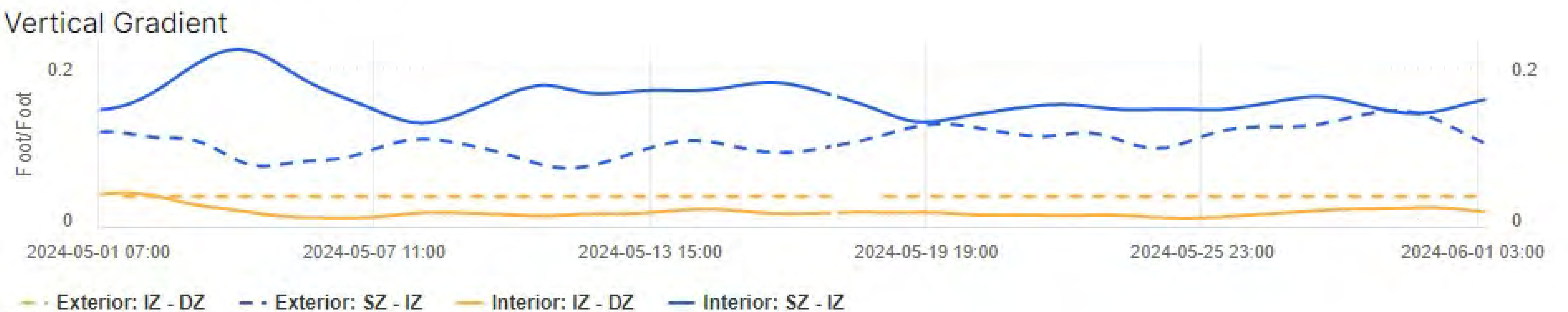
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6





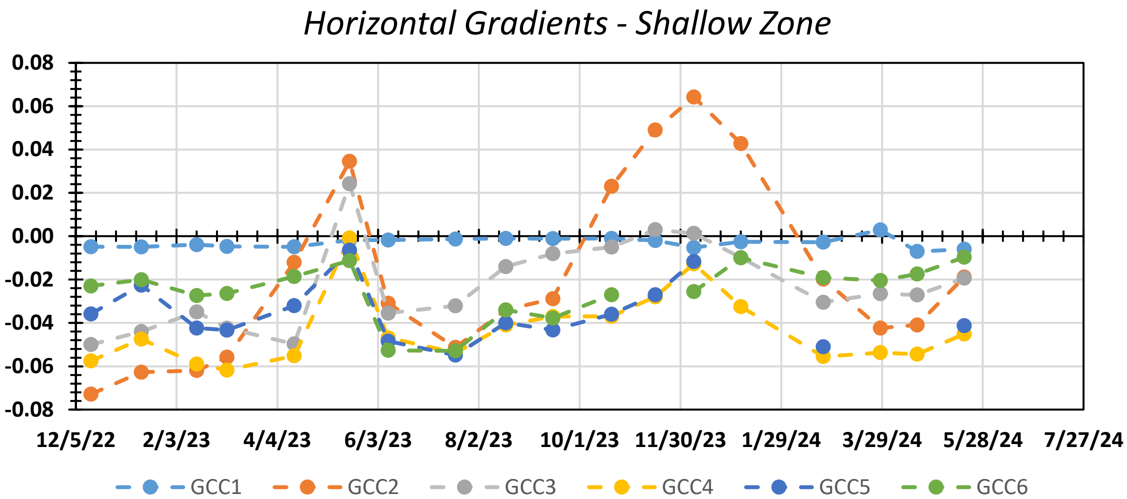


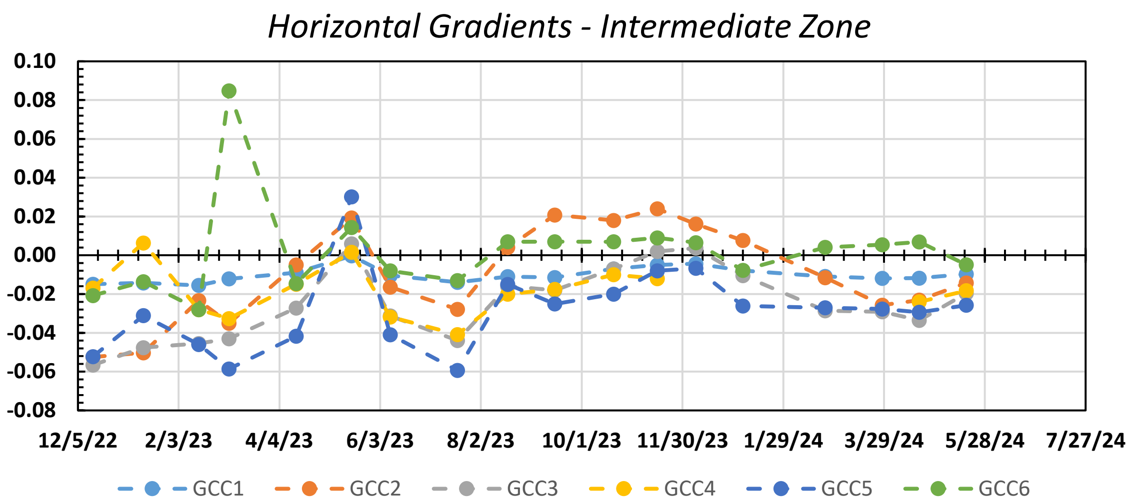
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

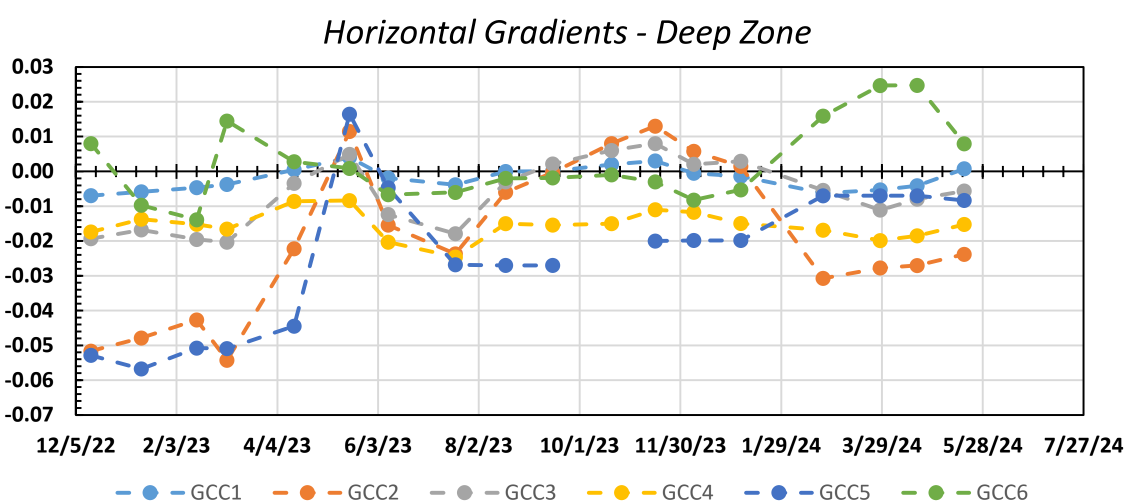
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: May 2024
Arkema Inc. Facility
Portland, Oregon





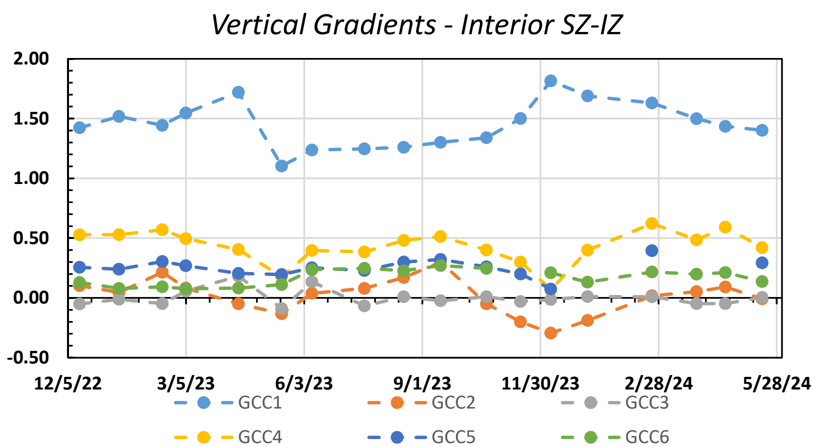


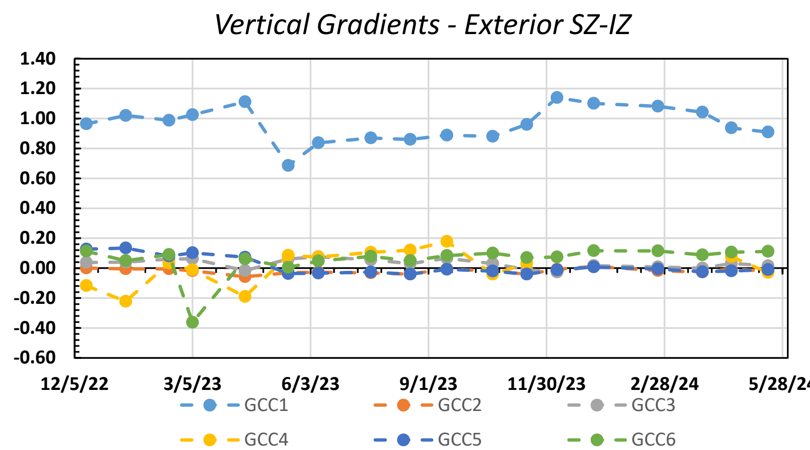
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

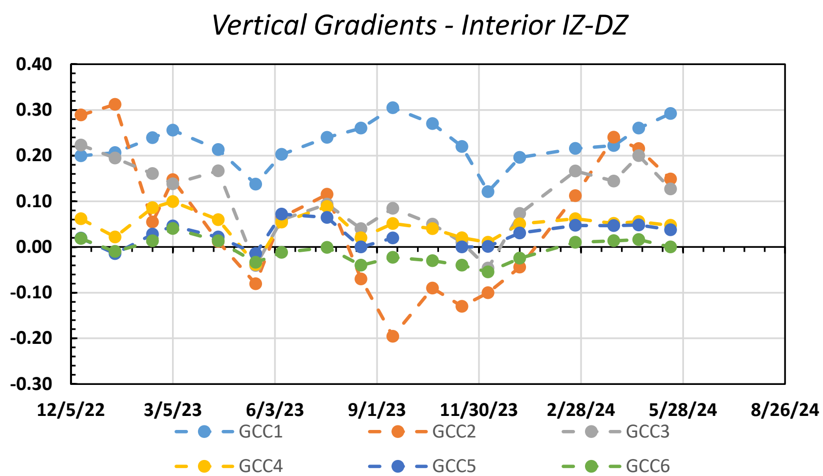
ATTACHMENT B-3 VERTICAL GRADIENTS

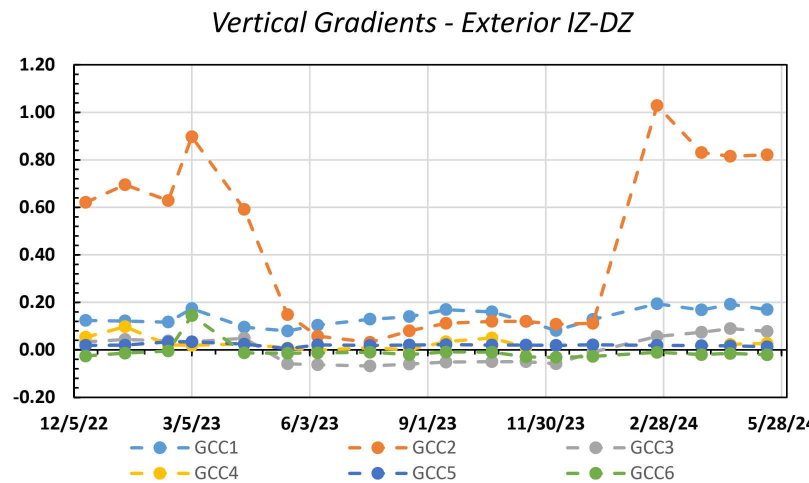
Attachment B-3

Vertical Gradients Summary: May 2024
Arkema Inc. Facility
Portland, Oregon



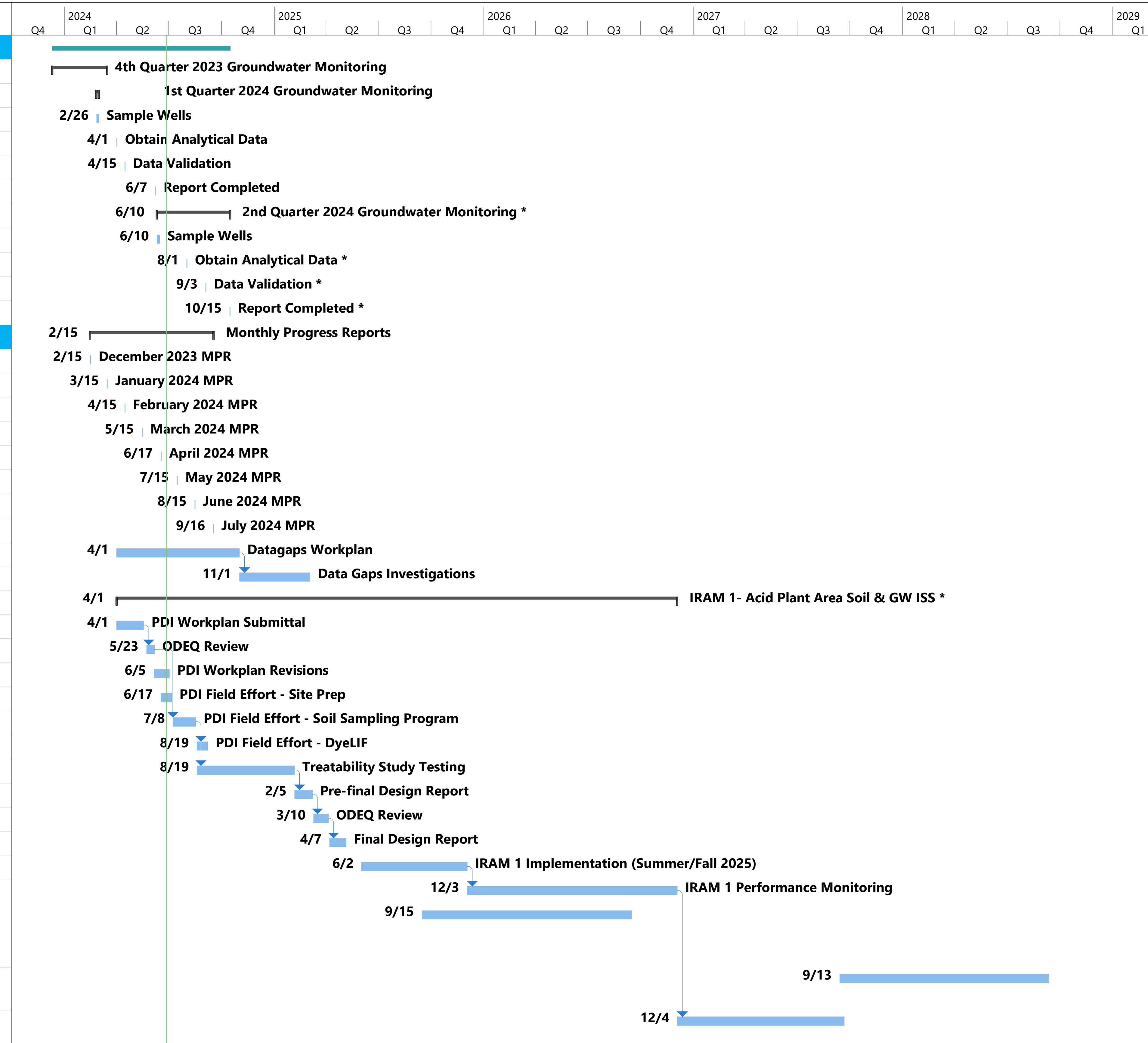






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring ***	**92 days**	**Mon 6/10/24**	**Tue 10/15/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	Obtain Analytical Data *	1 day	Thu 8/1/24	Thu 8/1/24
15	Data Validation *	1 day	Tue 9/3/24	Tue 9/3/24
16	Report Completed *	1 day	Tue 10/15/24	Tue 10/15/24
17	**Monthly Progress Reports**	**154 days**	**Thu 2/15/24**	**Mon 9/16/24**
18	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
19	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
20	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
21	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
22	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
23	May 2024 MPR	1 day	Mon 7/15/24	Mon 7/15/24
24	June 2024 MPR	1 day	Thu 8/15/24	Thu 8/15/24
25	July 2024 MPR	1 day	Mon 9/16/24	Mon 9/16/24
26	**Datagaps Workplan**	154 days	Mon 4/1/24	Thu 10/31/24
27	**Data Gaps Investigations**	87 days	Fri 11/1/24	Mon 3/3/25
28	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
29	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
30	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
31	PDI Workplan Revisions	19 days	Wed 6/5/24	Mon 7/1/24
32	PDI Field Effort - Site Prep	15 days	Mon 6/17/24	Fri 7/5/24
33	PDI Field Effort - Soil Sampling Program	30 days	Mon 7/8/24	Fri 8/16/24
34	PDI Field Effort - DyeLIF	15 days	Mon 8/19/24	Fri 9/6/24
35	Treatability Study Testing	122 days	Mon 8/19/24	Tue 2/4/25
36	Pre-final Design Report	23 days	Wed 2/5/25	Fri 3/7/25
37	ODEQ Review	20 days	Mon 3/10/25	Fri 4/4/25
38	Final Design Report	21 days	Mon 4/7/25	Mon 5/5/25
39	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
40	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
41	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
42	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
43	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland Monthly Progress Report Attachment C	Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone		Manual Progress	
	Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline			
	Milestone		Inactive Task		Manual Task		Manual Summary		External Tasks		Progress			

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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	15 August 2024
REFERENCE	0732445 Phase 204
SUBJECT	June 2024 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This June 2024 MPR summarizes the GW SCM performance monitoring data collected in June 2024. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells (RWs), and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 RWs prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four-remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is approximately 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and

GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 45.47 gallons per minute (gpm) for the entire month of June 2024, including non-operational periods. The average operational influent flow during operational periods was 56.38 gpm, an increase from May 2024.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. In late February 2024, a recordable injury occurred onsite during pump removal and maintenance activities. As a result, pump maintenance activities were paused while a root cause analysis was performed, and procedures updated to mitigate ergonomic and fall risks. An updated pump pulling and maintenance procedure was approved 30 April 2024, and implemented in May 2024. Trench 1 was off during June 2024 due to low pH from chemical redevelopment and will be restarted in July 2024. Conveyance line maintenance of the shallow and intermediate lines was completed 6 June 2024 to mitigate back pressure impeding flow rates (shutting off EW-09 through EW-14 from 2 June 2024 to 14 June 2024). Redevelopment was also completed at EW-07, EW-09, and EW-11 during May 2024. As a result of these changes, groundwater extraction rates (average and operational) have been steadily increasing even while groundwater elevations have been decreasing (see Figures 1-1 and 1-2). Ongoing redevelopment is anticipated in July and August 2024 to maintain the productivity of the groundwater extraction trenches, and conveyance line cleaning will be conducted as needed based on analysis of backpressure.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

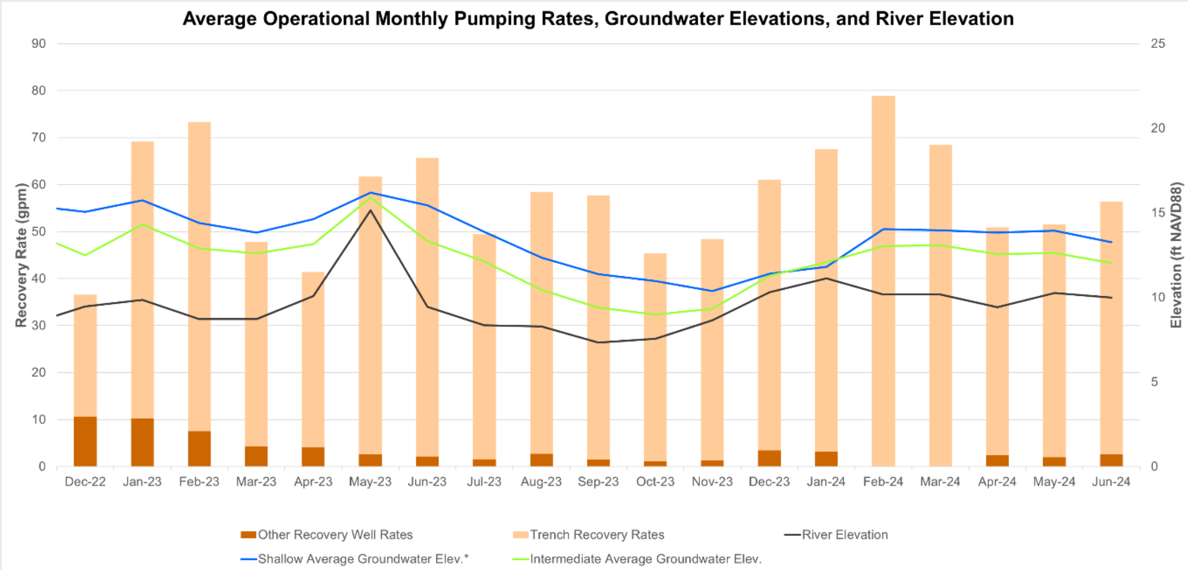
TABLE 1-1 RECOVERY WELL PUMPING RATES

Recovery Well	June 2024 Average Operational Pumping Rate (gpm)	June 2024 Average Monthly Pumping Rate (gpm)
RW-14*	0.00	0.00
RW-22*	0.00	0.00
RW-23	1.21	0.48

Recovery Well	June 2024 Average Operational Pumping Rate (gpm)	June 2024 Average Monthly Pumping Rate (gpm)
RW-25	1.42	1.19
EW-01	0.98	0.33
EW-02	0.55	0.17
EW-03	15.94	15.41
EW-04	3.73	2.49
EW-05	8.32	8.04
EW-06	2.03	0.41
EW-07	0.45	0.04
EW-08	3.33	3.10
EW-09	0.29	0.04
EW-10	3.59	2.99
EW-11	2.39	1.51
EW-12	2.49	0.25
EW-13*	0.00	0.00
EW-14	9.67	9.02
Total	56.38	45.47

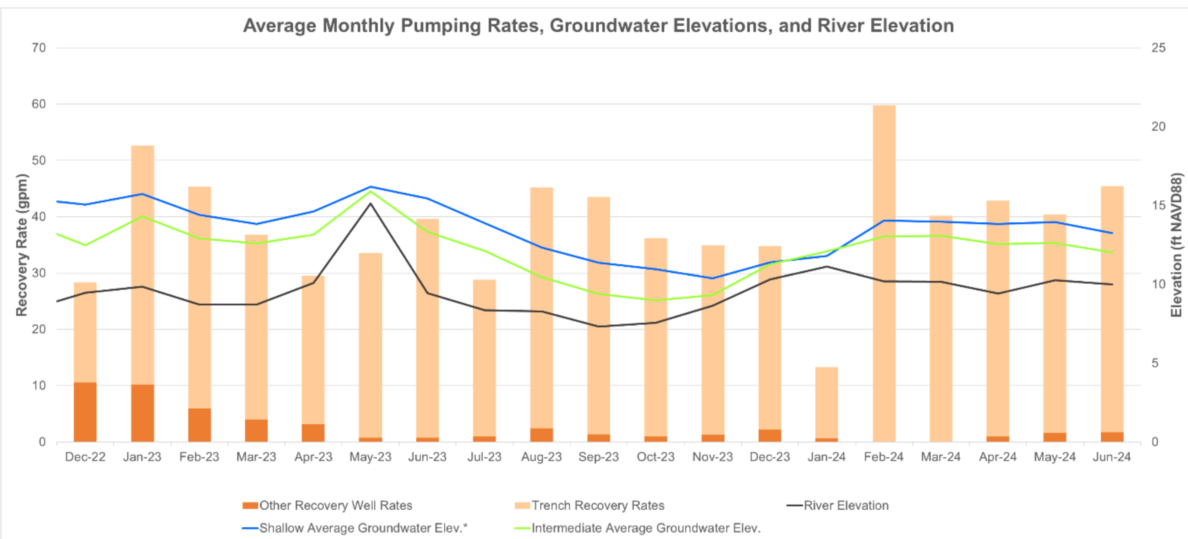
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There were two shutdowns:

- 5 June 2024: The GWET system was shut down for 2 hours due to conveyance line maintenance.
- 22 June 2024: The GWET system was shut down for 30 minutes due to solids handling issue.

4. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four-remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

4.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 7 June 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during June 2024, the following transducers were:

<u>Fully out of service pending repairs:</u>

- None

<u>Out of service for a period but returned to full operation:</u>

- MWA-58d
- MWA-19
- MWA-34i

MWA-58d, MWA-19, and MWA-34i were taken out of service during the abandonment and replacement of MWA-34i, but were rewired and back online 12 June 2024. MWA-34i was renamed to MWA-34iR.

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After June 2024 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 19 April 2024 are shown below at each GCC (Table 1-2 and Table 1-3).

TABLE 1-2 JUNE HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	26.59	PA-04	27.17	-0.006
	Intermediate	PA-17iR	14.43	PA-10i	15.04	-0.006
	Deep	PA-27d	13.66	PA-18d	13.08	0.005
GCC2	Shallow	MWA-2	11.33	PA-05^{M}	12.02	-0.010

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
	Intermediate	MWA-8i	12.57	PA-11i	13.24	-0.009
	Deep	PA-19d^{M}	12.14	PA-30d	12.76	-0.011
GCC3	Shallow	MWA-69	11.82	PA-06	13.34	-0.014
	Intermediate	MWA-66i	12.32	PA-12i^{M}	13.20	-0.008
	Deep	PA-21d	11.43	PA-20d	13.08	-0.013
GCC4	Shallow	MWA-19^{M}	12.26	PA-28	15.25	-0.030
	Intermediate	MWA-34i^{M}	13.02	PA-13i	12.49	0.006
	Deep	MWA-58d	12.61	PA-22d	13.28	-0.007
GCC5	Shallow	MWA-47	12.64	PA-07	15.15	-0.024
	Intermediate	PA-29i	12.72	PA-14i	12.59	0.002
	Deep	PA-24d	11.64	PA-23d	13.02	-0.026
GCC6	Shallow	PA-09	14.20	PA-08	14.57	-0.007
	Intermediate	PA-16i	12.89	PA-15i	12.26	0.011
	Deep	PA-26d	13.90	PA-25d	13.14	0.012

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation − Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
^{M} = manual groundwater elevation measurement

TABLE 1-3 JUNE VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	27.17	PA-10i	15.04	1.23
		GCC2	PA-05^{M}	12.02	PA-11i	13.24	-0.11
		GCC3	PA-06	13.34	PA-12i^{M}	13.20	0.01
		GCC4	PA-28	15.25	PA-13i	12.49	0.43
		GCC5	PA-07	15.15	PA-14i	12.59	0.27
		GCC6	PA-08	14.57	PA-15i	12.26	0.17
	IZ-DZ	GCC1	PA-10i	15.04	PA-18d	13.08	0.26
		GCC2	PA-11i	13.24	PA-30d	12.76	0.07

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
		GCC3	PA-12i^{M}	13.20	PA-20d	13.08	0.01
		GCC4	PA-13i	12.49	PA-22d	13.28	-0.04
		GCC5	PA-14i	12.59	PA-23d	13.02	-0.01
		GCC6	PA-15i	12.26	PA-25d	13.14	-0.02
Exterior	SZ-IZ	GCC1	PA-03	26.59	PA-17iR	14.43	0.77
		GCC2	MWA-2	11.33	MWA-8i	12.57	-0.07
		GCC3	MWA-69	11.82	MWA-66i	12.32	-0.03
		GCC4	MWA-19^{M}	12.26	MWA-34i^{M}	13.02	-0.10
		GCC5	MWA-47^{M}	12.64	PA-29i	12.72	-0.01
		GCC6	PA-09	14.20	PA-16i^{M}	12.89	0.09
	IZ-DZ	GCC1	PA-17iR	14.43	PA-27d	13.66	0.12
		GCC2	MWA-8i	12.57	PA-19d^{M}	12.14	0.28
		GCC3	MWA-66i	12.32	PA-21d	11.43	0.07
		GCC4	MWA-34i^{M}	13.02	MWA-58d	12.61	0.02
		GCC5	PA-29i	12.72	PA-24d	11.64	0.03
		GCC6	PA-16i	12.89	PA-26d	13.90	-0.03

Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; ^{M} = manual groundwater elevation measurement; SZ = Shallow Zone

4.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 7 June 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Intermediate Zone at GCC4, GCC5, and GCC6 and in the Deep Zone at GCC1 and GCC6. Horizontal gradients at GCCs across the Site mostly improved and are trending toward inward gradients in all three hydrogeological zones.

River elevations are shown over time on Figures 1-1 and 1-2 above, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in June 2024 had an average elevation of 9.99 feet NAVD88 with a minimum elevation of 6.89 NAVD88 and a maximum elevation of 13.72 NAVD88. Because the river did not experience a seasonal rise this year (typically in May), groundwater elevations outside the GWBW did not increase, making hydraulic containment more difficult to achieve. However, the average Shallow and Intermediate groundwater elevation decreased from May by 0.59 feet and 0.69 feet respectively, and the river elevation has been trending downward since January 2024.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC2 being upward (Figure 5). Vertical groundwater gradient trend lines are shown in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, GCC4, and GCC5 upward and the rest downward as shown on Figure 5 and in Attachment B-2.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC4, GCC5, and GCC6 upward and the rest downward. The direction of vertical gradients exterior to the GWBW were primarily downward with exception to GCC6 being upward, as shown on Figure 6 and Attachment B-3. While vertical groundwater gradients interior of the GWBW are generally downward, the magnitude of the gradients is getting smaller and approaching zero, indicating that mass flux of constituents of concern (COCs) is decreasing.

4.2.1 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates indicate that the active RWs and EWs are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

5. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	6/7/2024
2024 Quarter 2	6/10/2024–6/13/2024	9/13/2024*
2024 Quarter 3	9/9/2024–9/12/2024*	12/12/2024*

* Dates are tentative.

6. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in June 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

6.1 GROUNDWATER FLOW

- Horizontal groundwater gradients in the Shallow Zone were all outward, but the magnitude of the gradients has been decreasing over the last 3 months. Intermediate Zone horizontal gradients were inward at GCC4, GCC5, and GCC6, and trending toward inward at the remaining clusters. Horizontal gradients in the Deep Zone were inward GCC1 and GCC6 and are trending toward inward gradients except for GCC3 and GCC5. Additional improvements in gradients are anticipated as higher flow rates and uptime are achieved relative the flow rate of water toward the Target Capture Zone.

- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC2 being upward (Figure 5), and the magnitude of downward gradients continues to decrease. Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, GCC4, and GCC5 being upward and the rest downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC4, GCC5, GCC6 being upward and the rest downward. The direction of vertical gradients exterior to the GWBW were generally downward with GCC6 being upward, as shown on Figure 6.
- The average river elevation in June 2024 was 9.99 feet NAVD88 with a minimum elevation of 6.89 feet NAVD88 and a maximum elevation of 13.72 feet NAVD88, and has been trending downward since January 2025.

6.2 GROUNDWATER EXTRACTION

Based on June 2024 groundwater extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, 3, and 4 is largely gone, and the mound around Trenches 5, 6, and 7 is being reduced with increased extraction rates. Average monthly pumping rates in June 2024 were significantly higher than March 2024 to May 2024, resulting in improved horizontal and vertical gradients and increased COC containment.

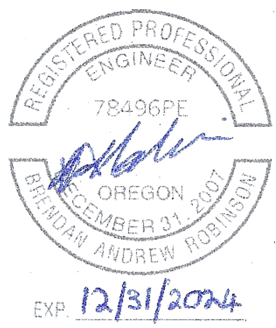
Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing generalized hydraulic capture throughout the Target Capture Zone. More operational time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

Due to work conducted throughout 2024, issues that have historically limited groundwater extraction rates including fouling of pumps, back pressure in the conveyance line, and a pause on pump maintenance, have been addressed resulting in improved average pumping rates. As of June 2024, the main limitations to groundwater extraction are water levels, and the accumulation of silt within the EW trenches filter pack. Efforts to successfully redevelop the trenches and remove silt are ongoing.

6.3 RECOMMENDATIONS AND FUTURE WORK

Redevelopment of the trenches is planned for August 2024 to mitigate accumulation of silt in the filter pack in both the vertical and horizontal sections using impulse redevelopment techniques. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,



Brendan Robinson, PE
Partner

7. References

ERM (ERM-West, Inc.). 2012. *Arkema Portland Groundwater Source Control Measure, Groundwater Barrier Wall Final Design, Arkema Inc., Portland, Oregon*. July 2012.

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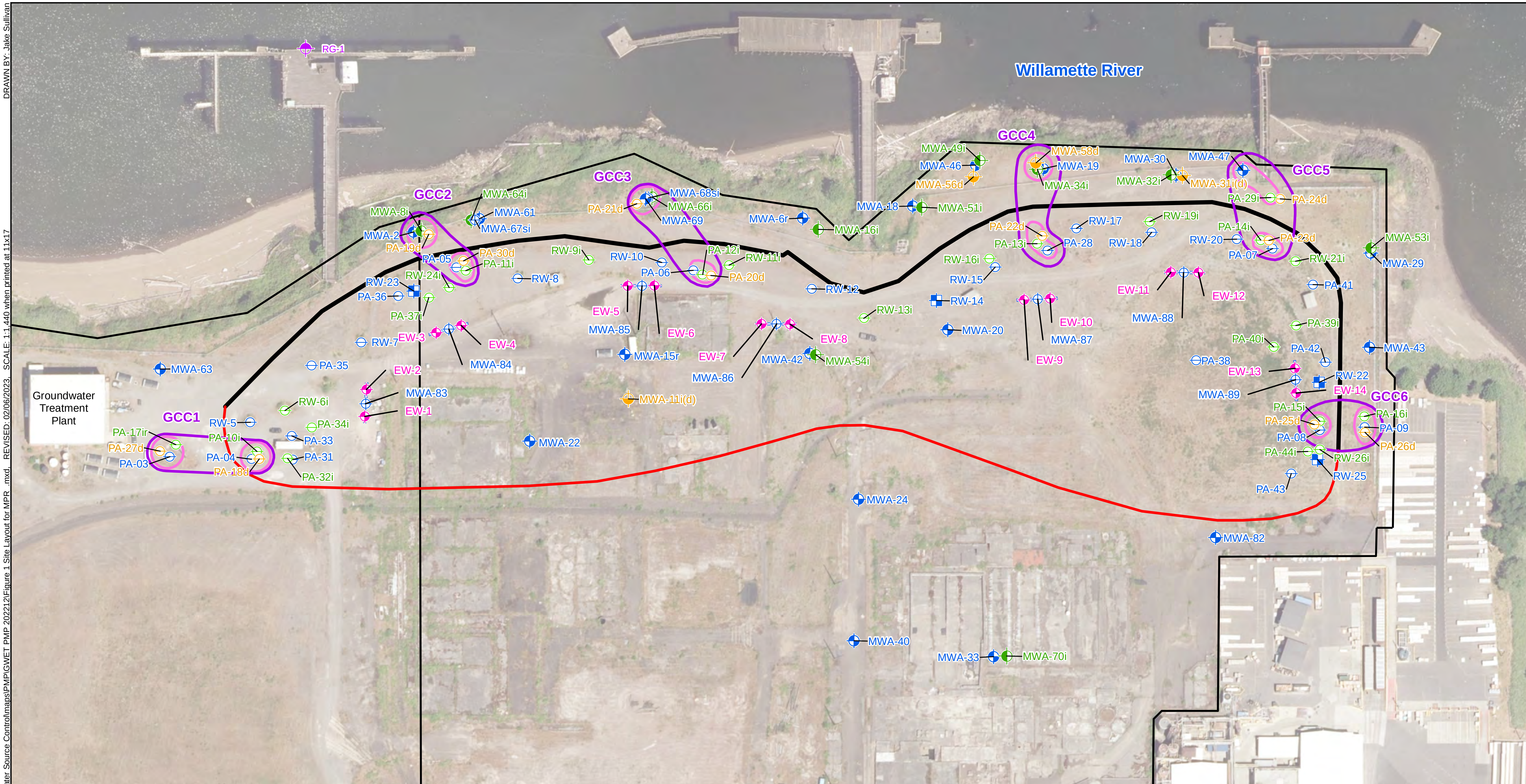
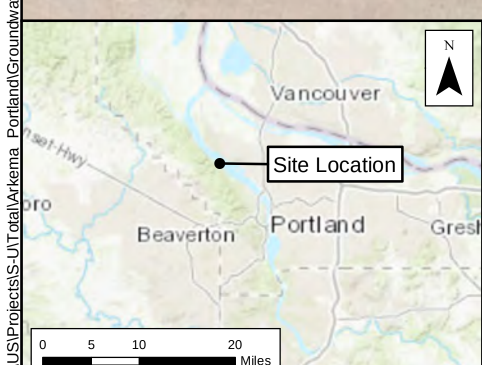
FIGURES





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

0 120 240

Feet

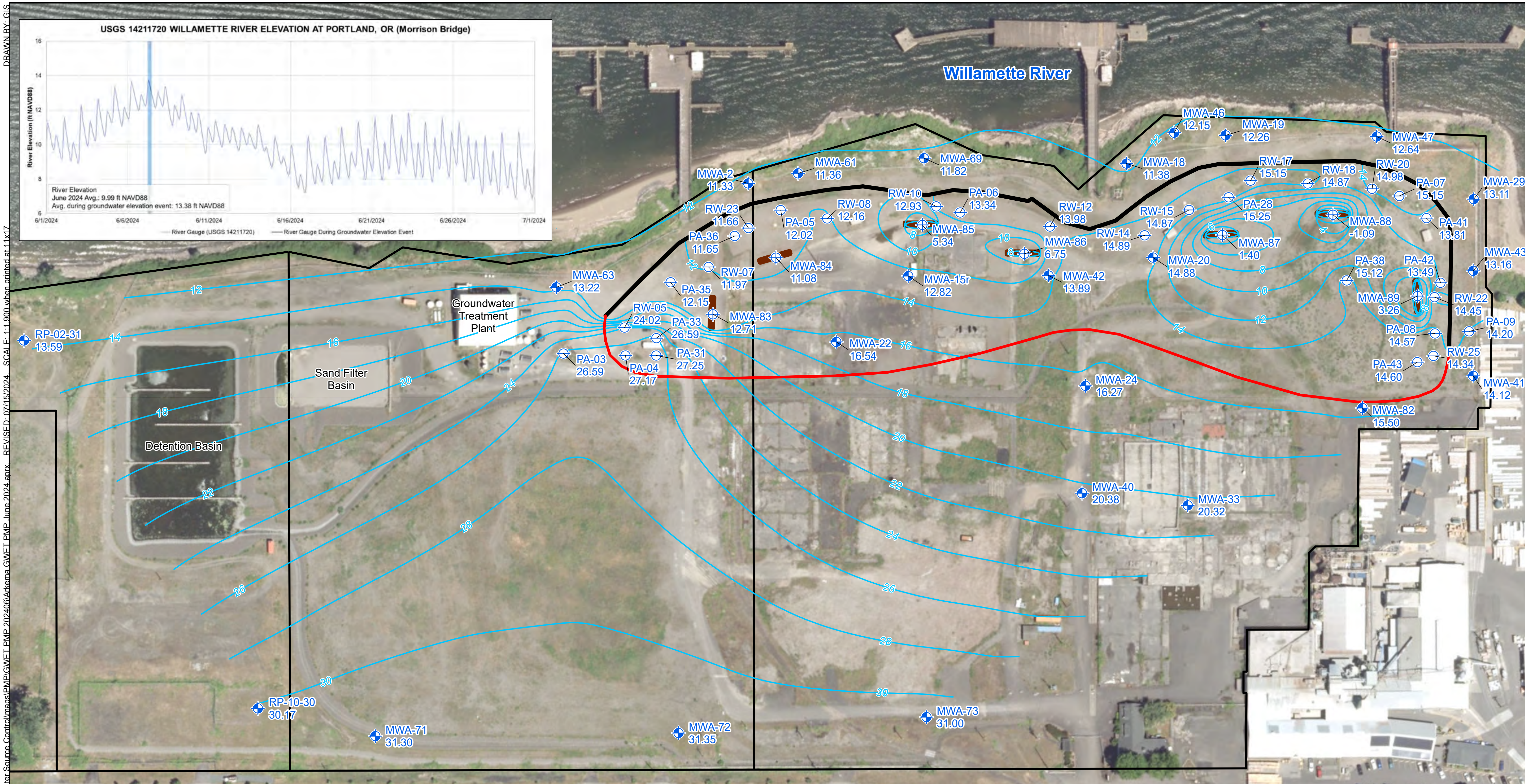
Figure 1

Site Layout

Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected June 7, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

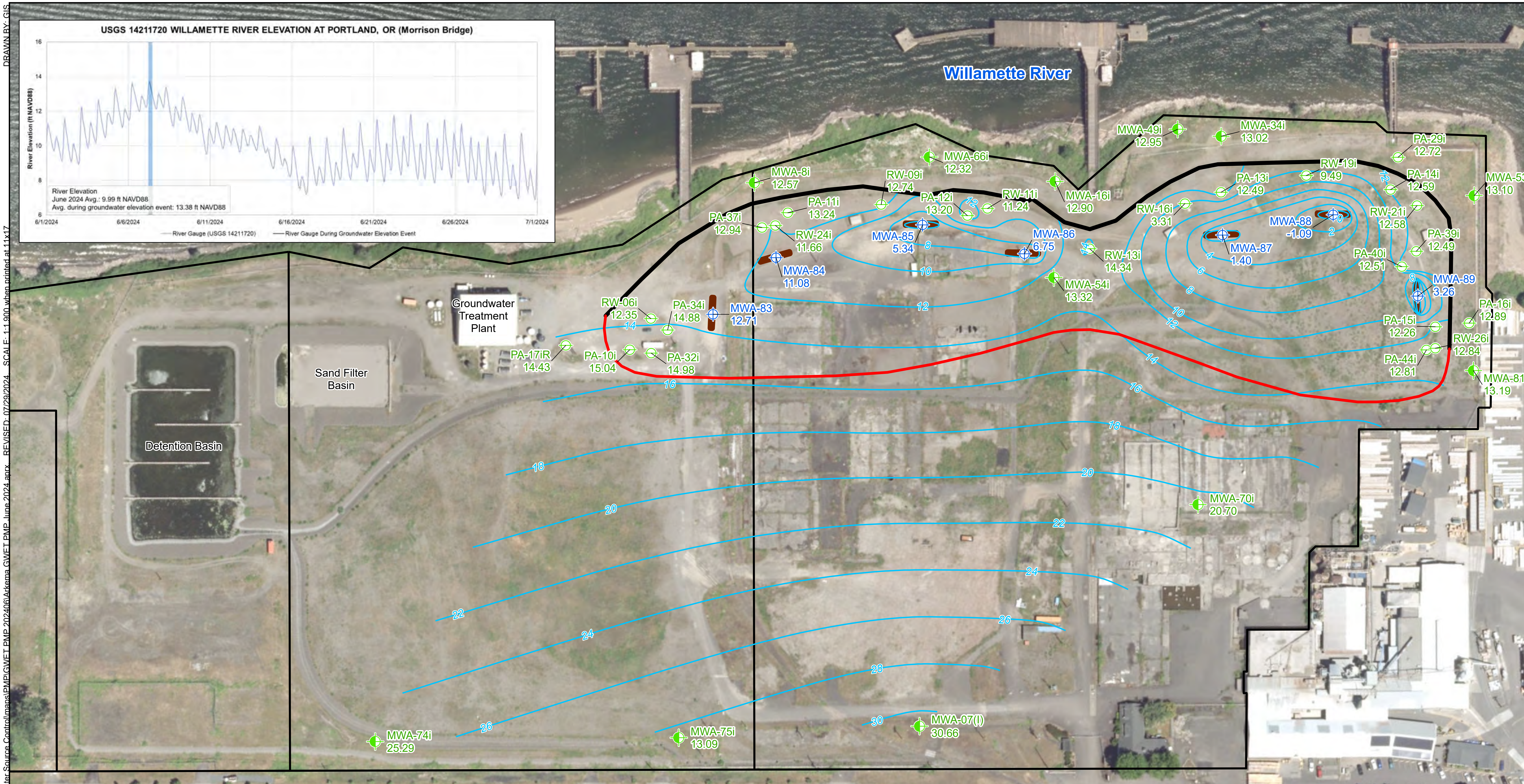
N

0 160 320
Feet

Figure 2
June 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected June 7, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
June 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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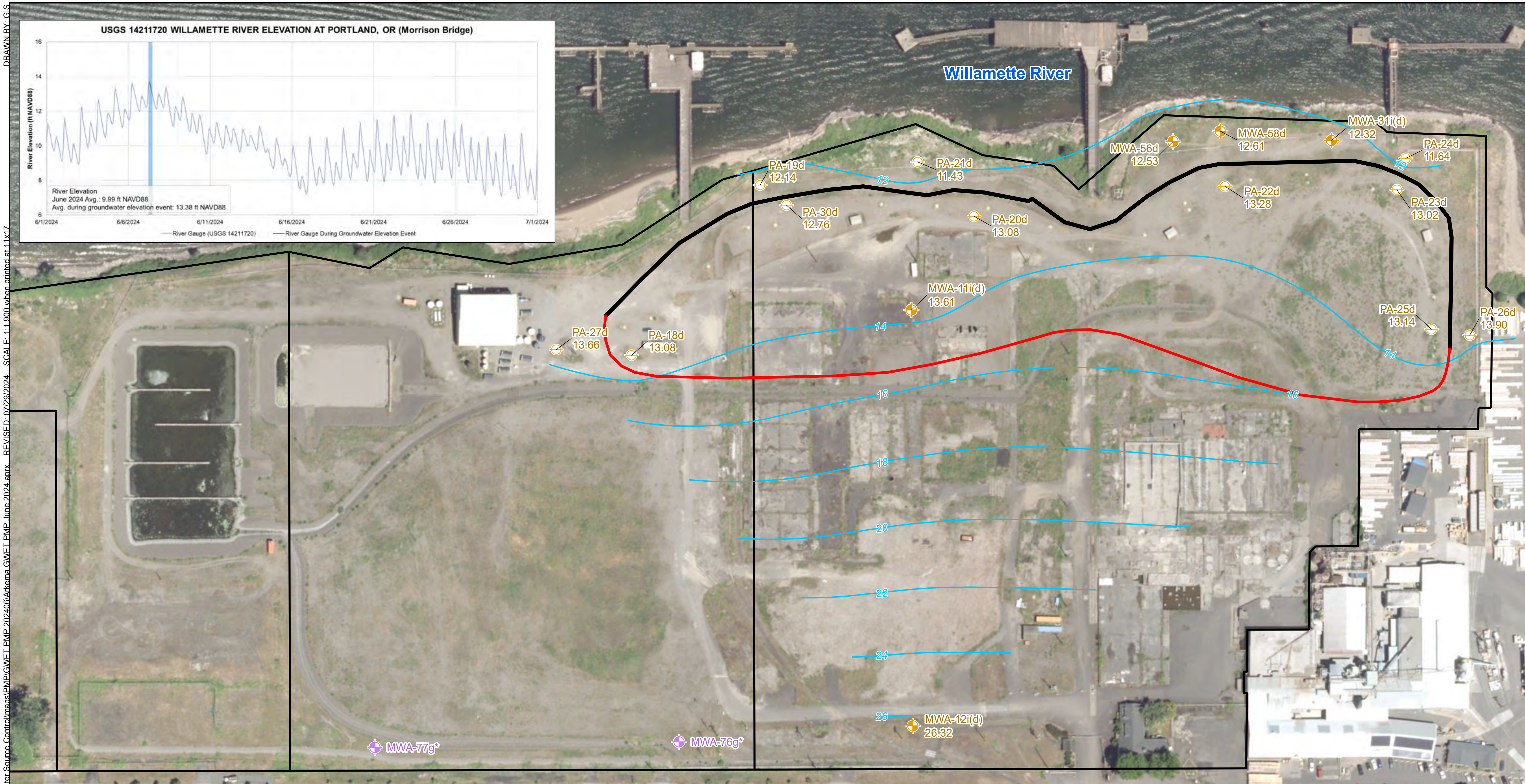
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected June 7, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
June 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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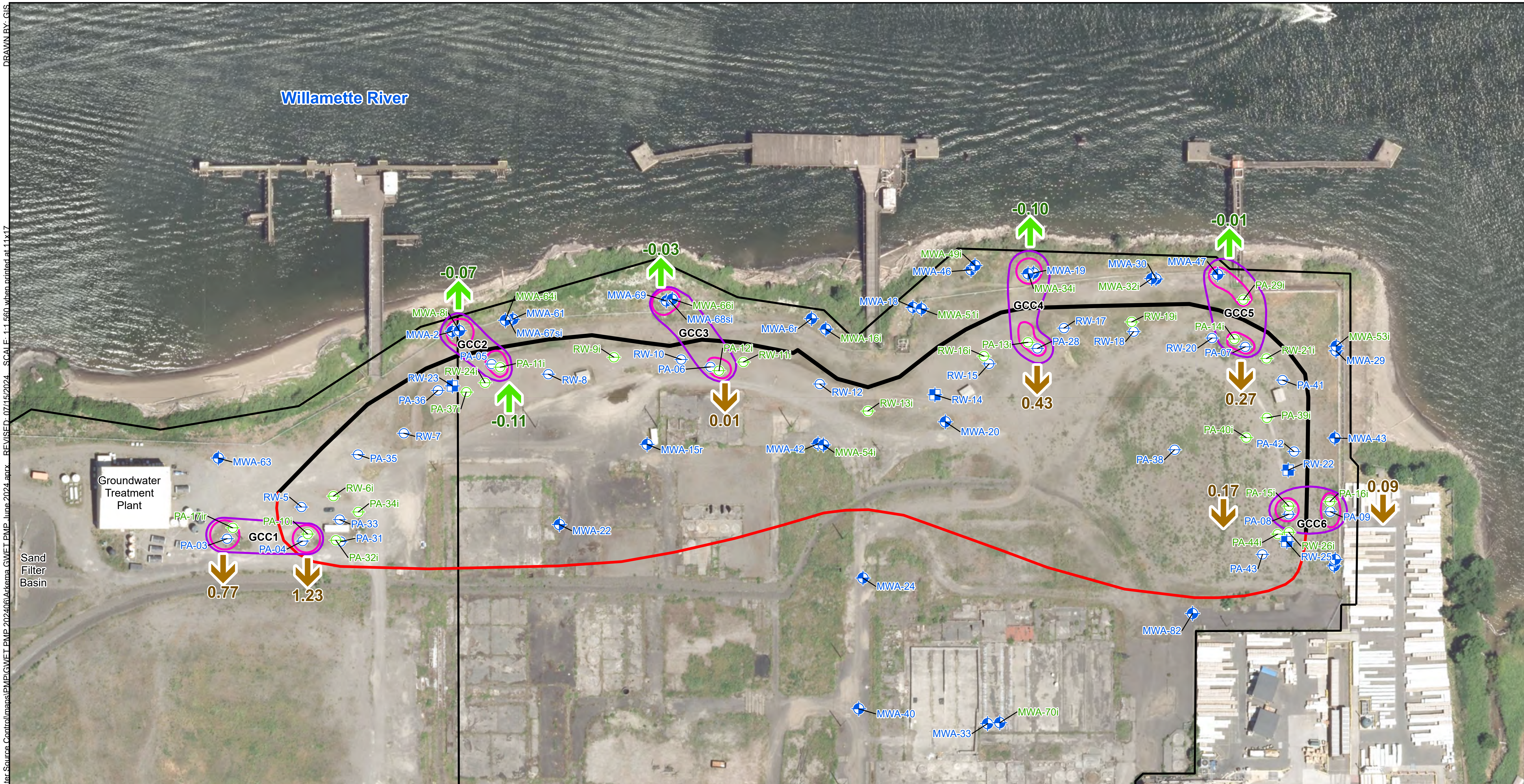
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

REVISED: 07/29/2024 SCALE: 1:1,900 when printed at 11x17 DRAWN BY: GIS



Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected June 7, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
June 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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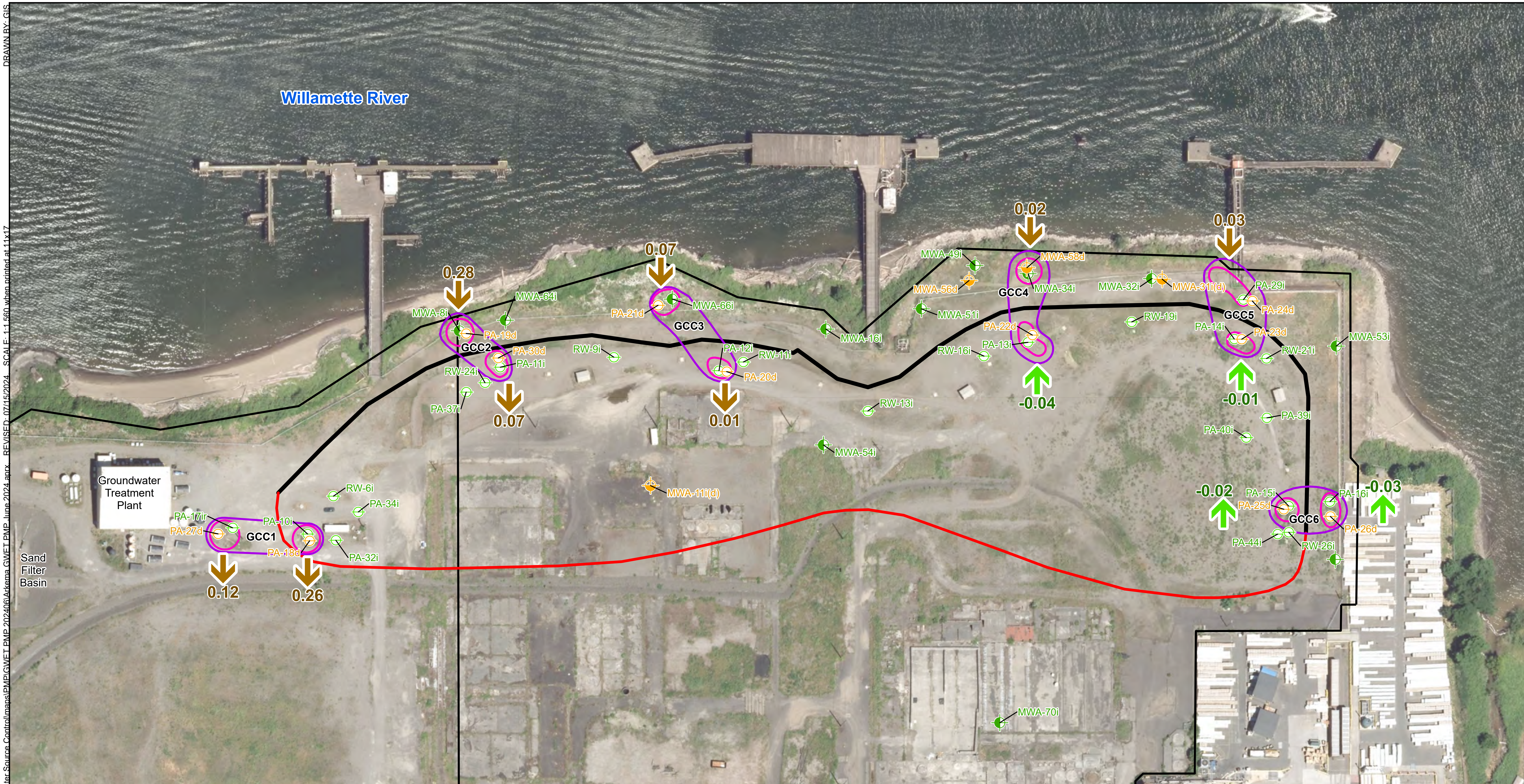

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Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected June 7, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
June 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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ERM

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: June 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC4	MWA-34i	Intermediate	5/28/2024	6/12/2024	Transducer taken out of service for MWA-34i abandonment and replacement. New name MWA-34iR.
GCC4	MWA-58d	Deep	5/28/2024	6/12/2024	Transducer rewired and back in service
GCC4	MWA-19	Shallow	5/28/2024	6/12/2024	Transducer rewired and back in service
	RW-15	Shallow	6/4/2024	6/21/2024	Transducer faulted, Repaired loose wire

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ERM

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: June 2024
Arkema Inc. Facility
Portland, Oregon

Recovery Well ID	Status as of 6/31/2024 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	7/2/2024	Good	Good	0.00	OFF*	Not turned on
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Cable leads need to be replaced
RW-23	Active	None	N/A	N/A	Good	Good	0.48	P**	Redeployed clean pump 6/19/2024
RW-25	Active	None	N/A	N/A	Good	Good	1.19	M**	
EW-01	Active	High Iron	Low Flow to GWET	N/A	Good	Good	0.33	P**	Started 6/24/2024
EW-02	Inactive	Totalizer	Troubleshoot totalizer	8/1/2024	Good	Not working	0.00	OFF*	Totalizer not communicating with PLC
EW-03	Active	None	N/A	N/A	Good	Good	15.41	G	
EW-04	Active	None	N/A	N/A	Good	Good	2.49	M**	
EW-05	Active	None	N/A	N/A	Good	Good	8.04	G	
EW-06	Inactive	None	N/A	N/A	Good	Good	0.41	P**	
EW-07	Inactive	Load Fault	Change Pump	7/12/2024	Good	Good	0.00	OFF	
EW-08	Active	None	N/A	N/A	Good	Good	3.10	G**	Changed out 1/2 HP motor and pump on 6/24
EW-09	Inactive	High Perchlorate	Reseed FBR	N/A	Good	Good	0.04	P**	Awaiting analytical results after reseeding
EW-10	Inactive	High Perchlorate	Reseed FBR	7/10/2024	Good	Good	2.99	M**	Awaiting analytical results after reseeding
EW-11	Active	None	N/A	N/A	Good	Good	1.51	M**	
EW-12	Inactive	None	N/A	N/A	Good	Good	0.25	P**	Pump removed for camera inspection and jetting
EW-13	Inactive	None	Repair plumbing	7/2/2024	Good	Good	0.00	OFF*	Reconfigured vault plumbing
EW-14	Active	None	N/A	N/A	Good	Good	6.53	G**	Redeployed clean pump and reconfigured vault plumbing

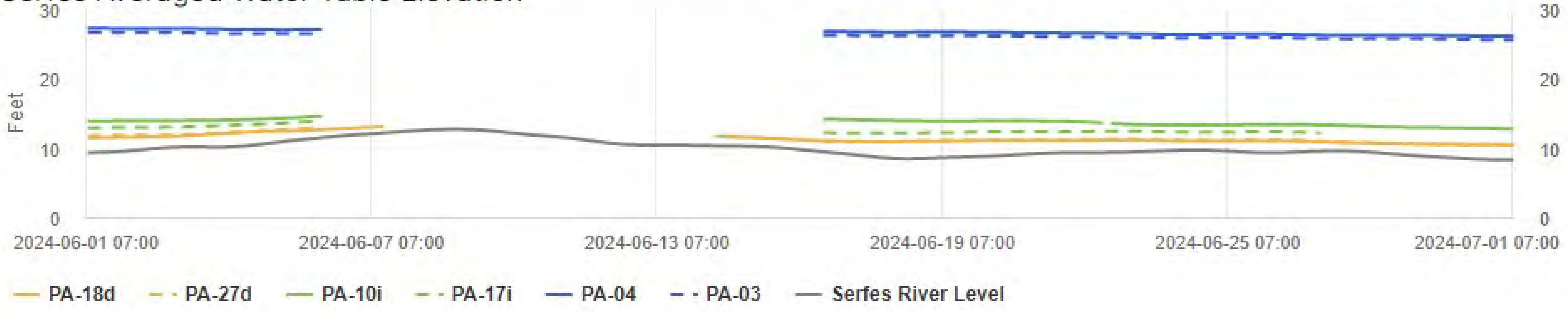
Notes:
* Recovery wells not in service
** Recovery wells in service part of the month
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ERM

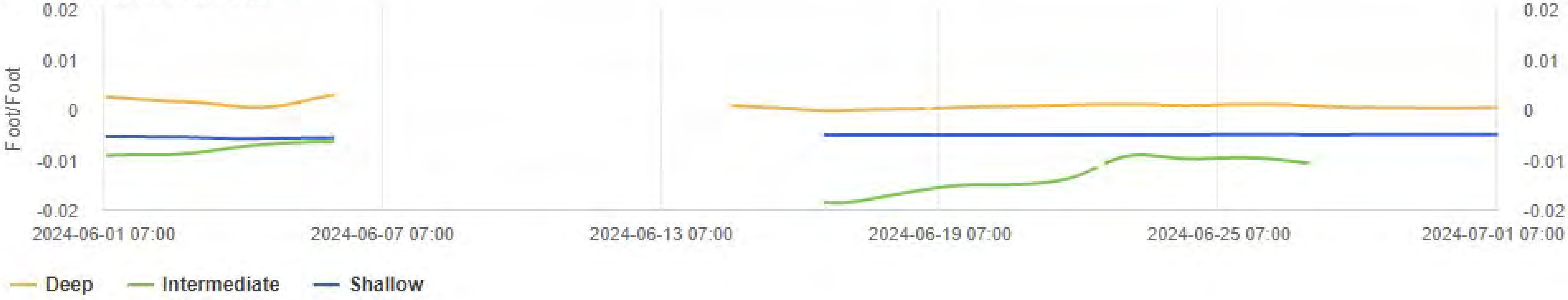
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

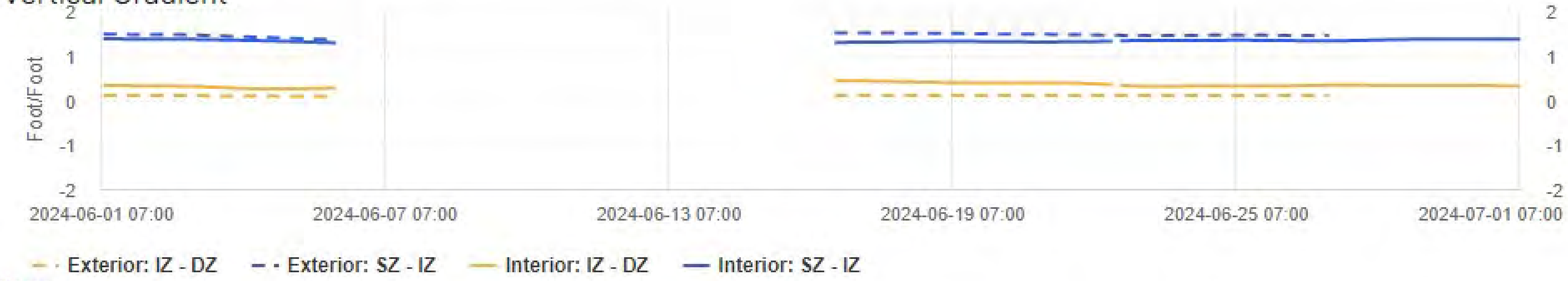
Serfes Averaged Water Table Elevation



Horizontal Gradient

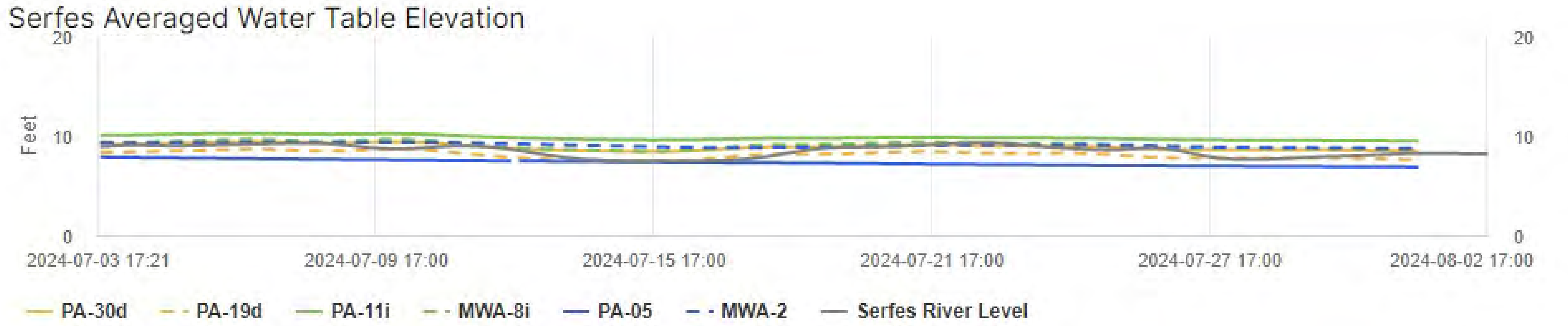


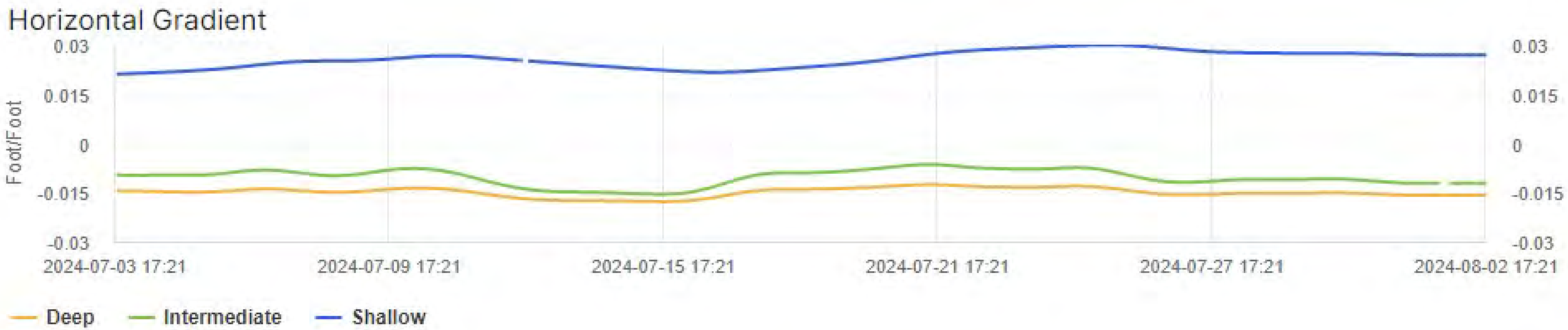
Vertical Gradient

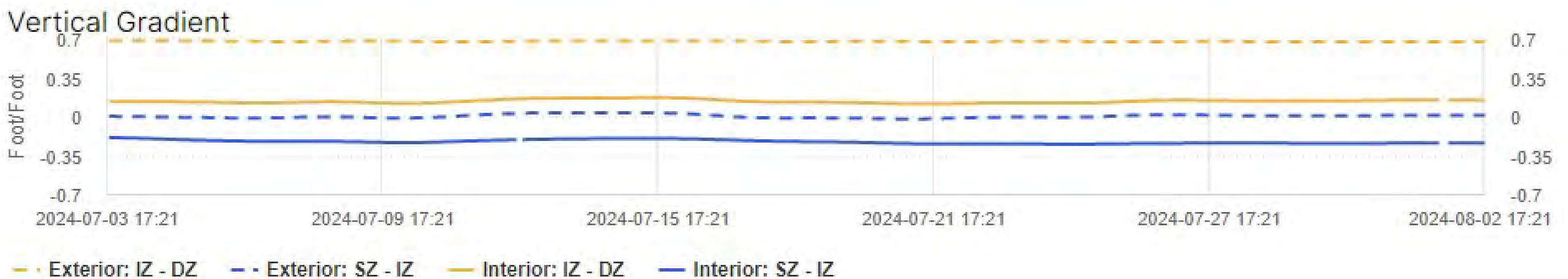


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

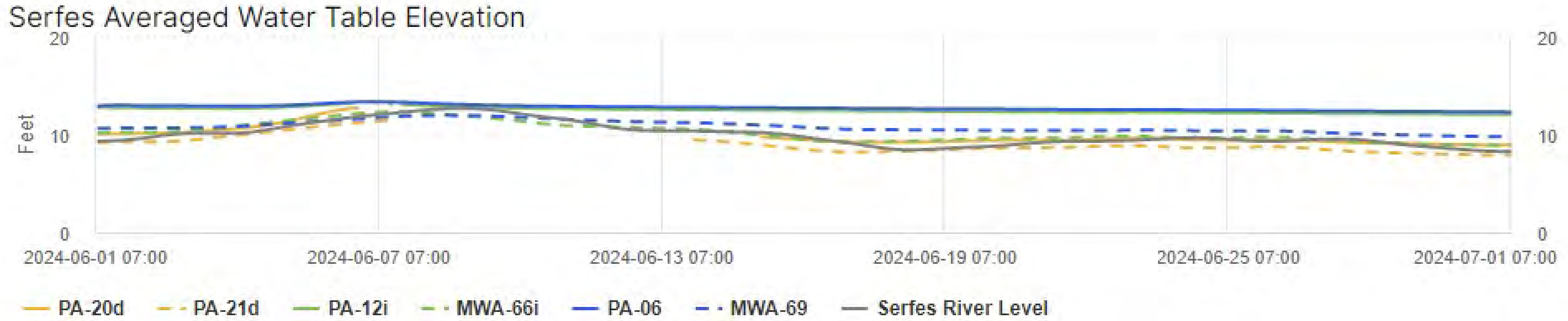


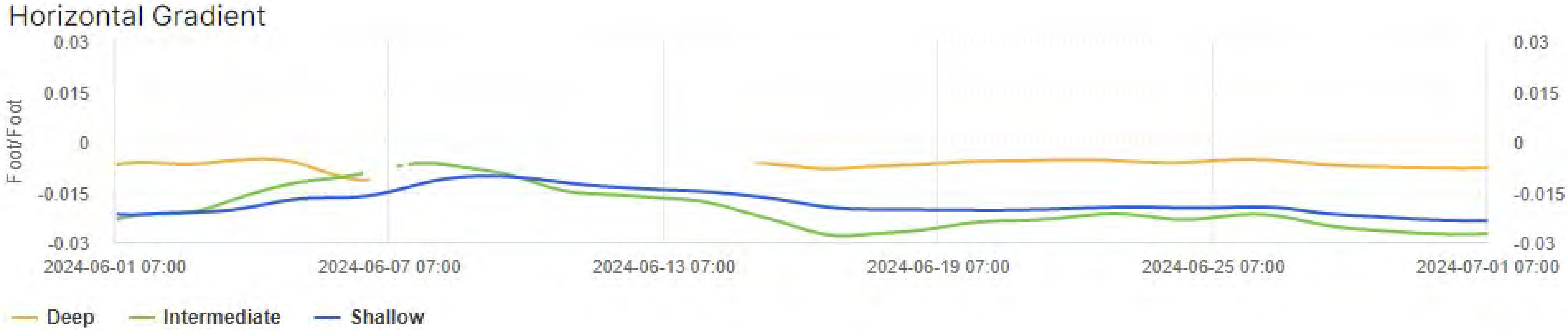


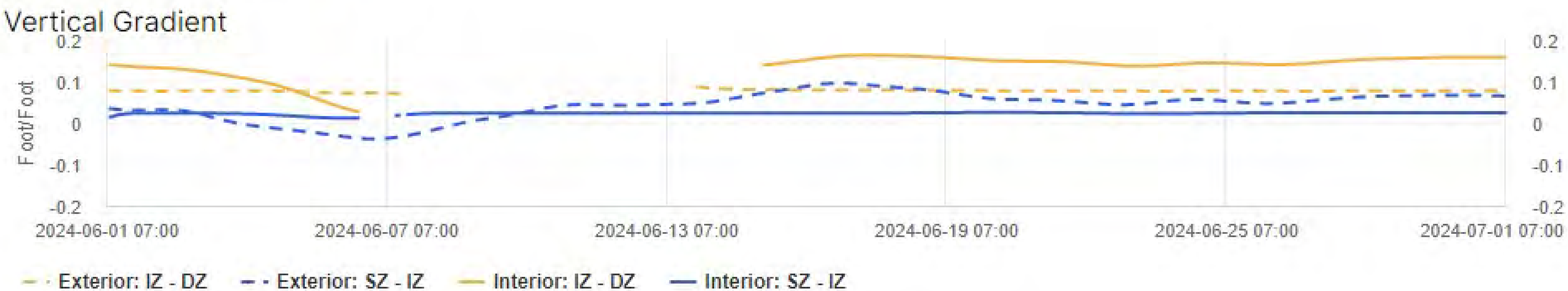


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

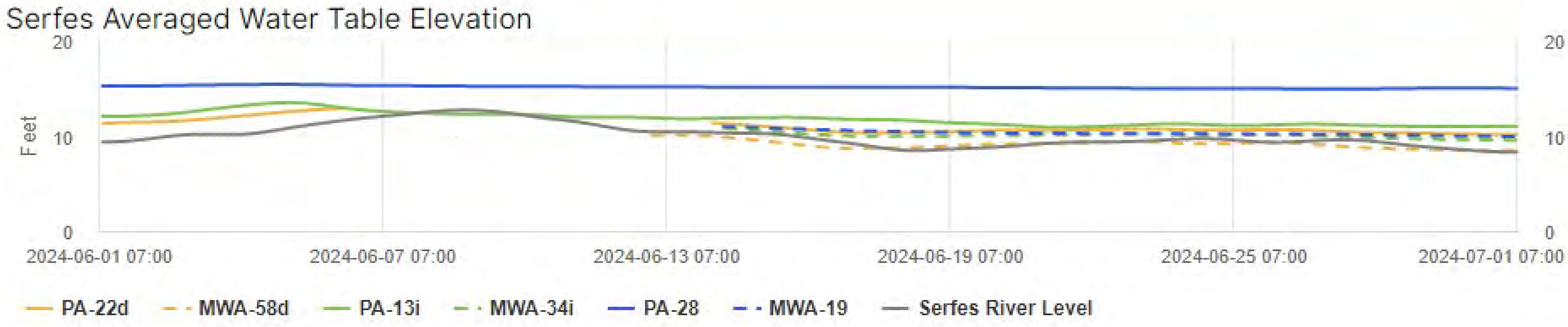


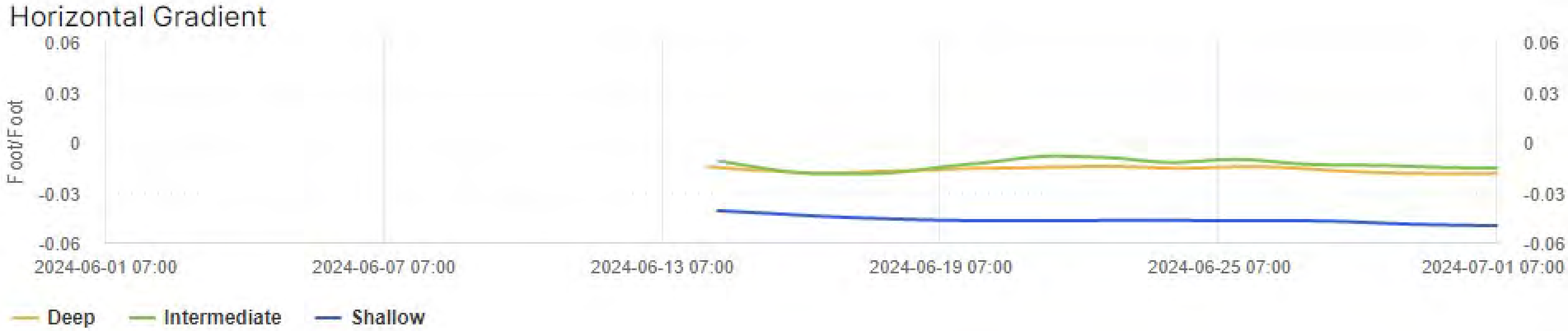


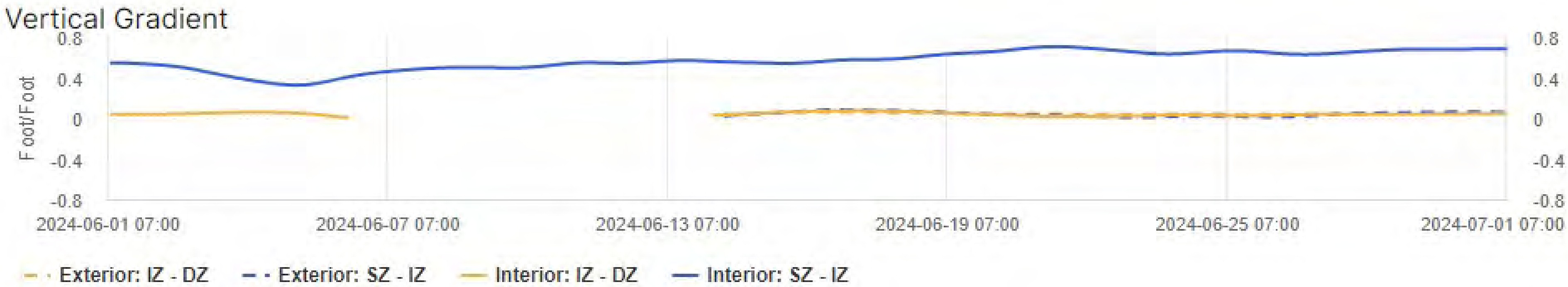


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

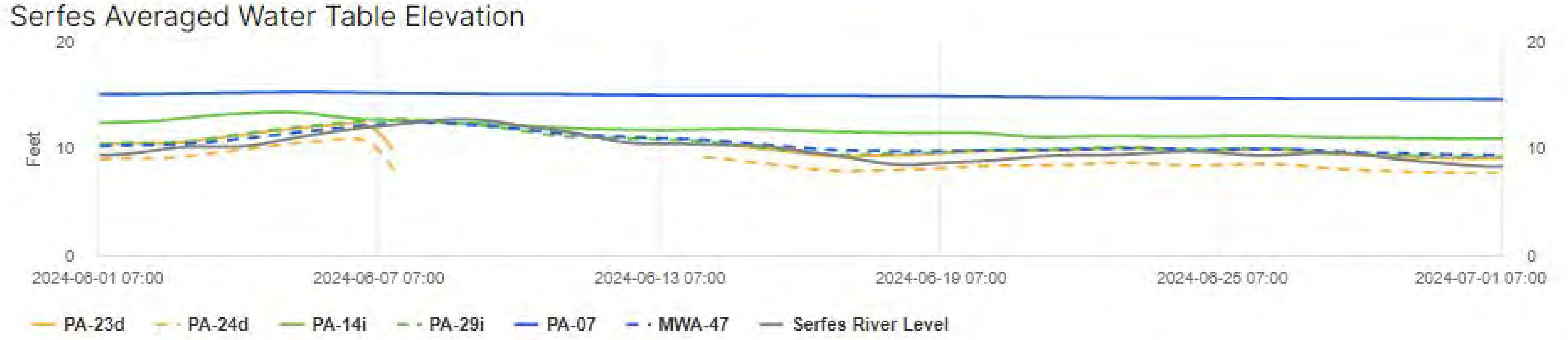


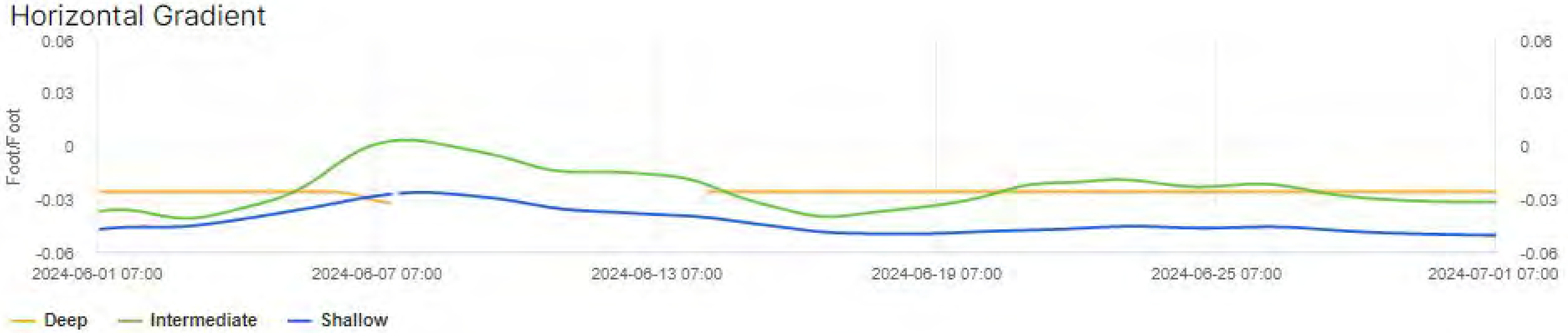


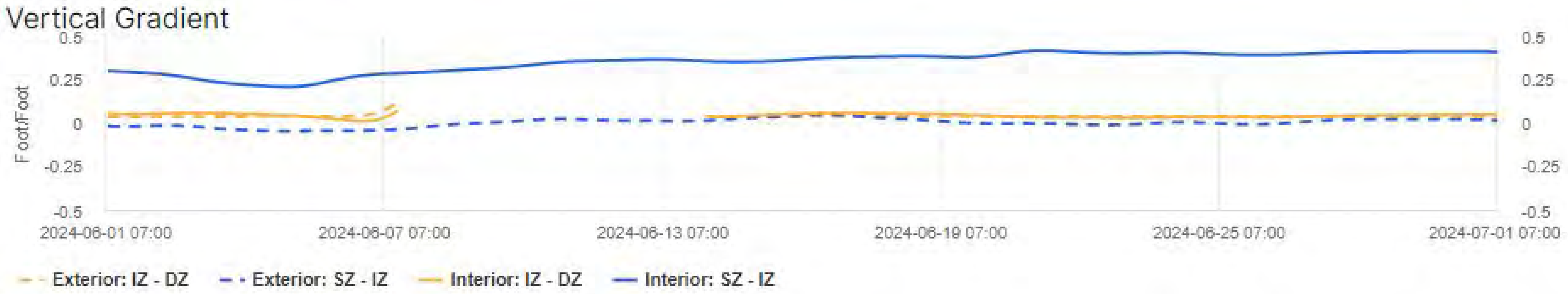


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5





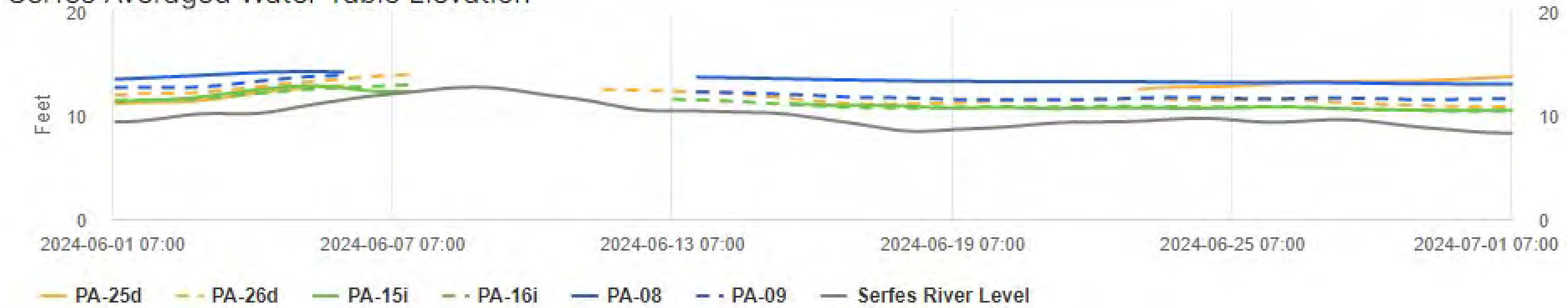


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

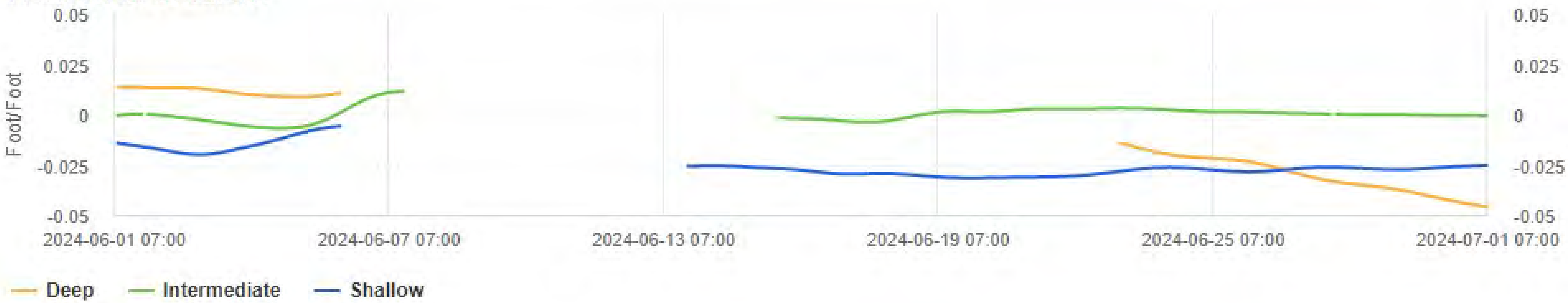
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

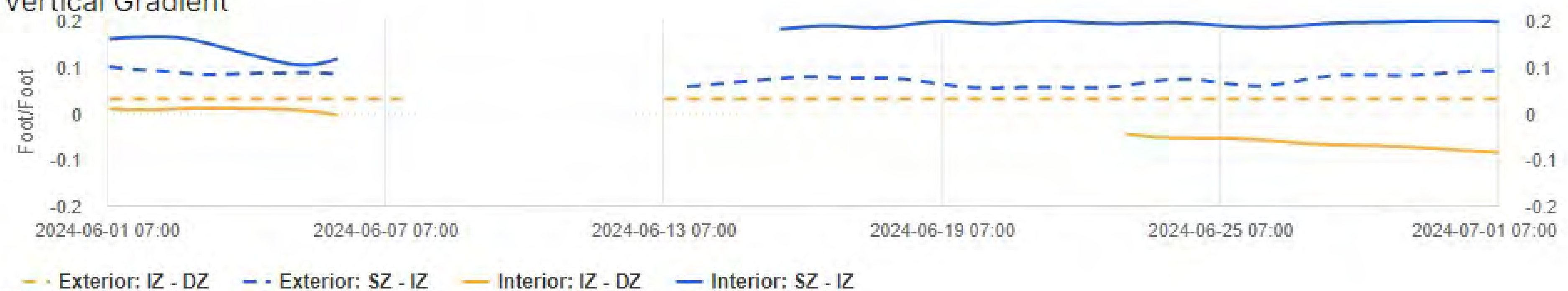
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

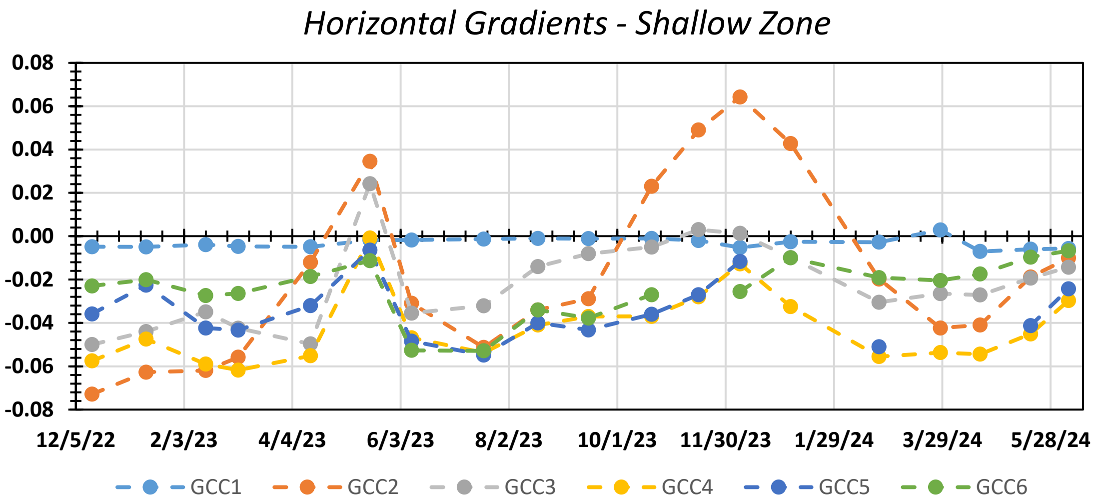


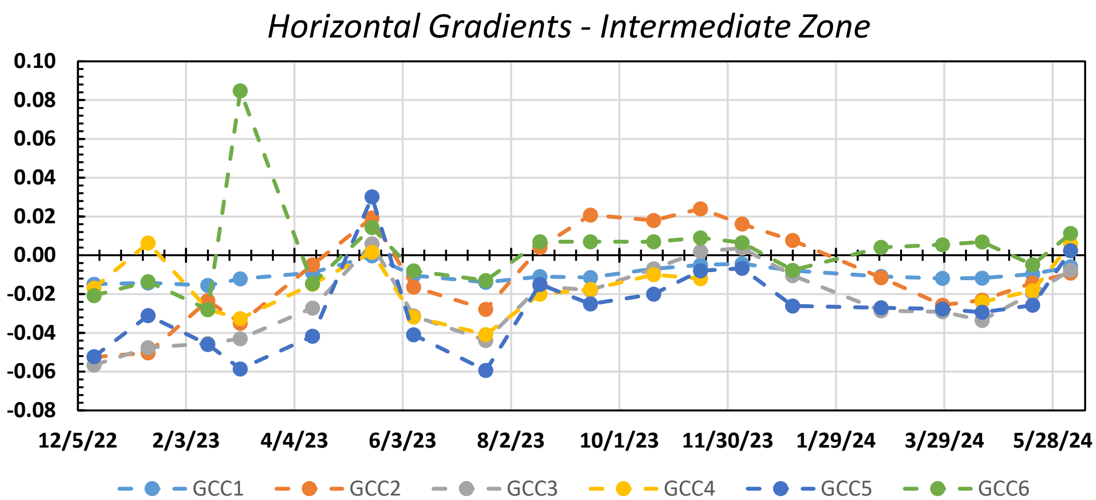
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

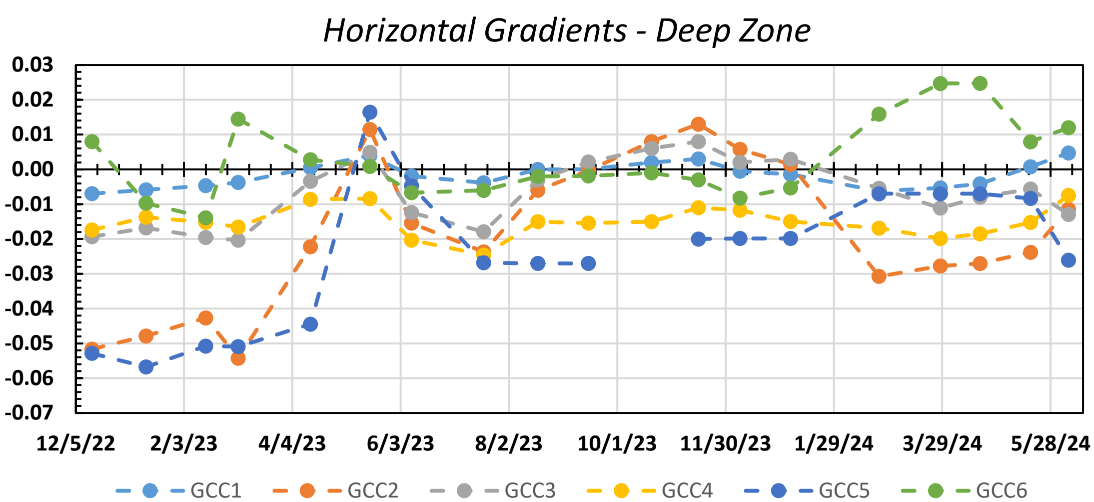
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: June 2024
Arkema Inc. Facility
Portland, Oregon







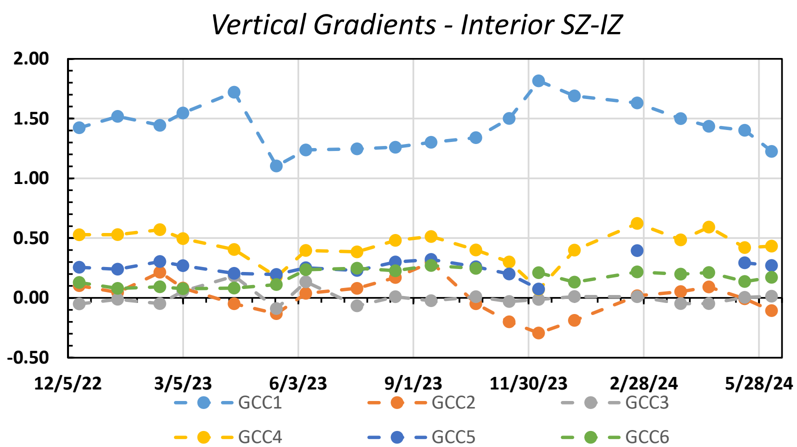
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

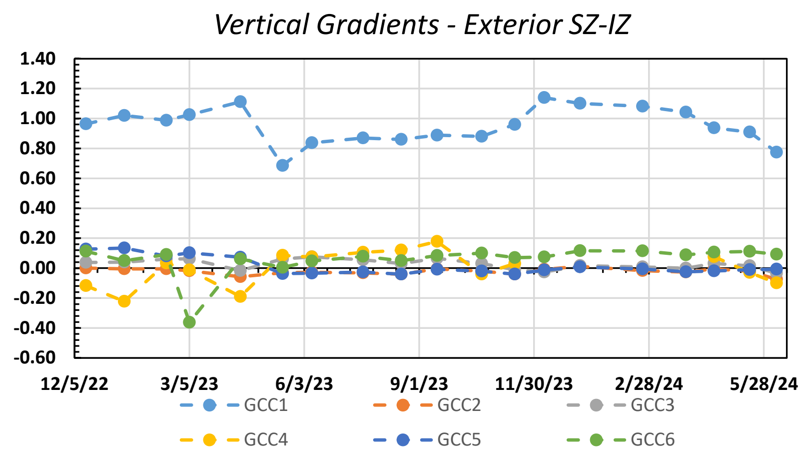
ERM

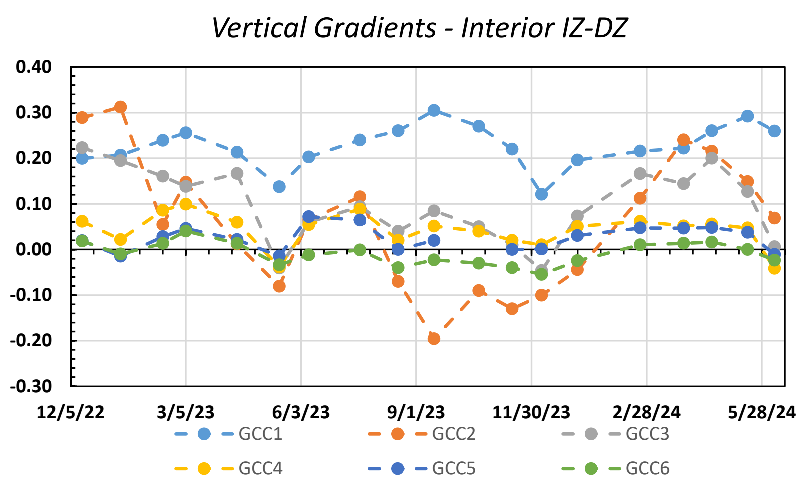
ATTACHMENT B-3 VERTICAL GRADIENTS

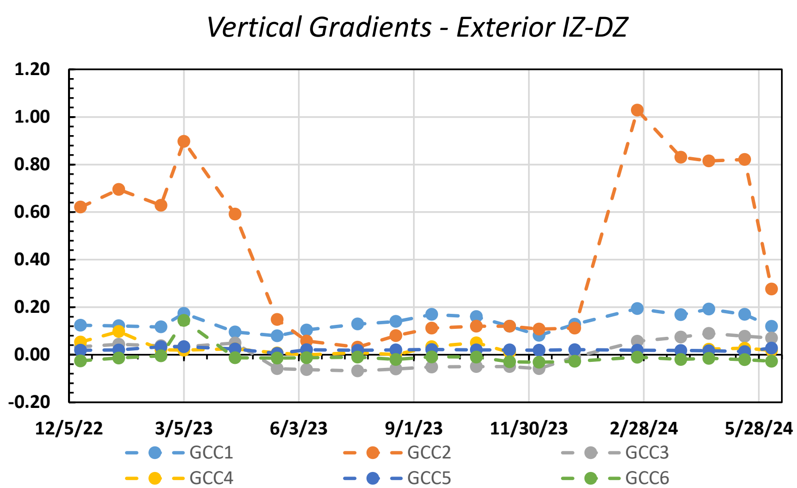
Attachment B-3

Vertical Gradients Summary: June 2024
Arkema Inc. Facility
Portland, Oregon



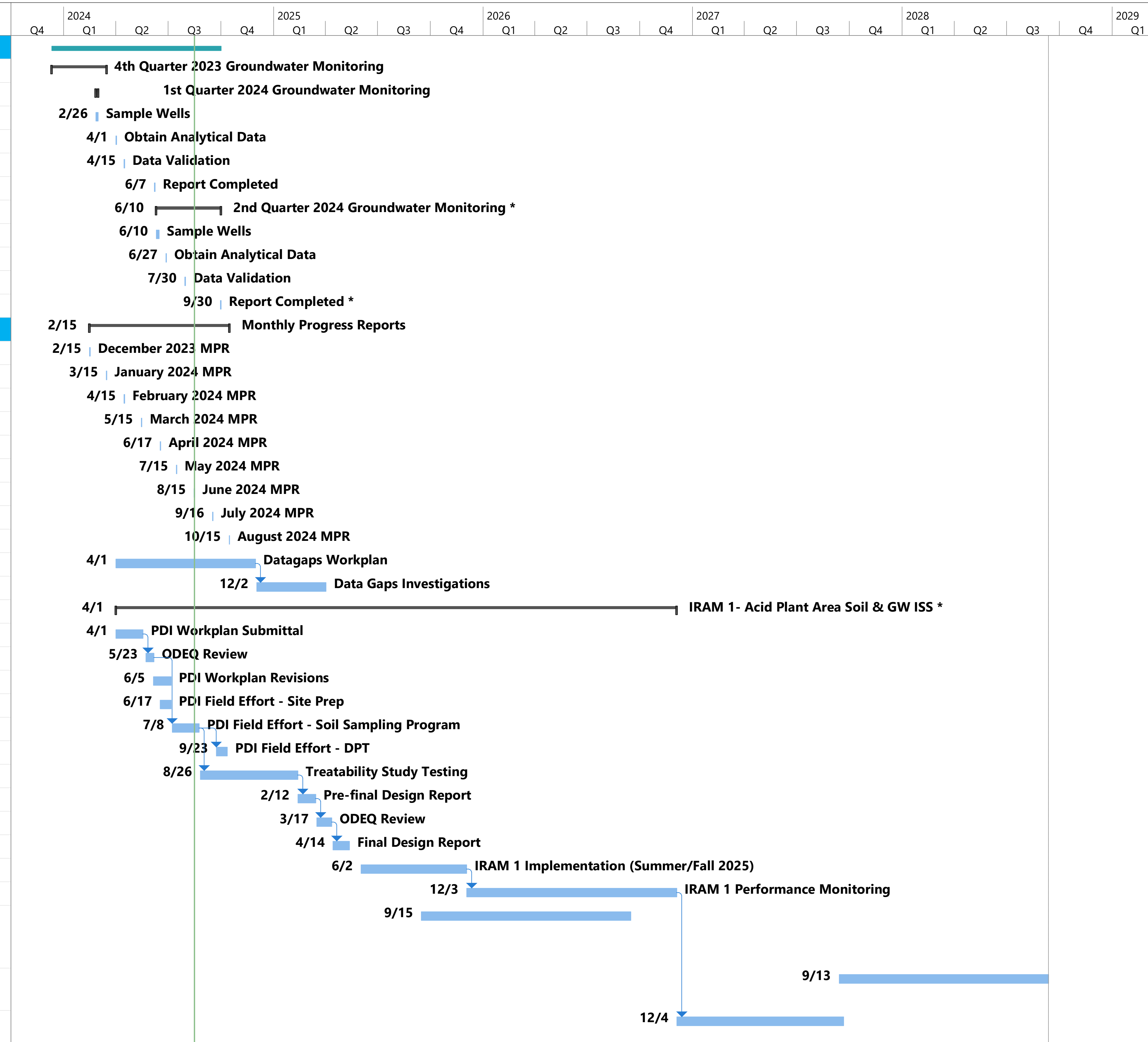






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring ***	**81 days**	**Mon 6/10/24**	**Mon 9/30/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	*Obtain Analytical Data*	*1 day*	*Thu 6/27/24*	*Thu 6/27/24*
15	*Data Validation*	*1 day*	*Tue 7/30/24*	*Tue 7/30/24*
16	Report Completed *	1 day	Mon 9/30/24	Mon 9/30/24
17	**Monthly Progress Reports**	**175 days**	**Thu 2/15/24**	**Tue 10/15/24**
18	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
19	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
20	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
21	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
22	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
23	*May 2024 MPR*	*1 day*	*Mon 7/15/24*	*Mon 7/15/24*
24	June 2024 MPR	1 day	Thu 8/15/24	Thu 8/15/24
25	July 2024 MPR	1 day	Mon 9/16/24	Mon 9/16/24
26	August 2024 MPR	1 day	Tue 10/15/24	Tue 10/15/24
27	**Datagaps Workplan**	175 days	Mon 4/1/24	Fri 11/29/24
28	**Data Gaps Investigations**	87 days	Mon 12/2/24	Tue 4/1/25
29	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
30	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
31	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
32	*PDI Workplan Revisions*	*23 days*	*Wed 6/5/24*	*Fri 7/5/24*
33	*PDI Field Effort - Site Prep*	*15 days*	*Mon 6/17/24*	*Fri 7/5/24*
34	PDI Field Effort - Soil Sampling Program	35 days	Mon 7/8/24	Fri 8/23/24
35	PDI Field Effort - DPT	15 days	Mon 9/23/24	Fri 10/11/24
36	Treatability Study Testing	122 days	Mon 8/26/24	Tue 2/11/25
37	Pre-final Design Report	23 days	Wed 2/12/25	Fri 3/14/25
38	ODEQ Review	20 days	Mon 3/17/25	Fri 4/11/25
39	Final Design Report	21 days	Mon 4/14/25	Mon 5/12/25
40	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
41	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
42	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
43	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
44	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline	
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress	

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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	16 September 2024
REFERENCE	0732445 Phase 204
SUBJECT	July 2024 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This July 2024 MPR summarizes the GW SCM performance monitoring data collected in July 2024. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the United

States Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells (RW), and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of constituents of potential concern to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 RWs prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed, but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four-remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EW). Each trench is approximately 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCC) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 38.02 gallons per minute (gpm) for the entire month of July 2024, including non-operational periods. The average operational influent flow during operational periods was 49.56 gpm, a decrease from June 2024.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. Trench 1 was off during June 2024 due to low pH from chemical redevelopment and was restarted in July 2024. Pressure jetting was completed at EW-11 and EW-12 during July 2024 to clean the well screen at Trench 6. Ongoing redevelopment is anticipated in August and September 2024 to maintain the productivity of the groundwater extraction trenches, and conveyance line cleaning will be conducted as needed based on analysis of backpressure. The reduction in groundwater extraction rate in July 2024 compared to June 2024 is believed to be a result of a significant decline in river elevation and average groundwater elevation as shown in Figures 1-1 and 1-2.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

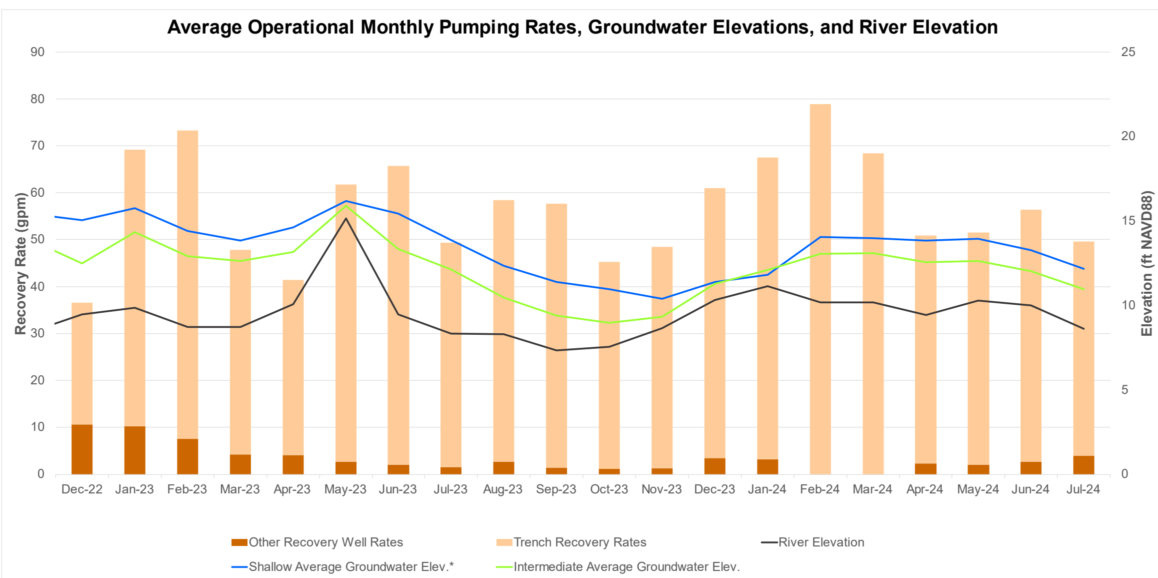
TABLE 1-1 RECOVERY WELL PUMPING RATES

Recovery Well	July 2024 Average Operational Pumping Rate (gpm)	July 2024 Average Monthly Pumping Rate (gpm)
RW-14	2.17	2.10
RW-22*	0.00	0.00
RW-23	0.43	0.36
RW-25	1.42	1.42
EW-01	1.05	0.88
EW-02*	0.00	0.00
EW-03	12.51	12.51

Recovery Well	July 2024 Average Operational Pumping Rate (gpm)	July 2024 Average Monthly Pumping Rate (gpm)
EW-04	2.59	0.83
EW-05	7.18	7.18
EW-06*	0.00	0.00
EW-07	1.53	0.99
EW-08	1.78	0.80
EW-09	1.15	0.04
EW-10	2.37	1.68
EW-11	1.84	1.54
EW-12*	0.00	0.00
EW-13	7.39	6.68
EW-14	6.13	0.99
Total	49.56	38.02

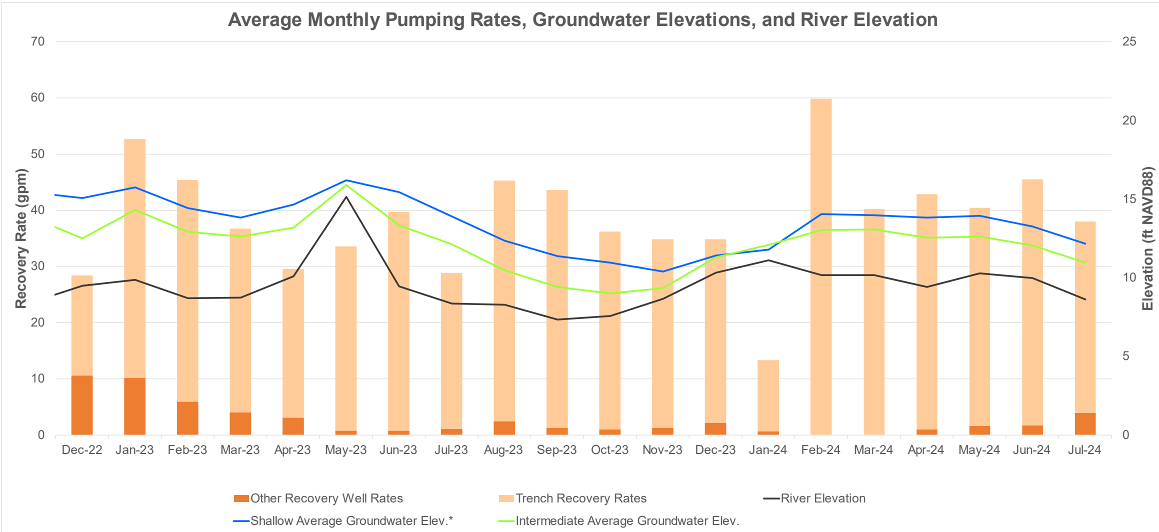
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

- 5 July 2024: The GWET system was shut down for 1.5 hours to clean the plate separator (PS-1).

4. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four-remaining active RWs and 14 EWs. High-resolution groundwater elevation data are also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

4.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 12 July 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during July 2024, the following transducers were:

Fully out of service pending repairs:

- None

Out of service for a period, but returned to full operation:

- None

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A-1. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After July 2024 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes-corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 12 July 2024 are shown below at each GCC (Tables 1-2 and Table 1-3).

TABLE 1-2 JULY HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	25.29	PA-04	25.80	-0.005
	Intermediate	PA-17iR	10.75	PA-10i	12.43	-0.016
	Deep	PA-27d	10.19	PA-18d	10.17	0.000
GCC2	Shallow	MWA-2	9.18	PA-05^{M}	7.42	0.026
	Intermediate	MWA-8i	8.79	PA-11i	9.80	-0.014
	Deep	PA-19d	7.81	PA-30d	8.72	-0.017
GCC3	Shallow	MWA-69	9.16	PA-06	12.09	-0.028
	Intermediate	MWA-66i	8.62	PA-12i	11.83	-0.018
	Deep	PA-21d^{M}	8.99	PA-20d	8.79	0.002
GCC4	Shallow	MWA-19	9.70	PA-28^{M}	14.60	-0.049
	Intermediate	MWA-34iR^{M}	9.44	PA-13i	10.81	-0.015
	Deep	MWA-58d	8.15	PA-22d	9.82	-0.019
GCC5	Shallow	MWA-47	9.18	PA-07	14.37	-0.050
	Intermediate	PA-29i	8.88	PA-14i	10.85	-0.036
	Deep	PA-24d^{M}	8.37	PA-23d	8.77	-0.008
GCC6	Shallow	PA-09^{M}	11.61	PA-08^{M}	12.84	-0.022
	Intermediate	PA-16i	10.24	PA-15i	10.33	-0.002
	Deep	PA-26d	10.59	PA-25d^{M}	10.24	0.006

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
^{M} = manual groundwater elevation measurement

TABLE 1-3 JULY VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	25.80	PA-10i^{M}	12.43	1.35
		GCC2	PA-05^{M}	7.42	PA-11i	9.80	-0.22
		GCC3	PA-06	12.09	PA-12i	11.83	0.02
		GCC4	PA-28^{M}	14.60	PA-13i	10.81	0.59
		GCC5	PA-07	14.37	PA-14i	10.85	0.37
		GCC6	PA-08^{M}	12.84	PA-15i	10.33	0.19
	IZ-DZ	GCC1	PA-10i^{M}	12.43	PA-18d	10.17	0.30
		GCC2	PA-11i	9.80	PA-30d	8.72	0.16
		GCC3	PA-12i^{M}	11.83	PA-20d	8.79	0.15
		GCC4	PA-13i	10.81	PA-22d	9.82	0.05
		GCC5	PA-14i	10.85	PA-23d	8.77	0.05
		GCC6	PA-15i	10.33	PA-25d^{M}	10.24	0.00
Exterior	SZ-IZ	GCC1	PA-03	25.29	PA-17iR	10.75	0.93
		GCC2	MWA-2	9.18	MWA-8i	8.79	0.03
		GCC3	MWA-69^{M}	9.16	MWA-66i	8.62	0.04
		GCC4	MWA-19	9.70	MWA-34iR^{M}	9.44	0.04
		GCC5	MWA-47	9.18	PA-29i	8.88	0.03
		GCC6	PA-09^{M}	11.61	PA-16i^{M}	10.24	0.10
	IZ-DZ	GCC1	PA-17iR	10.75	PA-27d	10.19	0.09
		GCC2	MWA-8i	8.79	PA-19d^{M}	7.81	0.63
		GCC3	MWA-66i	8.62	PA-21d^{M}	8.99	-0.03
		GCC4	MWA-34iR^{M}	9.44	MWA-58d	8.15	0.06
		GCC5	PA-29i	8.88	PA-24d^{M}	8.37	0.01
		GCC6	PA-16i	10.24	PA-26d	10.59	-0.01

Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; ^{M} = manual groundwater elevation measurement; SZ = Shallow Zone

4.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 12 July 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Shallow Zone at GCC2 and in the Deep Zone at GCC3 and GCC6. Horizontal gradients at GCCs across the Site mixed, with some areas trending toward an inward gradient, and some areas losing improvements made in June in all three hydrogeological zones.

River elevations are shown over time on Figures 1-1 and 1-2, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in July 2024 had an average elevation of 8.61 feet NAVD88 with a minimum elevation of 6.25 NAVD88 and a maximum elevation of 11.87 NAVD88, a decrease compared to June 2024. However, the average Shallow and Intermediate groundwater elevation decreased from June by 1.1 feet each, and the river elevation has largely been trending downward since January 2024. The river did not experience a seasonal rise this year as typically occurs during most years.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC2 being upward (Figure 5). Vertical groundwater gradient trend lines are shown in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were overall downward as shown on Figure 5 and in Attachment B-2.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were overall downward. The direction of vertical gradients exterior to the GWBW were primarily downward with exception to GCC6 and GCC3 being upward, as shown on Figure 6 and Attachment B-3.

4.2.1 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates indicate that the active RWs and EWs are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

5. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved *Arkema Quarterly Groundwater Monitoring Work Plan* dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	6/7/2024
2024 Quarter 2	6/10/2024–6/13/2024	9/13/2024*
2024 Quarter 3	9/9/2024–9/12/2024*	12/12/2024*

* Dates are tentative.

6. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in July 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

6.1 GROUNDWATER FLOW

- Horizontal groundwater gradients in the Shallow and Intermediate Zones were all outward and the magnitude of the gradients has increased somewhat since June as a result of a decrease in the elevation of the river and average groundwater elevation outside the GWBW compared to inside the GWBW. Horizontal gradients in the Deep Zone were inward GCC3 and GCC6 and are trending toward inward gradients except for GCC2 and GCC4. Additional improvements in gradients are anticipated as higher flow rates and uptime are achieved relative the flow rate of water toward the Target Capture Zone.

- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC2 being upward (Figure 5), and the magnitude of downward gradients has increased since June due to the decrease in river elevation and the average groundwater elevation outside the GWBW compared to inside the GWBW. Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were all downward and the magnitude of the gradients has generally increased since June.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were all downward and the magnitude of gradients has increased since June. The direction of vertical gradients exterior to the GWBW were generally downward with GCC6 and GCC3 being upward, as shown on Figure 6.
- The average river elevation in July 2024 was 8.61 feet NAVD88 with a minimum elevation of 6.25 feet NAVD88 and a maximum elevation of 11.87 feet NAVD88, a decrease compared to June, and has largely been trending downward since January 2024.

6.2 GROUNDWATER EXTRACTION

Based on July 2024 groundwater extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, 3, and 4 is largely gone, and the mound around Trenches 5, 6, and 7 is being reduced with increased average extraction rates compared to prior years. Average monthly pumping rates in July 2024 were lower than June 2024 due to lower groundwater elevation.

Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing generalized hydraulic capture throughout the Target Capture Zone. More operational time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

Due to work conducted throughout 2024, issues that have historically limited groundwater extraction rates including fouling of pumps, back pressure in the conveyance line, and a pause on pump maintenance, have been addressed resulting in improved average pumping rates. As of July 2024, the main limitations to groundwater extraction are groundwater elevation, and the accumulation of silt within the EW trenches filter pack. Efforts to successfully redevelop the trenches and remove silt are ongoing.

6.3 RECOMMENDATIONS AND FUTURE WORK

Redevelopment of the trenches is planned for September 2024 to mitigate accumulation of silt in the filter pack in both the vertical and horizontal sections using impulse redevelopment techniques. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

Brendan Robinson, PE
Partner

7. References

ERM (ERM-West, Inc.). 2012. *Arkema Portland Groundwater Source Control Measure, Groundwater Barrier Wall Final Design, Arkema Inc., Portland, Oregon*. July 2012.

_____. 2013. *Arkema Portland Groundwater Source Control Measure, Groundwater Extraction and Treatment Final Design, Arkema Inc., Portland, Oregon*. March 2013.

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_____. 2017. *Revised Upland Feasibility Study Work Plan, Arkema Facility, Portland, Oregon*. November 2017.

_____. 2018. *Draft GWET System Effectiveness Evaluation, Arkema Inc. Facility, Portland, Oregon*. September 2018.

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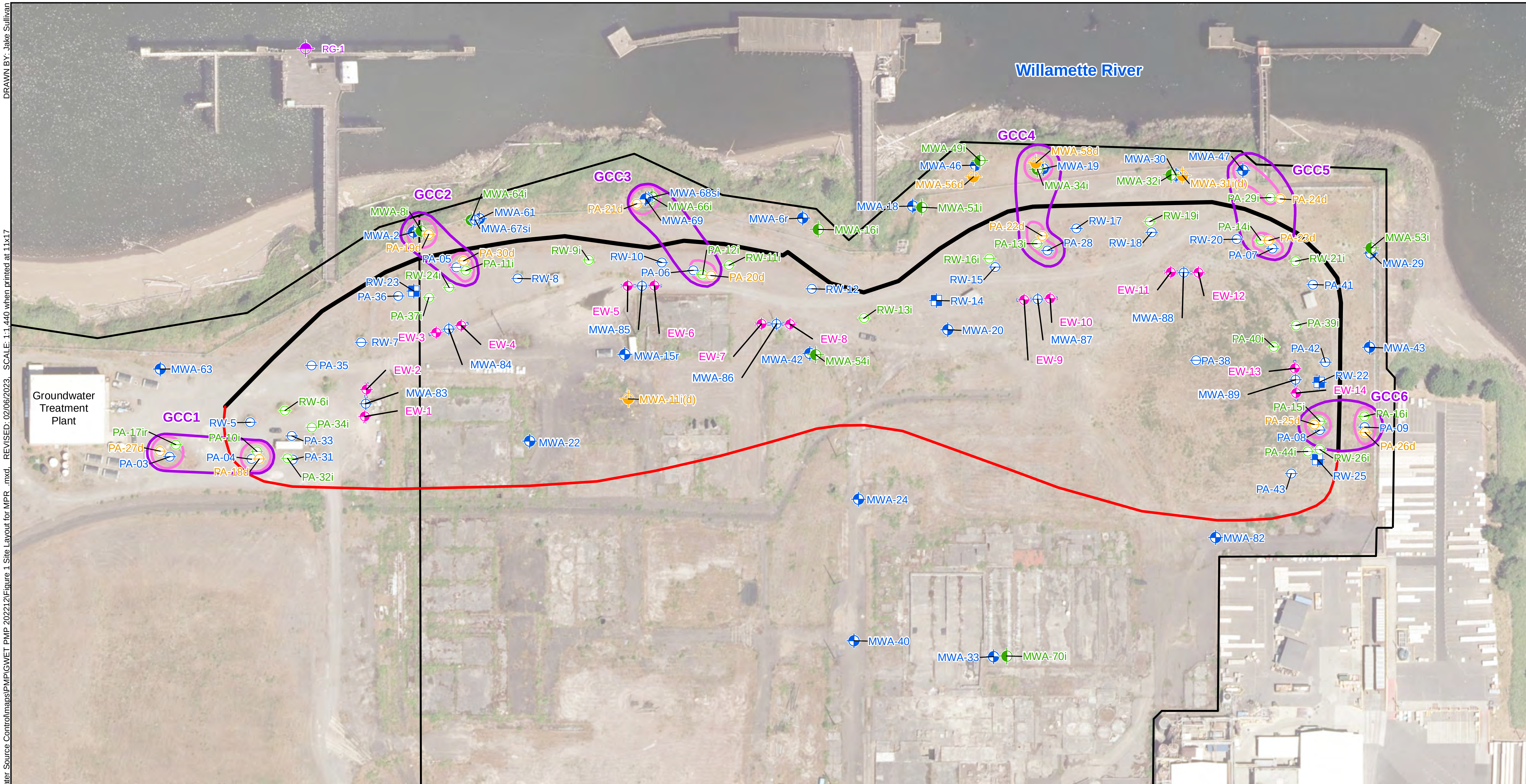
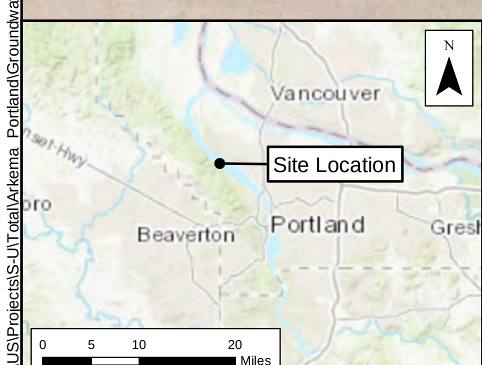
ODEQ (Oregon Department of Environmental Quality). 2019. DEQ Review "Draft GWET System Effectiveness Evaluation Report," Arkema Facility, ECSI #398. 31 May 2019.

Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater*, Vol. 29. No 4. July–August 1991.

FIGURES





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

0 120 240

Feet

Figure 1

Site Layout

Monthly Progress Report

Groundwater Source Control Measure

Arkema Inc.

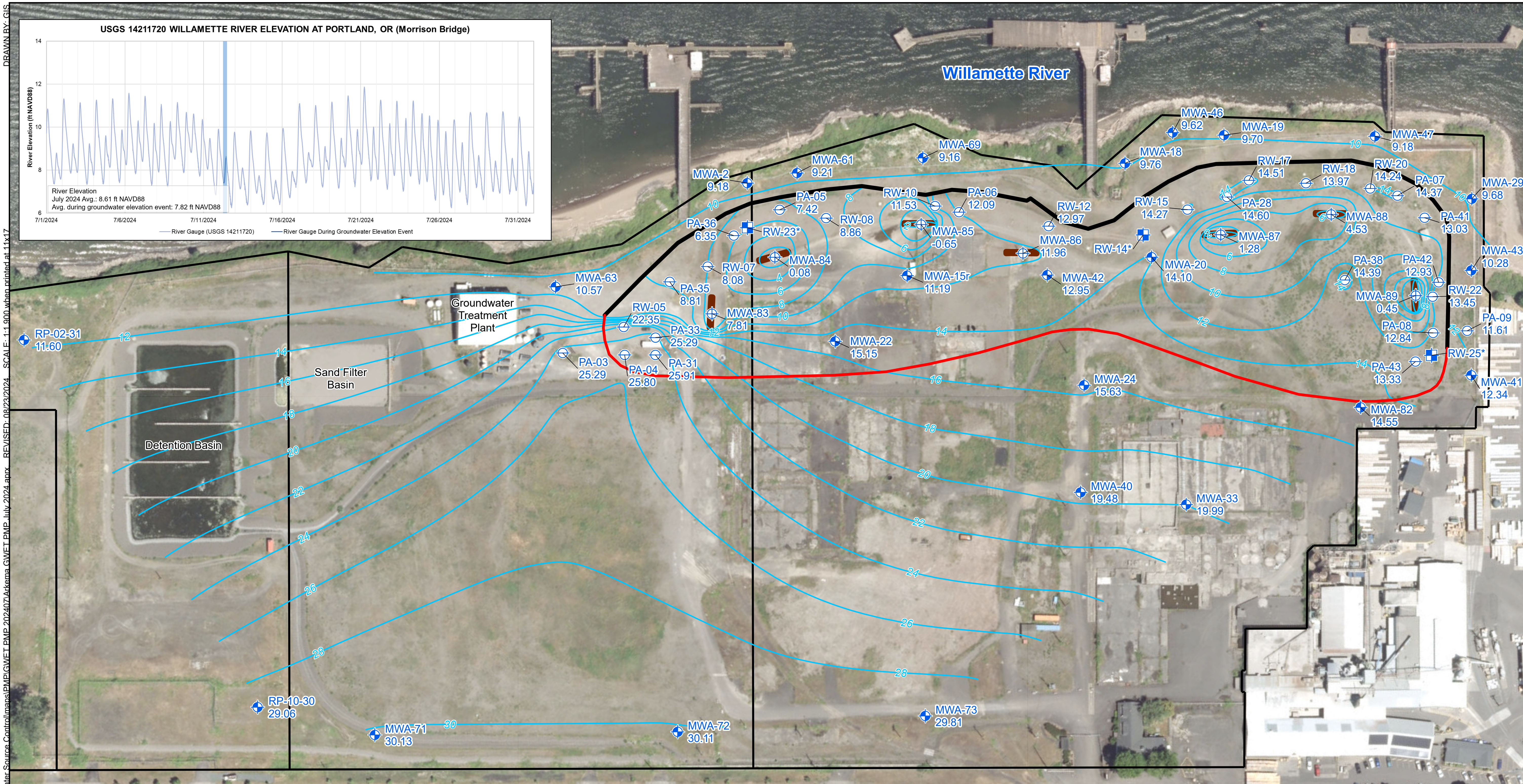
Portland, Oregon

Environmental Resources Management

www.erm.com

ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

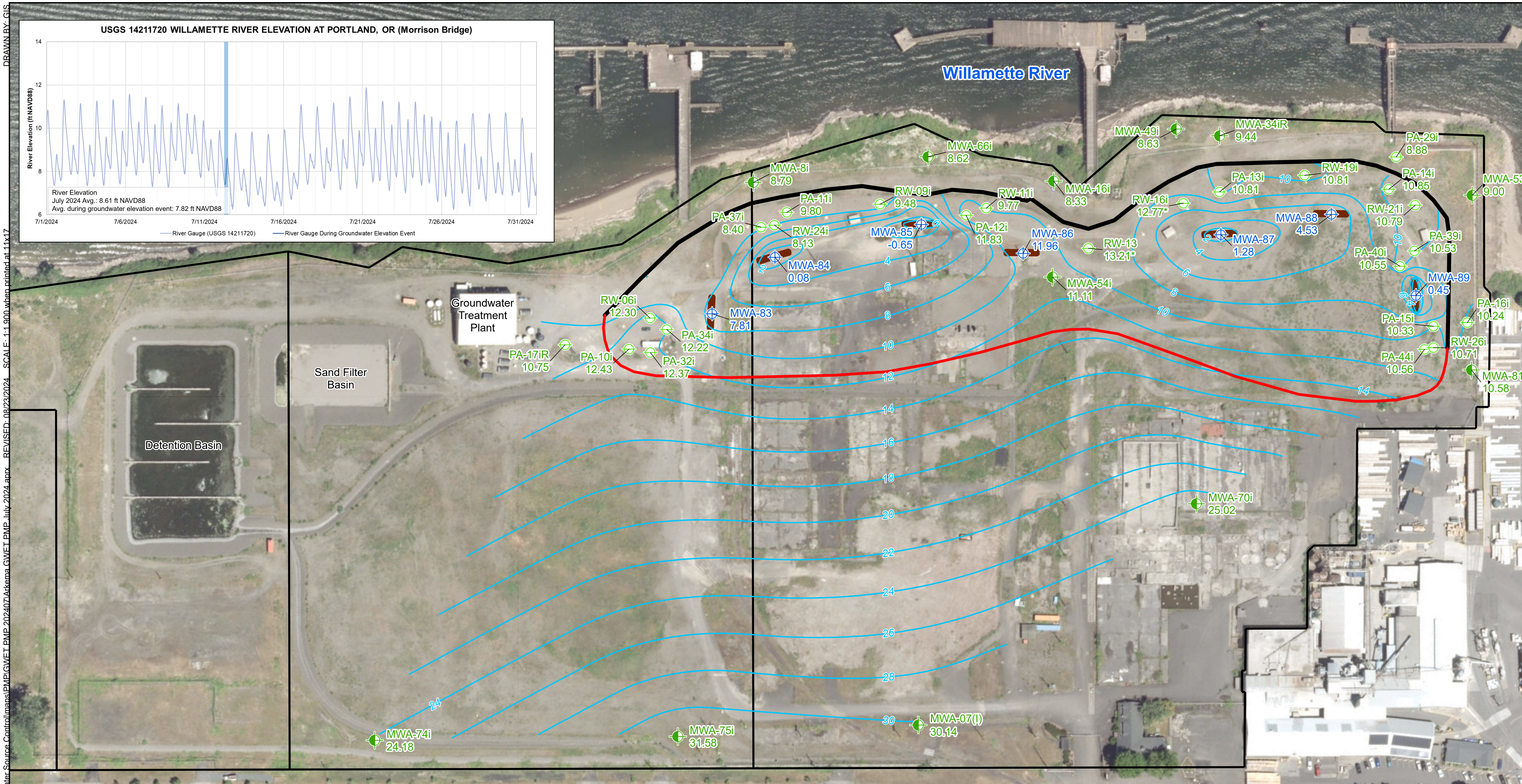
Notes:
* Value not used for contouring.
Water levels collected July 12, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

0 160 320
Feet

Figure 2
July 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected July 12, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

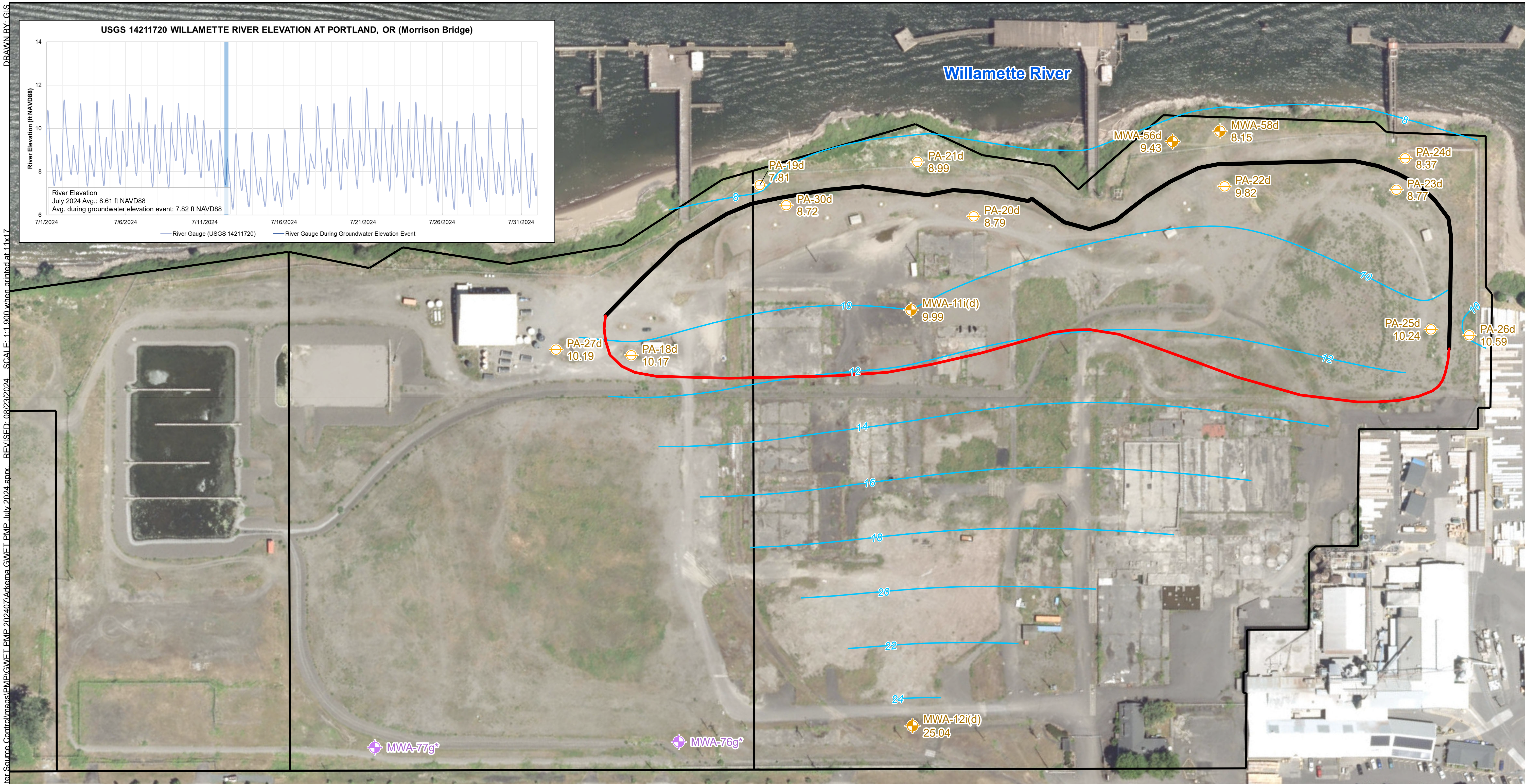
0 160 320
Feet

Figure 3
July 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\07\Arkema GWET PMP July 2024.aprx REVISED: 08/23/2024 SCALE: 1:1,900 when printed at 11x17 DRAWN BY: GIS

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected July 12, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
July 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected July 12, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
July 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected July 12, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
July 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: July 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC4	MWA-34iR	Intermediate	5/28/2024	8/1/2024	Transducer to be recalibrated following survey 8/1/2024.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: July 2024
Arkema Inc. Facility
Portland, Oregon

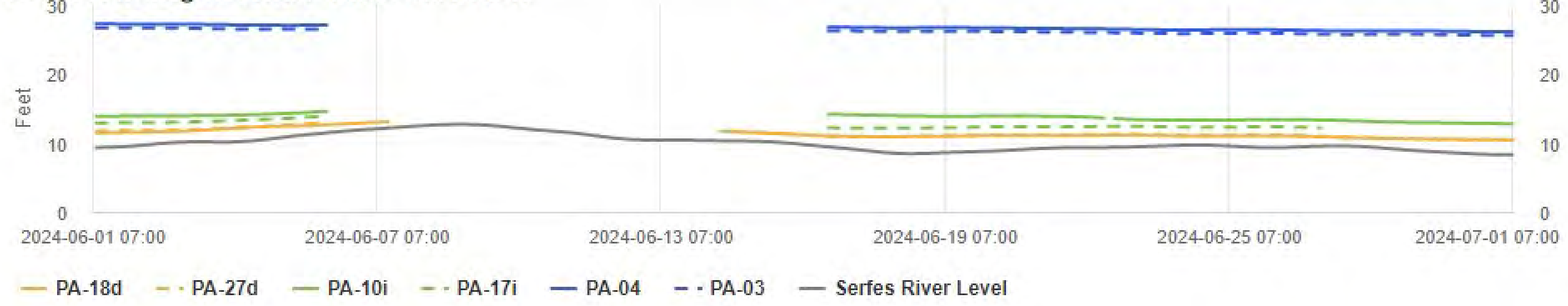
Recovery Well ID	Status as of 7/31/2024 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Active	None	N/A	N/A	Good	Good	2.17	M**	
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Cable leads need to be replaced
RW-23	Active	None	N/A	N/A	Good	Good	0.43	P**	
RW-25	Active	None	N/A	N/A	Good	Good	1.42	M**	
EW-01	Active	None	N/A	N/A	Good	Good	1.05	P**	
EW-02	Inactive	Totalizer	Troubleshoot totalizer	8/1/2024	Good	Not working	0.00	OFF*	Totalizer not communicating with PLC
EW-03	Active	None	N/A	N/A	Good	Good	12.51	G	
EW-04	Inactive	Low Water Table	N/A	N/A	Good	Good	2.59	M**	
EW-05	Active	None	N/A	N/A	Good	Good	7.18	G	
EW-06	Inactive	Low Water Table	N/A	N/A	Good	Good	0.00	OFF*	
EW-07	Inactive	Low Water Table	N/A	N/A	Good	Good	1.53	M**	
EW-08	Active	None	N/A	N/A	Good	Good	1.78	M**	Started 7/31/2024
EW-09	Active	None	N/A	N/A	Good	Good	1.15	M**	Started 7/31/2024
EW-10	Inactive	Low Water Table	N/A	N/A	Good	Good	2.37	M**	
EW-11	Active	None	N/A	N/A	Good	Good	1.84	M**	
EW-12	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Transducer removed for packer installation
EW-13	Inactive	None	N/A	N/A	Good	Good	7.39	G**	Changed out 1 HP motor and pump on 7/29
EW-14	Active	None	N/A	N/A	Good	Good	6.13	G**	Started 7/29/2024

Notes:
* Recovery wells not in service
** Recovery wells in service part of the month
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

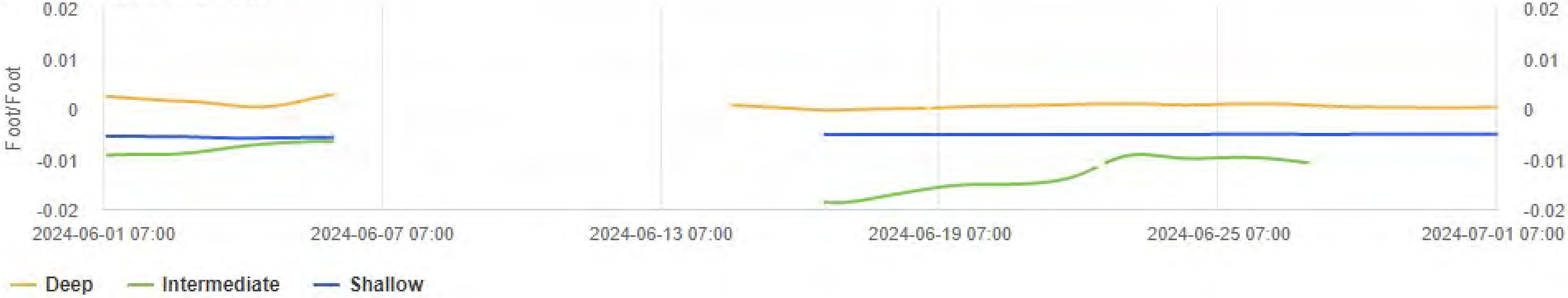
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

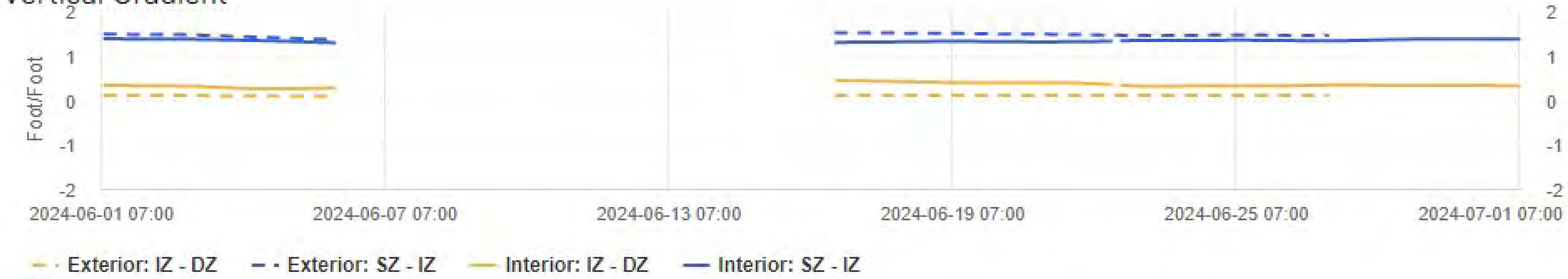
Serfes Averaged Water Table Elevation



Horizontal Gradient

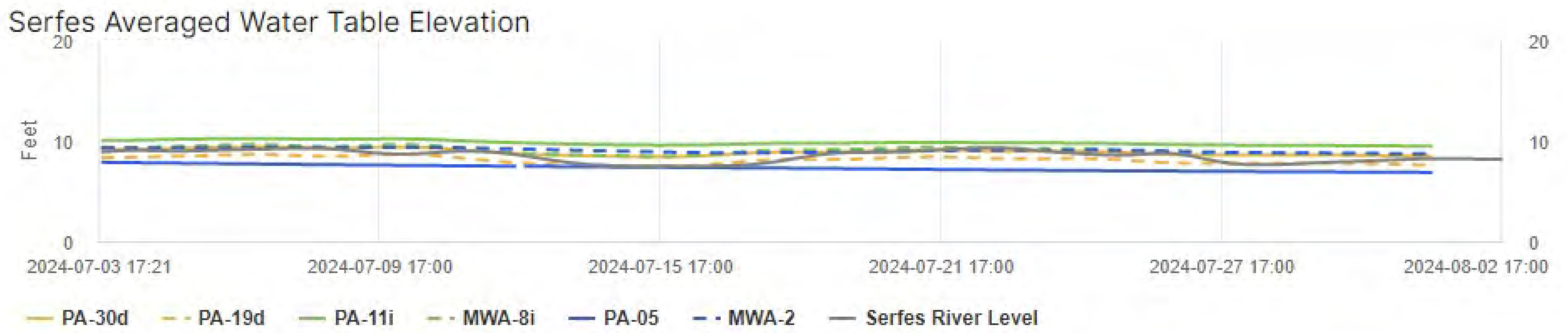


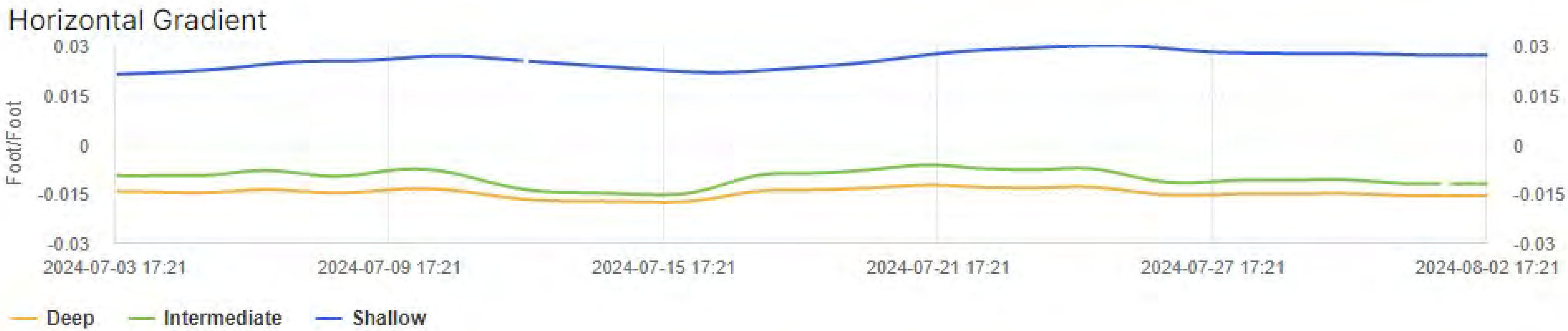
Vertical Gradient

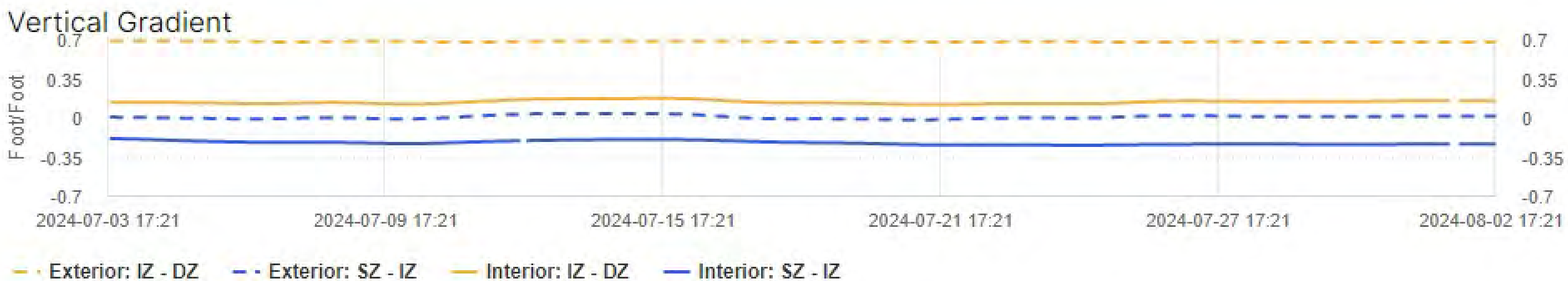


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2



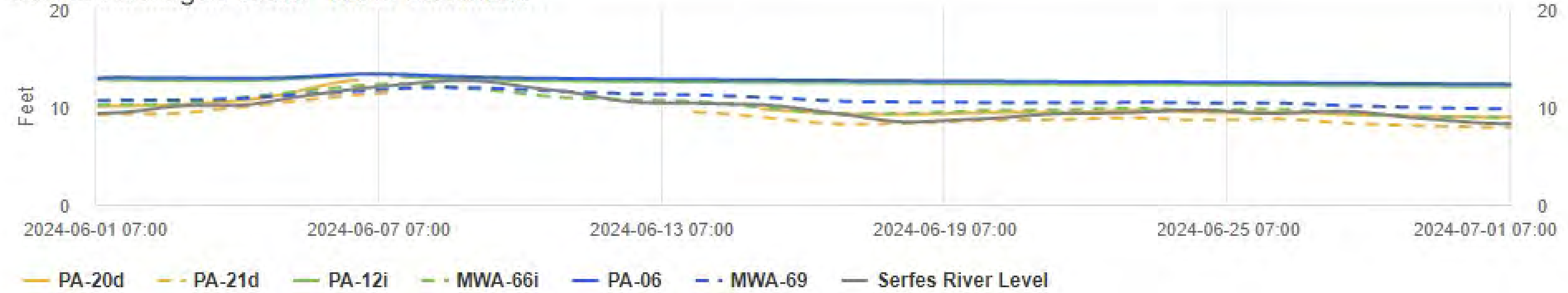




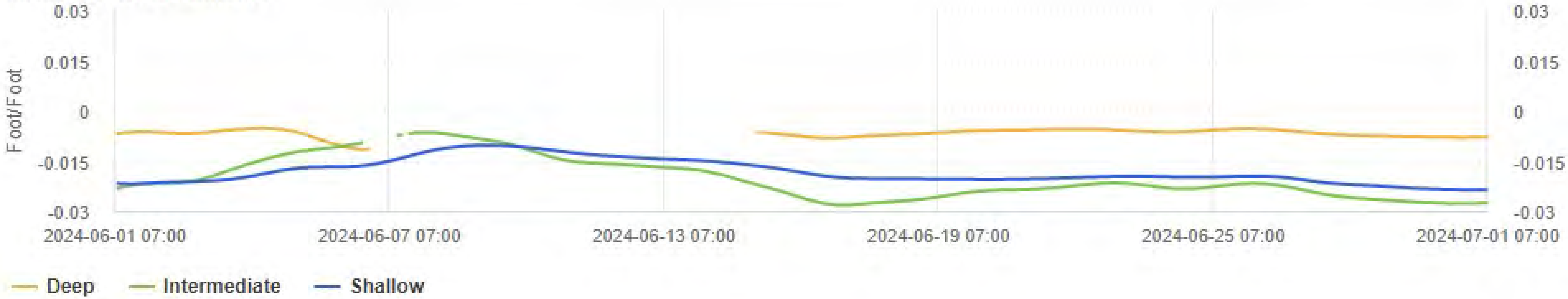
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

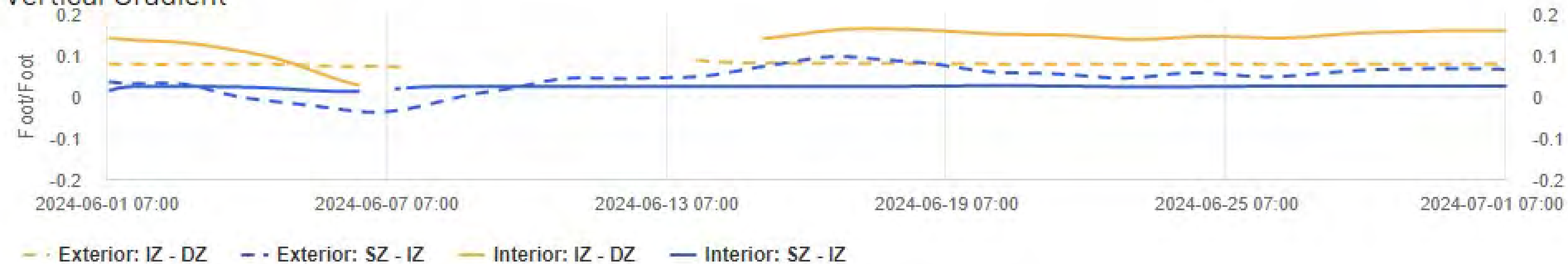
Serfes Averaged Water Table Elevation



Horizontal Gradient

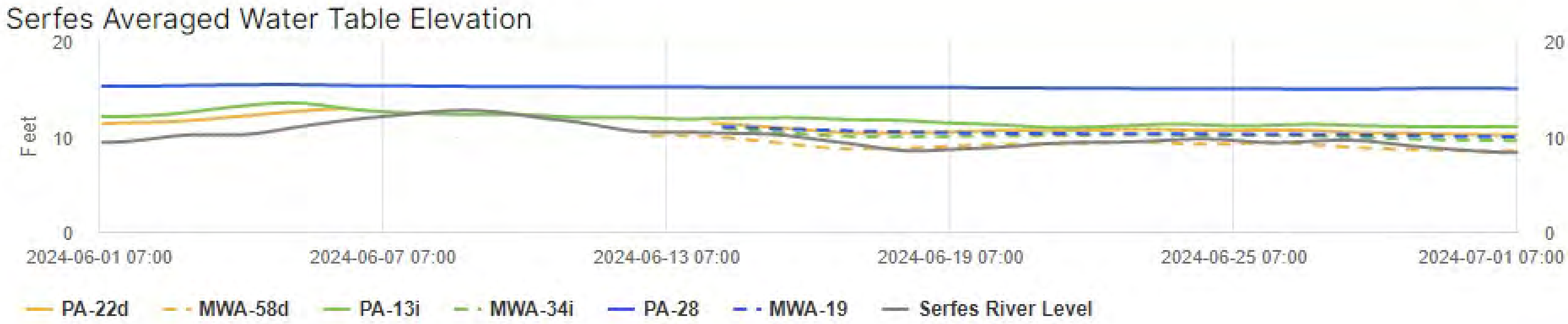


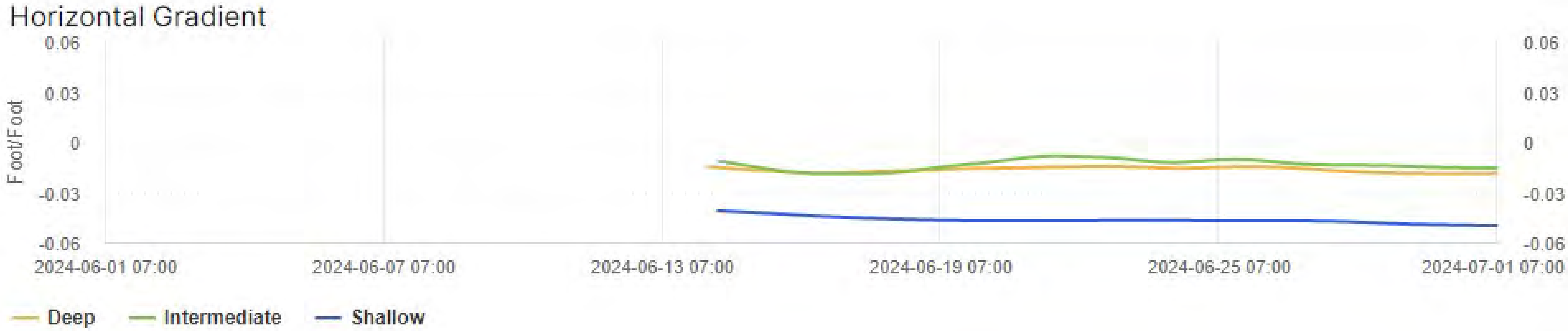
Vertical Gradient

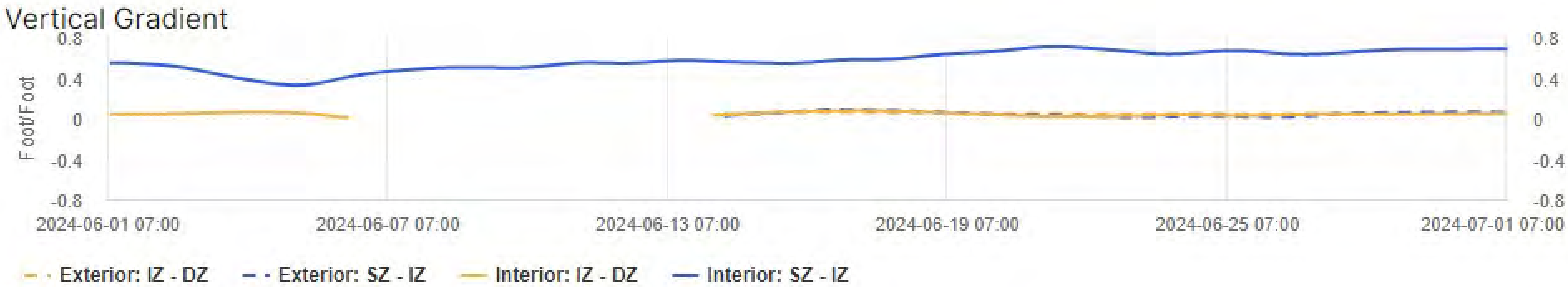


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

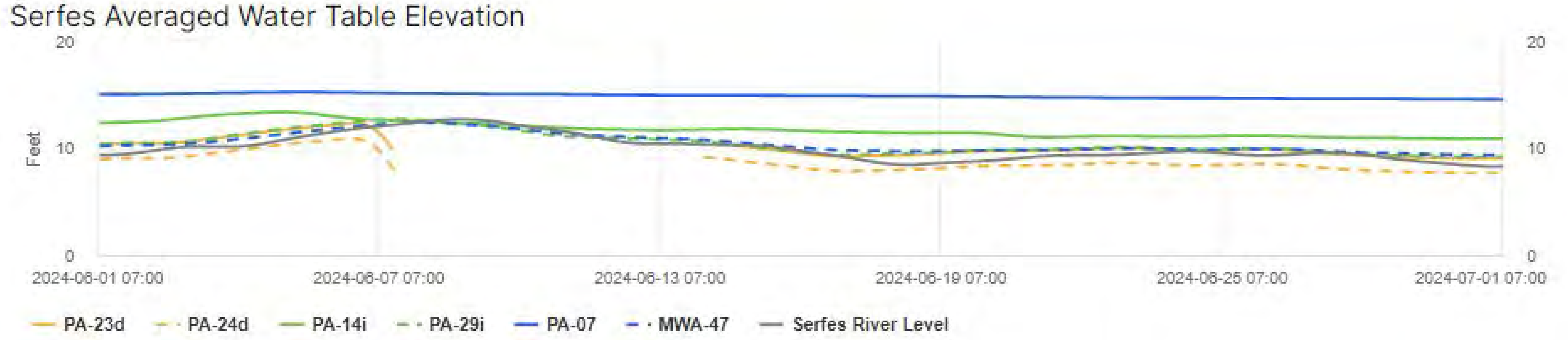


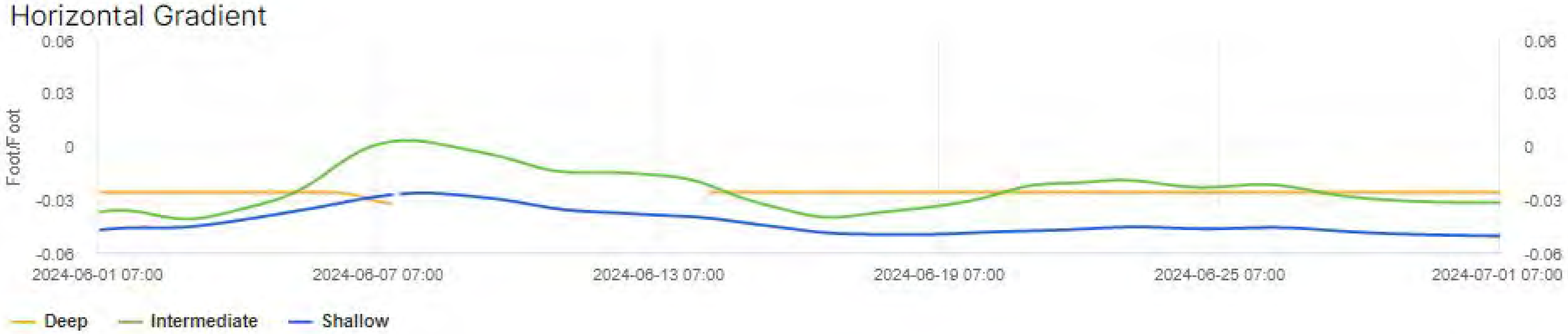


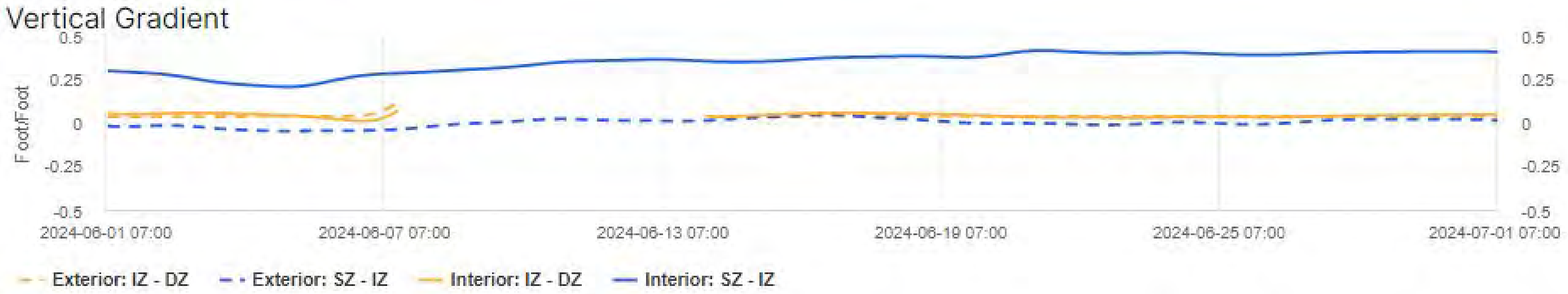


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5



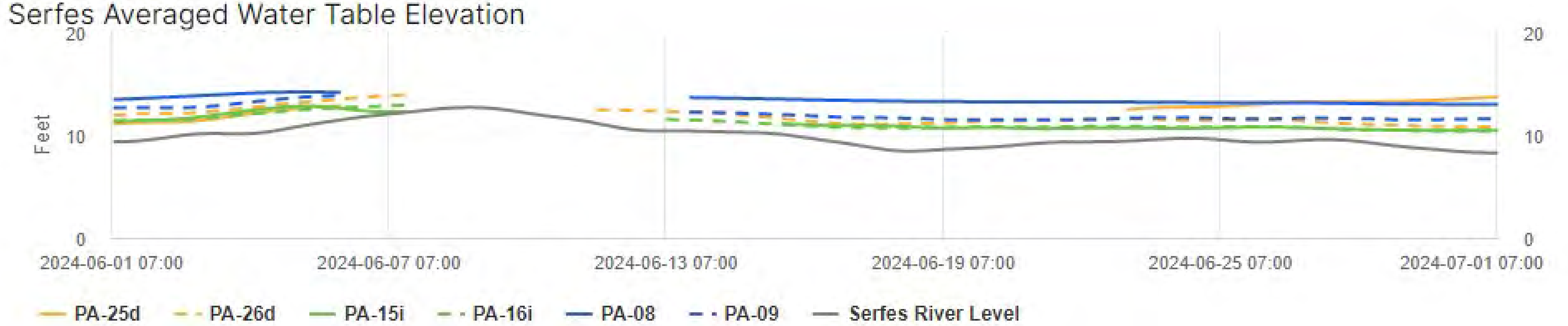


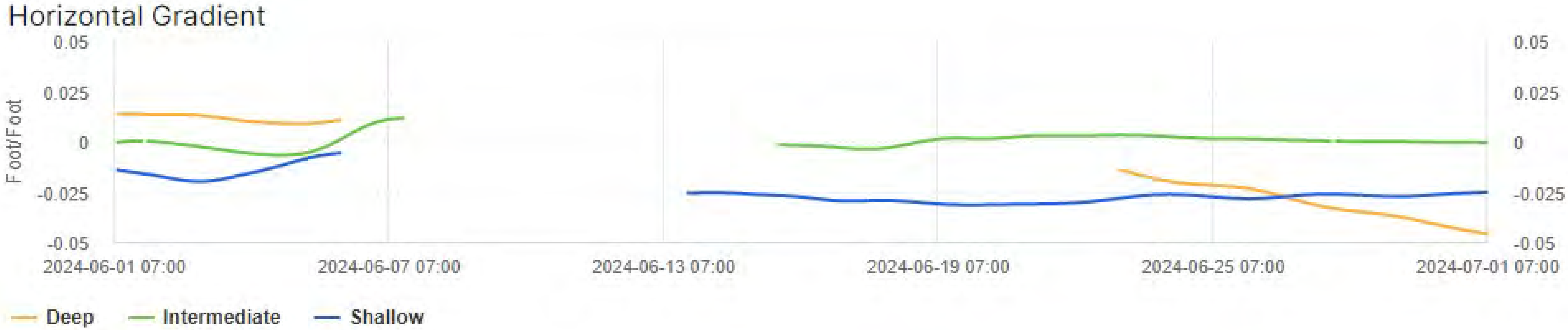


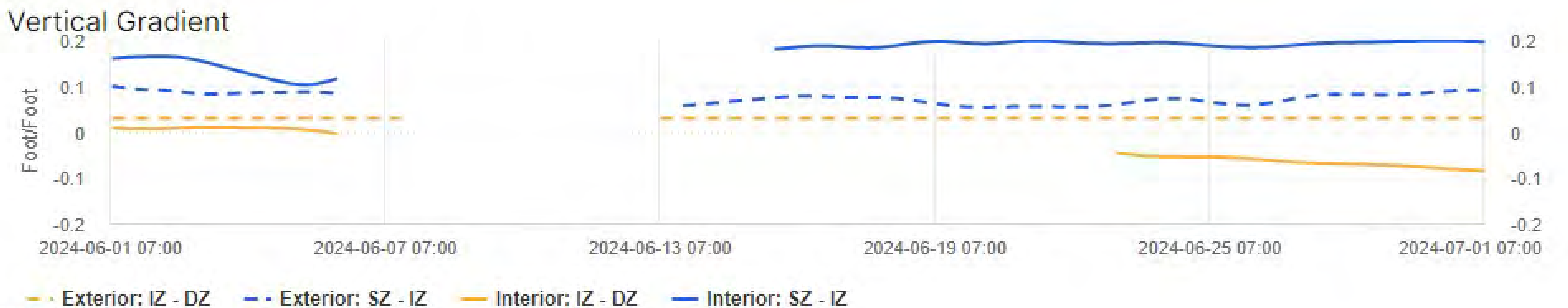
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6





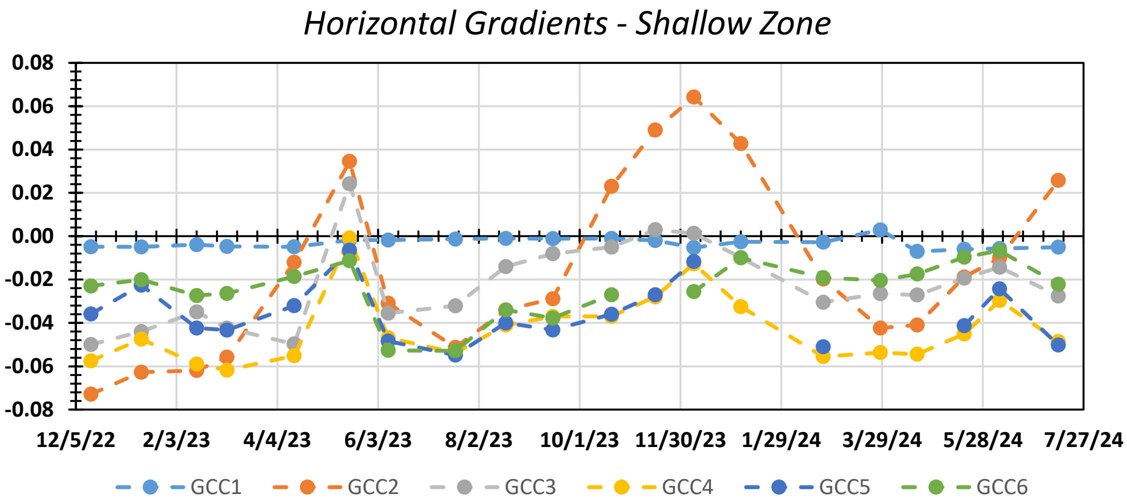


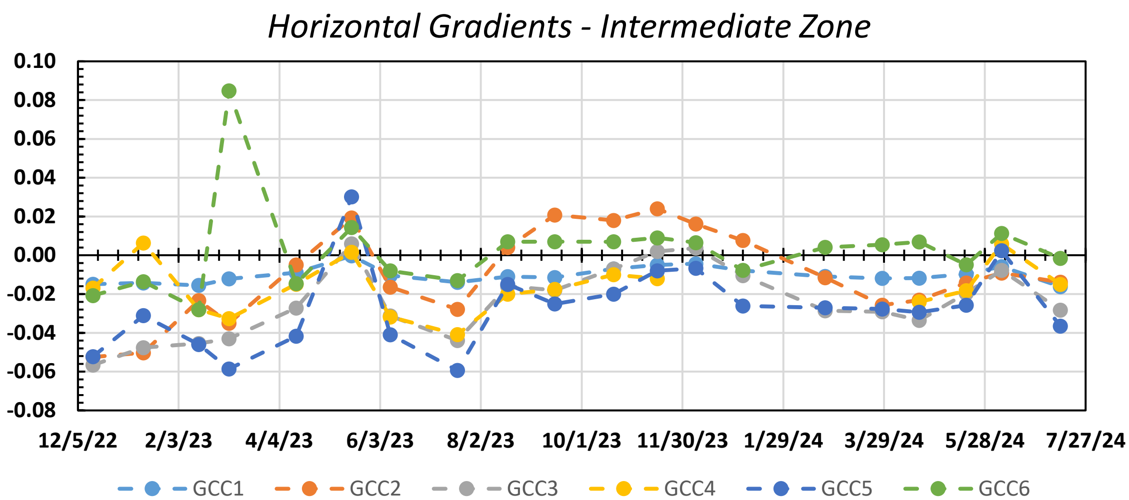
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

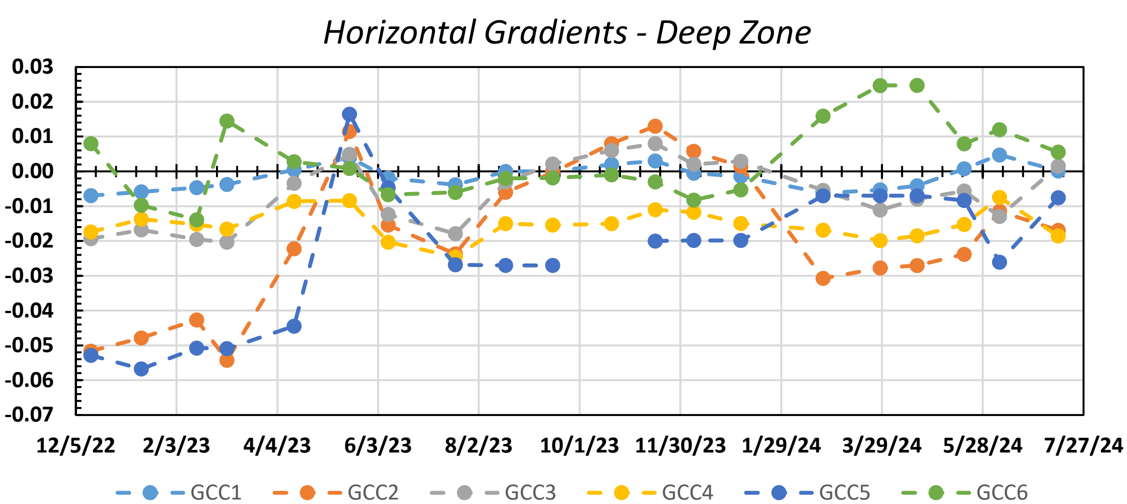
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: July 2024
Arkema Inc. Facility
Portland, Oregon







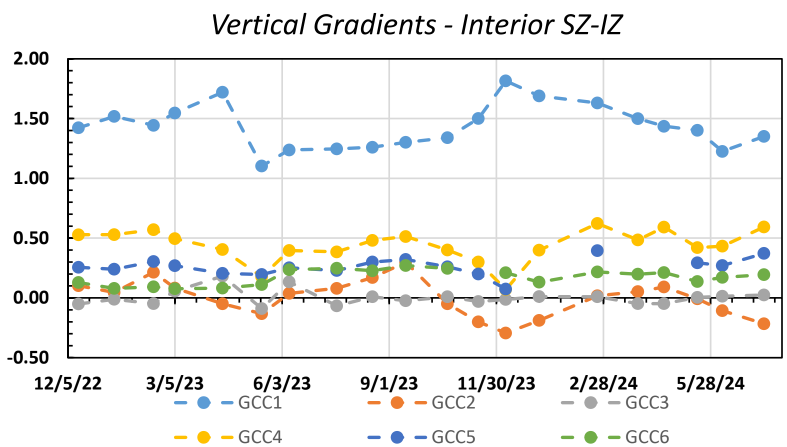
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

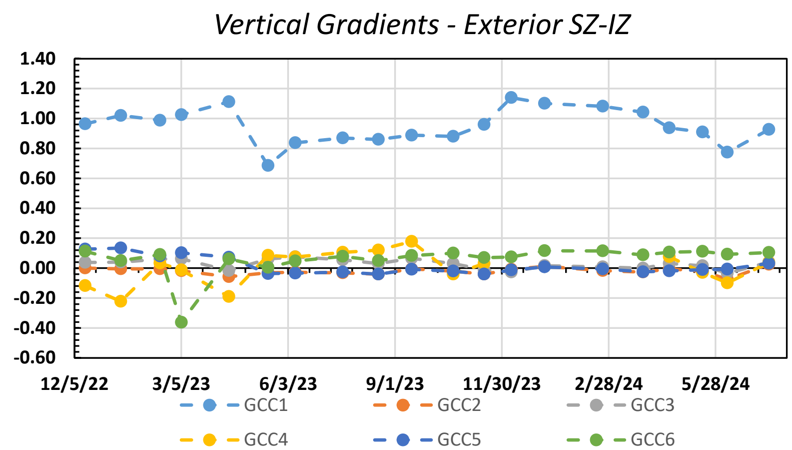
ERM

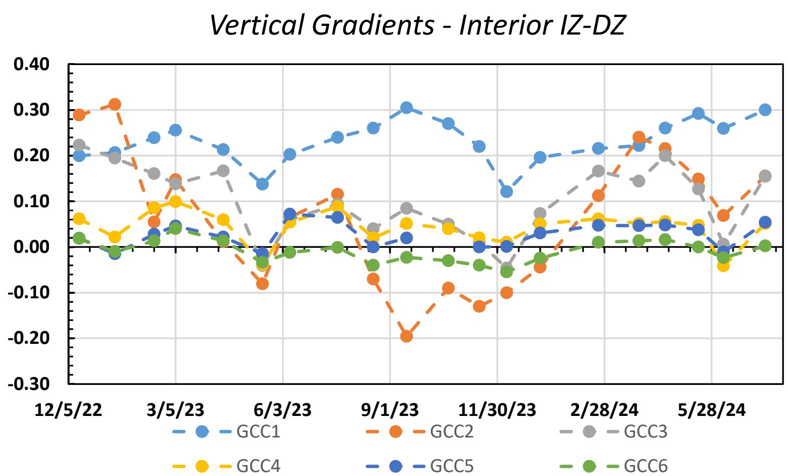
ATTACHMENT B-3 VERTICAL GRADIENTS

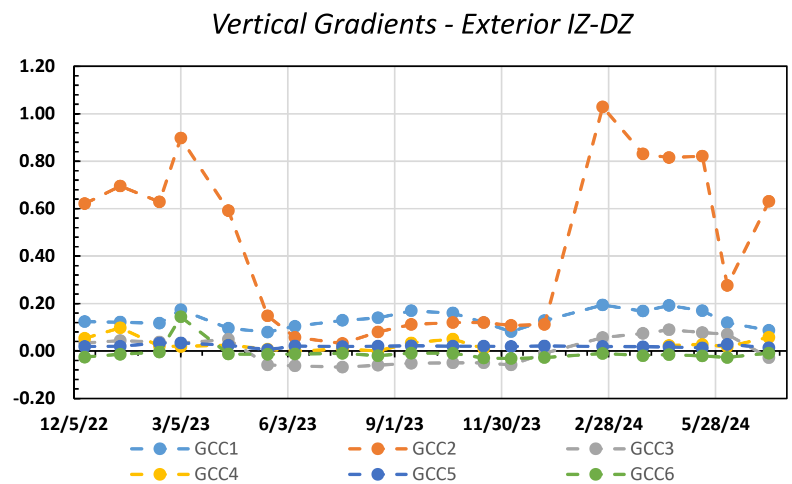
Attachment B-3

Vertical Gradients Summary: July 2024
Arkema Inc. Facility
Portland, Oregon





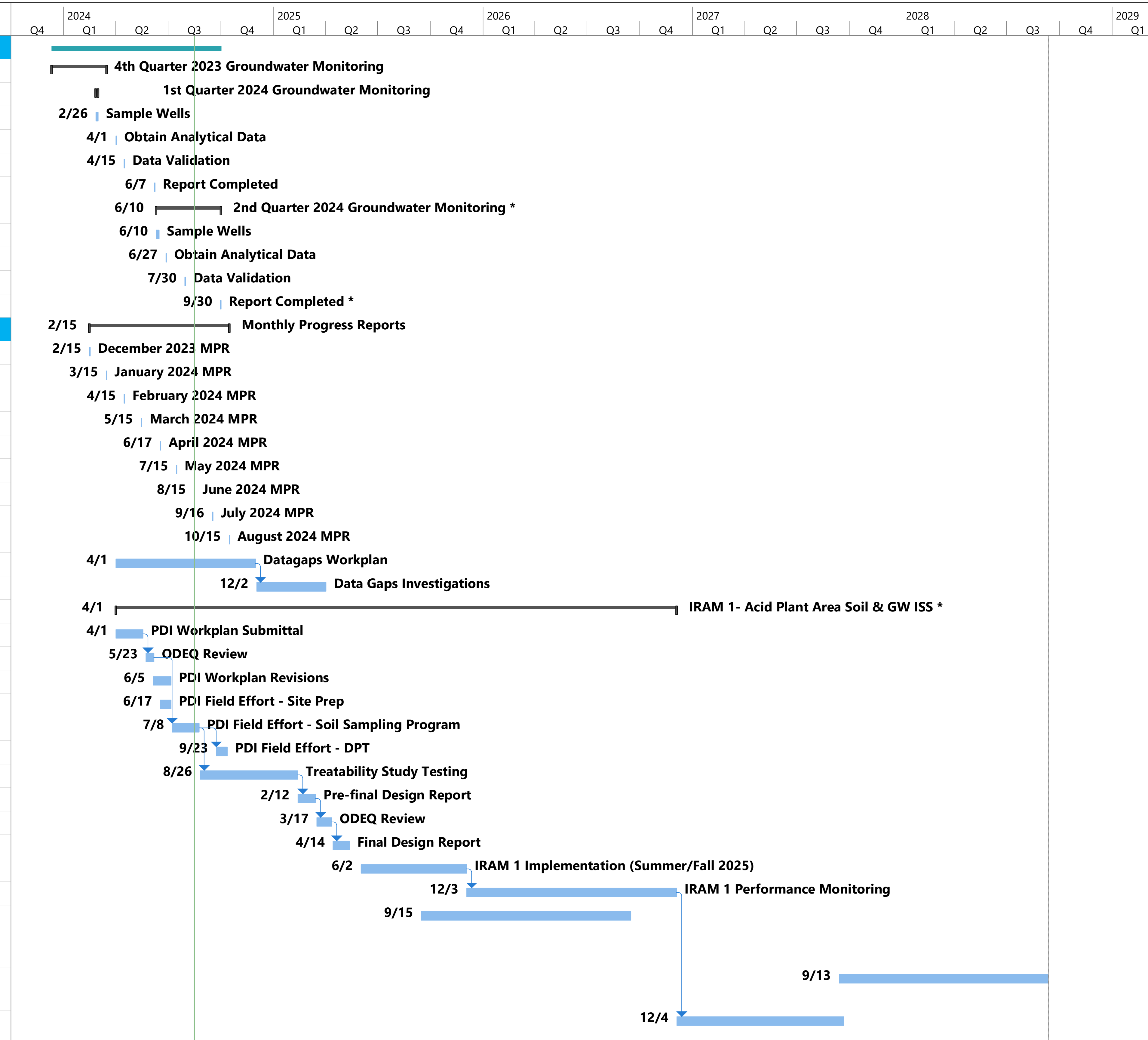




ERM

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	*4th Quarter 2023 Groundwater Monitoring*	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring ***	**81 days**	**Mon 6/10/24**	**Mon 9/30/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	*Obtain Analytical Data*	*1 day*	*Thu 6/27/24*	*Thu 6/27/24*
15	*Data Validation*	*1 day*	*Tue 7/30/24*	*Tue 7/30/24*
16	Report Completed *	1 day	Mon 9/30/24	Mon 9/30/24
17	**Monthly Progress Reports**	**175 days**	**Thu 2/15/24**	**Tue 10/15/24**
18	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
19	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
20	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
21	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
22	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
23	*May 2024 MPR*	*1 day*	*Mon 7/15/24*	*Mon 7/15/24*
24	June 2024 MPR	1 day	Thu 8/15/24	Thu 8/15/24
25	July 2024 MPR	1 day	Mon 9/16/24	Mon 9/16/24
26	August 2024 MPR	1 day	Tue 10/15/24	Tue 10/15/24
27	**Datagaps Workplan**	175 days	Mon 4/1/24	Fri 11/29/24
28	**Data Gaps Investigations**	87 days	Mon 12/2/24	Tue 4/1/25
29	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
30	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
31	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
32	*PDI Workplan Revisions*	*23 days*	*Wed 6/5/24*	*Fri 7/5/24*
33	*PDI Field Effort - Site Prep*	*15 days*	*Mon 6/17/24*	*Fri 7/5/24*
34	PDI Field Effort - Soil Sampling Program	35 days	Mon 7/8/24	Fri 8/23/24
35	PDI Field Effort - DPT	15 days	Mon 9/23/24	Fri 10/11/24
36	Treatability Study Testing	122 days	Mon 8/26/24	Tue 2/11/25
37	Pre-final Design Report	23 days	Wed 2/12/25	Fri 3/14/25
38	ODEQ Review	20 days	Mon 3/17/25	Fri 4/11/25
39	Final Design Report	21 days	Mon 4/14/25	Mon 5/12/25
40	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
41	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
42	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
43	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
44	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress	
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline		
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress		

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MEMO

TO	Katie Daugherty, ODEQ
FROM	Brendan Robinson, PE, ERM; Todd Slater, LSS
DATE	17 October 2024
REFERENCE	0732445.204
SUBJECT	Groundwater Source Control Measure Monthly Performance Monitoring Report

1. INTRODUCTION

The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with Legacy Site Services LLC (LSS) and Environmental Resources Management, Inc. (ERM) on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) at the Arkema site (Site) consistent with the Performance Monitoring Plan (PMP; ERM 2014[1]) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 Monthly Performance Monitoring Report (MPR), subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

On 6 June 2024, ODEQ requested that LSS and ERM reduce the scope of future MPRs to facilitate faster review. On 11 September 2024, ODEQ agreed for the first amended MPR to be the August 2024 MPR submitted in October 2024.

[1] ERM-West, Inc. 2014. *Revised Final Performance Monitoring Plan – Groundwater Source Control Measure, Arkema Inc. Facility, Portland, Oregon*. July 2014.

2. GWET SYSTEM PERFORMANCE

The average system influent flow rate was 24.03 gallons per minute (gpm) for the entire month of August 2024, including non-operational periods. The average operational influent flow during operational periods was 35.56 gpm, a decrease from July 2024.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. A low pressure Hydropuls redevelopment was completed at Trenches 5 and 6 during August 2024 to mitigate accumulation of silt in the filter pack. A smaller Hydropuls tool was used that produced insufficient power, and therefore the redevelopment effort was not effective. Ongoing redevelopment is anticipated in September and October 2024 to maintain the productivity of the groundwater extraction trenches, and conveyance line cleaning will be conducted as needed based on analysis of backpressure. The reduction in groundwater extraction rate in August 2024 compared to July 2024 is believed to be a result of a significant decline in river elevation and average groundwater elevation as shown on Attachments A-1 and A-2.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022[2]) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

2.1 GWET PLANT OPERATIONS

The groundwater extraction and treatment (GWET) plant operated within permit conditions during the reporting period. There were four shutdowns:

- 2 August 2024: The GWET system was shut down for 1 hour to clean the plate separator (PS-1).
- 11 August 2024: The wellfield was shut down for 8 hours due to failed pump P-6 at tank T-3.
- 16 August 2024: The wellfield was shut down for 3 hours to install recirculation pump P-7.
- 26 August 2024: The wellfield was shut down due to MCR (Media Capture and Recovery Vessel) failure and remained off for the remainder of August.

[2] ERM-West, Inc. 2022. *Final Design Report, Arkema Inc. Facility, Portland, Oregon*. May 2022.

3. CAPTURE ZONE EVALUATION

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the groundwater barrier wall (GWBW) and to evaluate the effective hydraulic capture produced by the GW SCM.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 9 August 2024. The Serfes (1991)[3] method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 9 August 2024 are shown in Table 1-2 and Table 1-3.

3.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

Groundwater elevation data collected on 9 August 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Horizontal gradients at gradient control clusters (GCCs) across the Site are mixed, with some areas trending toward an inward gradient, and some areas losing improvements made in June in all three hydrogeological zones. Horizontal gradients and trend lines are shown in Attachments B-1 and B-3.

River elevations are shown over time on Attachments A-1 and A-2, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in August 2024 had an average elevation of 8.04 feet North American Vertical Datum of 1988 (NAVD88) with a minimum elevation of 5.58 feet NAVD88 and a maximum elevation of 11.04 feet NAVD88, a decrease compared to July 2024. The average Shallow Zone groundwater elevation decreased from July by 0.69 feet and the average Intermediate Zone groundwater elevation decreased from July by 0.15 feet, and the river elevation has largely been trending downward since January 2024. There was not a significant seasonal rise in Willamette River level this year compared to previous years.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients and trend lines are shown in Attachments B-2 and B-4. Vertical groundwater gradients interior and exterior to the GWBW were primarily downward between the Shallow and Intermediate Zones and between the Intermediate and Deep Zones.

---

[3] Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater* 29(4): July–August.

4. CONCLUSIONS

Recovery rates indicate that the active recovery wells (RWs) and extraction wells (EWs) are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives. Redevelopment of the trenches is planned for September 2024 to mitigate accumulation of silt in the filter pack in both the vertical and horizontal sections using impulse redevelopment techniques. These efforts will be targeted at trenches that are currently underperforming, including Trenches 1, 4, 5, and 6. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to progress toward capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

Brendan Robinson, PE
Partner

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

ATTACHMENTS

FIGURE 1 – SITE LAYOUT

FIGURE 2 – SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3 – INTERMEDIATE ZONE GROUNDWATER CONTOURS

FIGURE 4 – DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5 – SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE MAPS

FIGURE 6 – INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE MAPS

ATTACHMENT A-1 – OPERATIONAL PUMPING RATE GRAPH

ATTACHMENT A-2 – AVERAGE MONTHLY PUMPING RATE GRAPH

ATTACHMENT A-3 – GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

ATTACHMENT B-1 – HORIZONTAL GRADIENTS SUMMARY GRAPH

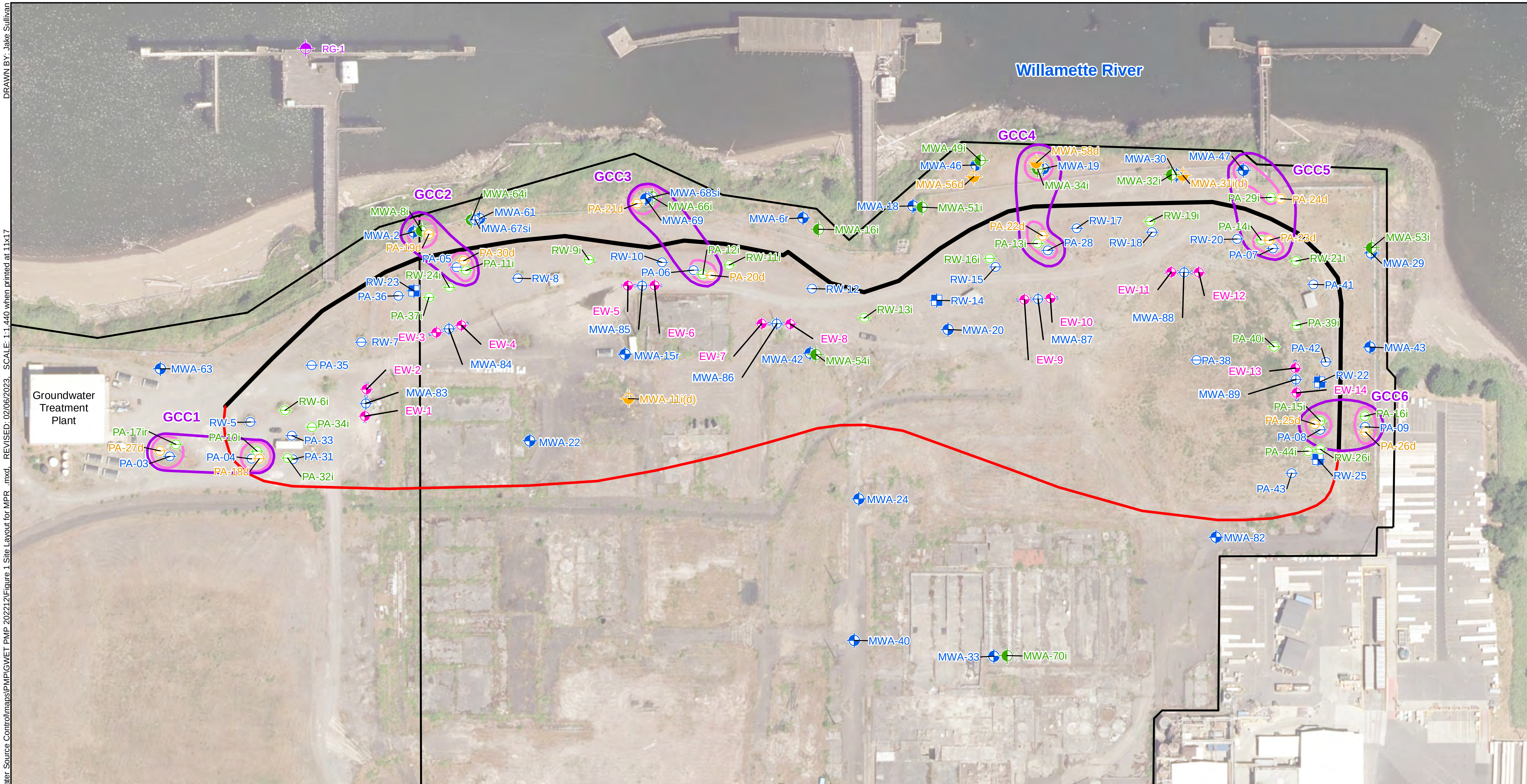
ATTACHMENT B-2 – VERTICAL GRADIENTS SUMMARY GRAPH

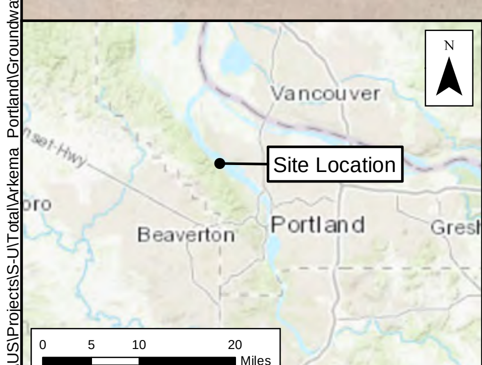
ATTACHMENT B-3 – WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

ATTACHMENT B-4 – WATER LEVELS AND VERTICAL GRADIENTS TABLE

ATTACHMENT C – PROJECT SCHEDULE

FIGURES





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

0 120 240

Feet

Figure 1

Site Layout

Monthly Progress Report

Groundwater Source Control Measure

Arkema Inc.

Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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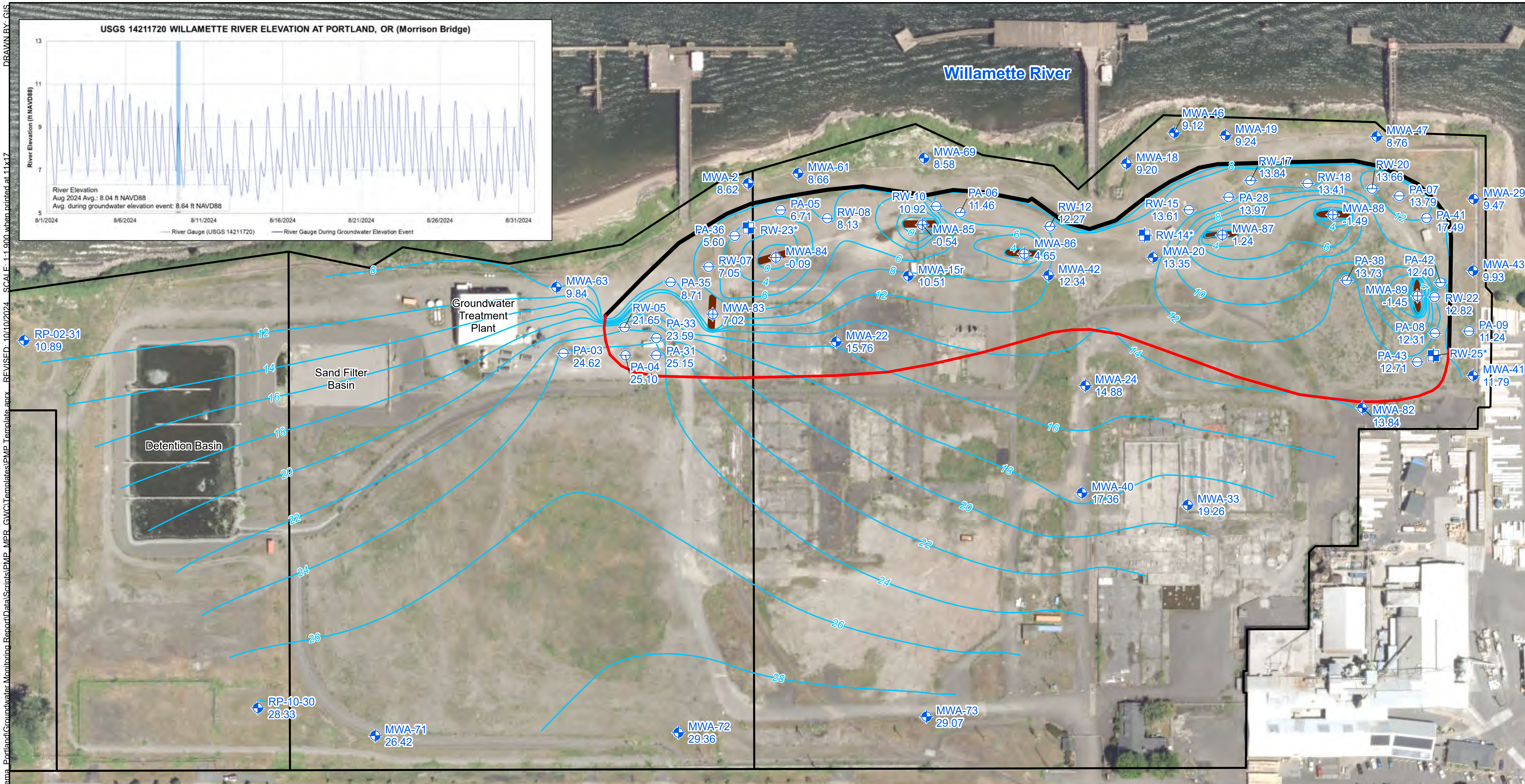

Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected August, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
August 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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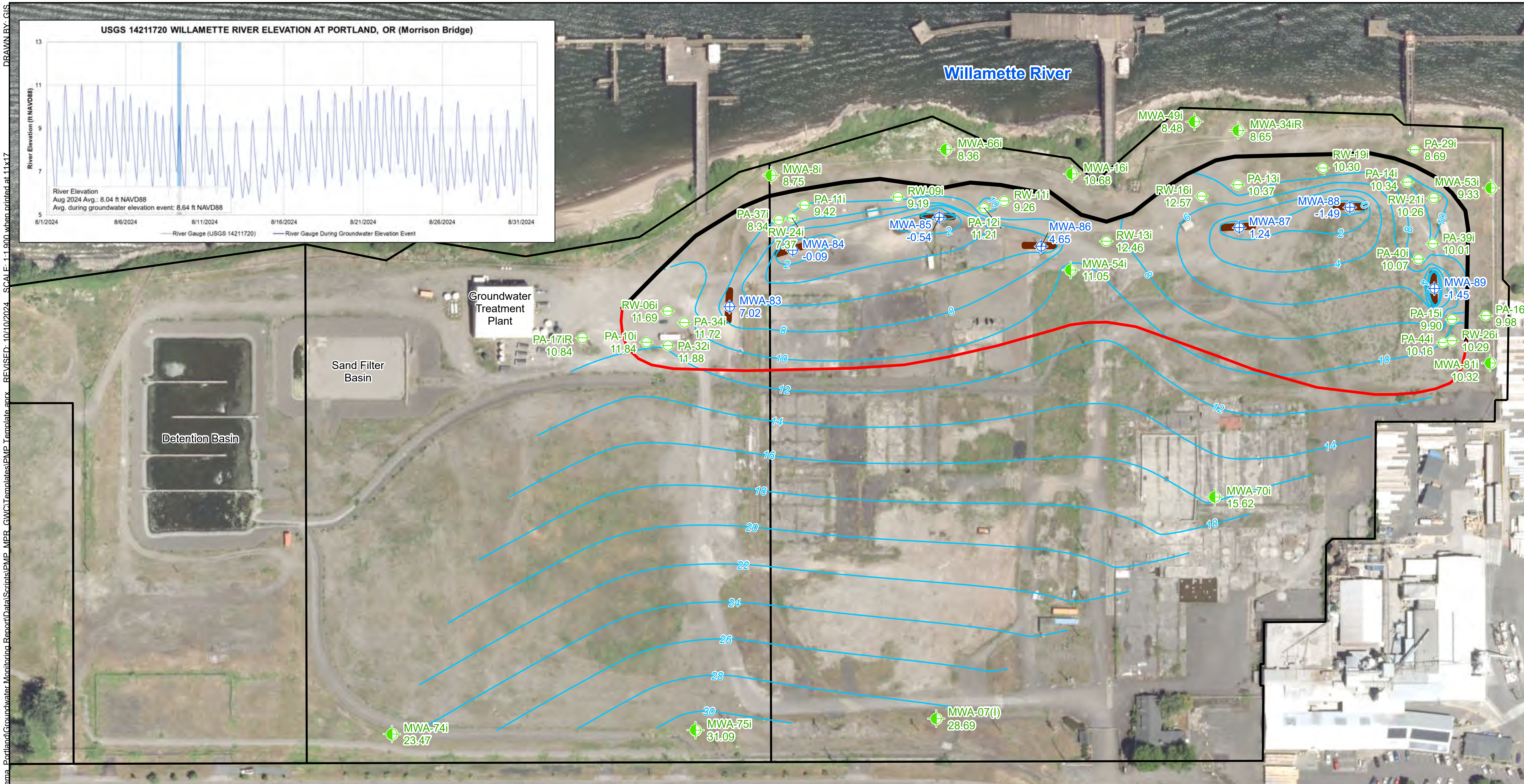

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected August, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3

August 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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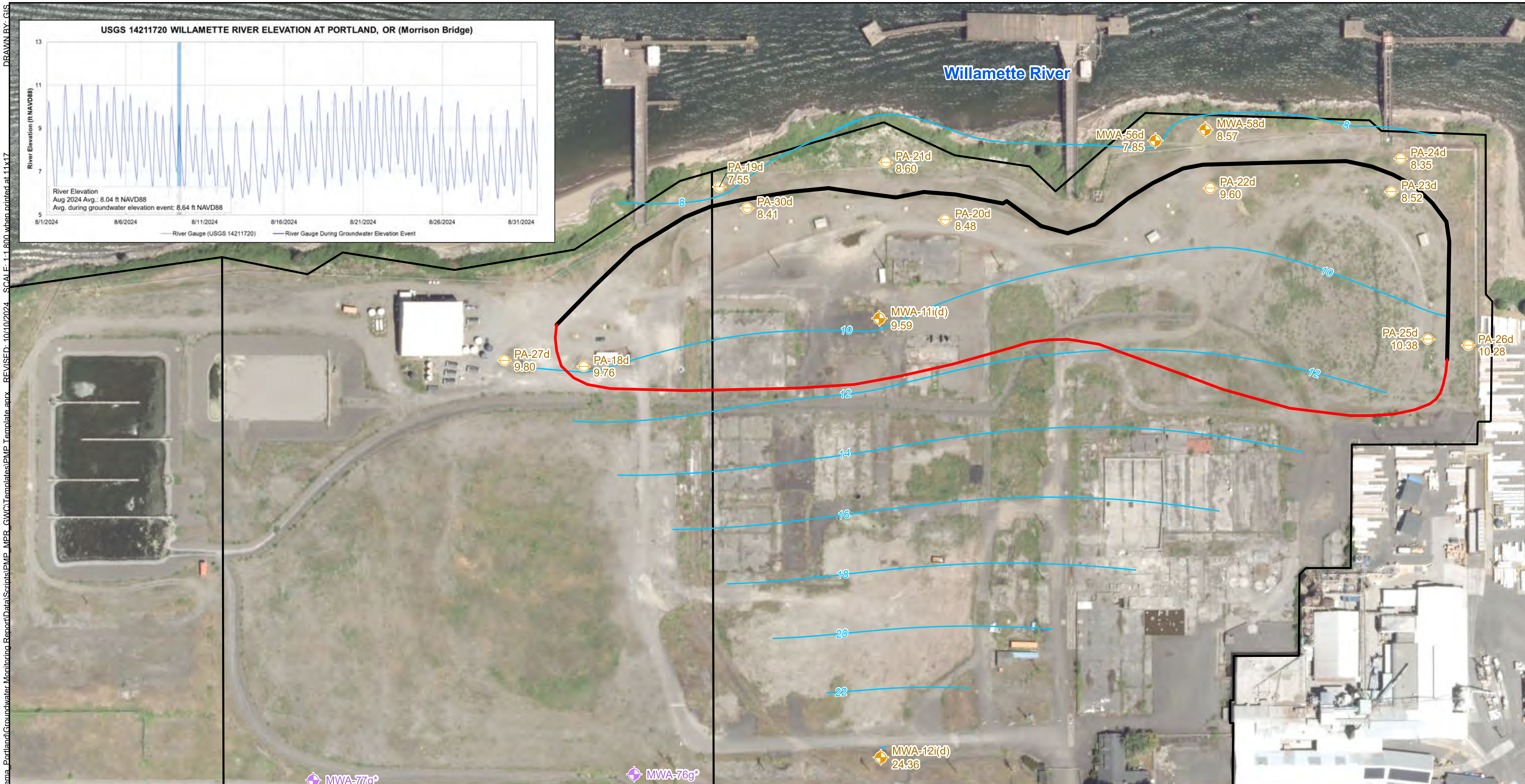
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected August, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
August 2024 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Trench Extraction Well
- Active Recovery Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected August, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
August 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

DRAWN BY: GIS SCALE: 1:1,560 when printed at 11x17 REVISED: 10/10/2024

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow-Intermediate Zone Monitoring Well
- Trench Extraction Well
- Active Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected August, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
August 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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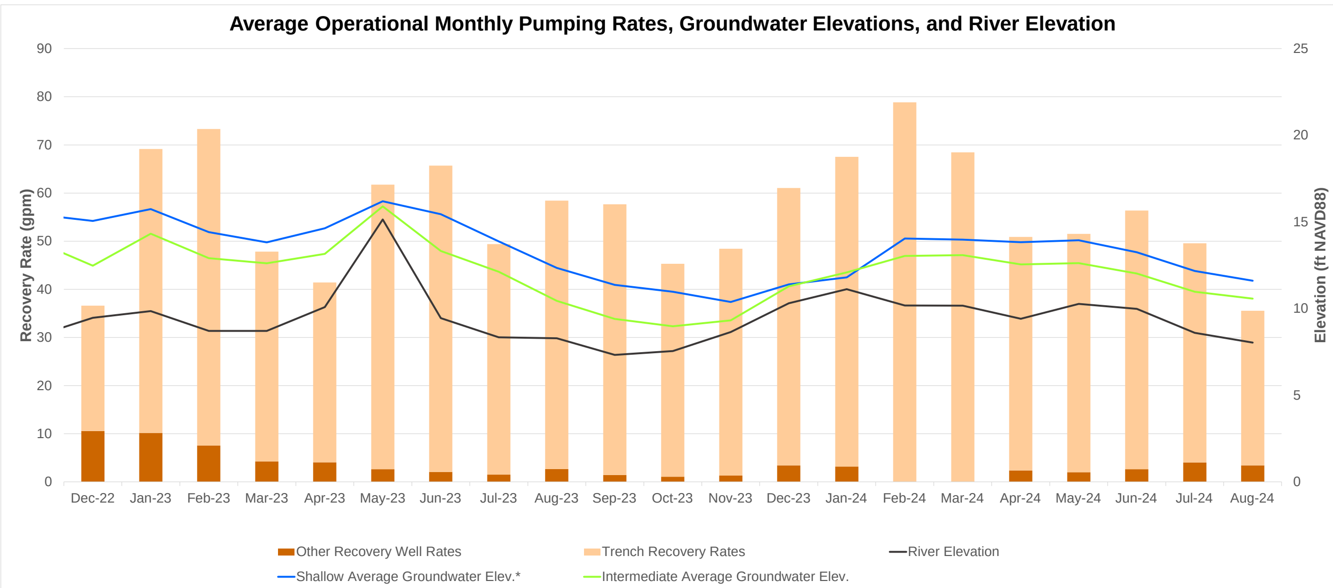
ATTACHMENT A-1 OPERATIONAL PUMPING RATE GRAPH

Attachment A-1

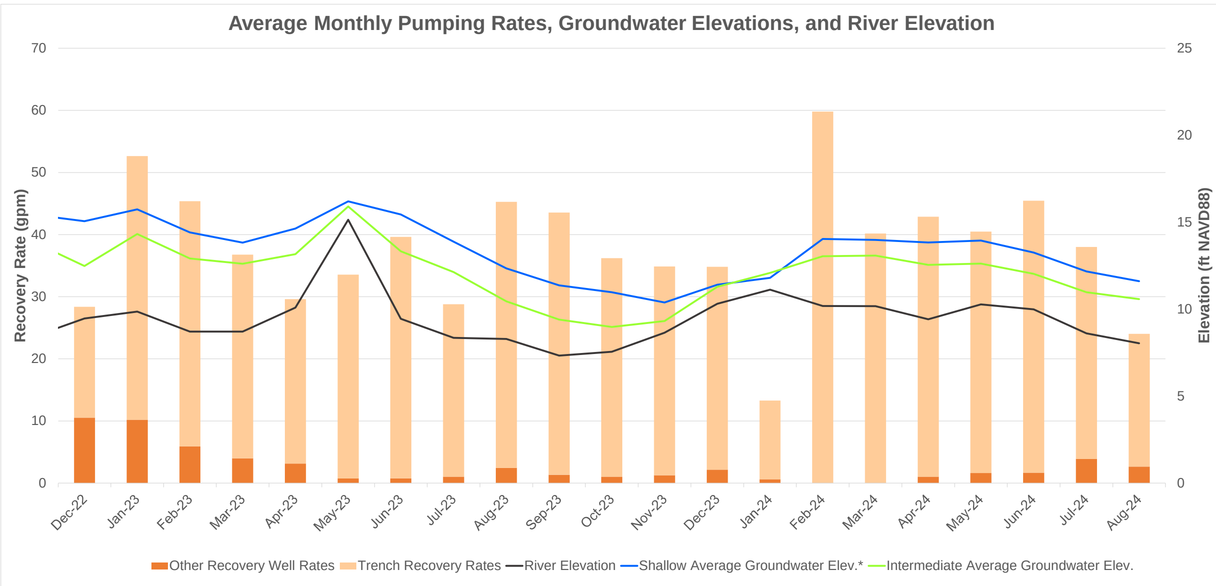
Operational Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



ATTACHMENT A-2 AVERAGE MONTHLY PUMPING RATE GRAPH

Attachment A-2

Average Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



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ATTACHMENT A-3 GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

Attachment A-3

GWET System Groundwater Extraction Rates Table
Arkema Inc. Facility
Portland, Oregon

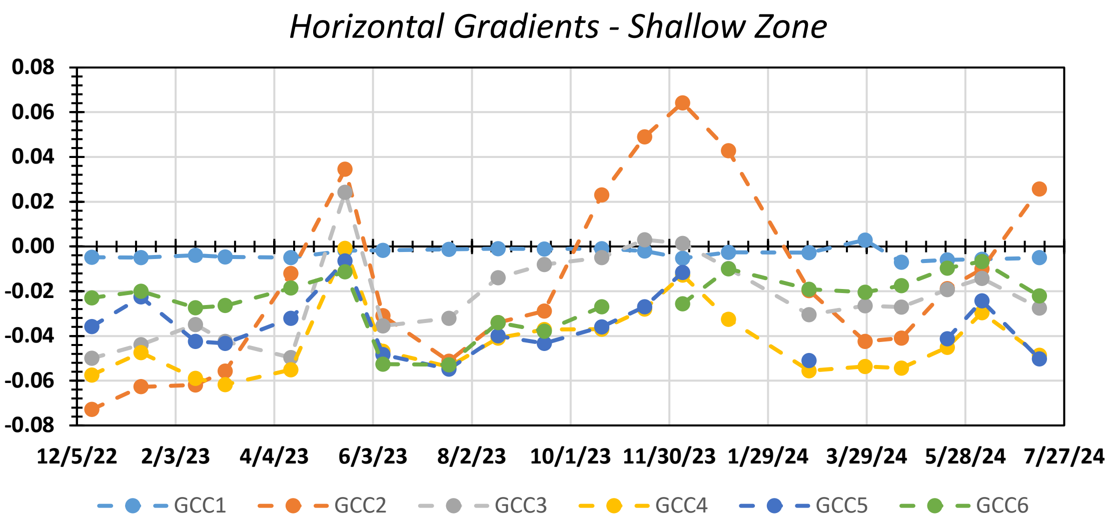
Recovery Well	August 2024 Average Operational Pumping Rate (gpm)	August 2024 Average Monthly Pumping Rate (gpm)
RW-14	1.36	0.92
RW-22*	0.00	0.00
RW-23	0.30	0.24
RW-25	1.77	1.48
EW-01	0.60	0.50
EW-02*	0.00	0.00
EW-03	9.61	8.06
EW-04	0.00	0.00
EW-05	5.20	3.19
EW-06	4.62	1.49
EW-07*	0.00	0.00
EW-08	1.29	1.09
EW-09	1.59	0.41
EW-10	1.76	0.62
EW-11	1.24	0.80
EW-12*	0.00	0.00
EW-13*	0.00	0.00
EW-14	6.22	5.22
Total	35.56	24.03

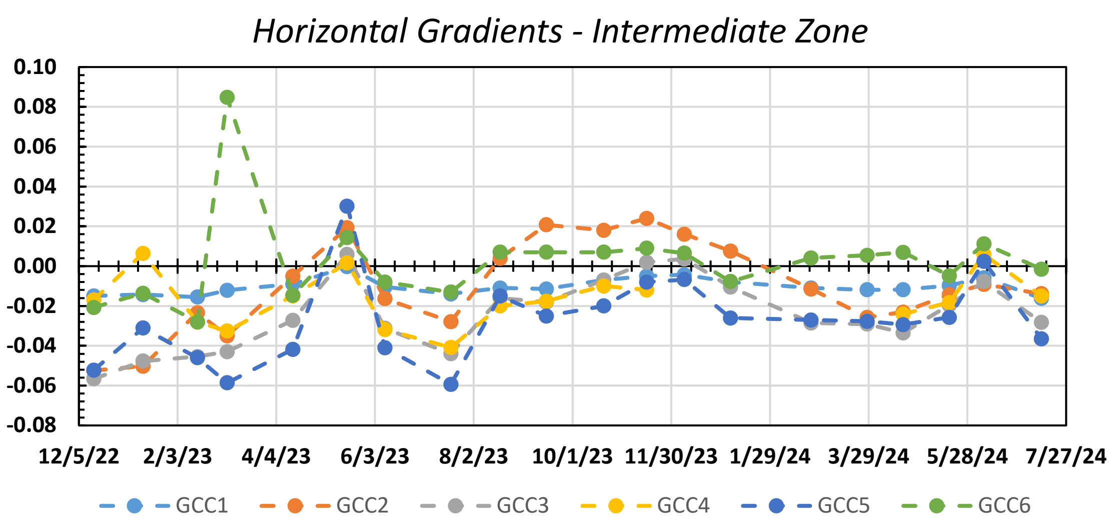
* = Recovery well not in service during reporting period
gpm = gallon per minute

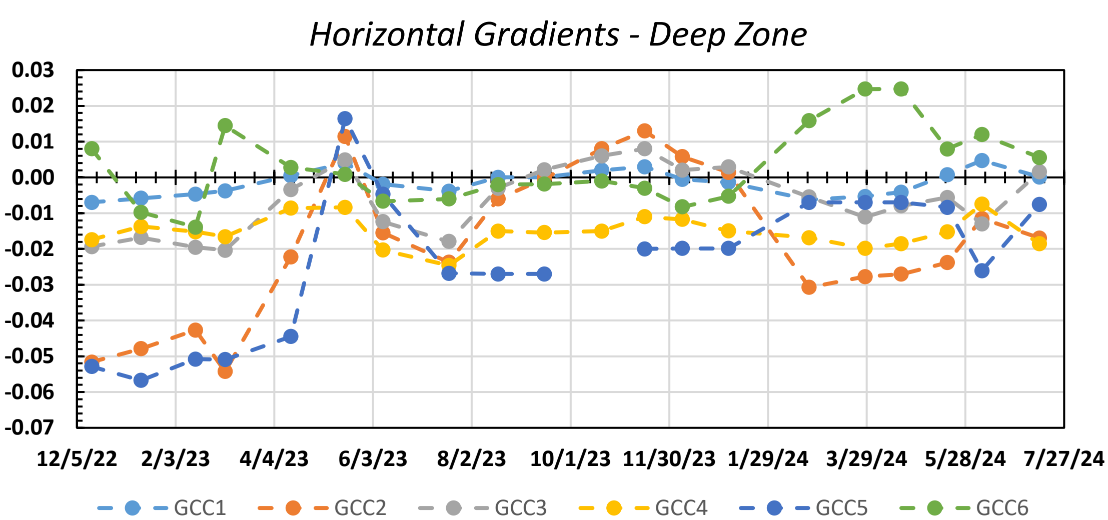
ATTACHMENT B-1 HORIZONTAL GRADIENTS SUMMARY GRAPH

Attachment B-1

Horizontal Gradients Summary: August 2024
Arkema Inc. Facility
Portland, Oregon







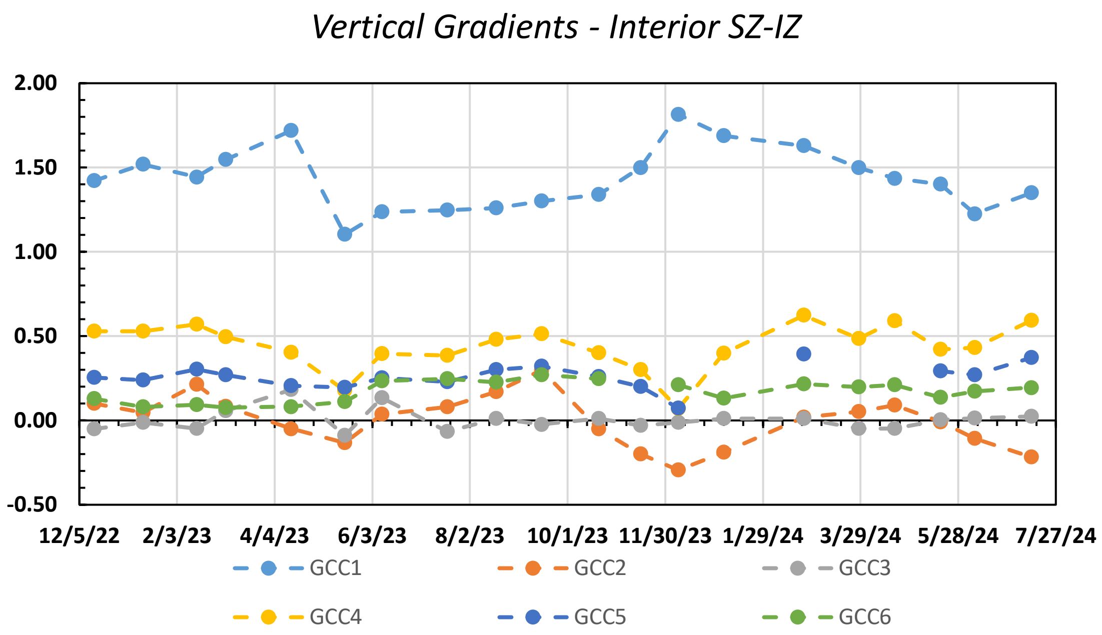
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

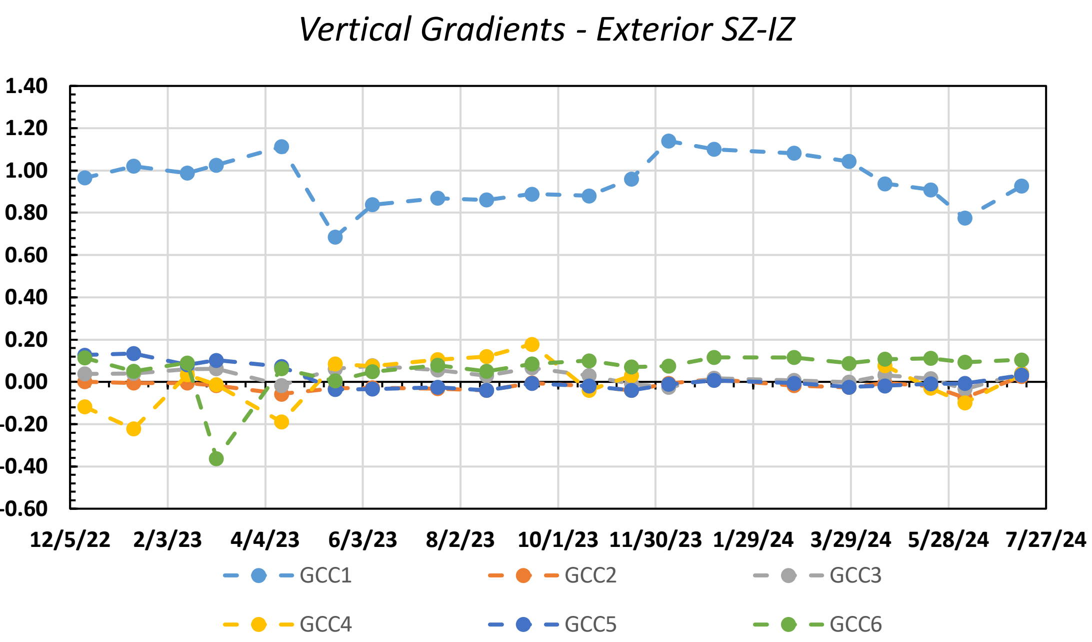
ERM

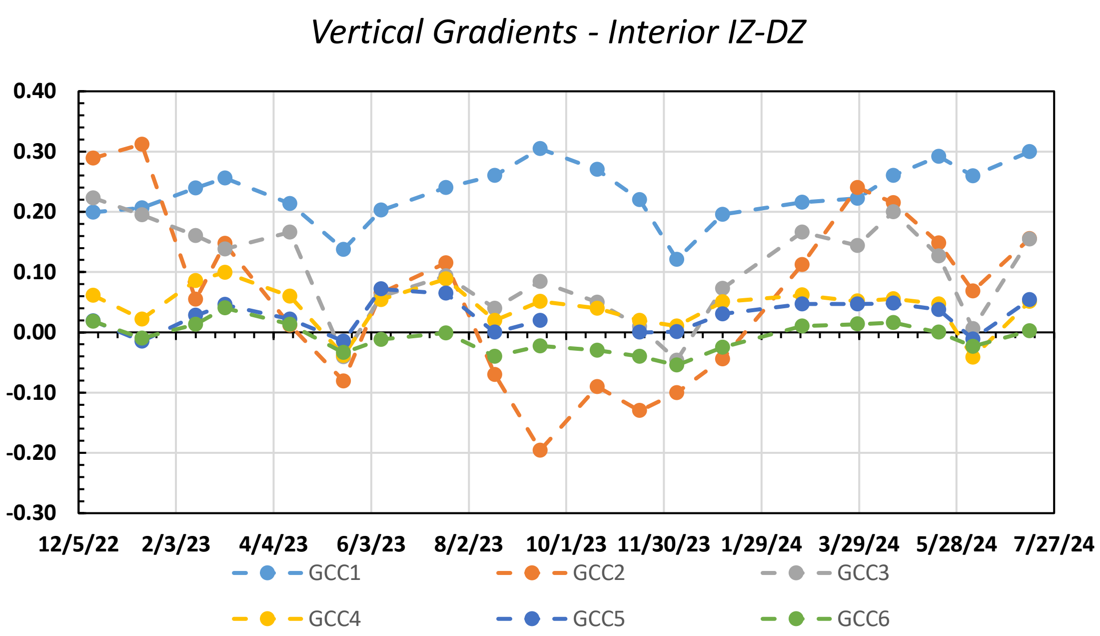
ATTACHMENT B-2 HORIZONTAL GRADIENTS

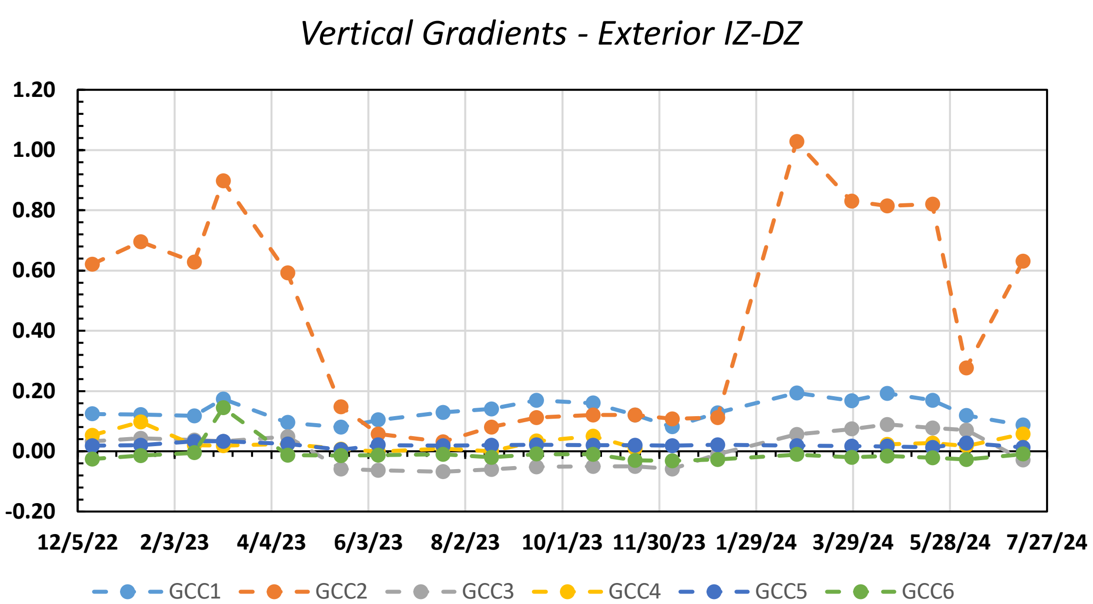
Attachment B-2

Vertical Gradients Summary: August 2024
Arkema Inc. Facility
Portland, Oregon









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ATTACHMENT B-3 VERTICAL GRADIENTS

Attachment B-3

Water Levels and Horizontal Gradients Table
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	24.62	PA-04	25.10	-0.005
	Intermediate	PA-17iR^{M}	10.84	PA-10i	11.84	-0.010
	Deep	PA-27d	9.80	PA-18d	9.76	0.000
GCC2	Shallow	PA-03	8.62	PA-04	6.71	0.028
	Intermediate	PA-17iR^{M}	8.75	PA-10i	9.42	-0.009
	Deep	PA-27d	7.55	PA-18d	8.41	-0.016
GCC3	Shallow	PA-03	8.58	PA-04	11.46	-0.027
	Intermediate	PA-17iR^{M}	8.36	PA-10i	11.21	-0.025
	Deep	PA-27d	8.60	PA-18d	8.48	0.001
GCC4	Shallow	PA-03	9.24	PA-04	13.97	-0.047
	Intermediate	PA-17iR^{M}	8.65	PA-10i	10.37	-0.019
	Deep	PA-27d	8.57	PA-18d	9.60	-0.011
GCC5	Shallow	PA-03	8.76	PA-04	13.79	-0.049
	Intermediate	PA-17iR^{M}	8.69	PA-10i	10.34	-0.031
	Deep	PA-27d	8.35	PA-18d	8.52	-0.003
GCC6	Shallow	PA-03	11.24	PA-04	12.31	-0.019
	Intermediate	PA-17iR^{M}	9.98	PA-10i	9.90	0.001
	Deep	PA-27d	10.28	PA-18d	10.38	-0.002

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

* = anonalous groundwater elevation

** = horizontal gradient cannot be calculated due to anomalous elevation reading

ft NAVD88 = feet North American Vertical Datum of 1988

^{M} = manual groundwater elevation measurement

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ATTACHMENT B-4 WATER LEVELS AND VERTICAL GRADIENTS TABLE

Attachment B-4

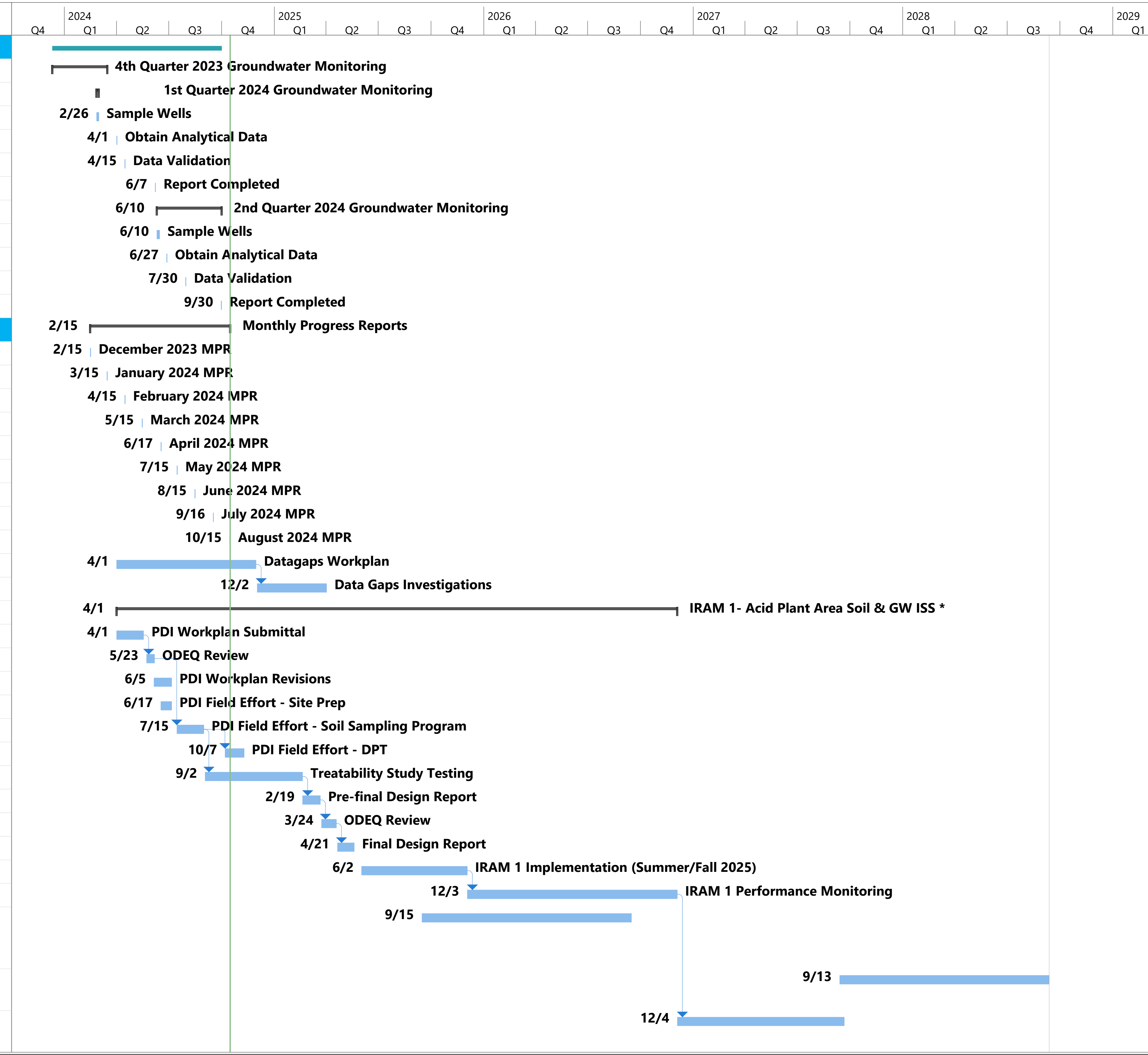
Water Levels and Vertical Gradients Table
Arkema Inc. Facility
Portland, Oregon

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	25.10	PA-10i	11.84	1.34
		GCC2	PA-05	6.71	PA-11i	9.42	-0.26
		GCC3	PA-06	11.46	PA-12i	11.21	0.02
		GCC4	PA-28	13.97	PA-13i	10.37	0.56
		GCC5	PA-07	13.79	PA-14i	10.34	0.36
		GCC6	PA-08	12.31	PA-15i	9.90	0.19
	IZ-DZ	GCC1	PA-10i	11.84	PA-18d	9.76	0.28
		GCC2	PA-11i	9.42	PA-30d	8.41	0.15
		GCC3	PA-12i	11.21	PA-20d	8.48	0.14
		GCC4	PA-13i	10.37	PA-22d	9.60	0.04
		GCC5	PA-14i	10.34	PA-23d	8.52	0.05
		GCC6	PA-15i	9.90	PA-25d	10.38	-0.01
Exterior	SZ-IZ	GCC1	PA-03	24.62	PA-17iR^{M}	10.84	0.88
		GCC2	MWA-2	8.62	MWA-8i	8.75	-0.01
		GCC3	MWA-69	8.58	MWA-66i	8.36	0.02
		GCC4	MWA-19	9.24	MWA-34iR	8.65	0.09
		GCC5	MWA-47	8.76	PA-29i	8.69	0.01
		GCC6	PA-09	11.24	PA-16i	9.98	0.10
	IZ-DZ	GCC1	PA-17iR^{M}	10.84	PA-27d	9.80	0.16
		GCC2	MWA-8i	8.75	PA-19d	7.55	0.77
		GCC3	MWA-66i	8.36	PA-21d	8.60	-0.02
		GCC4	MWA-34iR	8.65	MWA-58d	8.57	0.00
		GCC5	PA-29i	8.69	PA-24d	8.35	0.01
		GCC6	PA-16i	9.98	PA-26d	10.28	-0.01

Positive vertical gradient indicates an donward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anonalous groundwater elevation
** = vertical gradient cannot be calculated due to anomalous elevation reading
DZ = Deep Zone
ft NAVD88 = feet North American Vertical Datum of 1988
IZ = Intermediate Zone
^{M} = manual groundwater elevation measurement
SZ = Shallow Zone

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring**	**81 days**	**Mon 6/10/24**	**Mon 9/30/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	*Obtain Analytical Data*	*1 day*	*Thu 6/27/24*	*Thu 6/27/24*
15	*Data Validation*	*1 day*	*Tue 7/30/24*	*Tue 7/30/24*
16	*Report Completed*	*1 day*	*Mon 9/30/24*	*Mon 9/30/24*
17	**Monthly Progress Reports**	**175 days**	**Thu 2/15/24**	**Tue 10/15/24**
18	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
19	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
20	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
21	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
22	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
23	*May 2024 MPR*	*1 day*	*Mon 7/15/24*	*Mon 7/15/24*
24	*June 2024 MPR*	*1 day*	*Thu 8/15/24*	*Thu 8/15/24*
25	*July 2024 MPR*	*1 day*	*Mon 9/16/24*	*Mon 9/16/24*
26	August 2024 MPR	1 day	Tue 10/15/24	Tue 10/15/24
27	**Datagaps Workplan**	175 days	Mon 4/1/24	Fri 11/29/24
28	**Data Gaps Investigations**	87 days	Mon 12/2/24	Tue 4/1/25
29	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
30	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
31	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
32	*PDI Workplan Revisions*	*23 days*	*Wed 6/5/24*	*Fri 7/5/24*
33	*PDI Field Effort - Site Prep*	*15 days*	*Mon 6/17/24*	*Fri 7/5/24*
34	*PDI Field Effort - Soil Sampling Program*	*35 days*	*Mon 7/15/24*	*Fri 8/30/24*
35	PDI Field Effort - DPT	25 days	Mon 10/7/24	Fri 11/8/24
36	Treatability Study Testing	122 days	Mon 9/2/24	Tue 2/18/25
37	Pre-final Design Report	23 days	Wed 2/19/25	Fri 3/21/25
38	ODEQ Review	20 days	Mon 3/24/25	Fri 4/18/25
39	Final Design Report	21 days	Mon 4/21/25	Mon 5/19/25
40	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
41	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
42	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
43	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
44	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress	
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline		
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress		

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MEMO

TO	Katie Daugherty, ODEQ
FROM	Brendan Robinson, PE, ERM; Todd Slater, LSS
DATE	15 November 2024
REFERENCE	0732445.204
SUBJECT	Groundwater Source Control Measure Monthly Performance Monitoring Report

1. INTRODUCTION

The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with Legacy Site Services LLC (LSS) and Environmental Resources Management, Inc. (ERM) on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) at the Arkema site (Site) consistent with the Performance Monitoring Plan (PMP; ERM 2014[1]) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 Monthly Performance Monitoring Report (MPR), subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

On 6 June 2024, ODEQ requested that LSS and ERM reduce the scope of future MPRs to facilitate faster review. On 11 September 2024, ODEQ agreed for the first amended MPR to be the August 2024 MPR submitted in October 2024.

[1] ERM-West, Inc. 2014. *Revised Final Performance Monitoring Plan – Groundwater Source Control Measure, Arkema Inc. Facility, Portland, Oregon*. July 2014.

2. GWET SYSTEM PERFORMANCE

The average system influent flow rate was 21.38 gallons per minute (gpm) for the entire month of September 2024, including non-operational periods. The average operational influent flow during operational periods was 36.60 gpm.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. A low pressure Hydropuls redevelopment was completed at Trenches 5 and 6 during September 2024 to address accumulation of silt in the filter pack. Ongoing redevelopment is anticipated in October 2024 to maintain the productivity of the groundwater extraction trenches, and conveyance line cleaning will be conducted as needed based on analysis of backpressure.

The reduction in average monthly groundwater extraction rate in September 2024 compared to August 2024 is believed to be a result of extremely low groundwater elevations onsite as shown on Attachments A-1 and A-2. The average shallow groundwater level onsite, interior to the barrier wall, has been observed lower on only one occasion, in October 2023. This decrease in interior groundwater elevations onsite occurred despite a slight increase in average river elevation.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Groundwater Extraction Enhancement Final Design Report* (ERM 2022[2]) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

2.1 GWET PLANT OPERATIONS

The groundwater extraction and treatment (GWET) plant operated within permit conditions during the reporting period. There were two shutdowns:

- 19 September 2024: The GWET system was shut down for 25-minutes to install pressure gauges along the influent conveyance lines.
- 30 September 2024: The wellfield was shut down for 25.5-hours due to motor control maintenance necessitating lock-out-tag-out of the system.

[2] ERM-West, Inc. 2022. *Final Design Report, Arkema Inc. Facility, Portland, Oregon*. May 2022.

3. CAPTURE ZONE EVALUATION

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the groundwater barrier wall (GWBW) and to evaluate the effective hydraulic capture produced by the GW SCM.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 6 September 2024. The Serfes (1991)[3] method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 6 September 2024 are shown in Attachment B-3 and Attachment B-4.

3.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

Groundwater elevation data collected on 6 September 2024 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench primarily on the north end of the Site in the Shallow and Intermediate Zones. Horizontal gradients at gradient control clusters (GCCs) across the Site are generally outward, but steady. Horizontal gradients and trend lines are shown in Attachments B-1 and B-2.

River elevations are shown over time on Attachments A-1 and A-2, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in September 2024 had an average elevation of 8.25 feet North American Vertical Datum of 1988 (NAVD88) with a minimum elevation of 6.24 feet NAVD88 and a maximum elevation of 10.54 feet NAVD88, a slight increase compared to August 2024. The average Shallow Zone groundwater elevation decreased from August by 0.75 feet and the average Intermediate Zone groundwater elevation decreased from August by 1.00 feet, and the river elevation has largely been trending downward since January 2024 but is anticipated to rise over the coming months as the seasonal rains begin. There was not as significant of a seasonal rise in Willamette River level this year compared to previous years.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients and trend lines are shown in Attachments B-2 and B-4. Vertical

[3] Serfes, Michael. 1991. “Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations.” *Groundwater* 29(4): July–August.

groundwater gradients interior and exterior to the GWBW were primarily downward between the Shallow and Intermediate Zones and between the Intermediate and Deep Zones.

4. CONCLUSIONS

Recovery rates indicate that the active recovery wells (RWs) and extraction wells (EWs) are operating as designed, except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives. Redevelopment of the trenches is planned for October 2024 to mitigate accumulation of silt in the filter pack in both the vertical and horizontal sections using impulse redevelopment techniques. These efforts will be targeted at trenches that are currently underperforming, including Trenches 1, 4, 5, and 6. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to progress toward capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

Brendan Robinson, PE
Partner

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

ATTACHMENTS

FIGURE 1 – SITE LAYOUT

FIGURE 2 – SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3 – INTERMEDIATE ZONE GROUNDWATER CONTOURS

FIGURE 4 – DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5 – SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE MAPS

FIGURE 6 – INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE MAPS

ATTACHMENT A-1 – OPERATIONAL PUMPING RATE GRAPH

ATTACHMENT A-2 – AVERAGE MONTHLY PUMPING RATE GRAPH

ATTACHMENT A-3 – GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

ATTACHMENT B-1 – HORIZONTAL GRADIENTS SUMMARY GRAPH

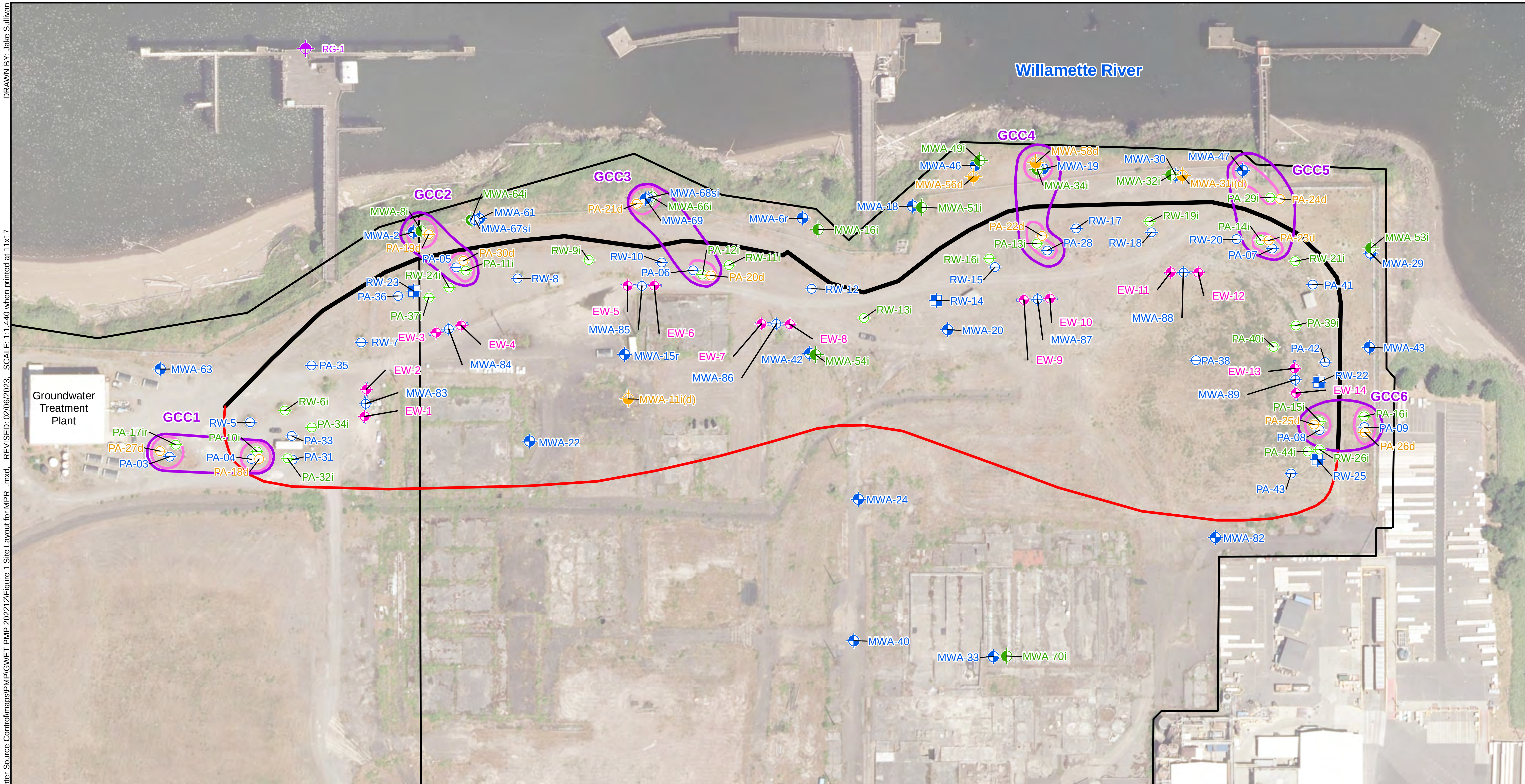
ATTACHMENT B-2 – VERTICAL GRADIENTS SUMMARY GRAPH

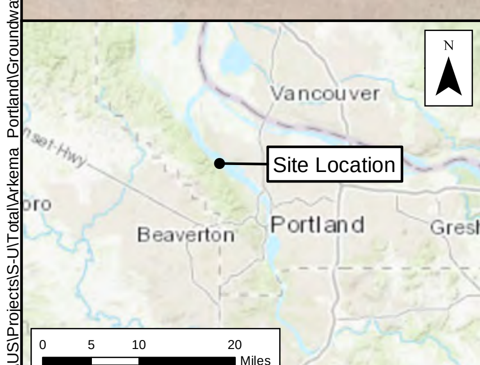
ATTACHMENT B-3 – WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

ATTACHMENT B-4 – WATER LEVELS AND VERTICAL GRADIENTS TABLE

ATTACHMENT C – PROJECT SCHEDULE

FIGURES





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

0 120 240

Feet

Figure 1

Site Layout

Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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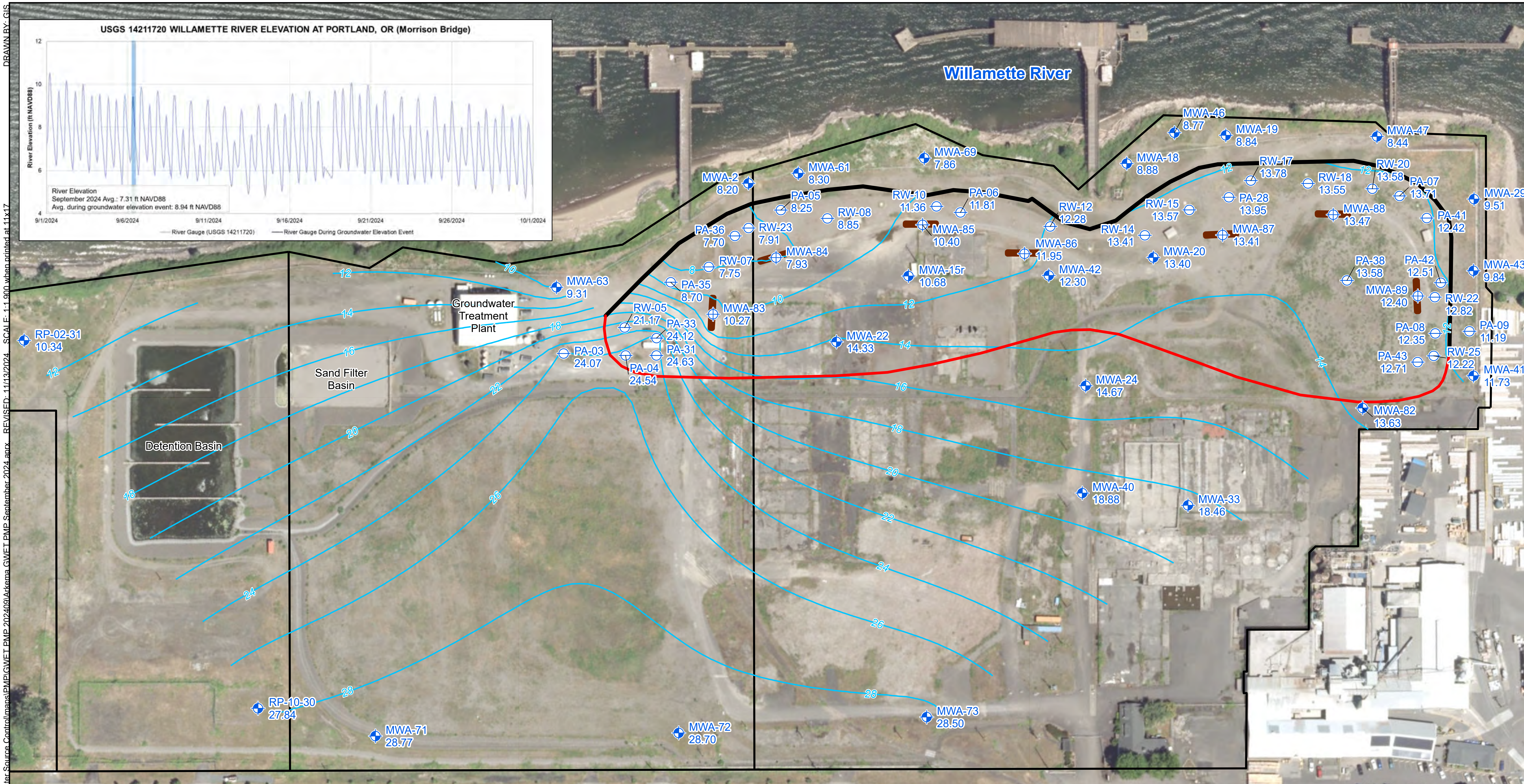

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Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected September 9–11, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
September 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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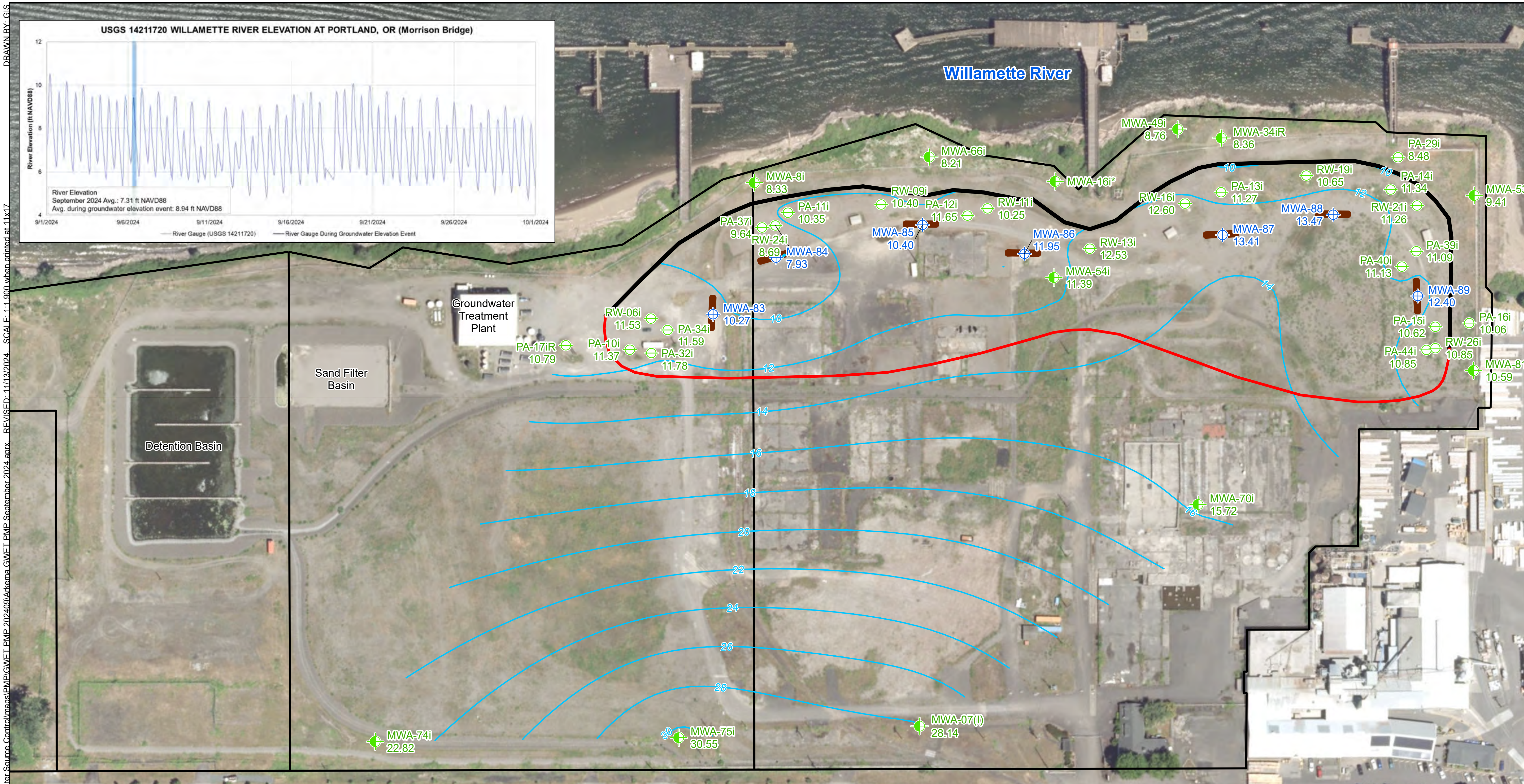
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected September 9–11, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
September 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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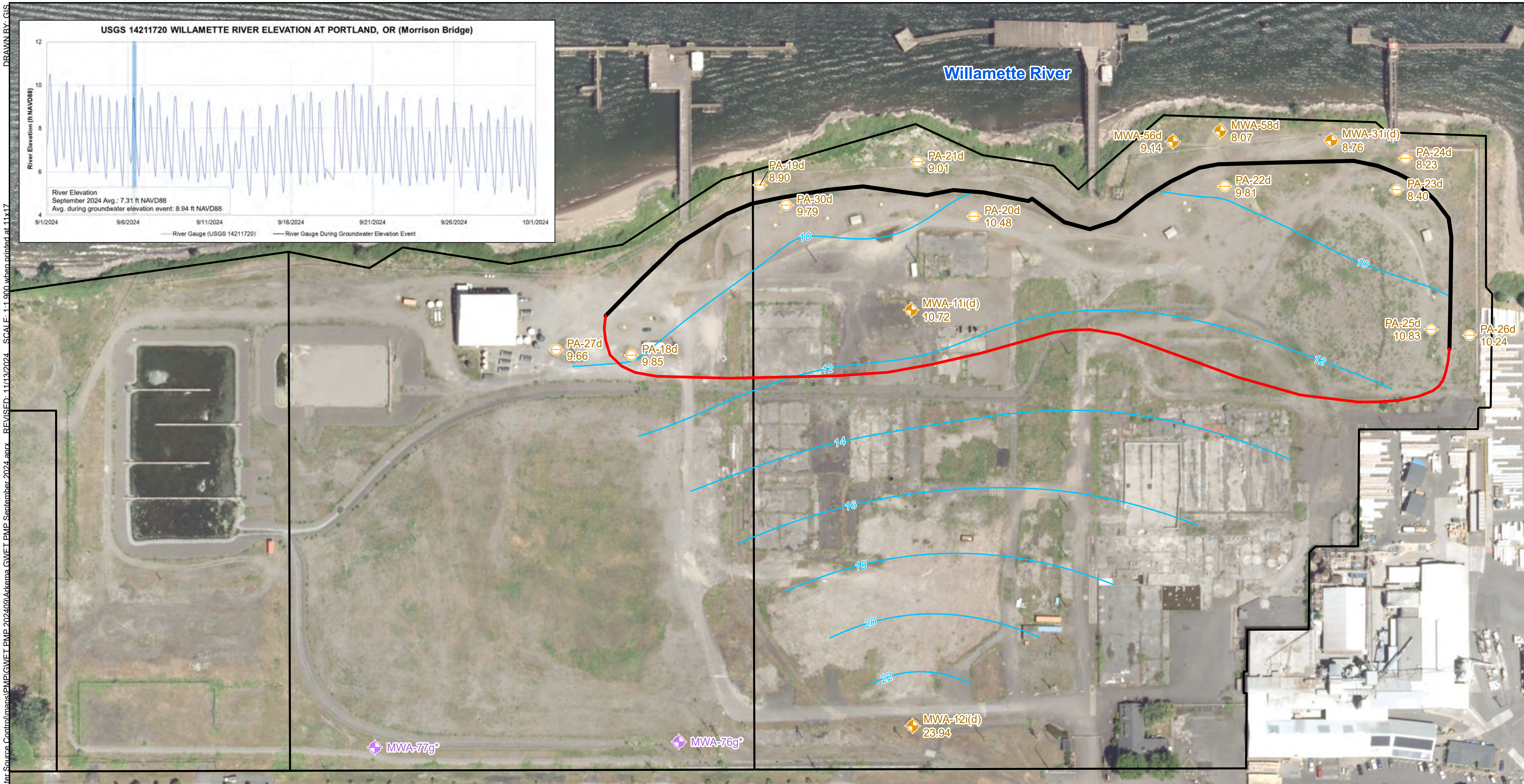

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected September 9–11, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
September 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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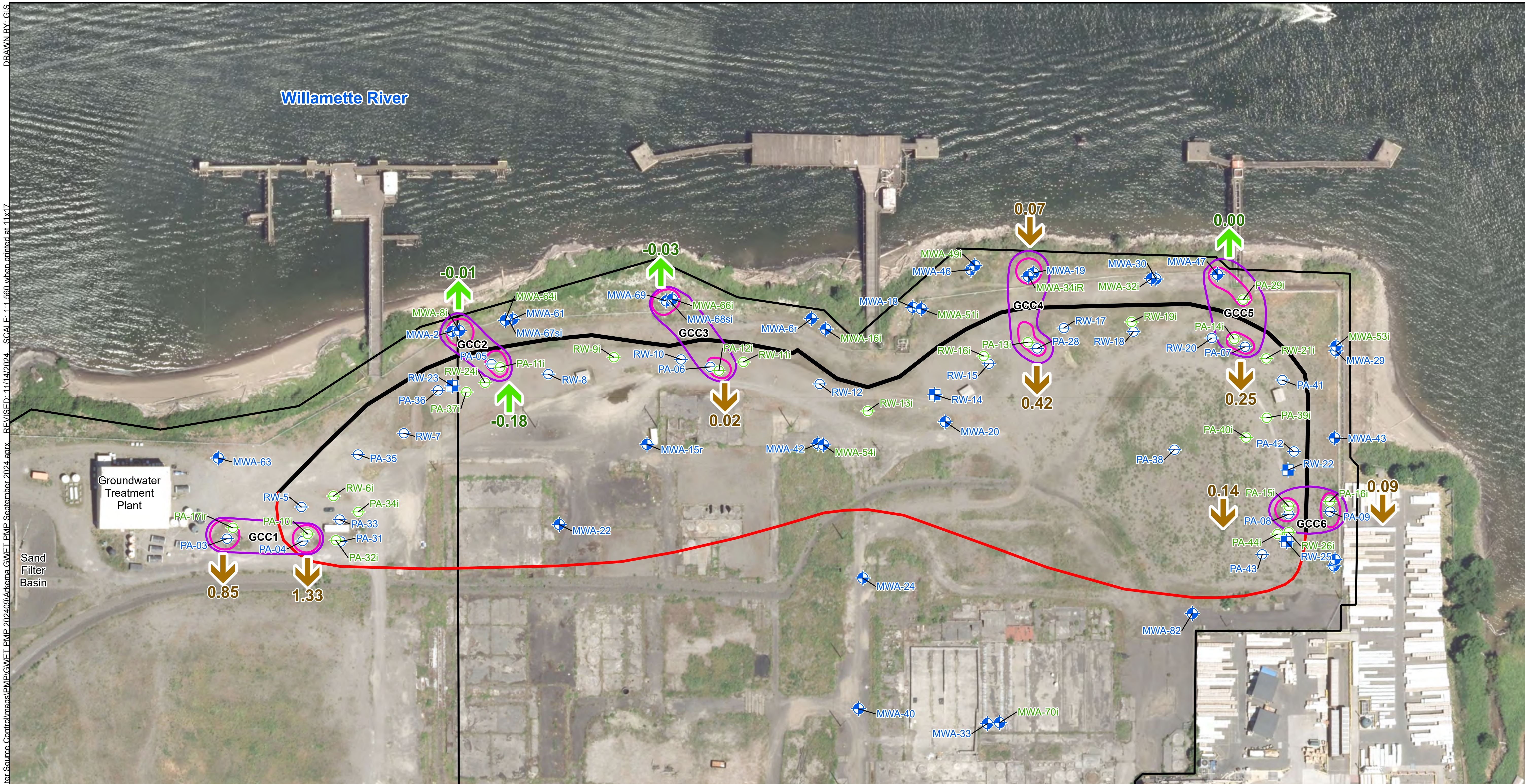

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected September 9–11, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
September 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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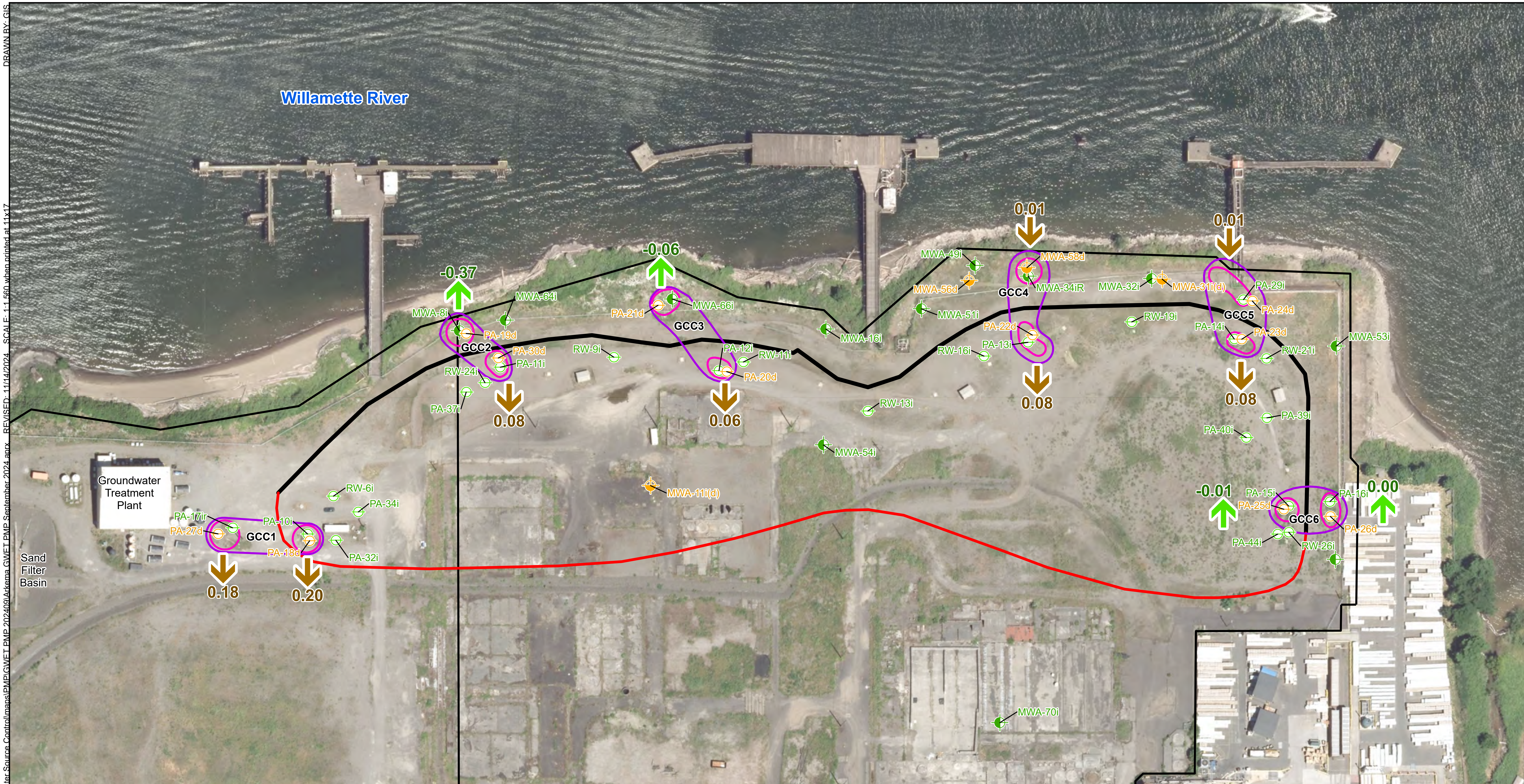

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected September 9–11, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
September 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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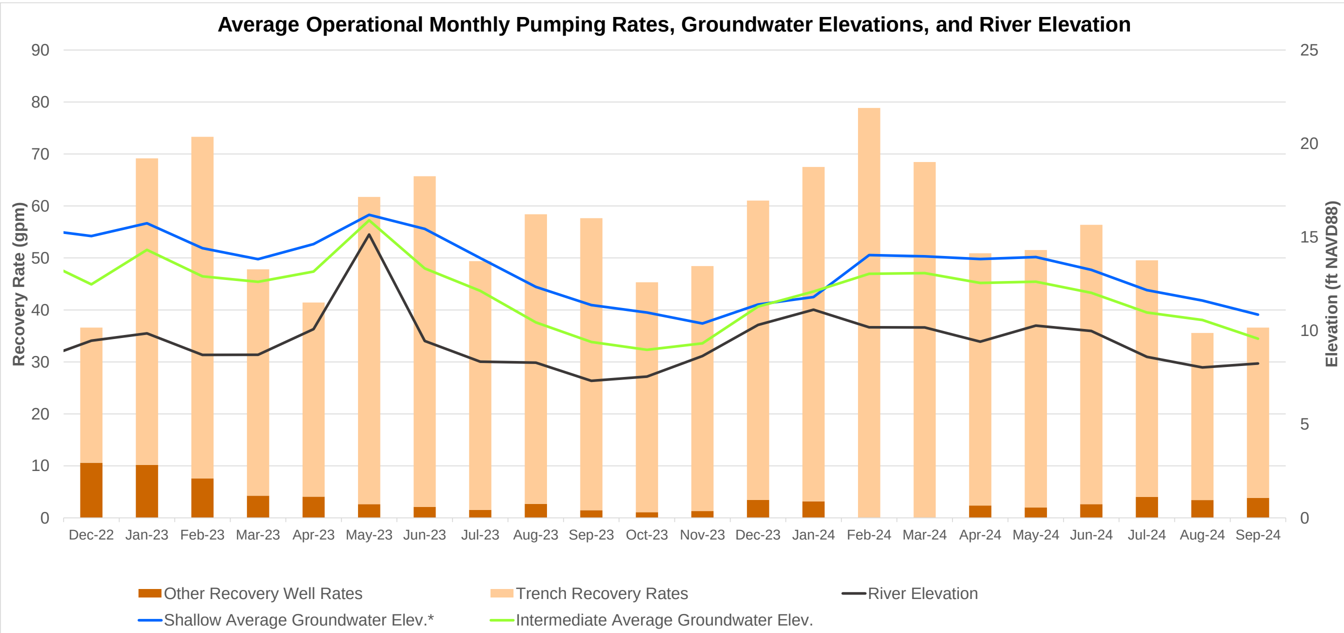
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ERM

ATTACHMENT A-1 OPERATIONAL PUMPING RATE GRAPH

Attachment A-1

Operational Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon

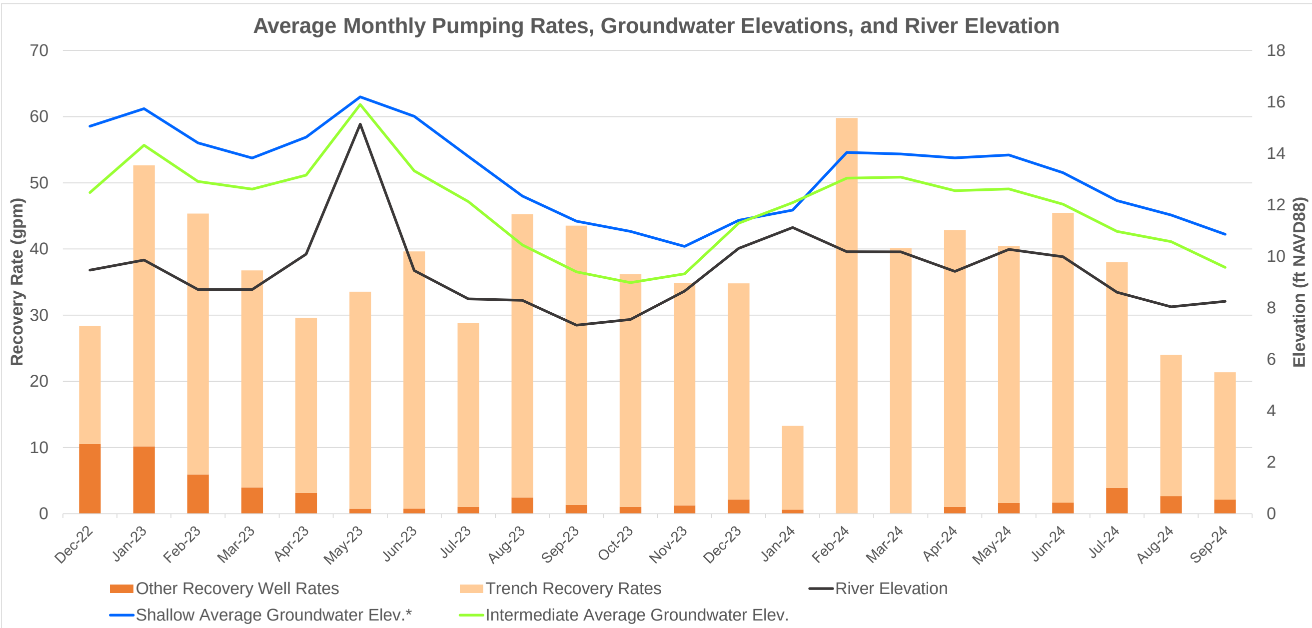


ERM

ATTACHMENT A-2 AVERAGE MONTHLY PUMPING RATE GRAPH

Attachment A-2

Average Monthly Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



ERM

ATTACHMENT A-3 GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

Attachment A-3

GWET System Groundwater Extraction Rates Table
Arkema Inc. Facility
Portland, Oregon

Recovery Well	September 2024 Average Operational Pumping Rate (gpm)	September 2024 Average Monthly Pumping Rate (gpm)
RW-14	1.18	0.16
RW-22*	0.00	0.00
RW-23	1.27	0.98
RW-25	1.36	1.00
EW-01	0.74	0.56
EW-02*	0.00	0.00
EW-03	9.99	7.66
EW-04	0.00	0.00
EW-05	4.94	3.79
EW-06*	0.00	0.00
EW-07*	0.00	0.00
EW-08	1.21	0.92
EW-09	1.77	0.24
EW-10	1.77	1.12
EW-11	1.30	0.99
EW-12*	0.00	0.00
EW-13	6.53	1.09
EW-14	4.54	2.87
Total	36.60	21.38

* = Recovery well not in service during reporting period

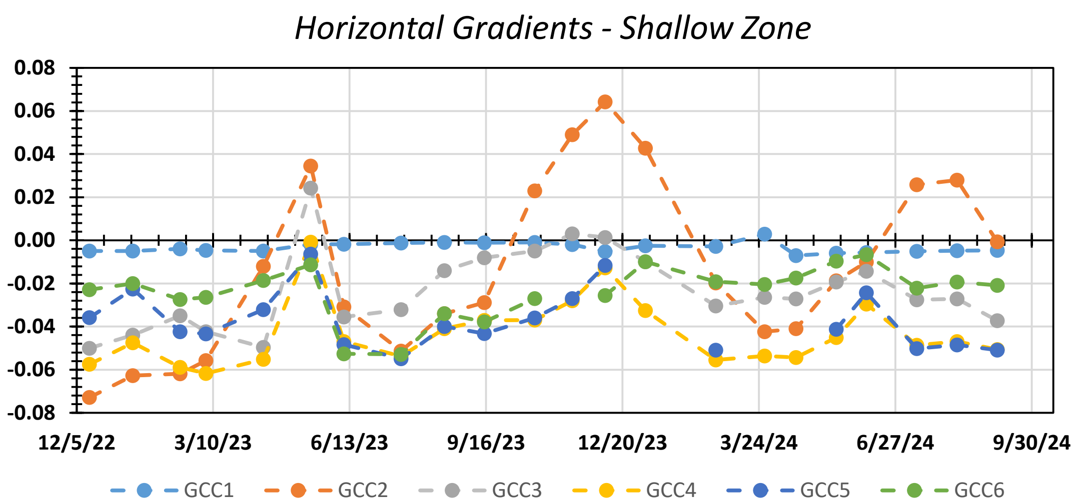
gpm = gallon per minute

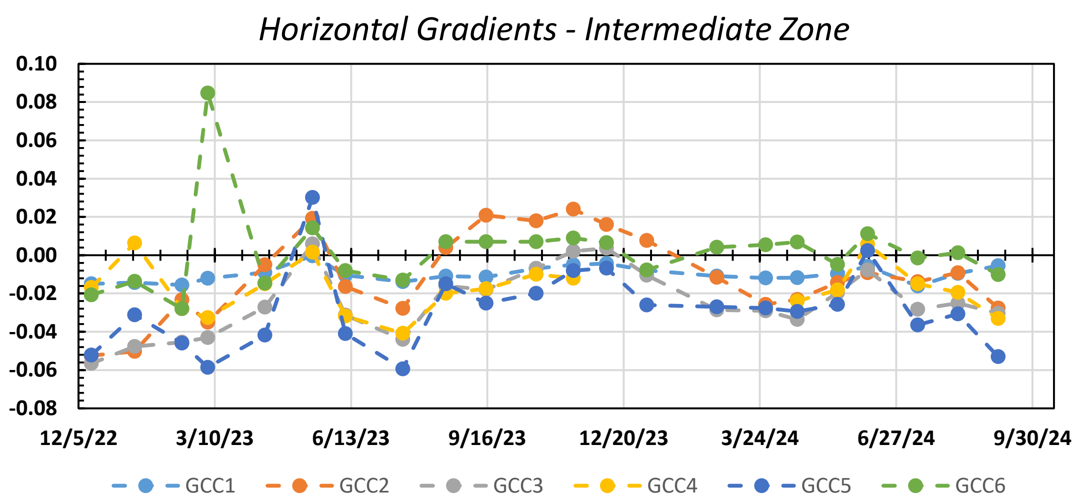
ERM

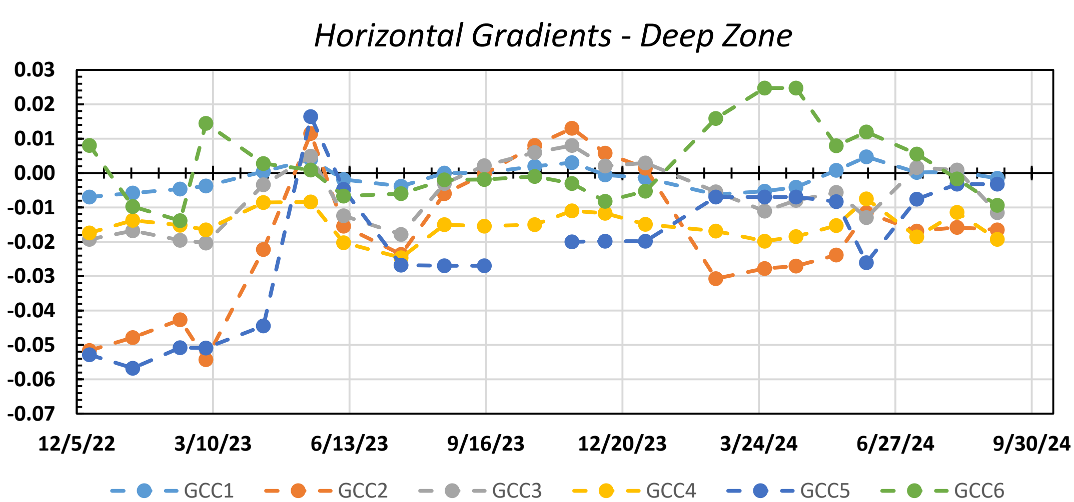
ATTACHMENT B-1 HORIZONTAL GRADIENTS SUMMARY GRAPH

Attachment B-1

Horizontal Gradients Summary: September 2024
Arkema Inc. Facility
Portland, Oregon







Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

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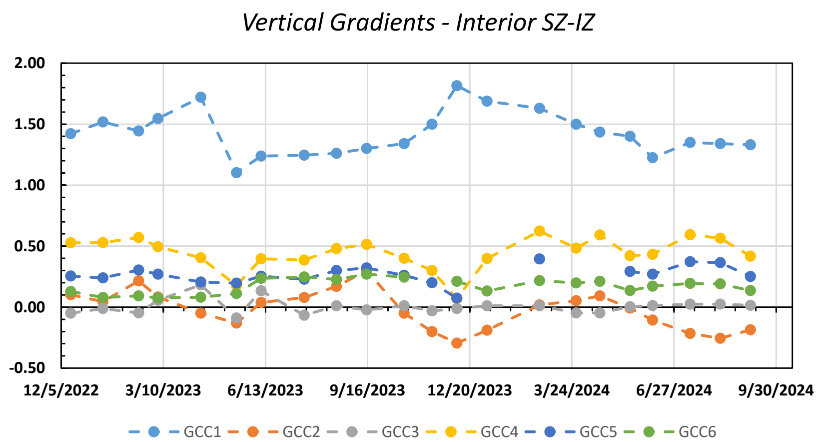
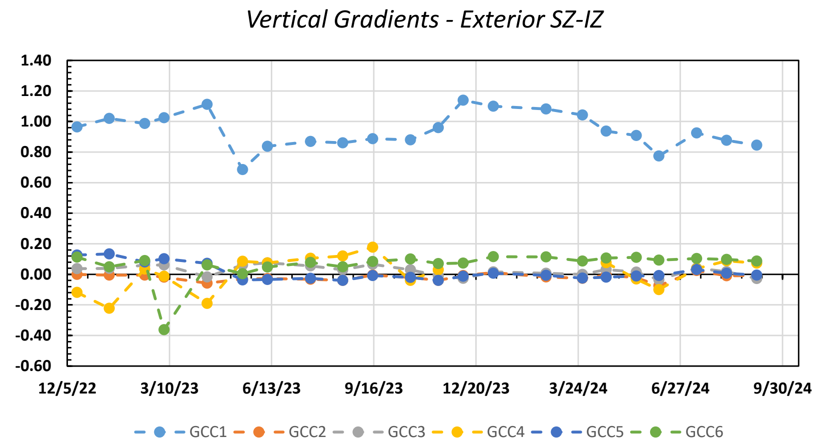
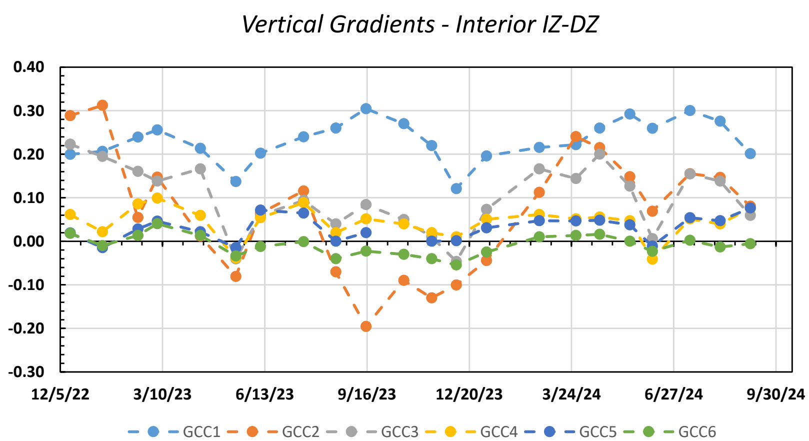
ATTACHMENT B-2 HORIZONTAL GRADIENTS

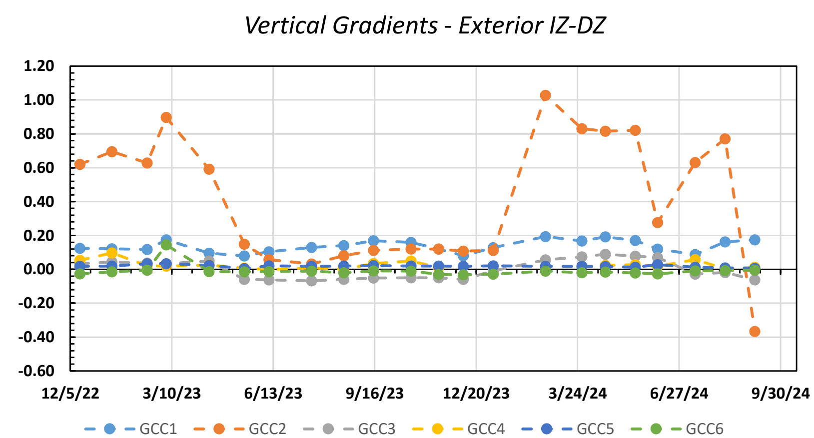
Attachment B-2

Vertical Gradients Summary: September 2024
Arkema Inc. Facility
Portland, Oregon









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ATTACHMENT B-3 VERTICAL GRADIENTS

Attachment B-3

Water Levels and Horizontal Gradients Table
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	24.07	PA-04	24.54	-0.005
	Intermediate	PA-17iR^M	10.79	PA-10i	11.37	-0.006
	Deep	PA-27d	9.66	PA-18d	9.85	-0.002
GCC2	Shallow	PA-03	8.20	PA-04	8.25	-0.001
	Intermediate	PA-17iR^M	8.33	PA-10i	10.35	-0.028
	Deep	PA-27d	8.90	PA-18d	9.79	-0.017
GCC3	Shallow	PA-03	7.86	PA-04	11.81	-0.037
	Intermediate	PA-17iR^M	8.21	PA-10i	11.65	-0.030
	Deep	PA-27d	9.01	PA-18d	10.48	-0.012
GCC4	Shallow	PA-03	8.84	PA-04	13.95	-0.051
	Intermediate	PA-17iR^M	8.36	PA-10i	11.27	-0.033
	Deep	PA-27d	8.07	PA-18d	9.81	-0.019
GCC5	Shallow	PA-03	8.44	PA-04	13.71	-0.051
	Intermediate	PA-17iR^M	8.48	PA-10i	11.34	-0.053
	Deep	PA-27d	8.23	PA-18d	8.40	-0.003
GCC6	Shallow	PA-03	11.19	PA-04	12.35	-0.021
	Intermediate	PA-17iR^M	10.06	PA-10i	10.62	-0.010
	Deep	PA-27d	10.24	PA-18d	10.83	-0.009

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anonalous groundwater elevation
** = horizontal gradient cannot be calculated due to anomalous elevation reading
ft NAVD88 = feet North American Vertical Datum of 1988
^M = manual groundwater elevation measurement

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ATTACHMENT B-4 WATER LEVELS AND VERTICAL GRADIENTS TABLE

Attachment B-4

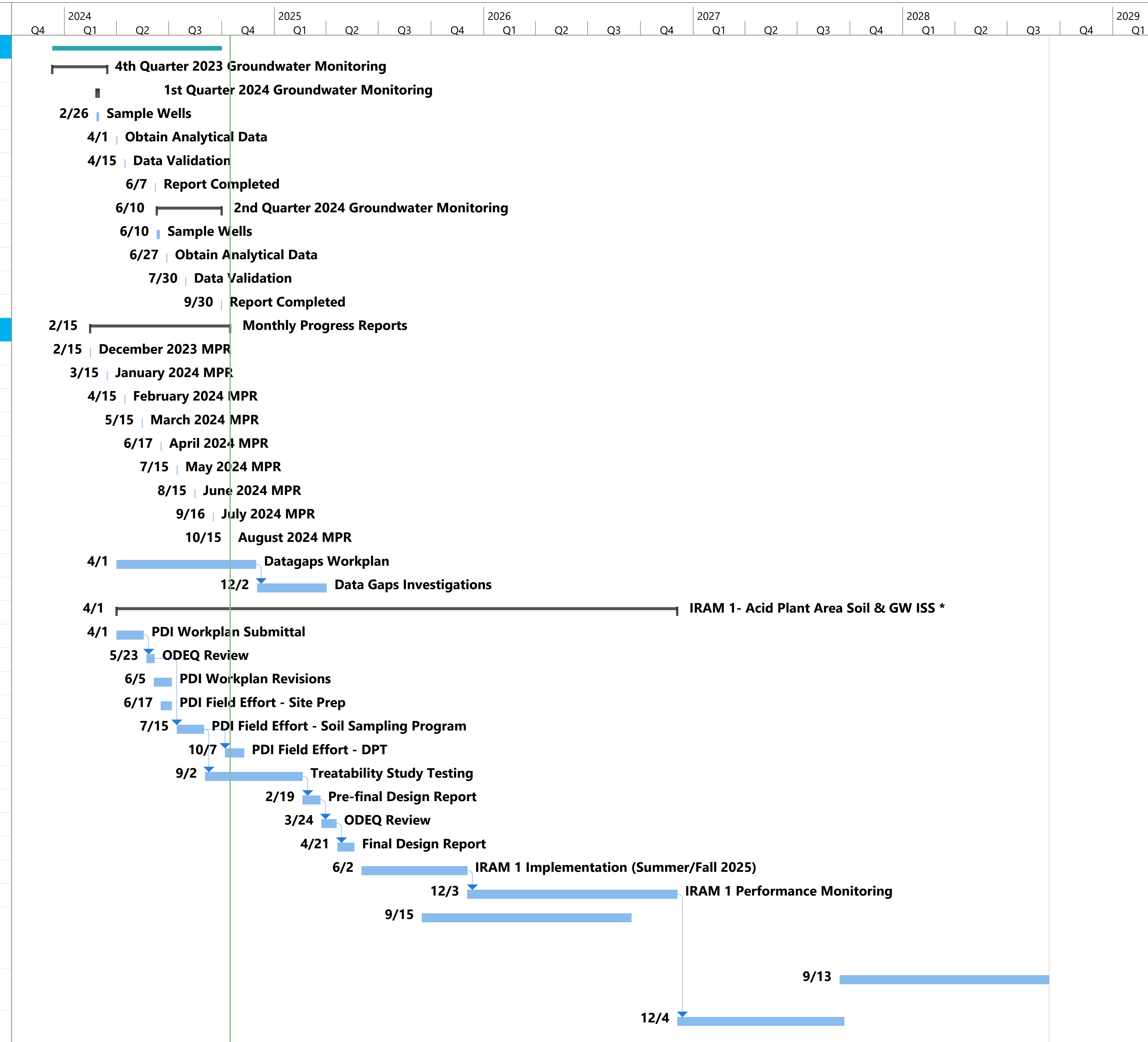
Water Levels and Vertical Gradients Table
Arkema Inc. Facility
Portland, Oregon

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	24.54	PA-10i	11.37	1.33
		GCC2	PA-05	8.25	PA-11i	10.35	-0.18
		GCC3	PA-06	11.81	PA-12i	11.65	0.02
		GCC4	PA-28	13.95	PA-13i	11.27	0.42
		GCC5	PA-07	13.71	PA-14i	11.34	0.25
		GCC6	PA-08	12.35	PA-15i	10.62	0.14
	IZ-DZ	GCC1	PA-10i	11.37	PA-18d	9.85	0.20
		GCC2	PA-11i	10.35	PA-30d	9.79	0.08
		GCC3	PA-12i	11.65	PA-20d	10.48	0.06
		GCC4	PA-13i	11.27	PA-22d	9.81	0.08
		GCC5	PA-14i	11.34	PA-23d	8.40	0.08
		GCC6	PA-15i	10.62	PA-25d	10.83	-0.01
Exterior	SZ-IZ	GCC1	PA-03	24.07	PA-17iR^{M}	10.79	0.85
		GCC2	MWA-2	8.20	MWA-8i	8.33	-0.01
		GCC3	MWA-69	7.86	MWA-66i	8.21	-0.03
		GCC4	MWA-19	8.84	MWA-34iR	8.36	0.07
		GCC5	MWA-47	8.44	PA-29i	8.48	0.00
		GCC6	PA-09	11.19	PA-16i	10.06	0.09
	IZ-DZ	GCC1	PA-17iR^{M}	10.79	PA-27d	9.66	0.18
		GCC2	MWA-8i	8.33	PA-19d	8.90	-0.37
		GCC3	MWA-66i	8.21	PA-21d	9.01	-0.06
		GCC4	MWA-34iR	8.36	MWA-58d	8.07	0.01
		GCC5	PA-29i	8.48	PA-24d	8.23	0.01
		GCC6	PA-16i	10.06	PA-26d	10.24	0.00

Positive vertical gradient indicates an donward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anonalous groundwater elevation
** = vertical gradient cannot be calculated due to anomalous elevation reading
DZ = Deep Zone
ft NAVD88 = feet North American Vertical Datum of 1988
IZ = Intermediate Zone
^{M} = manual groundwater elevation measurement
SZ = Shallow Zone

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring**	**81 days**	**Mon 6/10/24**	**Mon 9/30/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	*Obtain Analytical Data*	*1 day*	*Thu 6/27/24*	*Thu 6/27/24*
15	*Data Validation*	*1 day*	*Tue 7/30/24*	*Tue 7/30/24*
16	*Report Completed*	*1 day*	*Mon 9/30/24*	*Mon 9/30/24*
17	**Monthly Progress Reports**	**175 days**	**Thu 2/15/24**	**Tue 10/15/24**
18	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
19	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
20	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
21	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
22	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
23	*May 2024 MPR*	*1 day*	*Mon 7/15/24*	*Mon 7/15/24*
24	*June 2024 MPR*	*1 day*	*Thu 8/15/24*	*Thu 8/15/24*
25	*July 2024 MPR*	*1 day*	*Mon 9/16/24*	*Mon 9/16/24*
26	August 2024 MPR	1 day	Tue 10/15/24	Tue 10/15/24
27	**Datagaps Workplan**	175 days	Mon 4/1/24	Fri 11/29/24
28	**Data Gaps Investigations**	87 days	Mon 12/2/24	Tue 4/1/25
29	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
30	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
31	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
32	*PDI Workplan Revisions*	*23 days*	*Wed 6/5/24*	*Fri 7/5/24*
33	*PDI Field Effort - Site Prep*	*15 days*	*Mon 6/17/24*	*Fri 7/5/24*
34	*PDI Field Effort - Soil Sampling Program*	*35 days*	*Mon 7/15/24*	*Fri 8/30/24*
35	PDI Field Effort - DPT	25 days	Mon 10/7/24	Fri 11/8/24
36	Treatability Study Testing	122 days	Mon 9/2/24	Tue 2/18/25
37	Pre-final Design Report	23 days	Wed 2/19/25	Fri 3/21/25
38	ODEQ Review	20 days	Mon 3/24/25	Fri 4/18/25
39	Final Design Report	21 days	Mon 4/21/25	Mon 5/19/25
40	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
41	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
42	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
43	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
44	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress	
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline		
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress		

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MEMO

TO	Katie Daugherty, ODEQ
FROM	Brendan Robinson, PE, ERM; Todd Slater, LSS
DATE	15 December 2024
REFERENCE	0732445.204
SUBJECT	Groundwater Source Control Measure Monthly Performance Monitoring Report

1. INTRODUCTION

The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with Legacy Site Services LLC (LSS) and Environmental Resources Management, Inc. (ERM) on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) at the Arkema site (Site) consistent with the Performance Monitoring Plan (PMP; ERM 2014[1]) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 Monthly Performance Monitoring Report (MPR), subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

On 6 June 2024, ODEQ requested that LSS and ERM reduce the scope of future MPRs to facilitate faster review. On 11 September 2024, ODEQ agreed for the first amended MPR to be the August 2024 MPR submitted in October 2024.

[1] ERM-West, Inc. 2014. *Revised Final Performance Monitoring Plan – Groundwater Source Control Measure, Arkema Inc. Facility, Portland, Oregon*. July 2014.

2. GWET SYSTEM PERFORMANCE

The average system influent flow rate was 24.37 gallons per minute (gpm) for the entire month of October 2024, including non-operational periods. The average operational influent flow during operational periods was 27.94 gpm.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. Ongoing redevelopment is anticipated in November 2024 to maintain the productivity of the groundwater extraction trenches, and conveyance line cleaning will be conducted as needed based on analysis of backpressure.

The increase in average monthly groundwater extraction rate in October 2024 compared to September 2024 is believed to be a result of an increase in groundwater elevations onsite as shown on Attachments A-1 and A-2. This is likely due to groundwater migration from upgradient sources, since the river elevation is near a 5-year low.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Groundwater Extraction Enhancement Final Design Report* (ERM 2022[2]) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

2.1 GWET PLANT OPERATIONS

The groundwater extraction and treatment (GWET) plant operated within permit conditions during the reporting period. There were three shutdowns:

- 7 October 2024: The wellfield was shut down for 0.5-hours to due to pump P-1 faulting.
- 22 October 2024: The plant and wellfield was shut down for 1-hour due to a PLC program download.
- 28 October 2024: The wellfield was shut down for 25-hours due to drilling for ongoing PDI work and PLC troubleshooting.

[2] ERM-West, Inc. 2022. *Final Design Report, Arkema Inc. Facility, Portland, Oregon*. May 2022.

3. CAPTURE ZONE EVALUATION

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the groundwater barrier wall (GWBW) and to evaluate the effective hydraulic capture produced by the GW SCM.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 11 October 2024. The Serfes (1991)[3] method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 11 October 2024 are shown in Attachment B-3 and Attachment B-4.

3.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

Groundwater elevation data collected on 11 October 2024 was used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench primarily on the north end of the Site in the Shallow and Intermediate Zones. Horizontal gradients at gradient control clusters (GCCs) across the Site are generally outward, but the magnitude of horizontal gradients is approaching zero as shown in Attachments B-1 and B-2.

River elevations are shown over time on Attachments A-1 and A-2, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in October 2024 had an average elevation of 7.18 feet North American Vertical Datum of 1988 (NAVD88) with a minimum elevation of 4.76 feet NAVD88 and a maximum elevation of 10.22 feet NAVD88, a decrease compared to September 2024, and the lowest elevation observed in the last two years. The average Shallow and the average Intermediate Zone groundwater elevation increased from September 2024. The river elevation has largely been trending downward since January 2024 but is anticipated to rise over the coming months as the seasonal rains begin. There was not as significant of a seasonal rise in Willamette River level this spring compared to previous years.

To increase the volume of water drawn from the lowest elevations onsite, a pass-through packer is being deployed at Trench 6. The packer will block the vertical portions of the well screen at Trench

[3] Serfes, Michael. 1991. “Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations.” *Groundwater* 29(4): July–August.

6 from being used and will force groundwater to be extracted in the horizontal sections of the pipe at the bottom of the extraction trench to enable water to be drawn down further.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients and trend lines are shown in Attachments B-2 and B-4. Vertical groundwater gradients interior and exterior to the GWBW were primarily downward between the Shallow and Intermediate Zones and between the Intermediate and Deep Zones.

4. CONCLUSIONS

Analysis of horizontal gradients over time indicate that the extraction wells (EWs) are performing better than the historical recovery wells (RWs) and outward horizontal gradients are decreasing. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives. Redevelopment of the trenches is planned for November 2024 to mitigate accumulation of silt in the filter pack in both the vertical and horizontal sections using impulse redevelopment techniques, and resonant technology. These efforts, as well as the packers discussed above, will be targeted at trenches that are currently underperforming, including Trenches 1, 4, 5, and 6. LSS will continue to optimize new EWs, including pump maintenance and upgrades. Additional modifications to the system, if needed to progress toward capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

Brendan Robinson, PE
Partner

ATTACHMENTS

FIGURE 1 – SITE LAYOUT

FIGURE 2 – SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3 – INTERMEDIATE ZONE GROUNDWATER CONTOURS

FIGURE 4 – DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5 – SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE MAPS

FIGURE 6 – INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE MAPS

ATTACHMENT A-1 – OPERATIONAL PUMPING RATE GRAPH

ATTACHMENT A-2 – AVERAGE MONTHLY PUMPING RATE GRAPH

ATTACHMENT A-3 – GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

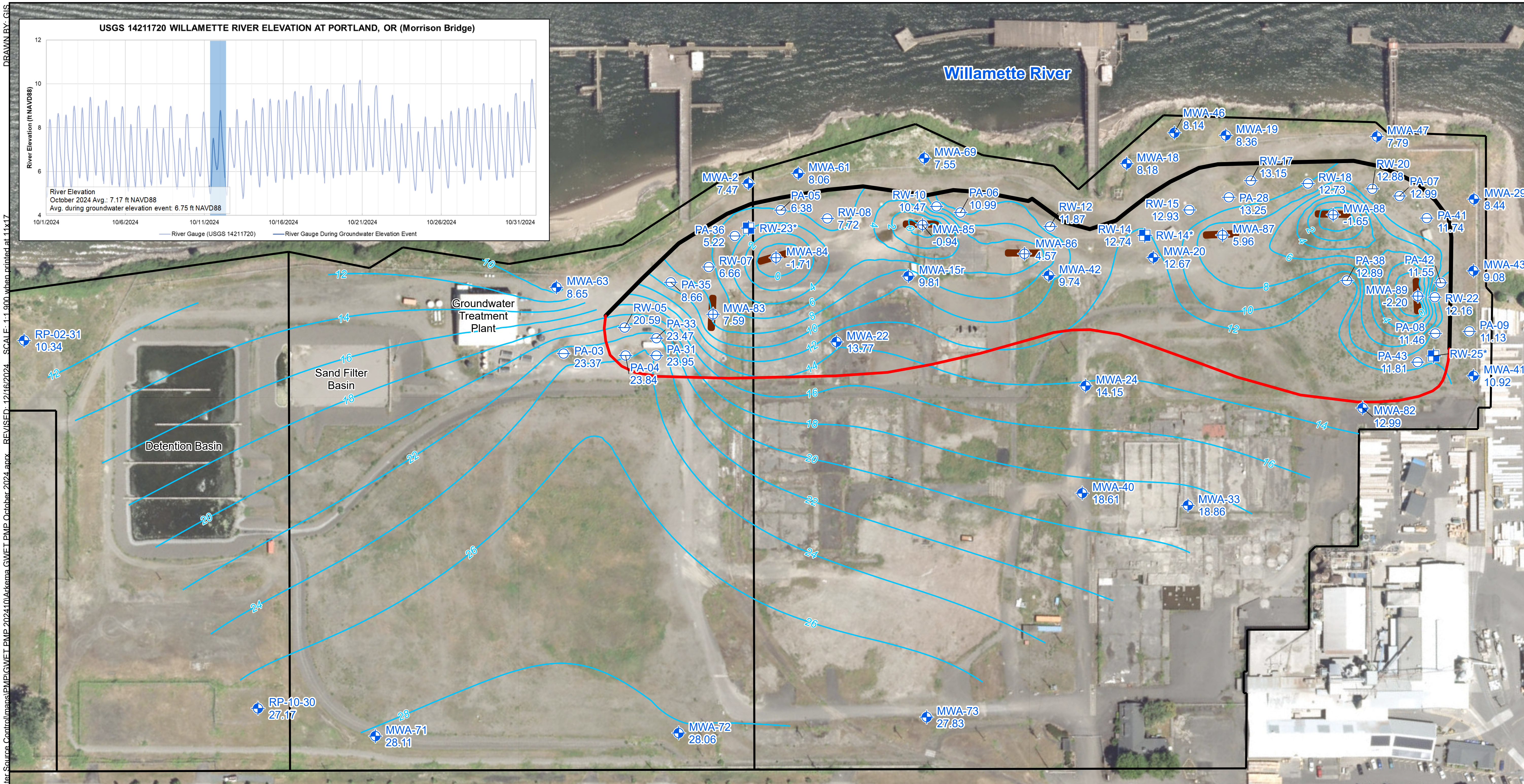
ATTACHMENT B-1 – HORIZONTAL GRADIENTS SUMMARY GRAPH

ATTACHMENT B-2 – VERTICAL GRADIENTS SUMMARY GRAPH

ATTACHMENT B-3 – WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

ATTACHMENT B-4 – WATER LEVELS AND VERTICAL GRADIENTS TABLE

ATTACHMENT C – PROJECT SCHEDULE



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected October, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
October 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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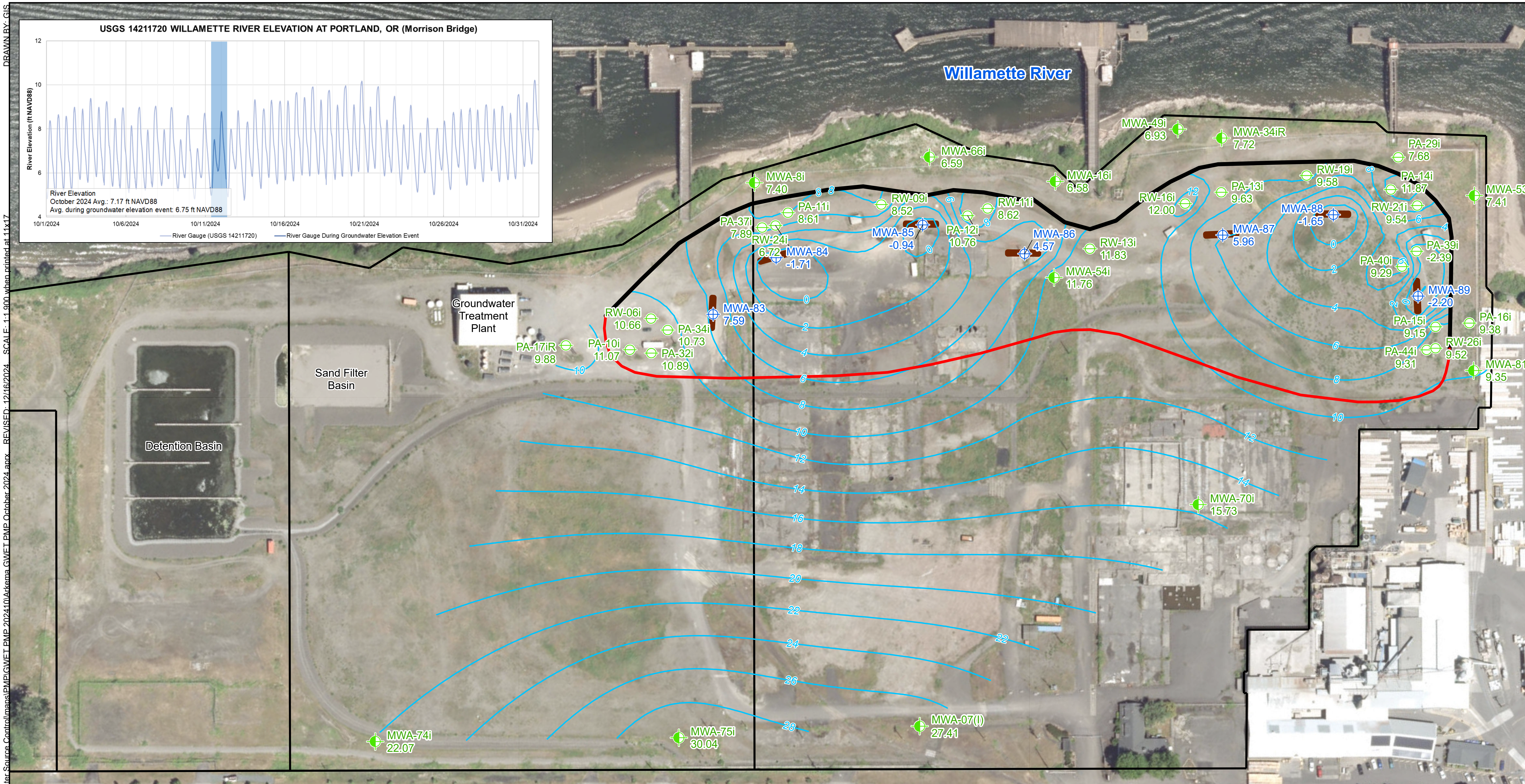

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected October, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
October 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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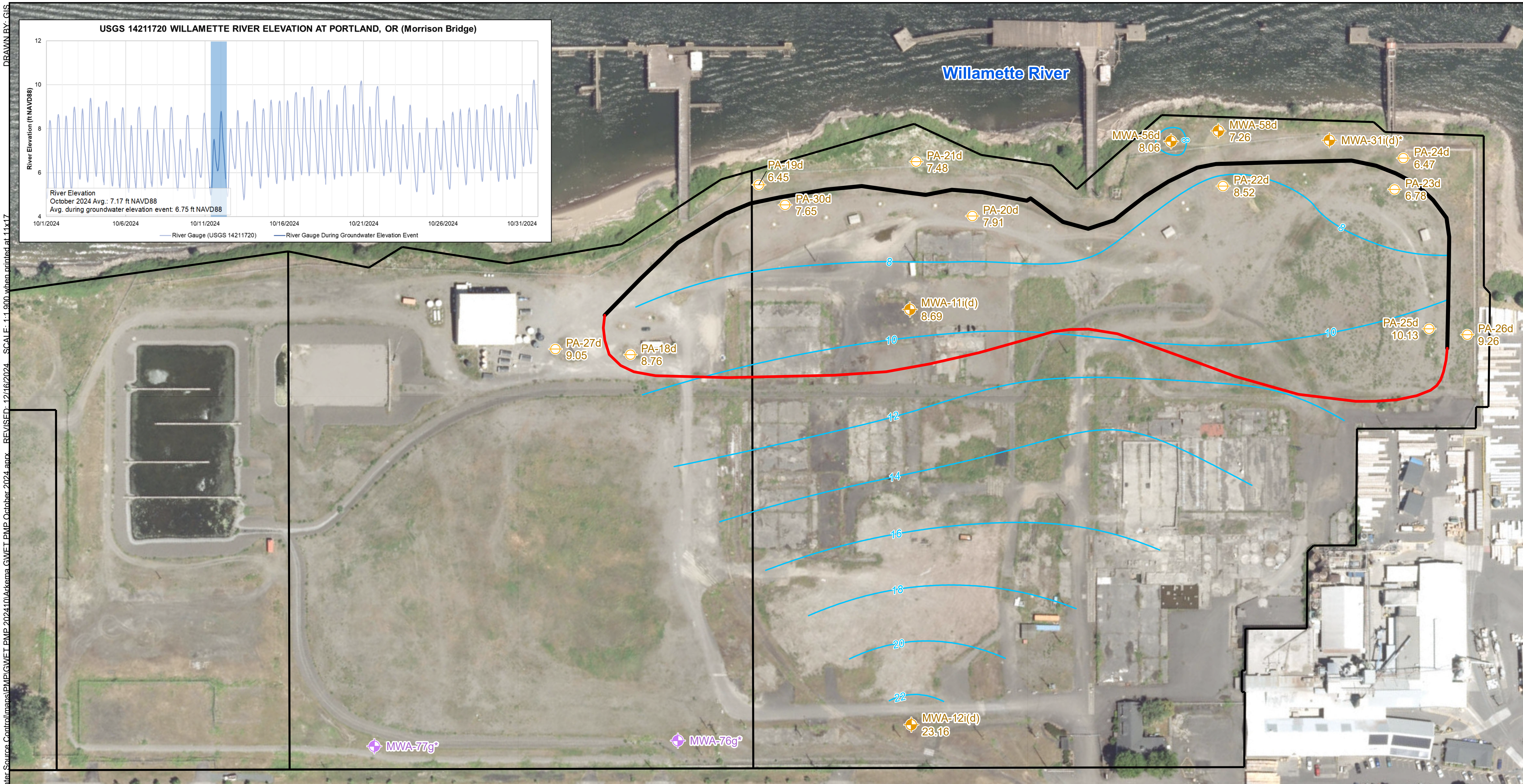

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected October, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
October 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Trench Extraction Well
- Active Recovery Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected October, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
October 2024 Shallow to Intermediate Zone Vertical Head Difference

Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow-Intermediate Zone Monitoring Well
- Trench Extraction Well
- Active Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected October, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
October 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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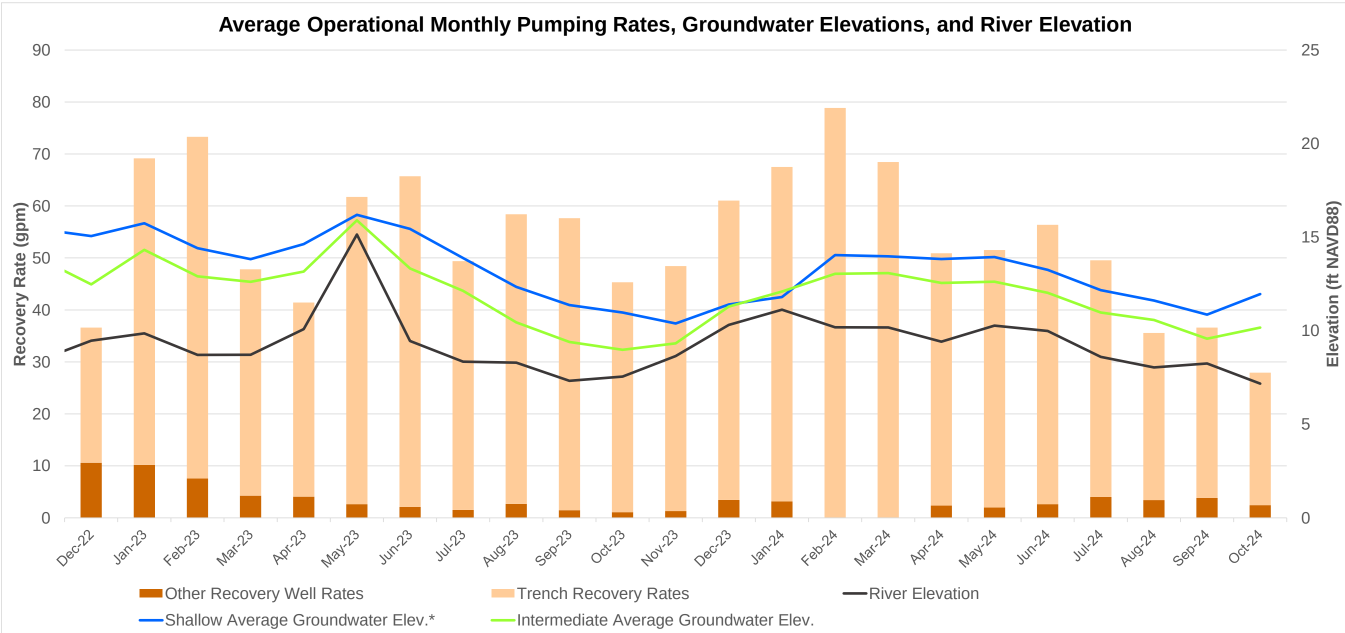
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 OPERATIONAL PUMPING RATE GRAPH

Attachment A-1

Operational Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon

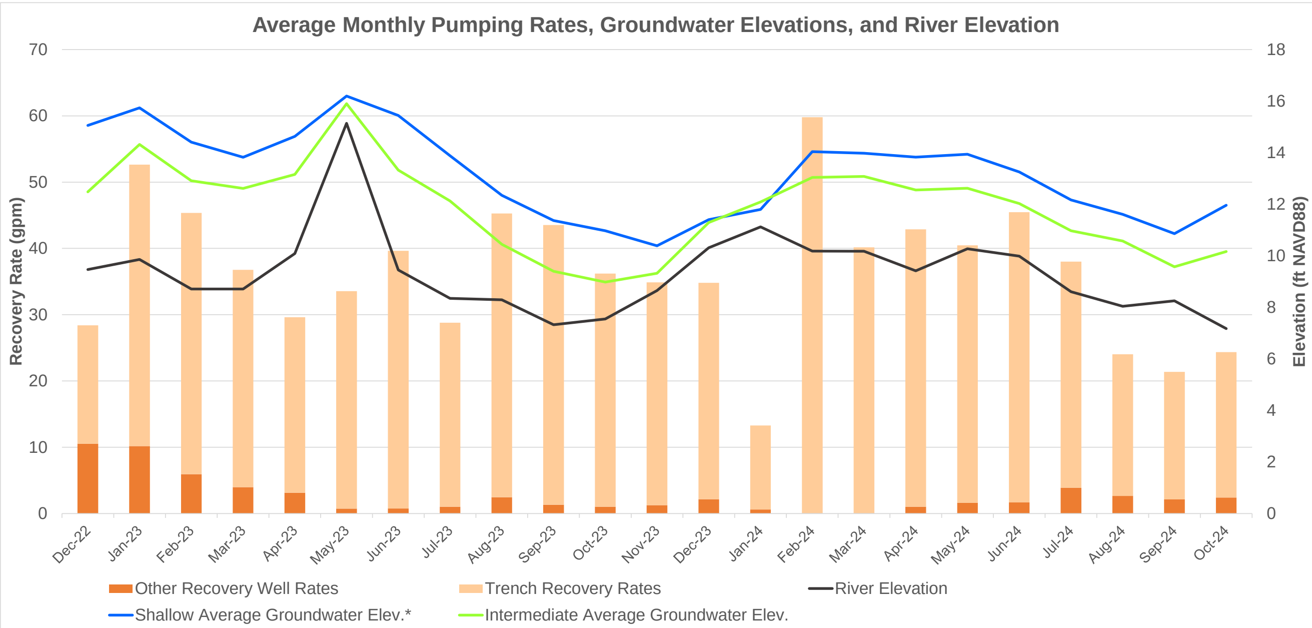


ERM

ATTACHMENT A-2 AVERAGE MONTHLY PUMPING RATE GRAPH

Attachment A-2

Average Monthly Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



ERM

ATTACHMENT A-3 GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

Attachment A-3

GWET System Groundwater Extraction Rates Table
Arkema Inc. Facility
Portland, Oregon

Recovery Well	October 2024 Average Operational Pumping Rate (gpm)	October 2024 Average Monthly Pumping Rate (gpm)
RW-14	0.91	0.91
RW-22*	0.00	0.00
RW-23	0.28	0.28
RW-25	1.26	1.22
EW-01	0.61	0.43
EW-02*	0.00	0.00
EW-03	8.71	8.71
EW-04*	0.00	0.00
EW-05	2.64	0.26
EW-06	4.55	4.26
EW-07*	0.00	0.00
EW-08	0.88	0.71
EW-09	1.42	1.15
EW-10*	0.00	0.00
EW-11	1.22	0.98
EW-12*	0.00	0.00
EW-13	5.47	5.47
EW-14*	0.00	0.00
Total	27.94	24.37

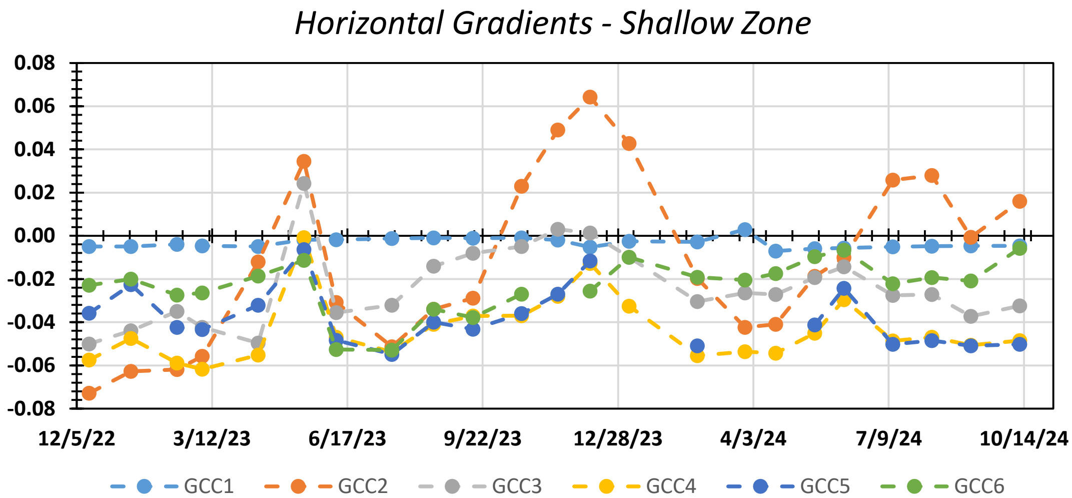
* = Recovery well not in service during reporting period

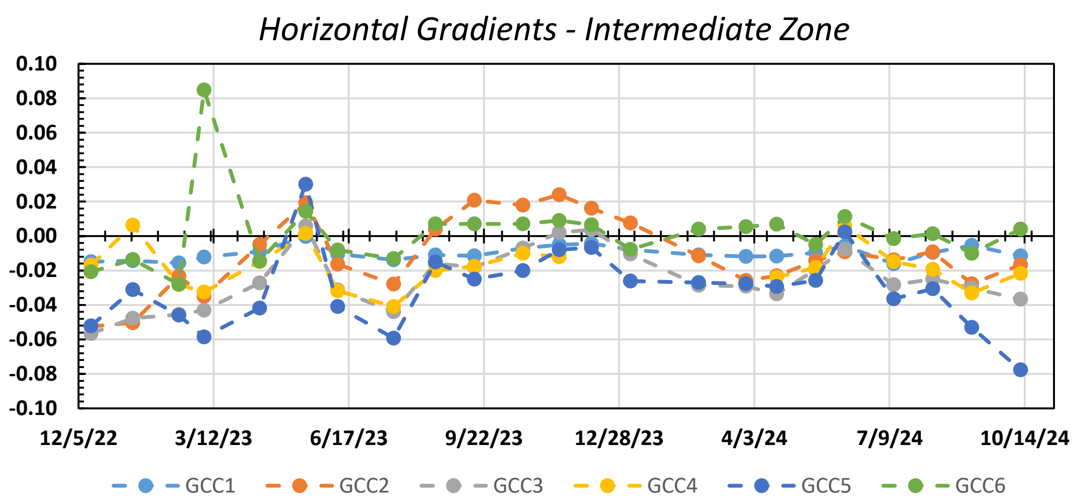
gpm = gallon per minute

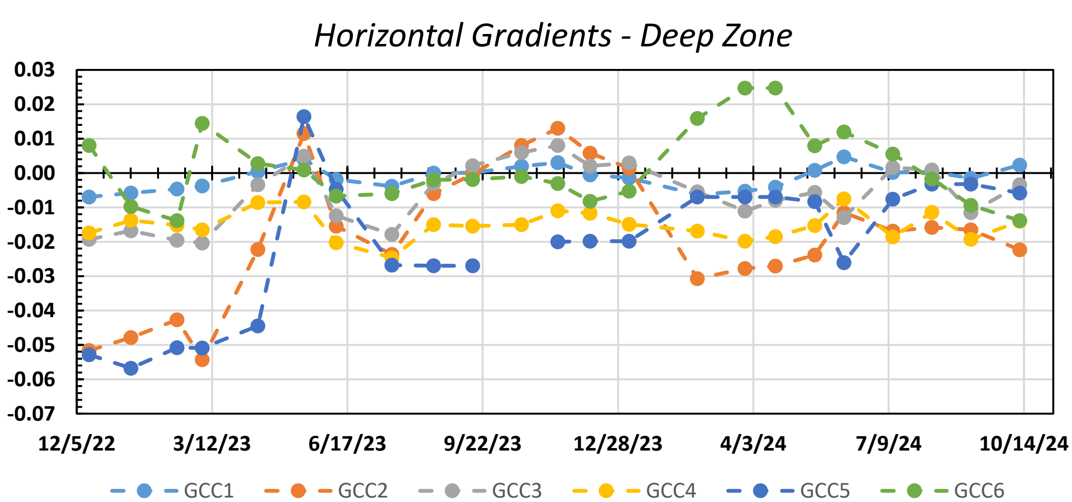
ATTACHMENT B-1 HORIZONTAL GRADIENTS SUMMARY GRAPH

Attachment B-1

Horizontal Gradients Summary: October 2024
Arkema Inc. Facility
Portland, Oregon





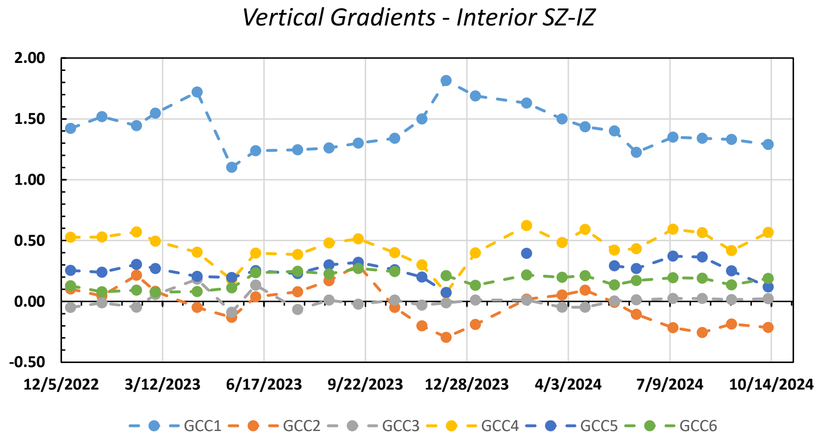


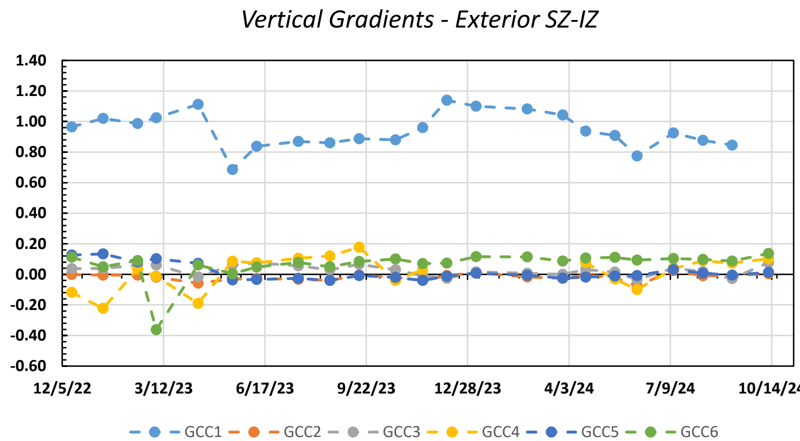
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

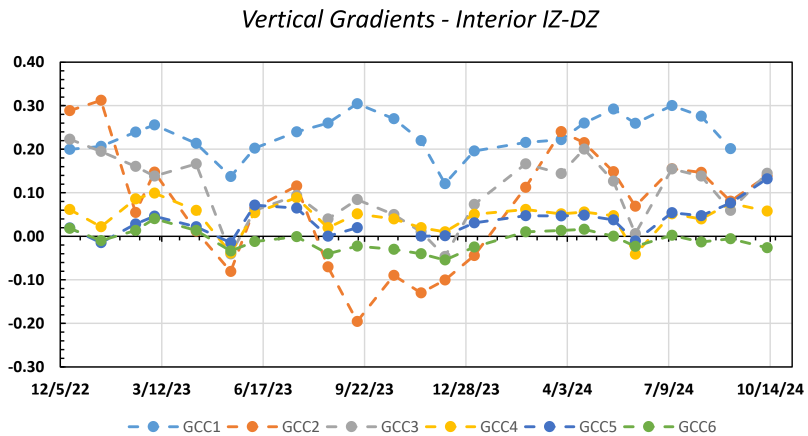
ATTACHMENT B-2 VERTICAL GRADIENTS SUMMARY GRAPH

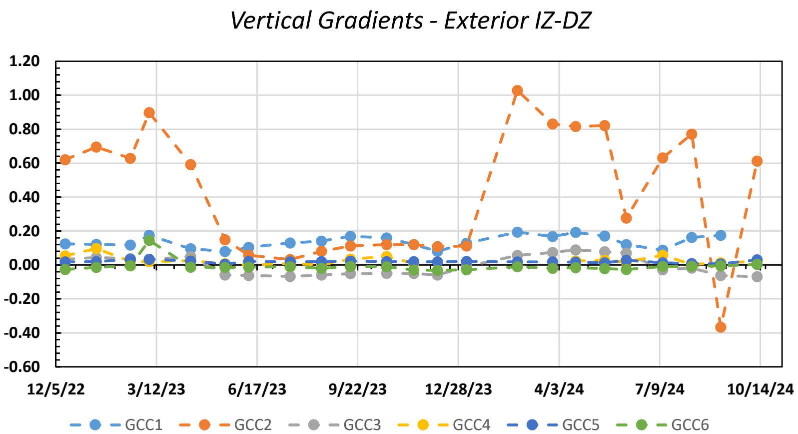
Attachment B-2

Vertical Gradients Summary: October 2024
Arkema Inc. Facility
Portland, Oregon









ATTACHMENT B-3 WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

Attachment B-3

Water Levels and Horizontal Gradients Table
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	23.37	PA-04	23.84	-0.005
	Intermediate	PA-17iR	9.88	PA-10i	11.07	-0.011
	Deep	PA-27d	9.05	PA-18d	8.76	0.002
GCC2	Shallow	MWA-2	7.47	PA-05	6.38	0.016
	Intermediate	MWA-8i	7.40	PA-11i	8.61	-0.017
	Deep	PA-19d	6.45	PA-30d	7.65	-0.022
GCC3	Shallow	MWA-69	7.55	PA-06	10.99	-0.032
	Intermediate	MWA-66i	6.59	PA-12i	10.76	-0.037
	Deep	PA-21d	7.48	PA-20d	7.91	-0.003
GCC4	Shallow	MWA-19	8.36	PA-28	13.25	-0.048
	Intermediate	MWA-34iR	7.72	PA-13i	9.63	-0.022
	Deep	MWA-58d	7.26	PA-22d	8.52	-0.014
GCC5	Shallow	MWA-47	7.79	PA-07	12.99	-0.050
	Intermediate	PA-29i	7.68	PA-14i	11.87	-0.078
	Deep	PA-24d	6.47	PA-23d	6.78	-0.006
GCC6	Shallow	PA-09	11.13	PA-08	11.46	-0.006
	Intermediate	PA-16i	9.38	PA-15i	9.15	0.004
	Deep	PA-26d	9.26	PA-25d	10.13	-0.014

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

* = anonalous groundwater elevation

** = horizontal gradient cannot be calculated due to anomalous elevation reading

ft NAVD88 = feet North American Vertical Datum of 1988

^{M} = manual groundwater elevation measurement

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ATTACHMENT B-4 WATER LEVELS AND VERTICAL GRADIENTS TABLE

Attachment B-4

Water Levels and Vertical Gradients Table
Arkema Inc. Facility
Portland, Oregon

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	23.84	PA-10i	11.07	1.29
		GCC2	PA-05	6.38	PA-11i	8.61	-0.21
		GCC3	PA-06	10.99	PA-12i	10.76	0.02
		GCC4	PA-28	13.25	PA-13i	9.63	0.57
		GCC5	PA-07	12.99	PA-14i	11.87	0.12
		GCC6	PA-08	11.46	PA-15i	9.15	0.19
	IZ-DZ	GCC1	PA-10i	11.07	PA-18d	8.76	0.31
		GCC2	PA-11i	8.61	PA-30d	7.65	0.14
		GCC3	PA-12i	10.76	PA-20d	7.91	0.14
		GCC4	PA-13i	9.63	PA-22d	8.52	0.06
		GCC5	PA-14i	11.87	PA-23d	6.78	0.13
		GCC6	PA-15i	9.15	PA-25d	10.13	-0.03
Exterior	SZ-IZ	GCC1	PA-03	23.37	PA-17iR^{M}	9.88	0.86
		GCC2	MWA-2	7.47	MWA-8i	7.40	0.00
		GCC3	MWA-69	7.55	MWA-66i	6.59	0.08
		GCC4	MWA-19	8.36	MWA-34iR	7.72	0.10
		GCC5	MWA-47	7.79	PA-29i	7.68	0.01
		GCC6	PA-09	11.13	PA-16i	9.38	0.14
	IZ-DZ	GCC1	PA-17iR^{M}	9.88	PA-27d	9.05	0.13
		GCC2	MWA-8i	7.40	PA-19d	6.45	0.61
		GCC3	MWA-66i	6.59	PA-21d	7.48	-0.07
		GCC4	MWA-34iR	7.72	MWA-58d	7.26	0.02
		GCC5	PA-29i	7.68	PA-24d	6.47	0.03
		GCC6	PA-16i	9.38	PA-26d	9.26	0.00

Positive vertical gradient indicates an donward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anonalous groundwater elevation
** = vertical gradient cannot be calculated due to anomalous elevation reading
DZ = Deep Zone
ft NAVD88 = feet North American Vertical Datum of 1988
IZ = Intermediate Zone
^{M} = manual groundwater elevation measurement
SZ = Shallow Zone

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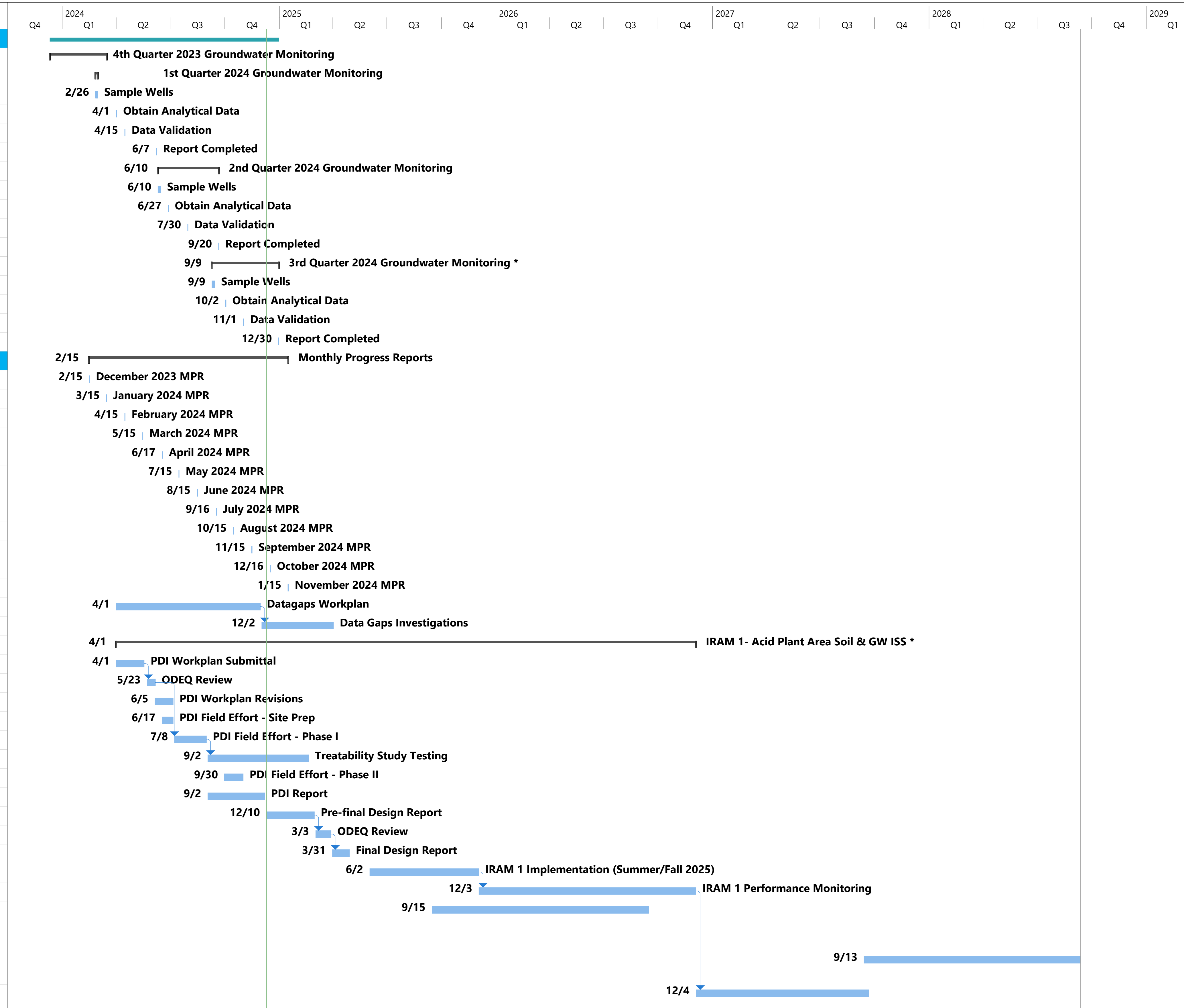
ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring**	**75 days**	**Mon 6/10/24**	**Fri 9/20/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	*Obtain Analytical Data*	*1 day*	*Thu 6/27/24*	*Thu 6/27/24*
15	*Data Validation*	*1 day*	*Tue 7/30/24*	*Tue 7/30/24*
16	*Report Completed*	*1 day*	*Fri 9/20/24*	*Fri 9/20/24*
17	**3rd Quarter 2024 Groundwater Monitoring ***	**81 days**	**Mon 9/9/24**	**Mon 12/30/24**
18	*Sample Wells*	*5 days*	*Mon 9/9/24*	*Fri 9/13/24*
19	*Obtain Analytical Data*	*1 day*	*Wed 10/2/24*	*Wed 10/2/24*
20	*Data Validation*	*1 day*	*Fri 11/1/24*	*Fri 11/1/24*
21	Report Completed	1 day	Mon 12/30/24	Mon 12/30/24
22	**Monthly Progress Reports**	**241 days**	**Thu 2/15/24**	**Wed 1/15/25**
23	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
24	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
25	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
26	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
27	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
28	*May 2024 MPR*	*1 day*	*Mon 7/15/24*	*Mon 7/15/24*
29	*June 2024 MPR*	*1 day*	*Thu 8/15/24*	*Thu 8/15/24*
30	*July 2024 MPR*	*1 day*	*Mon 9/16/24*	*Mon 9/16/24*
31	*August 2024 MPR*	*1 day*	*Tue 10/15/24*	*Tue 10/15/24*
32	*September 2024 MPR*	*1 day*	*Fri 11/15/24*	*Fri 11/15/24*
33	October 2024 MPR	1 day	Mon 12/16/24	Mon 12/16/24
34	November 2024 MPR	1 day	Wed 1/15/25	Wed 1/15/25
35	**Datagaps Workplan**	175 days	Mon 4/1/24	Fri 11/29/24
36	**Data Gaps Investigations**	87 days	Mon 12/2/24	Tue 4/1/25
37	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
38	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
39	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
40	*PDI Workplan Revisions*	*23 days*	*Wed 6/5/24*	*Fri 7/5/24*
41	*PDI Field Effort - Site Prep*	*15 days*	*Mon 6/17/24*	*Fri 7/5/24*
42	PDI Field Effort - Phase I	40 days	Mon 7/8/24	Fri 8/30/24
43	Treatability Study Testing	122 days	Mon 9/2/24	Tue 2/18/25
44	PDI Field Effort - Phase II	24 days	Mon 9/30/24	Thu 10/31/24
45	PDI Report	70 days	Mon 9/2/24	Fri 12/6/24
46	Pre-final Design Report	59 days	Tue 12/10/24	Fri 2/28/25
47	ODEQ Review	20 days	Mon 3/3/25	Fri 3/28/25
48	Final Design Report	21 days	Mon 3/31/25	Mon 4/28/25
49	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
50	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
51	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
52	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
53	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

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MEMO

TO	Katie Daugherty, ODEQ
FROM	Brendan Robinson, PE, ERM; Todd Slater, LSS
DATE	17 January 2025
REFERENCE	0732445.204
SUBJECT	Groundwater Source Control Measure Monthly Performance Monitoring Report

1. INTRODUCTION

The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with Legacy Site Services LLC (LSS) and Environmental Resources Management, Inc. (ERM) on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) at the Arkema site (Site) consistent with the Performance Monitoring Plan (PMP; ERM 2014[1]) beginning July 2019. The Site is located at 6400 NW Front Avenue in Portland, Oregon, and the Site location is shown on Figure 1. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 Monthly Performance Monitoring Report (MPR), subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

On 6 June 2024, ODEQ requested that LSS and ERM reduce the scope of future MPRs to facilitate faster review. On 11 September 2024, ODEQ agreed for the first amended MPR to be the August 2024 MPR submitted in October 2024.

[1] ERM-West, Inc. 2014. *Revised Final Performance Monitoring Plan – Groundwater Source Control Measure, Arkema Inc. Facility, Portland, Oregon*. July 2014.

2. GWET SYSTEM PERFORMANCE

The average system influent flow rate was 27.53 gallons per minute (gpm) for the entire month of November 2024, including non-operational periods. The average operational influent flow during operational periods was 27.53 gpm.

Extraction wells, pumps, and conveyance lines become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address pump fouling. Regularly scheduled redevelopment is anticipated to maintain the productivity of the groundwater extraction trenches and recovery wells. Conveyance line cleaning will be conducted as needed based on analysis of backpressure.

Compared to October 2024, the November 2024 average system influent flow rate was 3.16 gpm greater. During this same time period, the average Shallow Zone groundwater elevation decreased by 0.89 feet, and the average Intermediate Zone groundwater elevation increased by 0.83 feet, as shown on Attachments A-1 and A-2. The increase in average monthly groundwater extraction rate in November 2024 compared to October 2024 may be a result of seasonal increases in upgradient groundwater flow onto the Site and/or changes in the river stage.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Groundwater Extraction Enhancement Final Design Report* (ERM 2022[2]) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

Actions taken in November 2024 to optimize flow rates included:

- Installing two packers in Trench 6, one on each vertical riser. Pump EW-12 was removed and a solid packer was installed on that side. At EW-11, a pass-through packer was installed with a pump below the packer. This approach isolated the vertical and horizontal screens from each other, concentrating extraction from the horizontal screen and lowering the pump intake. This change lowered the water level in Trench 6 from approximately 2.5 feet to 2.0 feet, and flow increased approximately 50 percent from 2 to 3 gpm. This approach will be evaluated further and considered at other extraction trench locations based on long-term monitoring results.
- Initiating an evaluation of a vibratory resonance tool to redevelop and maintain trenches during groundwater extraction by agitating silt out of the formation.
- Procuring and testing a smaller Hydropuls device to focus redevelopment of the horizontal well screens in the extraction wells. Redevelopment of the horizontal screen section is scheduled for January 2025.

2.1 GWET PLANT OPERATIONS

The groundwater extraction and treatment (GWET) plant operated within permit conditions during the reporting period. There was one shutdown:

[2] ERM-West, Inc. 2022. *Final Design Report, Arkema Inc. Facility, Portland, Oregon*. May 2022.

- 30 November 2024: The GWET system was shut down for 1 hour to repair the pressure filter (PF-2) valves.

3. CAPTURE ZONE EVALUATION

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the groundwater barrier wall (GWBW) and to evaluate the effective hydraulic capture produced by the GW SCM.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 8 November 2024. The Serfes (1991)[3] method was used to account for tidal variations of groundwater and river elevations as described in the PMP. Horizontal and vertical gradients were calculated and plotted over time as shown in Attachments B-1 and B-2. Groundwater elevations, horizontal gradients, and vertical gradients from 8 November 2024 are tabulated in Attachment B-3 and Attachment B-4.

3.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

Groundwater elevation data collected on 8 November 2024 was used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical gradient difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows groundwater flow from upgradient toward the GWBW. Potentiometric surface maps (Figures 2, 3, and 4) show generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around the groundwater extraction trenches in the Shallow and Intermediate Zones. Horizontal gradient at gradient control cluster 2 (GCC 2) was inward in October and November 2024, nearly zero at GCC 1 and GCC 6, and decreasingly outward at GCC 3, GCC 4, and GCC 5, as shown in Attachments B-1 and B-2.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients and trend lines are shown in Attachments B-2 and B-4. Vertical groundwater gradients exterior to the GWBW were neutral to slightly downward between the Shallow and Intermediate Zones and between the Intermediate and Deep Zones.

Vertical gradients interior to the GWBW between the Shallow Zone and Intermediate Zone were inward at GCC 2, nearly neutral at GCC 3 and GCC 5, and downward at GCC 6, GCC 4, and GCC 1. Note that the vertical gradient for GCC 1 is exaggerated as a result of the localized pressure zone where soils are tight and water is relatively immobile. Vertical gradients interior to the GWBW between the Intermediate Zone and Deep Zone upward at GCC 6, nearly neutral at GCC 2 and

---

[3] Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater* 29(4): July–August.

GCC 4, and downward at GCC3 and GCC 5. Vertical gradient could not be calculated for GCC 1 because of a transducer failure.

River elevations are shown over time on Attachments A-1 and A-2, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation has generally been trending downward since January 2024. The river elevation in November 2024 had an average elevation of 9.29 feet North American Vertical Datum of 1988 (NAVD88) with a minimum elevation of 6.36 feet NAVD88 and a maximum elevation of 13.00 feet NAVD88, an increase of 2.12 feet NAVD88 compared to October 2024. This increase in river elevation is the first meaningful increase in river elevation since October 2023.

The average Shallow Zone groundwater elevation in November decreased from October by 0.89 feet and the average Intermediate Zone groundwater elevation increased from October by 0.83 feet. The contradictory movement of groundwater elevations is likely an artifact of the seasonal increases in upgradient groundwater flow.

4. CONCLUSIONS

Analysis of horizontal gradients over time indicate that the extraction wells are performing better than the historical recovery wells, and horizontal gradients are periodically inward, and the magnitude of outward gradients are decreasing over time, as shown on Attachment B-1. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives. Redevelopment of the trenches is planned to mitigate accumulation of silt in the filter pack in both the vertical and horizontal sections using impulse redevelopment techniques, and resonant technology. These efforts, as well as the packers discussed above, will be targeted at trenches that are currently underperforming, including Trenches 1, 4, 5, and 6. LSS will continue to optimize new extraction wells, including pump maintenance and upgrades. Additional modifications to the system, if needed to progress toward capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Attachment D shows the average influent groundwater flow rate from April 2019 through October 2024. As shown on this figure, the extraction trenches are removing approximately three times more water than the legacy system and achieving lower horizontal gradients over time.

Regards,

Brendan Robinson, PE
Partner

ATTACHMENTS

FIGURE 1 – SITE LAYOUT

FIGURE 2 – SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3 – INTERMEDIATE ZONE GROUNDWATER CONTOURS

FIGURE 4 – DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5 – SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE MAPS

FIGURE 6 – INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE MAPS

ATTACHMENT A-1 – OPERATIONAL PUMPING RATE GRAPH

ATTACHMENT A-2 – AVERAGE MONTHLY PUMPING RATE GRAPH

ATTACHMENT A-3 – GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

ATTACHMENT B-1 – HORIZONTAL GRADIENTS SUMMARY GRAPH

ATTACHMENT B-2 – VERTICAL GRADIENTS SUMMARY GRAPH

ATTACHMENT B-3 – WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

ATTACHMENT B-4 – WATER LEVELS AND VERTICAL GRADIENTS TABLE

ATTACHMENT C – PROJECT SCHEDULE

ATTACHMENT D – AVERAGE GROUNDWATER EXTRACTION RATE GRAPH

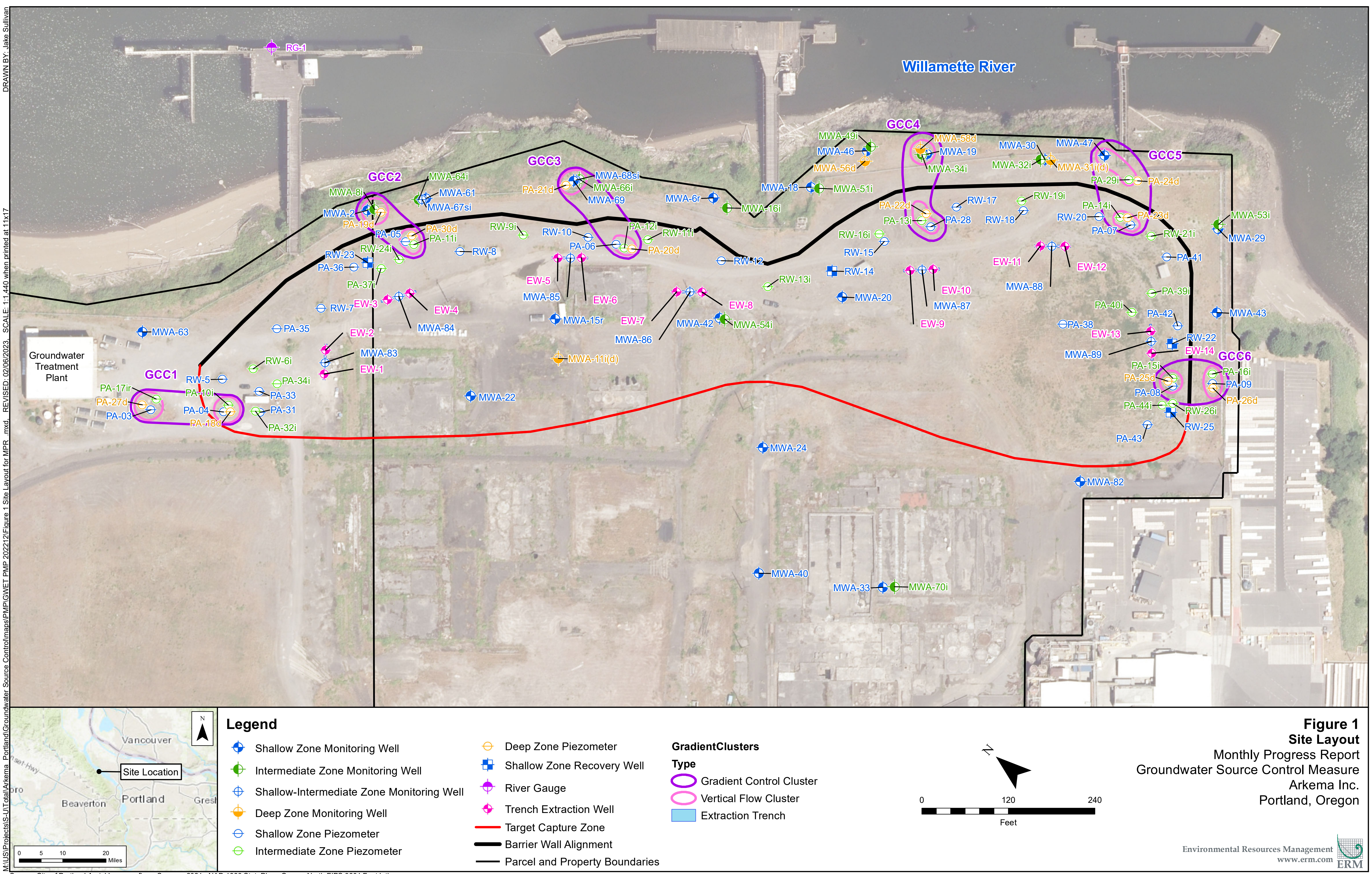
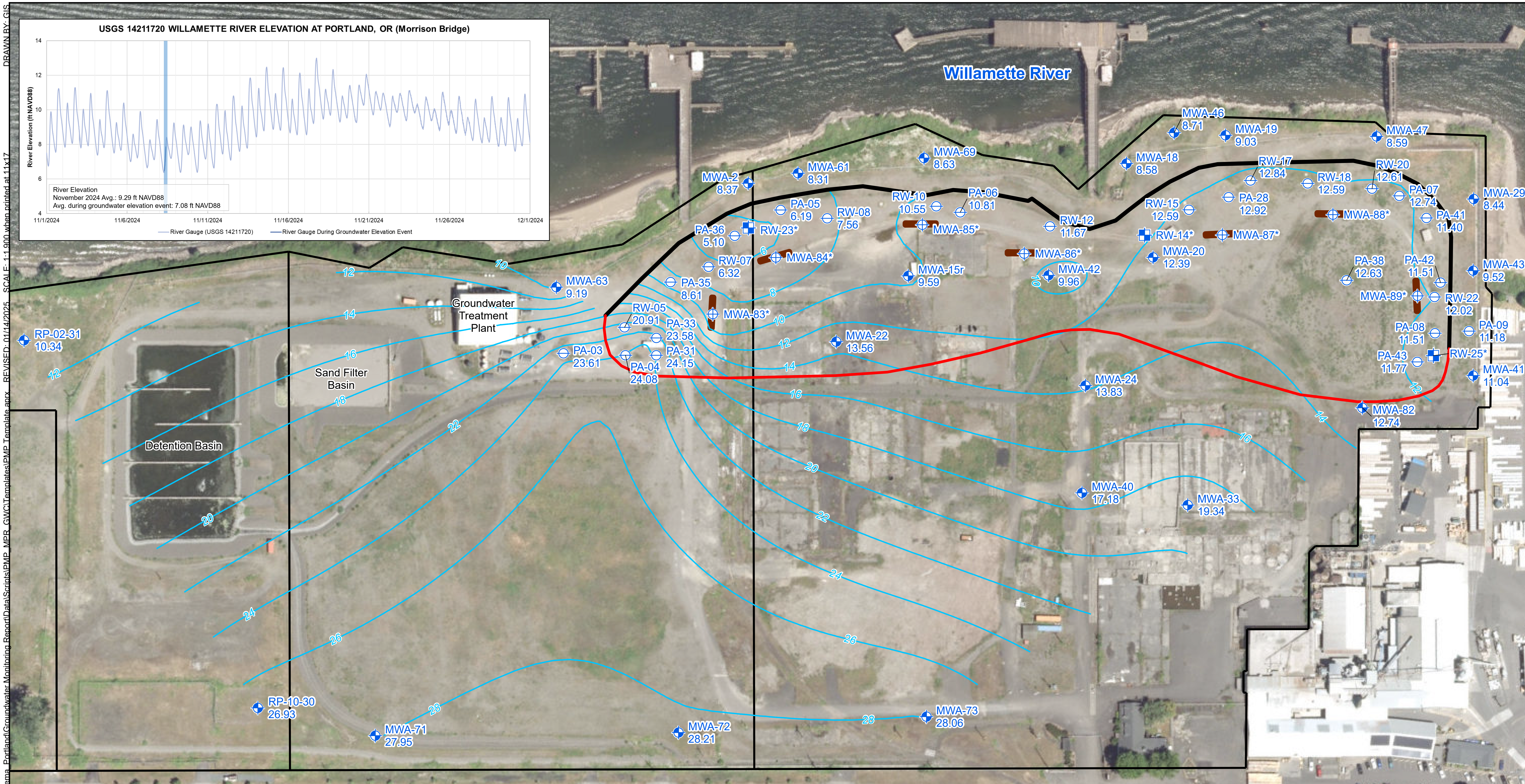


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected November, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

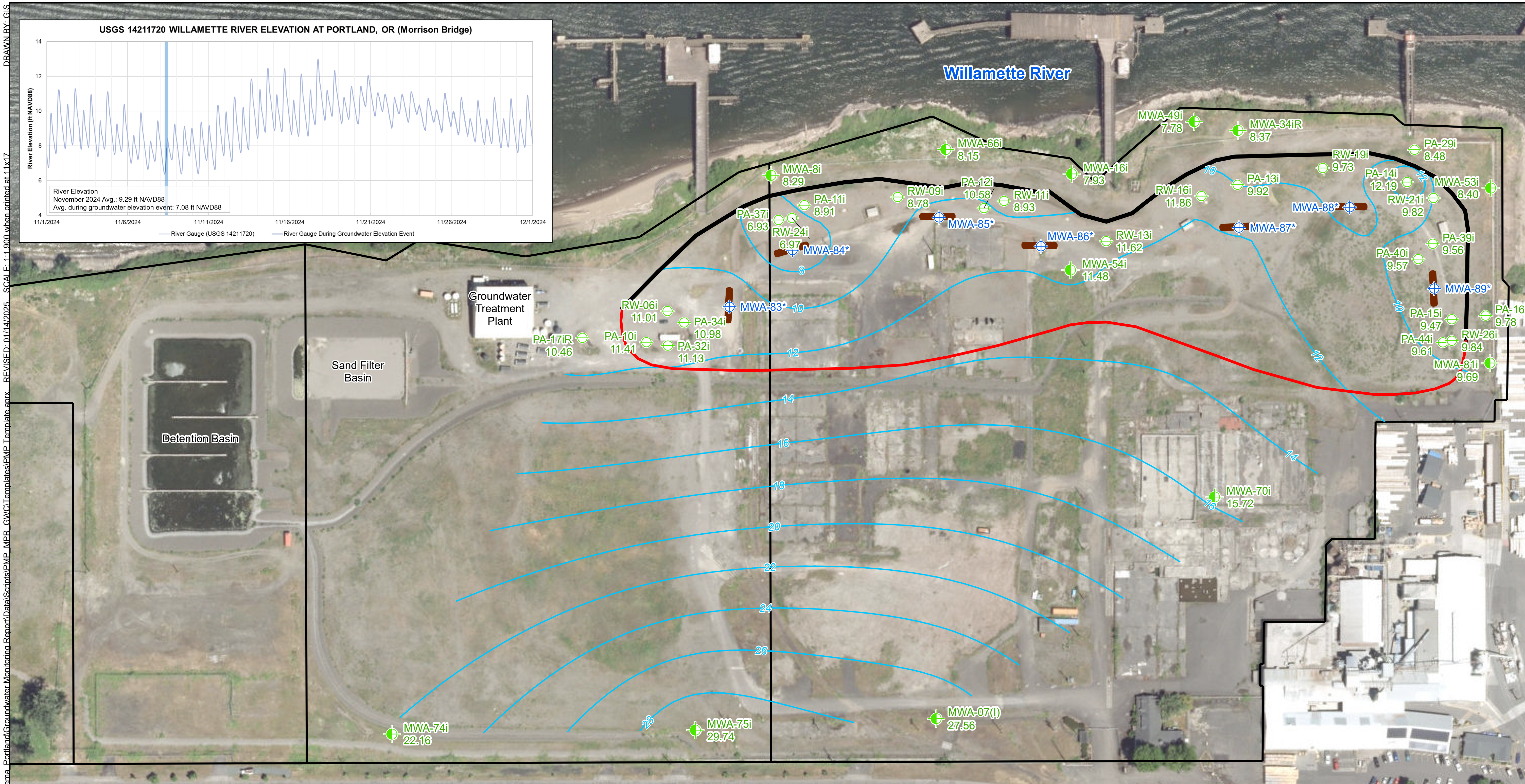
0 160 320
Feet

Figure 2
November 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\PMP_MPR_GWC\Templates\PMP Template.aprx REVISED: 01/14/2025 SCALE: 1:1,900 when printed at 11x17 DRAWN BY: GIS



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected November, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
November 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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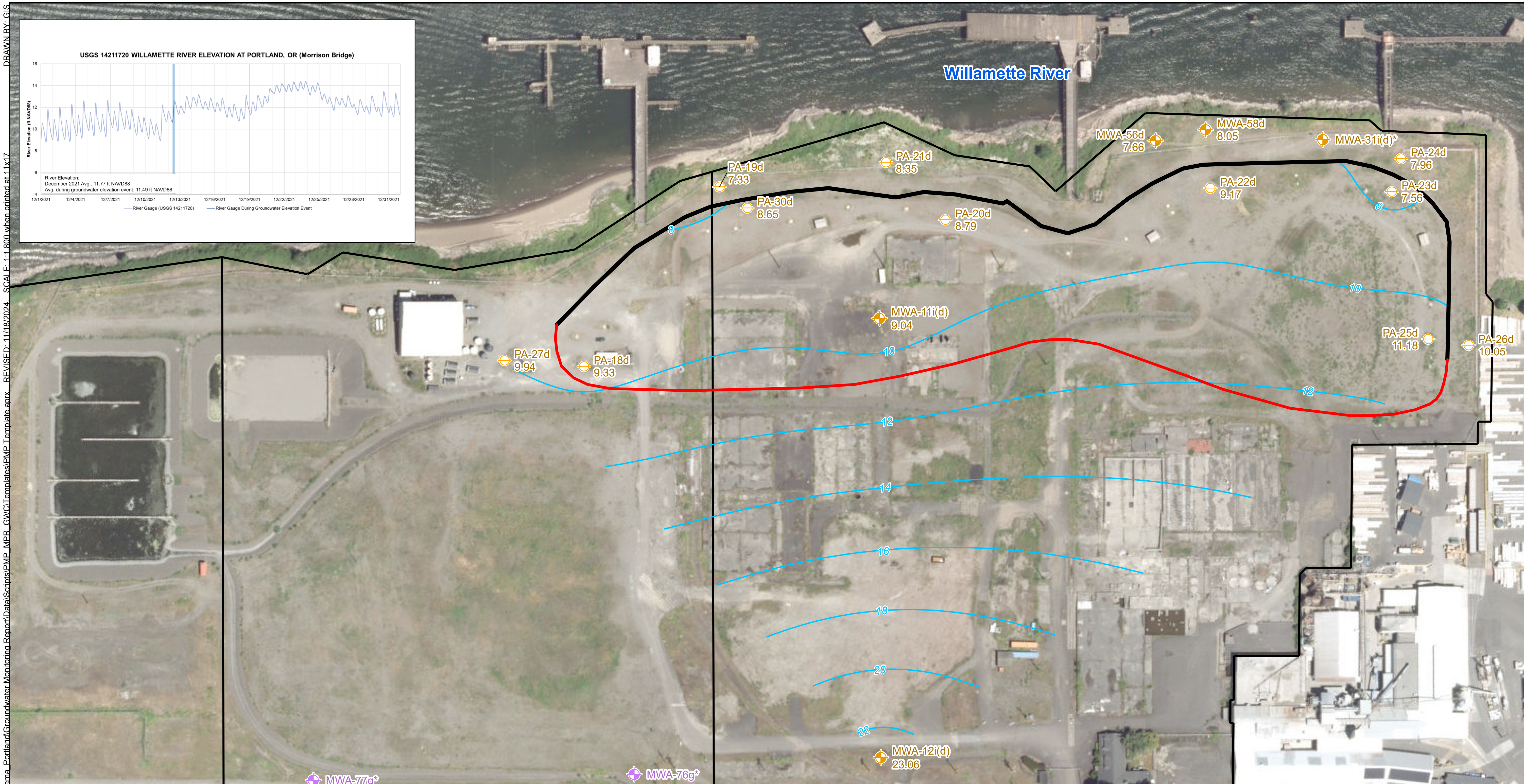

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Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected November, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
November 2024 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Trench Extraction Well
- Active Recovery Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected November, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
November 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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DRAWN BY: GIS SCALE: 1:1,560 when printed at 11x17 REVISED: 11/18/2024

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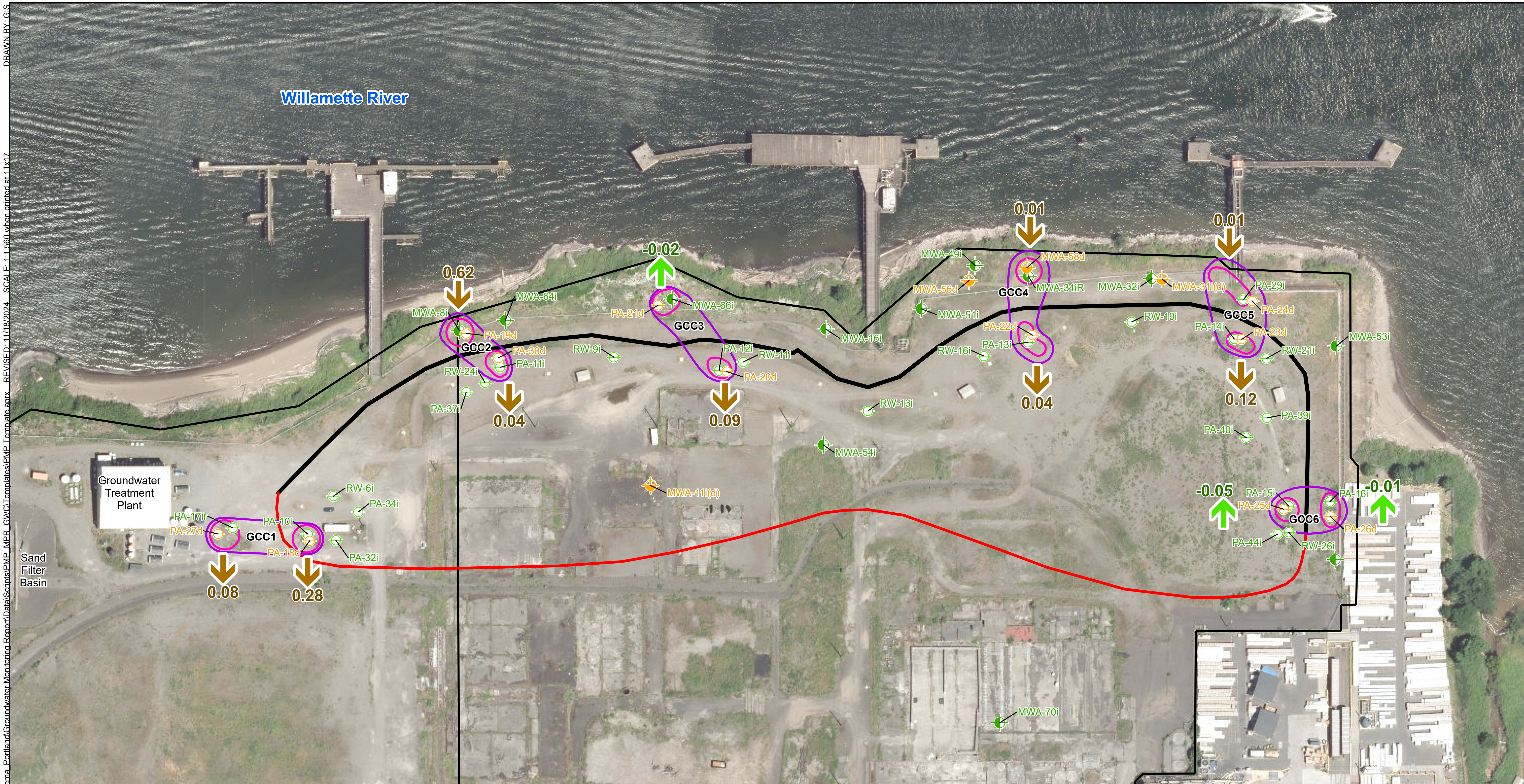
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow-Intermediate Zone Monitoring Well
- Trench Extraction Well
- Active Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected November, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
November 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\PMP_MPR_GW\Templates\PMP Template.aprx REVISED: 11/18/2024 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: GIS

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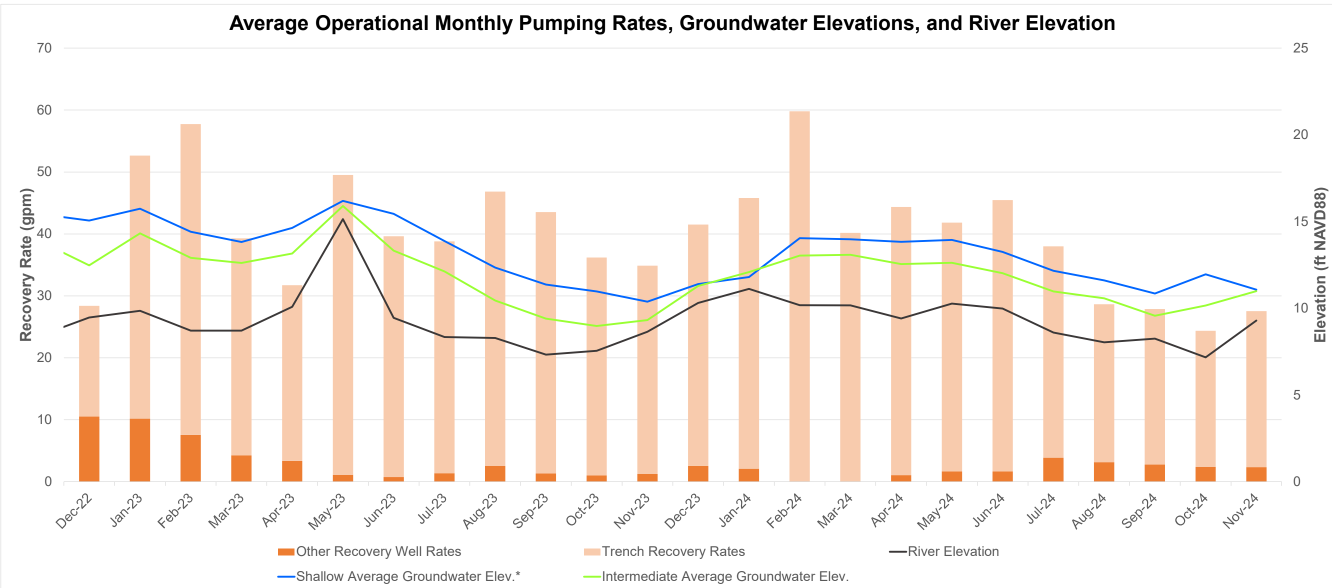
ATTACHMENT A-1 OPERATIONAL PUMPING RATE GRAPH

Attachment A-1

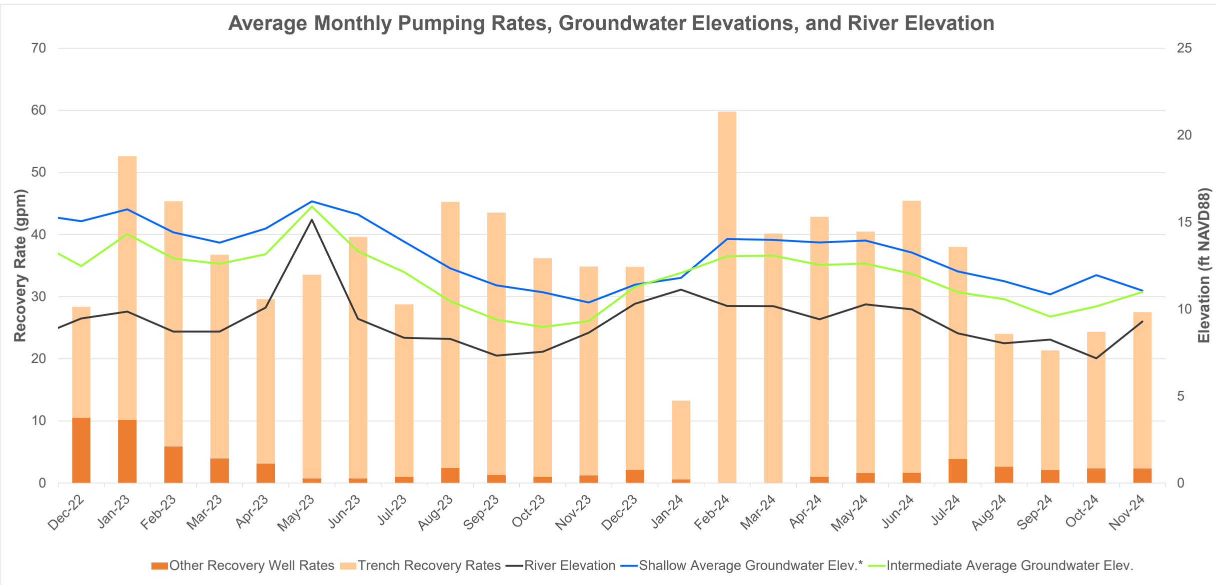
Operational Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



ATTACHMENT A-2 AVERAGE MONTHLY PUMPING RATE GRAPH

Attachment A-2

Average Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



ATTACHMENT A-3 GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

Attachment A-3

GWET System Groundwater Extraction Rates Table
Arkema Inc. Facility
Portland, Oregon

Recovery Well	November 2024 Average Operational Pumping Rate (gpm)	November 2024 Average Monthly Pumping Rate (gpm)
RW-14	0.59	0.59
RW-22*	0.00	0.00
RW-23	0.62	0.62
RW-25	1.16	1.16
EW-01	0.84	0.84
EW-02*	0.00	0.00
EW-03	8.73	8.73
EW-04	0.05	0.05
EW-05*	0.00	0.00
EW-06	4.75	4.75
EW-07*	0.00	0.00
EW-08	1.76	1.76
EW-09	1.50	1.50
EW-10*	0.00	0.00
EW-11	0.57	0.57
EW-12	1.20	1.20
EW-13	5.70	5.70
EW-14	0.07	0.07
Total	27.53	27.53

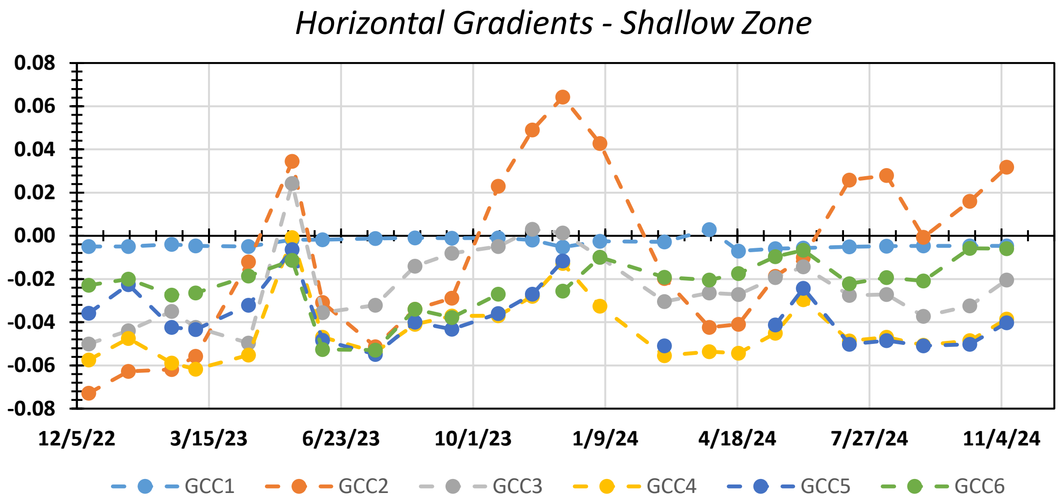
* = Recovery well not in service during reporting period

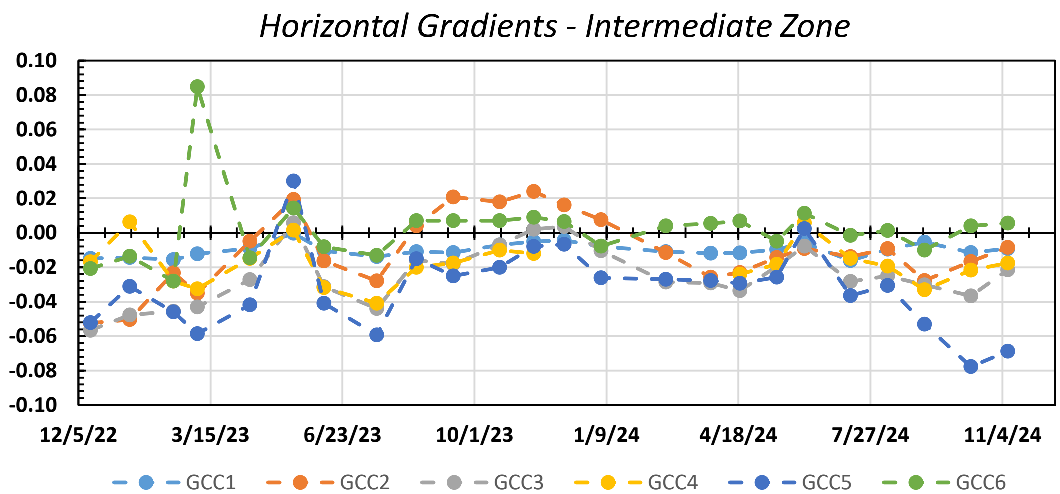
gpm = gallon per minute

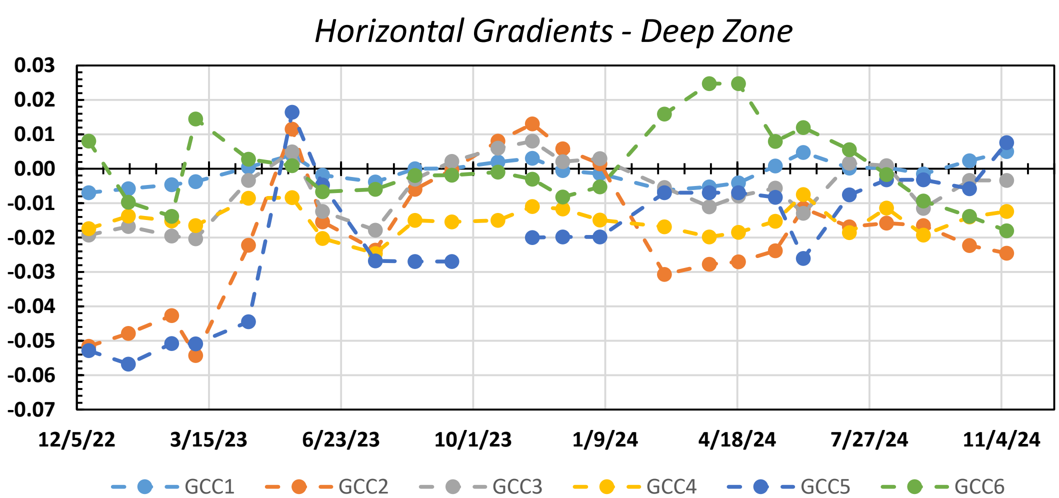
ATTACHMENT B-1 HORIZONTAL GRADIENTS SUMMARY GRAPH

Attachment B-1

Horizontal Gradients Summary: November 2024
Arkema Inc. Facility
Portland, Oregon





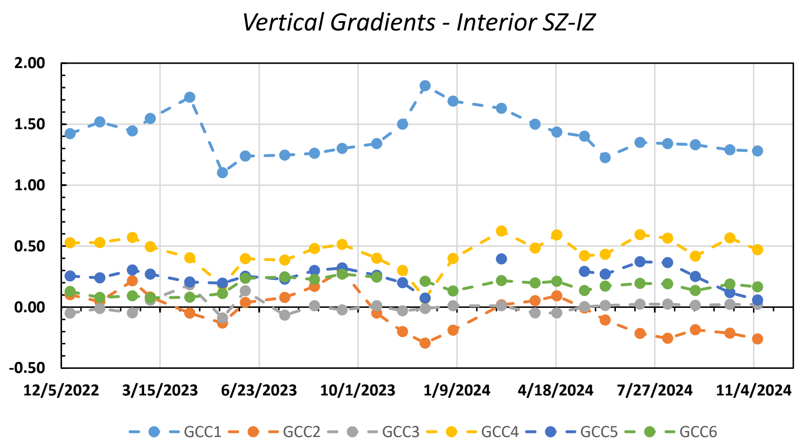


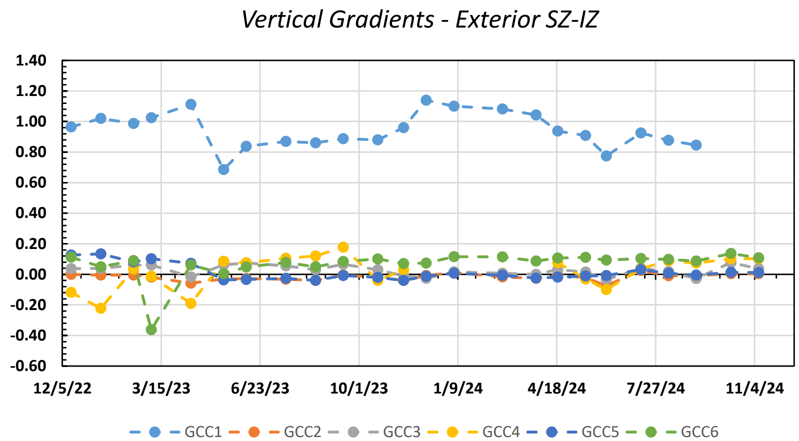
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

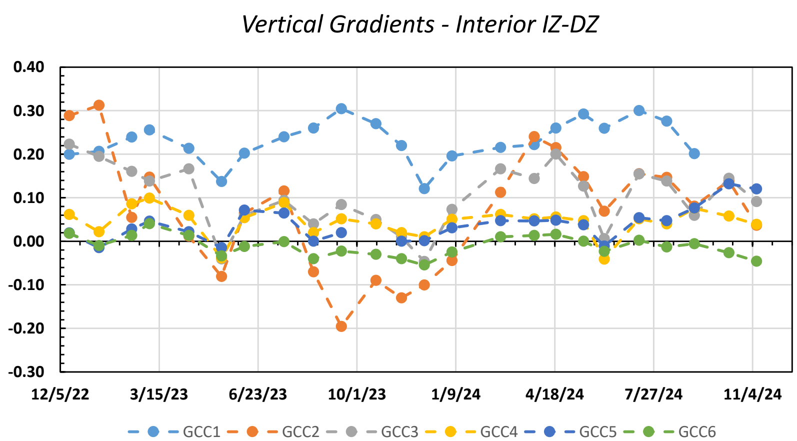
ATTACHMENT B-2 VERTICAL GRADIENTS SUMMARY GRAPH

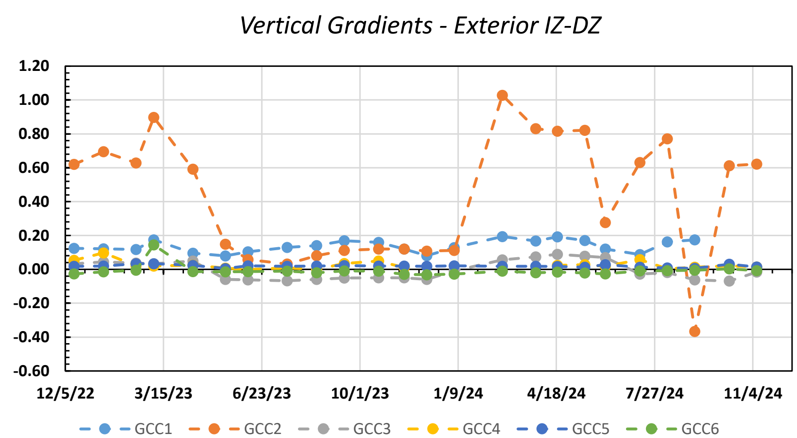
Attachment B-2

Vertical Gradients Summary: November 2024
Arkema Inc. Facility
Portland, Oregon









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ATTACHMENT B-3 WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

Attachment B-3

Water Levels and Horizontal Gradients Table
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	23.61	PA-04	24.08	-0.005
	Intermediate	PA-17iR	10.46	PA-10i	11.41	-0.009
	Deep	PA-27d	9.94	PA-18d	9.33	0.005
GCC2	Shallow	MWA-2	8.37	PA-05	6.19	0.032
	Intermediate	MWA-8i	8.29	PA-11i	8.91	-0.008
	Deep	PA-19d	7.33	PA-30d	8.65	-0.025
GCC3	Shallow	MWA-69	8.63	PA-06	10.81	-0.021
	Intermediate	MWA-66i	8.15	PA-12i	10.58	-0.021
	Deep	PA-21d	8.35	PA-20d	8.79	-0.003
GCC4	Shallow	MWA-19	9.03	PA-28	12.92	-0.039
	Intermediate	MWA-34iR	8.37	PA-13i	9.92	-0.018
	Deep	MWA-58d	8.05	PA-22d	9.17	-0.012
GCC5	Shallow	MWA-47	8.59	PA-07	12.74	-0.040
	Intermediate	PA-29i	8.48	PA-14i	12.19	-0.069
	Deep	PA-24d	7.96	PA-23d	7.56	0.008
GCC6	Shallow	PA-09	11.18	PA-08	11.51	-0.006
	Intermediate	PA-16i	9.78	PA-15i	9.47	0.006
	Deep	PA-26d	10.05	PA-25d	11.18	-0.018

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

* = anonalous groundwater elevation

** = horizontal gradient cannot be calculated due to anomalous elevation reading

ft NAVD88 = feet North American Vertical Datum of 1988

^{M} = manual groundwater elevation measurement

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ATTACHMENT B-4 WATER LEVELS AND VERTICAL GRADIENTS TABLE

Attachment B-4

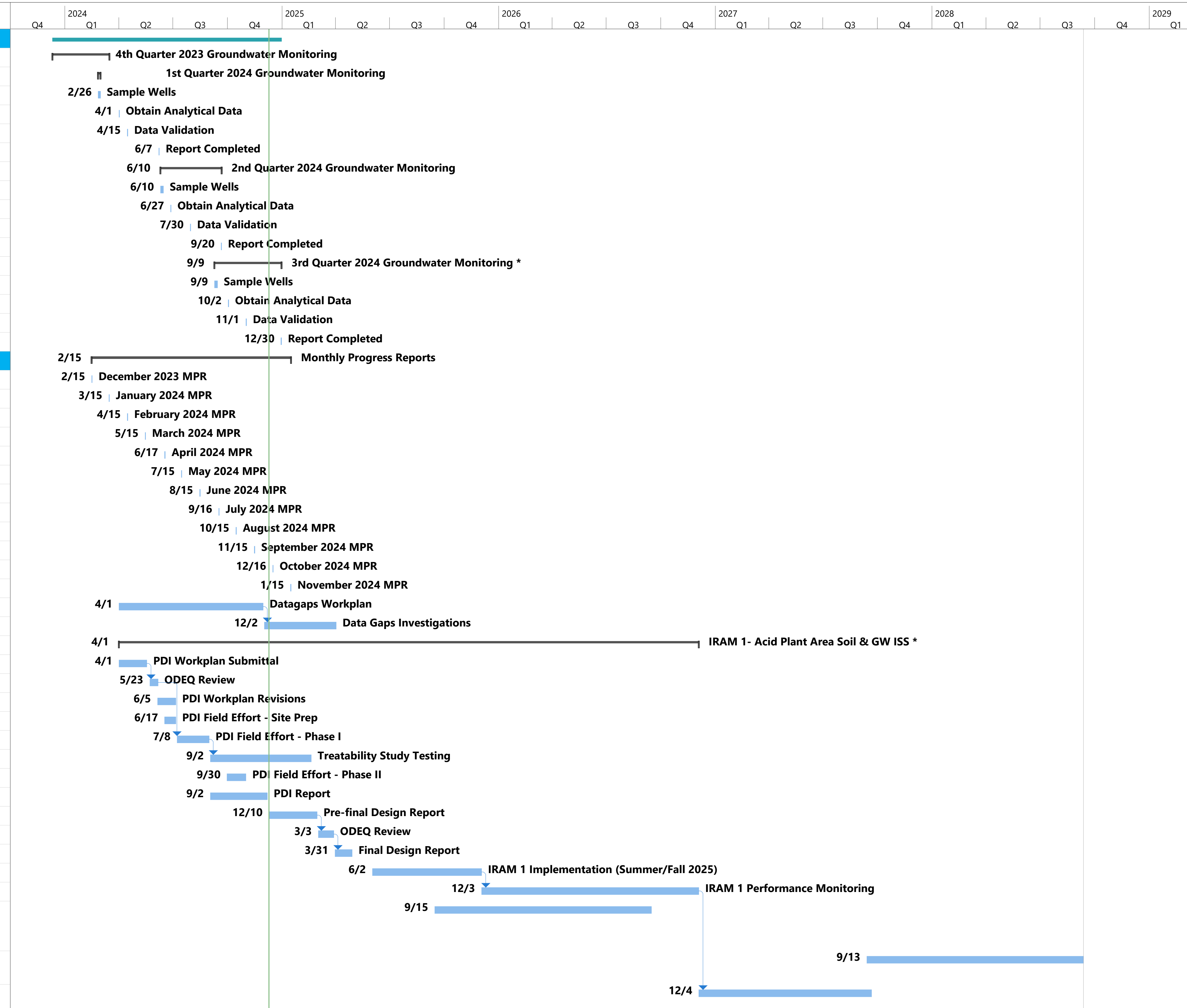
Water Levels and Vertical Gradients Table
Arkema Inc. Facility
Portland, Oregon

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	24.08	PA-10i	11.41	1.28
		GCC2	PA-05	6.19	PA-11i	8.91	-0.26
		GCC3	PA-06	10.81	PA-12i	10.58	0.02
		GCC4	PA-28	12.92	PA-13i	9.92	0.47
		GCC5	PA-07	12.74	PA-14i	12.19	0.06
		GCC6	PA-08	11.51	PA-15i	9.47	0.17
	IZ-DZ	GCC1	PA-10i	11.41	PA-18d	9.33	0.28
		GCC2	PA-11i	8.91	PA-30d	8.65	0.04
		GCC3	PA-12i	10.58	PA-20d	8.79	0.09
		GCC4	PA-13i	9.92	PA-22d	9.17	0.04
		GCC5	PA-14i	12.19	PA-23d	7.56	0.12
		GCC6	PA-15i	9.47	PA-25d	11.18	-0.05
Exterior	SZ-IZ	GCC1	PA-03	23.61	PA-17iR^{M}	10.46	0.84
		GCC2	MWA-2	8.37	MWA-8i	8.29	0.00
		GCC3	MWA-69	8.63	MWA-66i	8.15	0.04
		GCC4	MWA-19	9.03	MWA-34iR	8.37	0.10
		GCC5	MWA-47	8.59	PA-29i	8.48	0.01
		GCC6	PA-09	11.18	PA-16i	9.78	0.11
	IZ-DZ	GCC1	PA-17iR^{M}	10.46	PA-27d	9.94	0.08
		GCC2	MWA-8i	8.29	PA-19d	7.33	0.62
		GCC3	MWA-66i	8.15	PA-21d	8.35	-0.02
		GCC4	MWA-34iR	8.37	MWA-58d	8.05	0.01
		GCC5	PA-29i	8.48	PA-24d	7.96	0.01
		GCC6	PA-16i	9.78	PA-26d	10.05	-0.01

Positive vertical gradient indicates an donward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anonalous groundwater elevation
** = vertical gradient cannot be calculated due to anomalous elevation reading
DZ = Deep Zone
ft NAVD88 = feet North American Vertical Datum of 1988
IZ = Intermediate Zone
^{M} = manual groundwater elevation measurement
SZ = Shallow Zone

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring**	**75 days**	**Mon 6/10/24**	**Fri 9/20/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	*Obtain Analytical Data*	*1 day*	*Thu 6/27/24*	*Thu 6/27/24*
15	*Data Validation*	*1 day*	*Tue 7/30/24*	*Tue 7/30/24*
16	*Report Completed*	*1 day*	*Fri 9/20/24*	*Fri 9/20/24*
17	**3rd Quarter 2024 Groundwater Monitoring ***	**81 days**	**Mon 9/9/24**	**Mon 12/30/24**
18	*Sample Wells*	*5 days*	*Mon 9/9/24*	*Fri 9/13/24*
19	*Obtain Analytical Data*	*1 day*	*Wed 10/2/24*	*Wed 10/2/24*
20	*Data Validation*	*1 day*	*Fri 11/1/24*	*Fri 11/1/24*
21	Report Completed	1 day	Mon 12/30/24	Mon 12/30/24
22	**Monthly Progress Reports**	**241 days**	**Thu 2/15/24**	**Wed 1/15/25**
23	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
24	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
25	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
26	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
27	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
28	*May 2024 MPR*	*1 day*	*Mon 7/15/24*	*Mon 7/15/24*
29	*June 2024 MPR*	*1 day*	*Thu 8/15/24*	*Thu 8/15/24*
30	*July 2024 MPR*	*1 day*	*Mon 9/16/24*	*Mon 9/16/24*
31	*August 2024 MPR*	*1 day*	*Tue 10/15/24*	*Tue 10/15/24*
32	*September 2024 MPR*	*1 day*	*Fri 11/15/24*	*Fri 11/15/24*
33	October 2024 MPR	1 day	Mon 12/16/24	Mon 12/16/24
34	November 2024 MPR	1 day	Wed 1/15/25	Wed 1/15/25
35	**Datagaps Workplan**	175 days	Mon 4/1/24	Fri 11/29/24
36	**Data Gaps Investigations**	87 days	Mon 12/2/24	Tue 4/1/25
37	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
38	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
39	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
40	*PDI Workplan Revisions*	*23 days*	*Wed 6/5/24*	*Fri 7/5/24*
41	*PDI Field Effort - Site Prep*	*15 days*	*Mon 6/17/24*	*Fri 7/5/24*
42	PDI Field Effort - Phase I	40 days	Mon 7/8/24	Fri 8/30/24
43	Treatability Study Testing	122 days	Mon 9/2/24	Tue 2/18/25
44	PDI Field Effort - Phase II	24 days	Mon 9/30/24	Thu 10/31/24
45	PDI Report	70 days	Mon 9/2/24	Fri 12/6/24
46	Pre-final Design Report	59 days	Tue 12/10/24	Fri 2/28/25
47	ODEQ Review	20 days	Mon 3/3/25	Fri 3/28/25
48	Final Design Report	21 days	Mon 3/31/25	Mon 4/28/25
49	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
50	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
51	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
52	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
53	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone	
Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline	
Milestone		Inactive Task		Manual Task		Manual Summary		External Tasks		Progress	

Manual Progress

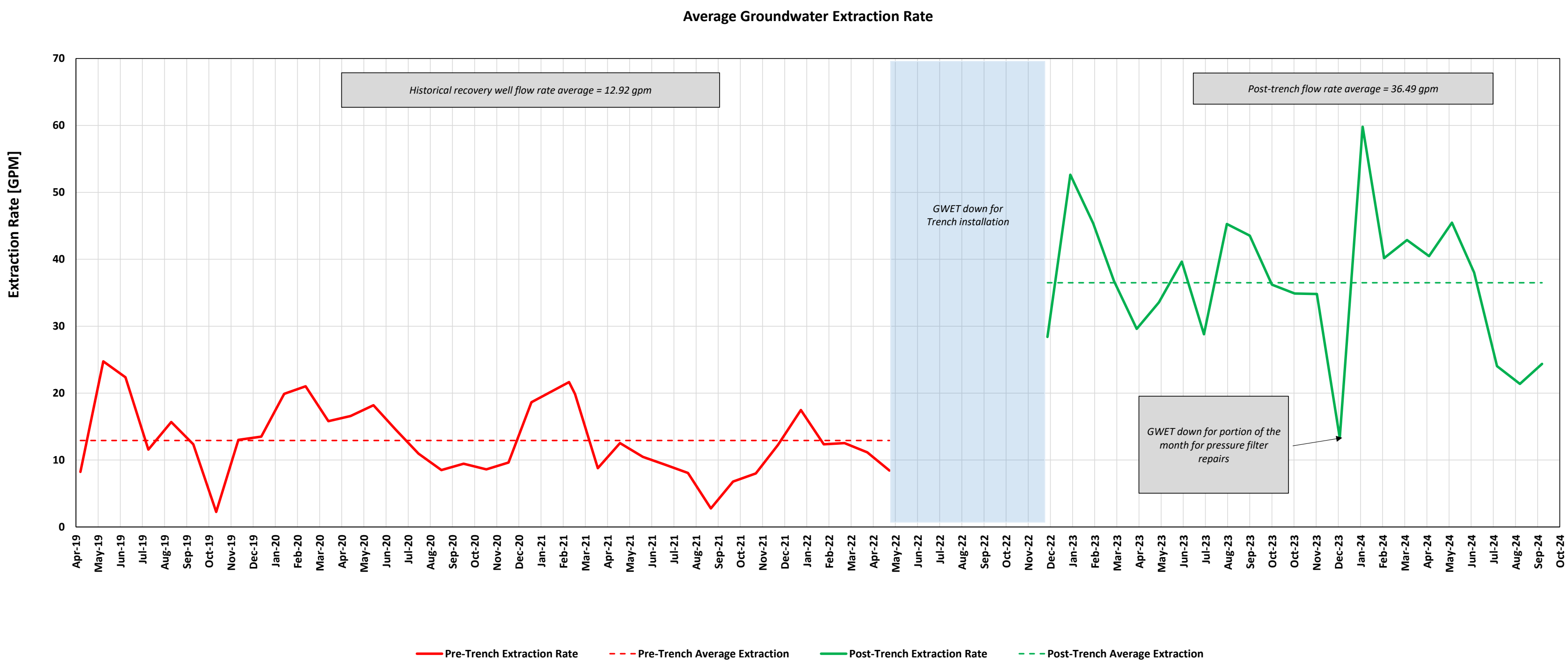
ERM

ATTACHMENT D

AVERAGE GROUNDWATER EXTRACTION RATE GRAPH

Attachment D

Average Groundwater Extraction Rate Graph
Arkema Inc. Facility
Portland, Oregon



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MEMO

TO	Katie Daugherty, ODEQ
FROM	Brendan Robinson, PE, ERM; Todd Slater, LSS
DATE	17 February 2025
REFERENCE	0732445.204
SUBJECT	Groundwater Source Control Measure Monthly Performance Monitoring Report

1. INTRODUCTION

The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with Legacy Site Services LLC (LSS) and Environmental Resources Management, Inc. (ERM) on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) at the Arkema site (Site) consistent with the Performance Monitoring Plan (PMP; ERM 2014[1]) beginning July 2019. The Site is located at 6400 NW Front Avenue in Portland, Oregon, and the Site location is shown on Figure 1. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 Monthly Performance Monitoring Report (MPR), subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

On 6 June 2024, ODEQ requested that LSS and ERM reduce the scope of future MPRs to facilitate faster review. On 11 September 2024, ODEQ agreed for the first amended MPR to be the August 2024 MPR submitted in October 2024.

2. GWET SYSTEM PERFORMANCE

The GWET system maintained 100 percent uptime during the month of December 2024. Consequently, the average system influent flow rate was 30.95 gallons per minute (gpm) for the

[1] ERM-West, Inc. 2014. *Revised Final Performance Monitoring Plan – Groundwater Source Control Measure, Arkema Inc. Facility, Portland, Oregon*. July 2014.

entire month of December 2024, including non-operational periods and the average operational influent flow during operational periods was also 30.95 gpm.

Extraction wells, pumps, and conveyance lines become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address pump fouling. Regularly scheduled redevelopment is anticipated to maintain the productivity of the groundwater extraction trenches and recovery wells. Conveyance line cleaning will be conducted as needed based on analysis of backpressure.

Compared to November 2024, the December 2024 average system influent flow rate was 3.41 gpm greater. During this same time period, the average Shallow Zone groundwater elevation increased by 0.61 feet, and the average Intermediate Zone groundwater elevation increased by 0.87 feet, as shown on Attachments A-1 and A-2. The increase in average monthly groundwater extraction rate in December 2024 compared to November 2024 is likely a result of the seasonal increase in river elevation, and the resulting increase in the groundwater elevation.

River elevations are shown over time on Attachments A-1 and A-2, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation has generally been trending downward since January 2024. The river elevation had an increase December 2024 had an average elevation of 9.99 feet North American Vertical Datum of 1988 (NAVD88) with a minimum elevation of 6.44 feet NAVD88 and a maximum elevation of 14.67 feet NAVD88. The river elevation had an increase of 0.70 feet NAVD88 compared to November 2024.

LSS is continuing to optimize extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Groundwater Extraction Enhancement Final Design Report* (ERM 2022[2]) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

Actions taken in December 2024 to optimize flow rates included:

- Procuring and testing a smaller Hydropuls device to focus redevelopment of the horizontal well screens in the extraction wells. Redevelopment of the horizontal screen section is scheduled for January 2025.
- The smaller Hydropuls tool was optimized with new hose connections and fittings to reduce the overall length of the rigid section of the tool to help it navigate the sweeping 45-degree elbows in the extraction trenches. Test results demonstrate that the smaller Hydropuls tool with the optimized fittings will be able to enter and exit the horizontal screens of the extraction trenches.

2.1 GWET PLANT OPERATIONS

The groundwater extraction and treatment (GWET) plant operated within permit conditions during the reporting period. There were no shutdowns during December 2024.

---

[2] ERM-West, Inc. 2022. *Final Design Report, Arkema Inc. Facility, Portland, Oregon*. May 2022.

3. CAPTURE ZONE EVALUATION

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the groundwater barrier wall (GWBW) and to evaluate the effective hydraulic capture produced by the GW SCM.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 6 December 2024. The Serfes (1991)[3] method was used to account for tidal variations of groundwater and river elevations as described in the PMP. Horizontal and vertical gradients were calculated and plotted over time as shown in Attachments B-1 and B-2. Groundwater elevations, horizontal gradients, and vertical gradients from 6 December 2024 are tabulated in Attachment B-3 and Attachment B-4.

3.2 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

Groundwater elevation data collected on 6 December 2024 was used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical gradient difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows groundwater flow from upgradient toward the GWBW. Potentiometric surface maps (Figures 2, 3, and 4) show generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around the groundwater extraction trenches in the Shallow and Intermediate Zones. Horizontal gradient at gradient control cluster 2 (GCC 2) was inward in December 2024, nearly zero at GCC 1 and decreasingly outward at GCC 3, GCC 4 and GCC 5, as shown in Attachments B-1 and B-3.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients and trend lines are shown in Attachments B-2 and B-4. Vertical groundwater gradients exterior to the GWBW were neutral to slightly downward between the Shallow and Intermediate Zones and between the Intermediate and Deep Zones.

Vertical gradients interior to the GWBW between the Shallow Zone and Intermediate Zone were inward at GCC 2, nearly neutral at GCC 3 and GCC 5, and downward at GCC 6, GCC 4, and GCC 1. Note that the vertical gradient for GCC 1 is exaggerated as a result of the localized pressure zone where soils are tight and water is relatively immobile. Vertical gradients interior to the GWBW between the Intermediate Zone and Deep Zone were upward at GCC 6, nearly neutral at GCC 2 and GCC 4, and downward at GCC3 and GCC 5. Vertical gradient could not be calculated for GCC 1 because of a transducer failure.

[3] Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater* 29(4): July–August.

4. CONCLUSIONS

Analysis of horizontal gradients over time indicate that the extraction wells are performing better than the historical recovery wells, and horizontal gradients are periodically inward, and the magnitude of outward gradients are decreasing over time, as shown on Attachment B-1. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives. Redevelopment of the trenches is planned to mitigate accumulation of silt in the filter pack in both the vertical and horizontal sections using impulse redevelopment techniques, and resonant technology. These efforts will be targeted at trenches that are currently underperforming, including Trenches 1, 4, 5, and 6. LSS will continue to optimize new extraction wells, including pump maintenance and upgrades. Additional modifications to the system, if needed to progress toward capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Attachment D shows the average influent groundwater flow rate from April 2019 through December 2024. As shown on this figure, the extraction trenches are removing approximately three times more water than the legacy system and achieving lower horizontal gradients over time.

Regards,

Brendan Robinson, PE
Partner

ATTACHMENTS

FIGURE 1 – SITE LAYOUT

FIGURE 2 – SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3 – INTERMEDIATE ZONE GROUNDWATER CONTOURS

FIGURE 4 – DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5 – SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE MAPS

FIGURE 6 – INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE MAPS

ATTACHMENT A-1 – OPERATIONAL PUMPING RATE GRAPH

ATTACHMENT A-2 – AVERAGE MONTHLY PUMPING RATE GRAPH

ATTACHMENT A-3 – GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

ATTACHMENT B-1 – HORIZONTAL GRADIENTS SUMMARY GRAPH

ATTACHMENT B-2 – VERTICAL GRADIENTS SUMMARY GRAPH

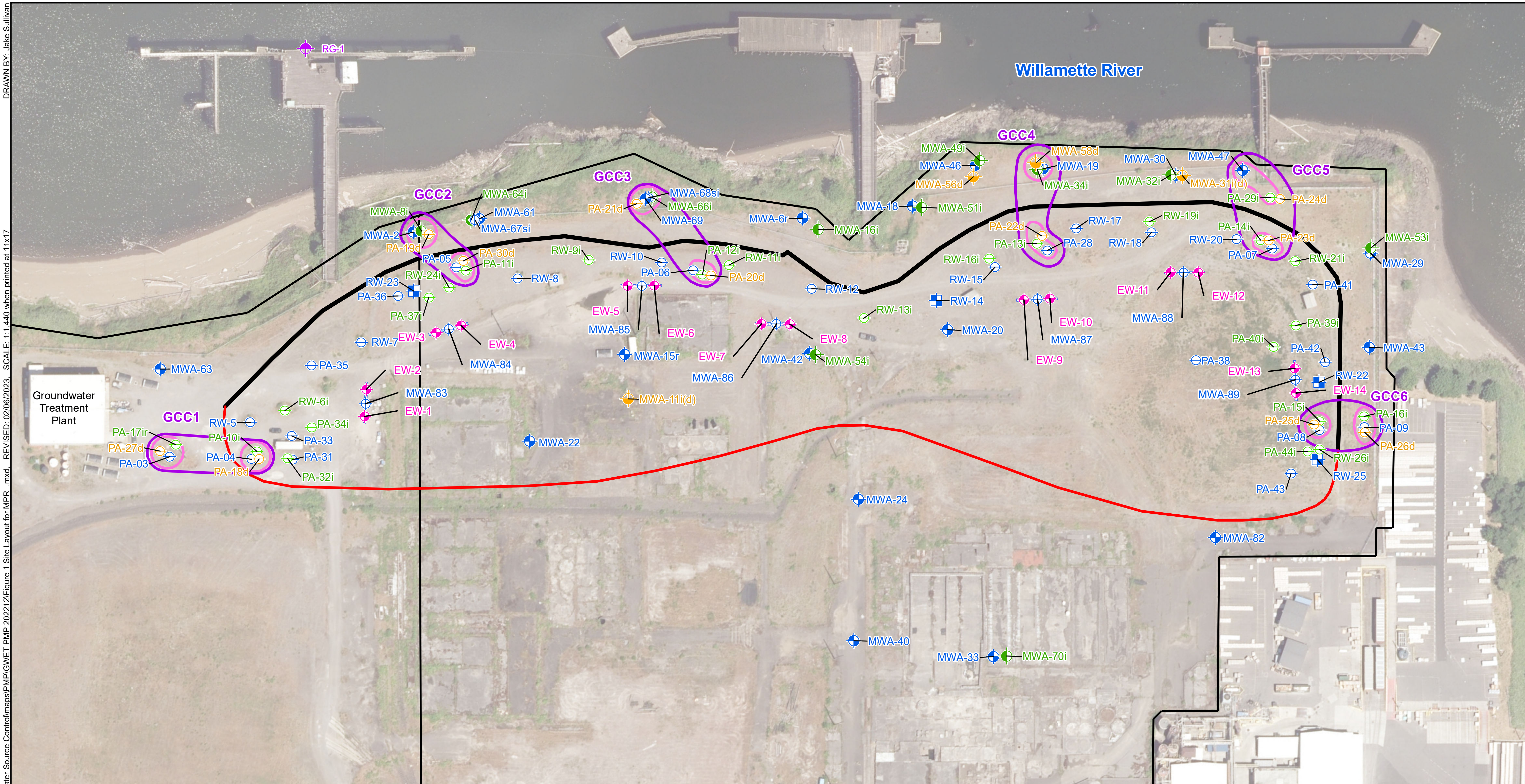
ATTACHMENT B-3 – WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

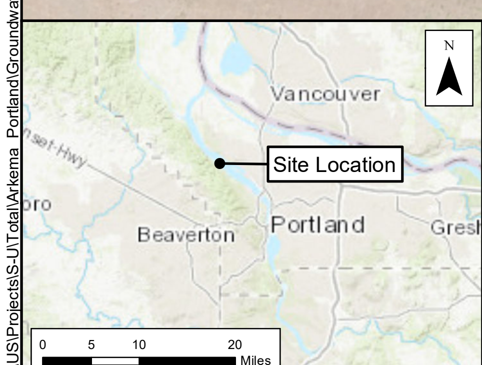
ATTACHMENT B-4 – WATER LEVELS AND VERTICAL GRADIENTS TABLE

ATTACHMENT C – PROJECT SCHEDULE

ATTACHMENT D – AVERAGE GROUNDWATER EXTRACTION RATE GRAPH

DRAWN BY: Jake Sullivan SCALE: 1:1,440 when printed at 11x17 REVISED: 02/06/2023 M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR.mxd





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

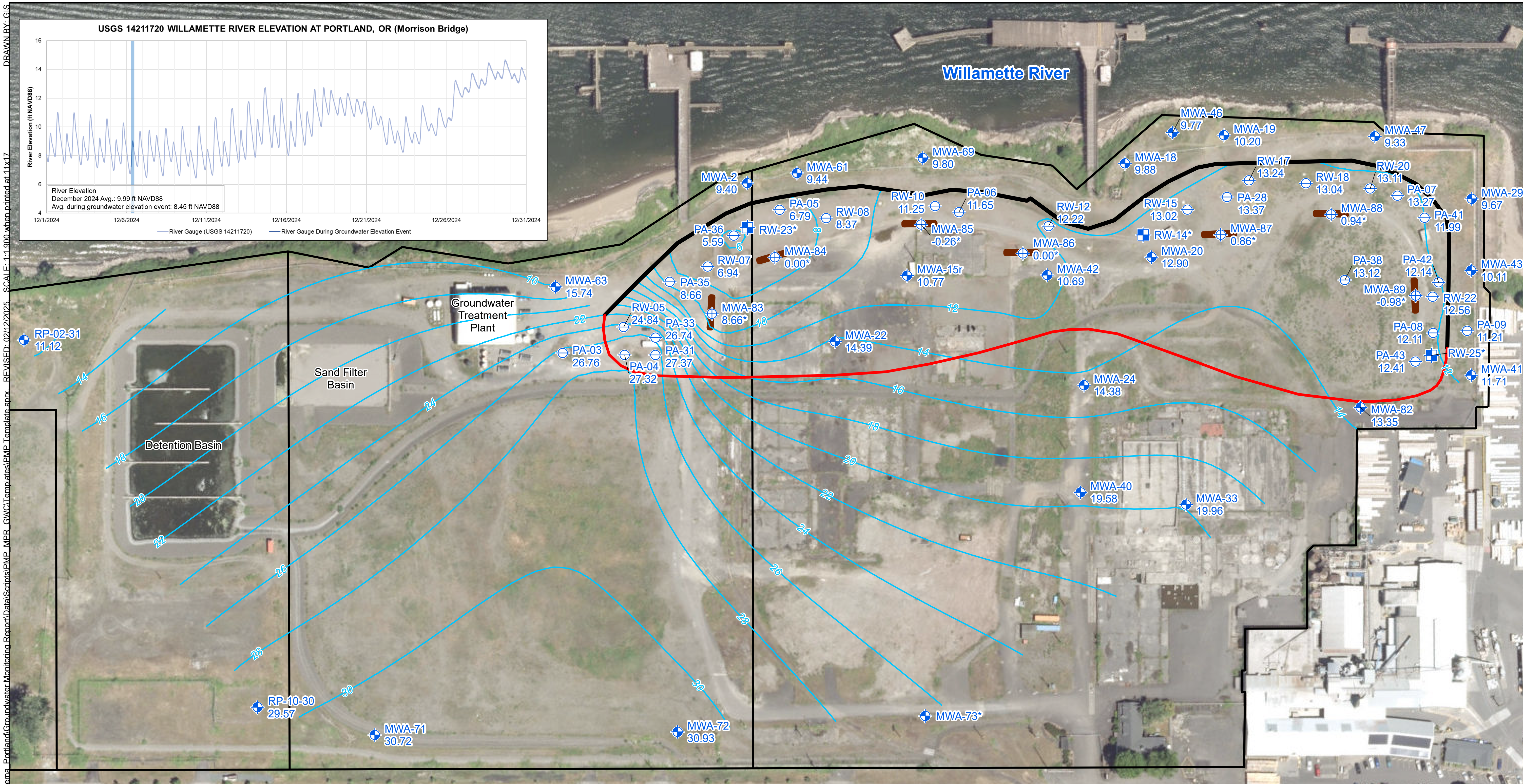
0 120 240

Feet

Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected December, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

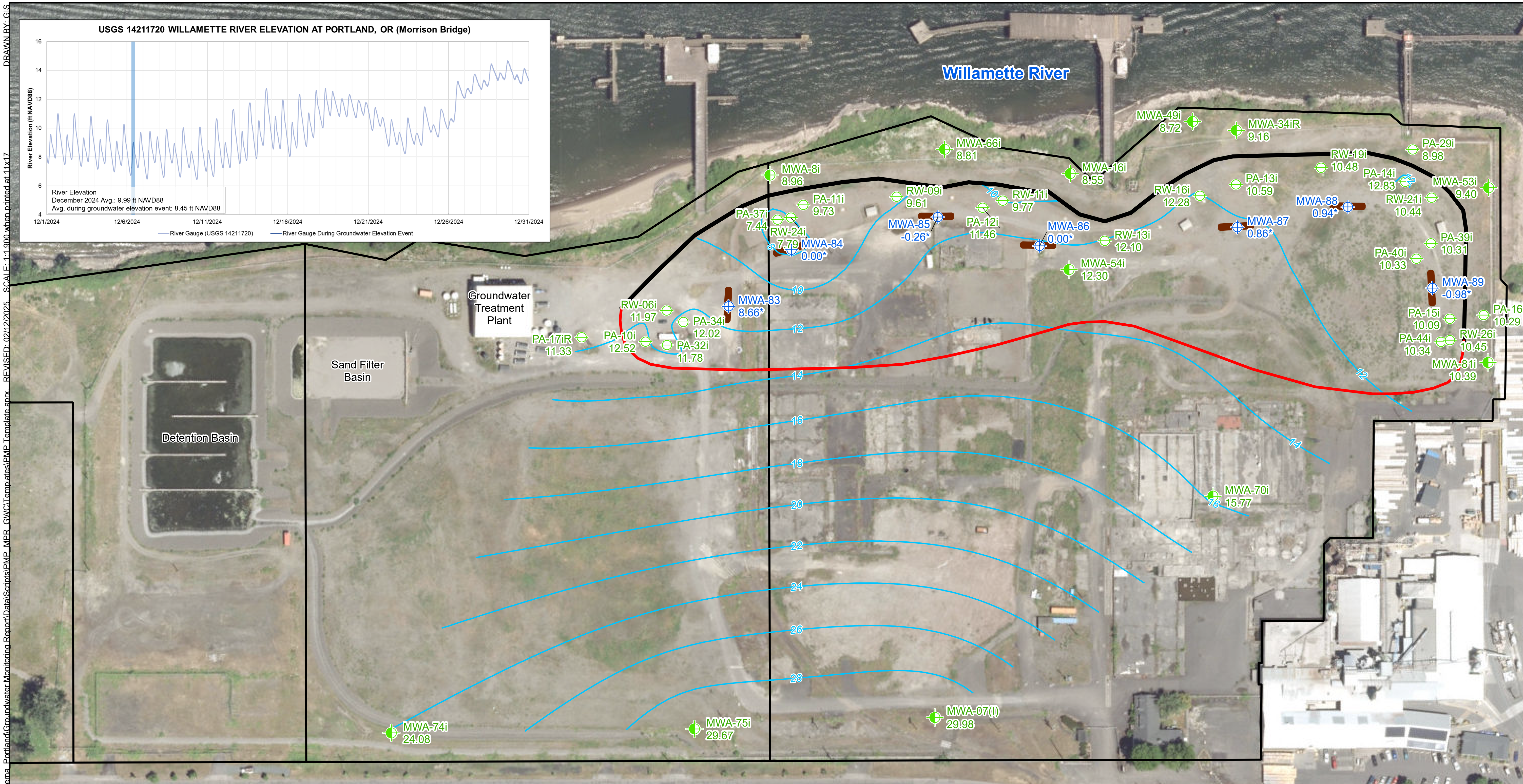
0 160 320
Feet

Figure 2
December 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

DRAWN BY: GIS SCALE: 1:1,900 when printed at 11x17 REVISED: 02/12/2025 \\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\PMP_MPR_GWC\Templates\PMP Template.aprx



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected December, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

Figure 3
December 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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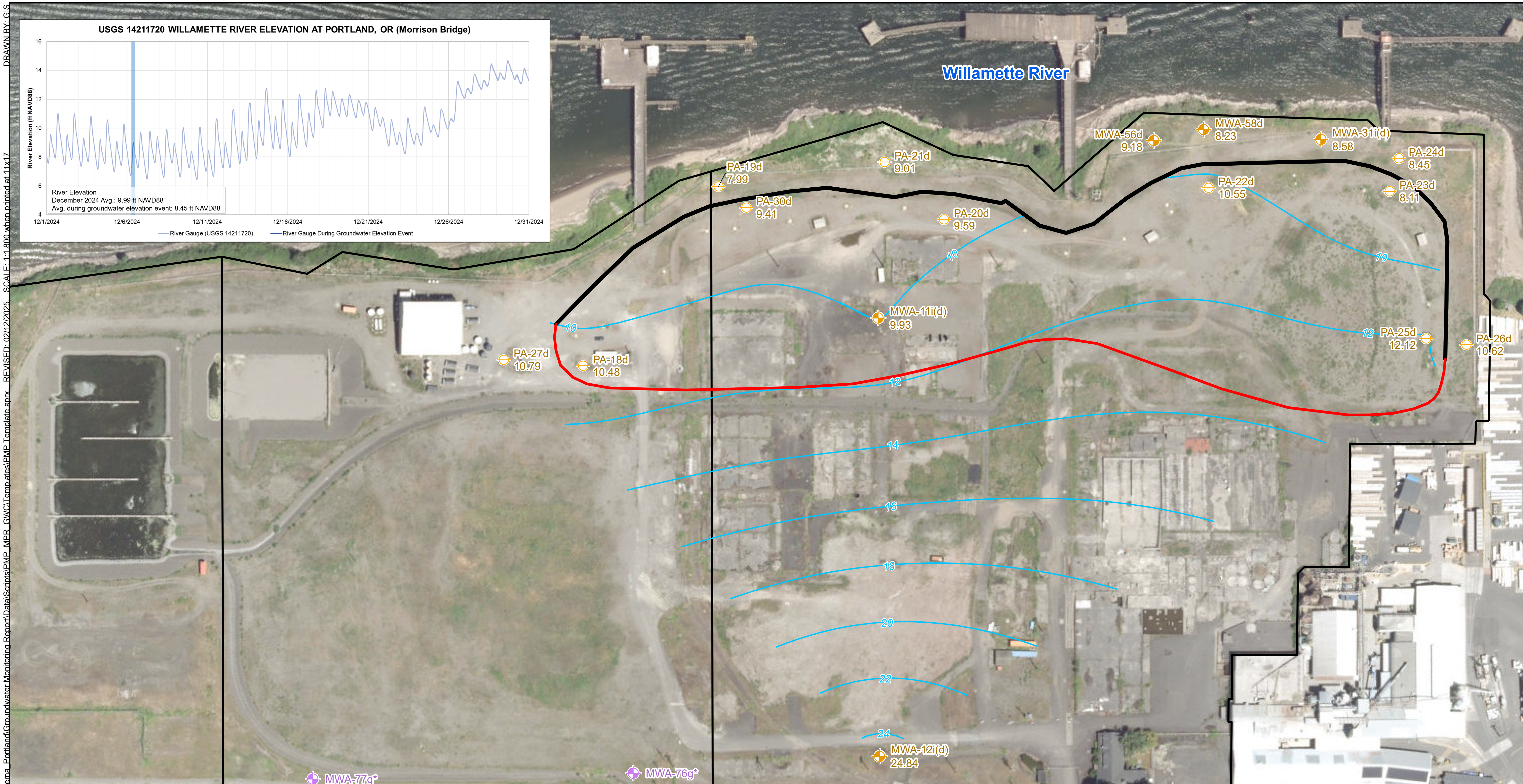

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected December, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
December 2024 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

DRAWN BY: GIS SCALE: 1:1,800 when printed at 11x17 REVISED: 02/12/2025

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Trench Extraction Well
- Active Recovery Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected December, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
December 2024 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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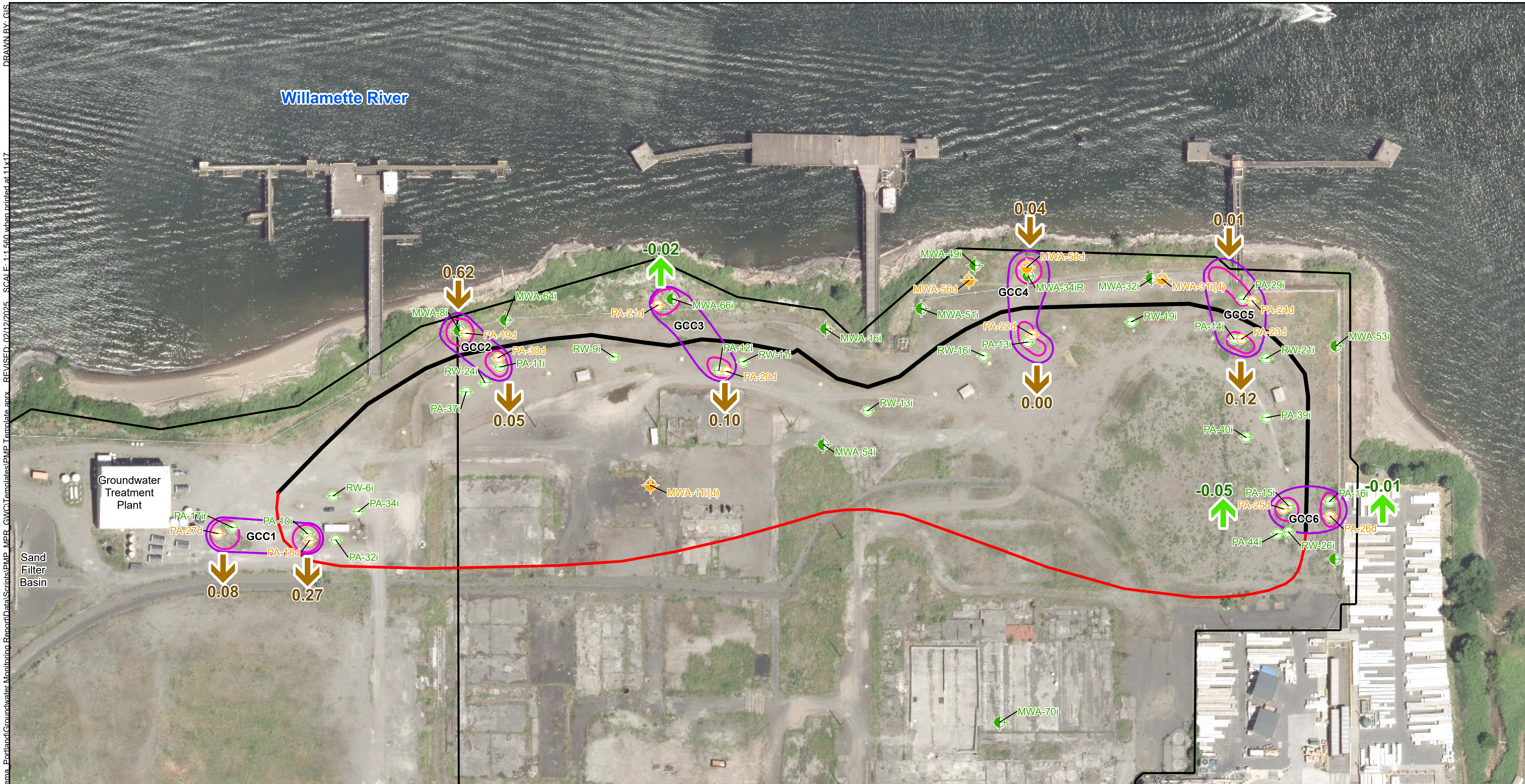

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow-Intermediate Zone Monitoring Well
- Trench Extraction Well
- Active Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Downward Gradient
- Upward Gradient

Notes:
Brown gradient: Downward gradient.
Green gradient: Upward gradient.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected December, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
December 2024 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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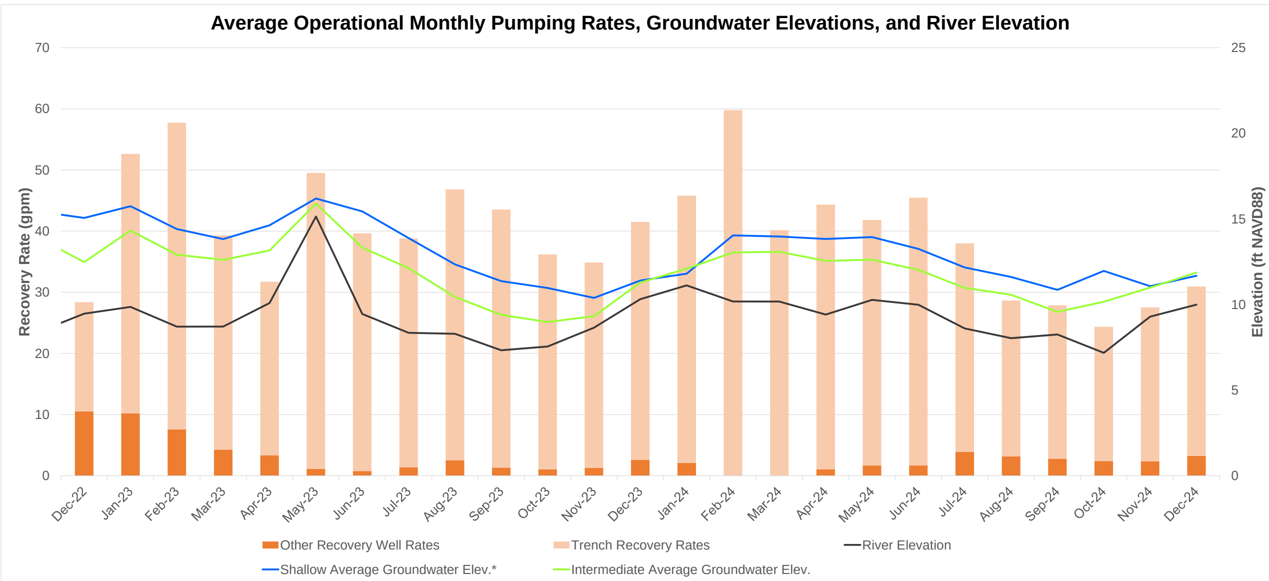
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 OPERATIONAL PUMPING RATE GRAPH

Attachment A-1

Operational Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



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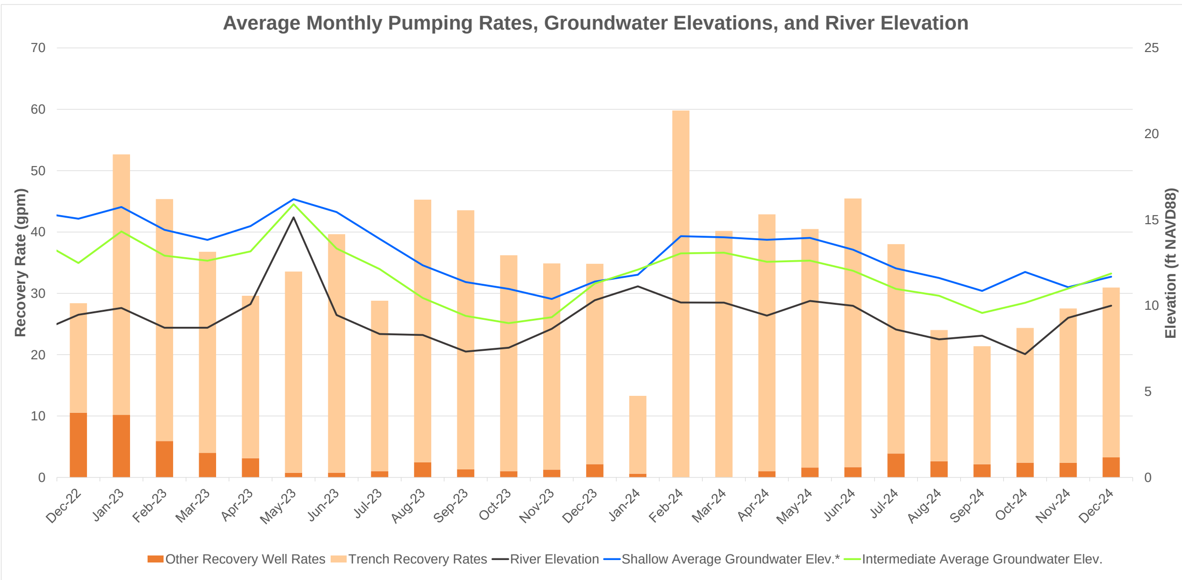
ATTACHMENT A-2 AVERAGE MONTHLY PUMPING RATE GRAPH

Attachment A-2

Average Pumping Rate Graph
Arkema Inc. Facility
Portland, Oregon



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ATTACHMENT A-3 GWET SYSTEM GROUNDWATER EXTRACTION RATES TABLE

Attachment A-3

GWET System Groundwater Extraction Rates Table
Arkema Inc. Facility
Portland, Oregon

Recovery Well	December 2024 Average Operational Pumping Rate (gpm)	December 2024 Average Monthly Pumping Rate (gpm)
RW-14	0.95	0.95
RW-22*	0.00	0.00
RW-23	0.91	0.91
RW-25	1.39	1.39
EW-01	1.04	1.04
EW-02*	0.00	0.00
EW-03	9.93	9.93
EW-04	0.21	0.21
EW-05*	3.79	3.79
EW-06	2.11	2.11
EW-07*	0.00	0.00
EW-08	1.74	1.74
EW-09	1.68	1.68
EW-10*	0.00	0.00
EW-11	0.83	0.83
EW-12	1.24	1.24
EW-13	5.05	5.05
EW-14	0.07	0.07
Total	30.95	30.95

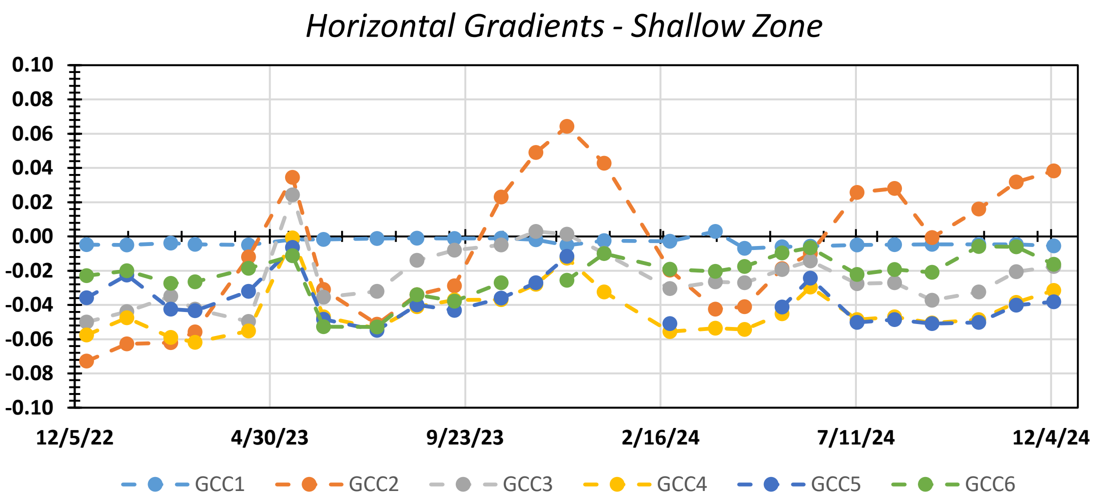
* = Recovery well not in service during reporting period

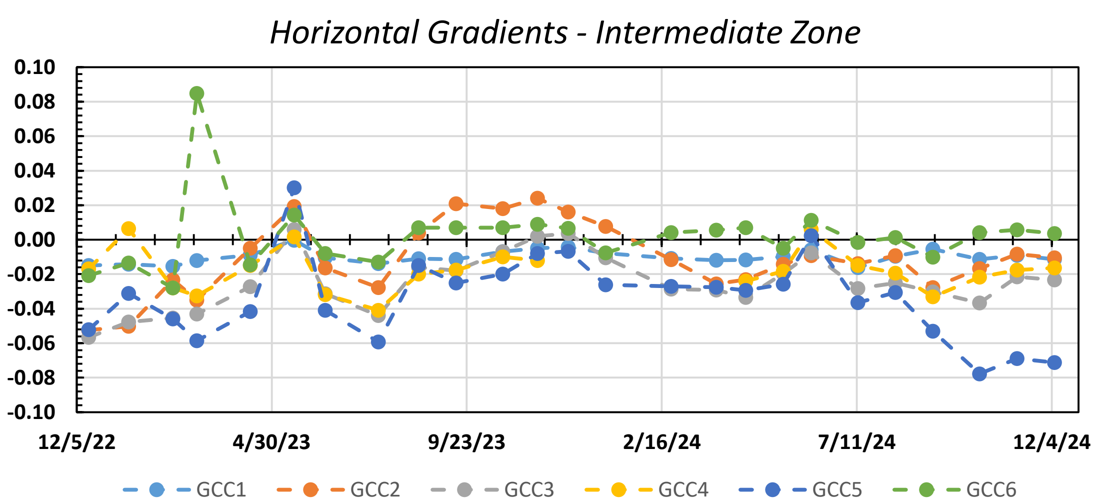
gpm = gallon per minute

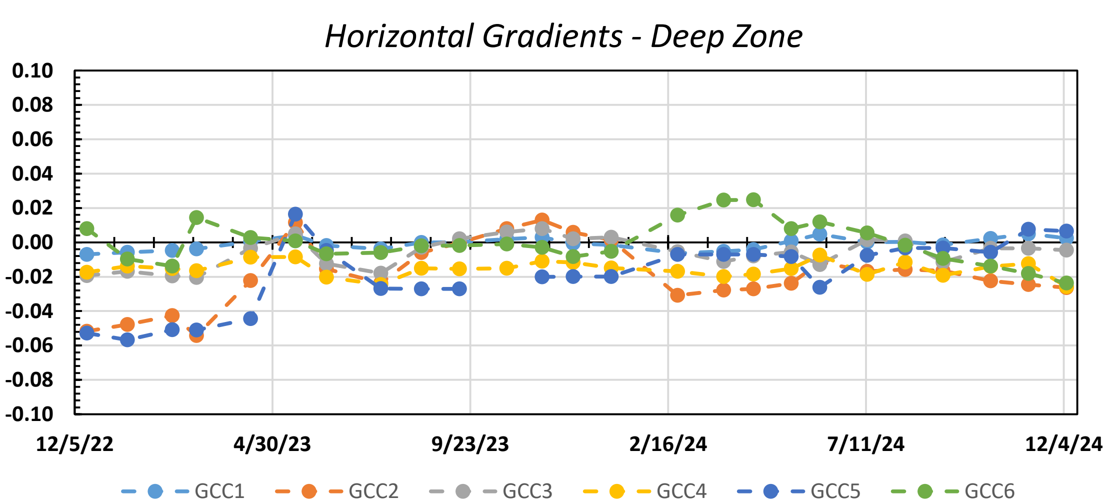
ATTACHMENT B-1 HORIZONTAL GRADIENTS SUMMARY GRAPH

Attachment B-1

Horizontal Gradients Summary: December 2024
Arkema Inc. Facility
Portland, Oregon







Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

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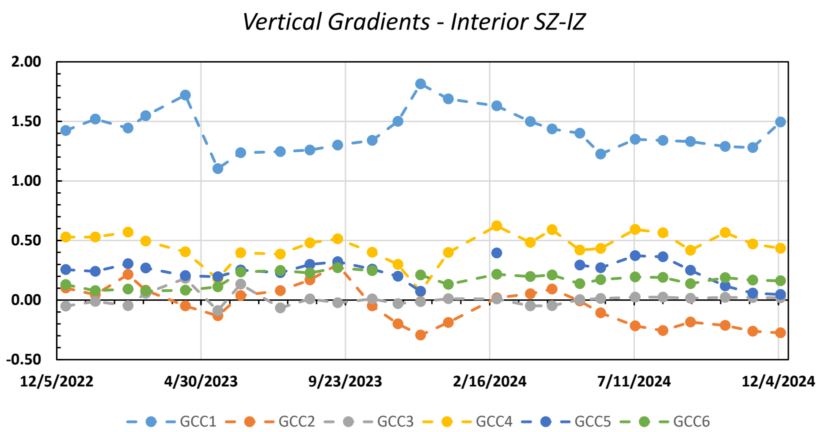
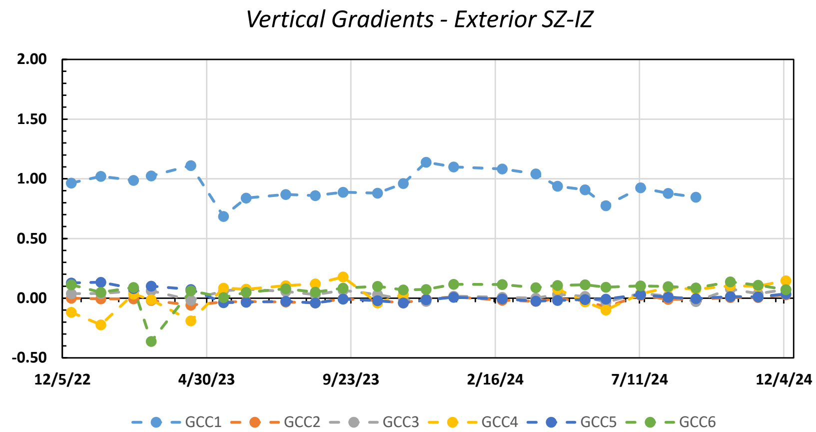
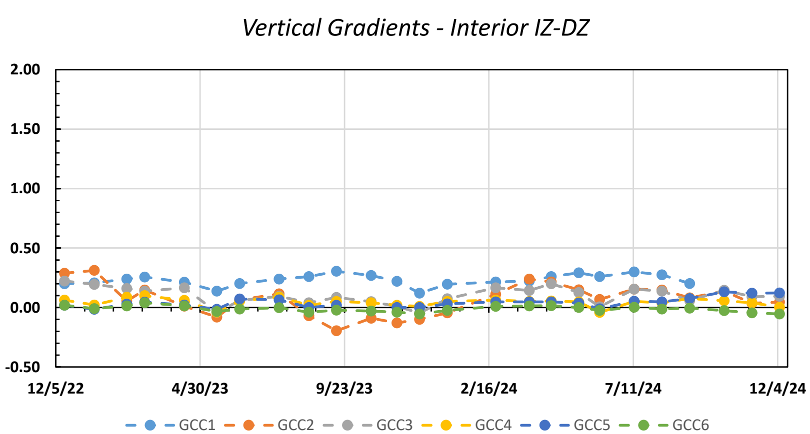
ATTACHMENT B-2 VERTICAL GRADIENTS SUMMARY GRAPH

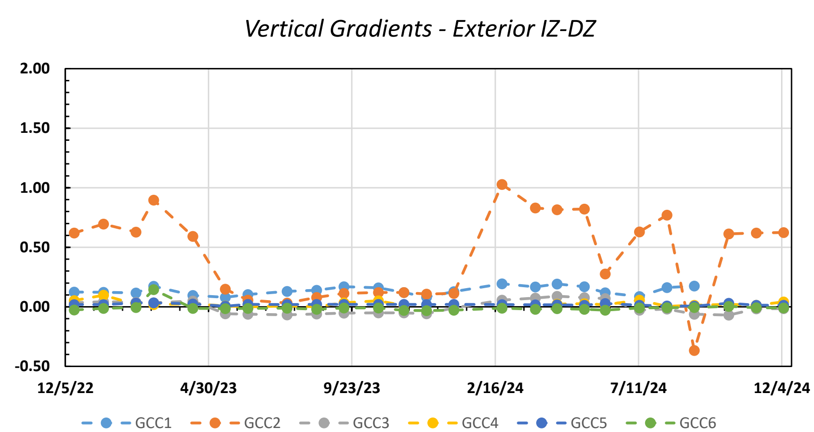
Attachment B-2

Vertical Gradients Summary: December 2024
Arkema Inc. Facility
Portland, Oregon









ATTACHMENT B-3 WATER LEVELS AND HORIZONTAL GRADIENTS TABLE

Attachment B-3

Water Levels and Horizontal Gradients Table
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	26.76	PA-04	27.32	-0.006
	Intermediate	PA-17iR	11.33	PA-10i	12.52	-0.011
	Deep	PA-27d	10.79	PA-18d	10.48	0.003
GCC2	Shallow	MWA-2	9.40	PA-05	6.79	0.038
	Intermediate	MWA-8i	8.96	PA-11i	9.73	-0.011
	Deep	PA-19d	7.99	PA-30d	9.41	-0.026
GCC3	Shallow	MWA-69	9.80	PA-06	11.65	-0.017
	Intermediate	MWA-66i	8.81	PA-12i	11.46	-0.023
	Deep	PA-21d	9.01	PA-20d	9.59	-0.005
GCC4	Shallow	MWA-19	10.20	PA-28	13.37	-0.031
	Intermediate	MWA-34iR	9.16	PA-13i	10.59	-0.016
	Deep	MWA-58d	8.23	PA-22d	10.55	-0.026
GCC5	Shallow	MWA-47	9.33	PA-07	13.27	-0.038
	Intermediate	PA-29i	8.98	PA-14i	12.83	-0.071
	Deep	PA-24d	8.45	PA-23d	8.11	0.006
GCC6	Shallow	PA-09	11.21	PA-08	12.11	-0.016
	Intermediate	PA-16i	10.29	PA-15i	10.09	0.004
	Deep	PA-26d	10.62	PA-25d	12.12	-0.024

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

* = anonalous groundwater elevation

** = horizontal gradient cannot be calculated due to anomalous elevation reading

ft NAVD88 = feet North American Vertical Datum of 1988

^{M} = manual groundwater elevation measurement

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ATTACHMENT B-4 WATER LEVELS AND VERTICAL GRADIENTS TABLE

Attachment B-4

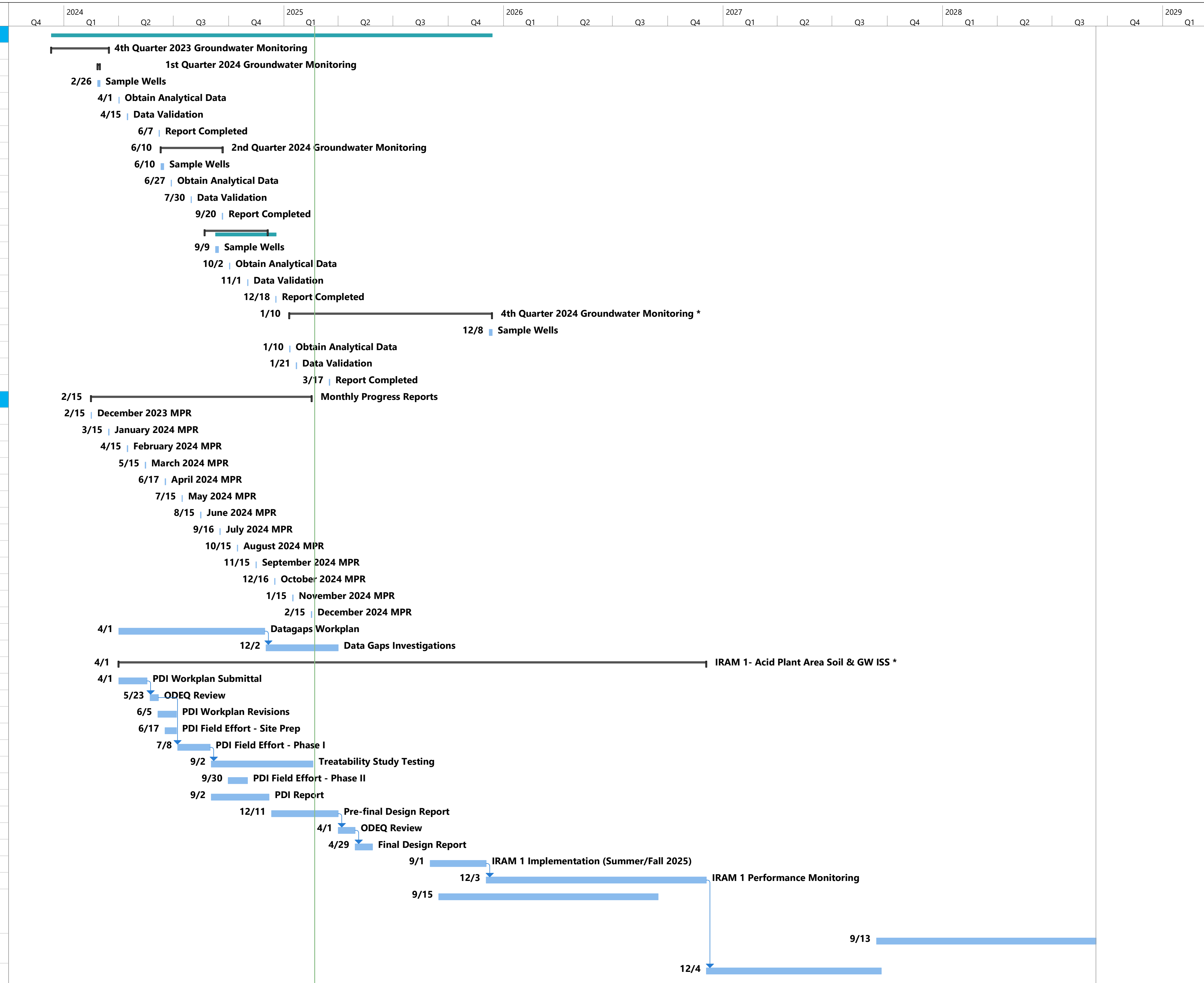
Water Levels and Vertical Gradients Table
Arkema Inc. Facility
Portland, Oregon

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	27.32	PA-10i	12.52	1.49
		GCC2	PA-05	6.79	PA-11i	9.73	-0.28
		GCC3	PA-06	11.65	PA-12i	11.46	0.02
		GCC4	PA-28	13.37	PA-13i	10.59	0.44
		GCC5	PA-07	13.27	PA-14i	12.83	0.05
		GCC6	PA-08	12.11	PA-15i	10.09	0.16
	IZ-DZ	GCC1	PA-10i	12.52	PA-18d	10.48	0.27
		GCC2	PA-11i	9.73	PA-30d	9.41	0.05
		GCC3	PA-12i	11.46	PA-20d	9.59	0.10
		GCC4	PA-13i	10.59	PA-22d	10.55	0.00
		GCC5	PA-14i	12.83	PA-23d	8.11	0.12
		GCC6	PA-15i	10.09	PA-25d	12.12	-0.05
Exterior	SZ-IZ	GCC1	PA-03	26.76	PA-17iR^{M}	11.33	0.98
		GCC2	MWA-2	9.40	MWA-8i	8.96	0.03
		GCC3	MWA-69	9.80	MWA-66i	8.81	0.07
		GCC4	MWA-19	10.20	MWA-34iR	9.16	0.15
		GCC5	MWA-47	9.33	PA-29i	8.98	0.04
		GCC6	PA-09	11.21	PA-16i	10.29	0.07
	IZ-DZ	GCC1	PA-17iR^{M}	11.33	PA-27d	10.79	0.08
		GCC2	MWA-8i	8.96	PA-19d	7.99	0.62
		GCC3	MWA-66i	8.81	PA-21d	9.01	-0.02
		GCC4	MWA-34iR	9.16	MWA-58d	8.23	0.04
		GCC5	PA-29i	8.98	PA-24d	8.45	0.01
		GCC6	PA-16i	10.29	PA-26d	10.62	-0.01

Positive vertical gradient indicates an donward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anonalous groundwater elevation
** = vertical gradient cannot be calculated due to anomalous elevation reading
DZ = Deep Zone
ft NAVD88 = feet North American Vertical Datum of 1988
IZ = Intermediate Zone
^{M} = manual groundwater elevation measurement
SZ = Shallow Zone

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring**	**75 days**	**Mon 6/10/24**	**Fri 9/20/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	*Obtain Analytical Data*	*1 day*	*Thu 6/27/24*	*Thu 6/27/24*
15	*Data Validation*	*1 day*	*Tue 7/30/24*	*Tue 7/30/24*
16	*Report Completed*	*1 day*	*Fri 9/20/24*	*Fri 9/20/24*
17	**3rd Quarter 2024 Groundwater Monitoring**	**75 days**	**Thu 8/22/24**	**Wed 12/4/24**
18	*Sample Wells*	*5 days*	*Mon 9/9/24*	*Fri 9/13/24*
19	*Obtain Analytical Data*	*1 day*	*Wed 10/2/24*	*Wed 10/2/24*
20	*Data Validation*	*1 day*	*Fri 11/1/24*	*Fri 11/1/24*
21	*Report Completed*	*1 day*	*Wed 12/18/24*	*Wed 12/18/24*
22	**4th Quarter 2024 Groundwater Monitoring ***	**242 days**	**Fri 1/10/25**	**Fri 12/12/25**
23	*Sample Wells*	*5 days*	*Mon 12/8/25*	*Fri 12/12/25*
24	*Obtain Analytical Data*	*1 day*	*Fri 1/10/25*	*Fri 1/10/25*
25	*Data Validation*	*1 day*	*Tue 1/21/25*	*Tue 1/21/25*
26	Report Completed	1 day	Mon 3/17/25	Mon 3/17/25
27	**Monthly Progress Reports**	**264 days**	**Thu 2/15/24**	**Sat 2/15/25**
28	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
29	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
30	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
31	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
32	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
33	*May 2024 MPR*	*1 day*	*Mon 7/15/24*	*Mon 7/15/24*
34	*June 2024 MPR*	*1 day*	*Thu 8/15/24*	*Thu 8/15/24*
35	*July 2024 MPR*	*1 day*	*Mon 9/16/24*	*Mon 9/16/24*
36	*August 2024 MPR*	*1 day*	*Tue 10/15/24*	*Tue 10/15/24*
37	*September 2024 MPR*	*1 day*	*Fri 11/15/24*	*Fri 11/15/24*
38	*October 2024 MPR*	*1 day*	*Mon 12/16/24*	*Mon 12/16/24*
39	*November 2024 MPR*	*1 day*	*Wed 1/15/25*	*Wed 1/15/25*
40	December 2024 MPR	1 day	Sat 2/15/25	Sat 2/15/25
41	**Datagaps Workplan**	175 days	Mon 4/1/24	Fri 11/29/24
42	**Data Gaps Investigations**	87 days	Mon 12/2/24	Mon 3/31/25
43	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**700 days**	**Mon 4/1/24**	**Thu 12/3/26**
44	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
45	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
46	*PDI Workplan Revisions*	*23 days*	*Wed 6/5/24*	*Fri 7/5/24*
47	*PDI Field Effort - Site Prep*	*15 days*	*Mon 6/17/24*	*Fri 7/5/24*
48	PDI Field Effort - Phase I	40 days	Mon 7/8/24	Fri 8/30/24
49	Treatability Study Testing	122 days	Mon 9/2/24	Mon 2/17/25
50	PDI Field Effort - Phase II	24 days	Mon 9/30/24	Thu 10/31/24
51	PDI Report	70 days	Mon 9/2/24	Fri 12/6/24
52	Pre-final Design Report	80 days	Wed 12/11/24	Mon 3/31/25
53	ODEQ Review	20 days	Tue 4/1/25	Mon 4/28/25
54	Final Design Report	21 days	Tue 4/29/25	Tue 5/27/25
55	IRAM 1 Implementation (Summer/Fall 2025)	67 days	Mon 9/1/25	Tue 12/2/25
56	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
57	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
58	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
59	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

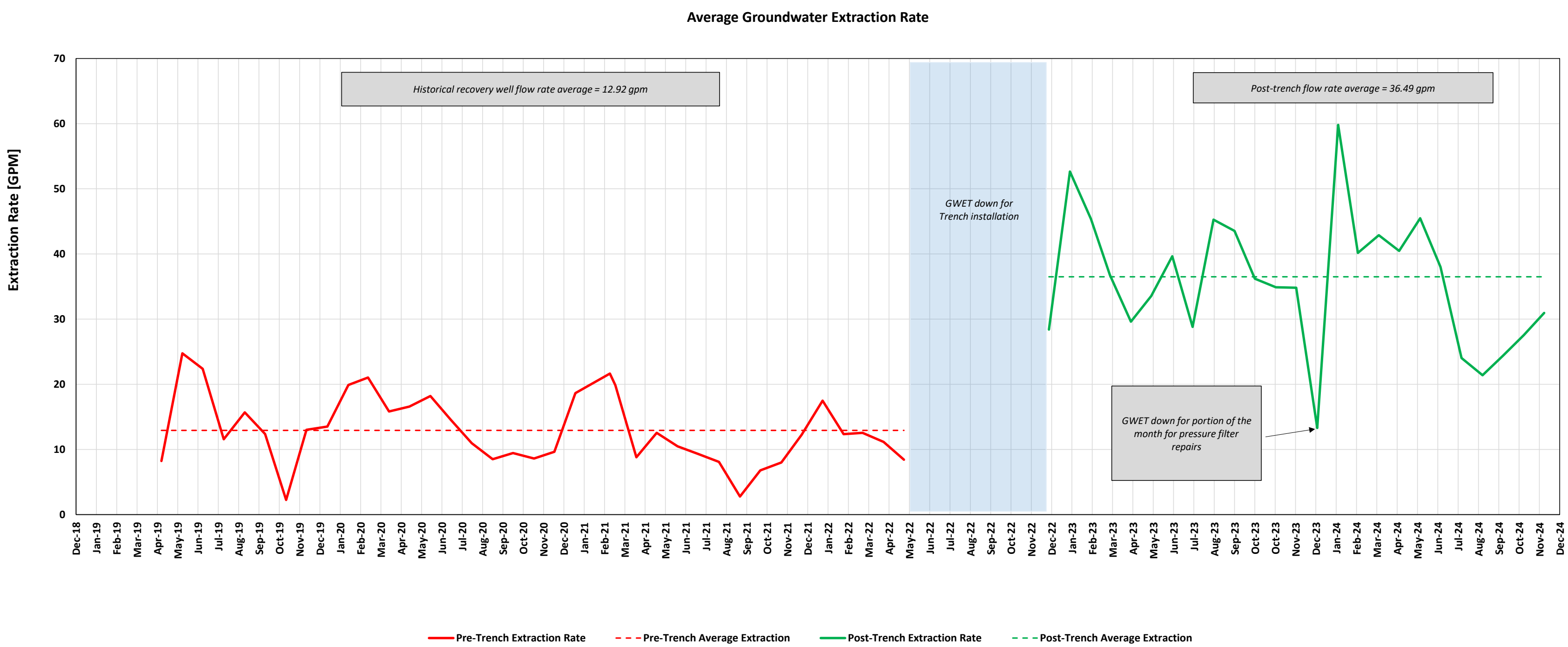
Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone		Manual Progress	
Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline			
Milestone		Inactive Task		Manual Task		Manual Summary		External Tasks		Progress			

ATTACHMENT D

AVERAGE GROUNDWATER EXTRACTION RATE GRAPH

Attachment D

Average Groundwater Extraction Rate Graph
Arkema Inc. Facility
Portland, Oregon



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APPENDIX B STATISTICAL DATA EVALUATION SUMMARY (TABLES B1 THROUGH B7)

Appendix B: Table B1
Statistical Data Evaluation Summary - GCC1 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2024)	Total Number of Samples	Historical Max Conc(2007-2010)	Current Max Conc(2019-2024)	Order of Magnitude Change[a]	Detect Status Change[b]	Statistical Trend Current(2019-2024)[c]
Chloride	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	8	8		98000	N/A	N/A	Stable
Chloride	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	19	19		1150000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	19	19		1300000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	19	19		73600	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	19	19		7600000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	2	19	21	690000	83000	Decrease	None	Stable
Chloride	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	19	19		10000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	19	19		14300	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	19	19		10500	N/A	N/A	Decreasing
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	8	8		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	19	19		3.5	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	19	19		5.7	N/A	N/A	Stable
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	19	19		24	N/A	N/A	Insufficient FOD
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	19	19		<0.7	N/A	N/A	Stable
Chlorobenzene	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	2	19	21	<100	<44	N/A	None	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	19	19		<2	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	8	8		<91	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	19	19		<95	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	19	19		<95	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	19	19		<190	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	19	19		<190	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	2	19	21	<8	13	N/A	ND to Detect	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	19	19		<95	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	19	19		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	19	19		<100	N/A	N/A	Insufficient detects

Notes
[a] Order of Magnitude Change:
Increase : The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease : The current concentration is at least an order of magnitude less than the historical concentration.
None : The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A : Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b] Detect Status Change:
Detect to non-detect : Status change from detect to non-detect.
Non-detect to detect : Status change from non-detect to detect.
Non-detect to detect, high historic detection limit : Historical detection limit was greater than current detection.
None : Same detection status between historical and current.
N/A : No historical data was collected for comparison.

[c] Statistical Trend (Historical and Current):
Stable, increasing, or decreasing : Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD : Trend criteria was not met and not calculated.
N/A : No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Appendix B: Table B2
Statistical Data Evaluation Summary - GCC2
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2024)	Total Number of Samples	Historical Max Conc(2007-2010)	Current Max Conc(2019-2024)	Order of Magnitude Change[a]	Detect Status Change[b]	Statistical Trend Current(2019-2024)[c]
Chloride	GCC2	Deep	PA-19D	ug/L	0	19	19		360000	N/A	N/A	Stable
Chloride	GCC2	Deep	PA-30D	ug/L	0	19	19		540000	N/A	N/A	Stable
Chlorobenzene	GCC2	Deep	PA-19D	ug/L	0	18	18		12000	N/A	N/A	Stable
Chlorobenzene	GCC2	Deep	PA-30D	ug/L	0	18	18		26000	N/A	N/A	Stable
Perchlorate	GCC2	Deep	PA-19D	ug/L	0	19	19		<200	N/A	N/A	Insufficient detects
Perchlorate	GCC2	Deep	PA-30D	ug/L	0	19	19		<200	N/A	N/A	Insufficient detects

Notes
[a] Order of Magnitude Change:
Increase : The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease : The current concentration is at least an order of magnitude less than the historical concentration.
None : The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A : Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b] Detect Status Change:
Detect to non-detect : Status change from detect to non-detect.
Non-detect to detect : Status change from non-detect to detect.
Non-detect to detect, high historic detection limit : Historical detection limit was greater than current detection.
None : Same detection status between historical and current.
N/A : No historical data was collected for comparison.

[c] Statistical Trend (Historical and Current):
Stable, increasing, or decreasing : Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD : Trend criteria was not met and not calculated.
N/A : No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Appendix B: Table B3
Statistical Data Evaluation Summary - GCC3
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2024)	Total Number of Samples	Historical Max Conc(2007-2010)	Current Max Conc(2019-2024)	Order of Magnitude Change[a]	Detect Status Change[b]	Statistical Trend Current(2019-2024)[c]
Chloride	GCC3	Deep	PA-20D	ug/L	0	19	19		1200000	N/A	N/A	Stable
Chloride	GCC3	Deep	PA-21D	ug/L	0	17	17		463000	N/A	N/A	Decreasing
Chlorobenzene	GCC3	Deep	PA-20D	ug/L	0	19	19		41	N/A	N/A	Decreasing
Chlorobenzene	GCC3	Deep	PA-21D	ug/L	0	17	17		49000	N/A	N/A	Stable
Perchlorate	GCC3	Deep	PA-20D	ug/L	0	19	19		140	N/A	N/A	Stable
Perchlorate	GCC3	Deep	PA-21D	ug/L	0	17	17		2400	N/A	N/A	Decreasing

Notes
[a] Order of Magnitude Change:
Increase : The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease : The current concentration is at least an order of magnitude less than the historical concentration.
None : The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A : Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b] Detect Status Change:
Detect to non-detect : Status change from detect to non-detect.
Non-detect to detect : Status change from non-detect to detect.
Non-detect to detect, high historic detection limit : Historical detection limit was greater than current detection.
None : Same detection status between historical and current.
N/A : No historical data was collected for comparison.

[c] Statistical Trend (Historical and Current):
Stable, increasing, or decreasing : Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD : Trend criteria was not met and not calculated.
N/A : No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Appendix B: Table B4
Statistical Data Evaluation Summary - GCC4 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2024)	Total Number of Samples	Historical Max Conc(2007-2010)	Current Max Conc(2019-2024)	Order of Magnitude Change[a]	Detect Status Change[b]	Statistical Trend Current(2019-2024)[c]
Chloride	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	2	19	21	27900000	26000000	None	None	Decreasing
Chloride	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	2	19	21	53600000	29000000	None	None	Stable
Chloride	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	19	19		10200000	N/A	N/A	Decreasing
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	2	19	21	<5	<4.4	N/A	None	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	2	19	21	<2.5	<4.4	N/A	None	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	2	19	21	2430	16000	Increase	None	Increasing
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	2	19	21	128000	61000	Decrease	None	Increasing
Perchlorate	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	19	19		54000	N/A	N/A	Decreasing

Notes
[a] Order of Magnitude Change:
Increase : The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease : The current concentration is at least an order of magnitude less than the historical concentration.
None : The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A : Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b] Detect Status Change:
Detect to non-detect : Status change from detect to non-detect.
Non-detect to detect : Status change from non-detect to detect.
Non-detect to detect, high historic detection limit : Historical detection limit was greater than current detection.
None : Same detection status between historical and current.
N/A : No historical data was collected for comparison.

[c] Statistical Trend (Historical and Current):
Stable, increasing, or decreasing : Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD : Trend criteria was not met and not calculated.
N/A : No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Appendix B: Table B5
Statistical Data Evaluation Summary - GCC5 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2024)	Total Number of Samples	Historical Max Conc(2007-2010)	Current Max Conc(2019-2024)	Order of Magnitude Change[a]	Detect Status Change[b]	Statistical Trend Current(2019-2024)[c]
Chloride	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	2	19	21	54300000	30000000	None	None	Decreasing
Chloride	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	19	19		33000000	N/A	N/A	Increasing
Chloride	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	19	19		46000000	N/A	N/A	Decreasing
Chlorobenzene	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	2	19	21	<2.5	<4.4	N/A	None	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	19	19		2.8	N/A	N/A	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Perchlorate	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	2	19	21	5730	100000	Increase	None	Stable
Perchlorate	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	19	19		<1000	N/A	N/A	Insufficient detects
Perchlorate	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	19	19		<400	N/A	N/A	Insufficient detects

Notes
[a] Order of Magnitude Change:
Increase : The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease : The current concentration is at least an order of magnitude less than the historical concentration.
None : The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A : Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b] Detect Status Change:
Detect to non-detect : Status change from detect to non-detect.
Non-detect to detect : Status change from non-detect to detect.
Non-detect to detect, high historic detection limit : Historical detection limit was greater than current detection.
None : Same detection status between historical and current.
N/A : No historical data was collected for comparison.

[c] Statistical Trend (Historical and Current):
Stable, increasing, or decreasing : Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD : Trend criteria was not met and not calculated.
N/A : No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Appendix B: Table B6
Statistical Data Evaluation Summary - GCC6 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2024)	Total Number of Samples	Historical Max Conc(2007-2010)	Current Max Conc(2019-2024)	Order of Magnitude Change[a]	Detect Status Change[b]	Statistical Trend Current(2019-2024)[c]
Chloride	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	19	19		34000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	19	19		80000	N/A	N/A	Increasing
Chloride	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	19	19		610000	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	19	19		850000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	18	18		530000	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	19	19		370000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	2	19	21	26600	21000	None	None	Stable
Chloride	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	19	19		34800	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	19	19		770000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	19	19		199000	N/A	N/A	Stable
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	19	19		0.71	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	19	19		<2.5	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	18	18		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	19	19		<0.6	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	19	19		<0.44	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	19	19		<9.5	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	19	19		<9.5	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	19	19		<10	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	19	19		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	18	18		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	19	19		390	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	2	19	21	<4	2.6	N/A	ND to Detect, high historic DL	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	19	19		530	N/A	N/A	Stable
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	19	19		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	19	19		120	N/A	N/A	Insufficient detects

Notes

[a] Order of Magnitude Change:
Increase : The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease : The current concentration is at least an order of magnitude less than the historical concentration.
None : The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A : Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b] Detect Status Change:
Detect to non-detect : Status change from detect to non-detect.
Non-detect to detect : Status change from non-detect to detect.
Non-detect to detect, high historic detection limit : Historical detection limit was greater than current detection.
None : Same detection status between historical and current.
N/A : No historical data was collected for comparison.

[c] Statistical Trend (Historical and Current):
Stable, increasing, or decreasing : Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD : Trend criteria was not met and not calculated.
N/A : No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Appendix B: Table B7
Statistical Data Evaluation Summary - Well Distal from BW and GCCs
System Effectiveness Evaluation
Arkema Inc.
Portland, Oregon

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2024)	Total Number of Samples	Historical Max Conc(2007-2010)	Current Max Conc(2019-2024)	Order of Magnitude Change[a]	Detect Status Change[b]	Statistical Trend Current(2019-2024)[c]
Chloride	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	2	19	21	1210000	6300000	None	None	Stable
Chlorobenzene	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	2	19	21	1.92	7	None	None	Insufficient FOD
Perchlorate	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	2	19	21	<8	<48	N/A	None	Insufficient detects

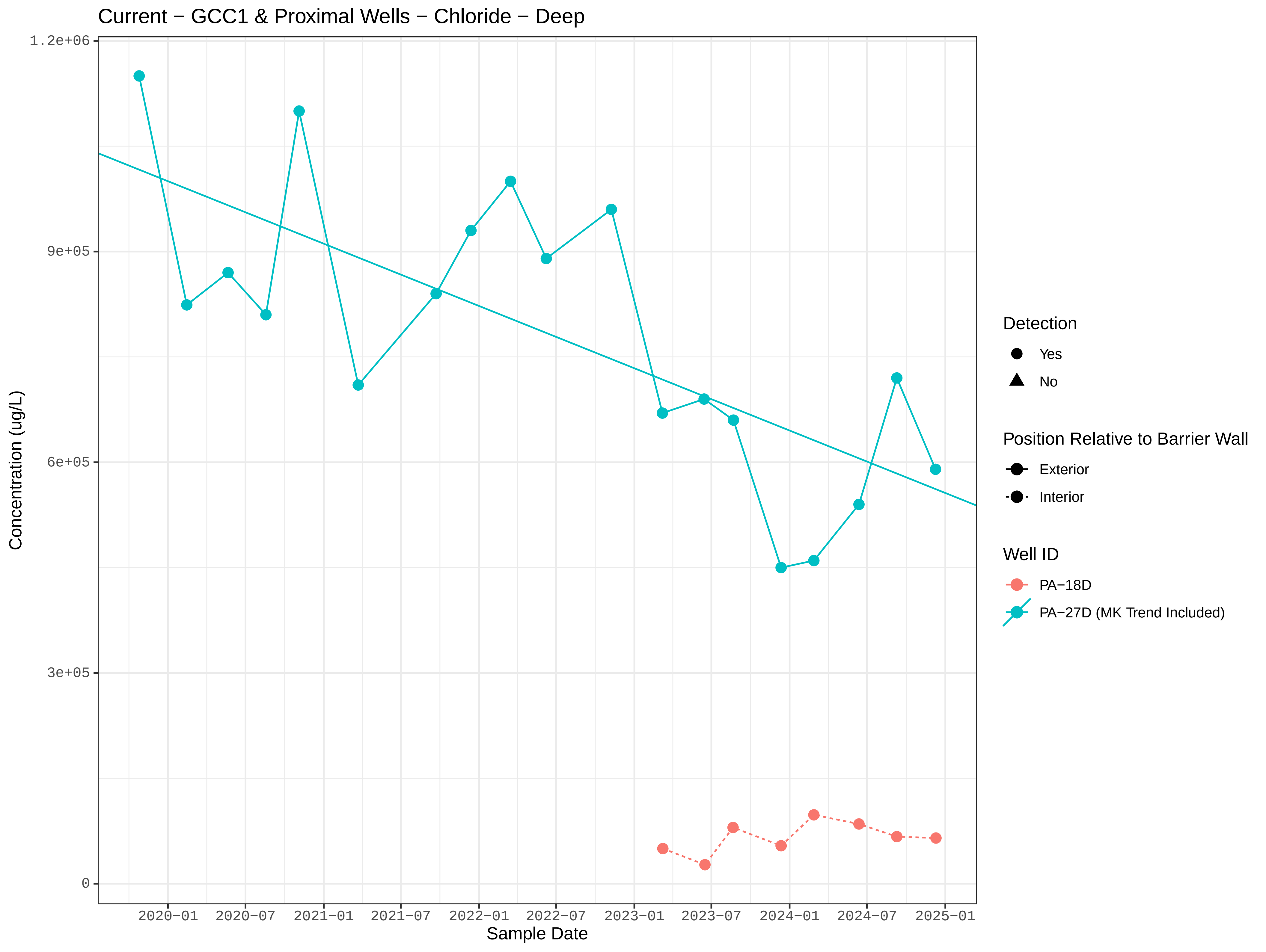
Notes
[a] Order of Magnitude Change:
Increase : The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease : The current concentration is at least an order of magnitude less than the historical concentration.
None : The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A : Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b] Detect Status Change:
Detect to non-detect : Status change from detect to non-detect.
Non-detect to detect : Status change from non-detect to detect.
Non-detect to detect, high historic detection limit : Historical detection limit was greater than current detection.
None : Same detection status between historical and current.
N/A : No historical data was collected for comparison.

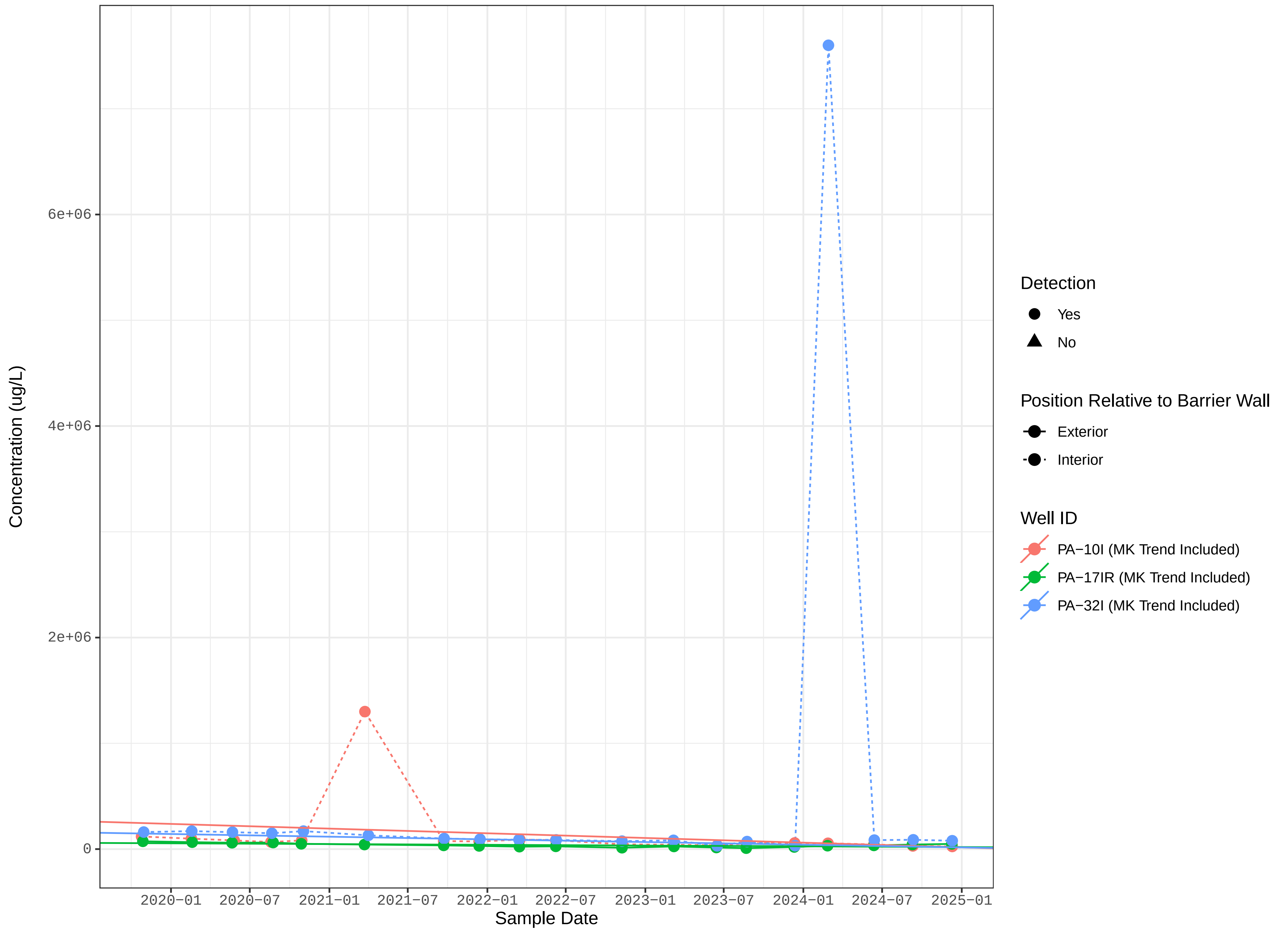
[c] Statistical Trend (Historical and Current):
Stable, increasing, or decreasing : Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD : Trend criteria was not met and not calculated.
N/A : No historical data is available for comparison.

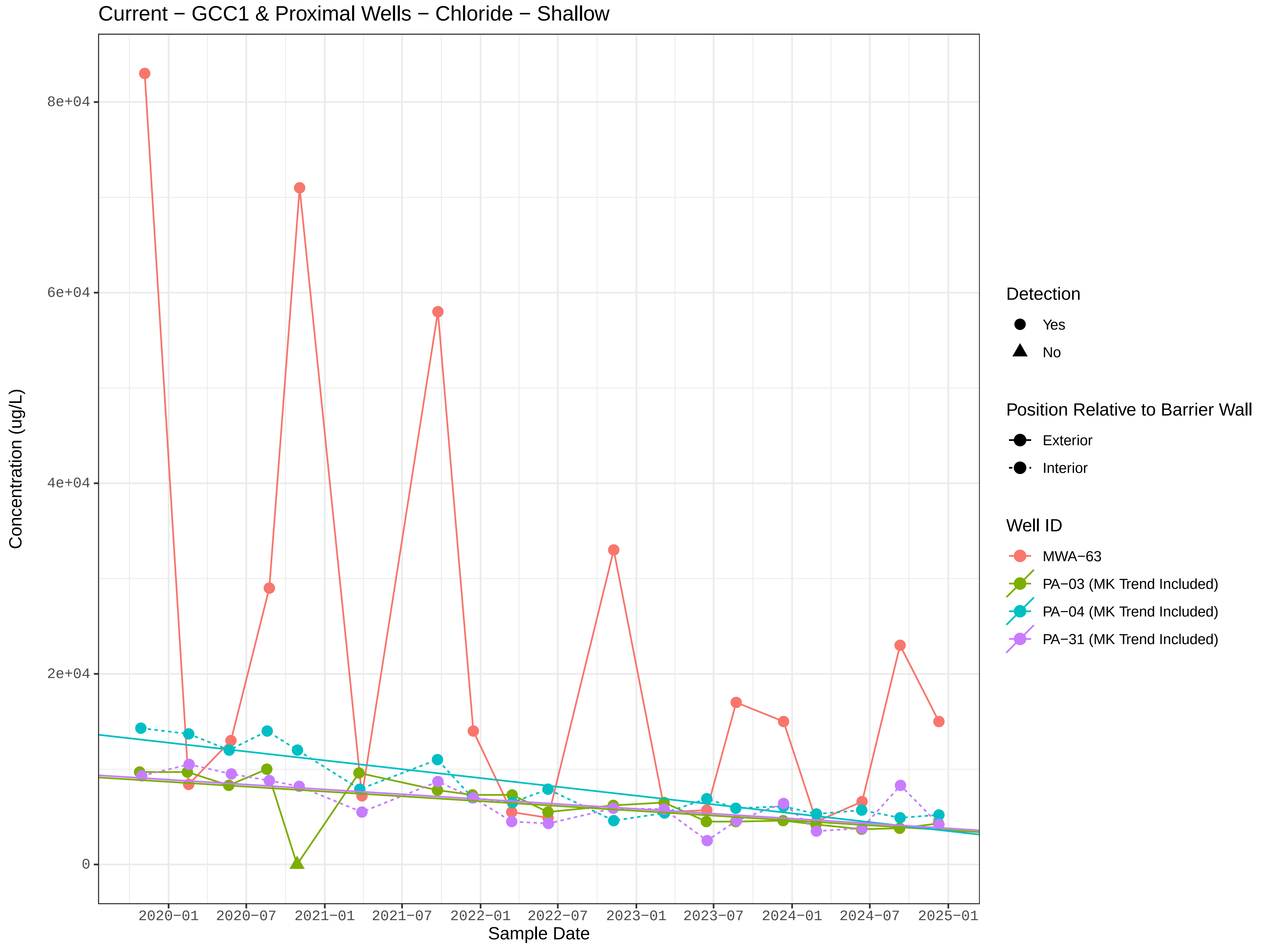
ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

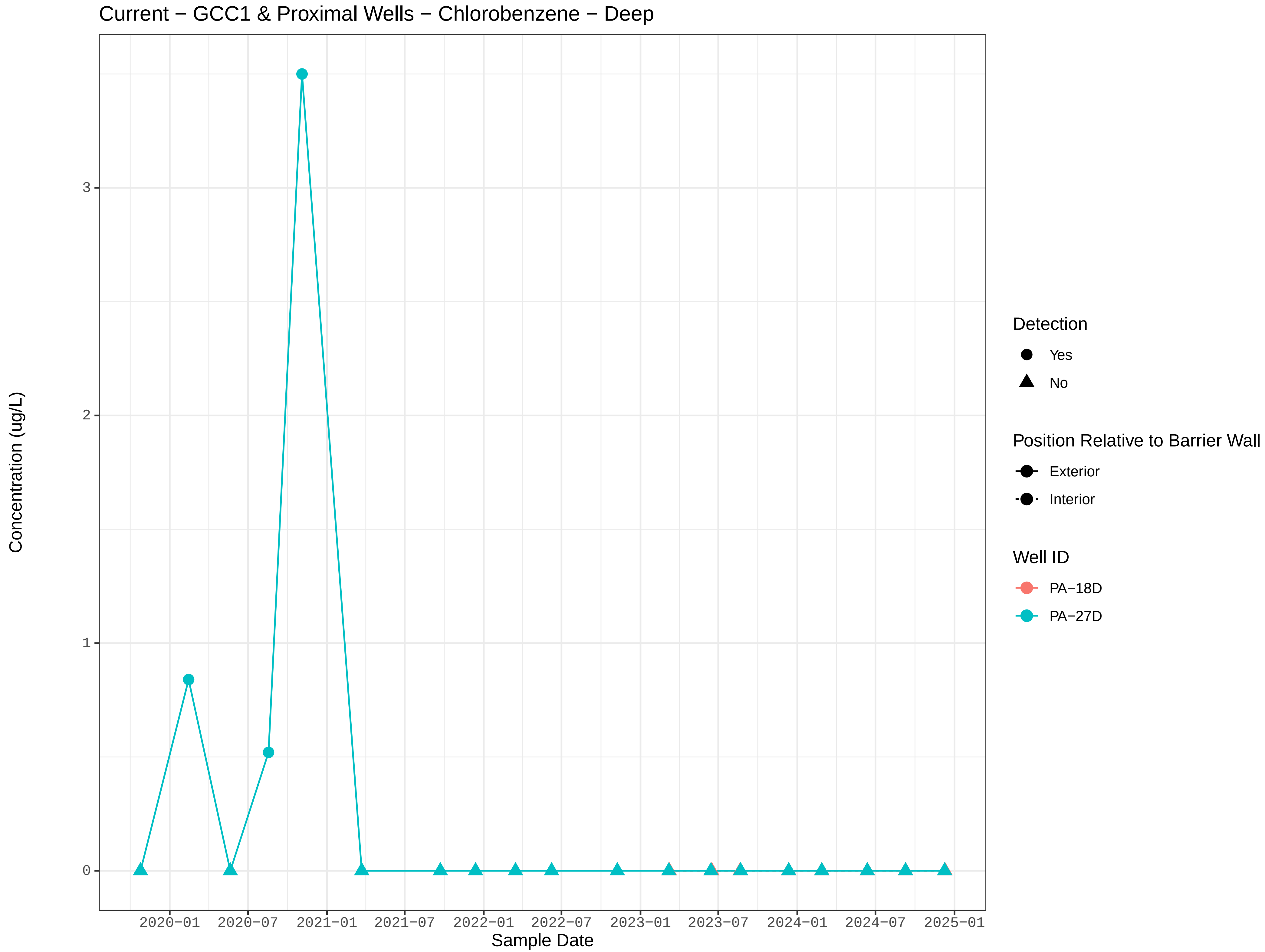
APPENDIX C MANN-KENDALL SCATTERPLOTS AND TREND ANALYSIS


Current − GCC1 & Proximal Wells − Chloride − Deep
Concentration (ug/L)
1.2e+06
9e+05
6e+05
3e+05
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−18D
PA−27D (MK Trend Included)

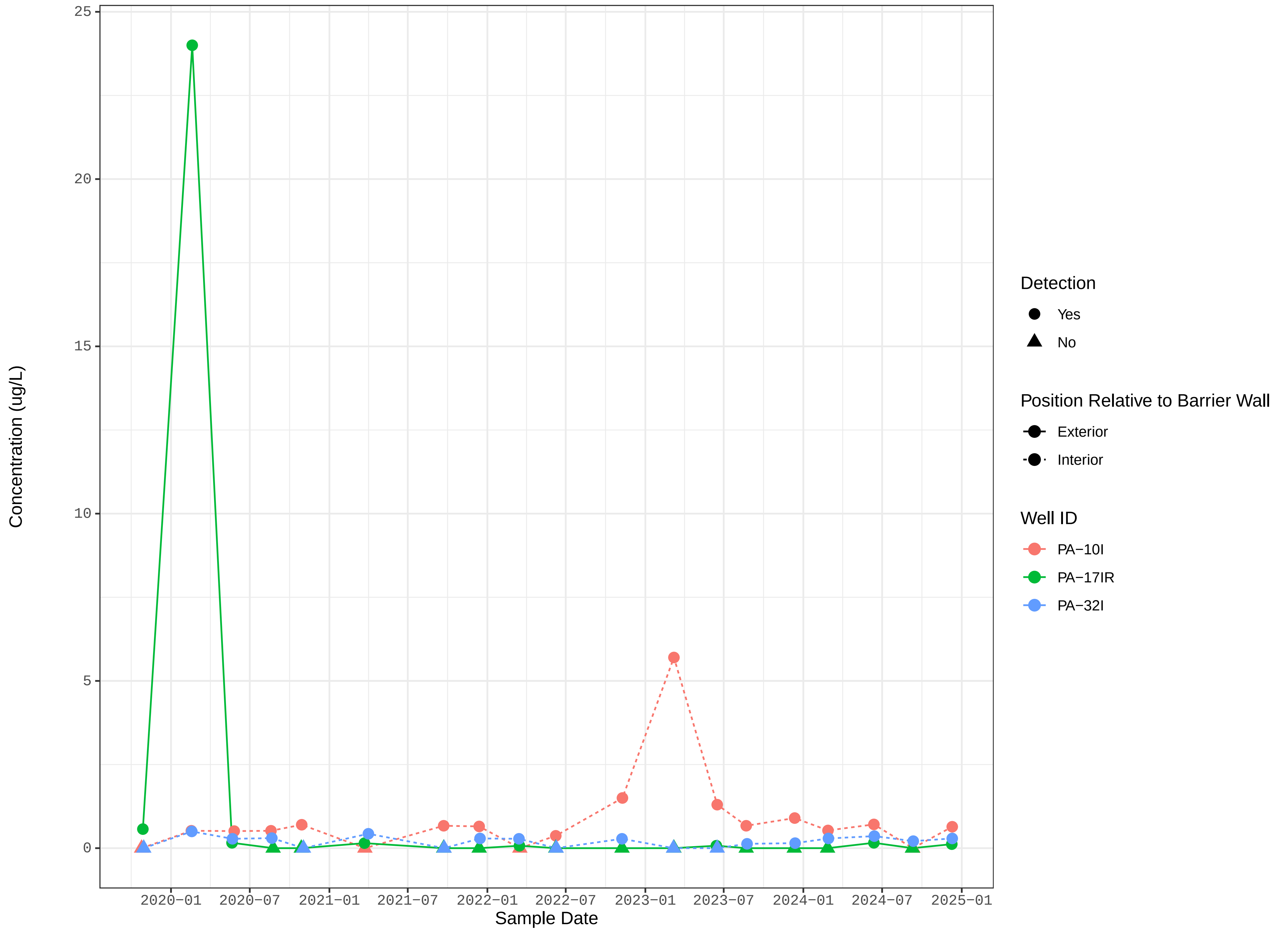
Current − GCC1 & Proximal Wells − Chloride − Intermediate

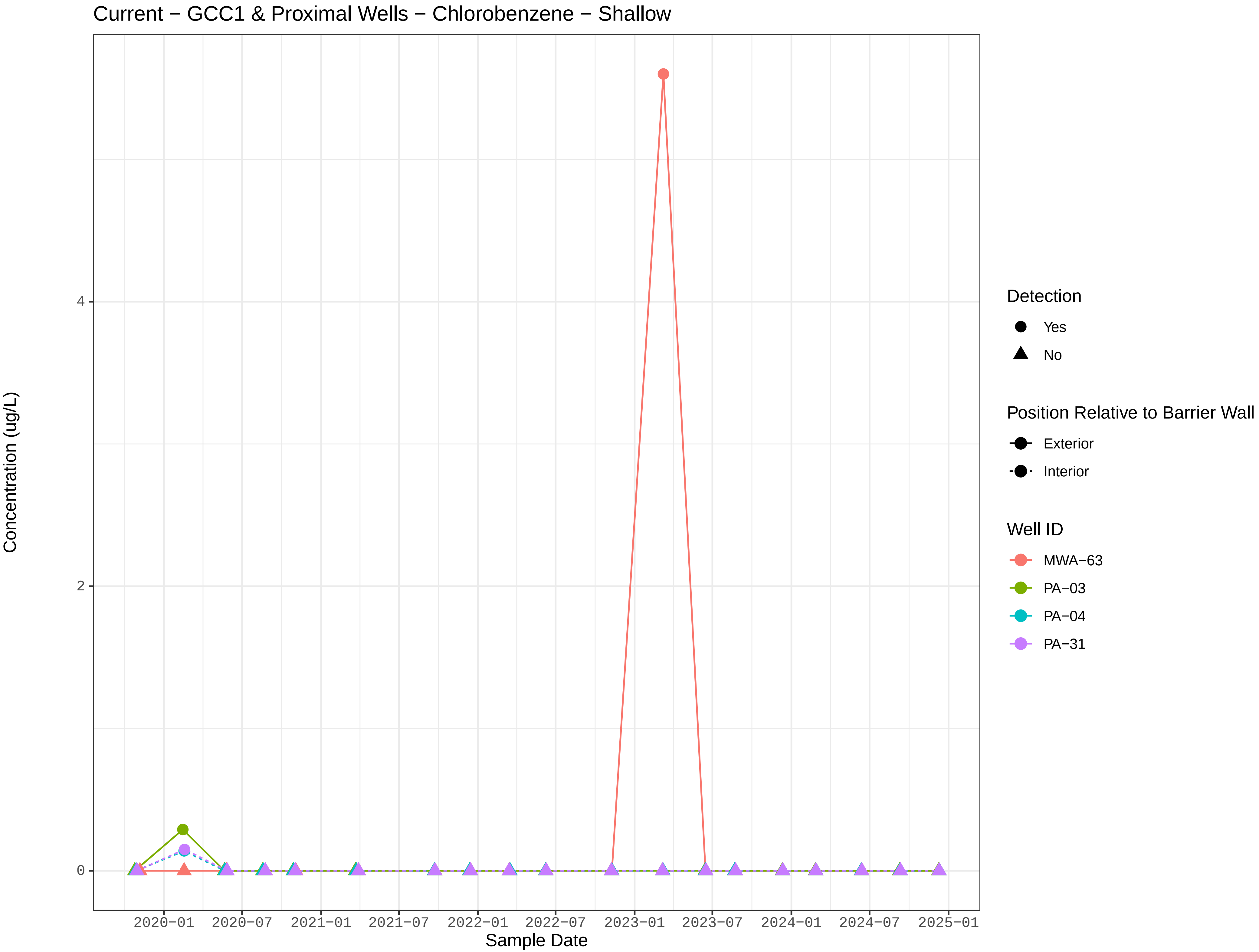



Current − GCC1 & Proximal Wells − Chloride − Shallow
Concentration (ug/L)
8e+04
6e+04
4e+04
2e+04
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−63
PA−03 (MK Trend Included)
PA−04 (MK Trend Included)
PA−31 (MK Trend Included)

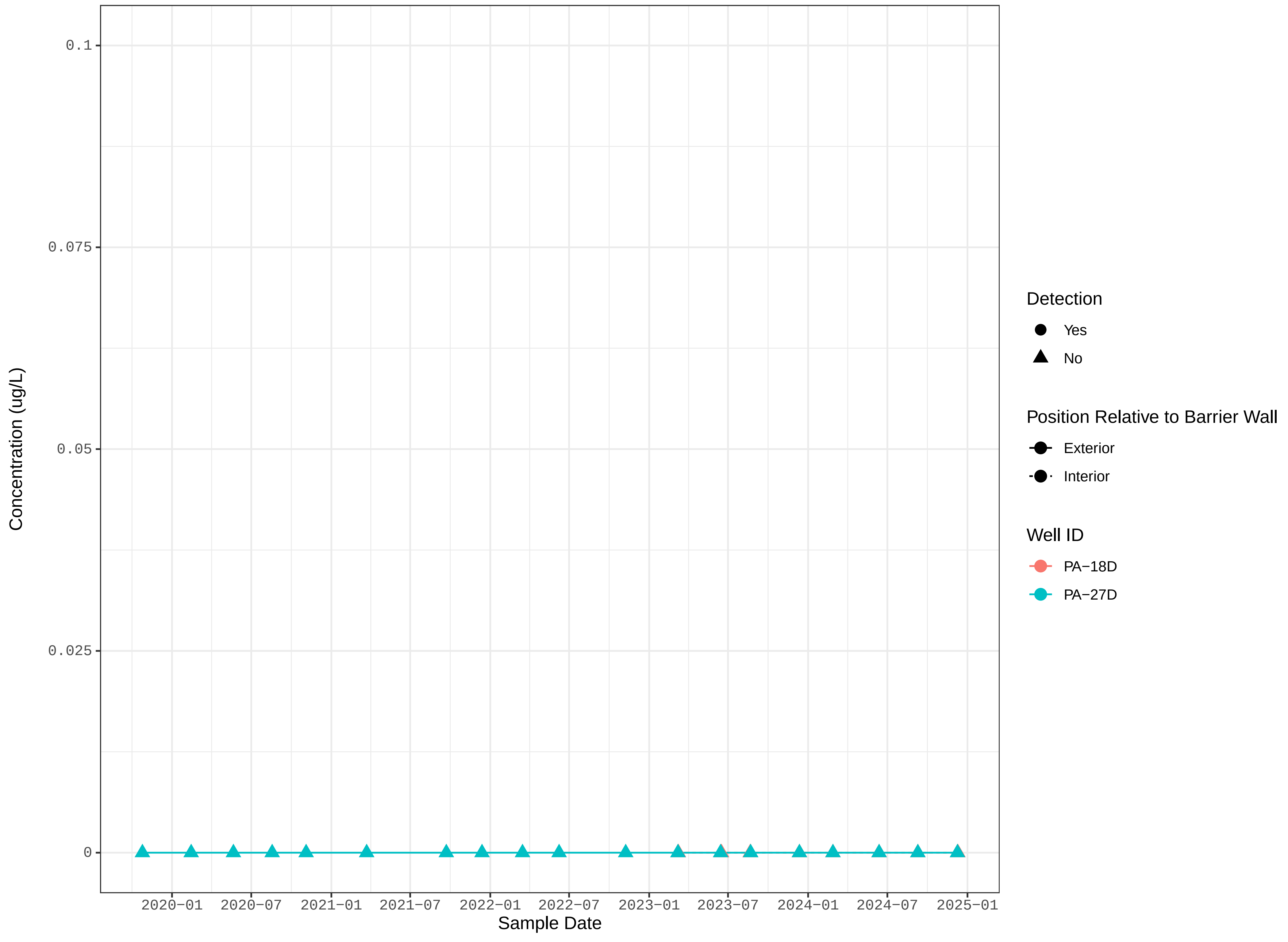

Current − GCC1 & Proximal Wells − Chlorobenzene − Deep
Concentration (ug/L)
0
1
2
3
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−18D
PA−27D

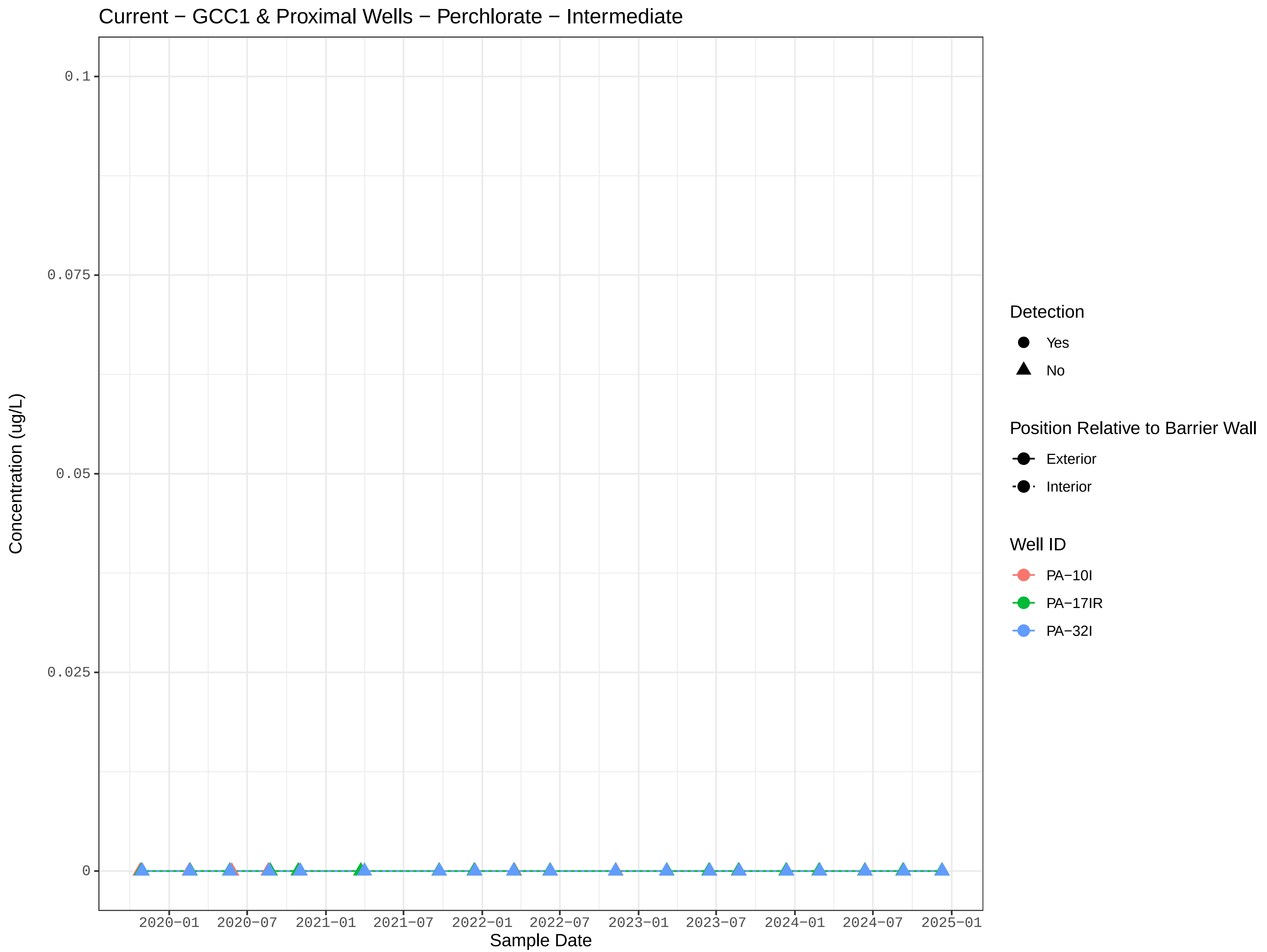
Current − GCC1 & Proximal Wells − Chlorobenzene − Intermediate



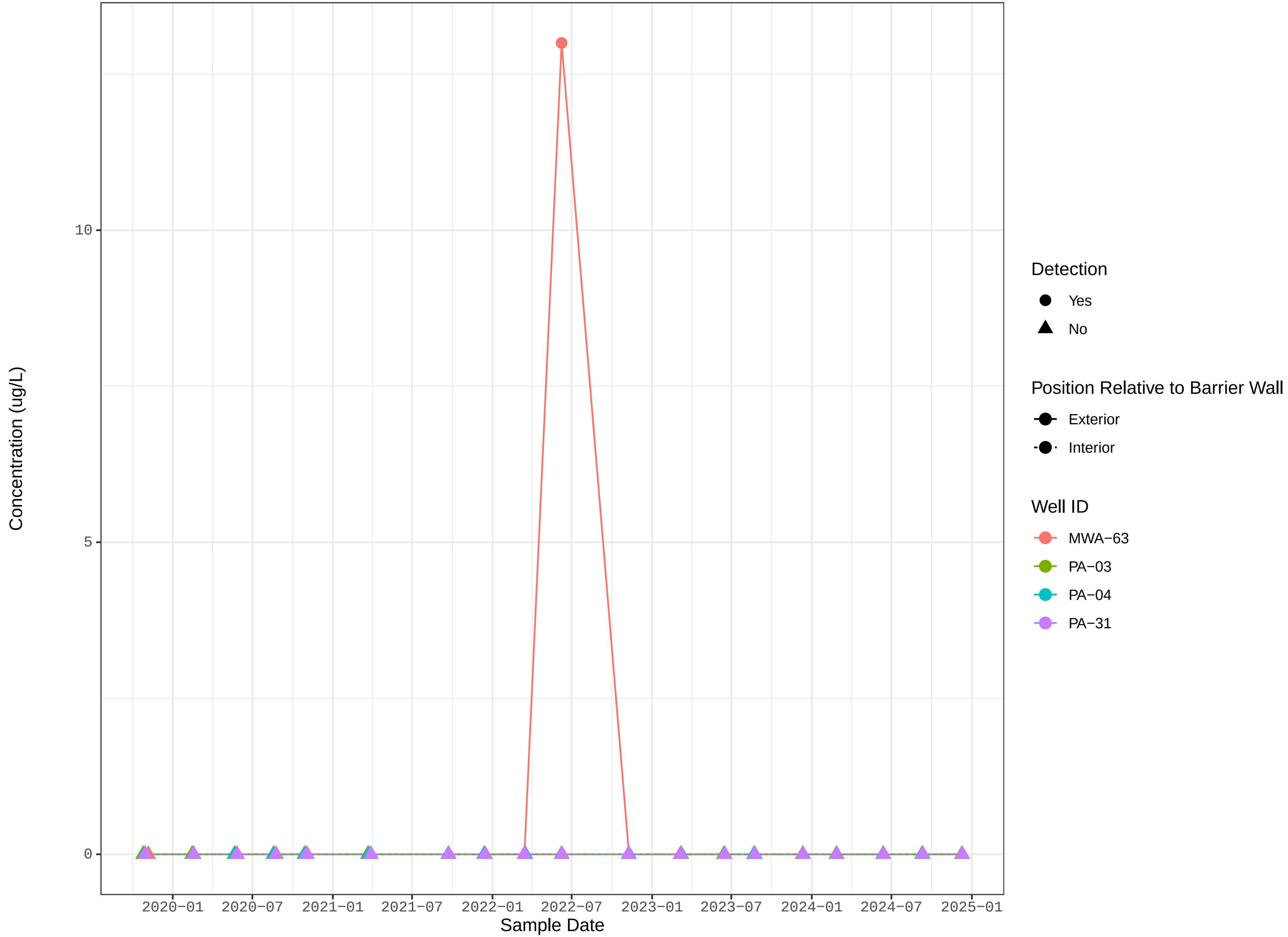

Current − GCC1 & Proximal Wells − Chlorobenzene − Shallow
Concentration (ug/L)
0
2
4
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−63
PA−03
PA−04
PA−31

Current − GCC1 & Proximal Wells − Perchlorate − Deep

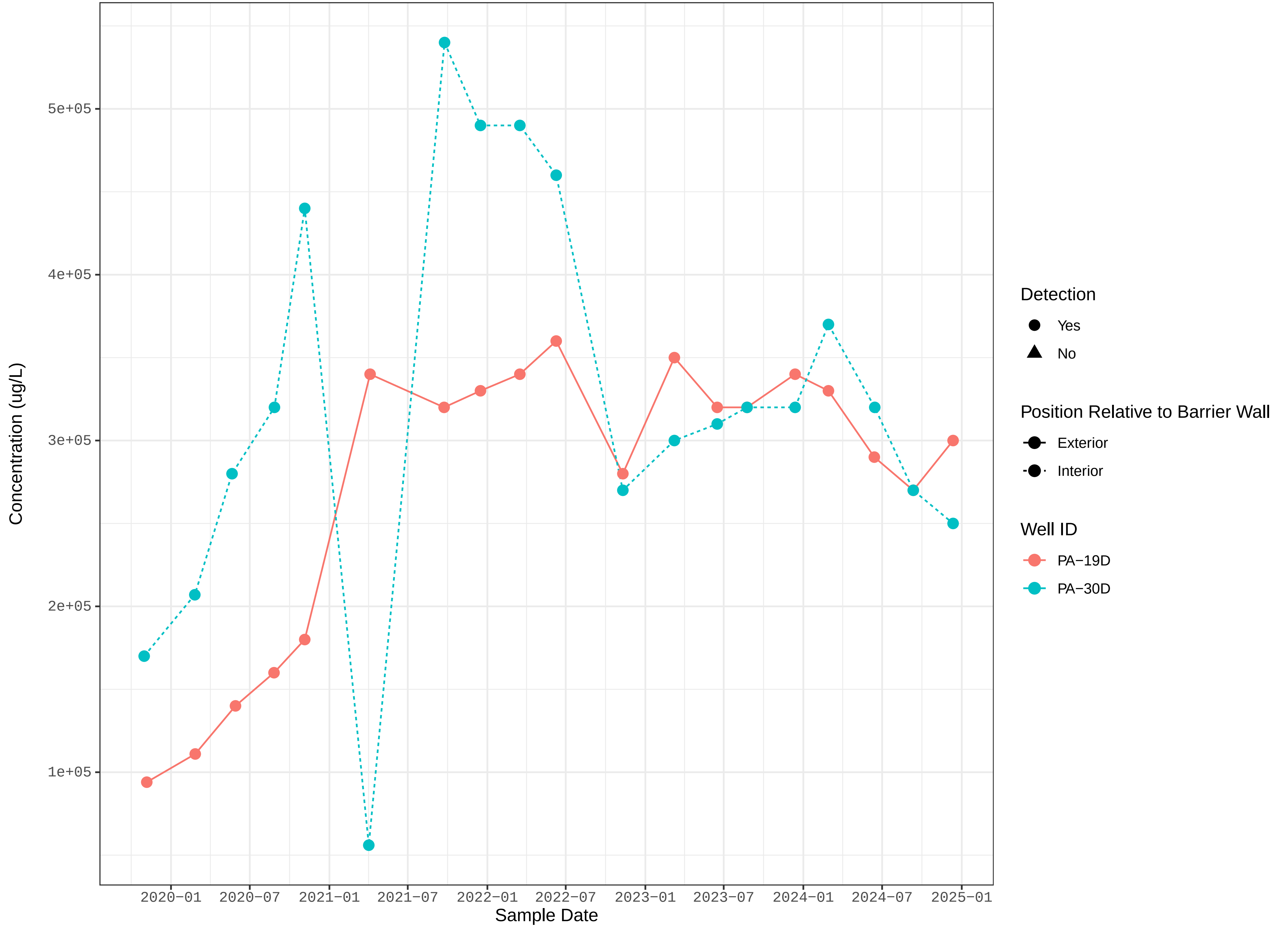


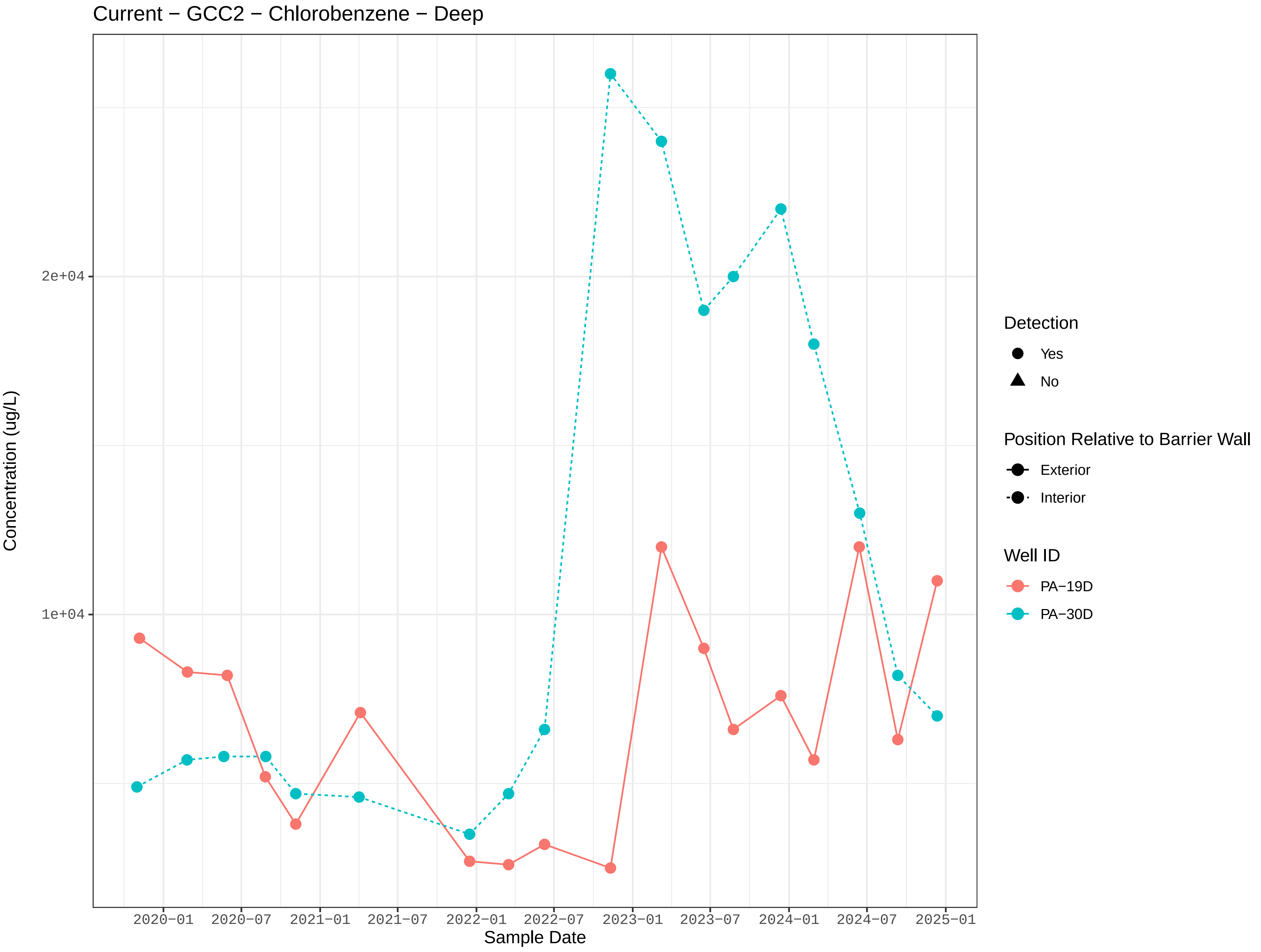

Current − GCC1 & Proximal Wells − Perchlorate − Intermediate
0.1
0.075
0.05
0.025
0
Concentration (ug/L)
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−10I
PA−17IR
PA−32I

Current − GCC1 & Proximal Wells − Perchlorate − Shallow



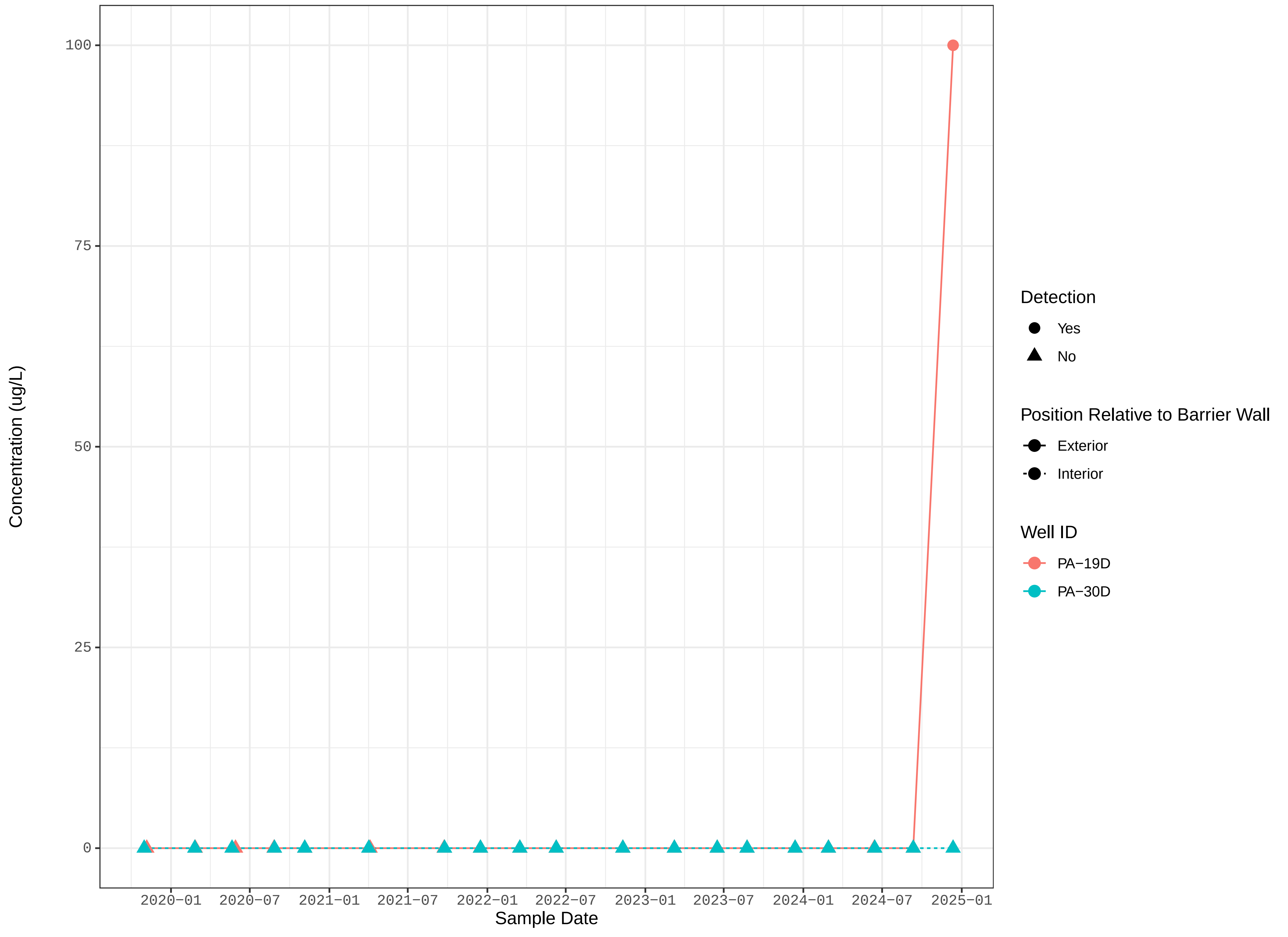
Current − GCC2 − Chloride − Deep

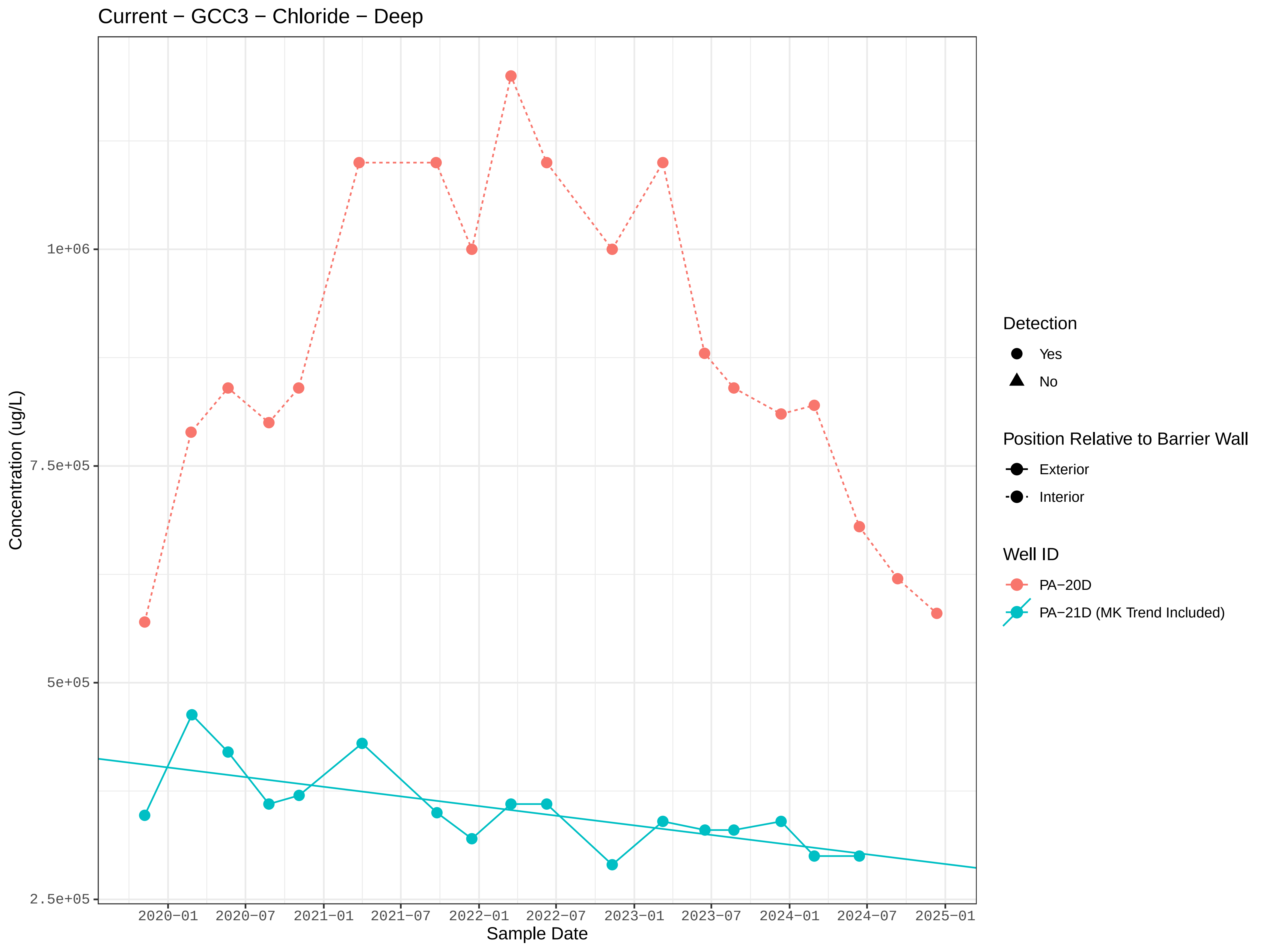


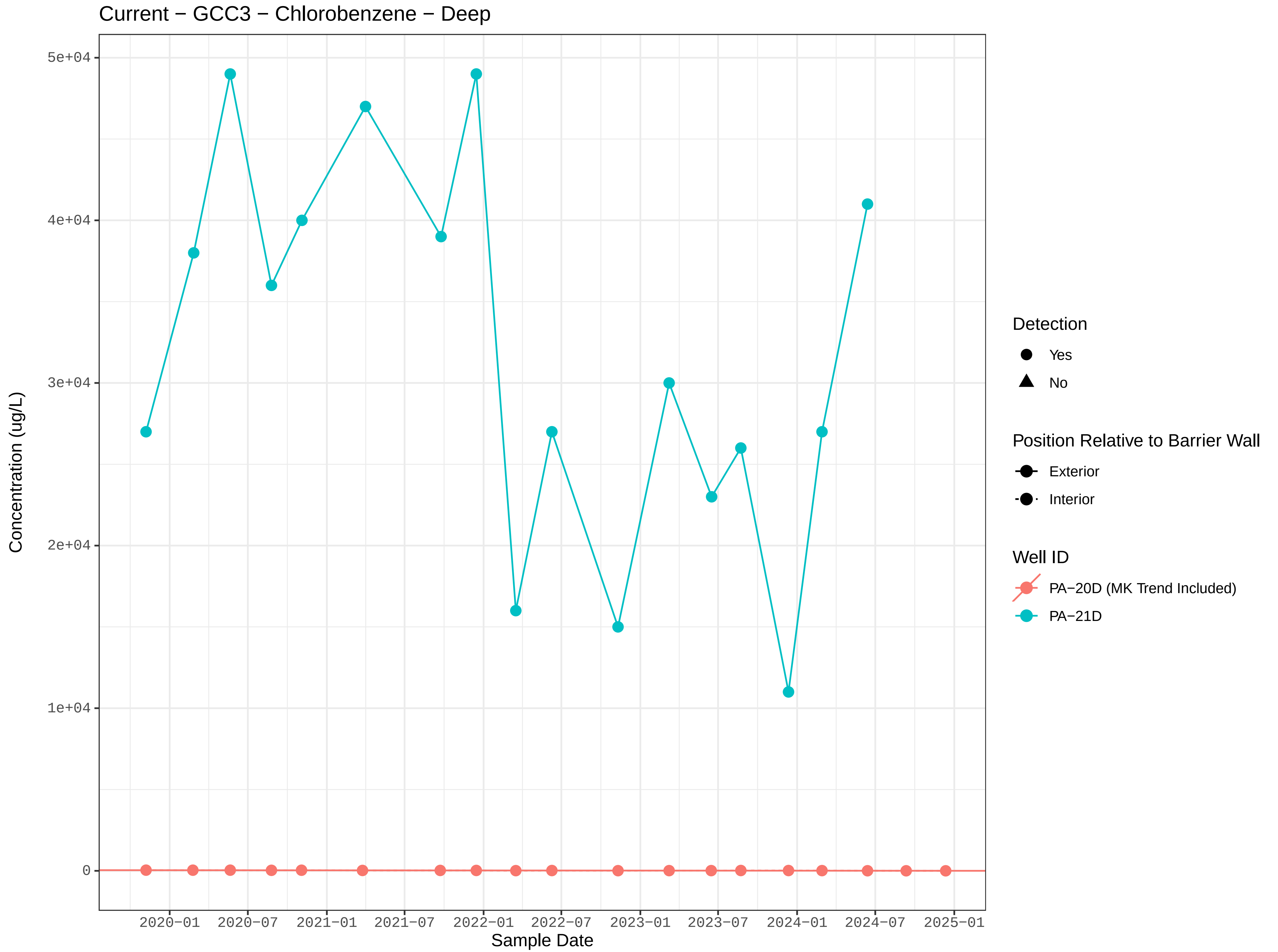


Current − GCC2 − Chlorobenzene − Deep
Concentration (ug/L)
2e+04
1e+04
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−19D
PA−30D

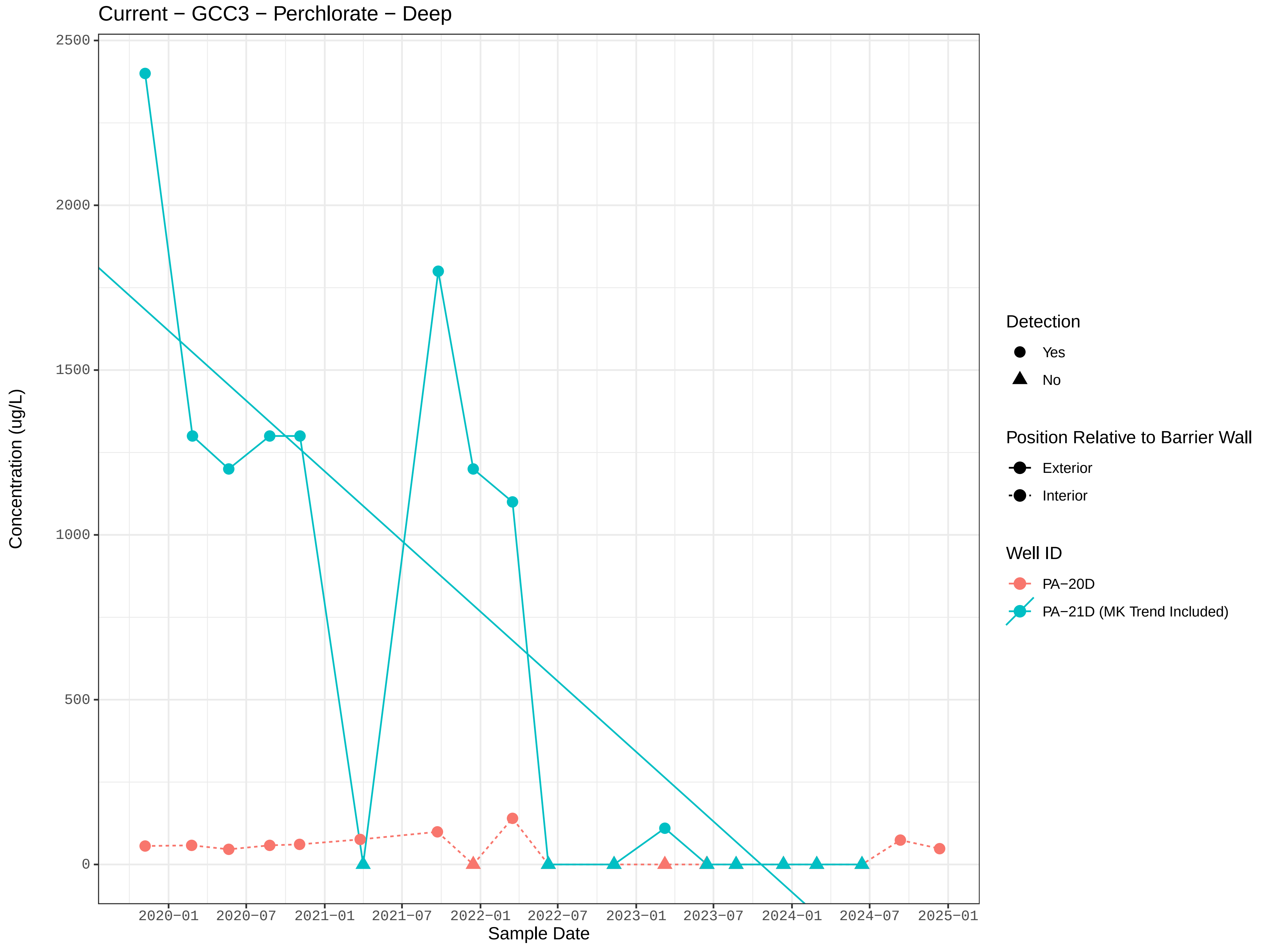
Current − GCC2 − Perchlorate − Deep

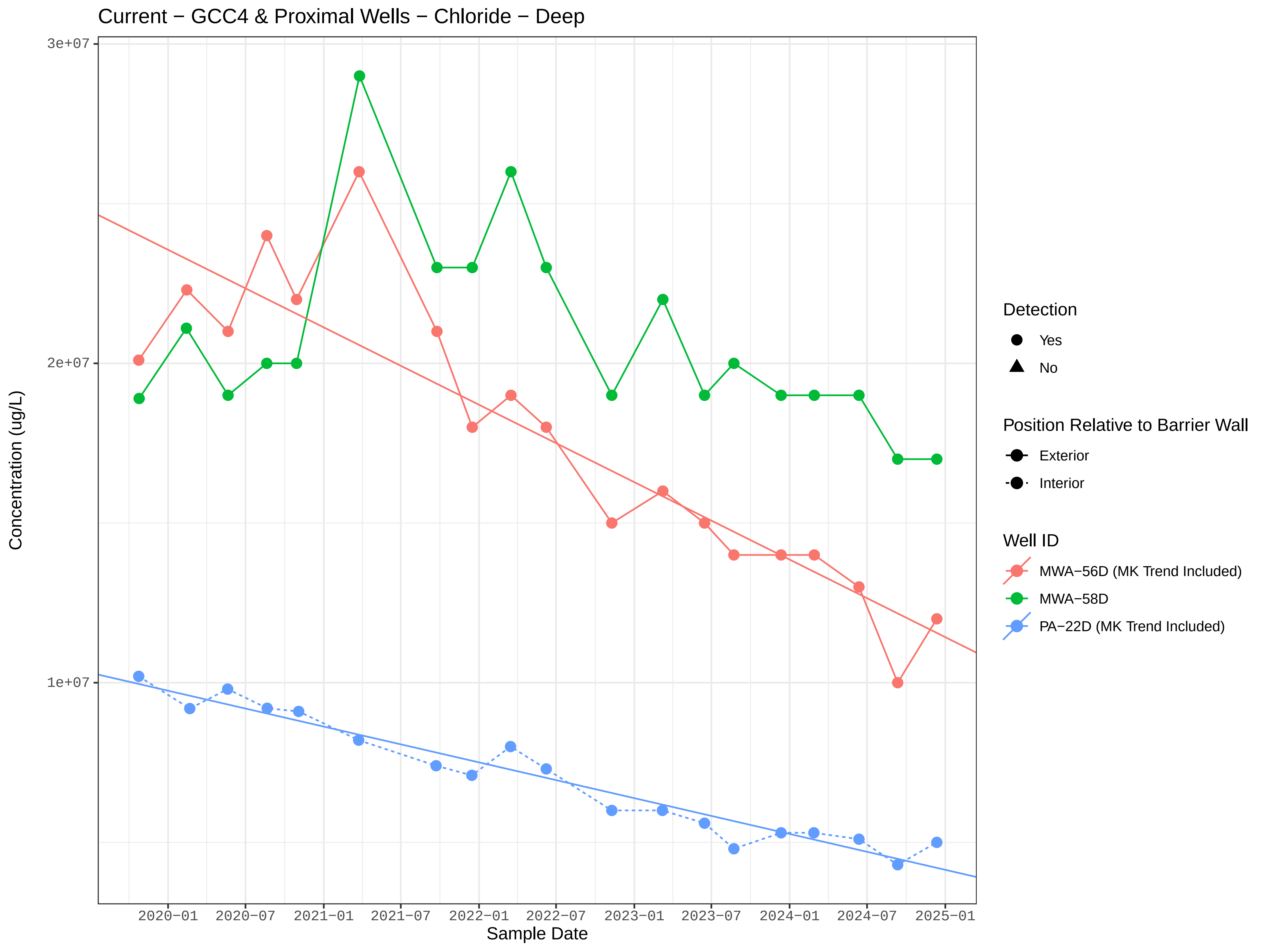



Current − GCC3 − Chloride − Deep
Concentration (ug/L)
1e+06
7.5e+05
5e+05
2.5e+05
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−20D
PA−21D (MK Trend Included)



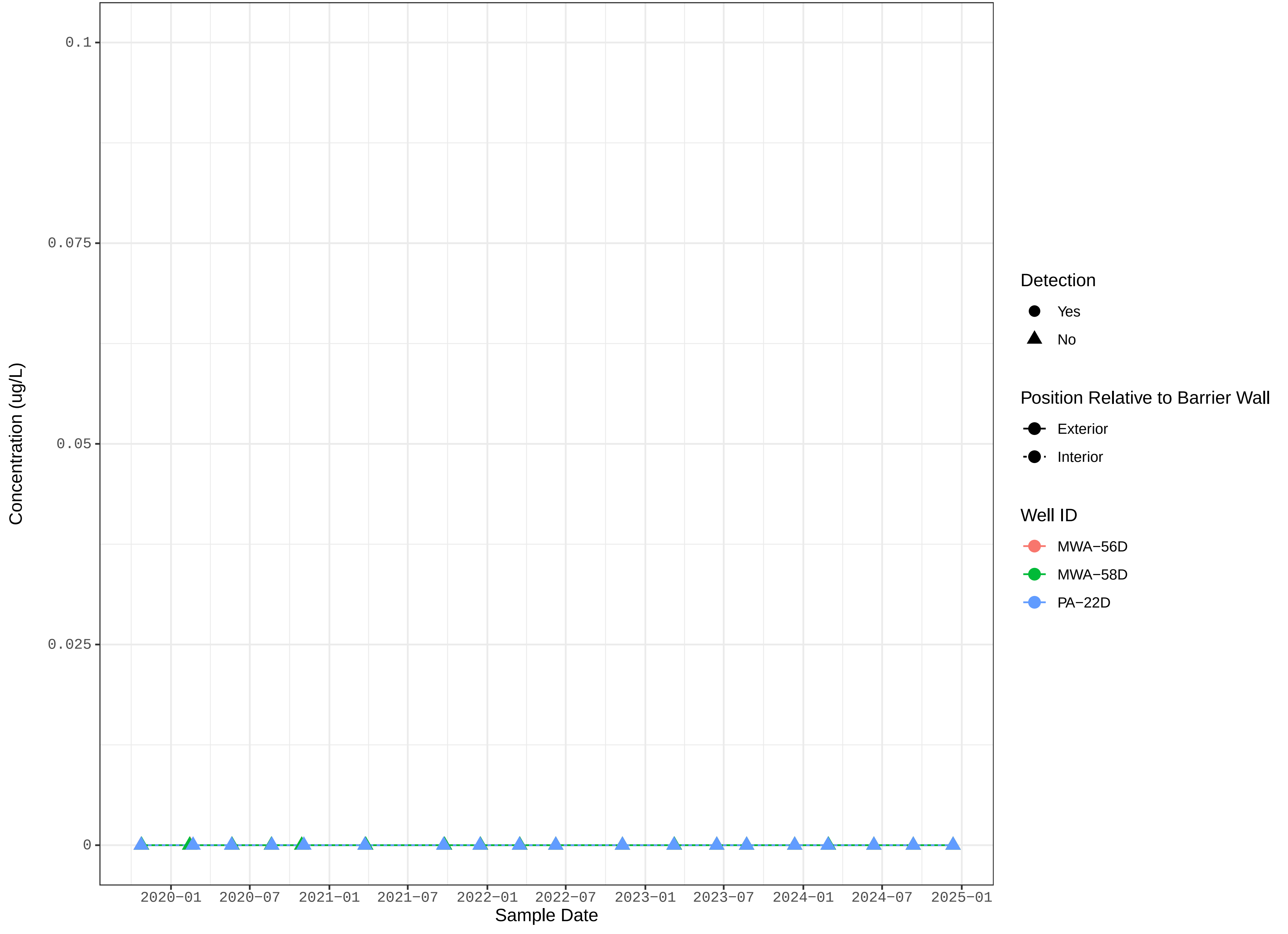
Current − GCC3 − Chlorobenzene − Deep
Concentration (ug/L)
5e+04
4e+04
3e+04
2e+04
1e+04
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−20D (MK Trend Included)
PA−21D

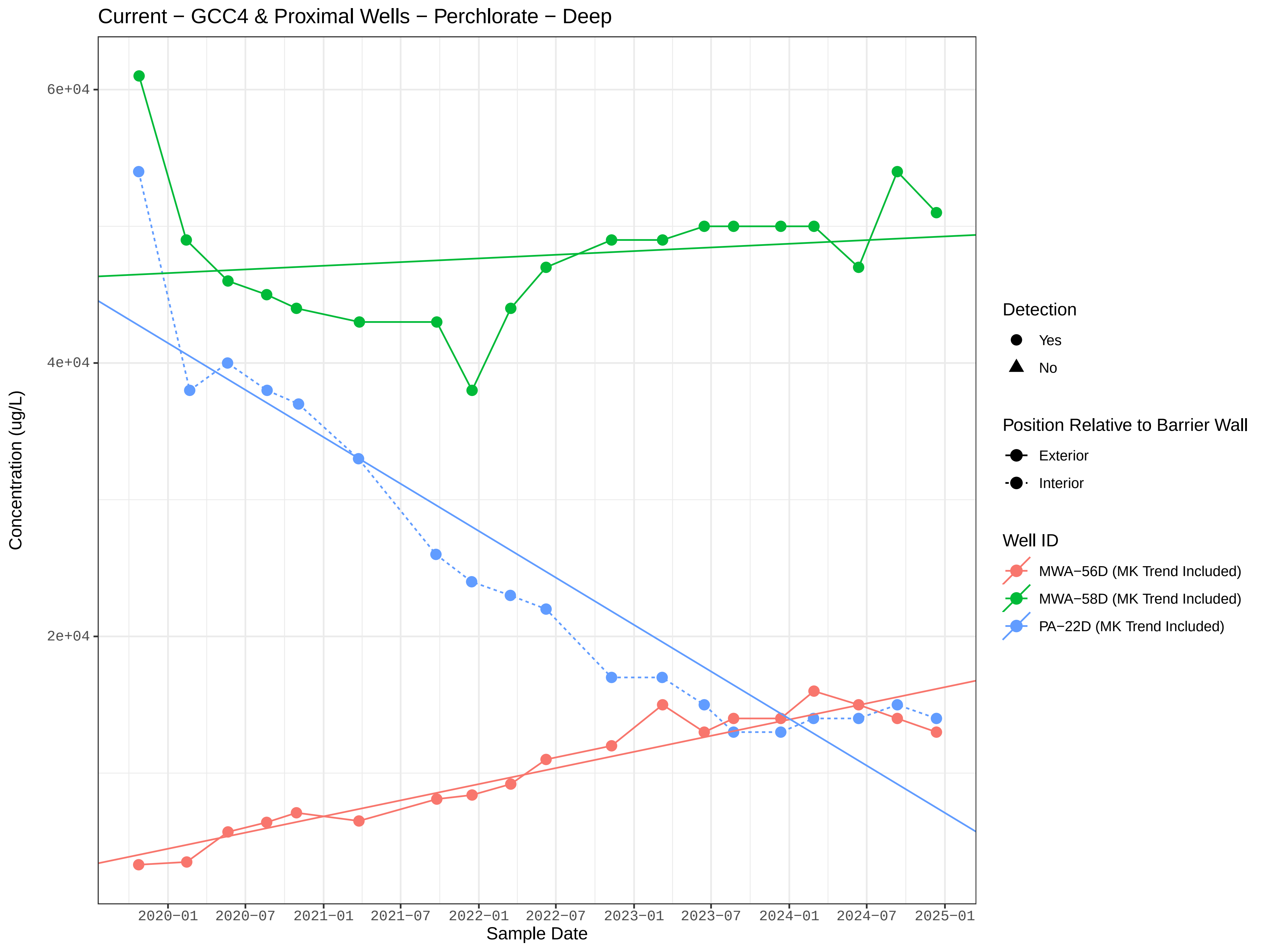

Current − GCC3 − Perchlorate − Deep
Concentration (ug/L)
2500
2000
1500
1000
500
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−20D
PA−21D (MK Trend Included)



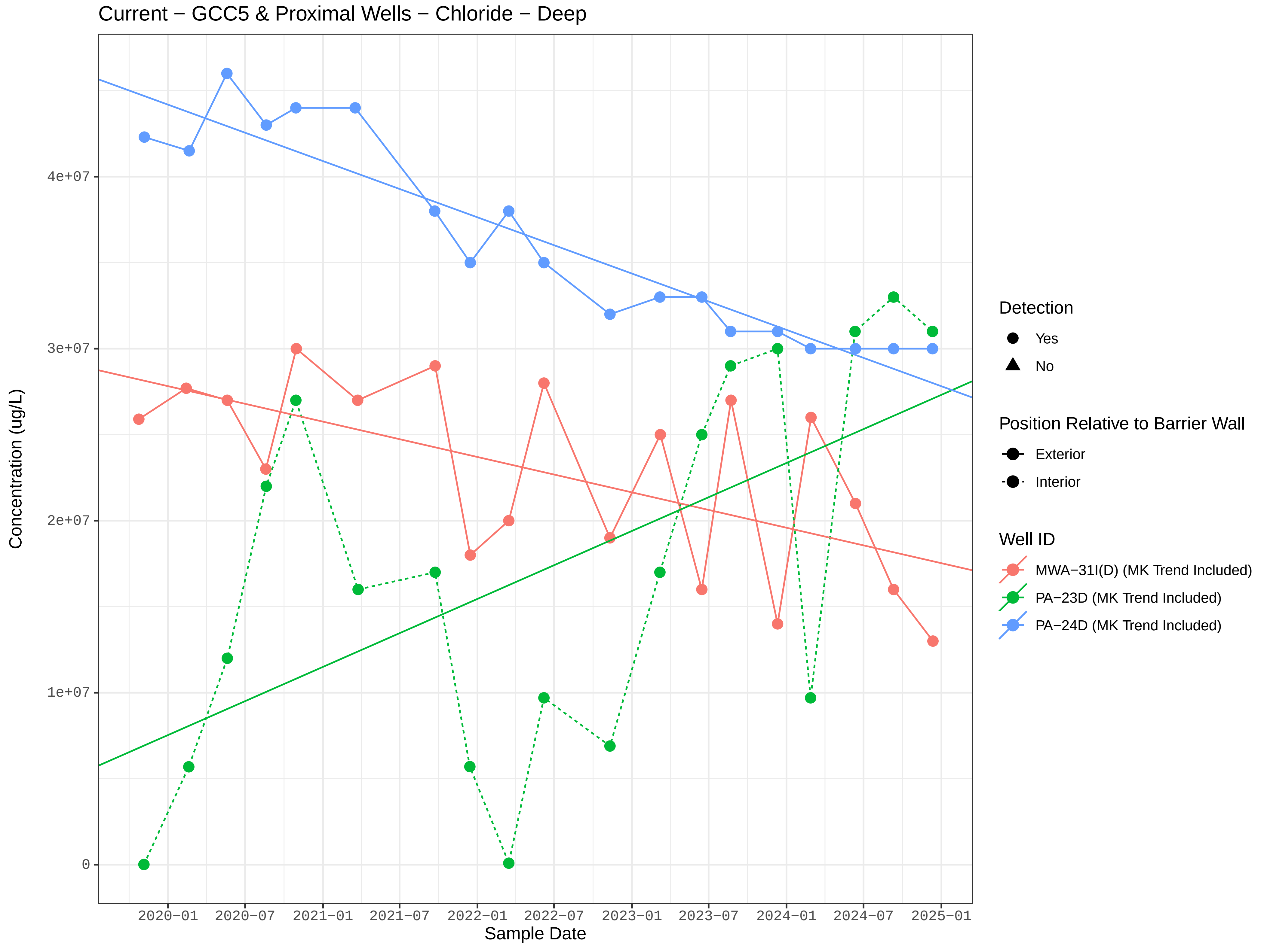
Current − GCC4 & Proximal Wells − Chloride − Deep
3e+07
2e+07
1e+07
Concentration (ug/L)
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−56D (MK Trend Included)
MWA−58D
PA−22D (MK Trend Included)

Current − GCC4 & Proximal Wells − Chlorobenzene − Deep

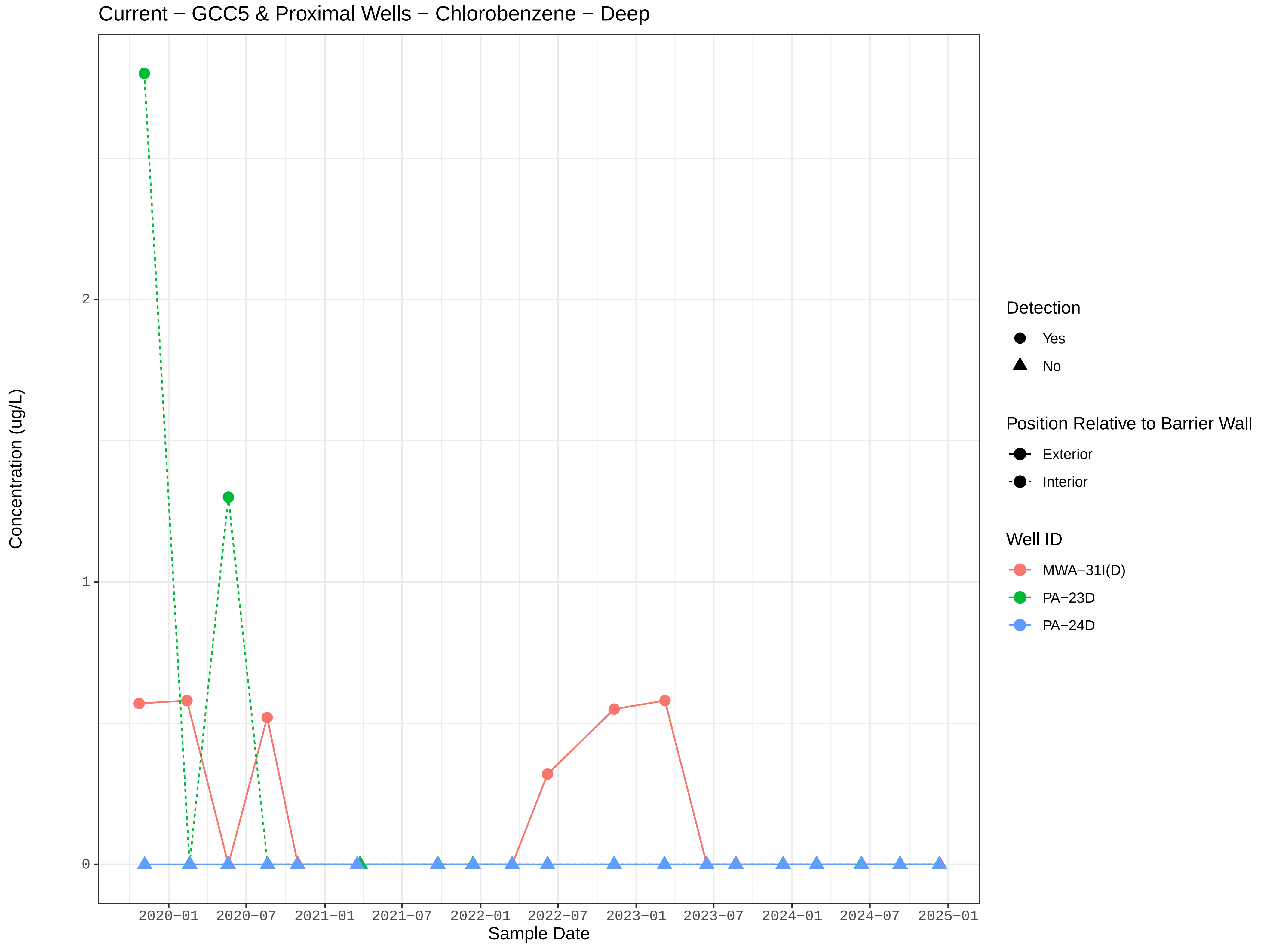




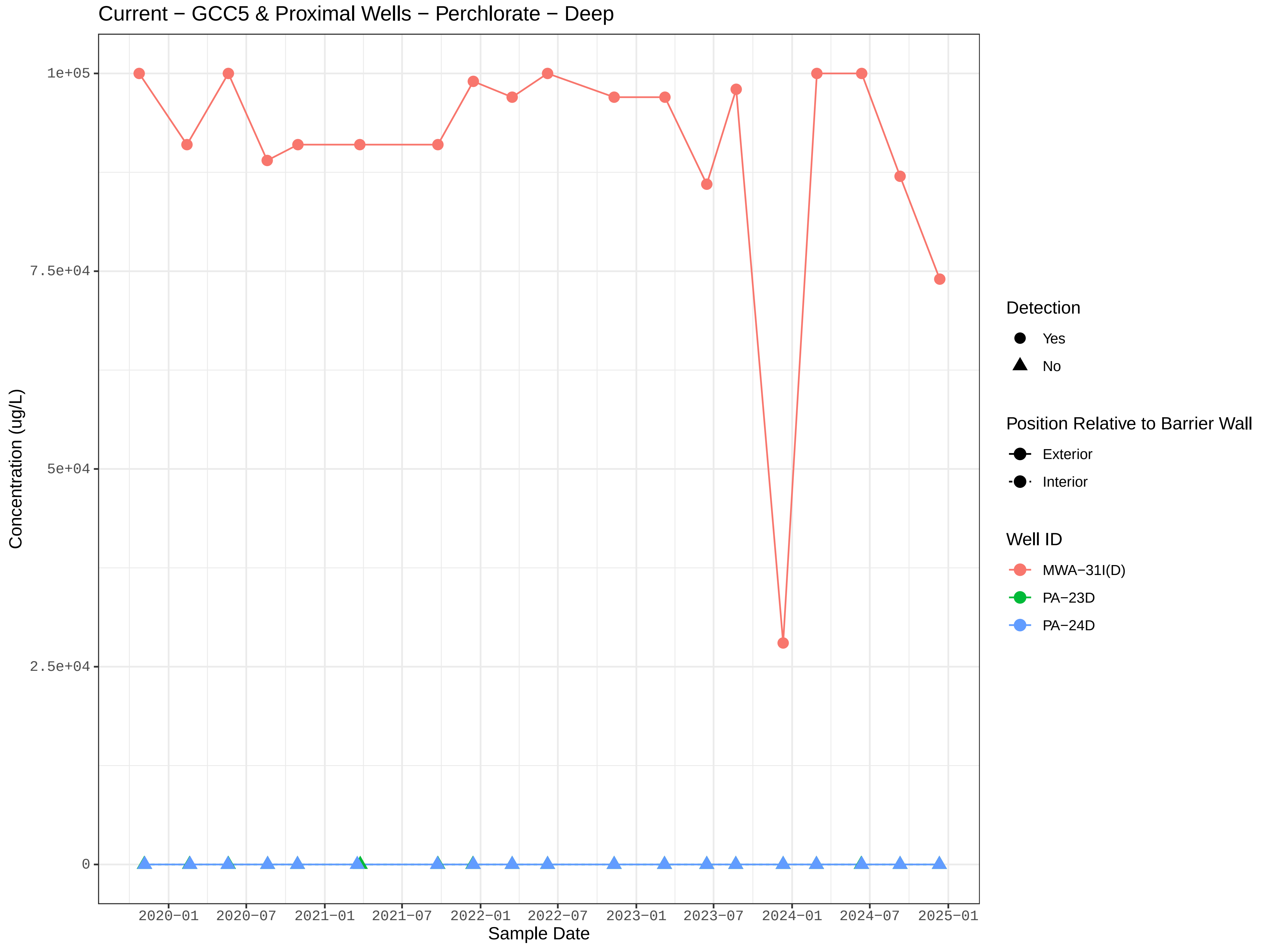
Current − GCC4 & Proximal Wells − Perchlorate − Deep
6e+04
4e+04
2e+04
Concentration (ug/L)
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−56D (MK Trend Included)
MWA−58D (MK Trend Included)
PA−22D (MK Trend Included)



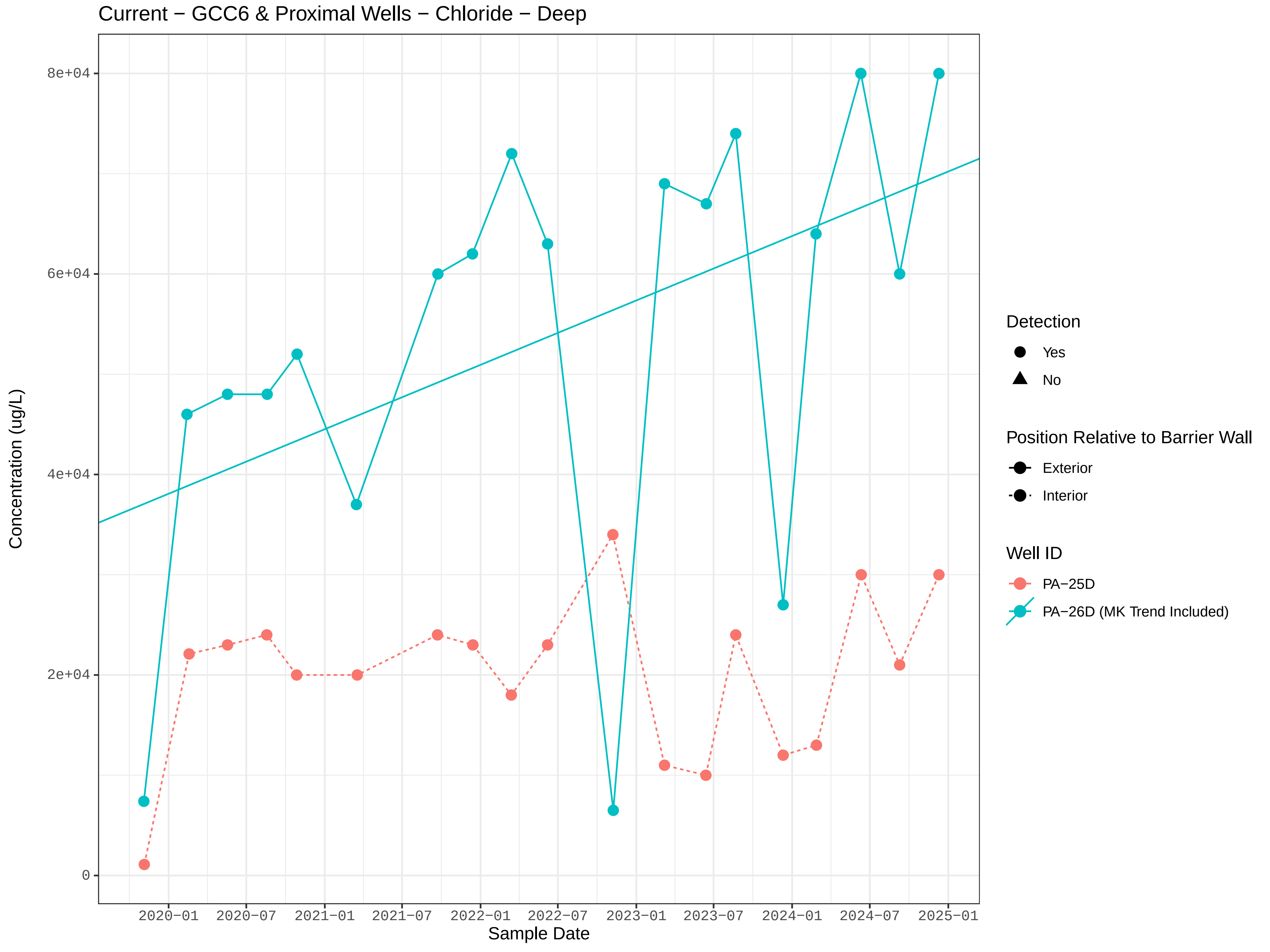
Current − GCC5 & Proximal Wells − Chloride − Deep
Concentration (ug/L)
0
1e+07
2e+07
3e+07
4e+07
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−31I(D) (MK Trend Included)
PA−23D (MK Trend Included)
PA−24D (MK Trend Included)

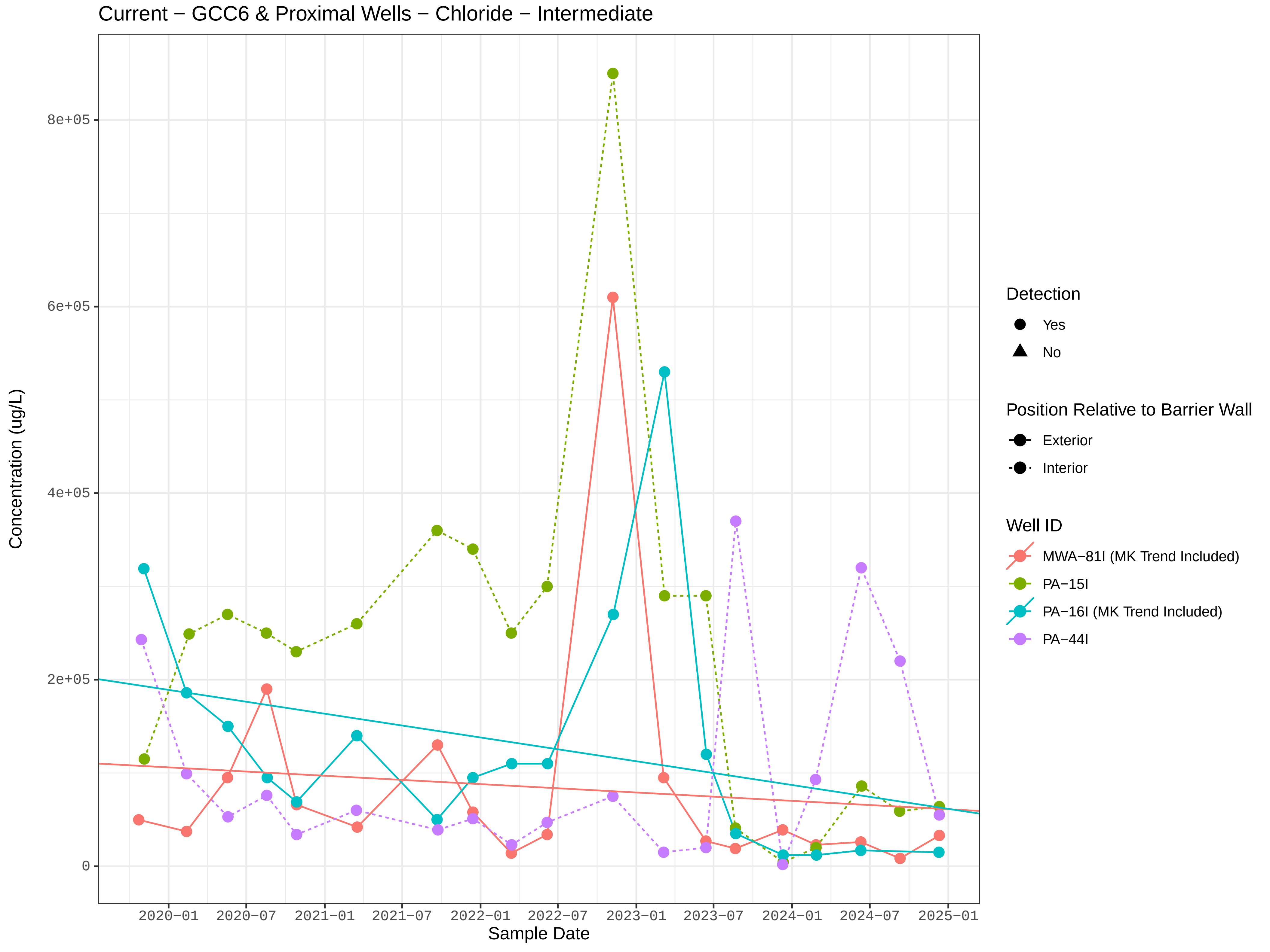


Current − GCC5 & Proximal Wells − Chlorobenzene − Deep
Concentration (ug/L)
0
1
2
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−31I(D)
PA−23D
PA−24D

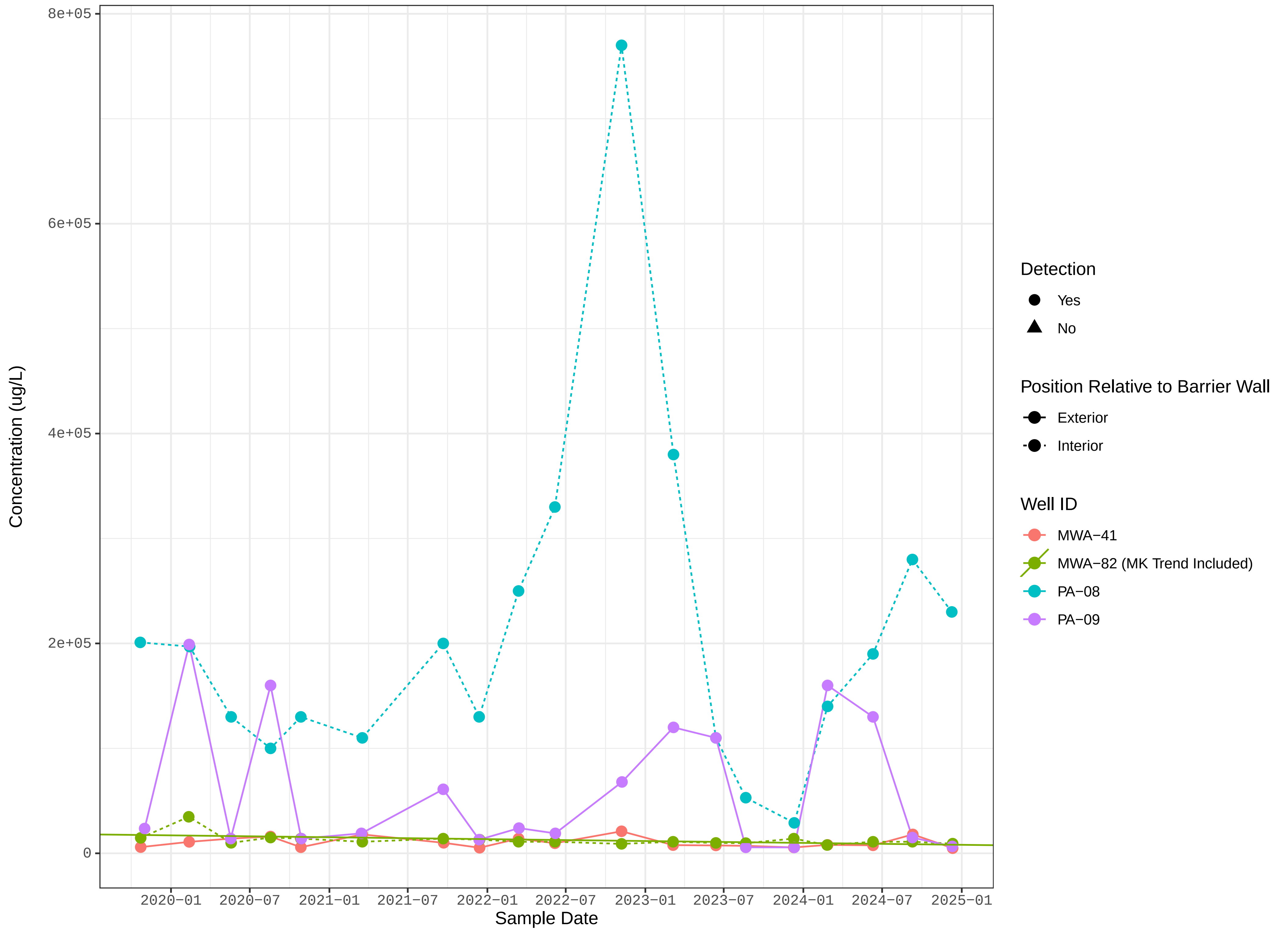


Current − GCC5 & Proximal Wells − Perchlorate − Deep
Concentration (ug/L)
1e+05
7.5e+04
5e+04
2.5e+04
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−31I(D)
PA−23D
PA−24D

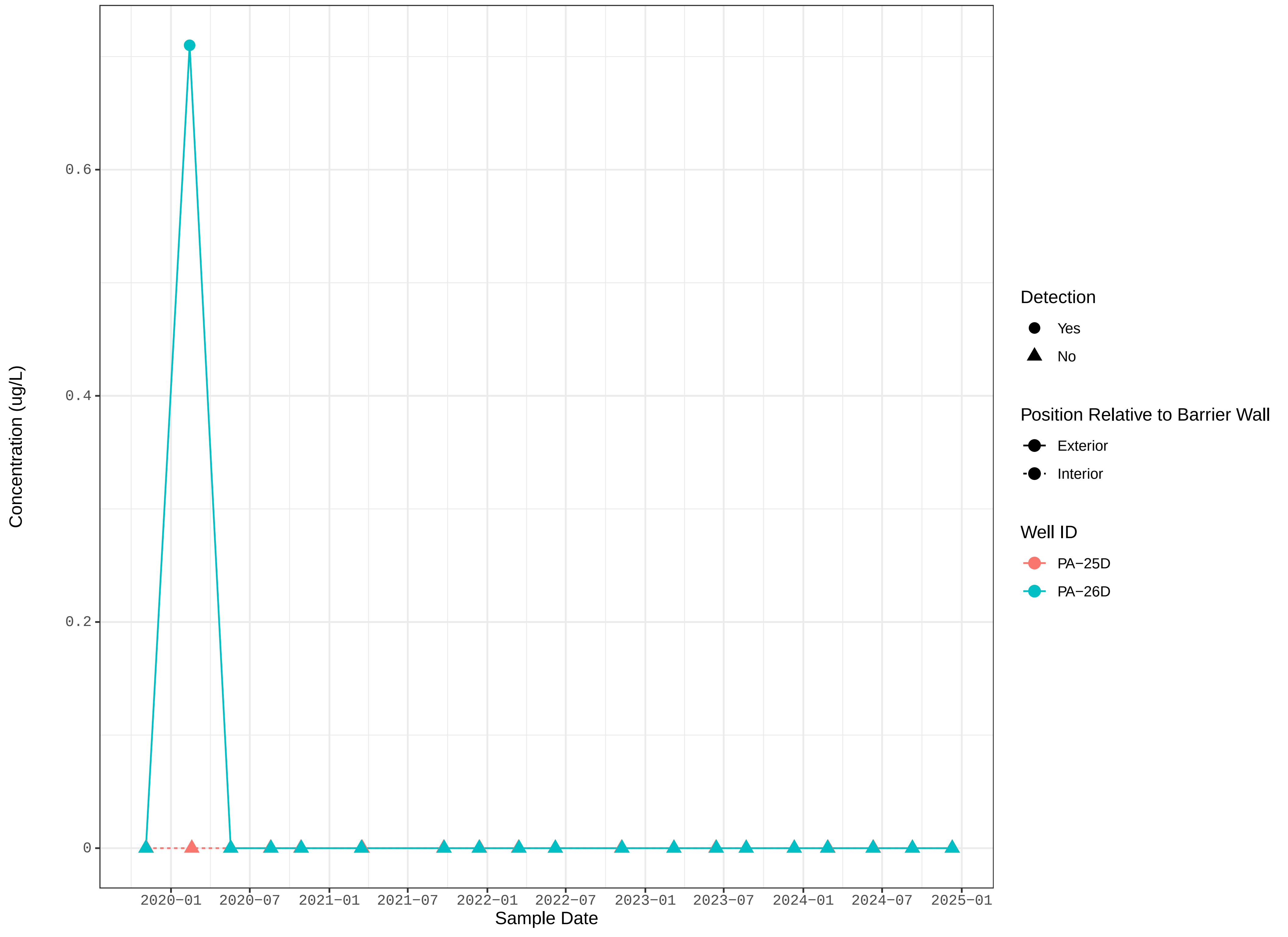

Current − GCC6 & Proximal Wells − Chloride − Deep
8e+04
6e+04
4e+04
2e+04
0
Concentration (ug/L)
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−25D
PA−26D (MK Trend Included)


Current − GCC6 & Proximal Wells − Chloride − Intermediate
Concentration (ug/L)
8e+05
6e+05
4e+05
2e+05
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−81I (MK Trend Included)
PA−15I
PA−16I (MK Trend Included)
PA−44I

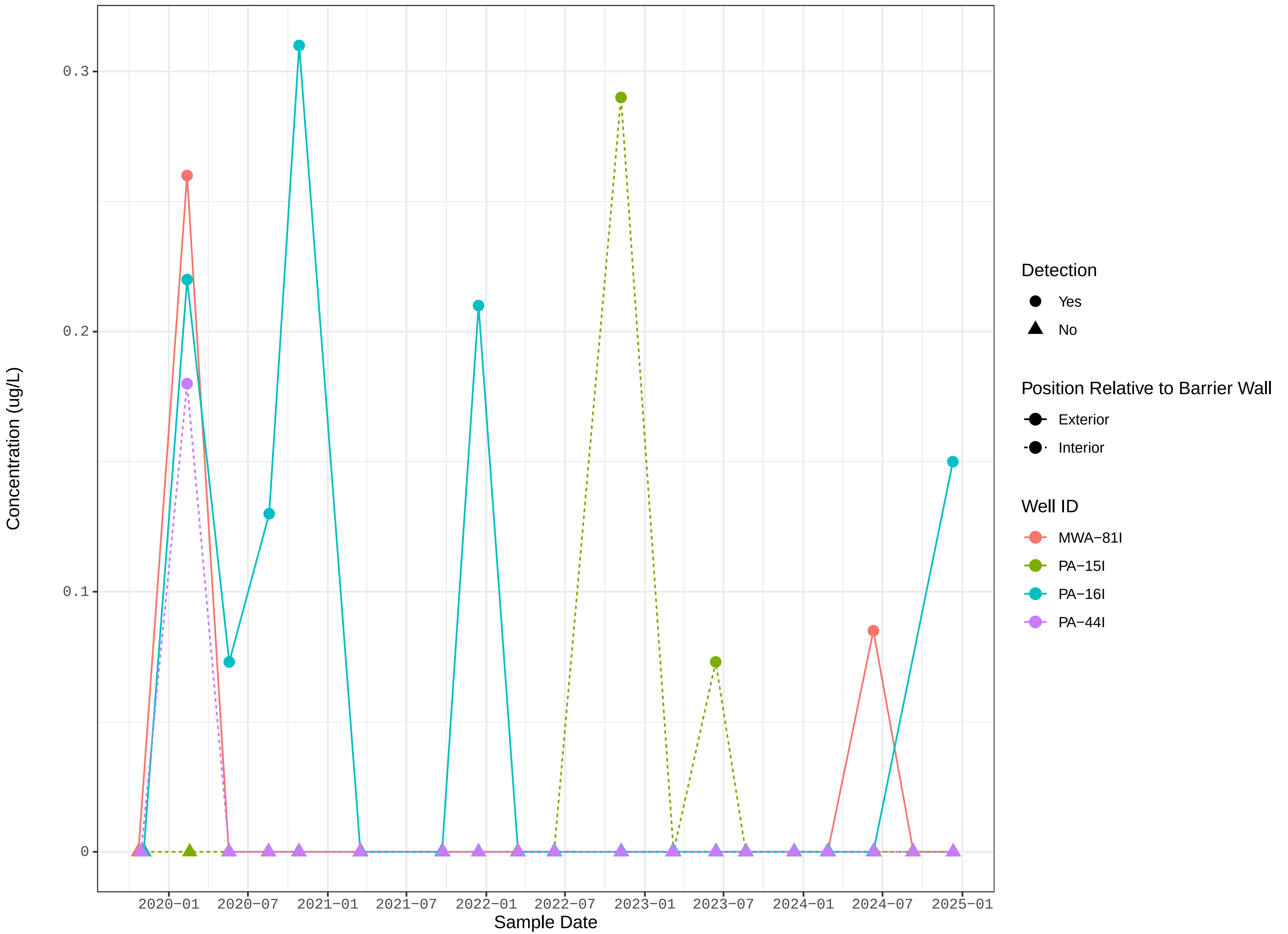
Current − GCC6 & Proximal Wells − Chloride − Shallow



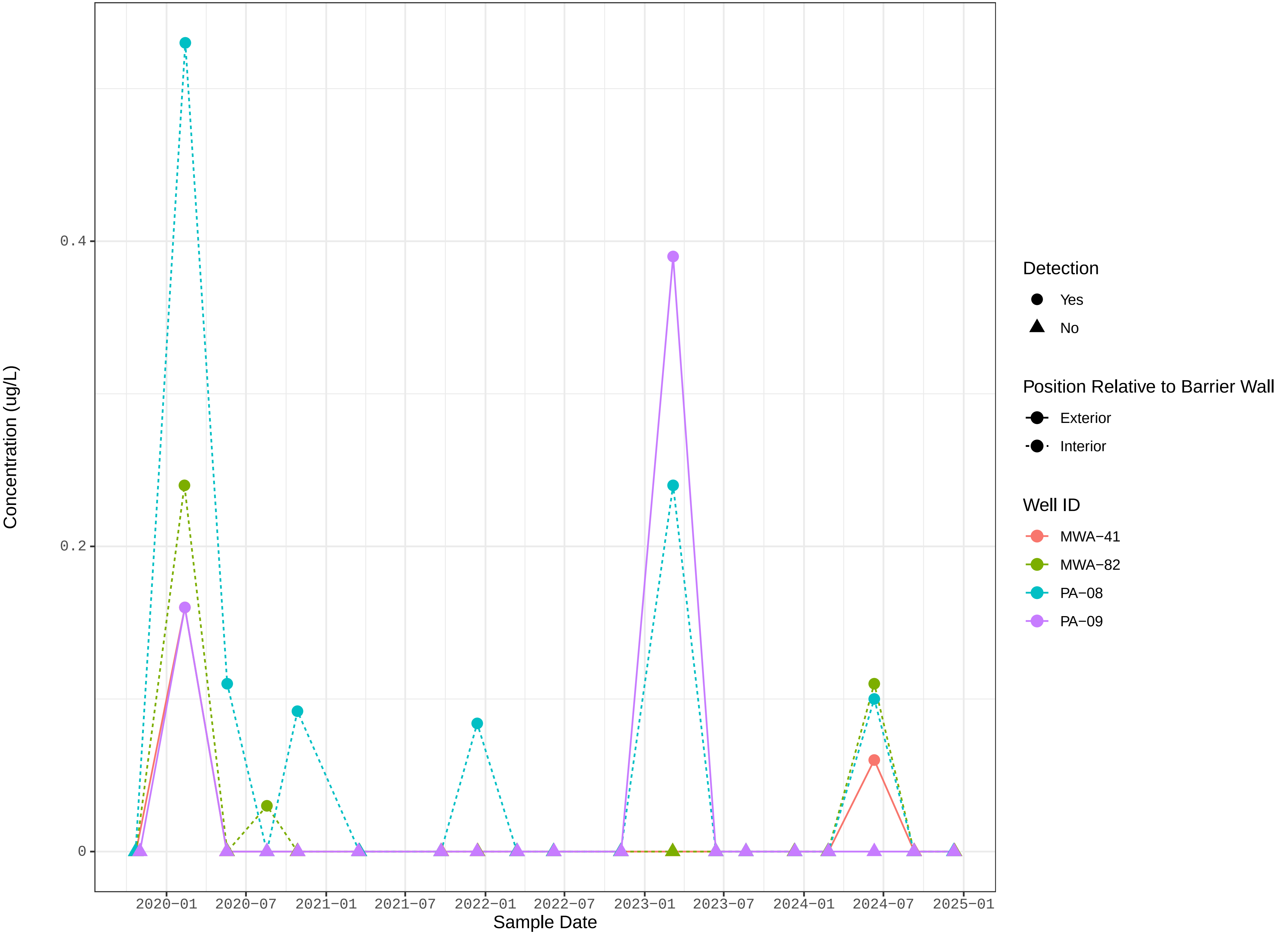
Current − GCC6 & Proximal Wells − Chlorobenzene − Deep

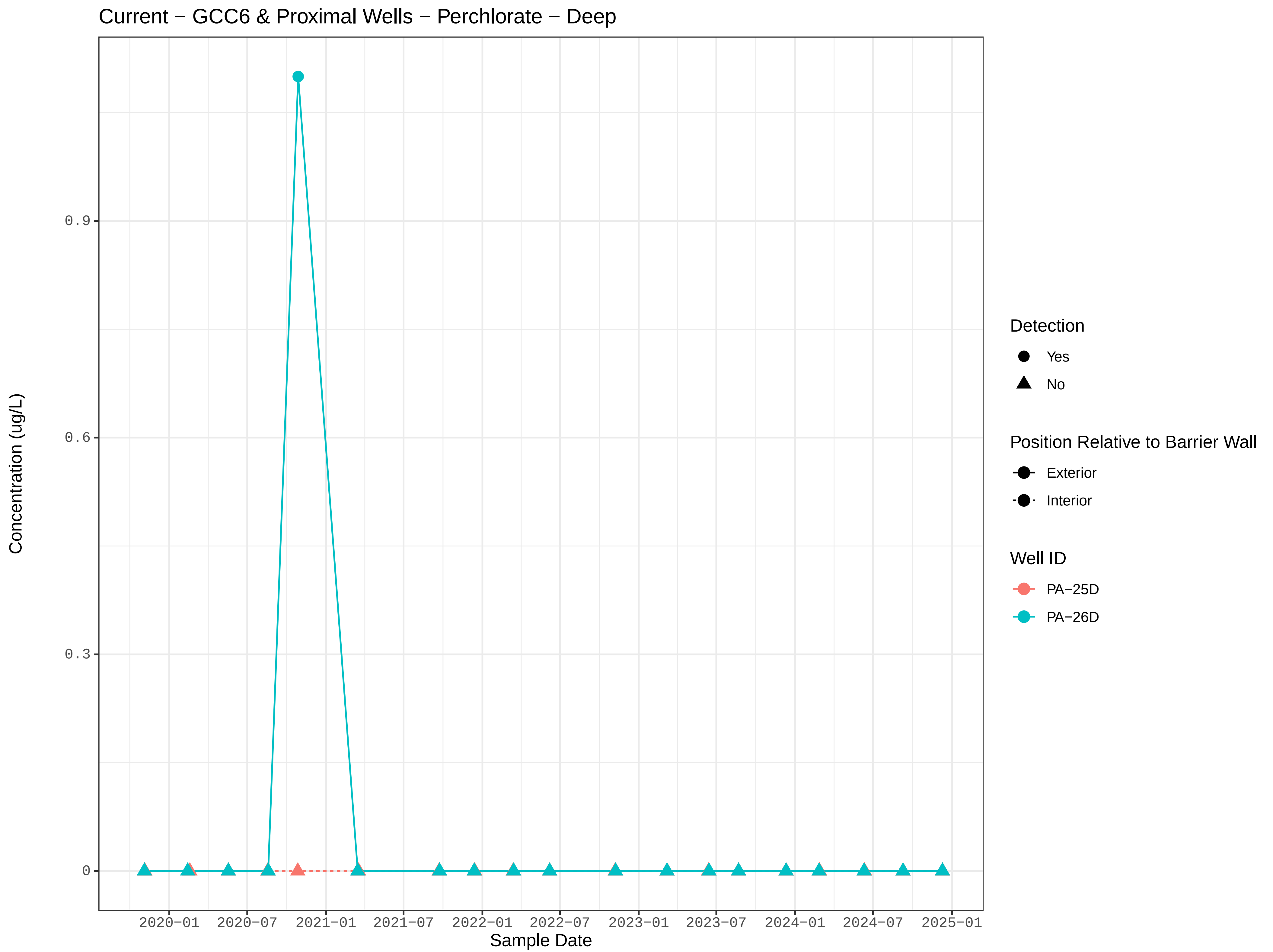


Current − GCC6 & Proximal Wells − Chlorobenzene − Intermediate

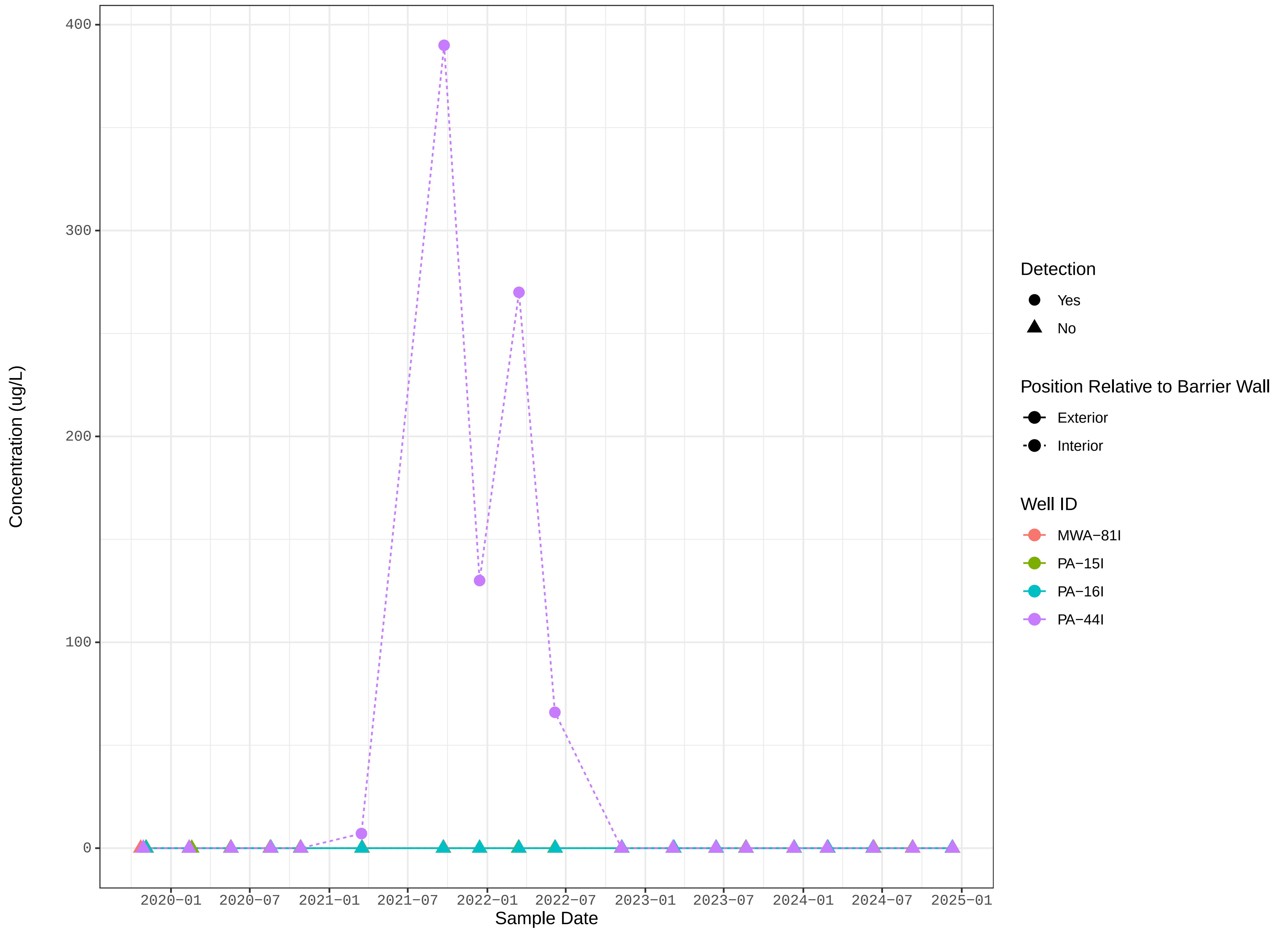


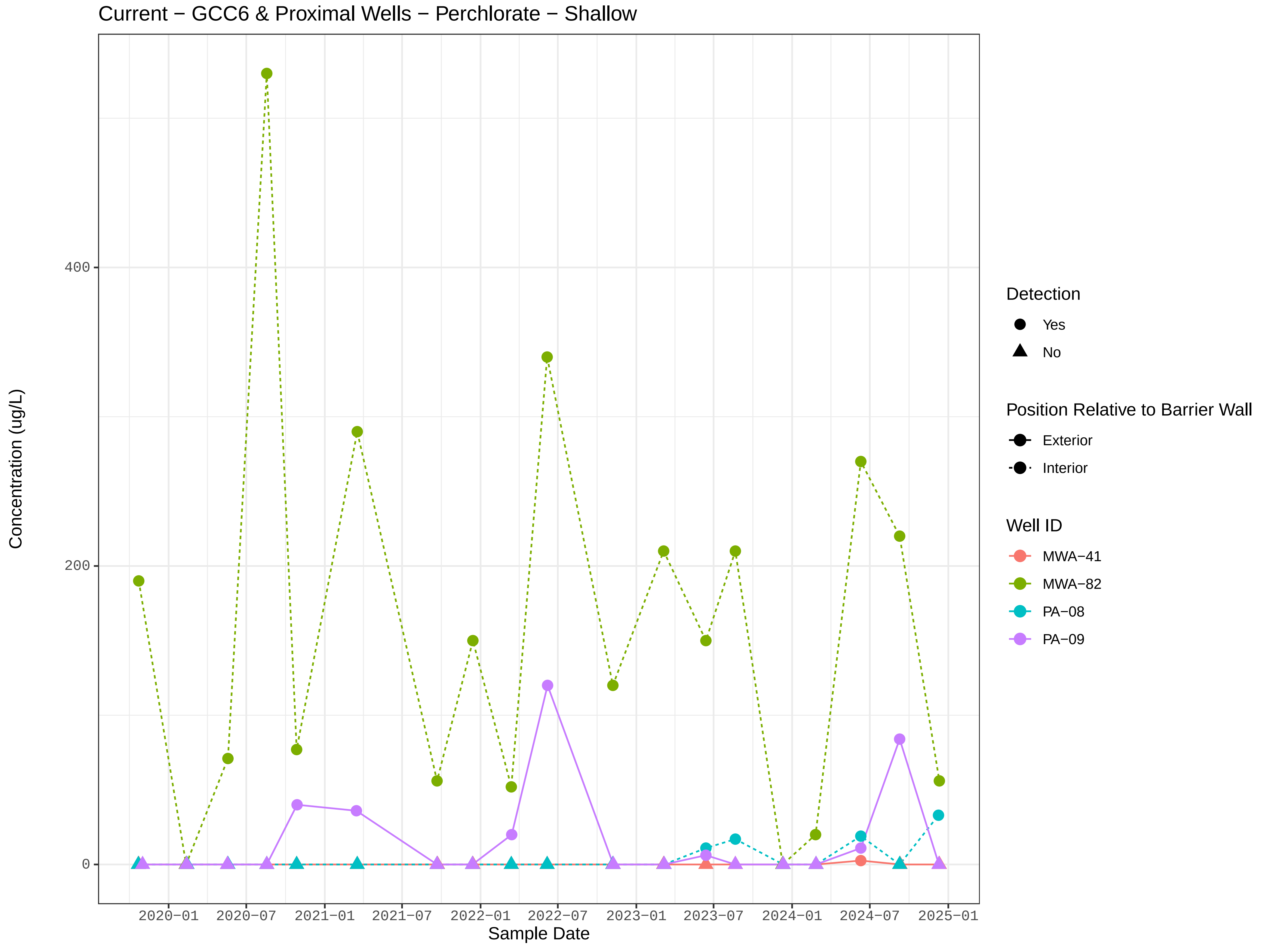
Current − GCC6 & Proximal Wells − Chlorobenzene − Shallow



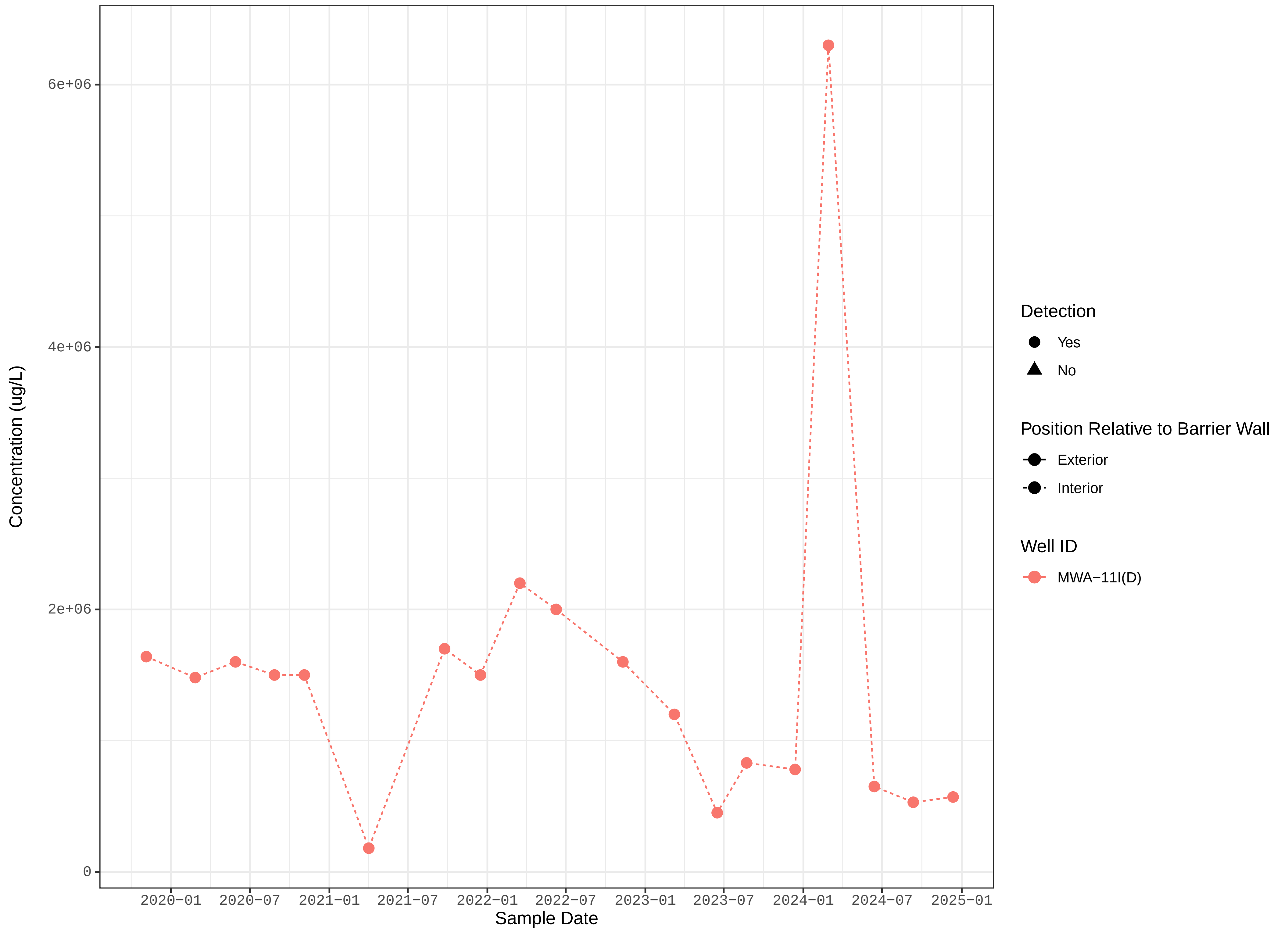

Current − GCC6 & Proximal Wells − Perchlorate − Deep
Concentration (ug/L)
0.9
0.6
0.3
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
PA−25D
PA−26D

Current − GCC6 & Proximal Wells − Perchlorate − Intermediate

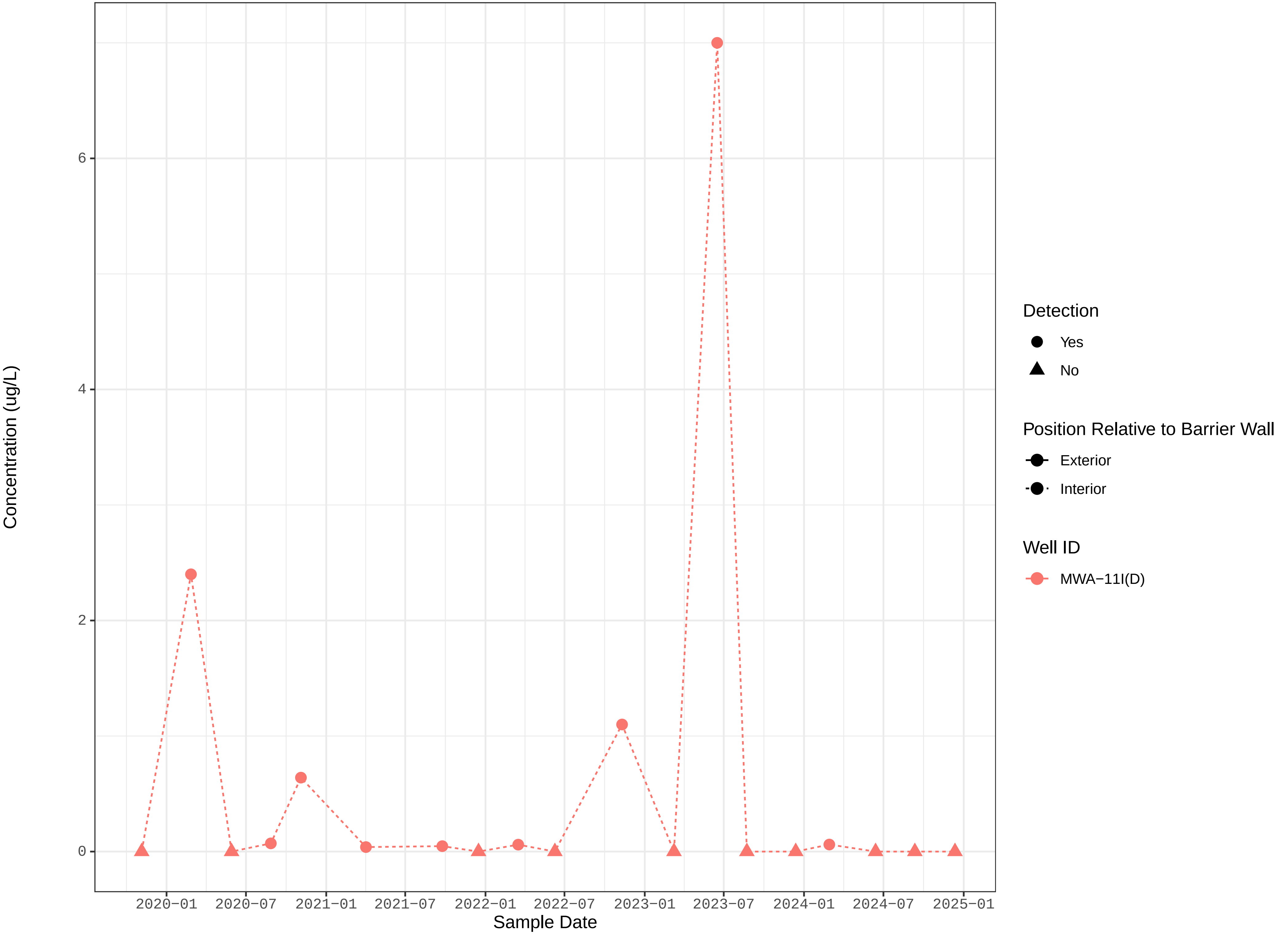



Current − GCC6 & Proximal Wells − Perchlorate − Shallow
Concentration (ug/L)
400
200
0
2020−01
2020−07
2021−01
2021−07
2022−01
2022−07
2023−01
2023−07
2024−01
2024−07
2025−01
Sample Date
Detection
Yes
No
Position Relative to Barrier Wall
Exterior
Interior
Well ID
MWA−41
MWA−82
PA−08
PA−09

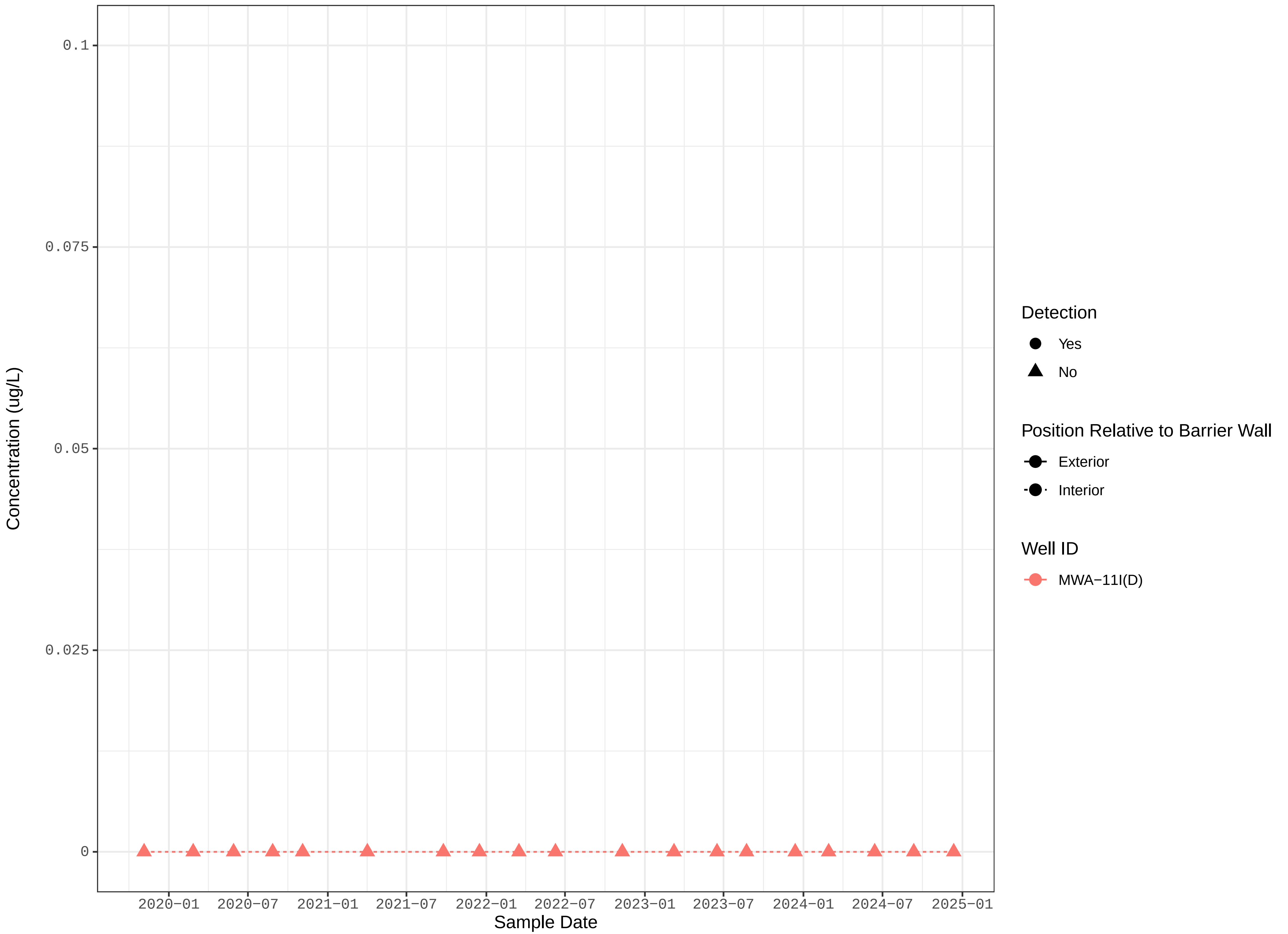
Current − Well Distal from BW and GCCs − Chloride − Deep



Current − Well Distal from BW and GCCs − Chlorobenzene − Deep



Current − Well Distal from BW and GCCs − Perchlorate − Deep



ERM

APPENDIX D COMPLETE STATISTICAL DATA ANALYSIS

Table 1
Descriptive Statistics
ARKEMA-PORTLAND

chemical_name	sys_loc_code	date_range	cluster	barrier	aquifer	Units	N	Num Detects	Num ND	Percent Detects	Min RL	Max RL	Min Detect	Median	Mean	Max Detect	SD	CV	Distribution
Chloride	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	ug/L	19	19	0	100.00%			180000	1500000	1485000	6300000	1297000	87.36%	Lognormal
Chloride	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	ug/L	2	2	0	100.00%			1090000	1150000	1150000	1210000	84850	7.38%	NDD
Chloride	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			13000000	25000000	22770000	30000000	5444000	23.91%	Normal
Chloride	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	ug/L	2	2	0	100.00%			53700000	54000000	54000000	54300000	424300	0.79%	NDD
Chloride	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	19	0	100.00%			4900	8000	10370	21000	4981	48.04%	Lognormal
Chloride	MWA-41	Historic	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	2	2	0	100.00%			26300	26450	26450	26600	212.1	0.80%	NDD
Chloride	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			10000000	18000000	17600000	26000000	4409000	25.05%	Normal
Chloride	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	2	2	0	100.00%			22800000	25350000	25350000	27900000	3606000	14.23%	NDD
Chloride	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			17000000	20000000	20740000	29000000	3019000	14.56%	NDD
Chloride	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	2	2	0	100.00%			33600000	43600000	43600000	53600000	14140000	32.44%	NDD
Chloride	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	19	0	100.00%			4500	14000	22070	83000	23460	106.31%	Lognormal
Chloride	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	2	2	0	100.00%			358000	524000	524000	690000	234800	44.80%	NDD
Chloride	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	19	19	0	100.00%			8400	39000	84030	610000	135100	160.82%	Lognormal
Chloride	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	19	19	0	100.00%			7900	11000	12690	34800	5741	45.23%	NDD
Chloride	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	18	1	94.74%	9000	9000	3700	6200	6421	10000	2241	34.90%	NDD
Chloride	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	19	19	0	100.00%			4600	6900	8226	14300	3408	41.43%	NDD
Chloride	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	19	19	0	100.00%			29000	190000	208400	770000	163000	78.20%	Lognormal
Chloride	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	19	0	100.00%			5600	23600	61450	199000	63920	104.03%	Lognormal
Chloride	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	19	19	0	100.00%			25000	67000	129300	1300000	284600	220.11%	NDD
Chloride	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	19	19	0	100.00%			4400	250000	227800	850000	190100	83.45%	NDD
Chloride	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	18	18	0	100.00%			12000	102500	129700	530000	131800	101.60%	Lognormal
Chloride	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	ug/L	19	19	0	100.00%			8800	35000	37310	73600	18810	50.43%	Normal
Chloride	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	ug/L	8	8	0	100.00%			27000	66000	65750	98000	22370	34.03%	Normal
Chloride	PA-19D	Current	GCC2	Exterior	Deep	ug/L	19	19	0	100.00%			94000	320000	272400	360000	87730	32.21%	NDD
Chloride	PA-20D	Current	GCC3	Interior	Deep	ug/L	19	19	0	100.00%			570000	840000	877300	1200000	189500	21.60%	Normal
Chloride	PA-21D	Current	GCC3	Exterior	Deep	ug/L	17	17	0	100.00%			290000	347000	353500	463000	46810	13.24%	Normal
Chloride	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	ug/L	19	19	0	100.00%			4300000	7100000	6994000	10200000	1890000	27.02%	Normal
Chloride	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	ug/L	19	19	0	100.00%			12500	17000000	17250000	33000000	11090000	64.28%	Normal
Chloride	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			30000000	35000000	36150000	46000000	5699000	15.76%	NDD
Chloride	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	ug/L	19	19	0	100.00%			1100	22100	20170	34000	7927	39.30%	Normal
Chloride	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			6500	60000	53840	80000	21570	40.06%	NDD
Chloride	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			450000	810000	782300	1150000	199600	25.52%	Normal
Chloride	PA-30D	Current	GCC2	Interior	Deep	ug/L	19	19	0	100.00%			56000	320000	325400	540000	120000	36.87%	Normal
Chloride	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	19	19	0	100.00%			2500	5900	6384	10500	2369	37.10%	Normal
Chloride	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	19	19	0	100.00%			31000	89000	497600	7600000	1720000	345.77%	NDD
Chloride	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	19	19	0	100.00%			1900	55000	99740	370000	106900	107.18%	Lognormal
Chlorobenzene	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	ug/L	19	9	10	47.37%	0.025	0.7	0.039	0.047	0.6417	7	1.646	256.44%	NDD
Chlorobenzene	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	ug/L	2	1	1	50.00%	0.78	0.78	1.92	1.155	1.155	1.92	1.082	93.67%	NDD
Chlorobenzene	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	6	13	31.58%	0.44	4.4	0.32	0.22	0.4337	0.58	0.4547	104.85%	NDD
Chlorobenzene	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	ug/L	2	1	1	50.00%	2.5	2.5	0.64	0.945	0.945	0.64	0.4313	45.64%	NDD
Chlorobenzene	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	2	17	10.53%	0.025	0.44	0.06	0.03	0.04658	0.16	0.05549	119.12%	NDD
Chlorobenzene	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	0	19	0.00%	0.3	4.4		0.22	1.091		0.9877	90.53%	NDD
Chlorobenzene	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	2	0	2	0.00%	2.5	5		1.875	1.875		0.8839	47.14%	NDD
Chlorobenzene	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	0	19	0.00%	0.3	4.4		1.1	1.027		0.8899	86.67%	NDD
Chlorobenzene	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	2	1	1	50.00%	2.5	2.5	2	1.625	1.625	2	0.5303	32.64%	NDD
Chlorobenzene	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	1	18	5.26%	0.3	44	5.6	0.22	1.854	5.6	5.058	272.76%	NDD
Chlorobenzene	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	2	1	1	50.00%	100	100	0.18	25.09	25.09	0.18	35.23	140.41%	NDD
Chlorobenzene	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	19	2	17	10.53%	0.025	0.44	0.085	0.03	0.05316	0.26	0.07015	131.96%	NDD
Chlorobenzene	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	19	3	16	15.79%	0.025	0.44	0.03	0.03	0.05895	0.24	0.06737	114.29%	NDD
Chlorobenzene	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	1	18	5.26%	0.025	0.44	0.29	0.03	0.05211	0.29	0.07497	143.89%	NDD
Chlorobenzene	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	19	1	18	5.26%	0.025	2	0.14	0.03	0.08895	0.14	0.2248	252.76%	NDD
Chlorobenzene	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	19	6	13	31.58%	0.025	0.6	0.084	0.03	0.1087	0.53	0.1319	121.27%	Lognormal
Chlorobenzene	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	2	17	10.53%	0.025	0.44	0.16	0.03	0.07671	0.39	0.09575	124.82%	NDD
Chlorobenzene	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	19	15	4	78.95%	0.06	0.44	0.37	0.64	0.8626	5.7	1.228	142.35%	NDD
Chlorobenzene	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	19	2	17	10.53%	0.025	2.5	0.073	0.03	0.1384	0.29	0.2847	205.63%	NDD
Chlorobenzene	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	18	6	12	33.33%	0.025	0.44	0.073	0.0865	0.1061	0.31	0.08863	83.50%	NDD
Chlorobenzene	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	ug/L	19	8	11	42.11%	0.025	0.7	0.072	0.1	1.385	24	5.478	395.59%	NDD
Chlorobenzene	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	ug/L	8	0	8	0.00%	0.44	0.44		0.22	0.22		0	0.00%	NDD
Chlorobenzene	PA-19D	Current	GCC2	Exterior	Deep	ug/L	18	18	0	100.00%			2500	6850	6839	12000	3131	45.79%	Normal
Chlorobenzene	PA-20D	Current	GCC3	Interior	Deep	ug/L	19	19	0	100.00%			1.7	18	20.27	41	12.53	61.81%	Normal
Chlorobenzene	PA-21D	Current	GCC3	Exterior	Deep	ug/L	17	17	0	100.00%			11000	30000	31820	49000	11810	37.10%	Normal
Chlorobenzene	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	ug/L	19	0	19	0.00%	0.3	0.44		0.22	0.2163		0.01606	7.42%	NDD
Chlorobenzene	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	ug/L	19	2	17	10.53%	0.3	0.44	1.3	0.22	0.4089	2.8	0.6302	154.11%	NDD
Chlorobenzene	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	0	19	0.00%	0.3	0.44		0.22	0.2163		0.01606	7.42%	NDD
Chlorobenzene	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	ug/L	19	0	19	0.00%	0.025	0.44		0.03	0.03816		0.04806	125.95%	NDD
Chlorobenzene	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	ug/L	19	1	18	5.26%	0.025	0.44	0.71	0.03	0.07026	0.71	0.1615	229.86%	NDD
Chlorobenzene	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	ug/L	19	3	16	15.79%	0.3	0.44	0.52	0.22	0.4374	3.5	0.7579	173.29%	NDD

chemical_name	sys_loc_code	date_range	cluster	barrier	aquifer	Units	N	Num Detects	Num ND	Percent Detects	Min RL	Max RL	Min Detect	Median	Mean	Max Detect	SD	CV	Distribution
Chlorobenzene	PA-30D	Current	GCC2	Interior	Deep	ug/L	18	18	0	100.00%			3500	6800	11310	26000	7861	69.53%	NDD
Chlorobenzene	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	19	1	18	5.26%	0.025	0.44	0.15	0.03	0.04105	0.15	0.05273	128.44%	NDD
Chlorobenzene	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	19	13	6	68.42%	0.025	0.7	0.13	0.28	0.24	0.5	0.1342	55.92%	Normal
Chlorobenzene	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	19	1	18	5.26%	0.025	0.44	0.18	0.03	0.04868	0.18	0.06156	126.44%	NDD
Perchlorate	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	ug/L	19	0	19	0.00%	0.91	48		5	7.001		6.342	90.60%	NDD
Perchlorate	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	ug/L	2	0	2	0.00%	4	8		3	3		1.414	47.14%	NDD
Perchlorate	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			28000	97000	90320	100000	16530	18.31%	NDD
Perchlorate	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	ug/L	2	2	0	100.00%			1840	3785	3785	5730	2751	72.67%	NDD
Perchlorate	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	1	18	5.26%	0.91	2	2.6	1	0.8887	2.6	0.4886	54.98%	NDD
Perchlorate	MWA-41	Historic	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	2	1	1	50.00%	4	4	1.7	1.85	1.85	1.7	0.2121	11.47%	NDD
Perchlorate	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			3300	11000	10270	16000	4094	39.85%	Normal
Perchlorate	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	2	2	0	100.00%			2140	2285	2285	2430	205.1	8.97%	NDD
Perchlorate	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			38000	49000	47890	61000	4886	10.20%	Normal
Perchlorate	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	2	2	0	100.00%			59600	93800	93800	128000	48370	51.56%	NDD
Perchlorate	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	1	18	5.26%	0.91	10	13	1	1.842	13	2.901	157.44%	NDD
Perchlorate	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	2	0	2	0.00%	4	8		3	3		1.414	47.14%	NDD
Perchlorate	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	19	0	19	0.00%	0.91	10		1	1.068		1.024	95.94%	NDD
Perchlorate	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	19	17	2	89.47%	10	48	20	150	160.1	530	133.3	83.28%	Lognormal
Perchlorate	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	0	19	0.00%	2	95		4.55	9.079		11.6	127.81%	Lognormal
Perchlorate	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	19	0	19	0.00%	2	48		2.4	4.868		5.528	113.54%	Lognormal
Perchlorate	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	19	4	15	21.05%	4	48	11	10	12.77	33	8.406	65.85%	Lognormal
Perchlorate	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	7	12	36.84%	0.95	48	6.2	10	21.15	120	31.18	147.41%	Lognormal
Perchlorate	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	19	0	19	0.00%	2	95		5	11.86		13.84	116.67%	Lognormal
Perchlorate	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	19	0	19	0.00%	4	48		5	9.974		7.871	78.92%	NDD
Perchlorate	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	18	0	18	0.00%	4	48		7.5	9.775		8.407	86.01%	NDD
Perchlorate	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	ug/L	19	0	19	0.00%	2	190		5	16.26		23.59	145.07%	Lognormal
Perchlorate	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	ug/L	8	0	8	0.00%	9.1	91		7.5	13.13		14.07	107.18%	Lognormal
Perchlorate	PA-19D	Current	GCC2	Exterior	Deep	ug/L	19	1	18	5.26%	4.5	200	100	10	23.72	100	28.91	121.87%	Lognormal
Perchlorate	PA-20D	Current	GCC3	Interior	Deep	ug/L	19	10	9	52.63%	10	100	46	48	43.21	140	38.08	88.14%	NDD
Perchlorate	PA-21D	Current	GCC3	Exterior	Deep	ug/L	17	9	8	52.94%	10	100	110	110	699.7	2400	784.9	112.17%	NDD
Perchlorate	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	ug/L	19	19	0	100.00%			13000	22000	24580	54000	12020	48.92%	NDD
Perchlorate	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	ug/L	19	0	19	0.00%	0.91	1000		50	86.4		124.5	144.06%	NDD
Perchlorate	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	0	19	0.00%	0.91	400		100	97.02		80.13	82.59%	NDD
Perchlorate	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	ug/L	19	0	19	0.00%	0.91	9.5		1	1.029		0.9352	90.84%	NDD
Perchlorate	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	ug/L	19	1	18	5.26%	0.91	9.5	1.1	1	1.115	1.1	0.9499	85.19%	NDD
Perchlorate	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	ug/L	19	0	19	0.00%	4.8	95		10	11.39		10.48	92.01%	NDD
Perchlorate	PA-30D	Current	GCC2	Interior	Deep	ug/L	19	0	19	0.00%	10	200		10	27.58		28.32	102.68%	NDD
Perchlorate	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	19	0	19	0.00%	2	100		4.75	8.271		11.89	143.78%	Lognormal
Perchlorate	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	19	0	19	0.00%	4	190		10	20.58		21.75	105.71%	NDD
Perchlorate	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	19	5	14	26.32%	2	95	7.1	5	52.12	390	104.9	201.36%	Lognormal

Notes

date_range: Historic includes dates from 2007 - 2010
date_range: Current includes dates from Q4 2019 - Q4 2024

Non-detects were substituted with a value of half the reporting limit for calculations
N: number of data points
Num ND: number of non-detected data points
Min RL: The minimum reporting limit value
Max RL: The maximum reporting limit value
SD: Standard Deviation
CV: Coefficient of Variation (standard deviation divided by the mean)
Normal: the data fit a normal distribution
Lognormal: the data fit a lognormal distribution
NDD: No discernible distribution
GammaHW or GammaWH: the data fit one of the particular gamma distributions

Table 2
Mann Kendall Test for Trends
ARKEMA-PORTLAND

chemical_name	sys_loc_code	date_range	cluster	barrier	aquifer	N	Num Detects	Percent Detects	Meet Data Reqs	p-value	tau2	tau	Trend
Chloride	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	19	19	100.00%	Yes	0.0991	0.0774	-0.278	NS
Chloride	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	0.0104	0.187	-0.432	Significant
Chloride	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	19	19	100.00%	Yes	0.278	0.0333	-0.182	NS
Chloride	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	<0.001	0.627	-0.792	Significant
Chloride	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	0.0578	0.11	-0.332	NS
Chloride	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	19	19	100.00%	Yes	0.22	0.0424	-0.206	NS
Chloride	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	19	19	100.00%	Yes	0.0209	0.15	-0.387	Significant
Chloride	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	19	19	100.00%	Yes	0.00384	0.251	-0.501	Significant
Chloride	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	19	18	94.74%	Yes	<0.001	0.452	-0.673	Significant
Chloride	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	19	19	100.00%	Yes	<0.001	0.558	-0.747	Significant
Chloride	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	19	19	100.00%	Yes	0.599	0.00788	0.0888	NS
Chloride	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	19	19	100.00%	Yes	0.575	0.00891	-0.0944	NS
Chloride	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	19	19	100.00%	Yes	<0.001	0.401	-0.633	Significant
Chloride	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	19	19	100.00%	Yes	0.22	0.0424	-0.206	NS
Chloride	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	18	18	100.00%	Yes	0.0122	0.19	-0.436	Significant
Chloride	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	19	19	100.00%	Yes	0.0129	0.174	-0.418	Significant
Chloride	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	8	8	100.00%	Yes	0.399	0.0816	0.286	NS
Chloride	PA-19D	Current	GCC2	Exterior	Deep	19	19	100.00%	Yes	0.0787	0.0891	0.299	NS
Chloride	PA-20D	Current	GCC3	Interior	Deep	19	19	100.00%	Yes	0.341	0.0265	-0.163	NS
Chloride	PA-21D	Current	GCC3	Exterior	Deep	17	17	100.00%	Yes	0.00217	0.31	-0.557	Significant
Chloride	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	19	19	100.00%	Yes	<0.001	0.768	-0.876	Significant
Chloride	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	19	19	100.00%	Yes	0.00204	0.27	0.519	Significant
Chloride	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	<0.001	0.656	-0.81	Significant
Chloride	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	19	19	100.00%	Yes	0.504	0.013	0.114	NS
Chloride	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	0.00324	0.246	0.496	Significant
Chloride	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	0.00315	0.236	-0.485	Significant
Chloride	PA-30D	Current	GCC2	Interior	Deep	19	19	100.00%	Yes	0.805	0.00176	0.0419	NS
Chloride	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	19	19	100.00%	Yes	<0.001	0.296	-0.544	Significant
Chloride	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	19	19	100.00%	Yes	<0.001	0.304	-0.551	Significant
Chloride	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	19	19	100.00%	Yes	0.73	0.00414	-0.0643	NS
Chlorobenzene	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	19	9	47.37%	Insufficient FOD				
Chlorobenzene	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	19	6	31.58%	Insufficient detects				
Chlorobenzene	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	19	2	10.53%	Insufficient detects				
Chlorobenzene	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	19	0	0.00%	Insufficient detects				
Chlorobenzene	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	19	0	0.00%	Insufficient detects				
Chlorobenzene	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	19	1	5.26%	Insufficient detects				
Chlorobenzene	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	19	2	10.53%	Insufficient detects				
Chlorobenzene	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	19	3	15.79%	Insufficient detects				
Chlorobenzene	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	19	1	5.26%	Insufficient detects				
Chlorobenzene	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	19	1	5.26%	Insufficient detects				
Chlorobenzene	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	19	6	31.58%	Insufficient detects				
Chlorobenzene	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	19	2	10.53%	Insufficient detects				
Chlorobenzene	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	19	15	78.95%	Yes	0.218	0.0439	0.21	NS
Chlorobenzene	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	19	2	10.53%	Insufficient detects				
Chlorobenzene	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	18	6	33.33%	Insufficient detects				
Chlorobenzene	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	19	8	42.11%	Insufficient FOD				
Chlorobenzene	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	8	0	0.00%	Insufficient detects				
Chlorobenzene	PA-19D	Current	GCC2	Exterior	Deep	18	18	100.00%	Yes	0.82	0.00155	0.0393	NS
Chlorobenzene	PA-20D	Current	GCC3	Interior	Deep	19	19	100.00%	Yes	<0.001	0.553	-0.743	Significant
Chlorobenzene	PA-21D	Current	GCC3	Exterior	Deep	17	17	100.00%	Yes	0.137	0.0722	-0.269	NS
Chlorobenzene	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	19	0	0.00%	Insufficient detects				
Chlorobenzene	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	19	2	10.53%	Insufficient detects				
Chlorobenzene	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	19	0	0.00%	Insufficient detects				
Chlorobenzene	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	19	0	0.00%	Insufficient detects				
Chlorobenzene	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	19	1	5.26%	Insufficient detects				
Chlorobenzene	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	19	3	15.79%	Insufficient detects				

chemical_name	sys_loc_code	date_range	cluster	barrier	aquifer	N	Num Detects	Percent Detects	Meet Data Reqs	p-value	tau2	tau	Trend
Chlorobenzene	PA-30D	Current	GCC2	Interior	Deep	18	18	100.00%	Yes	0.0746	0.0956	0.309	NS
Chlorobenzene	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	19	1	5.26%	Insufficient detects				
Chlorobenzene	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	19	13	68.42%	Yes	0.886	0.000624	0.025	NS
Chlorobenzene	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	19	1	5.26%	Insufficient detects				
Perchlorate	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	19	0	0.00%	Insufficient detects				
Perchlorate	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	0.521	0.0125	-0.112	NS
Perchlorate	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	19	1	5.26%	Insufficient detects				
Perchlorate	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	<0.001	0.671	0.819	Significant
Perchlorate	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	19	19	100.00%	Yes	0.0372	0.128	0.358	Significant
Perchlorate	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	19	1	5.26%	Insufficient detects				
Perchlorate	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	19	0	0.00%	Insufficient detects				
Perchlorate	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	19	17	89.47%	Yes	0.972	0.000035	0.00592	NS
Perchlorate	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	19	0	0.00%	Insufficient detects				
Perchlorate	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	19	0	0.00%	Insufficient detects				
Perchlorate	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	19	4	21.05%	Insufficient detects				
Perchlorate	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	19	7	36.84%	Insufficient detects				
Perchlorate	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	19	0	0.00%	Insufficient detects				
Perchlorate	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	19	0	0.00%	Insufficient detects				
Perchlorate	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	18	0	0.00%	Insufficient detects				
Perchlorate	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	19	0	0.00%	Insufficient detects				
Perchlorate	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	8	0	0.00%	Insufficient detects				
Perchlorate	PA-19D	Current	GCC2	Exterior	Deep	19	1	5.26%	Insufficient detects				
Perchlorate	PA-20D	Current	GCC3	Interior	Deep	19	10	52.63%	Yes	0.206	0.0504	-0.225	NS
Perchlorate	PA-21D	Current	GCC3	Exterior	Deep	17	9	52.94%	Yes	<0.001	0.452	-0.673	Significant
Perchlorate	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	19	19	100.00%	Yes	<0.001	0.719	-0.848	Significant
Perchlorate	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	19	0	0.00%	Insufficient detects				
Perchlorate	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	19	0	0.00%	Insufficient detects				
Perchlorate	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	19	0	0.00%	Insufficient detects				
Perchlorate	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	19	1	5.26%	Insufficient detects				
Perchlorate	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	19	0	0.00%	Insufficient detects				
Perchlorate	PA-30D	Current	GCC2	Interior	Deep	19	0	0.00%	Insufficient detects				
Perchlorate	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	19	0	0.00%	Insufficient detects				
Perchlorate	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	19	0	0.00%	Insufficient detects				
Perchlorate	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	19	5	26.32%	Insufficient detects				

Notes
date_range: Current includes dates from Q4 2019 - Q4 2024

Non-detects were substituted with a value of zero for trend analysis
N: number of data points
Meet Data Reqs: trend tests were performed only if the dataset had >=8 detected values and >=50 percent detects.
tau2: tau^2, measure of linear model fit
tau: Kendall's tau statistic
p-value: A two-sided p-value describing the probability of the H0 being true (a=0.99)

Table 3
Historical Barrier Wall Comparison Table
ARKEMA-PORTLAND

Analyte	Region	Aquifer Zone	Location	Unit	Historical N	Historical 2 N	Current N	Historical Max Conc	Current Max Conc	Order of Magnitude Change	Detect Status Change	Current Trend
Chloride	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	0	8		98000	N/A	N/A	Stable
Chloride	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	0	19		1150000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	0	19		1300000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	0	19		73600	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	0	19		7600000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	2	21	19	690000	83000	Decrease	None	Stable
Chloride	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	0	19		10000	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	0	19		14300	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	0	19		10500	N/A	N/A	Decreasing
Chloride	GCC2	Deep	PA-19D	ug/L	0	0	19		360000	N/A	N/A	Stable
Chloride	GCC2	Deep	PA-30D	ug/L	0	0	19		540000	N/A	N/A	Stable
Chloride	GCC3	Deep	PA-20D	ug/L	0	0	19		1200000	N/A	N/A	Stable
Chloride	GCC3	Deep	PA-21D	ug/L	0	0	17		463000	N/A	N/A	Decreasing
Chloride	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	2	21	19	27900000	26000000	None	None	Decreasing
Chloride	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	2	21	19	53600000	29000000	None	None	Stable
Chloride	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	0	19		10200000	N/A	N/A	Decreasing
Chloride	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	2	21	19	54300000	30000000	None	None	Decreasing
Chloride	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	0	19		33000000	N/A	N/A	Increasing
Chloride	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	0	19		46000000	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	0	19		34000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	0	19		80000	N/A	N/A	Increasing
Chloride	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	0	19		610000	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	0	19		850000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	0	18		530000	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	0	19		370000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	2	21	19	26600	21000	None	None	Stable
Chloride	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	0	19		34800	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	0	19		770000	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	0	19		199000	N/A	N/A	Stable
Chloride	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	2	21	19	1210000	6300000	None	None	Stable
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	0	8		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	0	19		3.5	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	0	19		5.7	N/A	N/A	Stable
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	0	19		24	N/A	N/A	Insufficient FOD
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	0	19		<0.7	N/A	N/A	Stable
Chlorobenzene	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	2	21	19	<100	<44	N/A	None	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	0	19		<2	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC2	Deep	PA-19D	ug/L	0	0	18		12000	N/A	N/A	Stable
Chlorobenzene	GCC2	Deep	PA-30D	ug/L	0	0	18		26000	N/A	N/A	Stable
Chlorobenzene	GCC3	Deep	PA-20D	ug/L	0	0	19		41	N/A	N/A	Decreasing
Chlorobenzene	GCC3	Deep	PA-21D	ug/L	0	0	17		49000	N/A	N/A	Stable
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	2	21	19	<5	<4.4	N/A	None	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	2	21	19	<2.5	<4.4	N/A	None	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	2	21	19	<2.5	<4.4	N/A	None	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	0	19		2.8	N/A	N/A	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	0	19		0.71	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	0	19		<2.5	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	0	18		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	0	19		<0.6	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	0	19		<0.44	N/A	N/A	Insufficient detects
Chlorobenzene	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	2	21	19	1.92	7	None	None	Insufficient FOD
Perchlorate	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	0	8		<91	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	0	19		<95	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	0	19		<95	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	0	19		<190	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	0	19		<190	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	2	21	19	<8	13	N/A	ND to Detect	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	0	19		<95	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	0	19		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	0	19		<100	N/A	N/A	Insufficient detects
Perchlorate	GCC2	Deep	PA-19D	ug/L	0	0	19		<200	N/A	N/A	Insufficient detects
Perchlorate	GCC2	Deep	PA-30D	ug/L	0	0	19		<200	N/A	N/A	Insufficient detects
Perchlorate	GCC3	Deep	PA-20D	ug/L	0	0	19		140	N/A	N/A	Stable
Perchlorate	GCC3	Deep	PA-21D	ug/L	0	0	17		2400	N/A	N/A	Decreasing
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	2	21	19	2430	16000	Increase	None	Increasing
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	2	21	19	128000	61000	Decrease	None	Increasing
Perchlorate	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	0	19		54000	N/A	N/A	Decreasing
Perchlorate	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	2	21	19	5730	100000	Increase	None	Stable
Perchlorate	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	0	19		<1000	N/A	N/A	Insufficient detects
Perchlorate	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	0	19		<400	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	0	19		<9.5	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	0	19		<9.5	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	0	19		<10	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	0	19		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	0	18		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	0	19		390	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	2	21	19	<4	2.6	N/A	ND to Detect, high Historical DL	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	0	19		530	N/A	N/A	Stable
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	0	19		<48	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	0	19		120	N/A	N/A	Insufficient detects
Perchlorate	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	2	21	19	<8	<48	N/A	None	Insufficient detects

Notes

date_range: Historical includes dates from 2007 - 2010
date_range: Current includes dates from Q4 2019 - Q4 2024

Historical Max Conc: maximum concentration from the Historical date range
Current Max Conc: maximum concentration from the Current date range
Order of Magnitude Change: concentration change from Historical date range to Current date range
- Increase - Current concentration is a magnitude larger than Historical
- Decrease - Current concentration is a magnitude smaller than Historical
- None - Current concentration is not a magnitude larger or smaller than Historical
- N/A - detection status is different between the Historical and Current concentration, or both are NDs, or one of Historical and Current concentrations not sampled

Detect Status Change: detect status change from Historical date range to Current date range
- Detect to ND - Historical detect with Current ND
- Detect to ND, high Current DL - Historical detect with Current ND, but Current DL greater than Historical detect
- ND to Detect - Historical ND with Current detect
- ND to Detect, high Historical DL - Historical ND with Current detect, but Historical DL greater than Current detect
- None - same detection status between Historical and Current
- N/A - one of Historical and Current concentrations not sampled

Current Trend: provides summary of trend results for Current date range
- Stable, Increasing, or Decreasing: trend criteria met and calculated
- Insufficient detects, Insufficient FOD (frequency of detects): trend criteria not met and not calculated
- N/A - no samples collected at all

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